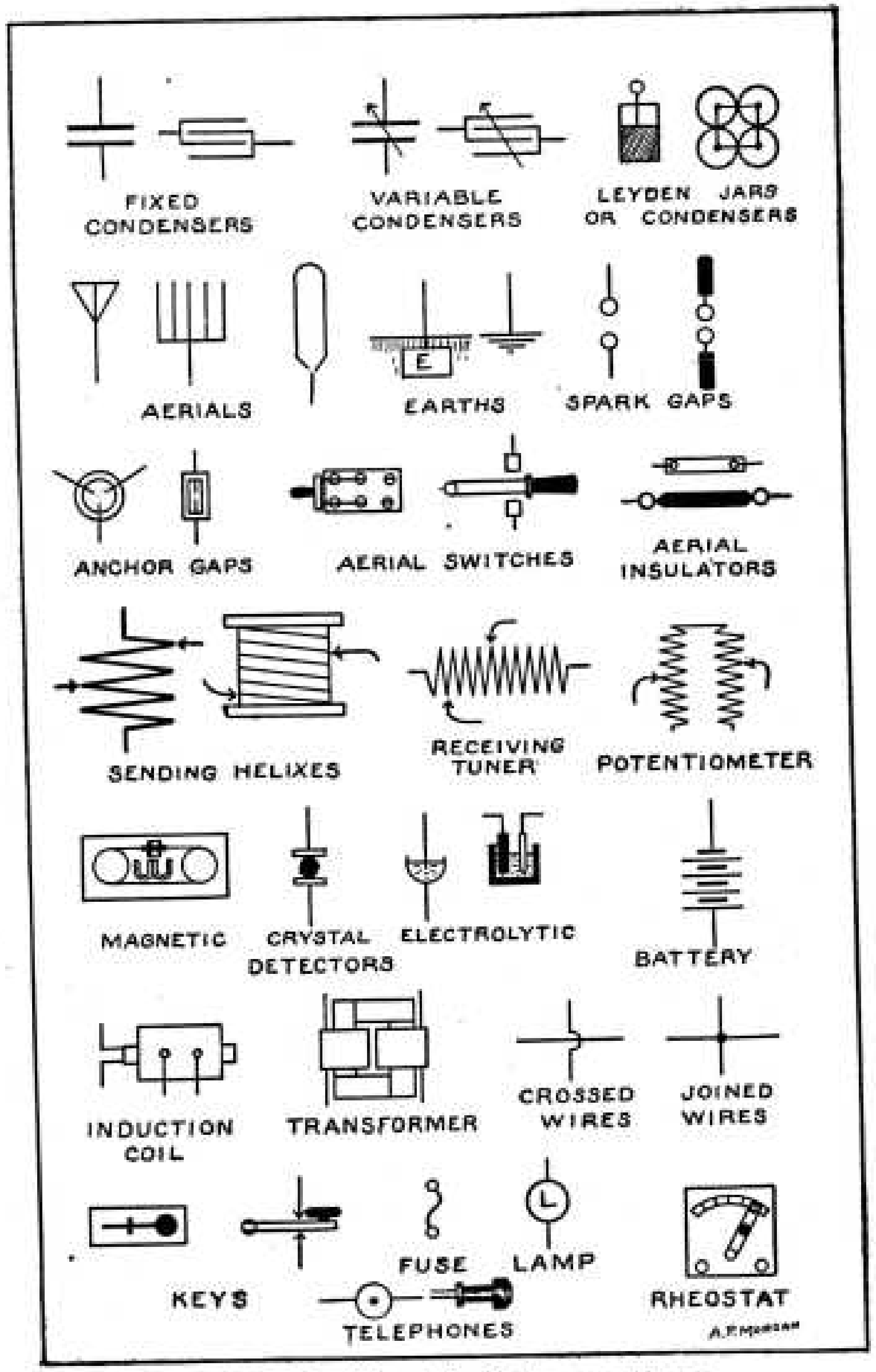

Frontispiece. **Plate I. Electrical Conventions.**

WIRELESS TELEGRAPH CONSTRUCTION FOR AMATEURS

BY

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AUTHOR OF "WIRELESS TELEGRAPHY AND TELEPHONY"

WITH 167 ILLUSTRATIONS

Third Edition, Revised and Enlarged

WITH A COMPLETE DESCRIPTION OF THE NEW WIRELESS LAW

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PREFACE.

In this work, the author has endeavored to present a book embracing practical information for those who may wish to build for private or experimental use a set of wireless instruments which are more than toys but yet not so expensive as the commercial apparatus.

Many books have been published on the subject of wireless telegraphy, but in them the interests of the novice have been rather neglected and in order to build an outfit he has been forced to rely upon a series of disconnected articles published in the amateur periodicals.

It is the object of this book to show the construction of simple, efficient instruments by means of clear drawings, and to give enough elementary theory and practical hints to enable the experimenter to build a size and type in keeping with his needs and resources.

The tiresome "how to make" style has been avoided as far as possible. History and all unimportant details are omitted to give in their place a concise explanation of the parts played by the different instruments and the influence of developing their various factors.

A small lathe and a set of taps and dies are necessary to produce apparatus having a good appearance, but a little ingenuity displayed in adapting screws and parts of old electrical instruments oftentimes at hand will make these tools unnecessary.

Ordinary precaution and plenty of time should be used in

Fig. 87 illustrates the form of hot wire ammeter used by the United Wireless Telegraph Co. for tuning their installations.

The pivotless meter just described should be fitted with heavy binding posts which are connected to the brass

Fig. 87. United Wireless Hot Wire Ammeter.

standards mounted on the glass strip by means of stranded copper wire.

The meter should be fitted with a case and glass cover to exclude dust and prevent injury to the working parts. It should be mounted in such a position that the weight of the pointer is sufficient to keep the silk thread taut so that when the wire expands the pointer which is normally at zero will fall of its own weight. When the wire cools after the current has ceased to flow, it will contract and draw the pointer up again.

Platinum wire will give good results, but for more accurate work an alloy known as platinoid is most suitable.

Detailed instructions for tuning the transmitting circuits by means of a hot wire ammeter are given in the chapter on Transmitting Helixes.

CHAPTER XIII.

OSCILLATION DETECTORS.

"UNIVERSAL" DETECTOR.

THE purpose and position of the detector in a wireless telegraph system has already received some notice in the first chapter, but its operation and adjustment are so important that this chapter deserves the most careful consideration. The receiving range of a station is not as much dependent upon the aerial system as it is upon the adjustment of the tuning circuits and the detector itself.

It is suggested that the amateur experimenter not confine his work to receiving only with a single type of detector but rather accustom himself to the different instruments.

During the past few years many wireless telegraph detectors have been invented which lend themselves readily to amateur construction. It is somewhat of a convenience to have a "universal" detector which with a little manipulation may be used as more than one type and thus save unnecessary expense and much labor.

The "universal" detector shown in Fig. 88 has been so designed as to present a good appearance and at the same time be successfully operated as an electrolytic, tantalum, peroxide of lead, silicon, carborundum or any of the crystal type detectors.

The standard, *R*, is a $\frac{3}{4}$-inch hard rubber rod, $1\frac{1}{4}$ inches long, with a $\frac{3}{16}$-inch hole bored through its axis. A spring, *S*, is made after the plan shown in Fig. 86. It is 2 inches long and $\frac{1}{16}$ inch thick. A brass collar $\frac{1}{8}$ inch thick and

$\frac{3}{8}$ inch diameter is soldered on the smaller end of the spring in order to so reënforce it that it may be bored and threaded with an 8–32 tap to receive a thumbscrew. The brass standard, *D*, is a small cylinder $\frac{3}{8}$ inch high and $\frac{1}{2}$ inch in diameter.

