ARTS and SCIENCES No. 6

# EXPERIMENTAL WIRELESS CONSTRUCTION

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ARTS AND SCIENCES—No. 6

# Experimental Wireless Construction

A PRACTICAL HANDBOOK GIVING DETAILED INSTRUCTIONS FOR BUILDING, INSTALLING AND OPERATING AMATEUR WIRELESS TELEGRAPH APPARATUS

BY

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## INTRODUCTION

This little volume enlarges the scope of our book "Wireless Construction and Installation for Beginners'' and gives detailed instructions for building, installing and operating amateur wireless telegraph instruments and outfits which are far more elaborate.

The purpose of "Wireless Construction and Installation for Beginners" is to aid the young experimenter in building and operating an inexpensive wireless outfit and to give him the proper guidance in taking up this interesting and instructive pastime, as a beginner.

Those wishing to progress farther and build more elaborate apparatus will find complete details and instructions in this book.

In our book "Lessons in Wireless Telegraphy," we have described the elementary principles of wireless telegraphy, and in the "Amateur's Wireless Handybook," will be found a list of commercial and amateur wireless telegraph stations and a comprehensive series of wiring diagrams for connecting together wireless telegraph instruments of every description.

The purpose of "The Operation of Wireless Telegraph Apparatus" is to aid the wireless experimenter and operator in understanding more fully the methods whereby best efficiency and consequently best results can be obtained with his instruments.

# CHAPTER I.

**The Location of the Station. The Aerial and Ground. How to Erect an Aerial. The Lightning Switch.**

Every wireless station is provided with a system of wires, elevated high in the air, above all surrounding objects. This system of wires is called the **aerial** or **antenna** and its purpose is to radiate or intercept the electromagnetic waves, accordingly as the station is transmitting or receiving.

The aerial might therefore be termed the mouth and ear of a wireless station.

The wires which compose the aerial may be arranged either vertically, horizontally, or sloping, or partly vertical. **The site and arrangement of the aerial will greatly determine the efficiency and range of the apparatus.** This fact is often entirely disregarded by the amateur wireless experimenter. It should be the first consideration in planning a wireless station, for even though you may have the best of equipment in the way of instruments you will be greatly handicapped in trying to cover long distances with your station if your aerial is a poor one.

Of course most amateur experimenters locate their station right in their home, and inasmuch as they are unable to change the surroundings of their home they must, to a certain extent at least, take things as they are. A careful study of the conditions will, however, often enable one to overcome any seeming handicaps which may exist.

The two principal qualities desired in an aerial are **height** and **length.** Within certain limits, the higher and longer an aerial, the more desirable it is.

The site selected for the aerial is, as far as it is possible, preferably such that the aerial will not be in the immediate neighborhood of any tall or metallic objects such as trees, smoke-stacks, telephone wires, etc., because such objects not only absorb an appreciable amount of energy when the station is transmitting messages, but also noticeably affects the incoming waves when receiving.

Trolley lines, telephone and telegraph wires, metal smoke-stacks, tin roofs and other conducting bodies will all affect an aerial to a certain extent, if they are too close to it.

If these obstacles cannot be removed, and it is necessary to locate the aerial in their vicinity, the aerial should be raised above them if possible.

In cases where neighboring telephone or power wires are objectionable, the aerial should be arranged at right angles to such wires if possible, with the "free end," that is, the end opposite that to which the instruments are connected, farthest away.

When an aerial is erected on a house or a building having a tin roof or metal cornices, the latter should be grounded by connecting with a wire running to earth.

When either an aerial or the "leading-in" wire is led down from the top of a building it should be kept as far away from the building as is possible.

Always lead in from the aerial as many and the same size wires as in the aerial itself, the entire distance from the aerial to the instruments.

**Amateur Wireless Stations** are usually located in the top floor of a house or in the corner of the owner's bedroom. The experimenter usually has small choice in the matter and must of necessity place his apparatus wherever he may. For that reason the actual location is not always as desirable as it might be.

Whenever any choice may be exercised it is of course best to select a room or portion of the house which will permit the arrangement of the aerial, lead-in and ground wire to be the most efficient under the circumstances. There are a number of things which should be taken into consideration, chief among which are the following:

1. The station should be located, if possible, so that the "free end" of the aerial, that is the end of the



aerial opposite to that to which the instruments are connected, is higher above ground than the station.

2. The actual end of the aerial to which the instruments are connected should be higher than the station.

3. Aerials send and receive best in certain directions and the station should be so located as to take advantage of these directive effects.

4. The station should be located so that the lead-in

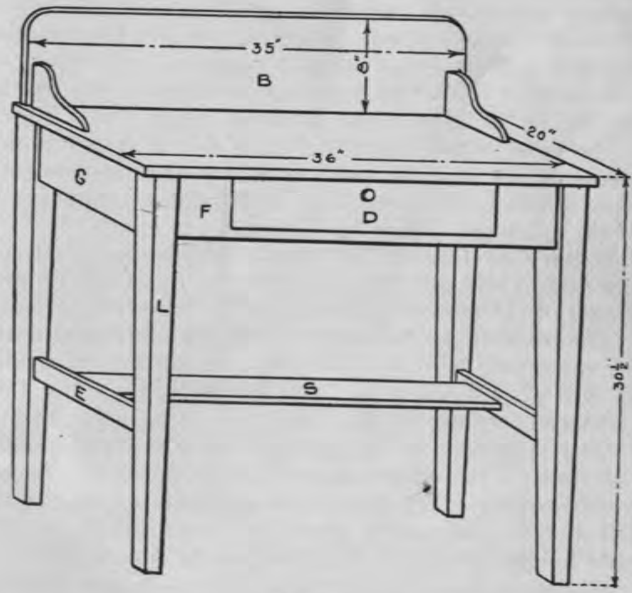



FIG. 2.
A Plan for a convenient Operating Table or Bench for a complete Amateur Wireless Outfit.

wire coming from the aerial is as straight and direct as possible. A long lead in wire which takes several turns or bends and which must pass through a house some distance before reaching the apparatus is undesirable for many reasons.

5. The station should be located so that the ground

wire is as short and direct as possible. **A good ground or earth connection is as important as a good aerial.**

**The actual arrangement of the apparatus on the operating bench** or table will of course depend greatly upon the instruments selected, their size and also the space at the disposal of the experimenter.

It is very important that the instruments be properly arranged so as to avoid the crossing or twisting of wires, etc. Wires and coils carrying high frequency electricity, such as flows in the circuits of wireless apparatus, act **inductively** upon one another through a distance of several feet.

A desk or a kitchen table makes an excellent operating bench provided that it is the right size. Figure 2 shows a small operating table for wireless instruments which may be easily built by any experimenter who is handy with wood working tools. The details of the table are shown in Figure 3. It is not of course necessary to follow the actual dimensions given but the design and size may be altered to suit the requirements of the person using the table. The vertical board at the back of the table will be found extremely useful for mounting switches, meters, and similar apparatus. It will also serve to protect the wall when the table is placed against it.

**The Supports or Masts** used to elevate the aerial are usually the chief concern of the average wireless experimenter. Tall flag poles are quite expensive and the question is usually therefore how to obtain a suitable height without a large outlay for a pole or mast.

Where no trees, poles, barns or houses are available a pole will of course be necessary but when such objects are in the near vicinity to the spot where the aerial is to be located, they offer a partial solution of the difficulty, for they are a start, at least, and may be used as a base or foundation for a pole.

A short mast is easily placed in the top of a tree or on the roof of a house or barn. The average house or tree is probably at least 35 feet high. A 25-foot pole on top of it gives an available height of 60 feet,



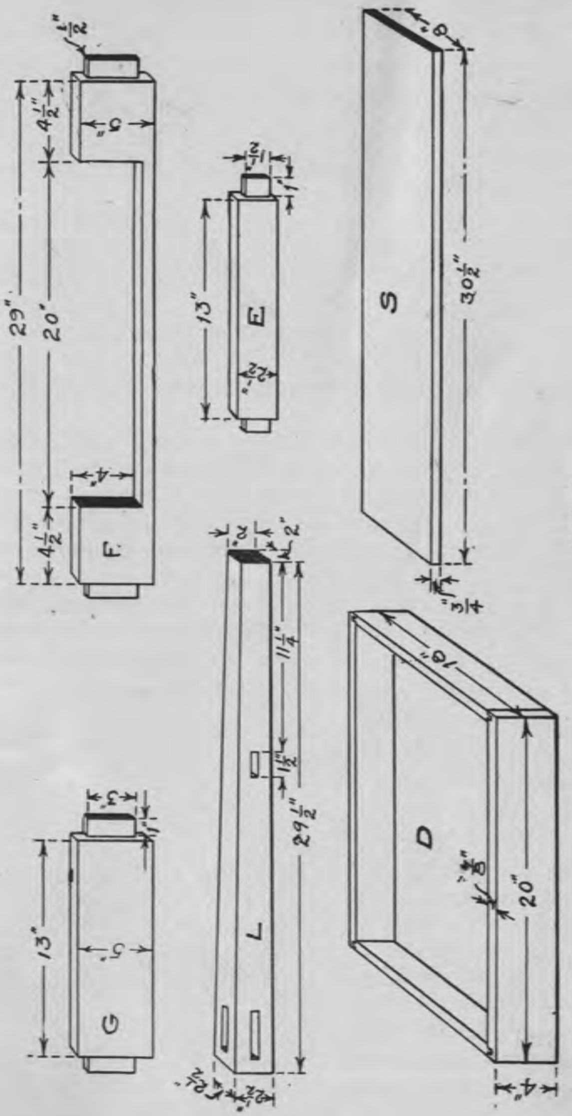


FIG. 3.

Details of the Operating Table illustrated in Figure 3. The various parts are lettered so that they may be identified by comparison with Figure 3.

which in most cases is satisfactory for experimental work.

A wooden pole or mast is more desirable than one made of metal or iron pipe. A metal pole will absorb a certain amount of energy and offers the same objection as any prominent obstruction in the neighborhood of the aerial would.

The large metal towers or masts employed by a great many high powered stations are used because a wooden mast of the same height would be almost out of the question and would not be strong enough. Such metal masts usually rest upon an insulated base. This arrangement eliminates to a large extent any losses of energy which might take place due to absorption by the pole itself.

Poles should be fastened to their supports by bolting or lashing. Spikes will not hold well and will also weaken both the pole and its support.

**Guy Wires** will usually be necessary in order to brace the pole and to counteract the strain or pull due to the weight of the aerial.

There is a wire regularly sold for this purpose by various firms dealing in wireless materials. It is a stranded, galvanized, mild steel cable composed of six No. 18 B. S. wires and usually sells for 35 cents per 100 feet.

Guy wires or stays, as they are also sometimes called, will absorb an appreciable amount of energy unless they are divided at one or two points by ar insulator so that currents tending to flow up and down the wires cannot pass the insulators.

A good grade of hemp rope is the best to use in suspending the aerial. It is well to tar the rope so that it will not be affected by the weather. The rope should pass through a tackle block or pulley at the top of the pole so that the aerial may be easily raised or lowered at will.

The aerial should never be pulled up perfectly taut but rather allowed to hang somewhat slack so that the strain is relieved when the wires tend to sway in the



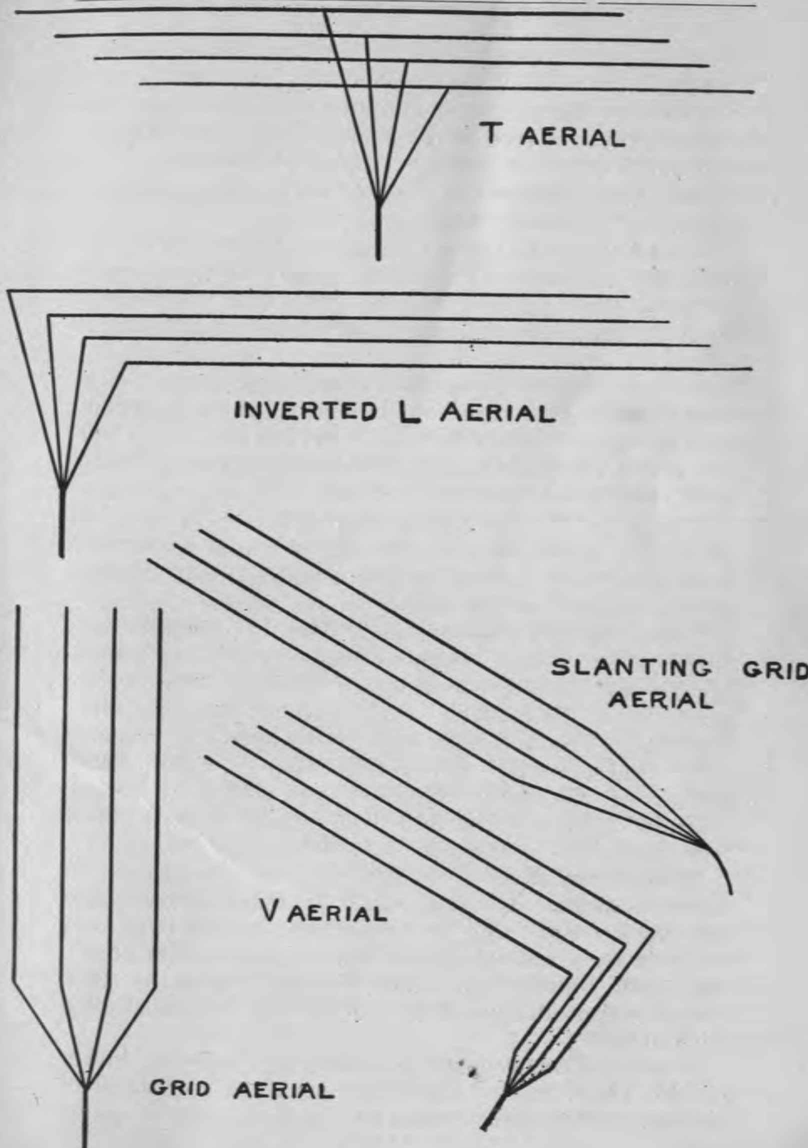



FIG. 4.
Diagrams representing the principal Types of Aerials in use.

wind. This precaution is especially necessary when one end of the aerial is supported in a tree because the motion of a tree in the wind is quite considerable and sufficient slack must be left to allow for it.

**The Aerial Wires** themselves may be composed of a number of different materials.

No. 14 B. and S. gauge aluminum wire is preferred by many amateur experimenters who find it necessary to make their aerial as light as possible. This wire costs 60 cents per lb. and there are about 250 feet in a lb.

No. 14 B. and S. gauge copper wire will also be found very satisfactory. It is slightly more expensive than aluminum on account of its greater weight. There are about 70 feet in a lb. and the average price for that amount is usually 45 cents.

Whenever the stretch is over 100 feet so that the wires are subjected to considerable strain from their own weight, it is best to use a cable made of hard drawn copper, or phosphor bronze wires. Commercial and navy stations use such wire. High frequency currents possess the peculiar property of only traveling on and near the surface of wires. They do not permeate to the centre of the conductor as do ordinary currents. The total surface of the wires in a cable is of course much greater than that of a solid conductor of the same diameter and for that reason stranded wire has the added advantage that it offers less resistance to the wireless currents.

**"Antennum wire"** finds great favor among amateur experimenters. It is a wire of exceedingly great tensible strength and is very reasonable in price. It is made by a special process which consists in covering steel billets with copper. The metal is then drawn and produces a wire composed of copper alloyed with steel.

It may be secured in the form of a single conductor of No. 14 B. and S. gauge or in cables composed of either four or seven strands of No. 22 B. and S. gauge wire.



**The Insulators** used on the aerial may vary according to its size and the power of the transmitting apparatus.

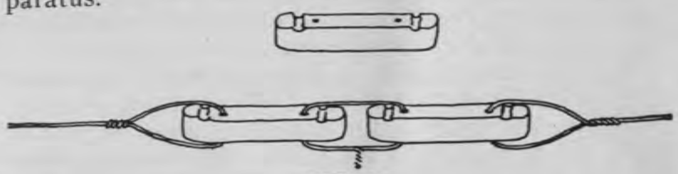


FIG. 5.
Showing how Porcelain Cleats may be used as Insulators for Light Aerials.

Ordinary porcelain cleats are very good insulators for light aerials. By connecting two cleats together with a short piece of wire as in Figure 5 their insulating value may be doubled.

