WIRELESS COMPONENT PARTS

AND HOW TO MAKE THEM

EDITED BY

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WITH OVER TWO HUNDRED ILLUSTRATIONS

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PREFACE.

In this, the first volume of the "Amateur Wireless" Series of Handbooks which in style and editorship will be closely allied to the famous "Work" Handbooks issued by the same publishers, detailed instructions are given on the making of the various components forming part of many kinds of wireless receiving apparatus. It is not the object of this book to describe the making of any one complete receiving set—that subject is covered in the "Work" Handbook "Wireless Telegraphy and Telephony: How to Make the Apparatus"—but all the parts likely to be required in any set are here illustrated, and their practical making or building explained in detail.

This Handbook has many authors inasmuch as it has been compiled from the columns of "Amateur Wireless" (weekly; price 3d.), the well-known journal for all amateurs interested in wireless telegraphy and telephony from any and every point of view.

Should the reader be in difficulty with regard to any matter dealt with in this book, or to any other subject within the scope of the weekly journal mentioned, he should send a query to "Amateur Wireless," La Belle Sauvage, London, E.C.4, *but should take particular care to accompany his query with a stamped and addressed envelope and a coupon from the current issue of that journal.*

THE EDITOR.

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WIRELESS COMPONENT PARTS

And How To Make Them

CHAPTER I

Components and their Varied Purposes

While later chapters will explain in detail how to make a variety of parts used in the assembling of both crystal and valve receivers, it is thought desirable that this first chapter should be of an introductory nature. Consequently it has been devoted to brief explanations of what the chief component parts of wireless receivers are, these explanations, given in the form of question and answer, being accompanied by miniature illustrations, by means of which the reader can easily identify the parts in question.

What Purpose does the Aerial Serve ?—It serves as a collector of the electro-magnetic waves necessary to operate the receiver. It is usually placed as high above the ground as possible, and is carefully insulated so that all the received energy will pass to the apparatus.

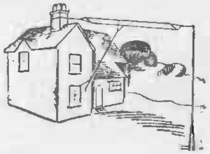


Fig. 1.—An Aerial

What is a Frame Aerial ?—One in which the wire composing the aerial is wound on a frame. Chief advantages: Portability and freedom from jamming by reason of its directional properties. Signals will be received only from those directions in which opposite sides of the frame are facing.

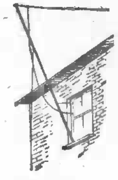


Fig. 2.—Lead-in

What is the Lead-in ?—It is a wire conductor connecting the aerial proper and the aerial terminal of the receiver. As its name implies, it "leads in" the oscillating currents from the aerial.

Why is a Tuner Necessary ?—In order to receive signals from a given transmitting station the receiver must be adjusted to the wavelength of the transmitter. This adjustment, or tuning, is effected by varying the amount of inductance and capacity in the receiver circuits. The values of inductance within the receiver will depend on the size of the inductance coil, the number of its turns included in the circuit, and the amount of capacity (in the form of a variable condenser) in series or parallel with the coil. A fixed inductance coil, that is, one in which the number of turns is not variable, will only tune to wavelengths allowed for by variations in the capacity of the condenser. A loose-coupler is employed where two tuning circuits, aerial and closed, are used for the purposes of reducing jamming. The two circuits are wound on separate cylindrical formers, one of which slides within the other, thus allowing for differences in the percentage of coupling.

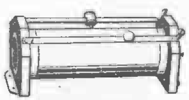


Fig. 3.—Slider Tuning Coil

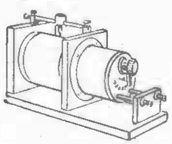


Fig. 4.—Loose-coupler

The three-coil tuner contains mountings for three coils, one in the aerial circuit, one in the closed circuit, the third one being the reaction coil. Coupling between the circuits is effected by varying the distances between the coils, which are of the pile-wound type.

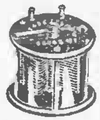


Fig. 5.—Variable Condenser

What is the Purpose of a Variable Condenser ?—It is employed in circuits, usually in conjunction with a coil possessing inductance, to enable the wavelength of that circuit to be varied within fine limits.

Why is a Telephone Condenser Used ?—To store signal currents from a detector and discharge them through the telephone. It also acts as a by-pass for high-frequency currents flowing in the plate circuit of a valve, which might otherwise be damped out by the impedance of the telephone windings.

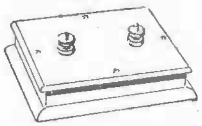


Fig. 6.—Telephone Condenser

Why and When is a Crystal Detector Used ?—Usually in commercial services where an expert operator is not employed, or where great strength of signals is not required. It is now used extensively as a detector in broadcast receivers for use within a short distance of a broadcasting station. The crystal detector may be used for rectification in conjunction with valve amplifiers.

What are Telephones ?—Instruments employed for converting electrical variations into sound waves of audible frequency. They usually consist of coils of fine wire wound round a magnet, in front of which is mounted

Fig. 7.—Telephones

a diaphragm. Electric impulses through the coils impart a movement to the diaphragm by magnetic attraction, thus setting up sound waves which affect the human ear.

What is a Buzzer and Why Used ?—This consists of a coil of wire round a soft-iron core, near which is placed a steel reed or armature. Currents flowing in the coil from a small battery magnetise the core and attract the armature, which automatically breaks the circuit, allowing the armature to return to its normal position. This action again closes the circuit, and once more the armature is attracted, and the vibratory action continues as long as the battery is connected in the circuit. The vibration of the armature sets up sound waves which are heard as a musical note. In wireless it is chiefly used for testing crystal detectors, the buzzer being allowed to function while the crystal set is being adjusted. When the buzzer sounds at its loudest in the phones the most sensitive spot in the crystal has been found, from which best reception is obtained. The buzzer can also be used for testing circuits.

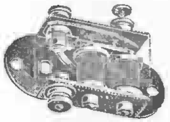


Fig. 8. — Buzzer

What is a Valve ?—The valve is a vacuum tube or bulb of glass containing a filament, grid, and plate. The grid is usually a wire spiral surrounding the filament, and the plate consists of a metal cylinder surrounding both filament and grid, neither component touching the other. For detecting purposes the tuner is connected to grid and filament; and the telephone or plate circuit, which contains the telephones and

high-tension battery, is joined to the plate and filament of the valve. An accumulator of four or six volts is connected to the filament in order that the latter may be made hot. When the filament is glowing it throws off particles of negative electricity (electrons) which are attracted by the plate, this being at a positive potential by reason of its connection to the positive pole of the high-tension battery. This flow of electrons between filament and plate constitutes a conducting path for currents from the high-tension battery, which currents pass through the telephones and impart a movement to the diaphragm when the current starts and stops. Incoming oscillations, which take the form of a wave, of which the upper half is positive and the lower negative, come on to the grid from the tuning circuits. The positive half of a wave charges the grid positively and thus assists the plate in its attraction of electrons from the filament, consequently a current flows in the plate circuit. The negative half of a wave charges the grid negatively, which means that the electrons, or negative particles of electricity, are repelled from the grid, on the principle that "like repels like," and thus no electrons are able to make their way to the plate. Under these conditions no current flows in the telephone circuit. Thus, at each half wave a passage of current from the high-tension battery produces a click in the telephone, and as these occur in rapid succession, sound waves are set up.

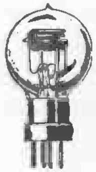


Fig. 9.—Typical Valve

What is a Filament Resistance ?— A device placed in series with a valve filament and its accumulator to limit the amount of current supplied to the valve. The brilliancy of the valve filament may thus be adjusted, and its best heat for good reception easily obtained. It consists usually of a spiral of resistance wire having a resistance value of between 5 and 10 ohms, according to the number of valves in use. The filament resistance is made variable by means of a slider which passes over the spiral.

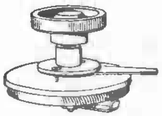


Fig. 10.—Variable Filament Resistance

What is the Use of a Grid Condenser ?—To prevent the flow of direct currents to the grid, and to enable the latter to be kept at a steady potential in respect of the filament.

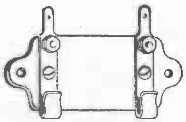


Fig. 11.—Grid Condenser

What does the Grid Leak Do ?—Placed in shunt across the grid condenser it provides a path or leak whereby the electrons which collect on the condenser from the grid may return to the filament. Without this leak the accumulation of electrons on the condenser would interfere with reception.

Fig. 12.—Grid Leak

How is a Valve Used for Amplification ?—A previous paragraph explains how extremely feeble aerial currents may be made to liberate much stronger currents in the plate circuit of the valve. If these new and stronger currents are led to the grid of a second valve, still stronger currents will be produced in the second plate circuit. These in turn may be led to the grid of a third valve, or passed through a pair of telephones.

What is a Telephone Transformer ?—An instrument consisting of primary and secondary windings of very fine wire, wound on a core of iron wires or plates. The primary usually contains more turns than the secondary. It is used with low-resistance telephones, and obviates the risk of damage to telephone windings by the direct passage of current from the high-tension battery.

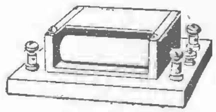


Fig. 13. — Telephone Transformer

What is a Low-tension Battery and Why Used ?— It is usually a secondary battery, or accumulator, and is connected to valve filaments in order to maintain them in the state of incandescence necessary for the liberation of electrons, which in turn enables the valve to function as a rectifier or amplifier.

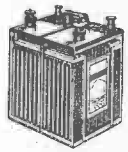


Fig. 14.—Low-tension Battery or Accumulator

What is a High-tension Battery and Why Used ?—It consists of a number of small primary dry cells (or it may be of wet cells or secondary cells) connected in series to give a pressure of between 45 and 80 volts, depending on the type of valve used. Placed in the plate circuit of a valve, it maintains the plate at positive potential and forms a source of supply for the operation of the telephones or subsequent valves.

What is the Use of an Earth ?—The earth may be regarded as an electrical reservoir into and out of which the received oscillations may flow as they oscillate in the aerial circuit.

Why is a Variometer Used ?—It is sometimes used as a tuner in place of the more equal inductance coil and variable condenser. It consists of two coils, an end of one being connected to one end of the other, the two free ends being connected in the same manner as an inductance coil. The two coils are wound on separate formers, one of which is made to rotate within the other through an arc of 180 degrees. Movement of the coils in relation to each other produces changes in the inductance and capacity of the circuit and thus alters the wavelength The variometer may also be used in the plate circuit of a detector valve to tune that circuit to the wavelength of the aerial oscillations, for purposes of reaction.

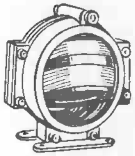


Fig. 15.—Variometer

What is the Purpose of a Vario-coupler? — A piece of apparatus employed for indirect magnetic coupling of two circuits. In construction it is usually similar to the variometer described above, except that the two windings are kept separate, each winding being part of a distinct circuit. Variation of the position of the coils produces changes in the strength of the coupling between the circuits.

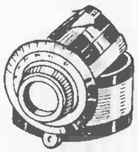


Fig. 16.—Vario-coupler

What is a Loud-Speaker?—This may consist of a telephone earpiece with its diaphragm placed very near the small end of a horn of conical or similar shape. The best loud-speakers are much more than adapted earpieces. The acoustic properties of the horn amplify the sound emitted.

Fig. 17.—Loud-speaker

What is the Purpose of a Potentiometer?—When used in conjunction with a small battery in crystal circuits, it is for the purpose of placing the correct potential across the crystal to enable it to rectify efficiently. Carborundum is about the only crystal which needs a potentiometer. It is also used in valve circuits to control the potential of the grids with respect to the filament. It consists of a coil of fine resistance wire on a former, which may be made variable by means of a slider. Usual resistance value is 300—500 ohms.

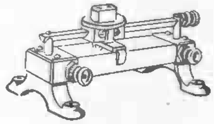


Fig. 18.—Potentiometer

What are Basket Coils? — Coils which, in appearance, resemble the bottom of a wicker basket. The wire is wound in and out between spokes set in the periphery of a small round object such as cork.

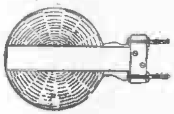


Fig. 19.—Basket Coil

What are Slab Coils?—Flat coils with the turns unspaced. They are wound on a centre core between two flat pieces of wood about $\frac{1}{8}$ in. apart, or more for larger coils. The self-capacity of these coils renders them inefficient on the shorter wavelengths.

What are Honeycomb Coils?—Coils of low self-capacity wound between two circular sets of spokes about $\frac{1}{2}$ in. apart. The finished coil has cavities between the layers which resemble the spaces in a honeycomb.

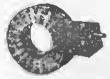


Fig. 20.—Honeycomb Coil

What are Duolateral Coils?—Coils similar in appearance to honeycomb coils, there being a slight difference in the method of winding.

What are Reactance Coils?—The coil used in the plate circuit of a detector valve, and usually magnetically coupled to the aerial or closed circuit of the receiver, is called the reactance coil. By its aid the stronger currents flowing in the plate circuit of the valve are made to react on the incoming oscillations in the aerial circuits. These two sets of oscillation currents are exactly in step, and provided the coupling between the reactance coil and the aerial or closed circuit is sufficiently close, the plate currents will be superimposed on the incoming oscillations and will pass with them through the valve, producing still stronger current variations in the plate circuit. In this way a single valve may be operated as a detector and reaction amplifier.

What is a Low-frequency Amplifier?—A device which magnifies signals received by the detector. The currents which would normally be passed through the telephones are led to the primary of a low-frequency iron-cored transformer, which has more turns in the secondary than the primary. Thus an increased voltage is delivered by the secondary winding to the grid circuit of a valve. This increased voltage liberates stronger currents in the plate circuit of the valve, and these stronger currents may be led through another transformer to the grid of a second valve, resulting in still further amplification in its plate circuit.

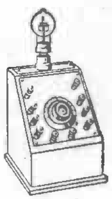


Fig. 21.—Low-frequency Amplifier

What is a High-frequency Amplifier?—One in which the incoming oscillations are magnified before

being passed to the detector for rectification. Amplification may be obtained in several ways, usually by means of air-core transformers between the valves, each transformer being tuned to the wavelength it is desired to receive.

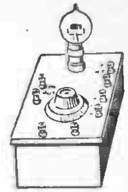


Fig. 22.—High-frequency Amplifier

What is a Low-frequency Transformer?—As just described, it consists of primary and secondary windings of very fine wire wound on a core of iron wires or plates. It is of the step-up variety, that is, the secondary has more turns than the primary, the ratio usually between three and five to one.

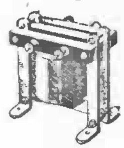


Fig. 23.—Low-frequency Transformer

Why is a High-frequency Transformer Used?—This is the coupling device used between successive valves in a high-frequency amplifier. It consists of primary and secondary windings wound close together on a core of non-conducting material. The primary winding is placed in the plate circuit and is shunted by a small variable condenser. Plate currents oscillate in this winding, and are tuned to the wavelength of the aerial circuit by means of the condenser across the primary. These stronger currents are transferred to the secondary winding and thence to the grid of a second valve, and these in turn liberate still stronger currents in the plate circuit of the second valve. By this means considerable amplification of the original currents is obtained.

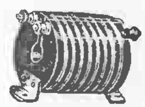


Fig. 24.—High-frequency Transformer

CHAPTER II

Crystal Detectors

MANY types of crystal detectors are shown diagrammatically in Figs. 25 to 32, and from the diagrams it will be apparent that any device which admits of adjustment to the contact pressure, and at the same time allows the crystal to be "searched" for sensitivity, will serve the purpose. Nearly every efficient type of detector is dealt with in this chapter; for convenience a simple type and methods of mounting

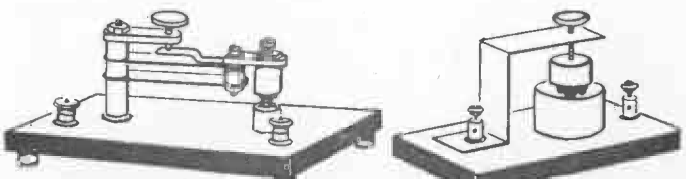


Fig. 25.—Two types of Detector, A, Spring-adjusted, B, Mercury-cup Detector

crystals are dealt with first, to avoid the repetition of information applicable to all types.

The detector should always be mounted upon an ebonite base, and care should be taken that the wires joining the cup and wire contact to the terminals do not run too close to each other; if they do so they will produce capacity effects which will seriously impair the working of the detector.

THE VARIOUS TYPES OF DETECTOR

A Simple Detector.—The principle of the detector will be better understood by reference to Fig. 33. The base, as previously stated, should be of ebonite, and the crystal cups may be drilled or turned from brass

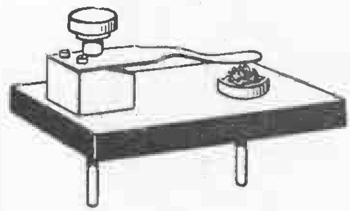


Fig. 26.—Carborundum-steel Detector

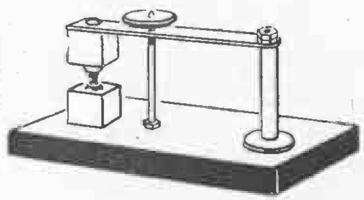


Fig. 27.—Perikon Detector

rod $\frac{1}{2}$ in. diameter, or they may be bought for a few pence. The centre terminal piece fixed to the top of the carbon rod of a dry cell, if broken off and the carbon cleaned out makes an excellent crystal cup. The success of the detector depends upon its rigidity;

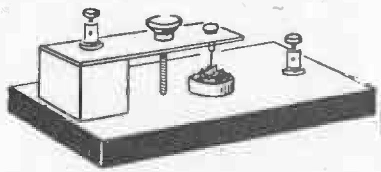


Fig. 28.—Simple One-crystal Detector

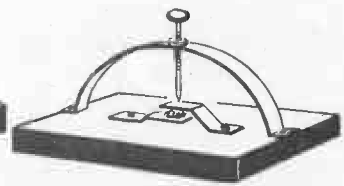


Fig. 29.—Improvised Detector

a weak or springy detector will never keep sensitive for more than a few minutes, and it will be found a source of everlasting annoyance. One crystal cup is fixed near the end of the base, as shown in Fig. 33, and the other is screwed to the end of a piece of brass

$2\frac{1}{2}$ in. long, $\frac{1}{2}$ in. wide, and a little less than $\frac{1}{16}$ in. thick.

A thick brass screw about 2 in. long is passed through a hole drilled at the other end of the base.