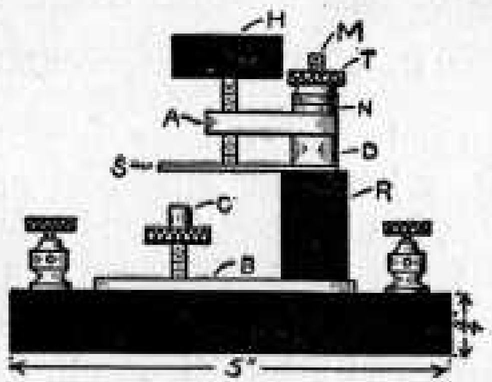

Fig. 88. Universal Detector.

A $\frac{3}{16}$-inch hole is bored through its axis. The arm, *A*, is brass and measures $1\frac{1}{2} \times \frac{1}{2} \times \frac{1}{4}$ inches. The ends are rounded

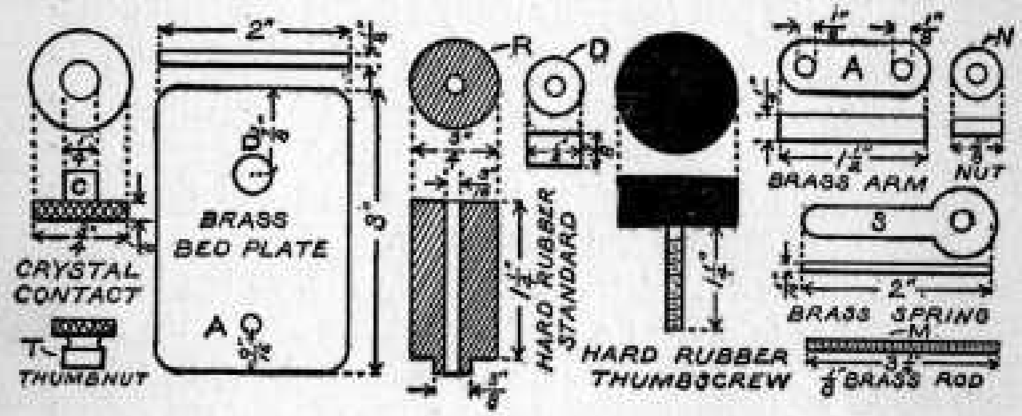

Fig. 89. Details of Universal Detector.

by filing or grinding so that they coincide with the semicircumference of a circle having a diameter of $\frac{1}{2}$ inch. Two holes are bored on the center line $\frac{1}{4}$ inch from each end.

One is a $\frac{1}{8}$-inch hole and the other is threaded with a 10–32

tap to fit the large adjusting screw. The adjusting screw, *H*, is $1\frac{1}{4}$ inches long and has a 10–32 thread. A hard rubber head $\frac{1}{2}$ inch thick and $1\frac{1}{4}$ inches in diameter is clamped to the upper end by means of two hexagonal brass nuts. A small brass washer should be placed between the head and each of the nuts to give it a more finished appearance and prevent the nuts from marring the rubber.

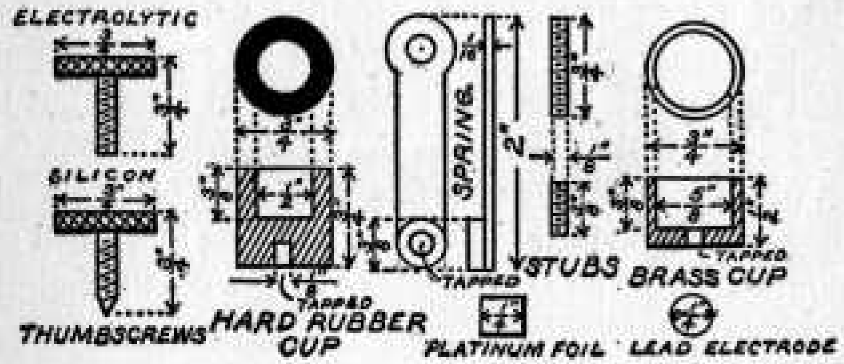

Fig. 90. Parts of Universal Detector.

The brass bed plate, *B*, is $\frac{1}{8}$ inch thick, 3 inches long and 2 inches wide. Two holes are drilled on the center line $\frac{3}{16}$ inch and $\frac{7}{8}$ inch from either end. One is $\frac{3}{8}$ inch in diameter and the other is threaded with an 8–32 tap. An insulating bushing in the shape of a hard rubber washer on the lower end of *R*, $\frac{1}{8}$ inch thick and $\frac{3}{8}$ inch in diameter, has a $\frac{3}{16}$-inch hole bored in its center and is fitted in the larger hole in the bedplate. The whole detector is assembled and mounted on a hard rubber base $4 \times 5 \times \frac{3}{4}$ inches. A brass binding rod, *M*, $3\frac{1}{4}$ inches long and having an 8–32 thread, is passed successively through the arm, the brass standard, the spring, the hard rubber standard and the bedplate. A hexagonal brass nut on the under side of the base and a thumb nut on the brass arm serves to bind the whole tightly together. Four binding posts are mounted on the four corners of the base. Two are connected to the brass binding rod and two to the bedplate. This completes the universal part of the detector. The remaining parts are each described under the headings of the respective detectors to which they belong.

Electrolytic Detectors.

"Bare Point" Type.—Although the electrolytic is the oldest of a long line of very sensitive detectors,* it still holds first rank when in the hands of an experienced and skillful operator. It exists in two different forms, but the more favored is that known as the Fessenden "bare point" type, which consists of a very fine Woolaston platinum wire (.001–.00002 of an inch in diameter) dipping in a small cup of dilute acid. The acid is either 20 per cent chemically pure nitric or sulphuric.

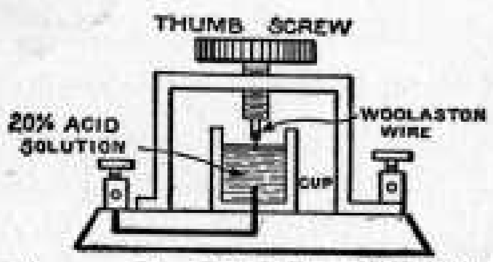

Fig. 91. Bare Point Electrolytic Detector.

A large electrode of platinum wire or foil dips into or is sealed in the bottom of the cup so as to make an electrical connection with the liquid. The fine Woolaston wire is clamped over the cup in a holder which permits of vertical adjustment, by means of a thumbscrew, so that the depth of immersion in the acid may be regulated.

Woolaston wire is covered with a comparatively thick

* The different detectors in order of their sensitiveness are electrolytic, perikon, magnetic, silicon, carborundum.

coating of silver, which before using must be removed from the end for about $\frac{1}{32}$ inch by dipping it in strong nitric acid, which will dissolve the silver and expose the almost invisible platinum core. Too much of the fine platinum core must not be exposed or else the surface tension of the acid will cause the wire to curl over and present a large flat surface

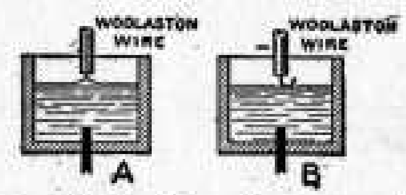

Fig. 92. Effect of Exposing too much Wire.

instead of a fine point. This is a very necessary and important precaution, for the detector is more sensitive as the area of contact between the fine wire and the liquid is smaller.

Whenever this condition is reached the end of the wire should be cut off with a pair of sharp scissors and a new point exposed.

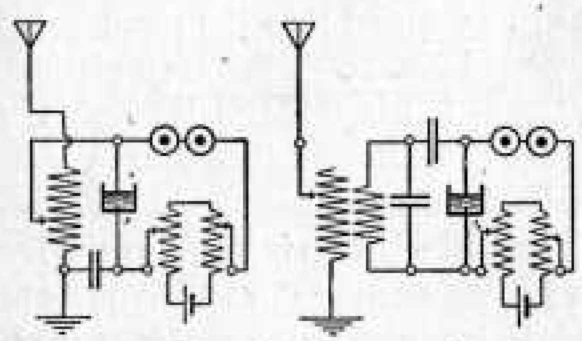

Fig. 93. Electrolytic Detector Circuits.