Long heavy aerials will require an insulator not only of high electrical value but also great mechanical strength so as to withstand the weight of the aerial especially in the winter time during storms when it is liable to become covered with ice. This need is supplied by the special moulded insulators made of "Electrose." They are very strong and have a high insulating value. An iron ring imbedded in each end provides a convenient means for attaching a wire or rope.

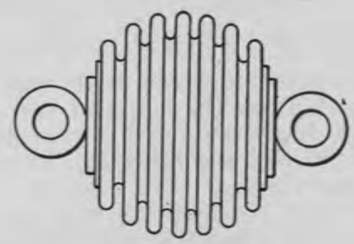


FIG. 6.
An Electrose Insulator of the Ball Type.

**Electrose Insulators** are made in the form of a ball and also in the form of corrugated rods. The ball insulators will prove suitable for aerials used for receiving or for transmitting sets of low power. The rod type of insulator may be secured in either a five, or ten and one-half inch size. The ten and one-half inch insulator is recommended for very long aerials or for transmitting sets employing a transformer.

The insulators shown in Figure 8 are very popular with amateur experimenters. They are made of glazed porcelain and possess an extremely high insulating value. They will hold over 35,000 volts without breaking down. The ribs or corrugations give a surface area twice as great as if the insulator were smooth. The low cost of these insulators recommends them for use to almost everyone, the price of the ball type being only 16 cents and the straight ribbed or "strain" insulator 10 cents.

**Types of Aerials.**—There are several forms and types of aerials which may be used.

When there is a high pole or tree available so that one end of the aerial is quite high and the other end drops down vertically or on a slant, the aerial is of the type known as a "grid" aerial.

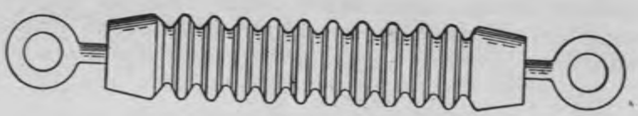


FIG. 7.
An Electrose Insulator of the Rod Type.

When two supports may be used, such as a tree in the yard and a pole on the house or two poles on the house, it is best to use an aerial of the "flat top" type.

The "T" aerial and the inverted "L" aerial belong to the "flat top" class.

The difference between these two forms of aerial lies in the place at which the wires leading in to the instruments are attached. In the "T" aerial they are attached to the middle of the flat portion of the aerial and in the "L" aerial they are attached to one end.

The "T" aerial is the best "all around" form and may be recommended wherever it is possible to erect



an aerial of this sort. The inverted "L" type is a very good aerial and is probably the one most employed by experimenters because they usually find that their stations have to be located at one end of the aerial and if they employed the "T" type the leading in wires would take too much of a slant.

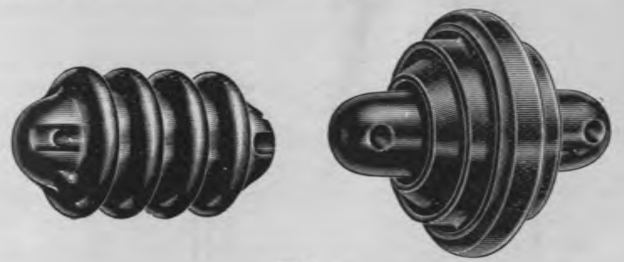


FIG. 8.
These are excellent Insulators. They are made of porcelain and have a very high insulating value.

Excellent results can be secured, in receiving, from a single stranded cable 500-1,000 feet long instead of a shorter aerial composed of four wires or cables. This form of aerial is not recommended for transmitting.

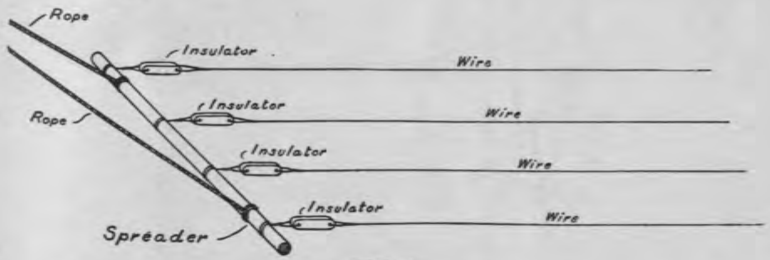



FIG. 9.
A Diagram showing how a four-wire Aerial is arranged and insulated from the Spreader.

**Erecting an Aerial** is not work usually involving any great difficulty but rather an operation which requires care and judgment.

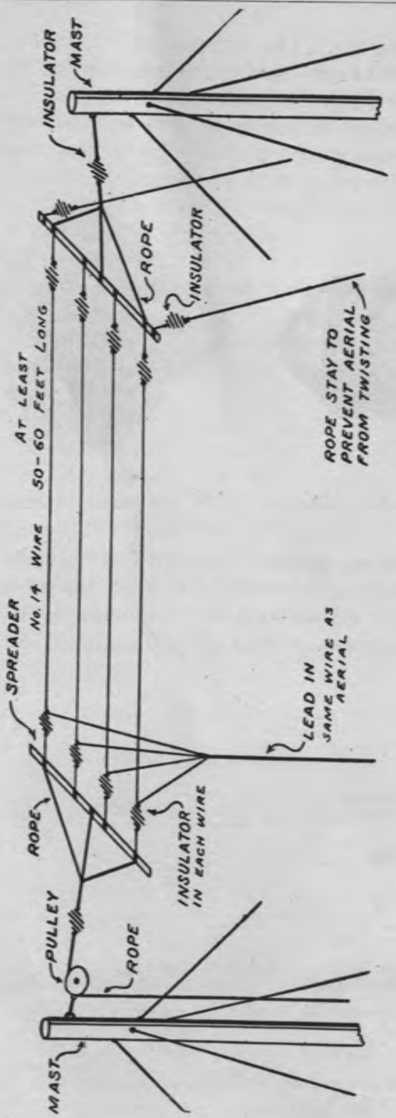



FIG. 10.

A Diagram of an inverted "L" Aerial showing how the Wires, Spreaders, Insulators, etc., are arranged.



The spreaders or spars used to separate the wires should be both light and strong. Spruce is an excellent wood for the purpose.

The separation of the wires or the distance between them is an important item. An aerial composed of wires close together is not as good as one in which the wires are separated. It is a safe rule to allow at least two feet between the wires for each fifty feet of their length.

**The wires composing an aerial should all be exactly the same length.** An easy method is to lay the spars or spreaders on the ground at a distance apart equal to the length of the aerial and stretch the wires between them.

All connections and joints in the wires should be **soldered.** This is important and is well worth the trouble.

**The Wires leading in** from the aerial should be just as carefully insulated as the rest of the aerial. The wires should be brought in gradually, that is, if the aerial has four wires, lead in four wires but do not connect them altogether until they reach the point where they enter the building.

The aerial should be carefully insulated at the point

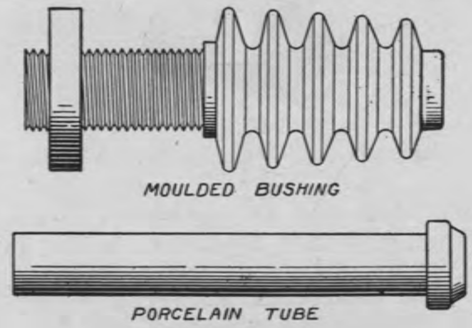



FIG. 11.

A Leading-in Bushing made of moulded Electrose and an ordinary Porcelain Tube which may be also used to serve the same purpose.

where it enters the building. A simple method is to bore a hole through the wall and push a porcelain tube through it. The leading in wire is then passed through and the space in the tube poured full of wax or pitch.

Insulating bushings made of "Electrose" especially for this purpose are on the market and will be found very convenient and far better in many ways than the porcelain tube just described.

**The Ground** or earth connection is well worth careful consideration and everything should be done to make it as efficient as possible.

In cities and towns it is usually possible to secure a very good ground from the water pipes. Gas pipes and radiator pipes are sometimes used but the ground so formed is usually not as good as that offered by a water pipe. When gas pipes are used, in a house where there are electric lights also, the fixtures or chandeliers are often electrically separated from the pipe by an insulating joint and attaching a wire to a fixture or chandelier will for this reason not usually give a good ground.

FIG. 12.
A Ground Clamp for facilitating connections to the Water or Gas Pipes.

A ground clamp such as is shown in Figure 12 provides an easy method of connecting a wire to a pipe.

In the country where no water or gas pipes are available, it is sometimes possible to secure a good ground by connecting a wire to a well pipe (this is not recommended), or to form a ground by burying a sheet of copper or zinc about four feet square in a moist spot in the earth and connecting a wire to it.



The ground wire should be of the same size as the aerial wire at least. It should be as short and as direct as possible. Avoid all sharp turns and moreover do not coil or wrap it around anything. All joints or connections should be soldered.

**A Lightning Switch** is required by the Fire Insurance Underwriters in most localities. The switch is installed on the outside of the building near the point where the aerial enters.

In order to meet the Underwriters' specifications, the switch must be a single pole, double throw and of 100 amperes, 600 volts current capacity. Such a switch is shown in Figure 13.

FIG. 13.
A Lightning Switch for Grounding the Aerial when the Apparatus is not in use.

The method of connecting is shown in Figure 14. It will be seen that the switch connects the aerial to the instruments or else to an outside ground accordingly as the blade is thrown up or down. The aerial is connected to the blade. The upper contact leads inside the building to the instruments. The lower contact is connected to the ground by a wire outside the building, and in as straight a line as possible. This wire should not be smaller than No. 4 B. and S. gauge capper.

The purpose of the switch is to allow electrical charges in the atmosphere in the neighborhood of the aerial to flow harmlessly to earth.

For this reason the switch should always be in such a position that the aerial is connected to the ground whenever the station is not in operation.

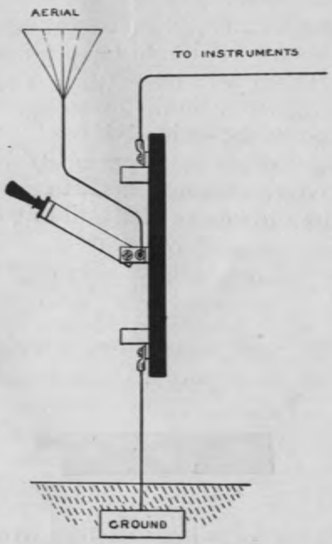



FIG. 14.
Diagram showing how to arrange and connect the Lightning Switch.



## CHAPTER II.

## SPARK COILS.

**The Construction of Spark Coils. Sources of Current. Dry Cells. Storage Cells. Transformers. Keys.**

The purpose of a spark coil is to generate enormously high voltages which are able to send sparks across an air space which ordinary battery currents of low voltage could not possibly pierce. The spark coil is connected to two metal rods separated by a short distance and called the spark gap. One side of the spark gap is connected to the ground or earth. The other side is connected to the aerial wires.

When the key is pressed, the current from the battery flows through the coil. The coil causes sparks to jump across the gap and they create electric currents which flow back and forth very rapidly in the aerial wires and which are known as oscillatory currents. These oscillatory currents are what create the electric waves.

FIG. 15.
A complete Wireless Spark Coil.

A spark coil consists of an iron core surrounded by a coil of heavy wire known as the **primary** and by a second outside winding of finer wire known as **secondary.** The primary is connected to a few cells of dry battery in series with an interrupter.

Every time that the interrupter shuts off the battery current in the primary, currents are induced in the secondary which are of sufficiently high voltage and pressure to leap across a space in the shape of sparks.

A spark coil is not very hard to construct but it requires careful workmanship and patience. It is not usually a job which can be finished in a day, but will take quite a little time, especially in winding the secondary.

In describing this work in this chapter, the general method of procedure is explained. Several tables are given which show the size of materials required to construct coils of several different sizes. The coils are all practically identical except in dimensions. It should be noticed that one-quarter and one-half inch coils have only one section of secondary winding whereas the others all have two.

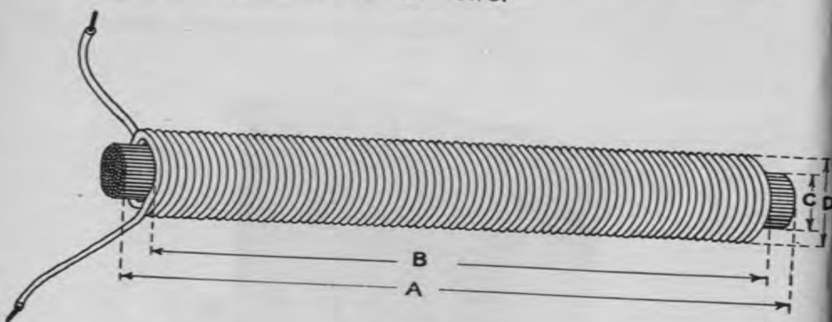



FIG. 16.

A complete Primary Winding and Core for a Wireless Spark Coil. A is the total length of the core and C the diameter. B represents the length of the Primary Winding and D the diameter.

**The Core** should be made of soft iron "core wire" of No. 20 or 22 B. and S. gauge. Ordinary soft iron



wire is not recommended. Regular core wire which has been annealed and which comes ready cut to length may be purchased from several firms dealing in experimenters' supplies for 20 cents per lb.

Considering the amount of labor required to cut each piece to length and then straighten it out, it is cheaper to purchase the wire ready cut.

Cut a piece of tough wrapping paper long enough to wrap around the core three or four times and one-half inch narrower in width than the length of the coil.

Roll the paper up in the form of a tube having an inside diameter equal to the outside diameter desired for the finished core. Glue the inside and outside edges of the paper so that the tube cannot unroll and then slip the core wires into it until the tube is packed tightly and no more can be slipped in.

The core is now ready for the primary which consists of two layers of double cotton covered wire wound over the core.

The winding should not cover the entire core but the latter should project a short distance at each end. The table below shows the size of wire and the length of the primary for the various sizes of coils.

## CORE AND PRIMARY DATA.

| | A | B | C | D | Size B. & S. |
|---|---|---|---|---|---|
| ¼ inch | 4¾ | 3½ | ½ | ¾ | 18 S. C. |
| ½ inch | 5 | 4⅜ | ⅝ | ⅞ | 18 S. C. |
| 1 inch | 7 | 6¼ | ⅝ | ⅞ | 18 S. C. |
| 1½ inch | 7 | 6¼ | ⅝ | ⅞ | 18 S. C. |
| 2 inch | 7 | 6¼ | ⅝ | 15/16 | 16 S. C. |
| | | | | 15/16 | 16 S. C. |

The primary wire must be wound on very tightly and smoothly. The inside end of the wire can be fastened so that it will not become loose by placing a short piece of tape lengthwise of the core and winding two or three turns over it. Then double the end back and complete the winding over it. The end of the wire can be fastened by imbedding a piece of tape under the winding with a small loop projecting and then passing the wire through the loop.

**The Secondary** is a much more tedious job than the primary and must be very carefully made. Whenever it is possible for the experimenter to purchase a secondary already wound he is advised to do so.

The secondary consists of several thousand turns of wire wound in smooth even layers with two layers of paper between every two layers of wire.

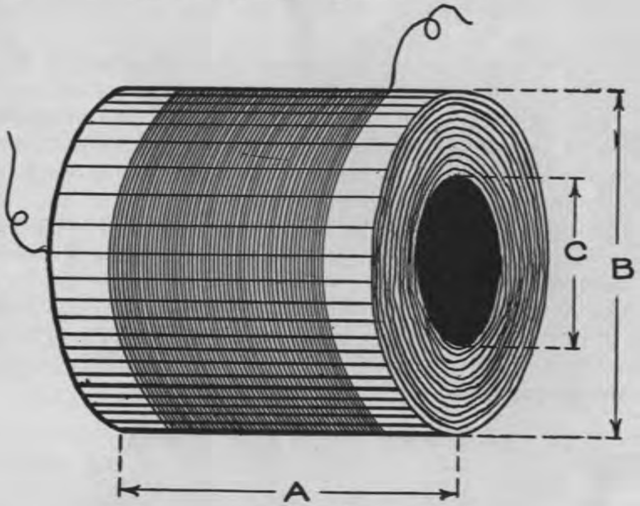



FIG. 17.
Secondary Winding for a Wireless Spark Coil.

The primary winding is made ready for the secondary by wrapping over it six layers in the case of the ¼ and ½ inch spark coils and twelve layers for the longer coils, of "empire cloth." Empire cloth is a yellow covered fabric which has been treated with linseed oil and possesses very high insulating qualities.