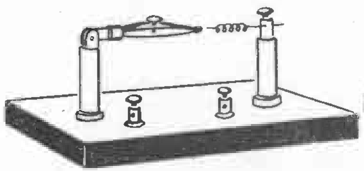


Fig. 30.—"Drawing-pen" Detector

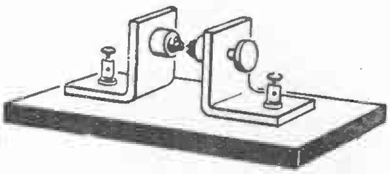


Fig. 31.—Another Double-crystal Detector

A strong washer (A, Fig. 33) is put on the screw, together with a length of brass tube about $\frac{3}{8}$ in. external diameter. This is followed by the brass strip, which is finally secured by two nuts. The length of the brass tube will depend, of course, upon the height of the crystal cups. A similar but longer screw is fixed to the base with a nut B, and the end is allowed to project through a slit in the brass arm. A nut to fit the screw is soldered to a small piece of thin brass, which is then screwed to an ebonite knob. It will be understood that by screwing the knob downwards the two cups will be brought nearer together, thus varying the pressure between the crystals.

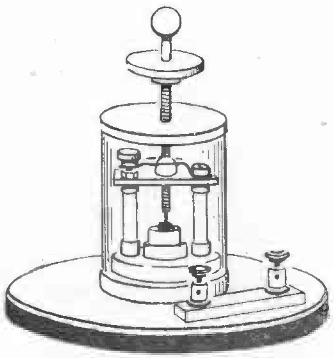


Fig. 32.—Enclosed Detector

Mounting Crystals.—The crystals are set in the cups with either molten solder or Wood's metal, which has an extremely low melting point, and so is not likely seriously to impair the sensitivity of the crystal, which high temperatures certainly do.

For mounting crystals in brass cups it is advisable to fix the cups in a vice or, failing that, between two pieces of wood tightly screwed together, of course leaving the bottom of the cup exposed to view and accessible. Apply a small quantity of fluxite (never use "spirits of salts") to the inside of the cup, heat the cup with a blowpipe and lamp, drop the Wood's metal into the cup, causing the metal to melt. Then place the crystal in the cup and hold it in position with a piece of wood until the metal has become solid. It is necessary to hold the crystal down, otherwise it will float, and when cool will drop out, leaving the metal still in the cup.

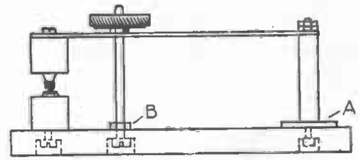


Fig. 33.—Simple Detector

In the case of several small pieces of crystal to be fixed, a good method is to put the pieces in position in a small piece of soft cork, and when the metal is melted press the end of the cork, holding the small pieces into the molten metal and maintaining pressure until the pieces have become embedded in the cooled metal.

A simple way of arranging the crystal in a detector, and one which gives results equal to the cup and set-screw type, is to use an old pocket-lamp bulb and break the globe off. The plaster filling is scraped out and the crystal, wrapped in tinfoil, is jammed in tightly. This cup is then screwed into one of the holders made for these bulbs, and a connection made to the screw on the side.

This arrangement enables one to change a crystal in a few moments by simply unscrewing one " globe " and inserting another.

Detector with Rotary Movement.—In the case of a detector which requires a rotary movement, a very good type to make is that having the cup as the moving member and not the contact screw.

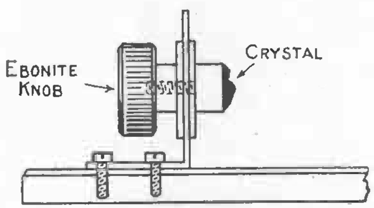


Fig. 34.—Rotary Crystal

Fig. 34 explains how this may be done. By unscrewing the knob the crystal can be moved so that any point on its surface can be touched by the metal contact.

Multi-crystal Detector.—In the crystal detector shown in Fig. 35 the crystal holders are revolver cartridges. It will be seen that any of one set of four crystals can be used with any one of the other set of four.

Clothes-peg Detector.—A novel detector may be made from a domestic clothes-peg. Fig. 36 shows how to connect it to the set, and the rearrangement of the peg to meet the requirements of a detector.

Detector Made from Sparking Plug.—The crystal detector shown in Fig. 37 is made with two mica-insulated sparking plugs, as used on motor-cars, etc. The fixed end of the spring is attached to the

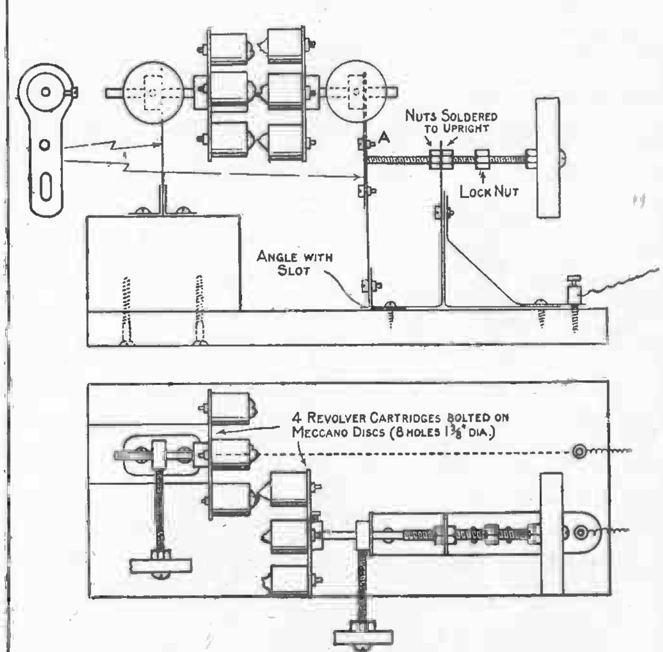


Fig. 35.—Elevation and Plan of Multi-crystal Detector

terminal of plug A by means of an additional nut which is screwed down tight by means of a spanner. The ordinary terminal secures the aerial lead.

The terminal nut of plug B is used for adjusting the spring.

An Enclosed Detector.—The detector shown by the photograph (Fig. 38) and in elevation and plan by Fig. 39 will work equally well with silicon or treated galena, and with a little modification it could be used with zincite and bornite or other combinations.

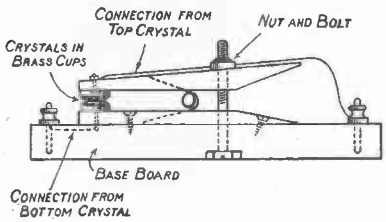


Fig. 36.—Detector made from Wooden Clip

It is advisable to have a heavy base as it prevents the detector getting out of adjustment owing to vibration. It should be turned up to the dimensions shown in Fig. 40 and polished only on the boss, the rest being enamelled black; three small ebonite studs are fastened in the bottom to support it. The two holes for the terminals are made $1\frac{1}{4}$ in. apart. One is drilled and tapped No. 3 B.A., and a short stud projecting $\frac{7}{16}$ in. screwed in. The other is drilled $\frac{1}{4}$ in. and fitted with an ebonite bush at the bottom (not shown in the drawing) for the terminal which is connected to the crystal cup. The terminal base of ebonite (Fig. 41) is held in place by the two terminals, the left hand one being screwed on to the stud.

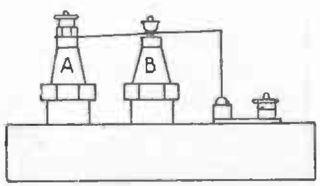


Fig. 37.—Crystal Detector made from Sparking Plugs

Fig. 42 shows the arrangement of the crystal cup. It is insulated from the base by two ebonite bushes which are clamped together with the nut and washer

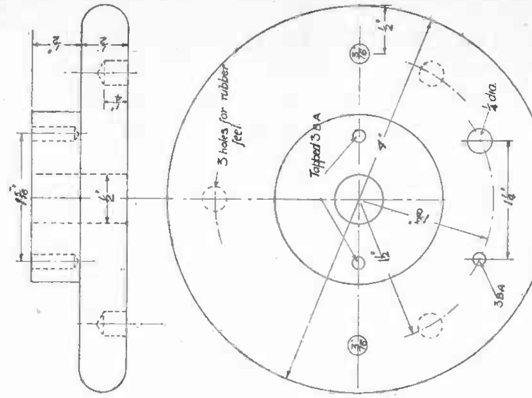


Fig. 40.—Details of Base

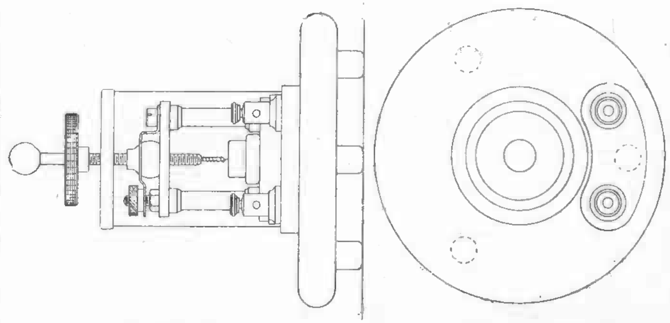


Fig. 39.—Elevation and Plan of Detector

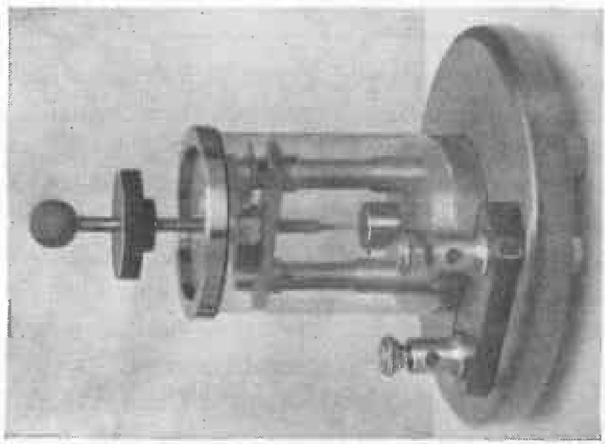


Fig. 38.—Enclosed Detector Complete

at the bottom, a short piece of copper strip being soldered to the washer and carried under the right-hand terminal. The cup is made from a piece of $\frac{1}{2}$-in. brass rod drilled out as shown, and the crystal is fixed in place in the manner already described.

The pillars (Fig. 43) are made from $\frac{3}{8}$-in. brass rod. It is probably quicker to drill out holes in the

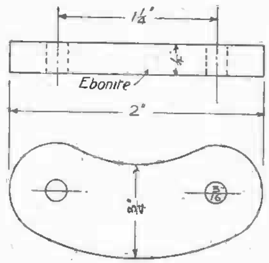


Fig. 41

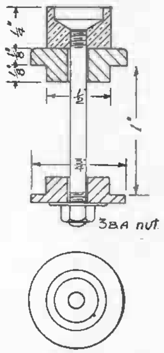


Fig. 41.—Terminal Base

Fig. 42.—Crystal Cup

Fig. 42

end and solder pieces of No. 3 B.A. tapped rod in place than to turn the screws down from the solid.

The bridge for the ball and socket joint (Fig. 44) is made from $\frac{1}{2}$-in. by $\frac{1}{8}$-in. brass strip, drilled out with a $\frac{1}{4}$-in. hole in the centre, and countersunk with a larger drill to take the ball. The strip which holds the ball in place must be carefully bent so as to get the holes in the correct position. It is best to turn the ball first and fit the joint to it afterwards. As will be seen from the assembly view a small terminal nut is used finally to adjust the tightness of the joint.

Fig. 45 shows the construction of the "point." It is made from No. 3 B.A. tapped rod, and has a $\frac{1}{2}$-in. ebonite sphere at one end. The other end is drilled

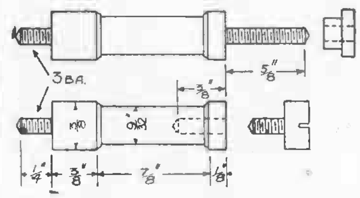


Fig. 43.—Pillars

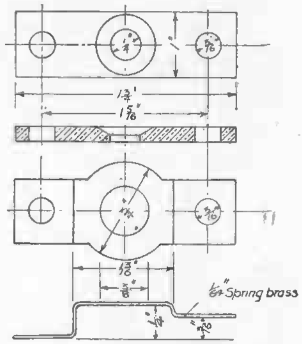


Fig. 44.—Ball-and-socket Joint

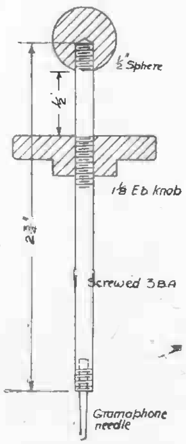


Fig. 45.—Crystal Contact Point

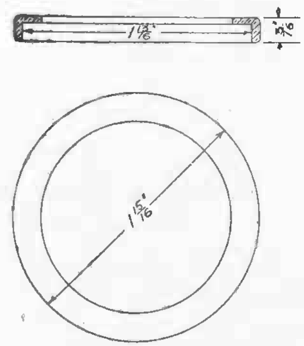


Fig. 46.—Rings for Bottom and Top of Enclosed Detector

out with a $\frac{1}{16}$-in. hole for a short distance. A gramophone needle is then soldered in position as shown. A piece of fine steel wire is wound on the end of a $\frac{3}{64}$-in. drill, and when this is allowed to spring it will be

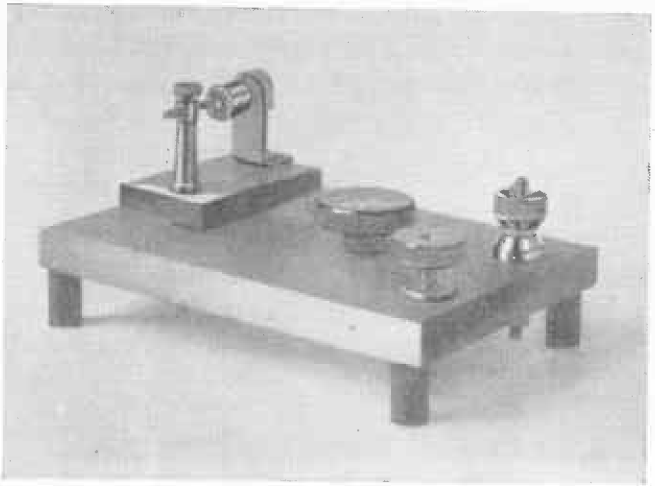


Fig. 47.—Detector and Potentiometer

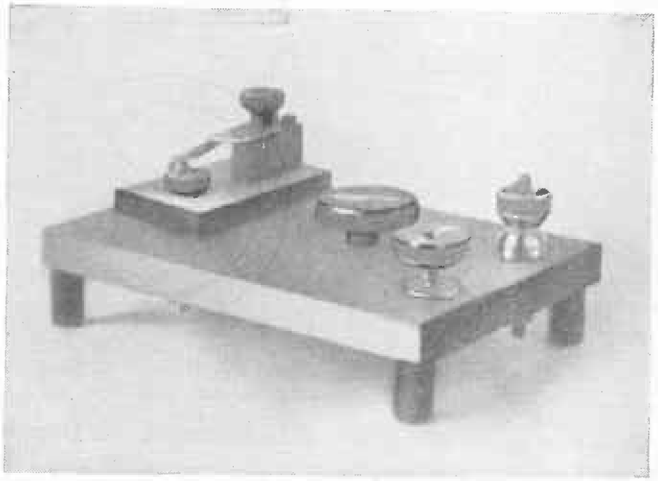


Fig. 48.—Another View showing Different Detector in Position

found to make a good tight fit on the needle. The end of the wire can then be bent to point along the axis of the needle.

The bridge and crystal cup are all enclosed in a clear celluloid cover. This can be made by bending a piece of $\frac{1}{32}$-in. sheet celluloid round a $1\frac{3}{4}$-in. diameter former, allowing a $\frac{1}{4}$-in. overlap which can be cemented up with celluloid solution. The side is made of a piece of celluloid $2\frac{3}{4}$ in. by 6 in., and the top is a

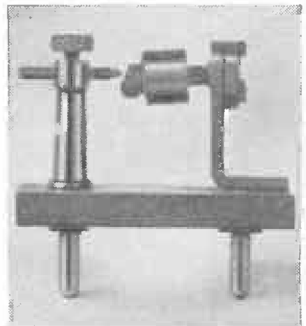


Fig. 49.—Horizontal Detector

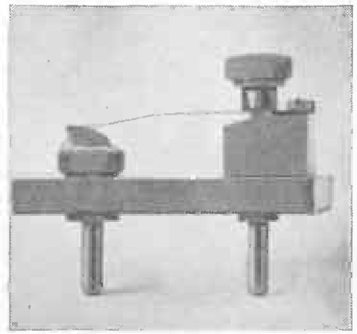


Fig. 50.—Vertical Detector

$1\frac{5}{8}$-in. disc with a $\frac{1}{2}$-in. hole in the centre. The side and top are cemented into a brass ring (Fig. 46).

Detector with Variable Resistance and Potentiometer.—One of the objections to some detectors is the fact that when it is desired to change the crystals or experiment with new combinations quite a considerable time is lost in getting the new crystals in position. With the instrument here described the time lost in changing is reduced to a minimum. Figs. 47 to 50 show various complete detectors.

The instrument consists of a main ebonite base, carrying an adjustable resistance and a pair of plug sockets. The crystal combinations are mounted on small bases fitted with special plugs which fit into the sockets on the main base.

Figs. 51 and 52 show the general design of the main base, Fig. 53 being one of the detector stands fitted with the plug connectors.

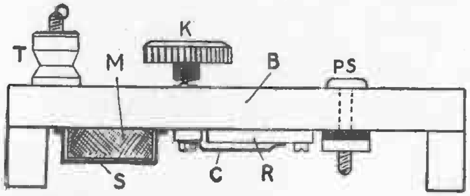


Fig. 51

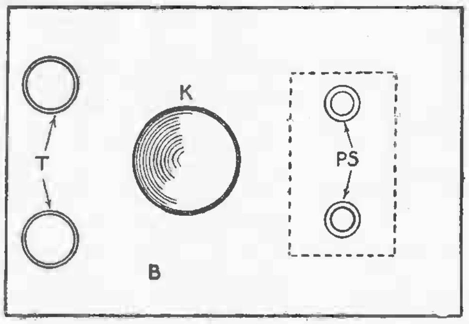


Fig. 52

Figs. 51 and 52.—Base of Detector with Variable Resistance and Potentiometer

The base B should measure about 5 in. long by $3\frac{3}{8}$ in. wide by $\frac{1}{2}$ in. thick. The positions for the holes to take the terminals T, the potentiometer knob K, and the plug sockets P S should be marked on the under side as shown in the diagram.

The terminals T fitted at one end of the main base B in Figs. 51 and 52 are of standard pattern.

The plug sockets P S which carry the crystal sets are mounted on the opposite end of the base, the dotted lines in Fig. 51 indicating the space occupied by the small ebonite blocks carrying the crystals.

A nut on the under side of the base keeps the plug socket in position, a few threads being left to enable the connections to be soldered thereto.