The detector circuit is shown in Fig. 93. The fine "bare point" is always made the positive or anode of the battery circuit. Otherwise the detector will not operate. A potentiometer must be shunted across the terminals of the battery to reduce the voltage to a value just below that which is required to break down the thin film of oxygen gas which collects on the "bare point" and polarizes it or insulates it from the liquid so that little or no battery current can flow. This film of gas is caused by the electrolysis of the acid solution and the decomposition of the water into hydrogen and oxygen gas.

When oscillations are set up in the receiving aerial and they surge through the detector, a sufficient e.m.f. is generated to break down the film of gas and permit the battery current to flow again. The passage of current causes the signals in the telephone receivers.

The electrolytic cup for the universal detector is illustrated in Fig. 90. It is made of a piece of hard rubber rod $\frac{3}{4}$ inch in diameter and $\frac{3}{4}$ inch high. A recess $\frac{1}{2}$ inch in diameter and $\frac{3}{8}$ inch deep is cut in the top to contain the acid. A small hole $\frac{1}{4}$ inch deep is bored in the under side and threaded with an 8–32 tap. A brass pin $\frac{1}{2}$ inch long, having a corresponding thread, is fitted in the hole. The pin may then be screwed into the small hole in the bedplate. A piece of No. 30 B. S. gauge platinum wire or a strip of platinum foil is clamped between the bottom of the cup and the bedplate and then bent over the top of the cup into the liquid.

A $\frac{1}{16}$-inch hole $\frac{1}{4}$ inch deep is bored in the lower end of a thumbscrew having an 8–32 thread. A piece of Woolaston wire $\frac{1}{2}$ inch long is placed in the center of the hole and tinfoil packed into the surrounding space with the head of a sewing needle until the wire is held firmly in position. The free end of the wire must then be dipped in some strong nitric acid to remove the silver. The thumbscrew is placed in the collar on the end of the spring of the universal detector and lowered until the "bare point" almost touches the surface of the electrolyte in the cup beneath. Pressure must then be applied to the spring by turning the large adjusting screw until the "bare point" touches the liquid and a click is heard in the telephone receivers and a faint bubbling sound is also audible. The adjusting screw must then be slowly and carefully turned in the opposite direction so as to raise the point until the bubbling changes to a hissing sound. The point is then above the level of the electrolyte in the çup but is still in contact with it because of the capillary action of the fine wire and the liquid.

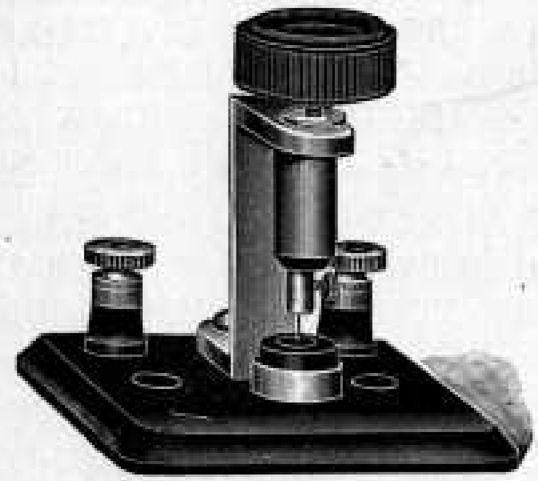

Fig. 94. Electrolytic Detector.

By using the large adjusting screw as much as possible, instead of the small thumbscrew, the point is raised or lowered without giving it a circular motion and much finer adjustment is made possible. The potentiometer is adjusted until the hissing noise caused by excessive battery voltage just disappears. The detector is then in its most sensitive condition for receiving signals.

When the detector is in use for long periods, the potentiometer must be frequently readjusted to compensate the gradual loss in voltage of the battery. It is well to provide a small switch which will disconnect the battery from the potentiometer when the detector is not in use. In the same case the acid should be removed and placed in a tightly stoppered bottle. A pipette or fountain pen filler furnishes the most convenient means for filling or emptying the cup. The acid must be kept perfectly pure and out of contact with all metals other than platinum. Great care should be exercised in filling the cup, for the acid, if spilled, will not only badly corrode the metal fittings, but will also provide a current leak and seriously weaken the signals.

Shoemaker and Stone Detectors. — These two types of detectors make use of "glass points," so called because the fine platinum wire is sealed in a glass tube and the end of the tube is then ground down on a fine oilstone until the platinum wire is exposed. This results in a very fine contact area and insures constant immersion of the point without readjustment.

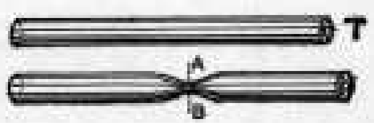

Fig. 95. Forming "Glass" Point.

The fine platinum wire for a glass point may be secured from one of the flaming pocket cigar lighters making use of spongy platinum. The center of a thick walled glass tube is softened by heat and contracted as shown at *A–B* in Fig. 95. After cooling, the tube is cut in half at the point indicated by the dotted line. The platinum wire is placed in the contracted end of the tube and carefully fused in so

that about one-half of the wire, which is about $\frac{1}{2}$ inch long, is embedded in the glass. The contracted end of the tube containing the wire should be closed. Connection is established to the upper end of the fine platinum wire by filling the tube with mercury and dipping a piece of flexible conductor in the mercury. The upper end of the tube is closed and the mercury prevented from escaping by a small dab of sealing wax.

The "point" is slowly and carefully rubbed on a fine oilstone kept well wet with water. The tube must be held in a vertical position so that the glass will be ground away at right angles. When it is thought that the platinum wire has been exposed by the grinding, connect the flexible conductor to one pole of a battery. The other pole of the battery is connected to a pair of sensitive telephone receivers and the telephone receivers to a vessel containing dilute acid. If the platinum wire is exposed, a *sharp* click will be heard in the telephone receivers when the "point" is dipped in the acid. Do not confuse the *sharp* click with the sound which may be occasioned because the outside of the glass tube is damp or wet.

After the point has been sufficiently ground, disconnect the testing apparatus and connect the free end of the flexible conductor to a binding post placed on the end of the detector spring, *S*. The detector circuit is similar to that of the "bare point" type.

The illustration shows what is sometimes called a "primary cell" detector because it furnishes its own current and does not require a battery. A Stone detector may be very easily changed to one of the Shoemaker type by substituting an amalgamated zinc rod for the platinum wire anode which makes connection with the liquid in the cup. This combination of platinum and zinc results in an electromotive force of about 0.7 volt, and the telephone receivers are connected directly to the terminals of the detector

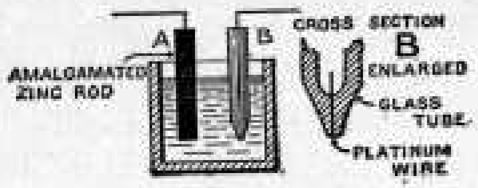

Fig. 96. Shoemaker Detector.

without any local battery or potentiometer. The electrolyte in the cup must be a 20 per cent solution of pure sulphuric acid, as nitric acid would dissolve the zinc in a very few minutes. The zinc must be kept well amalgamated with mercury.

The Shoemaker system makes use of a loop aerial, and the circuits with a single and double coil tuner are illustrated

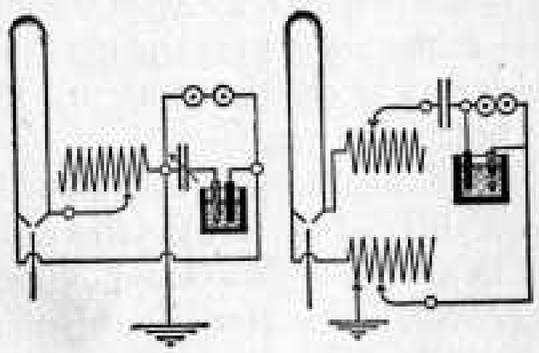

Fig. 97. Shoemaker Detector Circuits.

in Fig. 97. It is not necessary to use these, and the detector will operate just exactly as well on a "straightaway" aerial.