Roll up a paper tube of five or six layers of heavy paper so that the finished tube is of the diameter desired for the inside of the secondary winding and of the proper width.



The secondary is wound over this paper tube. It will be necessary to mount the tube on a round wooden mandrel fitted with a small crank or handle so that the tube may be revolved. A "winder" may be very easily made by mounting a round wooden stick of the same diameter as the inside of the paper tube in a pair of wooden supports. Bore a hole in one end of the stick and bend a piece of stiff wire in it so as to form a crank.

The paper placed between each two layers of the secondary winding should be the special waxed paper which is made for that purpose.

Start and end each layer of wire about three-eighths of an inch from the edges of the paper. Wind the wire in smooth even layers permitting each turn to touch the other, but none to lap over. Wind on two layers of waxed paper between each layer of wire and the next. The paper must be put on smoothly and evenly so as to afford a firm foundation for the next layer of wire.

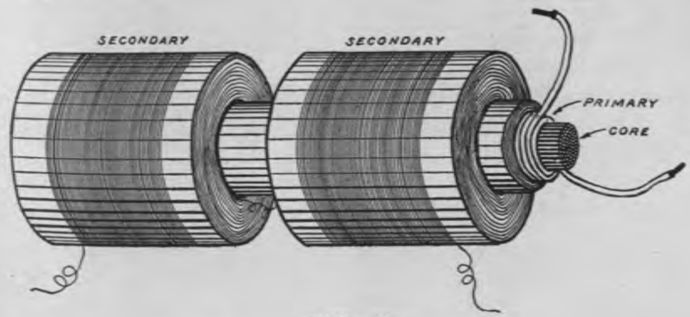



FIG. 18.
A complete Secondary Winding in two sections, in position on the Primary.

The wire should not be allowed to approach nearer than three-eighths of an inch to the edge of the paper or the insulating qualities of the coil will be decreased considerably.

The utmost care should be used not to break the wire. If it should break, the ends must be very carefully connected. The number of turns that each layer averages should be carefully noted so that by keeping a record of the number of layers it is possible to tell how many turns have been wound on.

When the winding is completed, the outside end of the wire may be fastened and prevented from unwinding by securing it with a thread or a drop of sealing wax.

While winding the secondary, remember that if at any point in the work you allow the winding to become irregular or uneven, the irregularity will be much exaggerated in the succeeding layers. For this reason, do not allow any irregularities to occur and if the wire tends to go unevenly, wind on two or three extra layers of the waxed paper to smooth it out.

| | A | C | Size of Wire | No. of turns | No. of Section |
|---|---|---|---|---|---|
| ¼ inch | 2⅜ | 1 3/16 | 37 en. | 5,500 | 1 |
| ½ inch | 2⅜ | 1⅛ | 37 en. | 10,000 | 1 |
| 1 inch | 2⅜ | 1⅛ | 37 en. | 10,000 | 2 |
| 1½ inch | 2⅜ | 1⅛ | 37 en. | 15,000 | 2 |
| 2 inch | 2⅜ | 1⅛ | 37 en. | 20,000 | 2 |

The secondary used on the ¼ and ½ inch coils is composed of only one section.

The 1, 1½ and 2 inch coils have two sections in their secondaries.


FIG. 19.

Two different methods of connecting a Secondary Winding composed of two sections. The sections at A are both wound in the same direction and the inside terminal of one is connected to the outside terminal of the other. At B, both sections are wound in the same direction and the two inside terminals are connected together. The method shown at B is the best.



It is a good plan to wind the sections in opposite directions and connect them as in the diagram B in Figure 19.

The two inside ends are connected together the result being to reduce the tendency of the secondary currents to jump into the primary.

If the sections are both wound in the same direction they should be connected according to the diagram shown at A in Figure 19. It will be noticed that the outside end of one section is connected to the inside end of the other.

**The Condenser** consists of alternate layers of tinfoil and paraffined paper piled on top of each other and then rolled up.

The alternate sheets of tinfoil are connected together.

The table below will give the dimensions and material required for making the condenser for each size of coil.

| Size of boil | Length of paper | Width of paper | Length of Tinfoil | Width of Tinfoil | No. Sheets of paper | No. Sheets of Tinfoil |
|---|---|---|---|---|---|---|
| ¼" | 30" | 4⅜" | 30" | 4" | 5 | 4 |
| ½" | 30" | 4⅜" | 30" | 4" | 5 | 4 |
| 1 " | 30" | 4⅜" | 30" | 4" | 7 | 6 |
| 1½" | 30" | 4⅜" | 30" | 4" | 7 | 6 |
| 2 " | 30" | 4⅜" | 30" | 4" | 9 | 8 |

The tinfoil strips are cut narrower than the paper so that there will be no possibility of the tinfoil sheets short circuiting.

Lay one sheet of tinfoil out flat on a table or board and place a sheet of tinfoil over it. The tinfoil should be placed on the paper so that there is a margin of paper along the sides. One end of the tinfoil should project over the end of the paper about two inches. Lay two sheets of waxed paper over the tinfoil making them line up with the first paper sheet all around. Then place another strip of tinfoil on the paper. It should be directly above the first sheet of tinfoil, but the end of the tinfoil must overlap the paper by two inches at the opposite end from the first sheet. Place

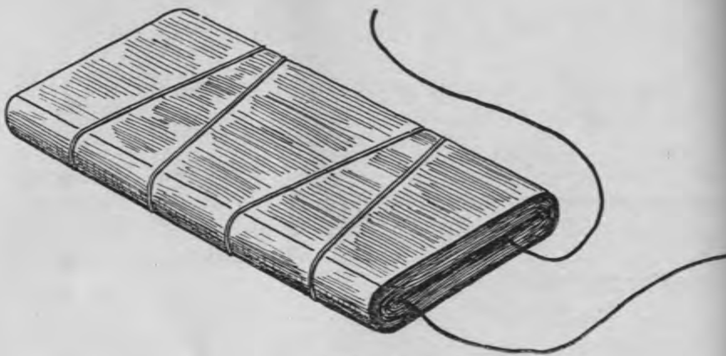


FIG. 20.
The Primary Condenser which is connected across the terminals of the Interrupter.

two more sheets of paper over the tinfoil and on top of that a third strip of foil. The third strip of foil should line up exactly with the first strip. Then lay two more sheets of waxed paper over the third sheet of foil and place the fourth sheet of tinfoil in position making it line up exactly with the second sheet.

The result should consist of alternate layers of tinfoil and paper, each strip of tinfoil being insulated from the next by two sheets of paper.

Connect the alternate sheets of tinfoil together and solder a wire to them. The first and third should be connected together and the second and fourth, etc.

Cut out a piece of cardboard, one and one-quarter inches wide and the same length as the width of the condenser paper strips. Lay the cardboard at one end of the condenser and roll the condenser up around it very tightly. Tie it with a piece of string to keep it from unrolling and dip it in some melted paraffine. Then place it between two boards with a weight on top so as to press it out flat.

**The Interrupter** or vibrator for the coil cannot be easily made by most experimenters and it is therefore best to buy one. The vibrator will play a very im-



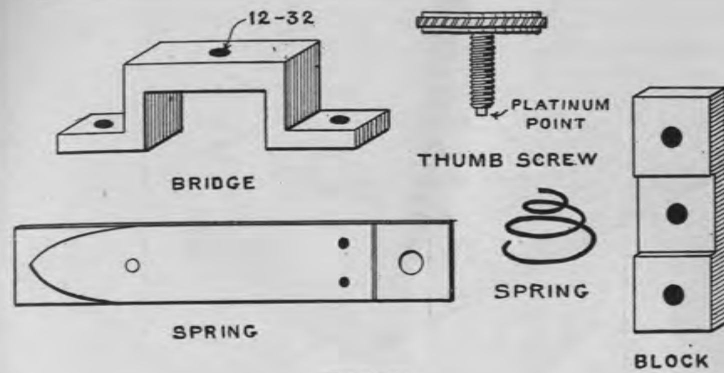



FIG. 21.
Parts for the Interrupter.

portant part in the successful working of the coil, and its proper construction and adjustment are quite important.

An interrupter like that shown in Figure 21 is the best for a wireless coil.

**The Case** for the coil should be constructed along the lines shown in Figure 22.

**Dimensions for Coil Cases.**

| Size of Coil | A | B | C | D | E |
|---|---|---|---|---|---|
| ¼ inch | 2⅞" | 5¼" | 3¼" | ½" | 2" |
| ½ inch | 3⅜" | 6½" | 3¼" | ⅝" | 2" |
| 1 inch | 3⅜" | 7¾" | 3¾" | ⅝" | 2" |
| 1½ inch | 3½" | 8" | 3½" | ⅝" | 2" |
| 2 inch | 3¾" | 8" | 3¾" | ⅝" | 2" |

The coil case may be purchased ready made or built by the experimenter. If home made, it should be very carefully stained and varnished. Birch or maple will take a mahogany stain very nicely and make a handsome looking case.

When the case is finished the coil is ready for assembling.

The illustration in Figure 23 shows exactly how the parts should be arranged. The condenser is laid in with terminals nearest to the end of the case upon which the interrupter is to be mounted.

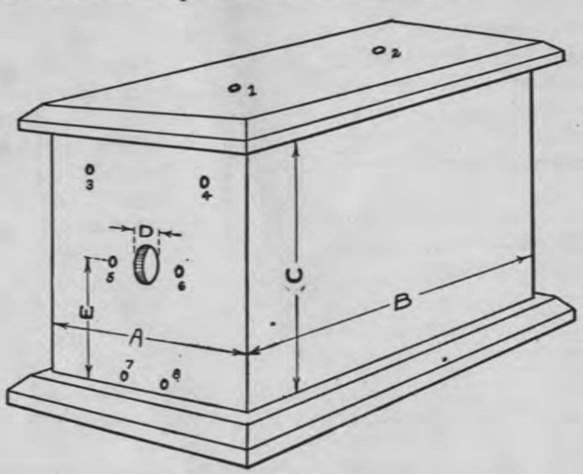



FIG. 22.
The Coil Case.

Cut a sheet of ordinary window glass which is just wide enough to slip into the case and about one inch shorter than the case in length. This is laid on the

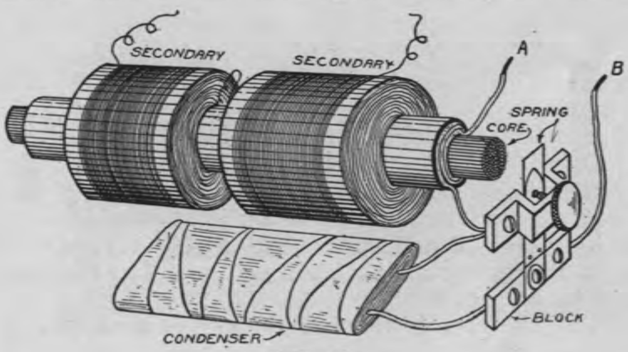



FIG. 23.
Diagram showing how the parts of the Coil are connected together.



top of the condenser and serves to prevent the high voltage currents in the secondary from jumping into the condenser.

The secondary is then slipped over the primary and placed centrally on the latter. Be sure that there is plenty of empire cloth or paper around the primary so that it is perfectly insulated from the secondary. If the coil is the 1½ or 2 inch size so that there are two sections to the secondary they should be spaced about one inch apart. Slip the end of the core nearest to the primary terminals through the hole in the end of the box. Place a small block of wood under the other end of the core so as to bring it level. Adjust the core so that it projects through the hole about one-sixteenth of an inch.

One terminal of the primary is connected to one of the primary binding posts. The other binding post is connected to the interrupter "block." The other terminal of the primary is connected to the interrupter "bridge."

The bridge and the block are mounted on the front of the coil case by means of round head brass screws threaded into a nut on the inside of the case.

One terminal of the condenser is connected to the

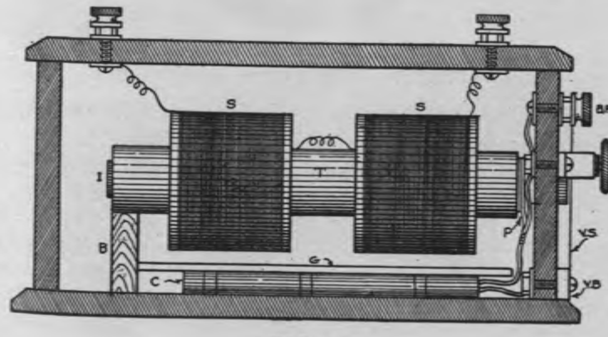



FIG. 24.
A Cross Section of a complete Coil before the Wax is poured in, showing how the various parts are arranged.

"bridge" and the other to the "block." The condenser is thus connected directly across the terminals of the interrupter.

The interrupter should be arranged so that the end of the core which projects through the case is directly under the interrupter spring near the upper end. The bridge should be placed so that when the thumbscrew


FIG. 25.
Dry Cell for operating a Spark Coil.

is in position the platinum contact on the end meets the platinum contact on the spring squarely.

Lead the two secondary terminals out as straight as possible, directly above the secondary. Fasten them to a strip of wood temporarily laid across the top of the case for that purpose and then pour the case full of molten "coil wax." "Coil wax" is a red colored insulating compound which may be purchased from almost any firm dealing in coil parts. It is far superior to paraffine for the purpose and much cheaper.

After the wax has cooled the secondary terminals should be connected to the under side of the binding



posts mounted on the cover and the cover screwed in place.

If all of this work has been carried out carefully using every precaution to see that all connections were tight and that all parts were carefully insulated and arranged so that there is no possibility of the high voltage currents leaking across the secondary or into the primary circuit, the result should be a coil which will render very efficient service for transmitting wireless messages or for general experimental work.

**A Battery** which can be relied upon for furnishing a steady current will be required for operating the coil. The ¼ inch coil will give good results on three ordinary dry cells. The ½ and 1 inch coils will require four to six dry cells. The 1½ and 2 inch coils are best operated by cells connected in series multiple.

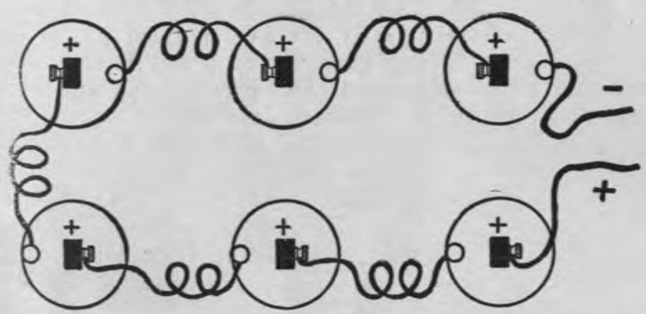



FIG. 26.
A Diagram showing how to connect six Dry Cells in series.

Figure 26 shows six cells connected in series. Figure 27 shows six cells connected in series multiple. In this, there are two groups of three cells, the latter connected in series. The two groups are then connected together in multiple so that the positive terminals are together and the negative terminals likewise. If cells are grouped together in this series multiple arrangement for operating the two larger sizes of coils they will last much longer than two separate sets in series used independently, because the strain will be divided.

Six cells in all will be required to operate the 1½ and 2 inch coils.

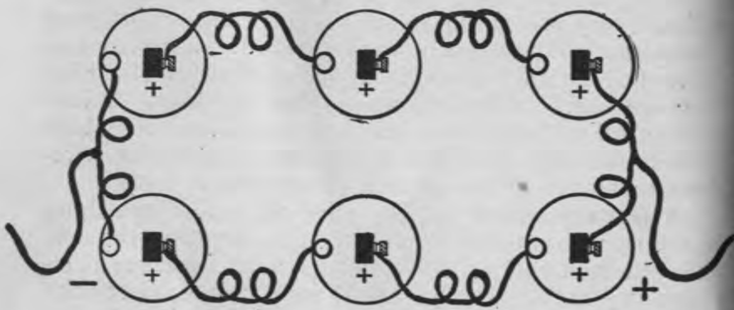



FIG. 27.

A Diagram showing how to connect six cells in series-multiple.

Storage cells are really the best sort of power for operating coils. They give a very heavy, steady current and when exhausted can be recharged and used over and over again almost indefinitely.

Figure 28 shows some types of storage cells which


FIG. 28.