Four small ebonite feet are required, and these

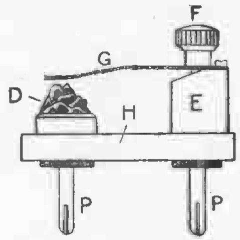


Fig. 53.—Detector Stand with Plug Connector

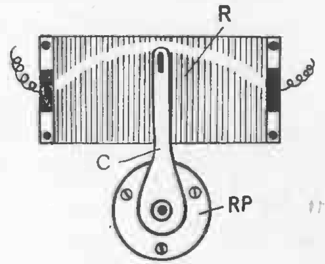


Fig. 54.—Potentiometer

should be turned up on the lathe and drilled and countersunk to take small screws which secure the feet to the base B. If they are made $\frac{3}{4}$ in. long by $\frac{1}{2}$ in. diameter they will raise the base sufficiently to enable

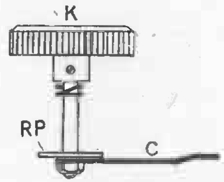


Fig. 55.—Moving Contact

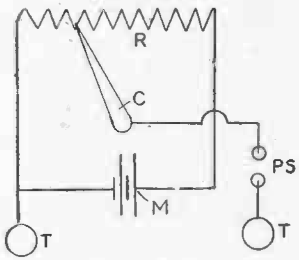


Fig. 56.—Diagram of Connections

the fittings on the under side to clear the table by $\frac{1}{8}$ in.

The potentiometer (Fig. 54), consisting of the resistance R, the contact finger C, and the knob K, should now be constructed, its purpose being to vary the potential or voltage across the crystal. The knob K is turned up from ebonite and polished with turps and fine emery cloth while in the lathe.

The complete moving contact is shown in Fig. 55, the plate R P serving as a terminal for connecting up in addition to providing a smooth surface for the contact C to move on. Before the movable portion of the potentiometer is fitted to the base a spring washer should be slipped on directly under the knob K, as shown in Fig. 51; this has the effect of making the contact more firm over the resistance and remaining in place after the adjustment has been made. The contact C should be made of phosphor-bronze strip.

The resistance R is built on a strip of ebonite measuring 3 in. long by $1\frac{1}{8}$ in. wide by $\frac{3}{16}$ in. thick. Four holes are drilled in the extreme corners to provide means of fixing to the base B. The resistance consists of No. 36 S.W.G. enamel-covered resistance wire, wound closely on the ebonite former, the ends of the wire being secured by slipping them through holes in the ebonite and pressing two small metal strips, bent up to form clips, over to further secure them. The whole coil should then be soaked in shellac varnish in order to keep the turns of wire firmly in position.

The insulation must now be carefully removed where the contact C is to touch the turns of wire; this can best be done with a small piece of emery-paper or by gently scraping with a penknife. The potentiometer battery is mounted on the under side of the base B, as shown in Fig. 51, M being the battery and S the strap which holds it in position.

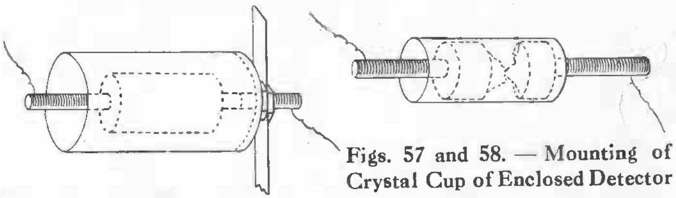
In order to avoid the complication of a switch to control the battery and prevent it running down through the resistance R, a small clip should be made to clamp on one of the battery contact strips and to easily be removable when it is required to break the circuit.

Coming to the point of crystal combinations, the object is to provide a means of rapidly changing from one combination to another. The combinations may consist of zincite-bornite, carborundum-steel plate, galena-graphite, etc., all mounted on small blocks as shown in Fig. 53, fitted with plugs P for the purpose of rapidly connecting the crystals to the main base B.

The crystal set shown in Fig. 53 is a carborundum crystal D set in a cup in direct contact with one of the plugs P, screwed through the ebonite base H. The other plug has an extra long thread on the upper portion which passes through the small ebonite block E and the steel plate G into the adjusting knob F. It will be noticed that the ebonite block E is filed off at an angle under the plate G, and it will be obvious that any pressure applied by screwing the knob F down will cause the plate G to press on the crystal, the amount of pressure being instantly variable. The adjusting knob F is of polished ebonite, and the plate G is a piece of clock spring softened at one end for drilling, and polished with fine emery-paper.

The diagram of connections is shown in Fig. 56, where it will be noticed that all the wiring is practically confined within the limits of the base B, the only connections necessary outside being by means of the two terminals T.

It is a good plan to solder all connections where possible; the work is then permanent and more satisfactory in every respect.



Figs. 57 and 58. — Mounting of Crystal Cup of Enclosed Detector

Another Enclosed Detector.—The detector shown in Figs. 57 to 59 is of the enclosed type, which renders it practically dust proof, and also ensures that the contact adjustment (once the best point is found) remains unaltered. All that is needed is a small quantity of paraffin wax, a few inches of stout paper, a couple of ordinary crystal cups, and two small discs of ebonite.

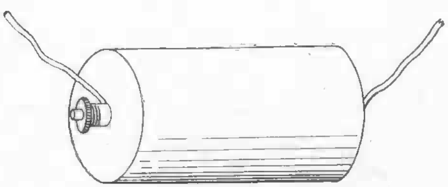


Fig. 59.—Complete Detector

Construct a small cylinder of waxed paper of such diameter as will just admit of the crystal cups sliding in—its length being twice that of a cup, plus, say, ½ in. for the projecting crystals. Another longer cylinder of larger diameter will be necessary to hold the wax until it is set. The paper for this need not be waxed.

Figs. 57 and 58 show how the lower crystal cup is held in a rigid cup—the thread having first been passed through a disc of the same diameter as the outside or containing cylinder; the inner or guiding cylinder being slipped over the cup.

Slip the upper crystal into its place in the guiding cylinder, having first connected both cups to the set by means of short leads. When by adjustment the rectification is found to be satisfactory, proceed to *seal* the crystal by slowly pouring melted wax into the containing cylinder until it is full.

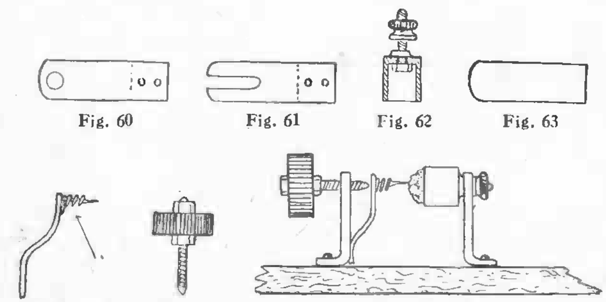


Fig. 60 Fig. 61 Fig. 62 Fig. 63

Fig. 64 Fig. 65 Fig. 66

Figs. 60 to 66.—Details of Detector with Screw Adjustment

The finished article is shown in Fig. 59.

Detector with Screw Adjustment.—In the detector shown by Figs. 60 to 66 the two ⅛-in. brass strips should be cut out and drilled as shown in Figs. 60 and 61, and bent at right angles at the dotted lines. The shank of the terminal fitted to the crystal cup (Fig. 62) should slide freely in the slot (Fig. 61).

Take the piece of spring brass 1½ in. long by ½ in. wide as shown by Fig. 63, solder the fine wire feeler or "cat's whisker" U (Fig. 64) to one end and bend to the shape shown. Solder the other end to the base of the piece of brass (Fig. 66). The hole at the top of the pillar should be tapped 2 B.A. An alternative method is to drill the hole slightly larger than the diameter of the detector screw and solder on a nut previously filled with clay to prevent the solder adhering to the thread. The detector screw (Fig. 65) is self-explanatory. A suitable wood or ebonite knob is clamped tightly to a short length of the 2 B.A. rod with two nuts, as shown, and the end of the rod rounded off to a point.

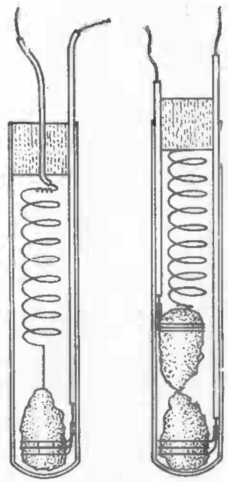


Fig. 67 Fig. 68

Figs. 67 and 68.—Cartridge-type Detectors

Cartridge-type Detectors.—Fig. 67 shows how to construct a cartridge type of crystal detector. A hertzite crystal is enclosed in a glass tube, the crystal with wire attached being at one end. The other end is provided with a cork with a wire passing through it, the wire resting on the crystal.

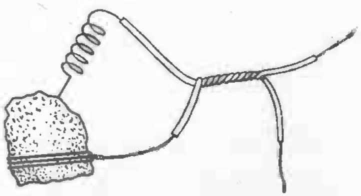


Fig. 69. Simple Improvised Detector

Fig. 68 shows how a zincite-bornite detector of the same type may be constructed. The two crystals, with the wires attached, are placed in the tube, while a rather weak wire spring holds them together.

Improvised Detector.—The manner in which crystals may be tested is shown in Fig. 69. Two No. 30-gauge wires are twisted tightly together and the ends then stripped, one end being twisted round the crystal and the other made into a spiral.

CHAPTER III

Coils : Making and Mounting

So many methods of making and mounting the various coils used in wireless receiving apparatus have been adopted that it would be idle to particularise any one method as being best. The efficiency of a coil is not so much dependent upon practical considerations as upon theoretical. That is to say, provided the coil is correct for the set under consideration, and that insulation is perfect, the winding and mounting can be left to the choice of the individual. This statement does not, however, apply to the *selection* of coils, as some types are undoubtedly more efficient than others.

Preliminary Considerations.—The longer the wavelength the greater is the amount of inductance required to tune it in. Therefore, before making a tuning coil, decide what range of wavelengths it is desired to tune. It is impossible to wind up one coil to receive all wavelengths.

CYLINDRICAL SLIDE-INDUCTANCE COILS

The Former for the Wire.—Cardboard postage tubes are very suitable for the purpose if they are previously prepared. A suitable length is cut off with a saw and the surface and ends are carefully smoothed with fine glass-paper. Three small holes are drilled

in each end of the tube in the position shown in Fig. 70. The tube is then heated in an oven to drive out any absorbed moisture, and while it is still hot it is given a coat of thick shellac varnish.

The Ends of the Former.—Wooden ends are fixed

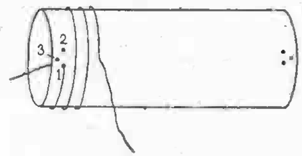


Fig. 70—Method of Fixing Winding to Cardboard Tube

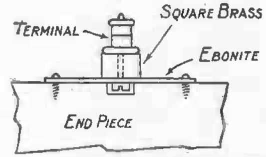


Fig. 71.—Method of Fixing Slider Rod to End Piece

to the cylinder, which serve as a support for the slider, as follows: Two wooden discs about $\frac{3}{8}$ in. thick are cut out with a fretsaw of such size as tightly to fit into the ends of the tube. This will be understood by reference to Fig. 72, and it will be seen that they

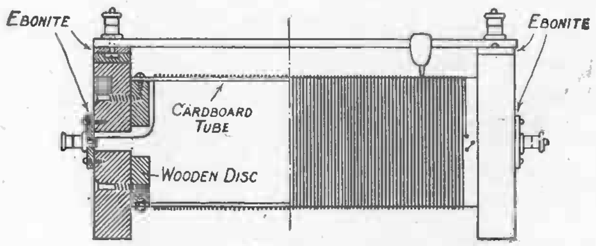


Fig. 72.—Half Section of Tuning Coil

are afterwards secured by small brass screws passed through the sides of the tube. The end pieces are made from any hard wood, and should be about $4\frac{1}{2}$ in. square and $\frac{1}{2}$ in. thick. These are fixed to the discs by brass screws after the coil has been wound.

Winding the Coil.— When winding a very large coil it is usual to arrange some form of winding apparatus, but it is not absolutely necessary. Referring to Fig. 70, about 6 in. of free end of the wire is passed down hole No. 1, up hole No. 2, and down hole No. 3, the end being put through the loop which has been formed inside the tube between holes No. 1 and No. 2. It will be found that this will fix the end of the wire quite firmly. The winding is then started, making each turn close against the other. When the other end of the coil is reached the wire is fastened off in a similar manner to the first turn. The best wire is double-silk covered, but cotton- or enamel-covered may be substituted. It should be remembered that enamelled wire is thinner than silk-covered, and therefore if this is employed more turns will be required to fill the winding space.

Mounting the Coil.—Although a connection is only required to one end of the winding, it is useful to bring both ends to terminals for use in other circuits. A hole about $\frac{3}{4}$ in. in diameter is made in the centre of each wooden disc and end piece. Two squares of ebonite about $1\frac{1}{2}$ in. long are placed over the holes in the end pieces, being fixed with small brass screws at each corner. A terminal is mounted on each, and the ends of the winding are brought through the holes in the wooden disc, being connected to the back of the terminals. Thus the winding does not come into electrical contact with either the cylinder or wooden ends and discs at any point; this, of course, ensures the best possible insulation.

The Sliding Contact.—The slider consists of a piece of moulded ebonite containing a spring and brass plunger which makes contact on the winding of the coil. Usually the slider is made to fit a $\frac{1}{4}$-in. square brass rod. A piece of square brass rod is cut of suitable length 7 in. long, and a hole is drilled in each end to take a small terminal screw. Two pieces of ebonite are next prepared. These should be made about 1 in. long and $\frac{1}{8}$ in. thick. The width is that of the end piece, the ebonite being fixed to this as shown in Fig. 71. It will be noticed that a hole is drilled in the middle of

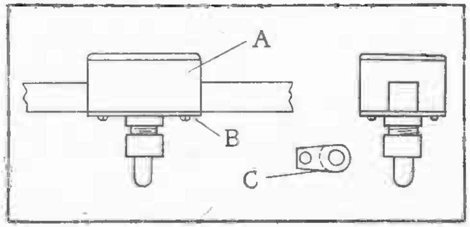


Fig. 73.—Inductance Slider

the ebonite, a small part of the end piece being cut away to accommodate the head of the terminal screw. The screw is put through the ebonite, passed through the hole in the square brass, and the two parts of the terminal are screwed up tightly. The same process is repeated at the other end of the square brass, and the pieces of ebonite are then screwed to the ends.

The Terminals.—Two terminals are connected to the slider rod, although only one is really needed. The two terminals make the appearance of the coil symmetrical, also the additional terminal may sometimes be of use in different circuits.

Another Method of Making the Slider. — By making use of the interior of an old L.B.C. lampholder quite good inductance sliders can be constructed. In Fig. 73 the block A is of ebonite or hard wood, and measures 1 in. by $\frac{3}{4}$ in. by $\frac{1}{2}$ in., and has a $\frac{1}{4}$-in. by $\frac{1}{4}$-in. groove cut along one face to enable it to slide along the usual $\frac{1}{4}$-in. by $\frac{1}{4}$-in. rod. B is a brass plate 1 in. by $\frac{3}{4}$ in. by $\frac{1}{32}$ in. drilled with four holes at the corners to take the brass securing screws. To the centre of the plate is soldered the large hollow screw from the lampholder. The pear-shaped piece C is cut and filed till circular, and is then screwed down over the plunger in the manner shown in the diagram.

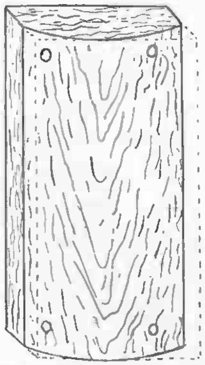


Fig. 75.—Wooden Support for Former

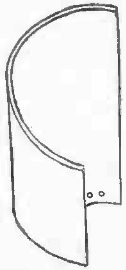


Fig. 74.—Former for Coil

SEMICIRCULAR INDUCTANCE COIL

The Wire Former.—Another method of making the simple slide tuner is to cut the cardboard cylinder lengthwise, as shown by Fig. 74, and put aside the other half, as this will not be required. Take a thick piece of board $3\frac{7}{8}$ in. wide by $7\frac{1}{2}$ in. long and shape it as shown in Fig. 75. Fit this to the inside of the semi-cylinder, as shown in Fig. 76, and secure it with a few small brass nails driven in so as the heads are flush with the cardboard. See that the straight edges

of the cardboard are flush with the curved edge of board, and that an equal portion of board is left projecting at each end. Give this a coat of shellac varnish inside and out, and when perfectly dry apply a second coat. When this is quite dry screw on the two end supports (Fig. 77), which are the two pieces of board $3\frac{7}{8}$ in. wide by 3 in. long, as shown in Figs. 81 and 82.

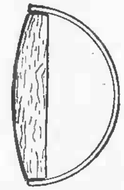


Fig. 76.—End View of Former for Semicircular Inductance Coil

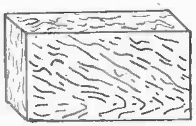


Fig. 77.—End Support

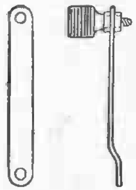


Fig. 78 Fig. 79

Fig. 80

Figs. 78 to 80.—Details of Knob and Arm

Winding the Wire.—Attach the end of the wire from the bobbin to a small screw T (Fig. 82), apply another coat of shellac, and while this is still "tacky" wind on the wire, taking care that there are no spaces between the layers, particularly where it covers the top curved portion. Leave about eight inches of wire at the end and pass it through the holes shown in the

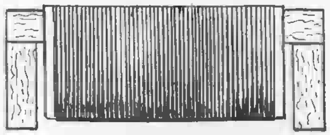


Fig. 81

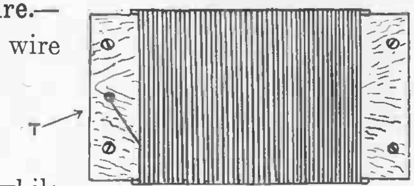


Fig. 82

Figs. 81 and 82.—Elevation and Plan of Semicircular Inductance Coil cardboard in Fig. 74 to prevent it unwinding. Apply shellac freely over the winding and allow the coil to dry.

Slider Details.—Next take a piece of spring brass 4 in. long by $\frac{3}{8}$ in. wide, round off the corners with a smooth file, and drill a hole in each end (see Figs. 78 and 79), one of which must take a length of the 2 B.A. rod and the other a round-headed wood-screw. Cut off about 1 in. of the screwed B.A. rod and fit one

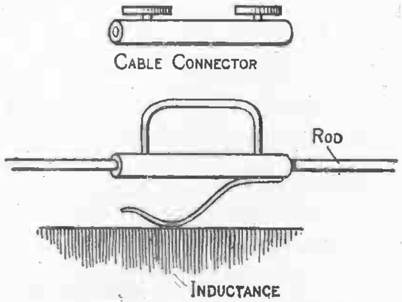


Fig. 83.—Inductance Slider made from Connector

end into a suitable wood or ebonite knob, as shown in Fig. 80. Bend the other end of the strip slightly so that it is parallel to the projecting part of the rod. The latter should be rounded off to a blunt point.