Lamp Detector. — All electrolytic detectors, more especially those of the "glass point" type, are subject to the

annoyance of "burn-outs." That is, the fine platinum wire melts when receiving strong signals from a near-by station.

In such case, the "bare point" must be lowered until it again makes contact with the liquid, and the "glass point" reground until the wire is again exposed.

When this trouble comes often it is very convenient to have at hand a simple detector which will not burn out and which may be substituted for the usual one when great sensitiveness is not required.

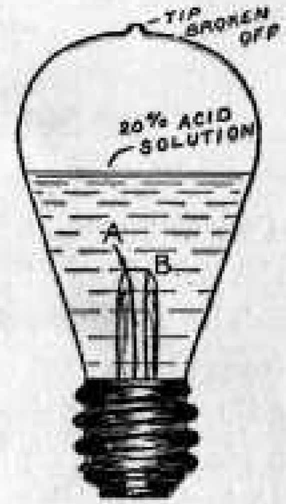

Fig. 98. Lamp Detector.

Such an instrument is made by snipping off the tip of a small incandescent electric lamp and removing the filament with a wire. One of the leading-in wires is broken off as close as possible to the glass stub and the globe half filled with a 20 per cent acid solution. The broken wire must be made the negative or cathode and connected like a Fessenden or Stone detector. This lamp detector though crude will give good service without burning out when used to receive from near-by stations.

In place of a lamp detector, a glass point having a larger wire than that of the cigar lighter may be used instead of the usual point, but it will not be so sensitive.

Fig. 99 illustrates a simple form of electrolytic detector which is not so sensitive as that shown in Fig. 100 but is still very serviceable.

The cup is made from the carbon of an old dry cell, the brass connecting cap serving very well to make the connections to. It has a recess about ½ inch in diameter and ¼ inch deep cut in the top to contain the electrolyte. The cup should be about one inch high. A file will smooth up any rough edges and give it a good appearance.

The yoke is made of a piece of $\frac{1}{8}$-inch sheet brass about $\frac{3}{4}$ inch wide, bent in the shape shown in the illustration.

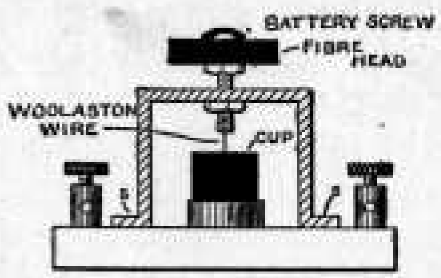

Fig. 99. Simple Electrolytic Detector.

Two small holes are drilled in the feet, to serve to fasten the yoke firmly to the base and also to make connection to.

The adjusting screw may be made from the screw taken from the carbon of an old dry cell. To permit of accurate adjustment, it should be fitted with a large head made from a piece of $\frac{1}{4}$-inch hard rubber or fiber cut in a circle about $1\frac{1}{2}$ inches in diameter. Bore a small hole about $\frac{1}{8}$ inch in diameter through the center of the head and force it on the screw. A nut screwed on the under side will then clamp it tightly against the brass head. A hole is bored in the center of the yoke and a battery nut which will fit the adjusting screw soldered directly under it.

The platinum wire may be either soldered to the adjusting screw or fastened with tinfoil in the method which has been described.

The cup and yoke are best mounted on a piece of hard rubber $\frac{1}{2}$ inch thick, 3 inches wide and 4 inches long. A binding post is placed near each of the four corners.

It is possible to do extremely fine and long distance work with the detector illustrated in Fig. 100. It is so arranged

that the "bare point" need not necessarily be revolved when making an adjustment, and so it is possible to place it in a very sensitive condition.

A brass standard, *U*, $1\frac{1}{4}$ inches long is cut from a piece of $\frac{1}{2}$-inch rod. A hole bored in the top and bottom of the standard is threaded with an 8–32 tap. A brass rod, *R*, 2 inches long is threaded with an 8–32 die throughout its entire length. One end is screwed in the top of *U*.

A piece of brass tubing, *P*, $1\frac{1}{4}$ inches long and having an internal bore of $\frac{1}{2}$ inch is slipped over *U*. A slot cut in *P* fits over a small pin set in *U* and permits *P* to be slid up and down but not to turn around.

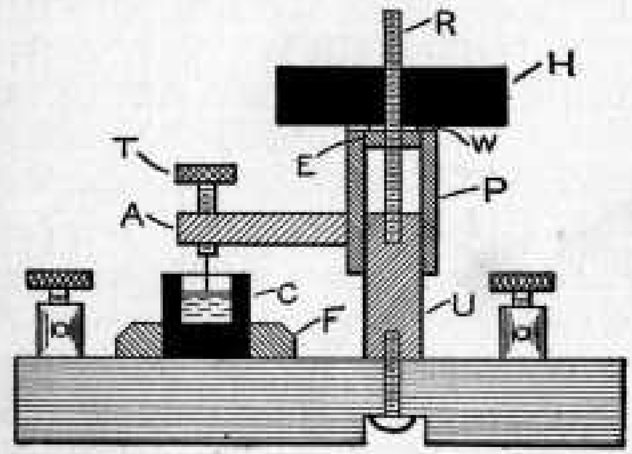

Fig. 100. Electrolytic Detector.

A head in the form of a circular brass washer, *E*, $\frac{1}{8}$ inch thick, $\frac{1}{2}$ inch in diameter and having a $\frac{5}{32}$-inch hole bored in the center is soldered in the top of the tube, *P*.

A circular piece of hard rubber, *H*, 2 inches in diameter and $\frac{1}{2}$ inch thick is fitted with a brass bushing having a hole in the center with an 8–32 thread to screw on the rod, *R*.

A spiral spring is placed around *R* between *U* and the head *E*. A small brass washer should be placed between

H and *E* in order to eliminate friction. When *H* is turned in one direction, the spring will cause *P* to rise, and when turned in the other direction it will be lowered.

A brass arm, *A*, ¼ × ¼ × 1½ inches carries a small thumb-screw, *T*, at one end, while the other end is soldered to *P* as shown in Fig. 96. The Woolaston wire is soldered to *T*.

A small carbon cup ¾ × ¾ inch serves to hold the electrolyte. A ⅛-inch hole is bored ¼ inch deep in the bottom

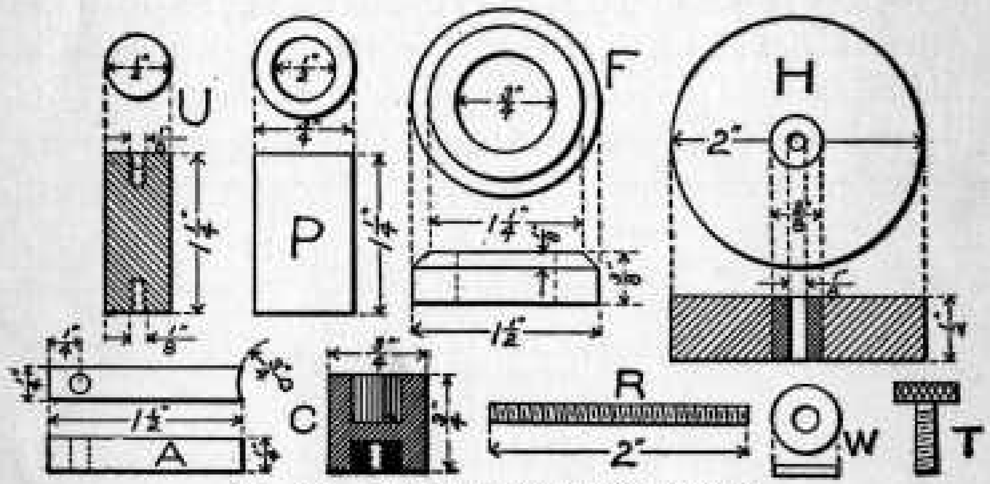

Fig. 101. Details of Electrolytic Detector.

of the cup and poured full of melted lead. The lead is then bored and tapped to fit a machine screw which fastens the cup to the base. Connection is made from a binding post to the machine screw. A second binding post is connected to the screw which fits into the bottom of *U* and holds it to the base.