Small Storage Batteries especially adapted to running Wireless Coils.



are excellent for this purpose. They are made in a variety of sizes and can be furnished separately or encased in wooden boxes so as to be readily portable. They may be recharged from any source of **direct** current such as, for instance, the 110 volt lighting supply. If the lighting current is alternating it may be "rectified" and changed into direct current for recharging the cells by means of a "rectifier." A small shunt wound dynamo may also be used to recharge such cells.

**The Key,** used to control the battery current flowing into the primary of the coil so that it may be broken up into dots and dashes corresponding to the telegraph code, should be of the type shown in Figure 29. These keys are made especially for wireless telegraph purposes and fitted with extra large contacts which are better adapted to carrying a heavy current than those of an ordinary key.

FIG. 29.

Keys for use with Spark Coils.

Those experimenters who prefer to make their own keys will find the instrument shown in Figure 30 to be quite satisfactory and very easy to make.

A key is really a switch arranged so that the current can be readily turned off and on by a slight movement of the fingers.

The frame of the key is shown in Figure 32 and is made from a small iron casting. The dimensions and the location of the holes can be easily understood from the drawing.

The key frame is made by first making a small wooden pattern similar to the finished article desired.

Send the pattern to a foundry and have a casting made from it.

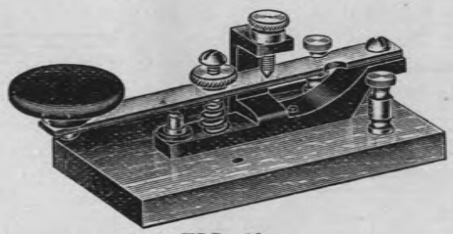


FIG. 30.
The Simplex Wireless Key.

The key lever is a strip of brass, four and one-half inches long. five-sixteenths of an inch wide and about one-sixteenth of an inch thick.

It has three holes in it, located as shown in the illustration.

The key knob, thumbscrews, springs and locknuts can be purchased from almost any electrical supply house.

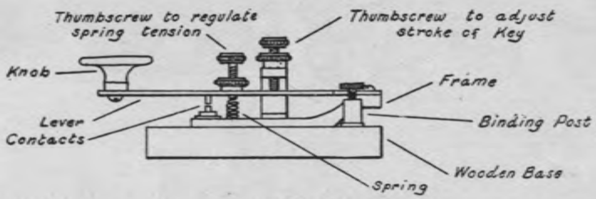



FIG. 31.
Side view of the Simplex Key.

The key is assembled as shown in Figures 30 and 31. It is mounted upon a wooden base three and three-quarters inches long and two inches wide.

The contacts are made from silver wire. The lower contact must be insulated from the frame of the key by a fibre washer. Two binding posts are mounted at the back of the wooden base. One of the posts is connected to the lower contact and the other post is connected to the iron frame. The frame should be painted black.



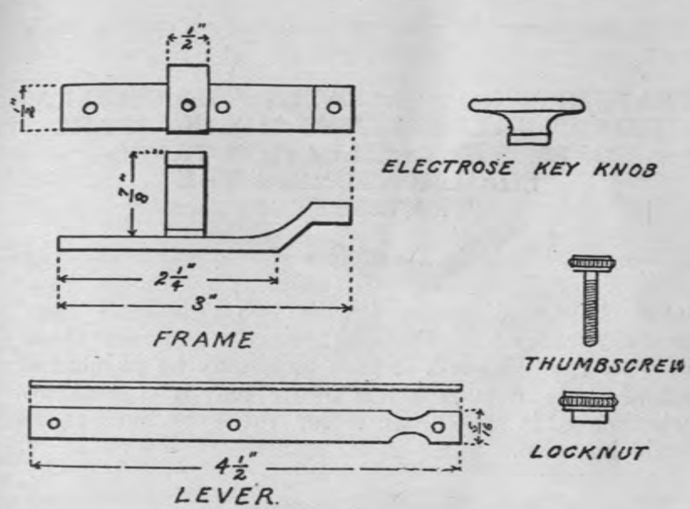



FIG. 32.
Parts of the Simplex Key.

## CHAPTER III.

### TRANSMITTING APPARATUS. THE OSCILLATION CONDENSER. THE HELIX. SPARK GAPS. THE OSCILLATION TRANSFORMER. TUNING THE TRANSMITTER.

The spark gap is a simple arrangement consisting of two double binding posts mounted upon an insulating base and provided with two adjustable electrodes arranged so that the distance between them may be easily varied. Spark gaps may be purchased ready made at such a low figure that it is doubtful whether it is worth while for the experimenter to build his own.


FIG. 33.
A Step-down Transformer especially made and adapted for operating Wireless Spark Coils from the 110V. A. C. current. When the Interrupter on the Coil is properly adjusted and a Step-down Transformer is used as the source of power, the range of a Spark Coil is considerably greater than if batteries were used.

Figures 34 and 35 show two inexpensive small spark gaps now on the market. The one in Figure 34 is provided with a hardwood base. The adjustable rods are tipped with zinc. The peculiar properties of zinc



make it particularly efficient for the electrodes of a spark gap.

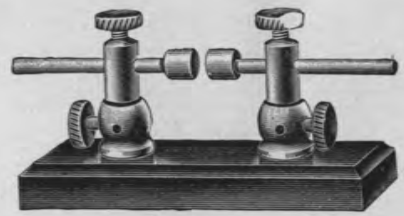


FIG. 34.
The Junior Spark Gap.

The gap shown in Figure 35 is also provided with two zinc electrodes. Insulating handles are provided, so that the spark length may be easily adjusted while the set is in operation. The base is made of hard rubber composition.

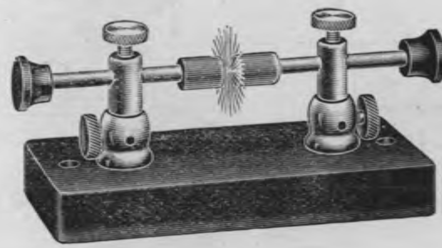


FIG. 35.
A well-known efficient Spark Gap having zinc Electrodes and a Composition Base.

The diagram in Figure 36 shows how to arrange a simple untuned transmitting set.

A key and a set of batteries are connected to the primary of a spark coil in the ordinary manner. The secondary terminals of the spark coil are connected to the terminals of a spark gap, such as, for instance, that shown in Figure 35. One terminal of the spark gap is then led to the ground and the other connected to the aerial.

The spark gap electrodes should be adjusted so that they are about 3/32 to 5/32 of an inch apart for coils ranging in size from ¼ to 1 inch. Coils capable of giving a heavy spark 1½ to 2 inches long will probably give the best result when the space between the spark gap electrode is 3/16 to ¼ of an inch. Much will depend upon the size of the aerial. The larger the aerial, the shorter the gap should be. Most experimenters are apt to open their gaps too wide. Some indication when the gap is properly adjusted may be secured by calling up some other wireless experimenter in the neighborhood and asking him how the signals sound.

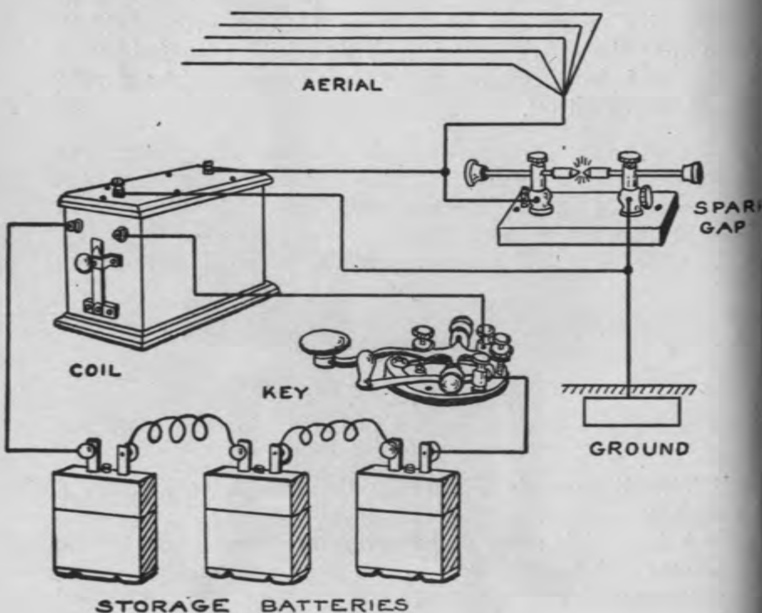



FIG. 36.

A Diagram showing how to connect a Key, Spark Coil, Spark Gap and Battery to the Aerial and Ground for Transmitting.



The table given below shows the approximate average distances which various sizes of coils will usually transmit, when connected to an ordinary amateur aerial, and when the receiving station at the other end is of the average sort.

| Size of coil | Approximate transmitting range (miles) |
|---|---|
| ¼ inch | ½-1 |
| ½ inch | 1-2 |
| 1 inch | 1½-3 |
| 1½ inch | 2-5 |
| 2 inch | 3-7 |

The ranges given presuppose that the coils are operated upon the usual number of batteries and are provided with an ordinary interrupter.

Coils operated by an excessive number of batteries or operated on the 110 volt current will send much greater distances.

Coils may be operated on the 110 volt direct current by blocking the vibrator and screwing it up tight so that it cannot operate and using an electrolyte interrupter in series.

Coils may be operated on the 110 volt alternating

FIG. 37.

A Tubular Oscillation Condenser composed of eight small Leyden Jars arranged in a rack.

current circuit by using a step down transformer. A coil operated on a step down transformer will usually send farther than the same coil operated on batteries. In order to get the best results, the transformer should be built especially for operating coils. Figure 33 shows a transformer especially built for that purpose.

The transmitter shown in Figure 36 is, as has already been mentioned, "untuned."

A station of this sort "comes in all over" at a receiving station, that is, it cannot be sharply tuned or located at a definite point on the tuning coil or coupler but may be plainly heard through a wide variation of adjustment in the tuning apparatus.

Such a transmitter will cause interference when receiving messages from another station.

In order to avoid such interference as much as possible the transmitting apparatus should be arranged to emit as far as is possible a certain wave or "tune" as it is called.

This will make necessary a condenser and a helix. A condenser for this purpose is simply some form of Leyden jar. A helix consists of a spiral or helix of brass or copper ribbon.

The tubular condenser shown in Figure 37 is a very convenient arrangement which is especially adapted for use with spark coils.

It consists of eight tubular Leyden jars made from test tubes and mounted in a rack.

The test tubes for this purpose should be made of

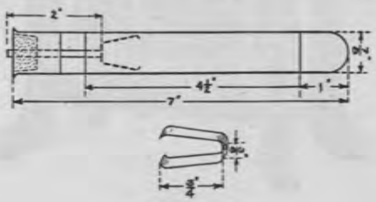


FIG. 38.

The Details of one of the tubular Leyden Jars used in the Oscillation Condenser.



hard or Bohemian glass. They should be about 7 inches long and ⅞ of an inch in diameter.

Eight tubes will be required in order to be suitable for use with coils ranging in size from 1-2 inches. They are all coated, inside and out with a strip of tinfoil 4½ inches wide and long enough to go all the way around the tube.

The lower edge of the tinfoil should be about one inch from the bottom of the tube.

Connection is established with the tinfoil coating upon the inside of the tube by means of a small brass clip made of strip brass. This strip is bent into a "U" shape and soldered on the end of a brass rod 2 inches long. The rod is passed through the centre of a cork which fits tightly into the open end of the test

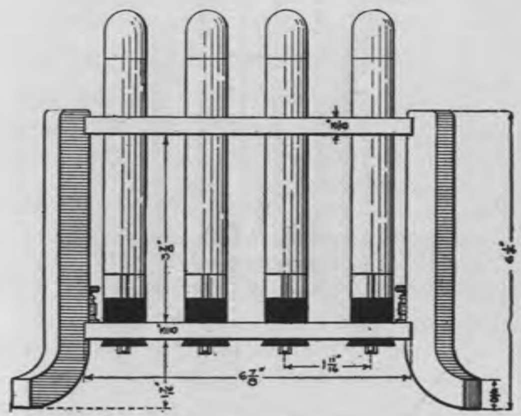


FIG. 39.

A Side View of the Condenser.

tube. The outside end of the brass rod should project beyond the cork about ⅛ of an inch.

The rod and the clip are shown in position in the tube by dotted lines in Figure 38. The lower part of the same illustration shows the details of the clip on the inside end of the rod.

The tubes are arranged in a frame or rack the details of which are probably best understood from Figures 39, 40 and 41, which are respectively front, end and top views of the complete condenser.

The top and bottom of the frame are rectangular pieces of hardwood 7$\frac{5}{8}$ inches long, 3$\frac{1}{2}$ inches wide and $\frac{3}{8}$ of an inch thick.

They are supported by four "J" shaped wooden legs, 6$\frac{1}{4}$ inches high, set into notches in the corners. The top is set down about $\frac{1}{8}$ of an inch below the top of the legs. The bottom should be placed so that it is 1$\frac{7}{16}$ above the bottom of the legs, thus leaving a distance of 3$\frac{7}{8}$ inches between.

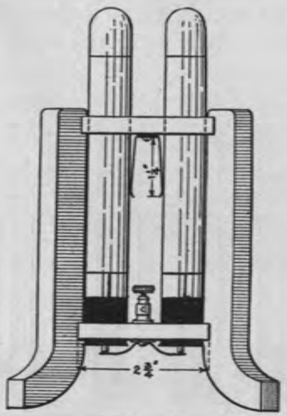


FIG. 40.
End View of the Condenser.

The test tubes are set into holes bored in the top and bottom of the rack. The holes should be just large enough to pass the tube but not large enough to allow the tubes to slip all the way through. The lip at the open end of the tube should prevent it from slipping all the way through.

The holes should be bored on centers 1$\frac{11}{16}$ inches apart.

The outside tinfoil coatings of all the tubes should



be connected together by brass strips on the under side of the top part of the condenser frame. These strips are shown by dotted lines in Figure 41. One

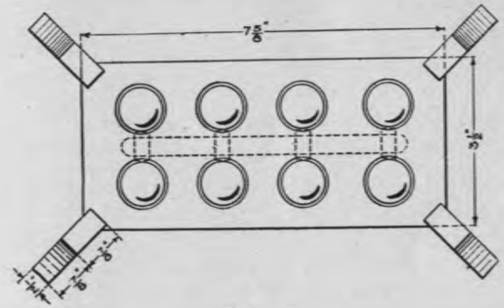


FIG. 41.
Top View of the Condenser.

long strip runs along the entire distance between the two rows of tubes. Short strips crossing the long one connect the tubes to the long strips in pairs. The short strips should be bent in the same manner as

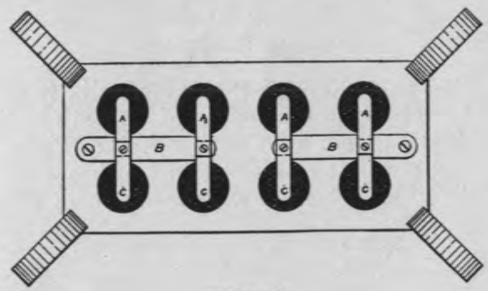


FIG. 42.
Bottom of the Condenser.

those used to make connection with the tinfoil coating on the inside of the tubes.

The tubes should be slipped into the rack from the under side.

They are held in position by brass strips which also serve to make connection with the brass rods projecting through the centres of the corks.

This arrangement will probably be better understood by examining the illustration in Figure 42.

Two long strips marked B and B in the illustration divide the tubes into two sets of four. Short strips marked A, A, A, A, branch out from each of the strips marked B and rest on the ends of the brass rods which project through the corks.

The end of each B strip is connected to a binding post mounted upon the lower part of the frame as shown in Figure 40.

A very efficient form of helix for use in connection with a condenser is shown in Figure 43.

FIG. 43.
The Junior Helix.

A detailed side view of the same helix is shown in Figure 44. The frame consists of two sticks 9 inches long notched and set into each other at right angles.

The spiral consists of eight turns of brass ribbon, 3/8 of an inch wide, set in saw cuts made in the frame. The ribbon is held in position by wooden strips, 1/4 of an inch thick and 1/2 of an inch wide fastened to the top of the frame.

A binding post is connected to the outside end of the ribbon.

Two clips will be necessary in order to make connection with any part of the spiral of ribbon.