Alternative Form of Slider.—Fig. 83 shows another method of making a slider. Procure a cable connecter and remove the two set screws. Into the two holes solder a piece of wire to form a handle, and after filing the under surface flat solder a piece of springy brass or phosphor-bronze to form a contact.

The rod should be a piece of round brass the length of the inductance and the same diameter as the hole.

The coil is now complete with the exception of the winding contact; where the slider touches the winding the insulation must be removed. This is best accomplished by rubbing it with a piece of very fine glass-paper, using the edge of a straight piece of wood as a guide, so that a neat line of bare copper wire appears.

SPOOL FOR WINDING INDUCTANCES

When winding a coil some means of supporting the full spool is necessary, and Fig. 84 shows a simple method of effecting this. Procure two hooks of the size and shape shown, and screw hook A in any wooden fixture. Screw it so that it can be turned either way without undue effort. Hold the spool in position almost touching the vertical portion of hook A. The position of hook B can now be marked on the wooden support, allowing only just enough of the horizontal part to enter the spool and support it, say $\frac{3}{8}$ in. Screw in hook B level with A. Now if the two hooks are turned slightly backwards, the spool pushed over A, it will be found quite easy to insert B, as there is sufficient clearance.

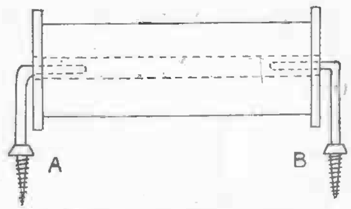


Fig. 84.—Spool for Supporting Wire during Winding

CONICAL SLIDE-INDUCTANCE COIL

The conical slide inductance provides for a finer adjustment than is possible with the usual cylindrical type, for two reasons. Owing to the cone shape adopted the length of each turn of wire decreases in regular progression from the base to the apex. By the use of a screw-driven slider it is possible to move the latter over one turn of wire at a time, which is very difficult when a slider is hand-operated in the ordinary way.

Fig. 85 shows a general view of the arrangement. Dimensions are not given as, of course, the size of coil adopted will vary according to the type of instrument for which it is intended. It will be necessary, in order to wind on the same amount of wire as a cylindrical coil, to either increase the diameter of the base end of the cone or increase the length, or compromise by increasing both.

The Cone.—The cone should first be constructed. This cone is made of moderately stout cardboard with a glued lapped joint. The lapped edges should be skived.

To facilitate mounting, and also to act as a stiffener to the cone, a cross-shaped piece (see Fig. 86) is cut out of a single piece of hard wood about $\frac{1}{2}$ in. thick and of sufficient diameter to fit flush inside the large end of the cone, being secured therein by tacks at the extremities as shown. A wooden disc glued in the small end completes the cone.

The Coil Holder.—The framework to hold the coil consists of the end uprights (Figs. 87 and 88) and the base. Hard wood $\frac{3}{8}$ in. to $\frac{1}{2}$ in. thick will be suitable for these. The pieces P to take the sliding mechanism are made of $\frac{1}{16}$-in. brass $\frac{3}{4}$ in. wide.

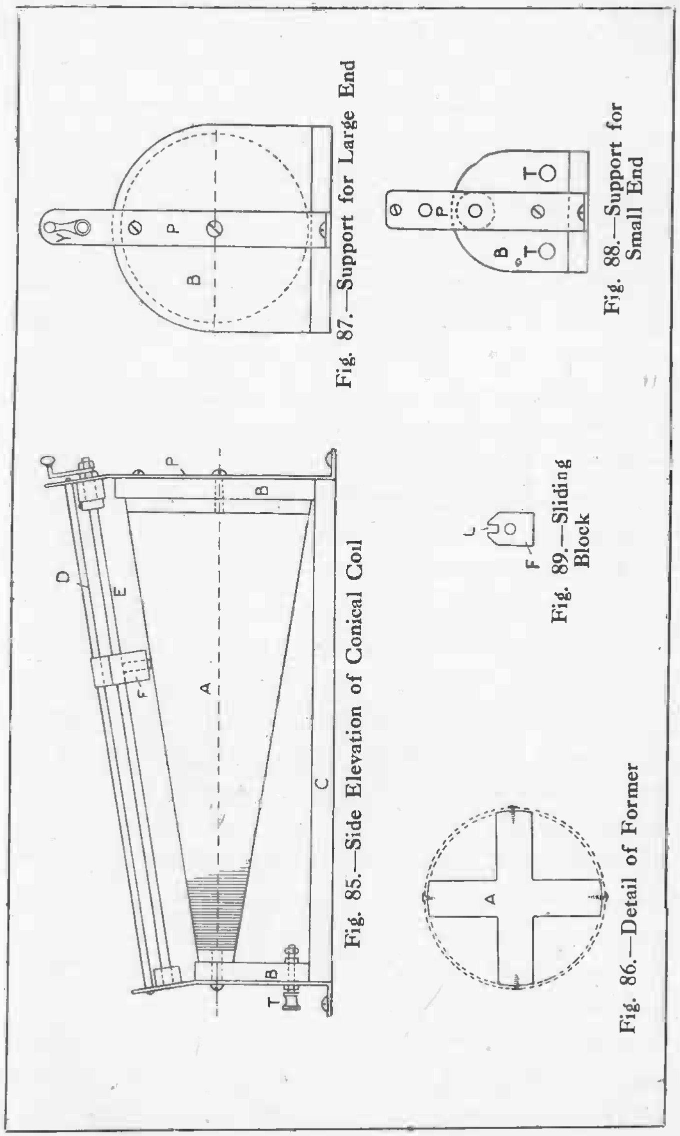


Fig. 85.—Side Elevation of Conical Coil

Fig. 86.—Detail of Former

Fig. 87.—Support for Large End

Fig. 88.—Support for Small End

Fig. 89.—Sliding Block

Fix the wooden ends B (Fig. 85) to the base C by small screws from underneath. After bending the brass strips as shown the position of the various holes to take the guide rod D and screwed shaft E (Fig. 85) should be marked out. The guide rod may be either square or round and of about ¼ in. diameter, drilled and tapped at each end to take the small screws. The screwed rod E can be bought in 13-in. lengths with the thread already cut along its whole length. A small block of brass is soldered to the inner side of each brass strip to act as a bush for the screwed shaft E. A short piece of thin brass tubing should be driven on each end to act as a bushing.

The brass block must be drilled to take the bushed ends of the spindle, the latter projecting to take two small nuts, by means of which the handle is secured.

The Sliding Block.—The sliding block F (Fig. 85) is of brass. This is fitted with a small plunger with a rounded end and pressed down by a light coiled spring above it. The centre hole (Fig. 89) is drilled and tapped to take the threaded spindle E, or, if preferred, the hole can be slightly enlarged and a nut soldered on each side of it for the spindle to work in. The top slot L (Fig. 89) is to take the guide rod D, and may be filed out square as shown, or the block can be made a little higher and a hole drilled to take the guide rod. A small bush with set screw prevents end movement of the screwed shaft.

Assembling.—The cone should have two or three coats of shellac varnish before winding on the wire which must be commenced from the smaller end, a

short length of the wire first being threaded through holes. The wire should come to about ¼ in. from each end of the cone. The terminals for the necessary connections can be screwed into either of the end uprights.

The Plunger.—The small plunger must be quite round at the end, as, if slightly flat, it will cover more than one turn of wire at a time, and thus reduce the fineness of the adjustment. A small brass ball would make the best plunger. An ordinary steel ball is not suitable.

Fig. 90.—Wooden Slip with Paper Attached

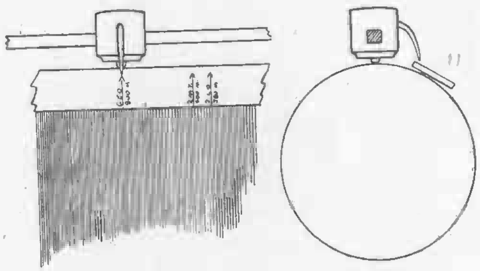


Fig. 91 Fig. 92

Figs. 91 and 92.—Details of Slider and Coil

In the design here shown only one sliding contact is employed. Should, however, two be required, it is merely a question of duplication, placing one on each side of the cone.

CALIBRATING A SLIDE INDUCTANCE

The calibration of the inductance enables the set to be quickly adjusted to any given wavelength. The general arrangement of a useful scale for this purpose is clearly indicated in Figs. 90 to 92. The only materials required for its construction comprise a strip of thin wood or ebonite 1 in. wide and long enough to fit tightly between the insides of the coil supports, a piece of good quality white notepaper, a small piece of brass wire, some glue and other oddments incidental to the making.

Smear some glue over one surface of the wooden strip, attach the paper as shown in Fig. 90, and fit it between the two coil supports in the position indicated

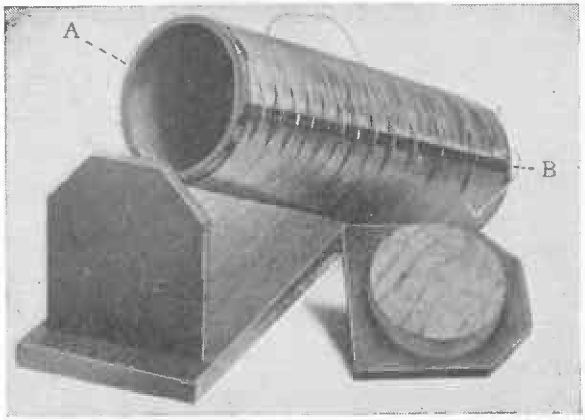


Fig. 93.—Photograph showing Method of Making Tappings from Cylindrical Coil

in Fig. 91. Drill a small hole in the side of the slider at right angles to the rod and fit a small brass wire pointer which can be bent to any convenient shape. The position of the lower end of the pointer should be as near to the scale as possible without actually coming into contact with it. It should be fixed flat so that it does not "cockle," but it should not be distorted.

As the various transmitting stations are tuned in, mark a small arrow directly under the pointer and add the station's call letters and wavelength.

SINGLE-TAPPED CYLINDRICAL COIL

The inductance coil here described dispenses with the slider knob, as the coil is tapped and brought out to switch studs, the tuning being effected by turning the switch-arm. In Fig. 93 A is a cardboard tube, B is a strip of ebonite, or even of hard wood, the same length as the tube, and about $\frac{1}{4}$ in. by $\frac{3}{16}$ in. cross section.

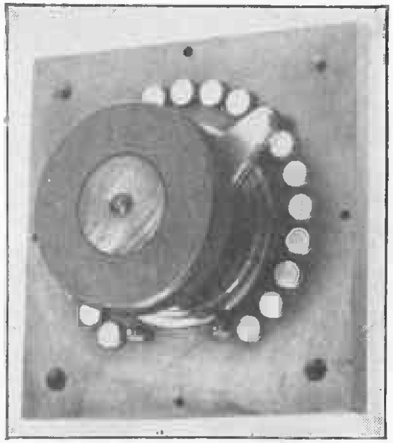


Fig. 94.—The Tuning Switch

Winding.— The tube is wound with copper wire, either enamelled or double-cotton-covered. The first two or three turns should be neatly secured by means of narrow tape tied in two or three places. After five turns lay the strip of ebonite on the coil so that the end just projects beyond the last turn; the sixth turn obviously will be brought over the strip. After another five turns on the tube the strip should be pushed along so that number twelve will again come over the end of it. This procedure is continued until the tube is fully wound, when the last few turns must be secured.

Connecting the Tappings.—The next thing is to scrape the insulation from each of the raised turns of wire just where they lie on the ebonite strip. To each of these bare spots a short length of well-insulated wire is soldered (as well as to each end, of course, of the whole winding), and these connections are taken to a stud switch, of which a very good pattern is shown in Fig. 94. The number and positions of the "tap-

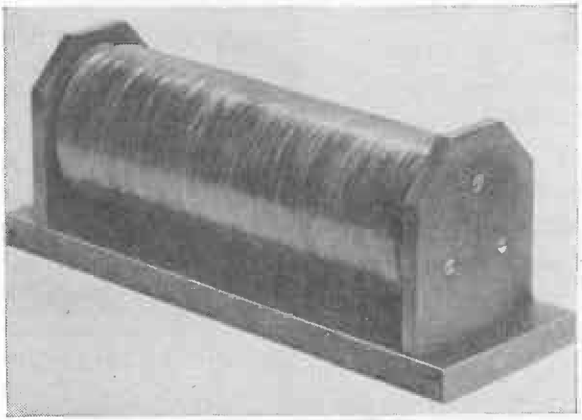


Fig. 95.—Photograph of Wound Coil

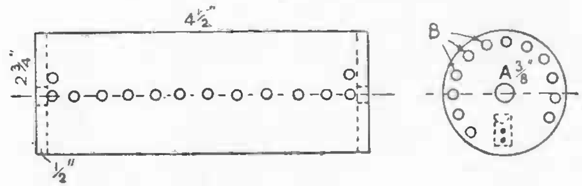
pings" can be varied according to individual requirements, there being no hard and fast rule. The appearance of the finished inductance is as in Fig. 95.

A LOOSE-COUPLER

Materials.—The materials required for the loose-coupler here described are two cylindrical formers, each $4\frac{1}{2}$ in. long by $2\frac{3}{4}$ in. and $3\frac{1}{2}$ in. diameter respectively; $\frac{1}{4}$ lb. of No. 30 s.c.c. and 1 oz. of No. 36 d.c.c copper wire; three bar switches with spring washers, nuts and bolts; thirty-two contact studs; four terminals and 15 ft. of flexible bell wire.

The Former.—First take the former and prepare two wood or ebonite end pieces exactly to fit in the end, with a hole $\frac{3}{8}$ in. in diameter bored through the centre of both, as illustrated at A in Fig. 96. If wood is used it should be perfectly dry and of a thickness of about $\frac{1}{2}$ in. Should ebonite be used, it need be only $\frac{3}{8}$ in. thick. In one of the end pieces drill ten or twelve small holes, as illustrated at B, Fig. 96 (see also Fig. 97).

The former, if of cardboard material, should be



Figs. 96 and 97.—Method of Preparing Cardboard Tube and End Piece for Loose-coupler

prepared with shellac varnish, several coats of this being applied. Now draw a straight line down one side, mark off $\frac{1}{2}$ in. from each end, and beginning just inside these marks bore twelve holes right through the former at equal distances from each other. The positions of these holes should be marked on the former before the commencement of operations. A second hole should now be drilled near the first and last holes for making the end of the wire fast.

Winding.—Now take the 36-gauge wire and commence winding it on to the former in precisely the same manner as adopted for winding an ordinary cylindrical coil, with the exception that the end of the wire has first of all a length of the flexible electric-bell wire soldered to it and is then pushed through the hole into the former. A slip of paper numbered 1 should now be attached to this flexible lead, which should be about a foot long. Proceed with the winding, and when the first hole is reached strip the cotton covering off the twisted wire and solder a flexible lead to this; insert

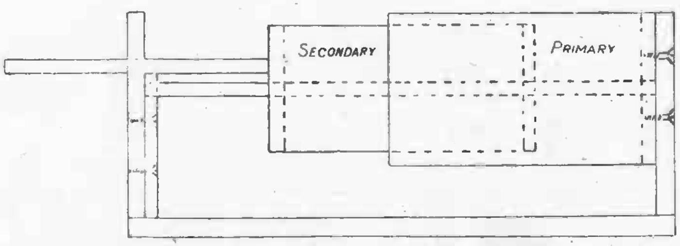


Fig. 98.—Diagram of Loose-coupler

it through the hole and number it 2. Proceed with the winding, and ensure that the next turn of wire bears closely against the one just soldered, and so carry on the soldering and numbering of the leads as the holes are reached until the coil is completed, when twelve flexible leads will be obtained. The leads will be numbered 1 to 12. Now insert the end pieces into the former, securing them in position by small brass screws, the one with the small holes being utilised at the end of the coil from which the leads emerge, the leads being passed through the small holes. The numbered tickets should be taken off the leads one at a

time whilst they are being pushed through, and then reattached after the lead is through.

Primary Coil.—The primary is wound in a similar manner except that two sets of tappings are made. 238 turns of No. 30 wire should be wound on, making 11 sections of 20 turns per section and 9 sections of 2 turns per section. The coil end-piece should now have a $\frac{3}{8}$-in. hole bored through it.

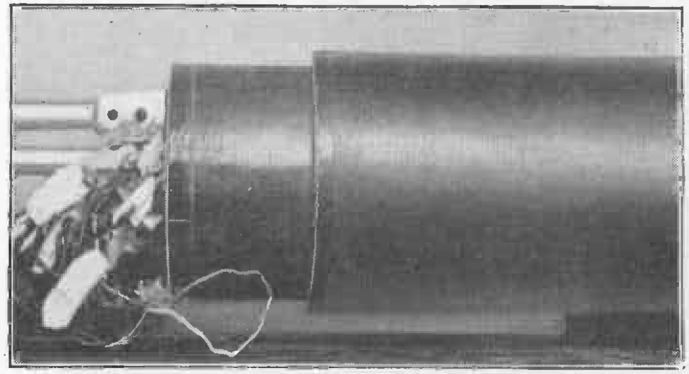


Fig. 99.—Photograph of Loose-coupler

Next take the dowelling and cut off a length exactly to fit inside and across the length of the case—that is, $12\frac{1}{2}$ in. long if the case has been made to the specification—and prepare another piece 8 in. long.

Prepare a small brass right-angle bracket 1 in. each way from the apex of the angle and bore two holes in each side to take small wood screws $\frac{1}{4}$ in. long and about $\frac{1}{16}$ in. thick.

On the end of the piece of dowelling 8 in. long make a flat surface and screw one side of the bracket to it.

Prepare a piece of wood $\frac{1}{2}$ in. thick and $2\frac{3}{4}$ in. by $2\frac{3}{4}$ in. and take off the end of the case which does not hold the primary coil. This side would be the right-hand side when the case is facing the constructor. Now pass the piece of dowelling which is to fit exactly into the case through the secondary coil and see that it slides easily and freely, then place the end in the hole just made in the end piece of the primary. Position the coils and dowelling in the case against the left-hand side about 1 in. clear of the base,,and place the piece of wood $2\frac{3}{4}$ in. by $2\frac{3}{4}$ in. against the other end of the dowelling and resting on the base of the case. Adjust the coils and dowelling to a horizontal position and mark on the piece of wood the centre position of the dowelling and bore a hole $\frac{3}{8}$ in. diameter at this position. Now screw the wood to the end piece of the case which has been removed.

Now take the piece of dowelling with the right-angle bracket attached to it and secure the other side of the right-angle bracket to the secondary coil end piece through which the flexible leads emerge. A hole must now be bored through the end of the case which has been removed to allow this piece of dowelling to project, and this forms the rod by which the coupling of the coils is varied. The coil when viewed from the back will now appear as in Figs. 98 and 99.