If desirable a circular piece of hard wood, *F*, may be turned out and glued to the base around the cup in order to give it a more finished appearance.

The thumbscrew, *T*, is used to lower the "bare point" until it almost touches the liquid, and then the large head, *H*, is brought into play to make the finer adjustment.

Increasing the Sensitiveness of an Electrolytic Detector. — The sensitiveness of an electrolytic detector may be increased in three ways, viz., by connecting two detectors in series, by warming the electrolyte and by agitating it.

The first method is clearly apparent.

The second is accomplished by placing the detector over a sand bath and gently warming it. It will then show a marked increase in the strength of the signals at a temperature of about 30° C. This increase will continue to rise with the temperature until it reaches a maximum at about 60° C.

Branly discovered that a fine stream of gas passed through the electrolyte in order to agitate it increases the strength

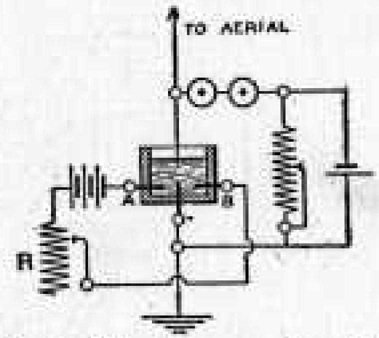

Fig. 102. Increasing the Sensitiveness of an Electrolytic Detector.

of the signals in the phones. He devised a detector provided with two extra platinum terminals sealed in the cup. When connected in series with a battery and an adjustable resistance, these terminals cause electrolysis of the water, and a fine stream of oxygen and hydrogen gas flows through the acid electrolyte. The stream of gas agitates the liquid just sufficiently so that when oscillations strike the detector they augment the breaking down of the film of gas which collects on the fine platinum point. This results in an increase in the battery current flowing through the telephone receivers of from two to four times and a corresponding increase in the volume of sound. The adjustable resistance is used to regulate the decomposition of the electrolyte and formation of gas, for if this proceeds too rapidly an undesirable rumbling noise will be produced in the telephone receivers.

Tantalum Detector.

The tantalum detector is especially suitable for the amateur experimenter because its change in resistance when struck by oscillations is so great that high resistance telephone receivers are not necessary. Its normal resistance is about 1000–2000 ohms, and this sometimes drops as low

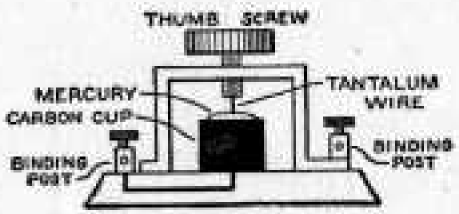

Fig. 103. Tantalum Detector.

as 125–100 ohms when struck by oscillations of ordinary strength. It is not nearly so sensitive as the electrolytic or crystal detectors, but gives very much louder tones in the telephone receivers when used for short distance work.

The detector is easily made by substituting a piece of tantalum wire for the Woolaston wire of an ordinary electrolytic detector. The dilute acid solution is removed from the cup and replaced by some pure mercury. The connections remain the same as for the "bare point." The potentiometer is adjusted until the potential of the battery is in the neighborhood of 0.2–0.4 volt.

The tantalum wire may be easily secured by breaking the globe of a tantalum lamp and using a piece of the filament. It is best to snip off the lamp tip before breaking the globe. This precaution admits the air and prevents an explosion which would shatter the glass and scatter the filament in fragments.

If the universal detector is used with a tantalum point, turn the small thumbscrew until the wire almost touches the surface of the mercury. Then lower it with the large adjusting screw until the tantalum touches the surface and a sharp click is heard in the telephone receivers. Adjust the potentiometer until the signals are the loudest.

Crystal Detectors.

Certain minerals and crystals, principally members of the carbon and sulphur groups, possess the peculiar property of rectifying electrical oscillations and converting them into a pulsating direct current. These crystals conduct the current better in one direction than in the other. In the case of a current having a potential of ten volts and applied to the ends of a carborundum crystal, the current may be one hundred times greater when flowing in one direction than when flowing in the other. This ratio decreases as the voltage is raised, for with 25 volts it may be only about forty times greater. The crystals when properly inserted in the aerial circuit are enabled to rectify the oscillations and produce sounds in the telephone receivers without the aid of a battery.

The following is a partial list of the minerals and crystals exhibiting these properties to a sufficient extent that they are of value as oscillation detectors in wireless telegraphy.

Common and Chemical Names.		Formula.
Carborundum	Silicon Carbide	SiC
Fused Silicon	Silicon	Si
Iron Pyrites	Iron Sulphide	FeS_2
Copper Pyrites	Copper Sulphide	$FeCuS_2$
Chalcopyrites	Copper Iron Sulphide	$Cu_2SFe_2S_3$
Hessite	Telluride of Silver and Gold	
Zincite	Zinc Oxide	ZnO
Octahedrite	Oxide of Titanium	TiO
Stibnite	Antimony Sulphide	Sb_2S_3
Galena	Lead Sulphide	PbS
Molybdenite	Molybdenum Sulphide	MoS
Zirconium	Zirconium	Zr
Niccolite	Nickel Arsenide	NiAs
Domeykite	Copper Arsenide	Cu_3As_2

In the case of iron pyrites the writer has found that a specimen of this mineral containing very little or no copper as an impurity does not exhibit these properties to an appreciable extent.

In order to use the universal detector for minerals, a special contact similar to that shown in Fig. 90 must be

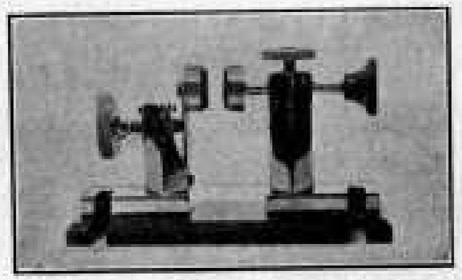

Fig. 104. United Wireless Carborundum Detector (horizontal type).

made. The contact is bored and threaded on its under side to fit a brass pin $\frac{3}{4}$ inch long and having an 8–32 thread. The other end of the pin screws into the hole in the bed-plate. The large knurled portion of the contact permits

it to be raised or lowered without the fingers coming in contact with the crystal. The crystal is clamped between the contact and the spring, *S*. The position is varied until a sensitive spot is found and then the pressure is carefully regulated by means of the large adjusting screw until the signals in the telephone receivers are the loudest. If possible avoid touching the crystals with the fingers, as the oil and dirt, even though it cannot always be seen, spoils their value for long distance work. Use instead a pair of steel forceps.

The United Wireless Telegraph Co. makes use of carborundum in the detectors shown in Figs. 104 and 105. The principal advantage of carborundum over such substances as silicon, etc., is that it is not affected by the heavy discharge

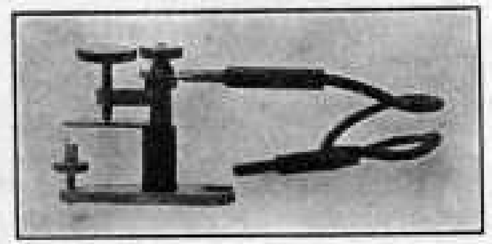

Fig. 105. United Wireless Carborundum Detector (vertical type).

of the transmitting apparatus and does not require a new adjustment after each period of sending. All the crystals will not work, and so a large cake should be purchased and the desired crystals selected. The dark blue portions of the mass, which are the hardest, will give the clearest tones in the telephone receivers, and are preferable to the lighter colored crystals. Since the crystals conduct better in one direction than in the other, as explained above, the adjustment must be made with the view of determining in which position the particular crystal will work the best.