The details of the clip are shown in Figure 46. It consists of two strips of German Silver or spring brass set into one end of a brass rod. The other end of the



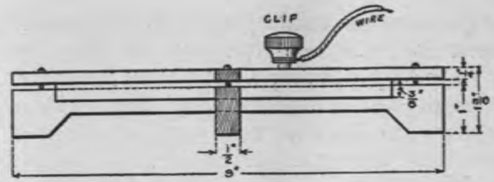



FIG. 44.
Side View of the Junior Helix.

rod is turned down and threaded to fit into a No. 8007 Electrose knob.

A flexible wire may be connected to the clip by placing it between two brass washers slipped over the threaded portion of the rod and clamped tightly together by screwing the knob down on them.

The diagram in Figure 47 shows how to connect the condenser and helix in the circuit.

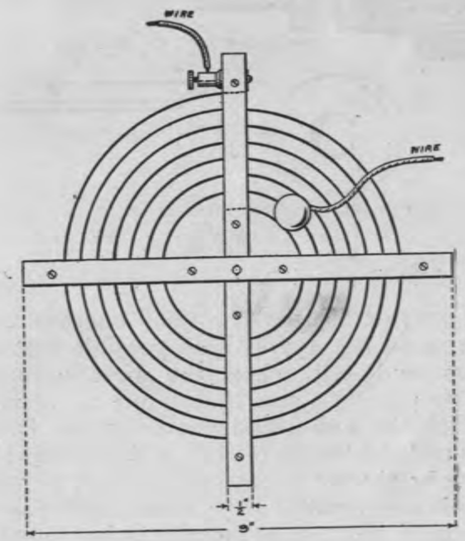



FIG. 45.
Top View of the Junior Helix.

In large stations employing a transformer in place of a spark coil, the best position for the clips on the helix is found by placing a "hot-wire ammeter" in the aerial circuit and then moving the clips until the meter shows the highest reading.

The average young experimenter will probably have to tune his set by moving the helix clips until the best results are obtained as reported by some receiving station a mile or two away.

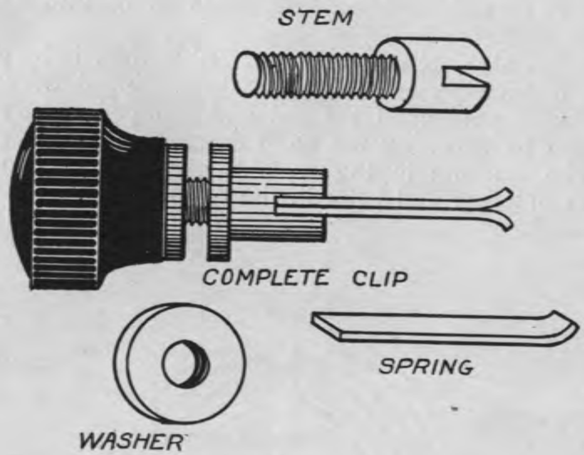



FIG. 46.

Details of the Clip used for making connection to the Helix.

If the spark coil used is a good one and capable of giving a good hot spark, it is possible to "tune" the apparatus and tell when the best adjustment is secured by placing a small miniature tungsten lamp in series with the aerial and changing the positions of the clips and the length of the spark gap until the lamp lights the brightest.

A spark coil smaller than a one inch coil will not usually give very good results when used with a condenser and a helix.

In order to secure still sharper tuning, as may often



be necessary when an amateur station is in the near vicinity of a commercial or naval station and is therefore required to avoid any possible interference, an **oscillation helix** will be needed.

An oscillation transformer is really two helixes arranged so that one acts as a **primary** and the other as a **secondary.** A device of this sort is illustrated in Figure 48.

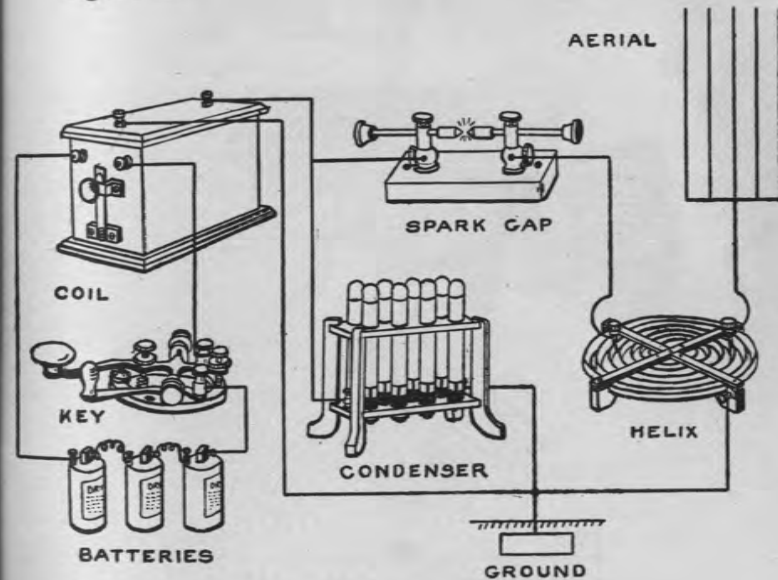



FIG. 47.

A Diagram showing how to connect the Helix and Oscillation Condenser.

The primary is formed by a helix identical in size and construction with that just described.

A $\frac{3}{16}$ round brass rod about 9 inches long is forced tightly into a hole in the centre of the primary at the place where the two cross pieces join so that it stands up vertically and at right angles to the frame.

FIG. 48.
The Junior Oscillation Transformer.

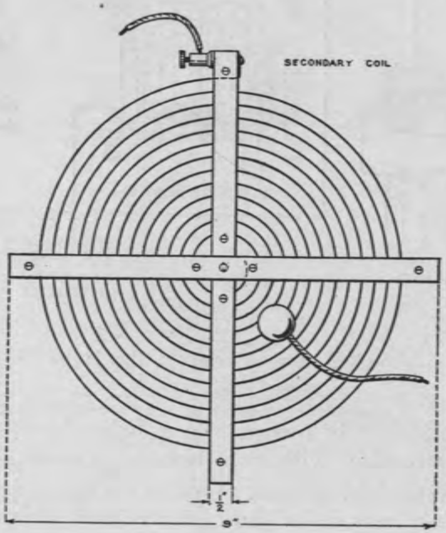



FIG. 49.
Top View of the Junior Oscillation Transformer.



The secondary is similar to the primary with the exception that it contains more turns. The frame is of the same size and made in the identical manner. It should be slotted, however, to receive 12 turns of brass ribbon $\frac{1}{4}$ of an inch wide.

A $\frac{3}{16}$ inch hole should be bored through the centre of the secondary frame at the point where the sticks join so that it may be slipped onto the vertical rod mounted on the primary and when in position will be parallel to the latter.

One clip will be required for the primary and one for the secondary. Both windings should terminate in a binding post at the outside end.

The diagram in Figure 51 shows how to connect a transmitter employing an oscillation helix. It will be seen that the aerial and ground are connected to the secondary, whereas the primary is made a part of the circuit including the condenser, spark gap and coil.

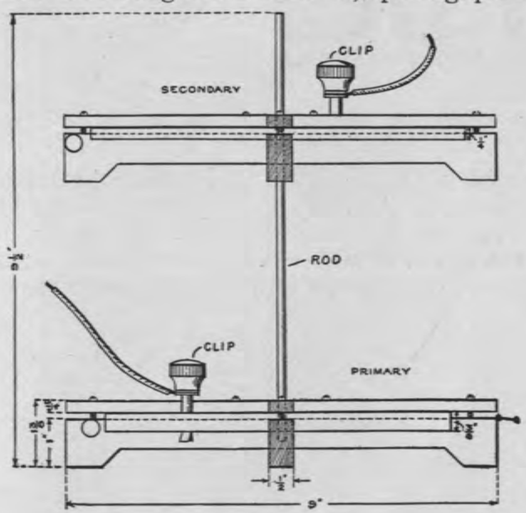



FIG. 50.
Side View of the Junior Oscillation Transformer.

The secondary of the oscillation helix should be

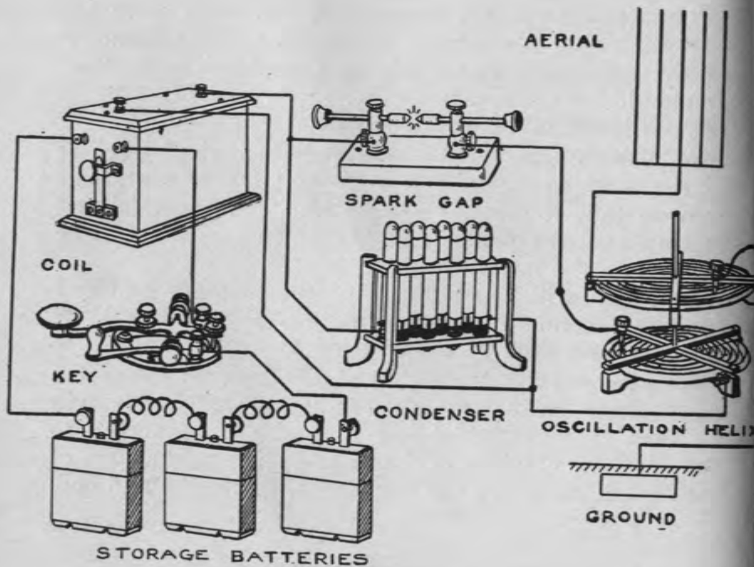



FIG. 51.
A Diagram showing how to connect an Oscillation Transformer and Condenser in circuit.

fitted with a set screw so that it may be fastened in any position on the rod. Varying the distance between the primary and secondary is varying the "coupling."

In the average amateur station using a spark coil a distance of 1-2 inches will be sufficient "coupling."



# CHAPTER IV.

## RECEIVING APPARATUS.

## DETECTORS, TUNING COILS, LOOSE COUPLERS, FIXED CONDENSERS, LOADING COILS, VARIABLE CONDENSERS, TELEPHONE RECEIVERS, AERIAL SWITCHES.

The currents which are set up in the aerial of a receiving station by signals from a transmitting station will not pass through a telephone receiver because the little magnets contained therein exert a choking action on such currents and effectually block their passage.

FIG. 52.
The Junior Silicon Detector.

In order to render the signals audible therefore, it is necessary to employ a device which will act as a valve, allowing the alternating currents set up in the aerial to pass in one direction but not permitting it to return or go in the opposite direction. The result is a **direct** current which will flow through a telephone receiver and produce a sound.

Such a device is called a **detector.**

The detectors in use by most amateur experimenters consist simply of an arrangement for holding a small piece of a certain mineral and making a contact against its surface.

### A Silicon Detector.

The detector shown in Figure 52 may be easily made by almost any experimenter.

The bracket may be made of a small casting or bent out of a strip of brass about $\frac{5}{8}$ of an inch wide and $\frac{1}{8}$ of an inch thick. The bracket is mounted upon a circular wooden base 3 inches in diameter, by two small round headed brass screws passing through holes bored in the foot of the bracket for that purpose.

A hole is bored at the top end of the bracket and threaded to receive a thumbscrew having an $\frac{8}{32}$ threaded shank. Large composition knobs fitted with a shank of that size may be purchased from any good dealer in wireless supplies.

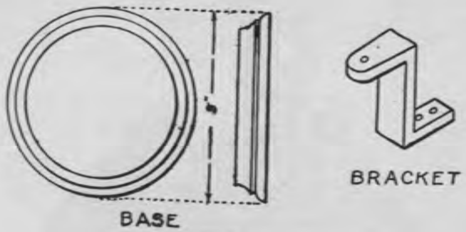



FIG. 53.
Details of the Detector Base and Bracket.

A small brass cup about $\frac{5}{8}$ of an inch in diameter is mounted on the base directly under the thumbscrew. The cup is used to hold the mineral and should be provided with a set screw to clamp it firmly in position.

Two binding posts are mounted on the base. The bracket should be connected to one of the binding posts and the cup to the other.



A fine wire spring, preferably a piece of No. 30 B. and S. phosphor bronze, should be soldered to the lower end of the thumbscrew and bent so as to make contact with the crystal in the cup.

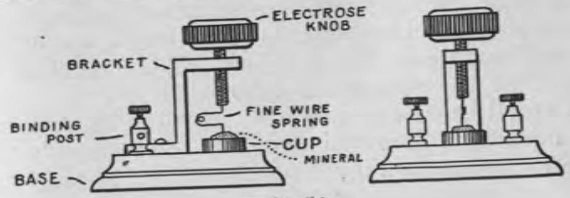



FIG. 54.
Details of the Silicon Detector showing the Mineral in position in the Cup.

Raising or lowering the thumbscrew will vary the pressure of the spring on the mineral and permit the most sensitive adjustment to be secured. The end of the wire may be moved over the surface of the crystal with the end of a toothpick or match until the best place is found.

Fused silicon will be found to be the best material to use as a mineral in the cup with this detector.

### A Galena Detector

The detector illustrated in Figure 55 is commonly known as a "cat-whisker" detector. The best mineral to use with a cat-whisker detector is galena. Galena may be purchased from almost any dealer in wireless apparatus.

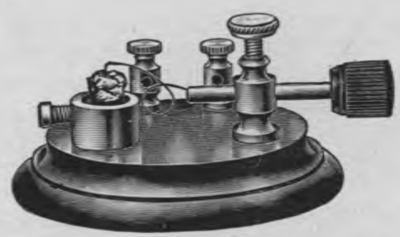


FIG. 55.
The Junior "Cat-whisker" or Galena Detector.

A piece of No. 30 B. and S. phosphor bronze wire is soldered to one end of a short length of 5/32 round brass rod. The other end of the rod is threaded to receive a small electrose knob. The rod is supported by a large binding post or standard.

The standard is mounted upon a round wooden base about 3 inches in diameter and similar to that used in making the silicon detector.

A small brass cup fitted with a set screw to clamp the mineral is mounted upon the opposite side of the base as shown in Figure 55.

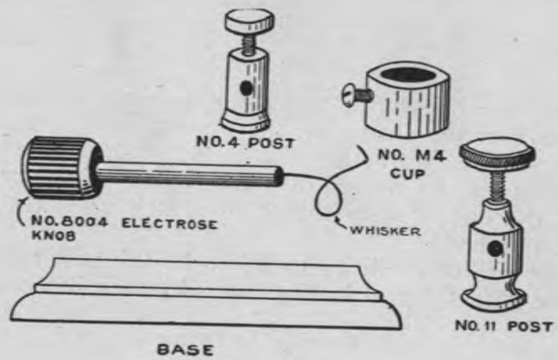



FIG. 56.
Details of the Parts of the Galena Detector.

Two binding posts are provided. One is connected to the cup and the other to the standard which supports the rod.

The long wire soldered on the end of the rod is called the "cat-whisker" or feeler. The standard should be mounted so that it may be twisted easily. By twisting the standard and sliding the rod back and forth the mineral may be searched and the most sensitive spot quickly found. Twisting the rod will regulate the tension of the "feeler" on the mineral.

When the best adjustment for the detector has been found, tighten the thumbscrews in the top of the standard so that the rod is held rigidly in position.



## The Junior Tuning Coil.

**The Junior Tuning Coil** is of the double slider type and considered from all standpoints, is one of the neatest and most efficient tuners for the young experimenter that there is. It is a very simple arrangement and makes it possible to receive messages from great distances, and also to eliminate to a certain extent any messages not desirable, and so listen without confusion to the one wanted.

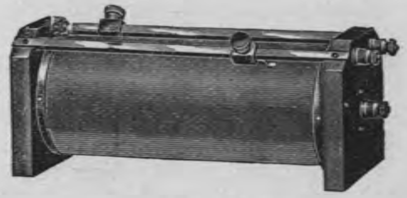


FIG. 57.
The Junior Tuning Coil.

A tuning coil is simply a single layer of wire wound upon a cylinder and arranged so that connection may be had with it by means of a sliding contact which moves back and forth over the turns of wire.

The cylinder upon which the wire is wound is a card board tube 6¾ inches long and having inside diameter of 2⅝ inches. The experimenter is advised to give the tube two or three coats of shellac both in-

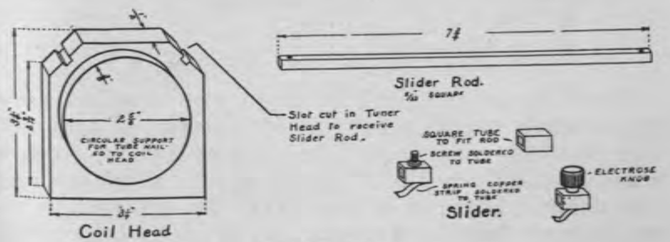



FIG. 58.
Details of the Junior Tuning Coil.

side and out, and then to lay it away to dry before winding on the wire. This will prevent the tube from shrinking and lessen the danger of the wire becoming loose after the tuner has been in service a short while. After the tube has thoroughly dried, it should be set in an oven or some other warm place and thoroughly warmed. It is then ready for winding.