Solder the ends of the flexible leads and the contact studs of the secondary bar switch, fix the coils in position in the case.

Another Device for Operating the Loose-coupler.—Fig. 100 shows a device for operating the secondary

coil of a loose-coupler. The exact measurements are immaterial, as they would probably have to be modified with different apparatus.

WINDER FOR CYLINDRICAL COILS

The photograph (Fig. 101) and sketch (Fig. 102) illustrate a simple machine for winding cylindrical coils of different sizes.

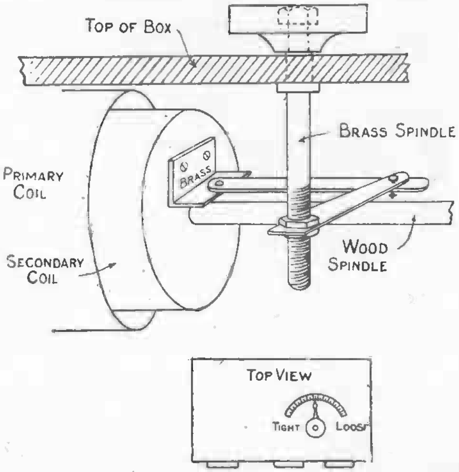


Fig. 100.—Device for Operating the Loose-coupler

The object of having a machine for winding coils is threefold: first, it ensures a better finish, since the turns are naturally at the correct angle to the axis of the coil, it is easy to obtain a tight winding throughout, and the time required to wind the coil is reduced to a few minutes.

Nothing elaborate is required to obtain the taut wire; a pile of books placed between the wire bobbin and the machine is all that is required.

The Base.—The base A (Fig. 102) of the machine should be of soft wood, so that the spindle bearings B and C are readily screwed into any suitable position for any size of former within the capacity of the instrument.

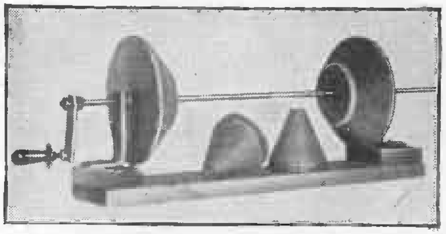


Fig. 101.—Completed Winder for Cylindrical Coils

The Bearings and Spindle.—The bearings are made from 1-in. by $\frac{1}{8}$-in. flat iron bent as shown and drilled to receive the screws and spindle. The spindle is a length of mild steel rod $\frac{1}{4}$ in. in diameter, screwed at the handle end $\frac{1}{4}$ in. Whitworth. The length can be made to suit the longest coil likely to be required; a good length should be chosen,

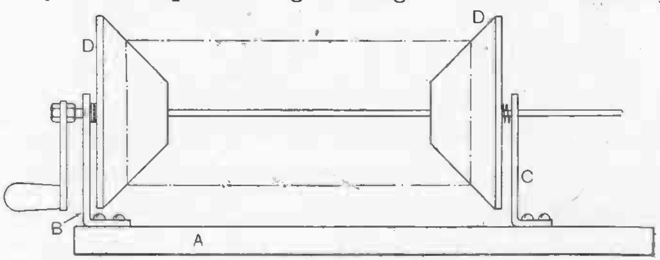


Fig. 102.—Elevation of Winder

say 18 in., as the extra length is not in the way. The handle is made from 1-in. by $\frac{1}{8}$-in. iron and a knob; both ends of the iron are tapped and nuts are used on both sides.

The Cones.—The cones D will take any coil from

1 in. to 6 in. diameter inside. It is not really necessary to have two sets of cones as shown in the photograph; a single cone can be made to suit the diameters mentioned. It will be seen that increase in the diameter of the cones will necessitate increase in the bearing height; this explains the blocks shown under the bearings in the photograph; in the sketch the blocks are, of course, dispensed with.

A few washers at the handle end of the spindle

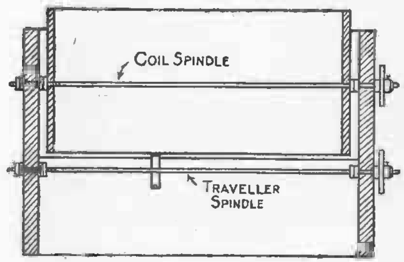


Fig. 103

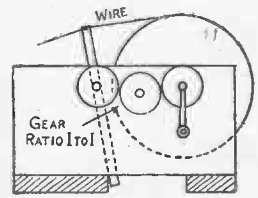


Fig. 104

Figs. 103 and 104.—Section and Elevation of Geared Coil Winder

and a fairly strong spring at the other end complete the apparatus.

Operation of the Winder.—To wind a coil, first remove the bearing and cone at the end away from the handle, slip on the former on which the coil is to be wound, put the cone on again, then a washer, spring, another washer, then the bearing; push the bearing along until the spring is well compressed, and screw it down.

ANOTHER COIL-WINDING APPARATUS

The apparatus shown by Figs. 103 and 104 shows another type of cylindrical-coil winder.

Make up a tube from a piece of glazed cardboard measuring $9\frac{1}{2}$ in. by 14 in. Bind lengthwise in a circle, glazed side out, and glue a butt-strap inside along the seam, leaving the latter $\frac{1}{2}$ in. short of each end for the insertion of the circular end pieces of hard wood.

Material.—To wind 24 S.W.G. enamelled wire the following material will be required: one rod screwed 4 B.A. 12 in. long; one spindle 12 in. long passing through the coil holder; three large size clock wheels; two wood end pieces 7 in. by 5 in.; two pieces of wood for the base—one 3 in. wide and the other $1\frac{1}{2}$ in. wide.

Take the 7-in. by 5-in. pieces and bore two holes in them about $2\frac{3}{4}$ in. apart to take the traveller spindle and coil spindle.

Screw a thread at each end of the coil spindle. Bore a hole in the centre of the coil ends to take the spindle. Insert the spindle in the coil and screw up tight, using two nuts each end (one nut acting as lock-nut).

The Traveller.—For the traveller a piece of $\frac{1}{4}$-in. square rod 5 in. long is required. Make a hacksaw cut at the top end, to run the wire through, and tap it 4 B.A. about 3 in. from the bottom end.

Screw the traveller on to its spindle and add two nuts to each end. Insert the traveller spindle and spindle with the coil holder between the two end pieces and then screw the end pieces on to the two bottom pieces.

The Train of Gears.—Place one gear wheel on each spindle, securing them by the small set screw provided, and then mesh the third gear wheel loosely

on a wood screw and tighten up all round with double nuts. Attach a handle to coil spindle and the apparatus is complete.

HONEYCOMB COILS

Efficient tuning coils of the honeycomb type can

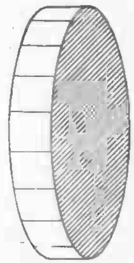


Fig. 105.—Wooden Disc for Winding Honeycomb Coils

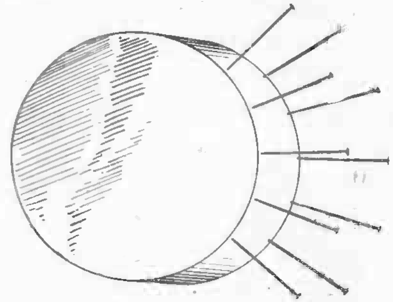


Fig. 106.—Pins Inserted into Disc

be wound by amateur wireless experimenters in quite a simple manner.

The Former.—The necessary former for winding these coils on can be made up by first obtaining a

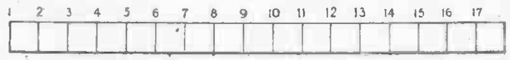


Fig. 107.—Divided Paper Strip

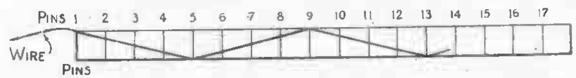


Fig. 108.—Method of Winding Honeycomb Coils

wooden cylindrical disc measuring about 2 in. in diameter and $\frac{1}{2}$ in. wide as shown by Fig. 105. This disc must be divided and marked off into seventeen equal parts round the periphery. The best method of doing this is to cut a strip of paper the same width as the edge and just sufficiently long to go round the circumference of the disc. The paper strip can then be marked off into seventeen equal parts quite easily whilst flat (see Fig. 107) and then be gummed on to the edge of the disc.

Next procure thirty-four ordinary pins and press two into each division opposite to each other (see Fig. 106).

Winding.—All that is now necessary is to wind on the wire. No. 32 gauge double- or single-silk-covered copper wire is suitable.

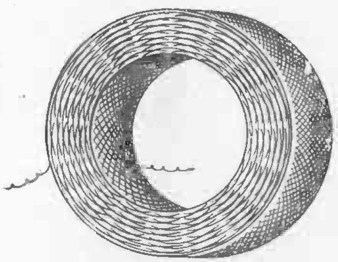


Fig. 109.—Finished Honeycomb Coil

To wind the coil, take the bobbin containing the wire and place it upon a suitable support, so that when the wire is pulled it will unwind quite readily. Now take the former in the left hand, the wire in the right hand, and after leaving a sufficient length from the end, say 10 in., commence to wind it on as shown diagrammatically by Fig. 108; that is, commencing with pin No. 1 pass round on the outside, then to the inside across to pin No. 5 on opposite side, round the outside of pin No. 5, then to the inside across to pin No. 9 on the opposite side, round the outside of pin No. 9 to the inside, and so on throughout the whole winding of the coil, going forward to the fifth pin ahead each time on each side alternately. The first layer should lie flush against the edge of the disc.

As a guide, it may be mentioned that in actual practice it has been found that a number of these coils having windings ranging from forty turns to 1,200 turns give a wavelength range of from 300 to 25,000 metres with a suitable aerial tuning condenser in the circuit.

Insulating the Coils.—When the desired number of turns has been wound on the former the free end of the wire should temporarily be twisted round the

Fig. 110.—Mounted Honeycomb Coils

last pin and cut after leaving, say, 10 in. spare. A small quantity of shellac varnish should then be poured into a flat tin and the whole coil and former laid into it for a few seconds to allow the varnish to soak in. The coil should then be removed and suspended by the wire for a few minutes to drain, after which it must be thoroughly dried either in front of a fire or in a moderately heated oven. The pins can be easily withdrawn and the coil removed from the disc. As a precaution it is advisable to bind the coil at intervals of 1 in. with fine thread to prevent the outside ends from slipping. The finished coil will have the appearance shown by Figs. 109 to 111.

BASKET COILS

The construction of basket coils is quite simple, and any convenient arrangement, such as pins stuck in the circumference of a disc of wood, will answer satisfactorily.

Fig. 111.—Honeycomb Coils in Use as Tuner

Another simple method is to use two pieces of stiff card, 4 in. in diameter, a circle $1\frac{1}{4}$ in. in diameter is drawn on each. Seventeen slots are now cut from the outside edge to the centre circle; these slots should be about $\frac{1}{8}$ in. in width and equal distances apart. Some wire should now be wound in and out of these slots until the required number of turns of wire are on the cards. Fig. 112 illustrates the method of winding, the end of the wire being passed through a hole at the edge of the card. Any spare card round the edge should be cut off and the whole shellacked.

Basket Reaction Coil in Inductance Coil.—This consists of a basket-wound coil wound as previously mentioned or on a cork 1 in. in diameter with pieces of cycle-wheel spoke or blanket pins spaced equally round its circumference. The wire is simply wound in and out round the spokes (Fig. 113) until the coil is just of sufficient diameter to rotate inside the inductance coil without touching. When the reaction coil is wound, leave about 6 in. of loose wire at each end for connections, and soak the coil in a bath of melted paraffin wax. When the wax is just about to set, remove the coil and allow it to harden. Afterwards the spokes can be withdrawn and the cork taken away.

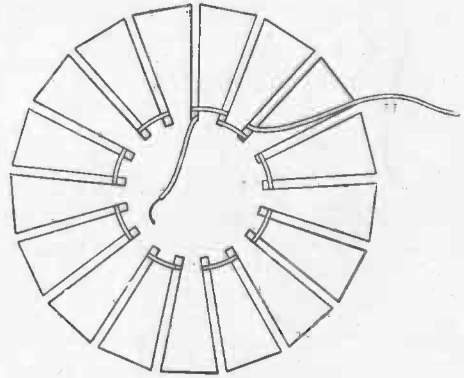


Fig. 112.—Method of Winding Basket Coil

A piece of brass rod is now passed through the inductance coil in the space left between the turns, and the coil lashed securely to the brass rod by means of adhesive tape. A hard-wood or ebonite knob is fastened to the end of the brass rod so that the reaction coil can be rotated inside the inductance coil (Fig. 114).

A BASKET-COIL TUNER

The Base.—The base of the tuner consists of a box 7 in. by $5\frac{1}{2}$ in. by 2 in. The ebonite panel to form the top of this box is $4\frac{1}{4}$ in. by $1\frac{3}{4}$ in. by $7\frac{1}{2}$ in. The two fit close together and leave $\frac{1}{4}$ in. overlap all round the box. On the top are mounted two wood pillars $\frac{1}{4}$ in. by 1 in. by $4\frac{1}{2}$ in. supporting a piece of ebonite $\frac{1}{4}$ in. by 2 in., which has a projection of 1 in. towards one side of the base. This allows the primary and reaction coils to swing well away from the secondary, which is fixed.

The Coil Holders.—The coil holders are composed

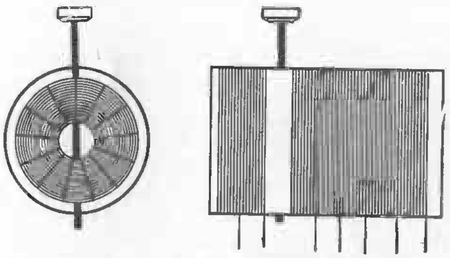


Fig. 114.—End and Side Views of Mounted Basket Reaction Coil Fitted in Inductance Coil

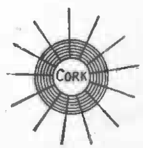


Fig. 113.—Basket Reaction Coil

of three pieces of ebonite 3 in. by 1 in. by $\frac{2}{5}$ in. (see Fig. 115). These are drilled at each end about $\frac{1}{2}$ in. from one edge, and are tapped 3 B.A. to accommodate pieces of brass rod, which should be 1 in. long for the top and $1\frac{1}{4}$ in. for the bottom of each holder. In addition, the rods of one holder, which is to be the centre one, should be threaded for about $\frac{1}{4}$ in. of their length. Holes are also drilled right through the breadth of the holder about $\frac{7}{8}$ in. apart to carry ordinary valve sockets. Next drill three holes in the top piece of ebonite $\frac{3}{8}$ in. from the edge and $\frac{3}{4}$ in. apart to take

the brass rods, the centre hole being tapped 3 B.A. The bottom rods of the holders fit in corresponding holes in a small strip of $\frac{1}{4}$ in. ebonite $3\frac{1}{2}$ in. by $\frac{1}{2}$ in., which is supported on brass screws $\frac{1}{2}$ in. above the wooden baseboard. The outer holes should be drilled not quite through the ebonite, the centre one being tapped right through as above.

Mechanism for Moving the Coils.—In order to provide means of moving the coils on the bottom rod

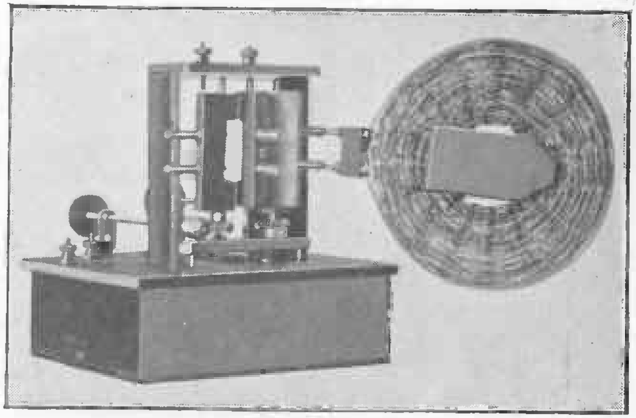


Fig. 115.—Photograph of Complete Basket-coil Tuner

of the primary holder clamp a bevel gear, and on the reaction holder a pinion. The holders are now assembled, the centre one being screwed into the top ebonite, then the bottom ebonite screwed on to the bottom rod. Then screw the bottom strip of ebonite to the baseboard and slip in the side holders, the rods being inserted in the top holes first. The bevel gear of the primary engages with a bevel on a rod, supported in the rear by a strip of tinned mild steel bent twice at right angles. The pinion of the reaction engages with a worm gear on a second rod.

Wiring Up.—The only thing remaining is to fit terminals and wire up. The terminals are in three sets of two, one set at each end of the ebonite base strip and one pair either in the middle of this strip or on the top piece of ebonite. Flex should be used in the wiring of the moving coils, the wires being separated, brought through holes in the base and soldered to the terminals.

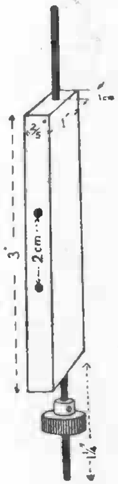


Fig. 117.—Method of Mounting Basket Coils

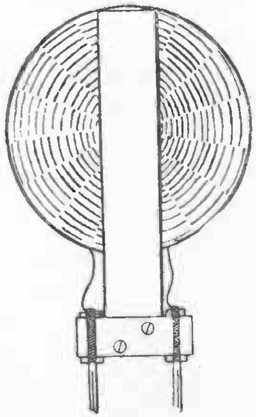


Fig. 116.—Basket Coil Holder

The coils used are baskets for short waves. Each is clamped between two pieces of wood, one piece being sufficiently long to protrude 1 in. from the side of the coil. Small pieces of $\frac{1}{4}$ in. ebonite 3 cm. by 2 cm. are drilled with two holes 2 cm. apart, and are fitted with valve legs to plug into the sockets. These may be obtained quite cheaply. The ebonite is screwed to the wood projection and the coil ends soldered to the pins. This is clear from Figs. 116 and 117.

The following table gives an idea of the turns

needed on the coils with a ·001 condenser on the primary and a ·0005 on the secondary, though a certain amount of experiment may be necessary to get the exact number of turns.

Mean Diam. (cms)	*No. of turns*	*Wavelength (metres)*	*Gauge*
6	9	180-360	Primary
$6\frac{1}{2}$	22	320-640	22 S.W.G.
10	60	600-1,500	d.c.c.
7	36	180-400	Secondary
8	68	370-800	30 S.W.G.
12	120	600-1,200	d.c.c.

Alternative Arrangement.—An improvement is shown in Fig. 118, where the coils may be moved about on a horizontal spindle, the upper spindle being a holder for spare coils. The four corner terminals are connected to the A.T.I. and reactance terminals of the valve panel respectively. The middle one is used as a common terminal when two of the coils are being connected in series. The ebonite is not a necessity, for if a piece of dry wood is well treated with shellac varnish it may be dispensed with. It is not suggested that this is as good as the more elaborate tuners, but it is less expensive and simpler for a beginner. Telephony can be received quite satisfactorily.