Carborundum will produce sounds in the telephone receivers without the aid of any battery, but for careful work a battery and a potentiometer are necessary.

The other crystals given in the column merely require that the telephone receivers be connected to the detector terminals as in the wiring diagram in Fig. 108.

The Clapp-Eastham detector makes use of a crystal of iron pyrites held in a brass retaining cup beneath the metal contact point. It is not affected by strong signals and requires no battery or potentiometer. When adjusted it will remain in a sensitive condition for a long time without further attention.

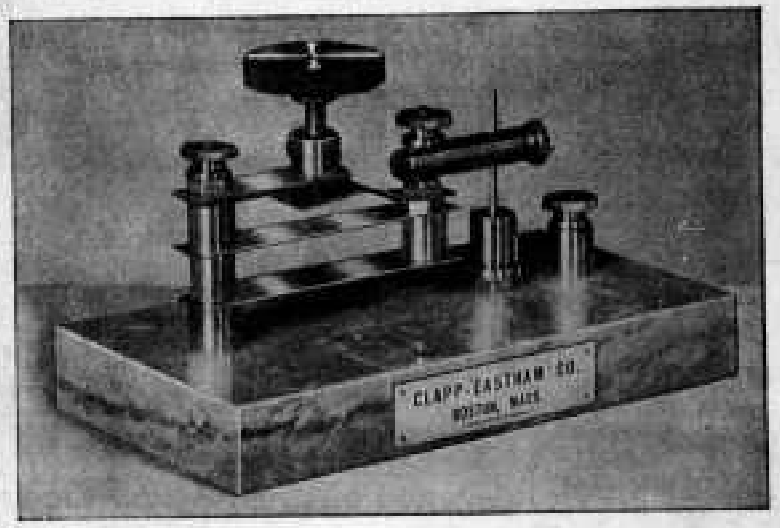

Fig. 106. Clapp-Eastham Ferron Detector.

Silicon Detector. — While the silicon and "perikon" detectors are classed as mineral or crystal detectors they deserve special attention.

Silicon gives fair results if a crystal is placed between two metal electrodes as, for instance, between the contact and spring of the "universal" detector, but is much more sensi-

tive when properly mounted. A brass cup such as that shown in Fig. 90 is made and the interior brightened by scraping with a file. The cup is then poured full of a molten fusible alloy and the silicon pressed in it until it cools and becomes set. It should then present an appearance similar

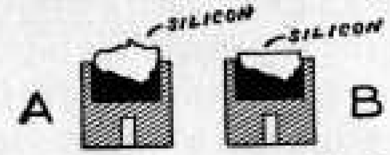

Fig. 107. Silicon Crystal in Cup.

to that shown by *A* in Fig. 107. The silicon is ground down by rubbing on the surface of a clean oilstone kept well wet with water, until the surface is flat and shows a polish.

The cup containing the silicon is placed over the hole in the bedplate of the universal detector. A knurled brass thumbscrew having a point on its lower end is screwed into

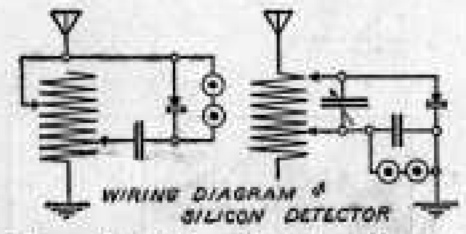

Fig. 108. Silicon Detector Circuits.

the collar on the spring, *S*, and brought to bear on the polished surface of the silicon. The pressure may be easily regulated by means of the large adjusting screw until the signals in the telephone receivers are the loudest. It is not advisable to fasten the cup to the bedplate but merely to brighten the bottom so as to insure a good contact. The cup may then be moved around so that different portions of the polished surface of the silicon may be brought into play when desirable.

If the knurled brass thumbscrew is fitted with a platinum point which can be brought to bear on the surface of the silicon, the efficiency of the detector will be materially increased.

When mounting silicon or other crystals some careless experimenters use lead or a metal having a high melting point instead of a fusible alloy. This is poor policy because the high temperature coats the surface of the crystals and the interior of the cup with a non-conducting layer which destroys the sensitiveness and makes it unfit for long distance work. A fusible alloy melting at about the boiling point of water or even lower should be used. Such alloys are usually composed of tin, lead and bismuth. The addition of a little cadmium serves to make the fusing point considerably lower in each case. The alloys may be prepared by the experimenter from the following formulæ, or are obtainable from a firm manufacturing fire plugs for automatic fire extinguishers.

Bismuth.	Lead.	Tin.	Cadmium.	Fusing Point.
8	5	3	....	201° F.
5	3	2	....	197 F.
5	3	2	1	167 F.
5	5	5	4	150 F.
4	2	1	1	138 F.

The lead should be melted first and then the bismuth, tin and cadmium added in the order named.

Perikon Detector. — The Perikon detector is one of the latest types to come into extensive use. It consists of two

crystals, zincite and chalcopyrites,* set in cups in the manner just described and placed in contact with each other. The minerals are mounted similar to those in Fig. 105. The zincite should present a rather flat surface with the grain of the crystal parallel to the sides of the cup so that the top surface corresponds to the end of a stick of wood sawed at right angles to the grain. More than one crystal of zincite is usually set in the same cup. The chalcopyrites should present a rather blunt point. The cup containing the chalcopyrites is the smaller and is bored and threaded to fit a thumbscrew which passes through the collar in the spring, *S*, of the "universal" detector. The bottom of the cup containing the zincite is brightened so as to insure a good contact and then placed on the bed plated under the cup containing the chalcopyrites which is fastened to the thumbscrew. The zincite may then be moved around until the

Fig. 109. Perikon Detector Elements.

most sensitive portion is found. The chalcopyrites is lowered until it comes into contact with the zincite and then the pressure regulated by means of the large adjusting screw.

The Perikon detector gives excellent results without a battery and is preferably used in that manner. If a battery is used, a potentiometer to lower the voltage is necessary.

When adjusting this or the carborundum detector where

* Peacock ore or bornite, which consists of about 60 parts of copper, 14 parts of iron and 26 parts of sulphur, may be substituted for the chalcopyrites with excellent results.

a battery is used, the pressure must be very carefully regulated until it is found to be the best. When the pressure is light the signals in the phones are due to an imperfect contact, and when it is slightly increased the rectifying properties of the crystal are brought into play.

The Perikon detector illustrated in Fig. 110 is somewhat similar to that used for commercial work.

The standards or posts supporting the cups which contain the elements are brass rods ½ inch square and 1½ inches high. A hole is bored in the bottom of each and threaded with an 8–32 tap to receive a machine screw which passes through the base and holds them in an upright position. A hole is bored 1¼ inches from the bottom, in the face of one standard and threaded with an 8–32 tap. A brass rod 1¼ inches long, carrying at one end a cup 1 inch in diameter and ⅜ inch deep, is threaded to fit in the hole in the standard. The zincite is mounted in this cup.

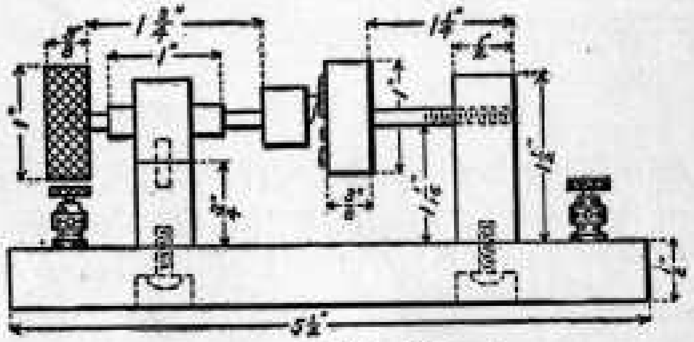

Fig. 110. Perikon Detector.