The winding consists of a single layer of No. 25 B. & S. gauge, single cotton or single silk covered wire. Single cotton covered wire is perfectly satisfactory, but green single silk covered wire will give the tuning coil a far better appearance. The wire must be wound on the tube very smoothly and tightly, starting and stopping about ¼ of an inch back from each end. Two small holes should be punched in the card board tube near the ends with a pin, and the ends of the wire fastened by winding them back and forth. After the winding is finished, it should be given a coat of varnish or shellac and put away until dry.

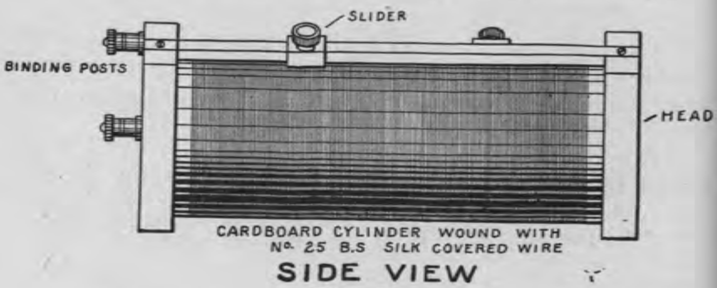



FIG. 59.
Side View of the Junior Tuning Coil.

The tube is mounted between two wooden ends which also serve as a support for the two slider rods. The wooden ends or coil heads may be cut from a board ½ an inch thick according to the shape and dimensions shown in Figure 60. The top corners of the ends are beveled and notched to receive the slider rods. The slider rods are made of a brass rod $\frac{3}{16}$ of an inch square. Two circular wooden supports 2⅝



inches in diameter and ⅜ to ½ an inch thick will be required. They will have to be turned out on a lathe in order to make them perfectly round. One of these circular wooden pieces is nailed to the inside of each of the coil heads to support the ends of the card board cylinder. They should be made just the right size so that they will slip into the end of the cylinder firmly. The wooden parts may then be sandpapered and stained mahogany or some other dark color. After the stain is dry, give them a coat of shellac or varnish.

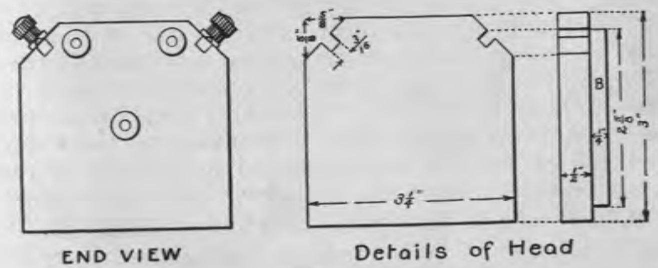



FIG. 60.
Details of the Wooden Head.

Two slider rods are required. They are each about 7¾ inches long and have a small hole bored near each end about ¼ of an inch back from the edge. Sliders may be purchased ready made or can be made at home by the experimenter by following the scheme shown in Figure 58. An easy method is to make them of square brass tube which will just fit over the square brass slider rod. Cut off two pieces of the tube about ½ an inch long. An 8/32 flat head brass screw is soldered to the center of one face of each of the pieces of tube. A small "Electrose" knob such as that known as No. 8005 or 8009 is screwed on to a slider and makes a neat and efficient handle.

A small sheet of phosphor bronze or spring copper about $\frac{3}{16}$ of an inch wide is soldered to the opposite side of the tube and forms a contact for making connection to the wires on the cylinder.

The tuning coil is now ready for assembling. The cardboard tube is slipped over the ends of the circular supporting blocks, nailed to the coil heads, and then the slider rods put in position. The cardboard tube may be held in place by means of glue or by several small tacks or brass nails driven through it into the circular piece on the coil heads.

A slider is placed on each of the slider rods and the rods are fastened in the slots in the coil ends by means of small round head brass screws passing through the holes in the rod bored near the end for that purpose.

Two binding posts are mounted on one of the coil ends as shown in the accompanying illustration. One of each of these posts should be connected to each of the slider rods by means of a short piece of copper wire. A third binding post is mounted on the opposite end of the coil and connected to one end of the wire wrapped around the cylinder.

A narrow path along the coil directly underneath each slider must be made by scraping the insulation off the wire with a sharp knife so that the copper strip soldered on the under side of the slider can make contact with each and every one of the wires as it passes over it. The sliders should slide smoothly over the wires without damaging or disarranging them in any way. The end of the copper strip should be bent so that it slides easily and only connects with one wire at a time.

Be very careful in scraping the wires not to loosen them or remove the insulation from between the turns so that adjacent turns touch one another. If they do, they will form a short circuit, and a tuning coil with a short circuit will not be nearly as efficient as one without.

Practically every wireless receiving circuit requires a fixed condenser.

It is advisable for the experimenter to purchase a fixed condenser because it is more likely to be of the correct capacity than any which he might make. A fixed condenser like that shown in Figure 62 only costs



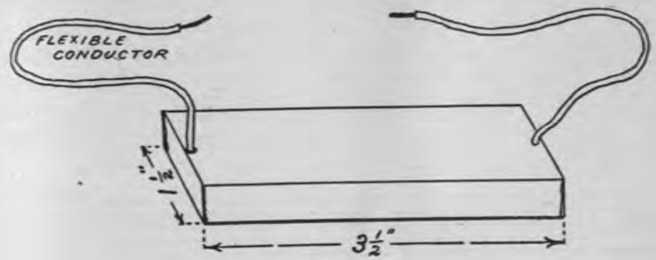



FIG. 61.
Simplex Fixed Condenser.

75 cents and will be found far superior to a home made condenser. For the benefit of those who may wish to experiment and build their own, however, the following instructions may prove valuable:

The fixed condenser must be very carefully made in order to insure its proper operation.

FIG. 62.
Fixed Condensers especially adapted to amateur use.

It consists of two strips of tinfoil, twenty inches long and two inches wide. A piece of copper wire about six inches long should be soldered to the end of each strip.

Lay one strip of tinfoil in the centre of a strip of paraffined paper, twenty-two inches long and two and one-half inches wide. Place a second trip of paraffined paper over the tinfoil. Lay the other strip of tinfoil in the centre of the second sheet of paper. The wire connected to this strip of tinfoil should be at the opposite end from the wire on the other strip. Place a third sheet of paraffined paper over the top strip of tinfoil. Cut out a small rectangular shaped piece of cardboard, two and one-half inches long and one inch wide. Place this at one end of the pile of paper and tinfoil and roll the whole thing up, using care to keep the edges even and to prevent the tinfoil from sliding or slipping.

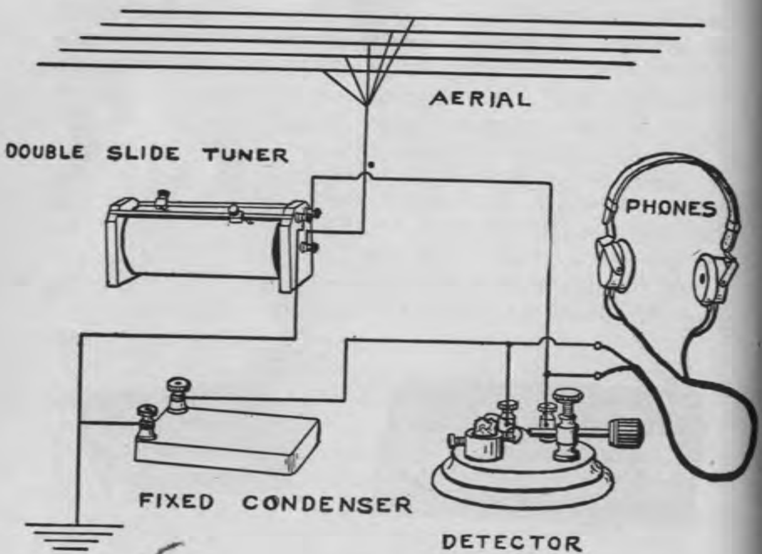



FIG. 63.
Diagram showing how to connect a double slider Tuning Coil, Detector, Condenser and Phones to the Aerial and Ground.

The cardboard will serve as a guide in rolling up the condenser and will keep it flat. When rolling the condenser around the cardboard, do not bend the cardboard so that the paper and tinfoil roll up round in the manner of a roll of wall paper, but instead take a flat form like a bolt of cloth. Tie the condenser with a piece of string to keep it from unrolling. The finished condenser should appear like that for an in-



duction coil shown in Figure 20 and have the wires coming out at opposite ends.

When selecting the paper for making the condenser be certain that it has no holes in it. The paper used in winding coils and sold under the name of waxed condenser paper is the best.

Use care not to damage or tear the paper when making the condenser. The two strips of tinfoil must be perfectly insulated from each other. If they touch or are electrically connected, the condenser is "short circuited" and a short circuited condenser is of no value on your wireless set.

The case for the condenser is made from a rectangular piece of sheet tin, four inches long and two inches wide. A notch, one-quarter of an inch square is cut in each corner. The case is then bent along each of the dotted lines so as to form a shallow tin box. Two small holes are drilled in the case near the ends to pass the wires which connect with the tinfoil sheets.

A piece of flexible conductor should be connected with each of the wires and led out through the holes in the case. The bare wires should not touch the case at any place or the condenser will be short circuited. The tin case should be poured full of molten sealing wax so as to hold the condenser in place. The case may then be finished by painting it black.

**The Junior Loose Coupler** is a far more efficient tuning instrument than a double slider tuner. It possesses far more selectivity, making it more easily

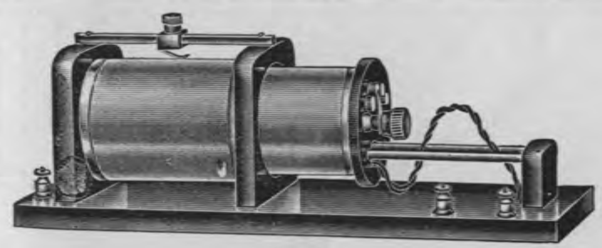


FIG. 64.
The Junior Loose Coupler.

possible to tune out any unwanted messages and to listen to those desired.

The base of the loose coupler is ½ inch thick, 12 inches long and 3⅝ inches wide. The primary winding consists of a single layer of No. 26 B. & S. gauge, single silk covered wire wound on a cardboard tube. The cardboard tube should be 2¾ inches in diameter and 3¾ inches long. It should be dried and soaked in shellac and then dried again.

The wire should be wound on smoothly and evenly, starting and stopping about ⅜ of an inch from the edges. The winding should be given a coat of clean

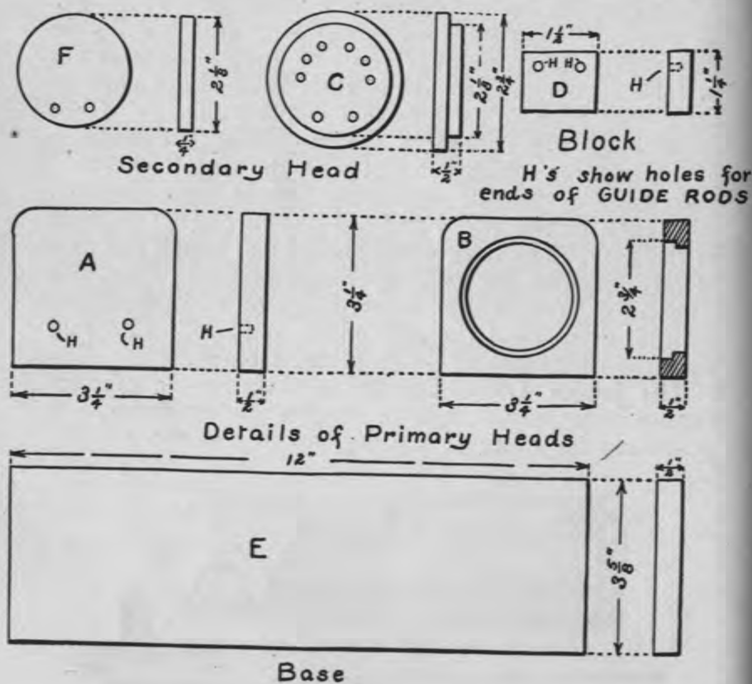



FIG. 65.
Details of the Woodwork required for the Junior Loose Coupler.



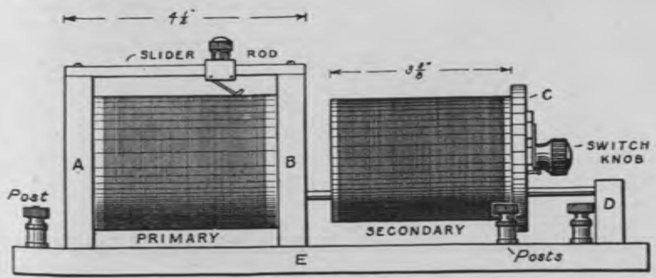
white shellac and allowed to dry so that the wire is fastened down to the tube tightly and will not loosen when the slider is moved back and forth.

The primary is mounted in two wooden heads, the details and dimensions of which are illustrated in Figure 65. The head marked B in the illustration has a flanged hole cut through the centre so as to permit the secondary to pass into the primary.

The secondary is wound on a cardboard tube 2¼ inches in diameter and 3⅜ inches long. The winding consists of a single layer of No. 30 B. & S. gauge silk covered wire and is divided into six equal sections. The tube is supported by two circular wooden heads marked C and F in the illustration. They fit into the ends of the secondary and are held in place by two or three small brass pins.

Each section of the secondary winding is connected to a contact mounted on the head C and arranged so that by turning a switch arm, either one, two, three, four, five or six sections may be connected.

The secondary slides in and out of the primary on two brass guide rods. The guide rods are supported at one end by the primary head A. Two small holes marked H and H in Figure 65 are bored in A to receive the ends of the rods but not so as to allow them to slip through. The other ends of the rods are supported by a small block D.




SIDE VIEW
FIG. 66.
Side View of the Loose Coupler.

Two small binding posts are mounted on the base near the secondary end of the instrument and connected to the terminals of the secondary winding by means of two flexible wires.

The primary is varied by means of a slider similar to those used on the double slide tuning coil. The slider is mounted upon a rod fastened across the top of the two heads by a small screw at each end.

A narrow path should be scraped through the insulation of the primary winding directly underneath the slider so that the spring makes contact with each wire independently as it passes over it.

The two primary binding posts are mounted upon the base next to the head A. One is connected to the slider and the other is connected to the end of the primary nearest the head B.

When the loose coupler is completed it will be seen that it is an instrument which consists of two sepa-

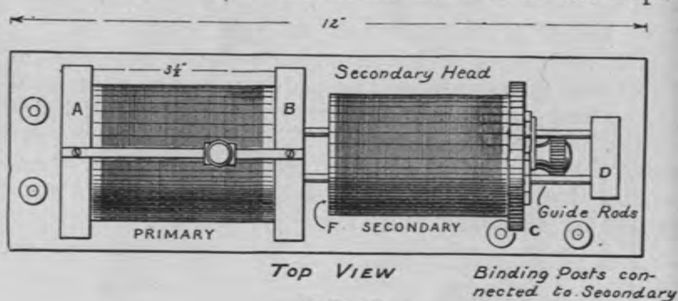



FIG. 67.
Top View of the Loose Coupler.

rate windings both of which can be varied, by a slider in the case of the primary and a switch in the case of the secondary. The windings are not connected to each other.

The currents from the aerial pass through the primary of the coupler into the ground. They **induce** currents in the secondary winding which are led to the detector. Moving the secondary in and out of the primary varies the **coupling** of the two circuits.



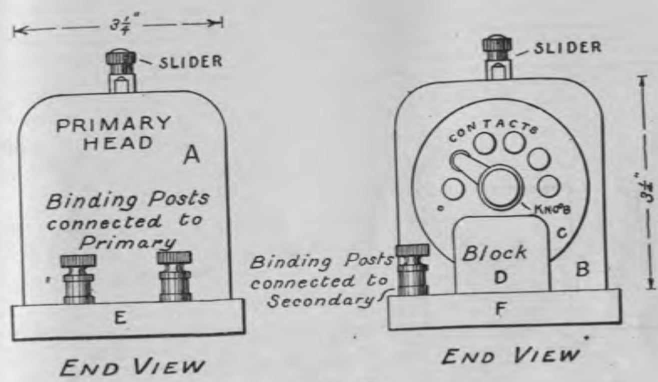



FIG. 68.
End Views of the Loose Coupler.