SLAB COILS

For winding slab coils three flat discs are cut from three-ply wood; two of these are 6 in. in diameter and one is 1½ in. in diameter. A slot is cut down one of the large discs to within ¾ in. of the centre, and the three are then screwed together as shown in Fig. 119. This former is now wound completely full with copper wire, tappings being taken off as the winding proceeds by means of the slot in one side. The tappings are brought to a switch on the front of the disc.

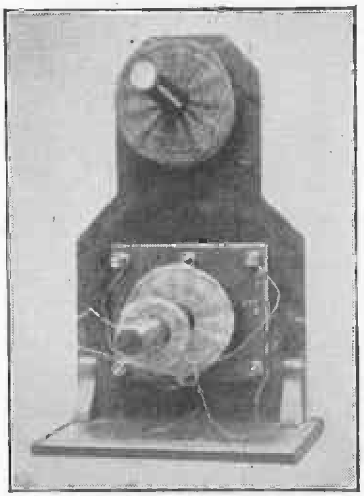


Fig. 118.—A Simple Tuning Inductance and Reactance

MULTI-BANK-WOUND TAPPED COIL

The multi-bank-wound coil has several points to recommend it. It is small and compact and exactly meets the requirements of the amateur who, while in possession of a satisfactory tuner for the reception of the broadcasting and telephony between, say, 300 and 1,500 metres, would very much like to bring in the high-power European and American stations between 2,000 and 25,000 metres.

Materials.—The materials required are as follows: Two hard-wood formers, the larger one for the A.T.I. and the smaller one for the reaction coil, one complete inductance switch with ebonite knob, eight inductance

studs, four brass terminals 4 B.A., about 3 oz. of No. 34 S.W.G. d.s.c. copper wire, and about a foot of rubber-covered flex.

The Former.—Fig. 120 shows the circular hard-wood former for the A.T.I., and it will be observed that it has five grooves which in the illustration are numbered from the top downward. These grooves, in which the d.s.c. wire is to be wound, are a little less than 2 in. in diameter by ⅛ in. wide, and are spaced $\frac{3}{16}$ in. apart. The over-all diameter of the former is 3 in. and its length $2\frac{1}{16}$ in. A hole ⅝ in. in diameter by 1½ in. deep is turned out in the centre of the top to accommodate the spindle and nuts of the switch.

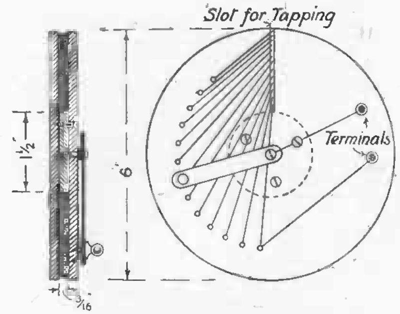


Fig. 119.—Former for Winding Slab Coils

Fig. 121 shows the hard-wood former for the reaction coil and also the square wooden base which serves to support the whole tuner. This base is fixed to the reaction former by means of a wood screw and also carries two of the four brass terminals for connecting up the reaction coil to the terminals provided on every amplifier.

The Switch.—The switch is shown in Fig. 122. It is fixed in position on the top of the former by means of two wood screws passing through the holes in the plate which forms part of the complete switch.

The Studs and Terminals.—Fig. 123 is a view of the top of the A.T.I. former showing how the eight brass studs are situated so that the copper contact blade of the inductance switch will pass smoothly from one to the other. The other two 4 B.A. terminals will also be observed; the screwed stems of these two terminals, as also the stems of the eight studs, should be cut to a little less than ½ in. in length, so that when screwed up tight in the holes provided

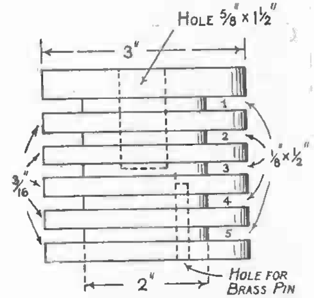


Fig. 120.—Hard-wood Former for Bank-wound Coil

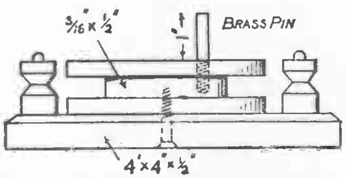


Fig. 121.—Hard-wood Former for Reaction Coil

for them in the top of the former they will not protrude into groove No. 1, which must be left clear to accommodate the d.s.c. wire. It is not necessary to tap out the holes in the top of the former to take the terminals and studs, as these holes should be drilled smaller in diameter than the actual diameter of the terminal and stud stems; when the terminals and studs are screwed up they will be found to be perfectly rigid.

Before screwing up the terminals and studs, however, a short length of the rubber flex, bared for about ½ in. at one end, should be slipped under each stud

and one of the terminals to provide connections for the tappings to be taken from the d.s.c. wire which is to be wound in the five grooves. The second terminal is connected to the inductance switch by means of a thin strip of copper or brass inserted under the switch plate and terminal before the wood screws passing through this plate and the terminal itself are screwed home.

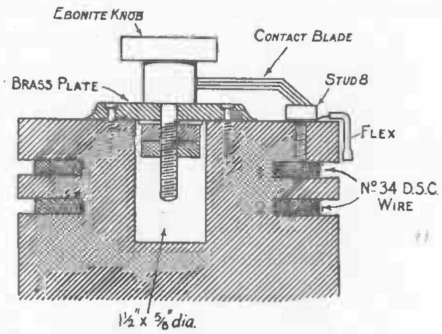


Fig. 122.—Part Section showing Method of Fixing Switch

Winding and Tapping the Wire.—The actual winding of the wire can now be proceeded with in the following manner: Bare the loose end of the short piece of flex attached to the stud No. 8, and also remove the silk insulation from the beginning of the d.s.c. wire, then twist the two together to make good electrical contact (this is important, and the joint may be soldered, although this is not essential). Now proceed to wind 280 turns of the d.s.c. wire into groove No. 1. Then bare the

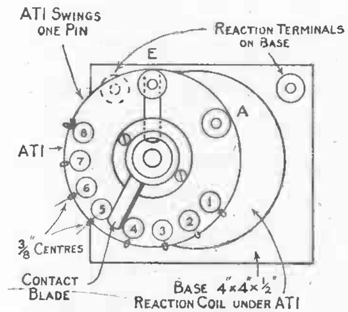


Fig. 123.—Plan of Complete Coil

loose end of the piece of flex attached to stud No. 7 and again remove the silk covering from the d.s.c. wire by gently scraping—do not cut the wire—then twist the flex and wire together and wind another 280 turns of wire, this time into groove No. 2, and take off a third tapping to the flex attached to stud No. 6.

The remaining three grooves should be wound in a similar manner, but a tapping should be taken from the middle point of each winding—that is, after every 140 turns. After winding the first 140 turns on groove No. 5 connection should be made to the last remaining stud, which is No. 1, and then a further 140 turns wound on. This completes the winding, and the end of the d.s.c. wire should now be connected to the piece of flex attached to the terminal on the top of the former. This terminal, by the way, is the one which should always be connected to the aerial, while the terminal in direct contact with the inductance switch is for the earth lead.

Winding the Reaction Coil.—The reaction coil can now be wound with 400 turns of the same No. 34 d.s.c. wire. It is so proportioned relative to the A.T.I. that no tappings are required. The ends of the d.s.c. wire should be attached to the two terminals on the base which were mentioned previously.

Variation of the coupling between the A.T.I. and the reaction coil is obtained in a very simple manner.

A brass pin $\frac{3}{16}$ in. in diameter is screwed into the top of the reaction former about $\frac{3}{4}$ in. from the edge as indicated in Fig. 121. This pin is left protruding about 1 in., so that it makes a fairly tight fit in a

hole bored in the bottom of the A.T.I. former in a position similar to the pin in the reaction former. This forms an eccentric pivoting device, so that when the A.T.I. former is gently moved by hand it swings away from the reaction coil, which remains at rest on the base to which it is affixed, and which, as previously mentioned, supports the whole tuner, which is shown complete by Fig. 124.

COIL HOLDERS AND MOUNTINGS

The methods of mounting coils here dealt with are additional to those more appropriately dealt with earlier in the chapter.

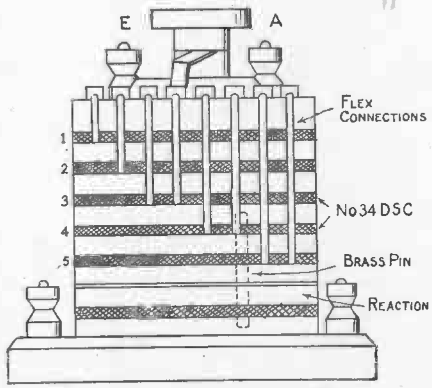


Fig. 124.—The Complete Tuner

An Inductance Coil Stand.—The tuning coil stand shown by Figs. 125 and 126 can be used in conjunction with either slab or basket coils.

The coil placed on the base remains stationary, whilst the coil which rests on the projecting strips can slide along, thus tightening or loosening the coupling. For short wavelengths basket inductances should be used, and for the longer wavelengths the slab coils function well.

Coil Holders from Electric-light Plugs.—A useful coil holder can be made with a minimum amount of labour and expense from an old electric-light plug and socket. Take the wooden plug and mark it so as to allow the maximum flat surface which can be filed at right angles to the terminal separator, and then file it to the marks (see Fig. 127). This done, obtain two ebonite strips for coil supports, approximately $\frac{3}{4}$ in. by $\frac{3}{16}$ in. by 4 in. (no definite diameters can be given for these strips, as the plugs vary according to manufacture), and fit them on to the flats by means of glue and four small screws. The coil can be mounted between the two supports by means of an old bobbin and screw, as shown in Fig. 128. The socket is an ordinary light socket and can be fixed on to the baseboard by means of the two screw collars attached. Suitable connections having been made to place same in circuit, the coil can now be plugged in ready for use.

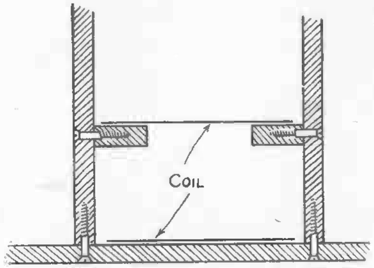


Fig. 125

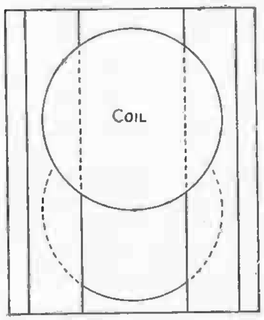


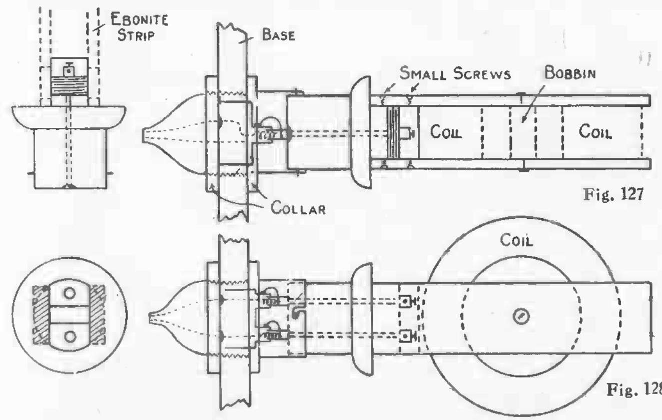
Fig 126

Figs. 125 and 126.—Section and Plan of Inductance Coil Stand

The socket is improved if two small pieces of flexible cord are soldered on to each section of the

sliding spring contact, thus ensuring minimum resistance and also a good connection.

A Slab-inductance Coil Stand.—This stand (see Fig. 129), with the exception of the ebonite manipulating knob, is cut from a disc of ebonite 2 in. in diameter by $\frac{1}{4}$ in. thick. Care must be taken that the holes indicated by the arrows A are drilled with $\frac{1}{8}$ in. clearance. If this is not attended to the moving element



Figs. 127 and 128.—Plan and Elevation of Coil Holder

will, of course, stick, and the coil holders will not grip the cards upon which the coils are mounted.

Mounting the Coils.—With reference to the coils, these may be mounted on discs of card which have previously been baked and immersed in melted paraffin wax. The fixed holder may be about $\frac{5}{16}$ in. broad. All screws are $\frac{1}{8}$ in. Whitworth brass.

Other Methods of Mounting Basket Coils.—Figs. 130 to 133 show a simple method of mounting coils of the basket type. An ordinary ebonite valve holder is used as a support, this being fitted to the panel in the ordinary manner.

The leads from each of the coils are soldered to two thick pieces of copper wire, and the latter are then put through the "spider holes" and twisted round, as shown, so as to form plugs to fit the valve sockets. The wire supports of the variable coils are

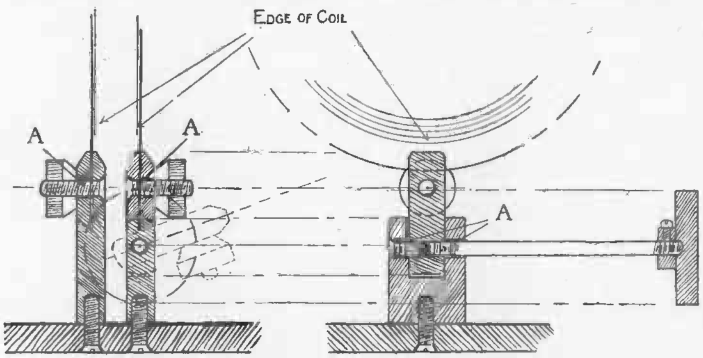


Fig. 129.—Sectional Views of Slab-inductance Stand

bent round and two other pieces attached to form a stiff hinge.

Mounting Slab Inductances.—The dimensions of the apparatus for mounting slab inductances shown by Figs. 134 to 139 will depend on the sizes of the coils to be used.

A Three-ply Holder.—In Figs. 134 and 135 the coil is shown shaded. It is mounted on a disc of $\frac{1}{16}$ in. three-ply wood, and is held in place by a strip of wood shown by A, which will vary in thickness according to the thickness of the coil it is to hold, the strip being cut on the under side to fit the coil. Another piece of

wood cut to the shape shown is attached at B. Two strips of $\frac{3}{8}$ in. by $\frac{1}{16}$ in. brass are fixed to the back by screws passing through the three-ply into the pieces

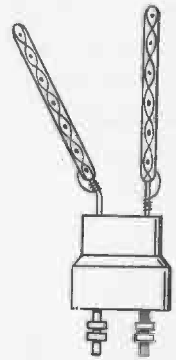


Fig. 130.—Coils on Holder

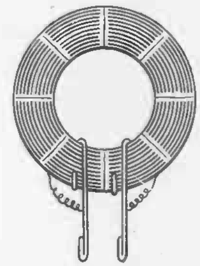


Fig. 131.—Mounting for Fixed Coil

of wood A and B; A is also fixed by screws at the ends as shown in the diagram.

The ends of the coil are led through the three-ply

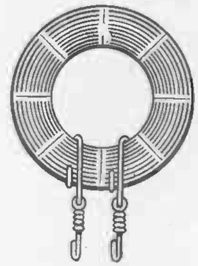


Fig. 132.—Coil on Hinged Supports

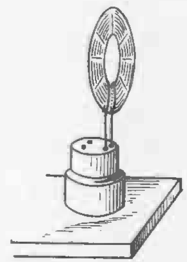


Fig. 133.—Holder with Coil on Base

wood, and are soldered to the two brass strips at the back. All the coils are mounted in the same manner, care being taken to see that they are central and that the brass strips are the same distance apart in every case.

The Coil Stand.—Fig. 136 shows a side elevation of a stand for holding the coils, and a coil is also shown in position. The coupling adjustment is obtained by varying the angle between the A.T.I. and the reactance coil, the latter being mounted on hinges for that purpose.

The base of the stand is hollow to allow of the wires being led to the terminals. It may be made entirely of $\frac{3}{8}$ in. mahogany. In the middle of one end is fixed an upright support for the fixed coil; this may also be made of mahogany, suitable approximate dimensions being 4 in. by $\frac{1}{2}$ in. by $\frac{3}{8}$ in. This upright is shown at A in Fig. 137, and is fixed by one screw B (Fig. 137); it also has a strengthening support C (Fig. 136). The upright should have two slots mortised in it, into which the brass strips on the coils are a loose fit. Small brass strips (these may be cut from flash-lamp battery contacts) bent at right angles are fixed by small screws in the slots as shown at D (Fig. 138); when these are fixed the coil should be a spring

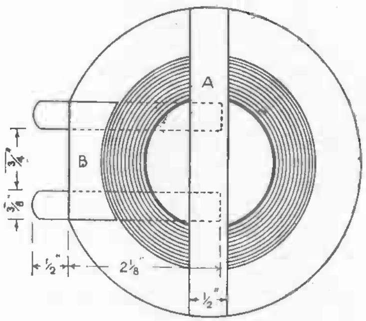


Fig. 134

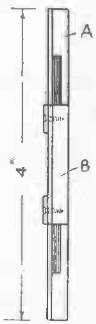


Fig. 135

Figs. 134 and 135.—Two Views of Coil Mounted on Holding Disc

fit into the slots between the brass clips. Wires are then led from the clips down the back of the support to the two middle terminals.

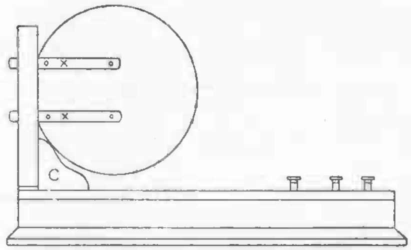


Fig. 136.—Side Elevation of Stand for Holding Coils

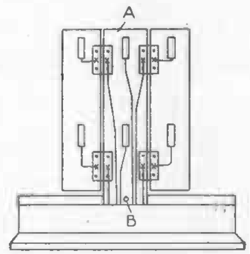


Fig. 137.—Back Elevation of Stand showing Wiring Connections

Two other supports are made exactly similar to A, and are attached to it by hinges through which the electrical connections are made, all joints being

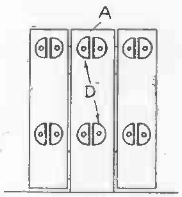


Fig. 138.—Positions of Brass Clips

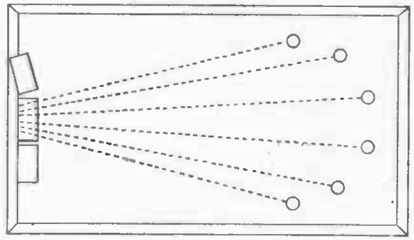


Fig. 139.—View showing Wiring Connections

soldered at the points marked X in the drawings. Figs. 137 and 139 show the wiring connections. No. 28 gauge d.c.c. wire will be suitable for these; the stand is varnished with thick shellac after the wiring is fixed, to secure it.