The other standard is cut in half with a hack saw and a ⅛-inch hole bored ¼ inch deep in the axis of each piece. A pin, ½ inch long, is set in the lower half by soldering it in the hole. The upper half of the standard is placed over the pin and left free to move when twisted. A ⅛-inch brass tube,

1 inch long, passes through the upper part of the standard. A ⅛-inch brass rod, 1¾ inches long, passes through the tube.

The small cup containing the zincite is mounted on one end of the rod and a hard rubber handle on the other.

A brass spring is placed between the cup and the standard in order to press the chalcopyrites against the zincite. The cup is mounted out of center so that by revolving it and twisting the standard at the same time the chalcopyrites may be brought into contact with any portion of the zincite. By screwing the rod supporting the zincite cup in or out of the standard the pressure with which the two elements are pressed together may be regulated.

The base of the detector is hard rubber of the dimensions indicated in the illustration. Four binding posts on each corner of the base are necessary. The detector is connected in a similar manner to the silicon detector shown in Fig. 108. If a battery is used the circuit should be like that of the "bare point" electrolytic, and the current must flow from the zincite to the chalcopyrites.

Lead Peroxide Detector.

The peroxide of lead detector makes use of no liquids, but still may be classed as an electrolytic since its action is of that nature.

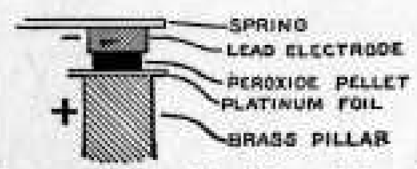

Fig. 111. Peroxide of Lead Detector.

It consists of a pellet of lead peroxide held between an electrode of lead and one of platinum. Contrary to most other detectors, the resistance is increased upon the passage of electrical oscillations. The oscillations stimulate chemical action and increase a counter-electromotive force sufficiently so that a decrease in the current sent through the phones by the local battery takes place. The action may be outlined more in detail as follows. The current of the local battery decomposes part of the lead peroxide into its components, lead and oxygen. The lead irons are positively electrified and so they tend to pass upward toward the lead electrode which is negative. The negative ions of oxygen gas tend to pass downwards towards the platinum. But the lead and platinum electrodes with the intervening lead peroxide constitute a small cell acting independently of the local battery and sending a current in the opposite direction. This counter-electromotive force tends to send the ions in an opposite direction to that in which they are sent by the battery current. Upon the passage of electrical oscillations this counter electromotive force is increased and sufficient ions sent out in opposition to those of the battery current so that an appreciable drop in the current flowing through the telephone receivers takes place. The sudden current drop produces a sound in the receivers.

The lead pellets may be secured from a druggist who can mold them in his tablet press. They should be subjected to as great a pressure as possible in order to reduce resistance and prevent crumbling.

A piece of platinum foil about ½ inch square is placed beneath the pellet on the crystal electrode. A piece of clean, bright sheet lead ⅜ inch in diameter and ⅛ inch thick is laid on the pellet and the whole clamped together by tightening the thumbscrew passing through the collar on the spring, *S*. The detector is connected up similar to the "bare point." The platinum is made the positive of

the local battery. Adjustment is secured by regulating the pressure.

It is very necessary that the pellets be kept dry, as otherwise a loud singing and hissing noise, due to the decomposition of the water, will render the reception of signals very difficult.

The Marconi Magnetic Detector.

When an oscillatory discharge takes place through a coil of wire surrounding a needle, it magnetizes the needle in a totally different manner from a voltaic current. The needle will have several poles throughout its length, many of them reversed. Rutherford applied this phenomenon to the detection of electrical oscillations, but it remained for Marconi to improve it and give the magnetic detector its existing form. This type of detector is very sensitive, free

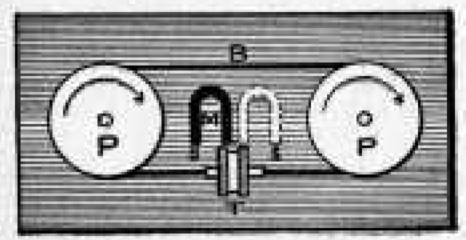

Fig. 112. Marconi Magnetic Detector.

from all adjustment and is not made inoperative by the heavy discharge of the transmitter during each period of sending.

A small transformer is provided with a core composed of a band or cord of iron wires in the form of an endless belt which passes around two pulleys kept in motion by a clockwork motor. The band revolves in the field of a strong horseshoe magnet and passes directly over the poles after issuing from the transformer bobbin, so that the portion approaching the bobbin are constantly in a state of increasing magnetism. The actual operation is based upon the property of iron called hysteresis, for the magnetism of the core lags behind that of the permanent magnet and is of a different degree from what it ought to be, in view of its position in the vicinity of the permanent magnet. The moment the oscillations pass through the primary coil of the transformer, this lag is set free and the magnetism assumes its full value. The change in magnetism induces a current in the secondary, which registers as a sound in the telephone receivers.

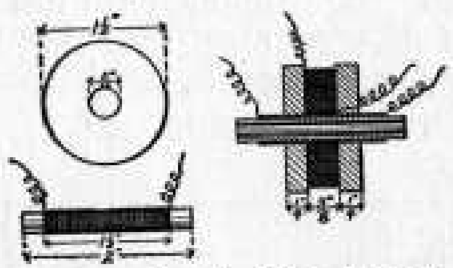

Fig. 113. Details of Transformer.

The primary coil is made up of a single layer of No. 36 B. S. gauge silk covered wire wound on a thin walled glass or hard rubber tube. The ends of the tube, which is 2 inches long and ¼ inch external diameter, are slightly flared so as not to chafe the band. The primary is thoroughly shellacked and covered with a single layer of paper.

The secondary is also of No. 36 B. S. silk covered wire and is wound between two disks of hard rubber, ¼ inch thick and 1½ inches in diameter, placed ⅜ inch apart in the center of the secondary and the intervening space wound full of wire.

The terminals of both the primary and secondary are

extended to binding posts mounted on the case of the instrument.

The core or revolving band is made by winding 100 strands of No. 36 silk covered soft iron wire between two small pegs, placed a distance apart, equal to twice the

Fig. 114. Method of Joining Ends of Band.

circumference of the oval formed by the two pulleys. The wire is all wound in the same direction. It should be carefully removed from the pegs and kept taut while it is slightly twisted, doubled, and then further twisted into a rope or cord. The ends are threaded together with a separate piece of insulated wire, into a link which will pass easily through the primary tube.

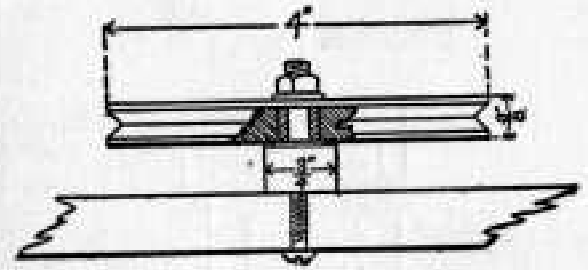

Fig. 115. Pulley.

The pulleys around which the band revolves are made of hard wood. They are 4 inches in diameter and ⅜ inch thick and have a V-shaped groove cut in the edge. In order to minimize friction and wear, it is advisable to fit them with a bearing which may be made out of brass tubing and a couple of washers. One of the pulleys is geared to a clock-work motor so that the band makes a complete revolution about once every two minutes. An old eight day clock may be adapted for this purpose, or, what is much better, the motor from an old phonograph.