The diagram in Figure 70 shows how to connect the loose coupler to the rest of the receiving instruments.

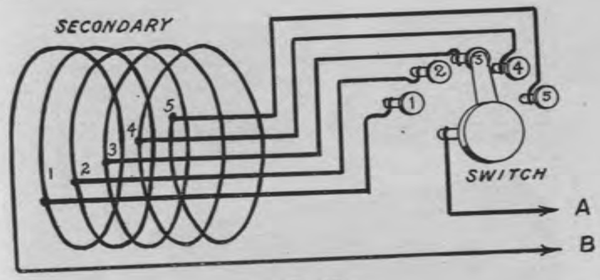



FIG. 69.
Diagram illustrating the Principle followed in connecting the Sections of the Secondary to the Contacts, etc.

## How to Build a Loading Coil.

Whenever it is desirable to receive stations which have a long wave which would be above the range of the tuning coil or loose coupler, it may be accomplished by means of a loading coil.

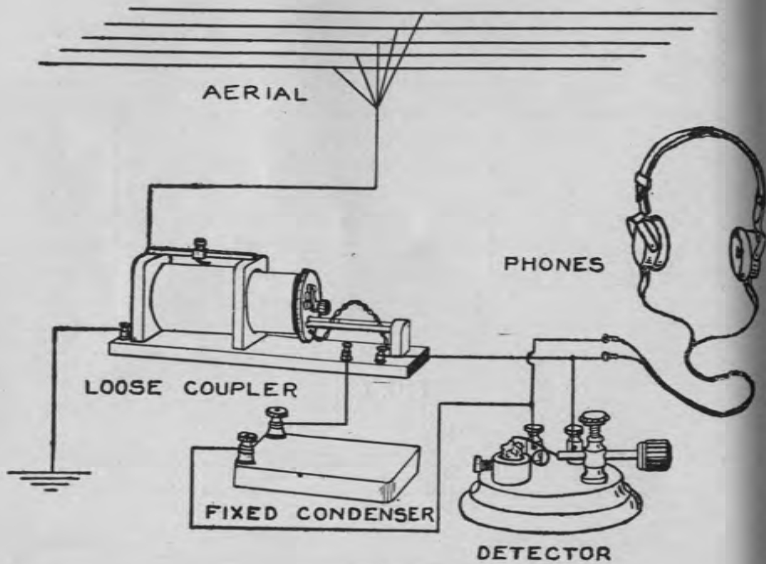



FIG. 70.
Diagram showing how the Loose Coupler should be connected in Circuit with the other Receiving Apparatus.

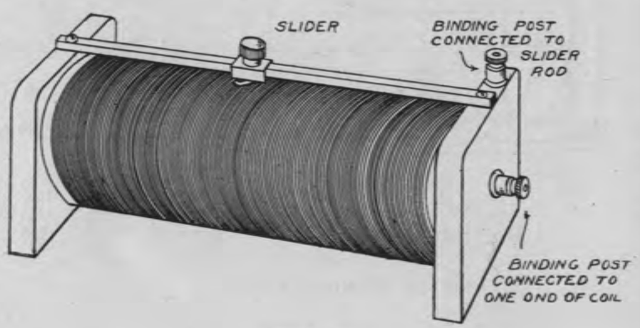



FIG. 71.
A Loading Coil for increasing the wave length range of the Primary of a Loose Coupler. A Loading Coil such as this may also be placed in the Secondary Circuit.



A loading coil is simply a tuning coil provided with one slider. It is connected in series with the double slide tuning coil or the primary of the loose coupler, depending which sort of tuner is used with the outfit. sliders, however, only one is used.

A very neat and efficient loading coil may be made by making a tuning coil according to the same dimensions and design as the double slider tuning coil shown in Figure 57. Instead of fitting the coil with two

Figure 72 shows how to connect a loading coil in series with the primary of the loose coupler.

The wire leading from the aerial is connected to the slider rod of the loading coil. One end of the winding on the loading coil is then led to the primary of the loose coupler.

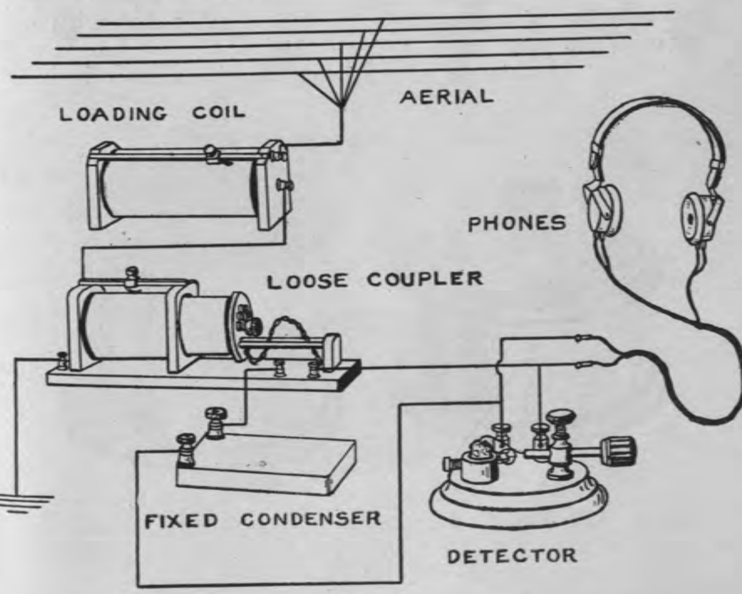



FIG. 72.
Diagram showing how the Loading Coil is connected in Circuit in series with the Loose Coupler.

## How to Build the Junior Variable Condensers.

The point of sharpest tuning does not always happen to come on a turn of the tuning coil or loose coupler where it can be reached by the slider. This difficulty is overcome by the use of a variable condenser. A variable condenser makes it possible to adjust the circuit to the exact point of resonance. Variable condensers are of several types. The style, however, in most common use is the "rotary" variable, this being the most convenient and easy to manipulate. It consists of a number of fixed semi-circular metal plates between which swings a set of smaller movable semi-circular plates. The fixed plates form one-half of the condenser and the movable plates the other. In this way the capacity of the condenser is very closely adjustable. The movable plates are provided with a pointer moving over a graduated scale so that the comparative amount of capacity in the circuit is indicated.

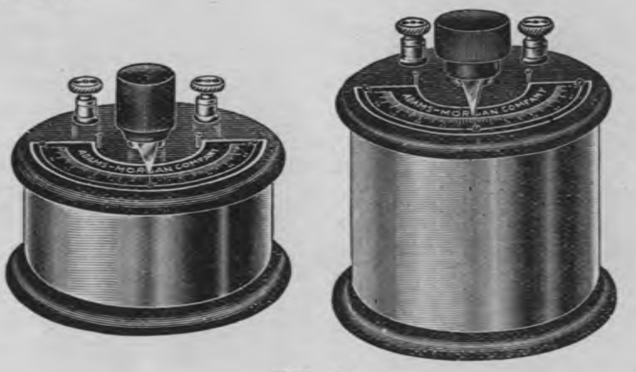


FIG. 73.
Junior Rot. Variable Condensers. The smallest Condenser is adapted for use in the Secondary Circuit and the large Condenser for the Primary.

Two variable condensers are usually required in a receiving circuit employing a loose coupled tuner. One is placed in the primary circuit and the other in the



secondary circuit. The condenser used in the primary circuit should have more capacity than the condenser in the secondary circuit. The capacity of a condenser is dependent upon the size, number and spacing of the plates. Therefore if the size and spacing of the plates are equal, the condenser having the largest number of plates will have the greatest capacity.

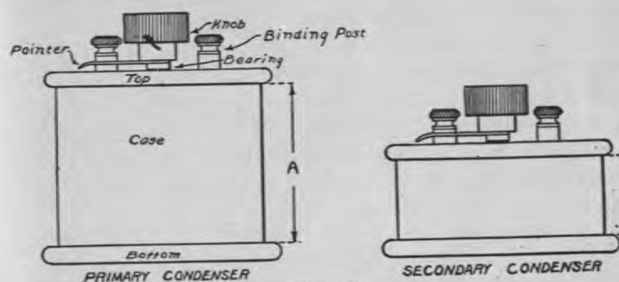



FIG. 74.
Side View of the Junior Condensers. A represents the length of the brass tube forming the case.

The illustrations in Figure 73 show two amateur types of variable condensers which may be easily built by the experimenter. The larger one has thirty-one plates (sixteen of them being fixed and fifteen movable) and is best adapted to use in the primary circuit.

A condenser placed in series with the primary or secondary of a loose coupler will decrease the wave length range and is usually placed in the circuit in that position when a station has a very long aerial which has a longer natural wave length than the station it is desired to receive. In such a case, a variable condenser placed in series with the primary of the loose coupler so that the energy passing from the aerial, through the loose coupler primary, and into the ground, must also pass through the condenser either before or after passing through the primary, will enable the operator to "tune down" to the wave length to which he desires to listen. For example, it would be necessary to place a variable condenser in series when using an aerial having a natural period of 600 metres to receive from an amateur station having a wave length of 200 metres.

Connecting a variable condenser across the terminals of a loose coupler primary so that the energy from the aerial has a double path through both the primary and the condenser in passing to the ground, will have the effect of increasing the wave length range of the primary circuit. For instance, the greatest wave length it might be possible to tune in on the primary of a certain loose coupler in connection with a certain sized aerial might only be 1,000 metres. The placing of a suitable variable condenser across the primary of the loose coupler would then make it possible to tune in waves having a considerably greater length than 1,000 metres.

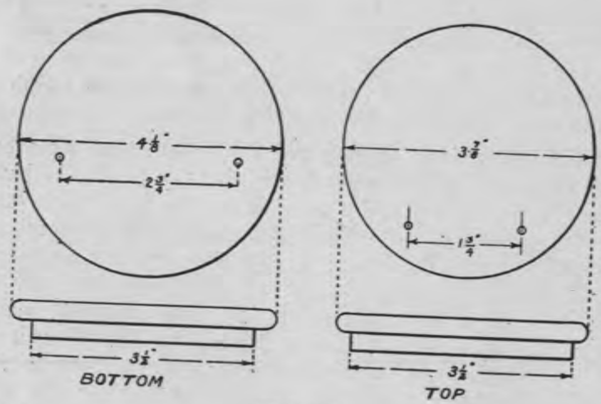



FIG. 75.
Details of the Wooden Top and Bottom.

It often happens that it is desirable to tune in a wave which is above the limit of the secondary winding and in that case a small variable condenser should be connected directly across the terminals of the secondary.

The cases of the variable condensers shown in Figure 73 are made from brass tubing $3\frac{9}{16}$ inches in diam-



eter outside and 3½ inches in diameter inside. The exact length as shown by A in Figure 74 will be dependent upon the number of plates used and their spacing. The Junior Condensers, as regularly made for the market, have 31 and 17 plates respectively, accordingly as they are intended for the primary or the secondary. When building the condensers it is best to assemble the plates first and then cut the tubing to the proper length to fit.

The bottom and top of the case are turned out of hardwood and polished. They are flanged so as to fit snugly into the top and bottom of the tube. The details and dimensions are shown in Figure 75.

The plates are shown in Figure 76. It will be quite hard for the experimenter to make his own plates because they can only be properly produced by means of a punch and a die which will stamp them out of the sheet metal. Plates of the dimensions shown in Figure 76 can be purchased very cheaply from dealers in wireless supplies and for that reason it would not be worth while to try and cut them out of sheet metal by hand.

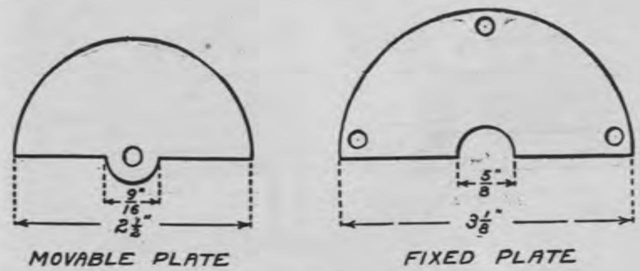



FIG. 76.
Details of the Condenser Plates.

The drawings in Figure 77 are cross sections of the completed condensers showing exactly how the parts are arranged and assembled.

The fixed plates are held in position by three threaded brass rods. The upper ends of the rods or "stems," as they are labeled in the drawings, are threaded into the under side of the wooden condenser top. The plates are separated by brass washers, $\frac{3}{16}$ of an inch in diameter outside, $\frac{1}{16}$ of an inch thick and having a hole through the centre so that they will slip over the brass stems. The stems are long enough to pass down through the wooden base. The base is clamped into position by a nut on the end of each rod, countersunk into the under side.

The plates are clamped tightly together by a fibre plate made according to the dimensions shown in Figure 78. This plate is slipped over the threaded rods after the last fixed plate is in position and then clamped firmly in place by three brass nuts on the under side. A $\frac{1}{16}$ inch separation, the same as those used between the fixed plates, should be used between the last fixed plate and the fibre plate.

The movable plates are assembled on a brass rod passing through the hole in the small projecting ear. The separators used between the movable plates are ½ inch in diameter but should be of **exactly the same thickness** as those used between the fixed plates.

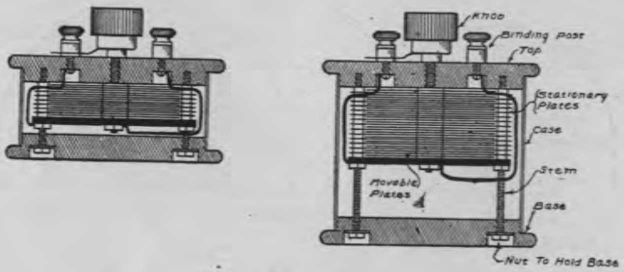



FIG. 77.
Cross Sections of the Condensers showing how they are assembled.

The washer used on top of the top movable plate must be threaded so that its position may be fixed on the rod. All the other separators except the one



on the under side of the last plate should **slip** over the rod. The last one should be threaded so that when it is screwed up into its proper position, the plates will be clamped tightly together.

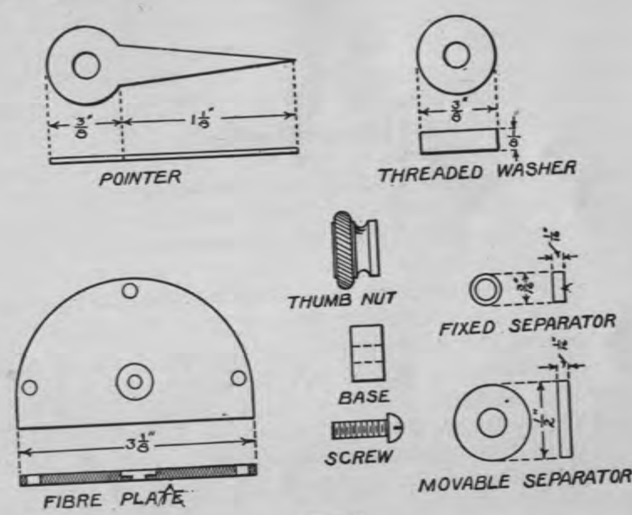



FIG. 78.
Details of some of the Parts and Fittings for the Junior Condensers.

The separator on the under side of the last movable plate should rest in a small depression in the fibre plate assembled with the fixed plates. The lower end of the threaded rod or stem on which the movable plates are assembled passes through a hole in the center of the depression.

The depression should be just deep enough so that the movable plates will line up half way between each pair of the fixed plates.

The top bearing for the movable plates is formed by a hole through the wooden top of the condenser case. The upper end of the threaded rod passes through this hole. A pointer and a knob are fitted to the rod. The details and dimensions of the pointer are shown in Figure 75. It may be easily cut out of sheet brass with the aid of a pair of tin snips. The pointer is mounted by clamping it against the under side of a knob which screws onto the end of the rod, by a threaded washer. The knob should be a No. 8008 Electrose Knob.

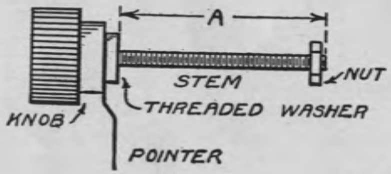



FIG. 79.
The Knob Pointer and Stem upon which the Movable Plates are assembled.