METHODS OF TAPPING COILS

First Method.—Perhaps the simplest method of tapping coils is that shown in Fig. 140, where a piece of ebonite rod is bound in with the wire. At the point where the tapping is required the wire passes over the

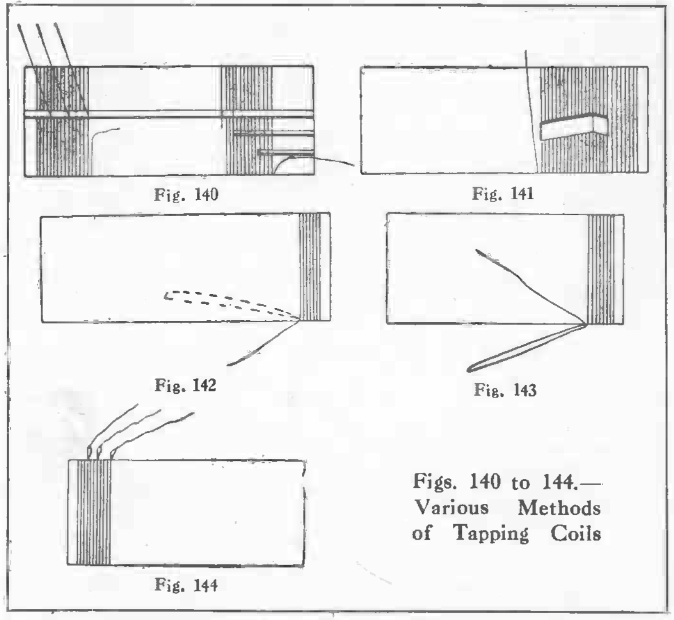


Fig. 140 Fig. 141 Fig. 142 Fig. 143 Fig. 144

Figs. 140 to 144.—Various Methods of Tapping Coils

rod as indicated, and the wire at that point is subsequently bared and the tapping soldered to it. This method has the advantage that the soldering operation is not likely to affect the insulation of the adjacent coils. All the tappings, however, will be in a straight line, whereas it is desirable to make them lie along a spiral line. For very fine tapping, therefore, additional

pieces of rod may be made, used so that the tappings may be stepped.

Second Method.—This method makes use of copper foil, strips of which are pushed under the convolution of the wire at the location of the tapping as in Fig. 141. The insulation is scraped away and the wire soldered to the foil.

Third Method.—Another simple method is to bore holes in the former tube with an awl at appropriate places, and then push the wire inside the tube, forming a loop and twisting the wire to lock it into the hole (see Fig. 142).

Fourth Method.—A variation of the foregoing method, but one that is hardly as neat, is to twist the wire into a simple loop on the outside of the coil, as shown by Fig. 143.

Fifth Method.—Fig. 144 shows the wire coils at the point from which a tapping is required twisted into a fine loop, thus providing a soldering point for a single length of wire from each tapping.

CHAPTER IV

Condensers

What a Condenser Is.—The condenser is a device for storing electrical strain or energy. It consists of two conductors separated by an insulator. The insulator is known as the dielectric.

The capacity of a condenser, whether fixed or movable, depends upon several points. The quality of dielectric, by virtue of which it is able to store electrical strain energy, is known as its "specific-inductive capacity."

Air is taken as the standard dielectric, so that its S.I.C. is said to be unity or one. All other dielectrics are standardised by this, and are said to be so many times greater or less than air.

Condenser Capacities.—Hence the capacity of a condenser is directly proportional to: (1) The opposing area of the plates; (2) the S.I.C. of the dielectric; (3) the nearness which the plates are together.

FIXED CONDENSERS

Fixed condensers, as used for the grid, etc., are of the simplest construction. They are usually made by fixing together alternate layers of mica and tinfoil, or waxed paper and tinfoil, or copper foil, although other combinations may be employed. The mica

should be about 0·004 in. thick. The mica should be cut into strips about 2¼ in. by 1 in. The tinfoil or thin copper, etc., should be cut into strips about 2¼ in. by ¾ in., the number depending on the required capacity of the condenser. To each side of one piece of the mica a strip of tinfoil is attached by means of shellac varnish; one piece of tinfoil is placed exactly above the other, but with the mica between them, and alternate ends of the tinfoil are allowed to project so that the actual area of tinfoil opposite each other is ¾ in. by 1¾ in. This is then enclosed between the two remaining pieces of mica by means of shellac varnish. When the varnish is dry the condenser should be pressed beneath a warm flat iron.

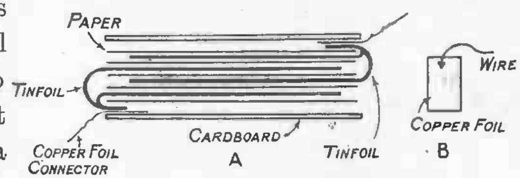


Fig. 147

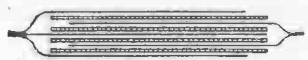


Fig. 146

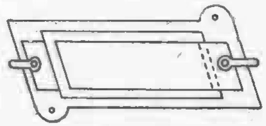


Fig. 145

Figs. 145 to 147.—Details of Fixed Condensers.

Mounting the Condenser.—The condenser may be mounted as it is, or, better, fastened between two pieces of thin ebonite, a small brass bolt passing through the ends, and contact being made with the projecting tinfoil by means of a soldering washer (see Fig. 145). The bottom piece of ebonite should have two projecting pieces, by which the condenser may be attached to the panel by means of brass wood-screws. Fig. 146 is a section showing the tinfoil projecting alternately, a method frequently employed.

The Tinfoil and Paper Method.—Fig. 147 illustrates the method of assembling a tinfoil and paper condenser, only four plates being shown for clearness. To ensure that the insulation of the condenser is as good as possible, before the plates are assembled the paper should be well soaked in paraffin wax. When the tinfoil plates are assembled the four plates which project on one side are bent on to the top piece of paper, and the other four are bent on to the bottom piece of paper.

Two pieces of waxed cardboard are cut to the same size as the paper to act as a kind of cover. Connection has yet to be made to the plates, and this is best done as follows: Two short lengths of copper wire are soldered to two small pieces of copper foil. These are placed one against each of the bent pieces of tinfoil, being slipped between the top and bottom pieces of paper and the cardboard.

GRID CONDENSER AND GRID-LEAK

The Use of a Grid Condenser and Leak.—The grid condenser is usually used with "hard" valves, and is best made with a good insulating dielectric. The necessary leakage is given by shunting it with a high resistance known as the grid-leak.

Practical Grid Condensers.—Grid condensers have a small capacity, usually between ·00001 and ·0001 of a microfarad. Two plates with an area of overlap of about 10 square centimetres and separated by a sheet of mica about the thickness of an ordinary postcard will give quite good results. There are several ways of making up grid condensers, as already noted in connection with fixed condensers, and a variety of materials are suitable for their construction.

Various Forms of Simple Grid Leaks.—The grid-leak is simply a resistance of 2 or 3 megohms (1 megohm = 1,000,000 ohms). Even the thinnest wire has far too great a conductivity for the construction of grid-leaks for receiving valves, so that substances which are only poor conductors for their construction have to be employed. A piece of damp cotton forms a readily-made grid-leak and a method of mounting it is shown in Fig. 148. The cotton is kept damp by the water soaked up, and the correct resistance is obtained by varying the depth of the water in the jar until the results are best. Another simple but effective leak is shown in Fig. 149. Here two terminals are screwed into a piece of wood, previously boiled in paraffin wax for preference, and blacklead or stove polish is rubbed over the surface of the wood between the terminals until the best signals are obtained. If the application of blacklead is overdone the excess may be removed by scrubbing with a piece of cork or india-rubber. It is important to see that the blacklead reaches right under the terminals; in fact, it is best to blacklead the places where the terminals come before inserting the terminals.

A modification of this form of leak may be made by screwing two terminals into an ebonite base, cutting a straight groove between them and rubbing a lead pencil into the groove until the resistance is right. Another piece of ebonite may be clamped down on to the first and the edges sealed with paraffin wax; in this way the leak is preserved from moisture and should remain fairly constant. Grid-leaks can also be made by blacking a strip of paper with indian ink, allowing to dry and connecting between two terminals. The strip is narrowed by cutting until the correct resistance is obtained.

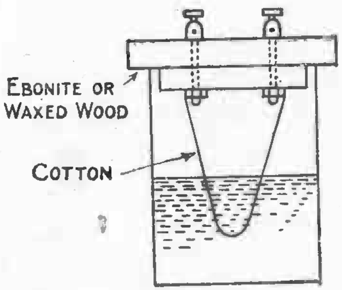


Fig. 148.—Damp-cotton Grid Leak

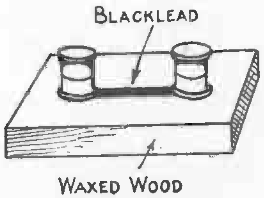


Fig. 149.—Pencil-line Grid Leak

A further method of grid-leak construction is shown in Fig. 150. A piece of glass tube about 4 millimetres in diameter and 4 centimetres long is filled with a mixture of lampblack and chalk, contact being made by sealing in a stout piece of copper wire at each end with sealing-wax. By varying the proportion of lampblack to chalk in the mixture almost any desired resistance may be obtained; final adjustment is made by altering the distance between the ends of the copper wires in the mixture. The actual proportions are best found by trial, it being remembered that the less the

proportion of lampblack the higher the resistance of the leak.

A Variable Grid Leak.—Owing to the difficulty of obtaining a grid-leak of the correct capacity, it may be found useful to fit one of variable capacity. A form that is simple to make and perfectly satisfactory in use is shown in Fig. 151.

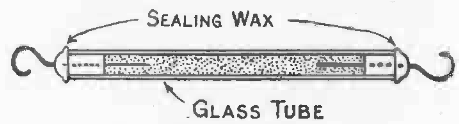


Fig. 150.—Powder Leak

A fan-shaped piece of mica with a radius of about $1\frac{1}{2}$ in. has small copper plates shellacked on in the angle and round the curved edge. Lines drawn with a graphite pencil and varying in thickness from $\frac{1}{32}$ in. to $\frac{3}{32}$ in. run spoke-wise between the plates. Connections are made by means of leads taken from opposite sides of the grid condenser. One is soldered to the corner plate, the other to an ordinary spring tie-clip, which can be slipped in an instant on to any plate.

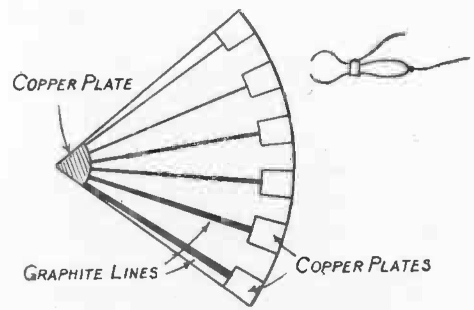


Fig. 151.—A Simple Variable Grid Leak

As soon as the correct resistance for any valve is found, a permanent leak, copied from the dimensions of the "spoke" that gives the best results, can be made up for it.

Another Variable Grid Leak.—Fig. 152 shows another idea for a variable grid-leak which works very well. As will be seen, it consists merely of a circular base which may be ebonite or fibre, on which is mounted a switch arm that is connected to one of the terminals C. The leak D is an indian ink line and contact is made to it by the contact studs E which are screwed down tight.

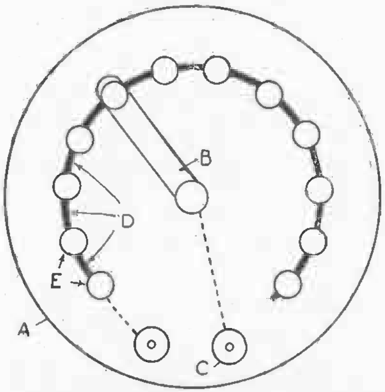


Fig. 152.—Variable Grid Leak

VARIABLE CONDENSERS

A Four-plate Variable Condenser.—The simplest form of variable condenser (chiefly used as an aerial tuning condenser) consists of four semicircular plates, A B C D, arranged as shown in Fig. 153. A and C are insulated from one another and are mounted together so that they can rotate about O, and the plates AB and CD are connected by two flexible wires. In the position shown there is a negligible capacity across T1 and T2, but if A and C be rotated through 180 deg., A becomes opposite to D, and C opposite to B, and a condenser is formed, since A is connected to one terminal and D to the other.

The Box.—A simple variable condenser on this principle can easily be constructed. A box about 4 in. by 4 in. by 1 in. should be made out of cigar-box wood, and to the under side of the top, two pieces of tinfoil (such as is used for wrapping chocolates, etc.), should be attached by means of shellac varnish.

The Tinfoil.—The shape of the tinfoil is shown in Fig. 154. Two tags protrude, through which two terminals pass. A piece of thin mica about 0·004 in. thick is then placed over the tinfoil, as shown by the dotted line. The mica may be split, to obtain the correct thickness, by burring the edge over and inserting the finger nail. A piece of wood $3\frac{1}{4}$ in. in diameter should have a $\frac{3}{16}$ in. centre hole drilled, two small countersunk holes being made at each side of this. Two semicircles of tinfoil, $1\frac{1}{2}$ in. radius, should then be cut out and shellacked to the disc of wood on the side on which the holes are countersunk, the semicircles being separated by $\frac{1}{4}$ in., as in the case of the tinfoil fixed to the top of the box.

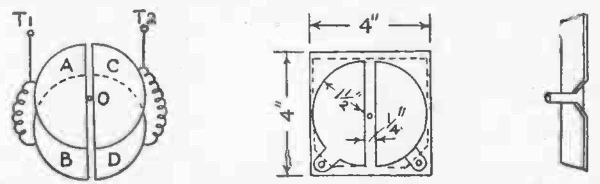


Fig. 153 Fig. 154 Fig. 155

Figs. 153 to 155.—Details of Four-plate Variable Condenser

Assembling.—A screw is pushed through the tinfoil covering each of the countersunk holes, and screwed right into the wood, so that it protrudes at the other side, and the flat head of the screw is below the surface of the tinfoil (Fig. 155). Contact is thus made between the brass screw and the tinfoil. On the other side of the disc a small brass bridge is placed over the centre hole with a $\frac{3}{16}$-in. hole drilled in it. The surface of the mica is then rubbed with a piece of cloth damped with olive oil. This is to ensure the smooth working of the condenser.

The disc is placed over the mica with the tinfoil side next to it, and a short $\frac{3}{16}$-in. spindle screw at one end is placed through the centre hole of the top of the disc and a nut placed on each side of the bridge to prevent the spindle rotating without the disc.

The Knob.—The knob may then be attached to the other end of the spindle. Each of the pieces of tinfoil on the rotating disc is connected to one of the pieces fixed to the top by means of a spiral coil of No. 28 d.c.c. copper wire.

Encased Variable Condenser.—This simple condenser allows for mounting on a panel, if preferred, when, of course, the box will hardly be necessary. Capacity varies from zero to ·001 m.f.

In Fig. 156 A is a piece of brass rod screwed No. 0 B.A. (or near) and $2\frac{1}{2}$ in. long. A groove is cut $\frac{1}{8}$ in. from the bottom to fit into slot of I. B B are two nuts to fit A. The one fitted into the knob is soldered to the spindle, the other acts as a carrier for opening or closing plate F. C shows one of four ebonite washers $\frac{1}{2}$ in. in diameter and $\frac{1}{4}$ in. thick (one at each corner

of plate D); these are drilled through the centre. D is a brass plate $\frac{1}{16}$ in. thick, $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. A hole $\frac{1}{2}$ in. in diameter is drilled through the centre to clear the spindle, and a small hole at each corner, $2\frac{1}{4}$ in. centres, for fixing screws. E is a circular disc of mica $2\frac{1}{4}$ in. in diameter and ·002 in. thick, provided with a hole in the centre $\frac{3}{4}$ in. in diameter. F is a circular piece of brass $2\frac{1}{2}$ in. in diameter and $\frac{1}{16}$ in. thick; the hole in the centre is $\frac{1}{2}$ in. in diameter. G is an ebonite washer 1 in. in diameter and $\frac{1}{4}$ in. thick and drilled through the centre to clear the spindle.

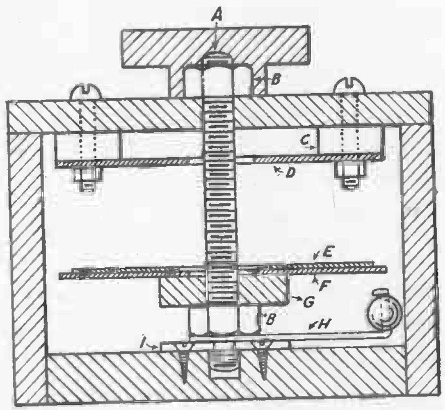


Fig. 156.—Section of Encased Condenser

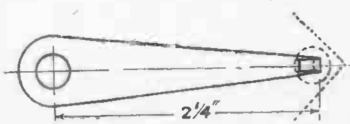


Fig. 157.—Brass Arm

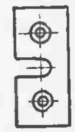


Fig. 158 —Slotted Plate

The arm (see Fig. 157) is a piece of brass 3 in. long and $\frac{1}{16}$ in. thick, $\frac{1}{2}$ in. wide at the nut end, and tapered off the whole length. A hole to clear spindle is drilled at the wide end, from the centre of which measure off $2\frac{1}{4}$ in. and bend up remainder at right angles. A glass bead (about $\frac{3}{8}$ in. in diameter) is fitted to allow of easy movement up and down the side of the box.

Fig. 158 shows a piece of brass 1 in. by $\frac{1}{2}$ in. by $\frac{1}{16}$ in. thick; a slot is cut in one side to fit the groove at the bottom of the spindle preventing up and down movement. Drill as shown and fix to the wooden base with two wood screws.

The bead end of the arm (Fig. 157) rests in the corner of the box and, coming into contact with the sides, prevents the nut from revolving.

A flexible lead is soldered to the top of the plate D, and another to the bottom of the plate F; these are taken through the top to terminals if and as required. Both plates D and F should be perfectly flat.

A piece of ebonite $3\frac{1}{4}$ in. by $3\frac{1}{4}$ in. by $\frac{1}{4}$ in. thick forms the top. A hole is drilled through the centre to clear the spindle, and four holes at $2\frac{1}{4}$-in. centres for screws fixing the plate D.

Tubular Variable Condenser.—The design of this condenser will, it is thought, be new to many readers, so a word or two as to its action is here given.