The horseshoe magnet is mounted with its north pole pointing towards and nearly touching the middle of the

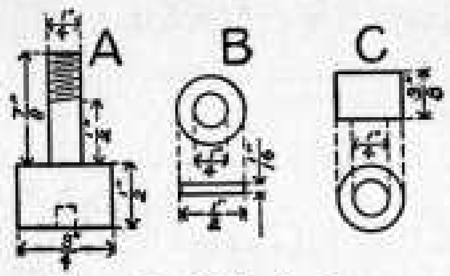

Fig. 116. Pulley Bearings.

outside of the secondary. The south pole is placed opposite the end of the primary tube which is on the side towards which the band is revolving, that is, the band in revolving passes first over the north pole and then over the south. Two magnets are sometimes used with their north poles

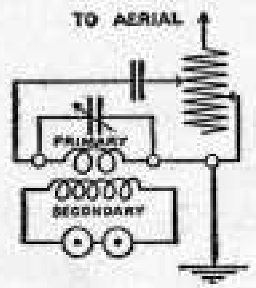

Fig. 117. Circuit of Magnetic Detector.

together in the center of the secondary, and a south pole opposite each end of the primary tube.

The commercial instrument is placed in a glass covered case which protects it from dust and injury. The clockwork motor is concealed in the lower part of the case. This is a good plan but an experimental detector may be merely mounted on a flat wooden base as illustrated in Fig. 112.

The secondary terminals are connected directly to the telephone receivers while the primary leads to the aerial and the ground. When the detector is started up it should make a very slight hissing sound in the telephone receivers as the band passes slowly through the coils. This shows the instrument to be in good working order and ready for the reception of signals.

The Audion. — Dr. Lee DeForest was led by the flickering of a sensitive gas flame to investigate whether or not it would respond to Hertzian vibrations as well as to those of heat and sound. His experiments led to the invention of the audion, a peculiar instrument making use of ionized gas for its operation.

The audion consists of an incandescent lamp having a metallic filament, on either side of which are a grid and a plate made of nickel. When the filament is lighted it throws off ions which act as a relay to high frequency oscillations passing between the plate and the grid. A properly constructed audion is exceedingly sensitive and produces very loud tones in the telephone receivers. It has the further advantages of entire absence of adjustment except the governing of the battery voltage, and is capable of extremely fine tuning.

Fleming originated the oscillation valve illustrated in Fig. 118. It consists of an ordinary incandescent lamp with a carbon filament, having a metal cylinder, *C*, placed around the filament, but attached to an independently insulated platinum wire sealed in the glass. When the lamp is lighted by passing a current through the filament, the incandescent carbon liberates negative ions. If oscillations are then set up in a circuit which includes a pair of sensitive telephone receivers and is formed by connecting the negative terminal of the filament with the platinum cylinder, negative electricity will be enabled to pass from the filament to the cylinder but not in the opposite direction,

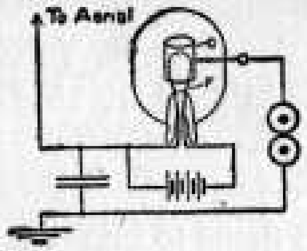

Fig. 118. Fleming Oscillation Valve.

and so sounds will be produced in the telephone receivers. High frequency oscillations themselves could not be made to pass through the telephone receivers because of the choking action of the iron cores of the electromagnets.

The simple but sensitive form of detector illustrated in

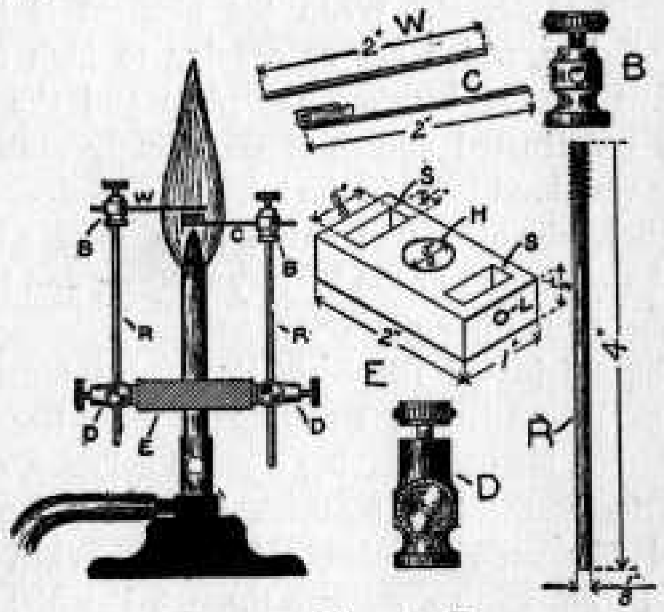

Fig. 119. Flame Audion.

Fig. 119 is not of practical value for commercial work, but is very interesting as the progenitor of the audion, and

provides a good field for amateur investigation. Its only drawback is that the gas flame is very difficult to keep steady and every flicker registers as a sound in the telephone receivers.

A Bunsen burner using coal gas furnishes the flame, and a salt of an alkaline metal heated in the flame, the ions. The hydroxides of cæsium, potassium and sodium give the best results in the order named.

The salt is contained in a piece of trough-shaped platinum foil, about $\frac{3}{8}$ inch long and $\frac{1}{16}$ inch wide. This trough is made the cathode or negative of the telephone circuit and placed in the outer oxidizing flame just above its juncture with the interior reducing flame and must be kept incandescent. The upper electrode or anode is a piece of platinum wire about $\frac{1}{16}$ inch above the trough.

The arrangement and construction of the detector is clearly indicated by the drawing so that it is unnecessary to go into details. The block, *E*, which fits on the tube of the Bunsen burner, is made of fiber. Two double binding

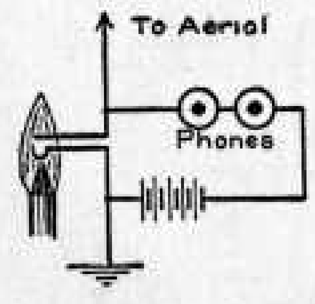

Fig. 120. Circuit of Flame Audion.

posts, *D*, are fastened to *E* to support the rods, *R*, which are fitted at the tops with binding posts, *B*, into which the electrodes may be clamped.

Twelve dry cells are connected with a multiple point switch so that an electromotive force of 6–18 volts, varying in steps of one cell at a time, may be secured. The flame is best provided with a mica chimney to protect it from drafts. By keeping plenty of salt in the trough and carefully adjusting the voltage, this detector may be made marvelously sensitive.

CHAPTER XIV.

TUNING COILS AND TRANSFORMERS.

A TUNING coil is merely a variable inductance wound in single layer on a suitable form.

Fig. 121 illustrates a double slide tuner. The base is a piece of hard wood, 12 inches long, 1 inch thick and $5\frac{1}{2}$ inches wide. Two wooden heads $4 \times 4 \times \frac{3}{4}$ inches support the form upon which the coil is wound.

The form is a piece of wooden curtain pole, 9 inches long and 3 inches in diameter. Some may prefer to use a cardboard tube in place of the curtain pole. A tube can be made by winding a long strip of cardboard 9 inches wide around a suitable form and cementing the layers together with shellac. The liberal use of shellac will stiffen the tube

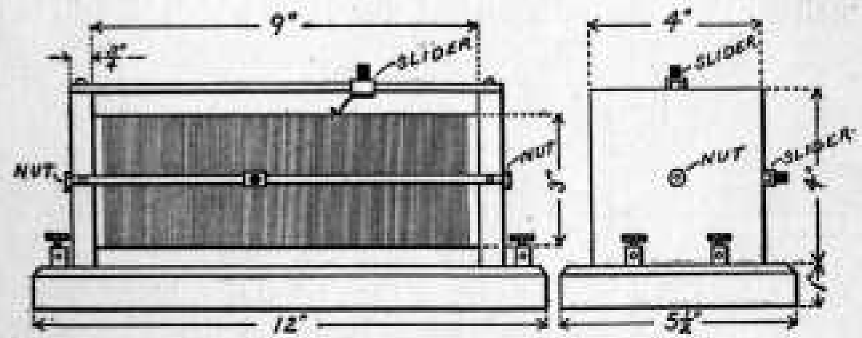

Fig. 121. Double-slide Tuning Coil.

and cause it to better retain its shape. The tube is held tightly between the two heads by means of a brass rod which passes through the center and is clamped by two nuts.

A square brass rod $10\frac{1}{2}$ inches long is fastened to the cen-