A brass scale showing 180° made especially for condensers of this sort may be purchased and mounted under the pointer. The pointer should indicate 0° when the movable plates are entirely out of the fixed plates and 180° when they are entirely in.

Two binding posts are mounted on the top of the condenser. One of them is connected to the fixed plates. The other is connected to the movable plates

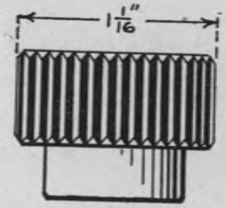



FIG. 80.
Details of the Knob used on the Condensers.

by a flexible wire soldered to the bottom of the stem.

The condensers must be adjusted so that the movable plates swing in and out of the fixed plates without




FIG. 81.
The Scale.

touching or short circuiting at any point. The adjustment of such a condenser is somewhat of a "ticklish" and painstaking job sometimes, but must be persisted in until finally accomplished because a condenser which short circuits at any point is absolutely worthless.

The illustration in Figure 82 shows how to use the condensers in the receiving circuit.

CHAPTER V.

## THE ARRANGEMENT AND OPERATION OF THE APPARATUS.

Considerable emphasis has been laid, in Chapter I, upon the selection of a proper location for the apparatus and a design has been suggested for the construction of a suitable operating table or bench to accommodate the instruments. It is equally important after a suitable bench and location have been secured, that the instruments should be properly arranged and connected.

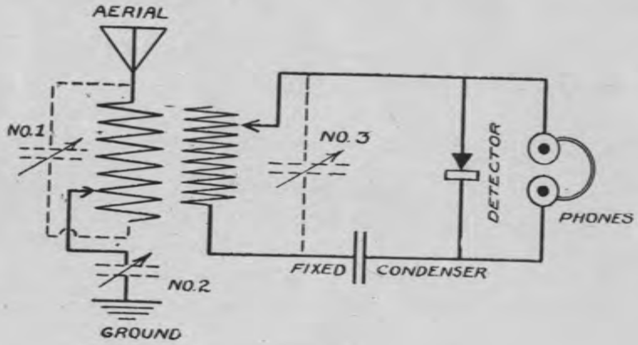



FIG. 82.
Diagram showing where a Rotary Variable Condenser may be employed in the receiving circuit. Condenser No. 1 is connected in parallel with the Loose Coupler Primary. No. 2 is in series with the Aerial Circuit and No. 3 is across the Secondary.

The receiving instruments should be placed towards one end of the table and the transmitting apparatus towards the other, their position being such that they can be connected without its being necessary to cross any wires. All wires should be as short as possible, as long wires and leads are the cause of considerable losses of energy in wireless telegraph circuits.



The best sort of wire to use in connecting the receiving apparatus is a flexible conductor composed of 16 No. 31 B. & S. gauge copper wires insulated with a double, green silk covering. This wire not only has the advantage of being very flexible but also, since it is stranded, offers less resistance to the wireless currents.

It is well to also use stranded wire in connecting the transmitting apparatus. The rubber covered stranded wire used for electric light wiring is just the thing for the purpose.

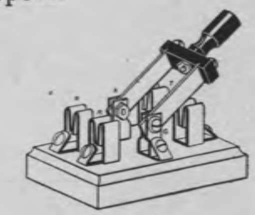


FIG. 83.
Porcelain Base Aerial Switch

### Aerial Switches.

The aerial and ground must be arranged so that they may be easily and quickly connected to either the transmitting or receiving apparatus accordingly as it is desired to transmit or receive. This is accomplished by means of an aerial switch.

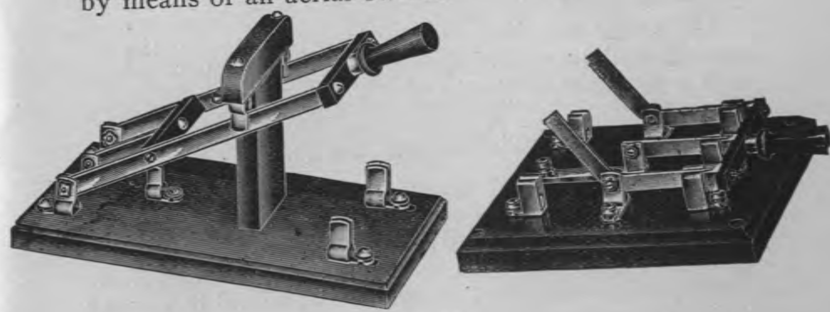


FIG. 84.
Two well-known Aerial Switches.

The simplest and most inexpensive type of aerial switch for use with outfits having a transmitter no larger than a ½ inch spark coil is a double-pole, double-throw, porcelain base switch such as that shown in Figure 83. The aerial should be connected to one of the blades and the ground to the other. The receiving instruments are then connected to one set of contacts and the transmitting apparatus to the other.

The aerial switches shown in Figure 84 will be found the most suitable. They are much larger than the ordinary double-pole, double-throw switch and there is less liability of losses due to current leakage. Both of these switches are also provided with a third blade and contacts which may be used to "shunt" or short circuit the detector while transmitting so that the spark will not destroy its adjustment, or else made part of the primary circuit of the spark coil so that the current is shut off when the switch is in position for receiving and there is no possibility of an accidental touch of the key doing any damage.

The diagram in Figure 85 shows how to connect the transmitting and receiving instruments to a switch similar to one of those shown in Figure 84. In this diagram, the third blade on the switch is made a part of the battery circuit so that the coil cannot be operated when the aerial and ground are connected to the receiving apparatus.

The aerial switch is usually located between the receiving and transmitting apparatus in a place where it is convenient to the hand.

### The Buzzer Test.

Some convenient means for testing crystals and also telling when the detector is in its most sensitive adjustment should be provided by the experimenter.

The simplest method is to arrange a buzzer as shown in Figure 86. The buzzer is preferably a small one. The contacts and the armature should be adjusted so that the period or pitch is as high as possible.



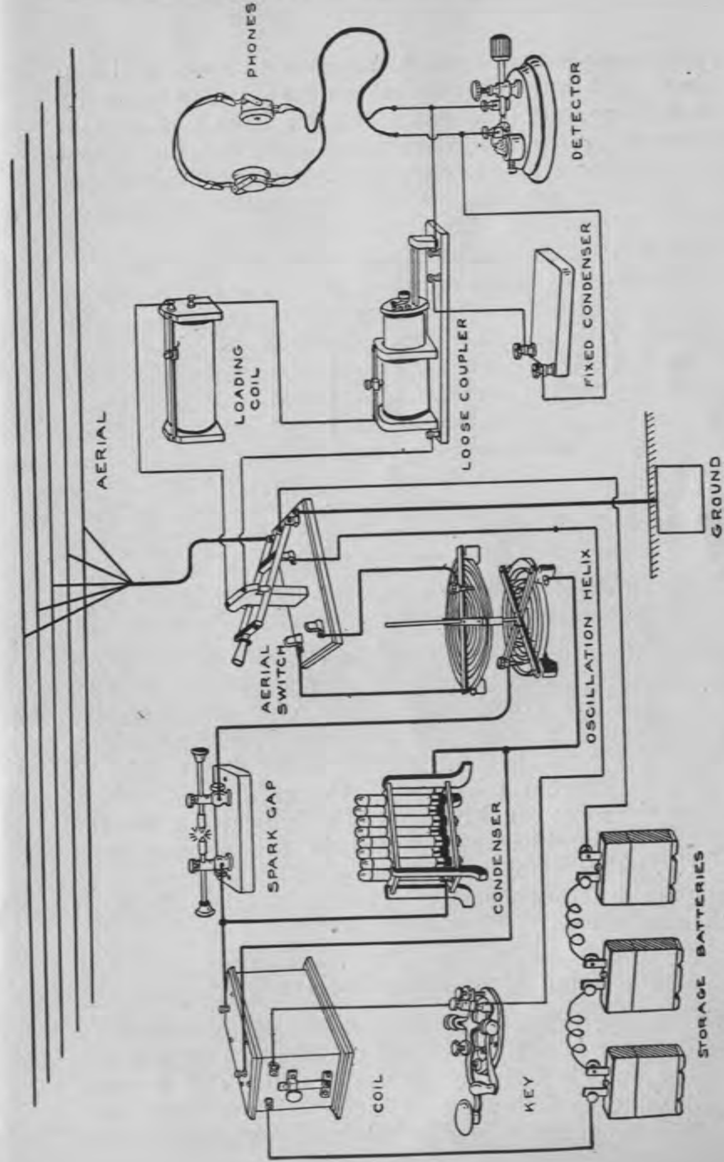



FIG. 85.
A Diagram showing how to connect a complete Transmitting and Receiving Outfit.

The buzzer is connected in series with a dry cell and a key, push button or switch so that it may be easily set into operation at will. A wire from one contact on the buzzer is led to the ground. When the buzzer is set in operation it sends out electromagnetic waves in the same manner as the transmitting apparatus

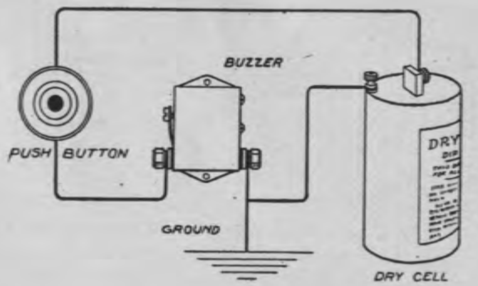



FIG. 86.
Diagram showing how to arrange a buzzer for testing and adjusting the Detector.

(only they are, of course, much weaker) which affect the detector. The latter may then be adjusted to its most sensitive condition by observing the intensity of the sound produced in the receivers. Adjusting the detector so that the contact point is brought to bear on different portions of the crystal will show where the most sensitive spot is as indicated when the sound of the buzzer is heard in the phones most clearly. This same arrangement makes it possible to compare different pieces of crystal and select the most sensitive ones.

### Using More Than One Detector.

Some experimenters may desire to arrange more than one detector in their receiving circuits so that any one may be quickly switched in use at will. This is quite easily done by following the suggestion in Figure 87. All that is necessary is a switch having a contact point



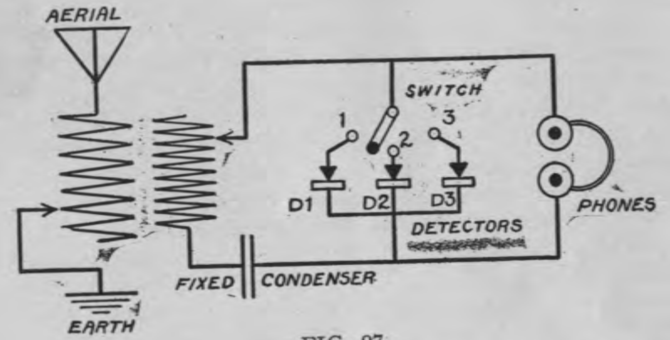



FIG. 87.
Diagram showing how to arrange three Detectors so that any one may be instantly thrown into the Circuit. D1, D2 and D3 are the Detectors.

for each detector it is desired to use. When the switch is on contact 1, detector number 1 is in circuit. When the switch is moved to contact 2, detector 2 is in circuit.

### Shunting the Detector.

Very often the powerful waves set up by the transmitting apparatus are sufficient to disarrange and

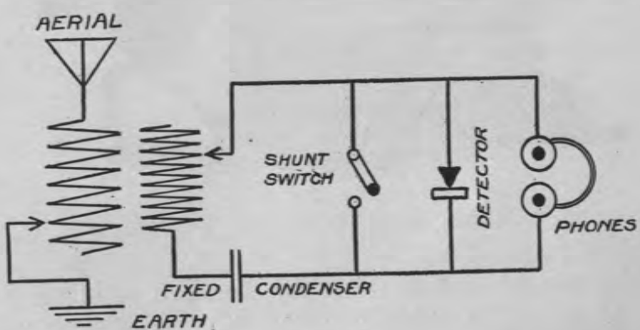



FIG. 88.
Diagram showing how to "shunt" the Detector.

destroy the adjustment of the detector in the same station. The easiest way to protect against this is to arrange a small "shunt" switch directly across the terminals of the detector as shown in Figure 88. The switch should always be closed when it is desired to send. It offers a better current path than the detector and most of the energy induced in the receiving apparatus by the transmitter when it is in operation will pass through the switch instead of the detector.

## Complete Outfits and Portable Sets.

Many experimenters may wish to have their apparatus in the form of a complete unit so that all the instruments are mounted on one base and always connected ready for use.

Figure 89 shows a set composed of a Junior Tuning Coil, a silicon detector and a fixed condenser all mounted on one base. The wires which connect the instruments together pass through small holes beneath the instrument and are concealed along the under side of the base.

FIG. 89.
A complete Receiving Outfit consisting of a Tuning Coil, Detector and Condenser mounted on a wooden Base.

The two binding posts at the forward right hand corner are for the accommodation of the telephone receivers.



The outfit illustrated in Figure 90 is practically the same as that shown in Figure 89 except that it is provided with a Junior Loose Coupler in place of a double slide tuning coil. The base is the same width but is made longer so as to accommodate the Loose Coupler.

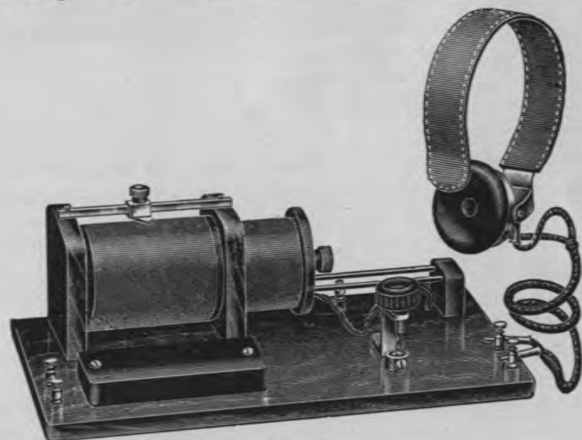


FIG. 90.
A somewhat similar Outfit employing a Loose Coupler in place of the Tuning Coil.

The two binding posts at the forward left hand corner are for the aerial and ground whereas those to the right are for the telephone receivers. It is also a very good plan to place binding posts at the back of the base and connect them directly across the secondary so that a variable condenser may be added to that part of the circuit whenever it is desirable.

This same idea can be carried still farther and the spark coil, spark gap, key and aerial switch included on the base with the receiving instruments. An outfit of this sort is illustrated in Figure 91.

The spark coil is placed at the right hand end of the base. It should be noticed that the spark gap is mounted directly on the top of the spark coil.

A double-throw double-pole, porcelain base switch is used for an aerial switch and placed between the

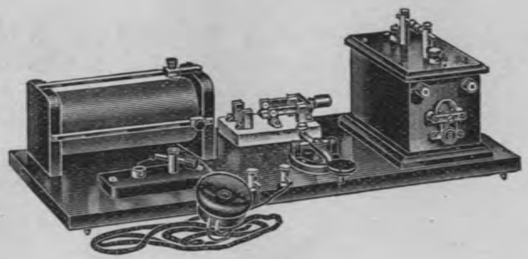


FIG. 91.
Complete Transmitting and Receiving Outfit mounted on one base.

spark coil and the tuning coil. The key is placed directly in front of the aerial switch. The detector is mounted on top of the fixed condenser and placed in front of the tuning coil.

All the wires run along the under side of the base. Binding posts are provided for the aerial and ground, telephone receivers and the spark coil battery.

The same scheme is followed in making up the outfit shown in Figure 92, except that the double slide Tuning Coil is replaced with a Junior Loose Coupler.

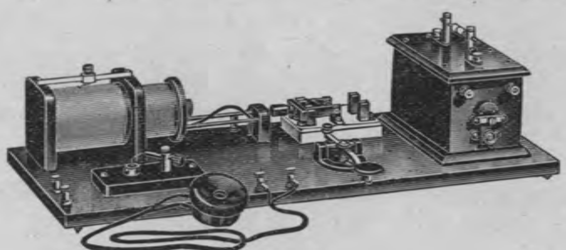


FIG. 92.
A Complete Transmitting and Receiving Outfit similar to that shown in Fig. 91, but provided with a Loose Coupler in place of a Double Slide Tuning Coil.

The young experimenter may follow these same schemes and build for himself a set enclosed in a suitcase or a square box fitted with a handle so that the outfit is readily portable and may be easily carried about.

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