Referring to Fig. 159, which is an end view of the plates only of the condenser, it will be seen that as the inner plates C and D are each connected to the outer plate beneath which they lie, there is practically no capacity between the points X and Y. If, however, the inner plates are rotated in the direction indicated by the arrows, C will gradually pass beneath B, and D beneath A, thus giving a variable capacity between the points X and Y (that is, between the plates A and B, to which the connecting leads are attached), which is at maximum value when C is entirely underneath B, and D under A.

Specification.—Wood, 4 in. by 2 in. by $\frac{1}{2}$ in. thick. Ends: Plywood, $\frac{3}{16}$ in. thick, $2\frac{1}{2}$ in. by 2 in., cut to shape. Disc supporting outer plates, of wood, $1\frac{5}{8}$ in. in diameter by $\frac{3}{8}$ in. thick. Screws: Six small brass screws, say $\frac{1}{4}$ in. long. Plates and cover: One square foot of thin brass (or tinplate) will be ample for these.

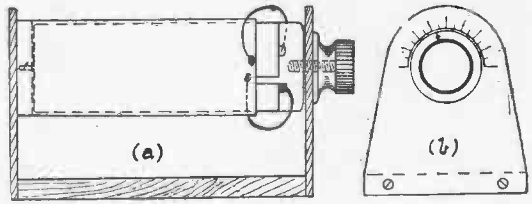
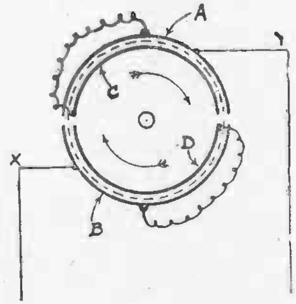


Fig. 160



Fi 159

Figs. 159 and 160.—Details of Tubular Variable Condenser

Roller carrying inner plates, wood, $1\frac{1}{2}$ in. in diameter by $3\frac{1}{2}$ in. long. Handle: Ebonite rod, 1 in. in diameter and 1 in. long. Leads: Short length (say 6 in.) of light insulated flex for connecting inner and outer plates. Dielectric: One piece of mica $5\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by (say) 1 mm.

With regard to the construction first prepare the wooden stand as shown in Fig. 160, and temporarily remove one end. Two small holes are to be drilled through the base near the end to which the fixed plates are attached, to permit the two connecting leads from the condenser to pass through. Next cut two pieces of the thin brass (or tinplate) each

$3\frac{1}{4}$ in. by $2\frac{5}{8}$ in., bend round the $1\frac{1}{2}$ in. diameter roller, and fit to the circular disc, securing thereto by means of the six small brass screws, so as to form a split tube $3\frac{1}{4}$ in. long by $1\frac{5}{8}$ in. in diameter having adjacent parallel edges about $\frac{1}{8}$ in. or $\frac{3}{16}$ in. apart, but for greater convenience have the slots vertically one above the other.

Place the $1\frac{1}{2}$-in. diameter roller inside the outer plates, and see that it is a very loose fit, having clearance of, say, $\frac{1}{16}$ in. all round. Also try it for length, by placing the other end of the stand (that is, the shaped plywood) against the end of the base as finally intended. The roller should clear this end by about $\frac{1}{32}$ in.

The two inner plates have now to be cut, each $2\frac{3}{4}$ in. by $2\frac{3}{16}$ in., with a small tab left on one corner, to which the flexible lead can be soldered. If these plates are bent round a 1-in. diameter roller, they can be sprung on to the $1\frac{1}{2}$-in. roller and will remain in place. The space between adjacent parallel edges of these plates should be the same as in the case of the outer plates. After trying in place and adjusting as necessary, remove and apply to the roller a coat of thick shellac varnish, springing the plates into position again when the varnish has become "tacky."

Prepare a very thin sheet of mica, by splitting up the sheet specified, of such dimensions as will enable it to be wrapped once round the roller and inner plates with an overlap of, say, $\frac{1}{2}$ in., and of a length to ensure the plates being well covered at the ends. Coat the outer surface of the plates (and the roller between) with thick shellac, and when "tacky" carefully wrap the

sheet of mica round same, fastening down the overlap with shellac.

When the shellac has thoroughly set, one end of the roller is to be fitted with a "bearing pin," consisting of a brass screw $\frac{3}{4}$ in. long with the head cut off, which turns in a central hole in the $1\frac{5}{8}$-in. wood disc.

The other end of the roller requires drilling to suit the screw attached to the ebonite handle; also there must be fitted the "coupling lever" made from a piece of strip brass and bent so that the end projects through the prepared slot in the ebonite front panel of the set.

Fig. 160 shows the completed condenser minus the cover, *a* being a side view and *b* a view of the front end showing the ebonite handle and scale.

Small stops, not shown, should be fitted to prevent the handle and roller being turned through more than 180°.

BUILDING A VARIABLE CONDENSER FROM STANDARD PARTS

As the reader is doubtless aware, various standard parts are obtainable for making a variable condenser, and the following information relates to the construction of one from such parts; the actual making of the parts is not dealt with, it being presupposed that the reader intends to purchase them.

Parts Required. — The necessary parts required are: Fixed vanes, moving vanes, large spacing washers, small spacing washers, centre shaft, studs for fixed vanes with nuts to fit, terminals, bushes, a spring or other contrivance to take up end thrust, pointer and 180° scale, a knob, and a pair of ebonite end plates.

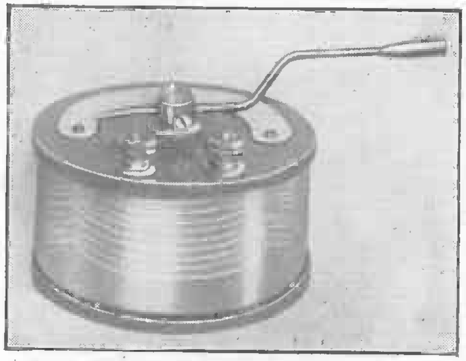


Fig. 161.—Standard Variable Condenser

The number of several of the parts required will vary in accordance with the required capacity of the condenser. The table below shows the number of fixed and moving vanes for various sizes of condensers. The most common size of the vanes now being sold is shown in Fig. 164, the material from which they are made being aluminium.

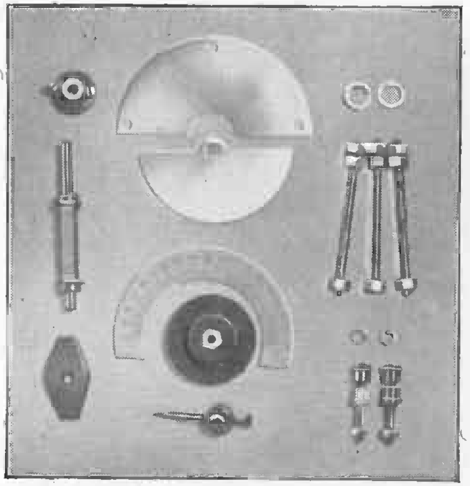


Fig. 162.—Parts of Variable Condenser

The number of large spacers required is one less than the number of moving vanes, and the number of small spacers is three times the number of fixed plates minus one. The half-tone reproduction (Fig. 162) shows a group of component parts, Fig. 163 showing a half-section and elevation of an assembled condenser. Fig. 161 shows a condenser of the dust-proof variety, the plates in this case being enclosed with a celluloid casing.

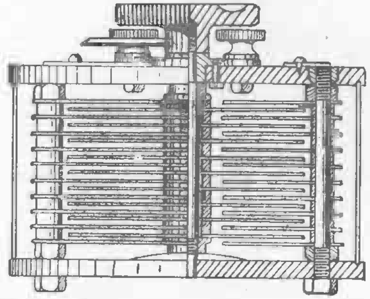


Fig. 163.—Half-section and Elevation of Variable Condenser

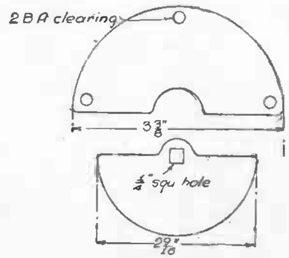


Fig. 164.—Plates of Variable Condenser

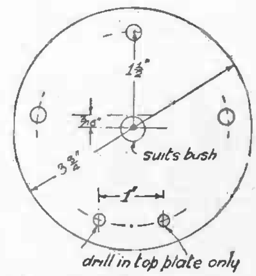


Fig. 165.—Ebonite Ends Marked Out

Assembling the Parts.—Assuming that the ebonite ends are not drilled, they should be marked out as shown in Fig. 165, the terminal holes being required on the top plate only. Drill the stud holes to suit the method of fixing provided, drill and tap the terminal holes and drill the bush and fixing screw holes. Look over the spacing washers and free them from any burrs

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or fins left by the parting tool during their manufacture (this item is very important, as if not attended to will throw the assembled vanes out of line). Commence the centre shaft assembling by screwing the bottom nut hard against the square shoulder, thread on the moving vanes and large spacers, commencing with a vane and locking the whole of them together by means of the top nut. It is, of course, obvious that these

No. of Fixed Plates	*No. of Moving Plates.*	*Approx. Capacity in mfds.*
43	42	·0015
29	28	·001
22	21	·00075
15	14	·0005
10	9	·0003
7	6	·0001
2	1	Vernier

NOTE:—The distance between the plates (the dielectric) is ⅛ in.

vanes are assembled in line with each other. The studs should be screwed into the top ebonite plate by the means provided, Fig. 166 showing three alternative methods of attaining this object. A shows the studs tapped into the ebonite, B showing them screwed by means of coned and slotted nuts recessed into the ebonite, and C shows cheese-head screws sunk flush into the ebonite and screwing into the tapped ends of the studs. At this stage it would be as well to make provision for connecting the fixed and moving vanes to their respective terminals, this being accomplished

by means of wire or copper foil. Fig. 167 shows a view of the under side of the top end plate, making this point clear. Lock the stud nuts securely against the under face of the top plate, taking care that the studs themselves do not project above the top face, as this will cause some trouble when fixing the scale. Commencing with a plate, assemble the fixed vanes and small spacers on to the studs, locking them in position with nuts.

Contacts.—Fig. 168 shows a method of securing a positive contact to the moving vanes by means of a strip of foil soldered at one end to the projecting end of the centre shaft and to a pin or terminal at the other, and is particularly recommended in cases where the condenser is to be either panel or cabinet mounted. Fig. 169 shows several methods of taking the end thrust of the centre shaft; A is a flat spring of springy sheet brass, B is a spring washer of special section also of brass, C is a screw bearing against the end of the shaft and working in a tapped bush in the bottom end plate. The scale is fixed by means of screws and occupies a position immediately over the fixed vanes. The pointer is set on the shaft to register with the 180° line of the scale, when the moving vanes are fully interleaved with the fixed vanes.

Index Pointers.—Fig. 170 shows various classes of pointers, A showing one fixed into a collar, which is secured to the shaft with a set screw. B shows one which screws directly into the knob, and C shows one of sheet metal fixed to the under side of the knob by means of small screws.

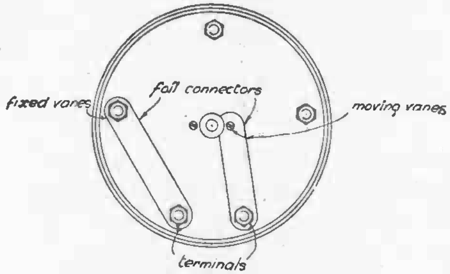


Fig. 167.—Bottom View of Top Plate showing Connections

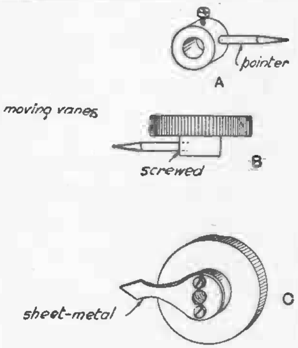


Fig. 170.—Various Methods of Making Pointers

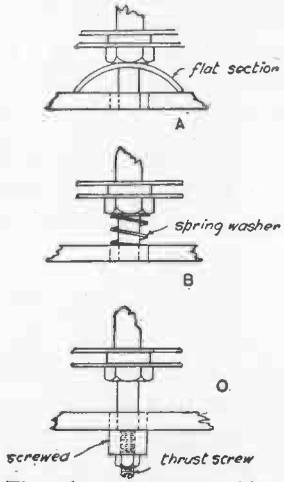


Fig. 169.—Methods of Taking End-thrust

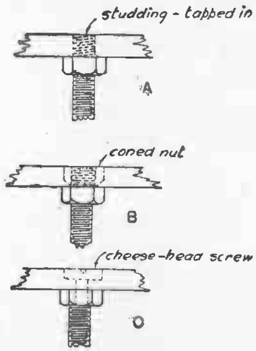


Fig. 166.—Methods of Securing Studs in Top Plate of Condenser

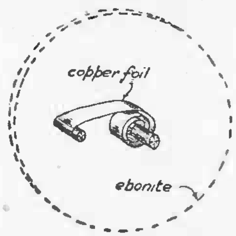


Fig. 168.—Positive Contact for Moving Vanes

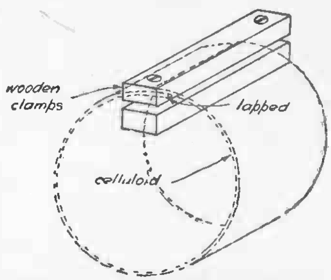


Fig. 171.—Method of Making Celluloid Cover

Celluloid Shield.—The condenser should be provided with a shield capable of excluding dust or other foreign matter (liable to cause trouble) from the vanes. This is usually arranged by surrounding the vanes with a cylindrical celluloid sheath, the end plates being grooved or recessed to accommodate it. The sheet celluloid, cut to a sufficient length to allow a lapped joint of $\frac{1}{4}$ in. to be made, may be satisfactorily jointed by clamping between wooden clamps as shown in Fig. 171, amyl-acetate or acetone being applied to the joint by means of a camel-hair brush and leaving in the clamps until dry.

CHAPTER V

Variometers and Vario-couplers

THE only difference between a variometer and a vario-coupler, as stated in the first chapter, is that in the latter the windings are kept separate, each winding forming part of a distinct circuit, and a variation of the position of the coils produces changes in the strength of the coupling between the two circuits. As the construction is almost identical, only the construction of a variometer need be dealt with.

THE VARIOMETER

Construction. — The variometer consists of two honeycomb coils. They should be made about $\frac{1}{2}$ in. wide and 2 in. internal diameter. They should be wound with fairly thick wire, say 24 gauge d.c.c. High-frequency cable will give even greater efficiency, but is very expensive and is not an essential.

The inner coil is wound first, then the wire is cut off and string wound on to form a layer about $\frac{1}{4}$ in. thick. The outer coil is wound on top of this. On completion the whole must be dipped in melted paraffin wax or shellac varnish, and when set, the string carefully removed, thus separating the two coils. The end of the inner coil and the beginning of the outer must be connected by a few inches of flexible wire (if high-

frequency cable is used it need not be cut; just leave a loop of it between the two sections of the coil when winding).

The outer or fixed coil may be mounted in the standard way, if desired, but this is somewhat expensive and is not necessary for a variometer. A simple method is to cut with a fretsaw in three-ply wood a

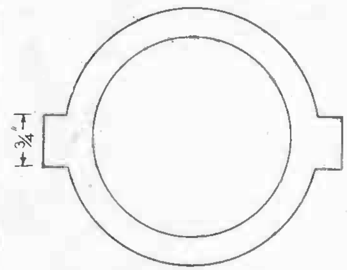


Fig. 172.—Support for Fixed Coil

Fig. 173.—Support for Moving Coil

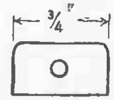


Fig. 174.—Support for Spindle

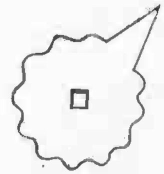


Fig. 175.—Pointer

ring the same size as the coil, leaving a tab at each end as shown in Fig. 172. The coil is then placed on this, and tape is wound round both coil and wood to hold them together. Rubber tape will be found rather too thick and messy for this, and ordinary black tape fastened on with thin glue will make a much neater job. The inner coil should also be taped in the same way, but without a wooden support. To hold the inner coil a piece of wood should be cut as shown in Fig. 173.

The coil can be pulled slightly oval to enable it to be slipped into the slots at the ends.

The two coils have now to be fixed in position so that the inner one will revolve with the outer. Place one inside the other and push a thin spindle (preferably of wood or ebonite) carefully through the windings. A spot of glue on the spindle where it goes through the strip which holds the inner coil will fix the latter to the spindle. An ebonite knob with pointer may be fixed on the end of the spindle, or a serviceable one can be cut out of cigar-box wood with a fretsaw, shaped as shown in Fig. 174.

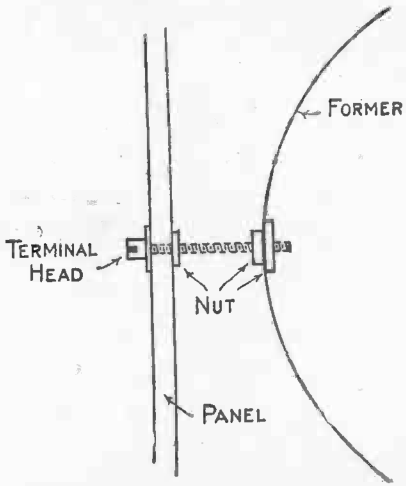


Fig. 176.—Method of Mounting Variometer.

To mount the variometer on a panel a hole is made in the latter to take the spindle. Two small pieces of wood, cut as shown in Fig. 175, are fixed at right angles to the tabs on the outer coil holder. The first is then screwed to the back of the panel, the second one forming a bearing for the spindle. Another method of mounting is shown in Fig. 176. A scale (0° to 180°) is fixed on the front of the panel, and two terminals.

Connections to Set, etc.—A small variometer of this type may with advantage be made to replace a variable condenser in any set. It must, of course, be connected in series with the existing coil, not in shunt like the condenser. Larger ones may be made to cover a greater range; for instance, one with forty turns on each coil make a useful short-wave tuner with a range of about 300 to 900 metres. A set of honeycomb coils may be used in conjunction with such a variometer to cover any range. If the variometer is required to tune to a lower wavelength the two coils should have equal inductances; less turns must then be put on the outer coil to compensate for its greater diameter.

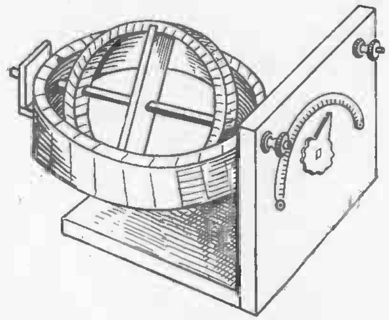


Fig. 177.—Variometer Complete

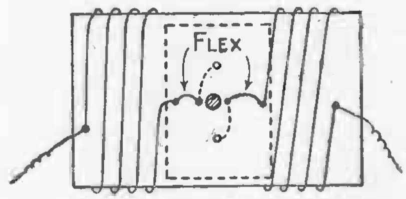


Fig. 178.—Details of Connections

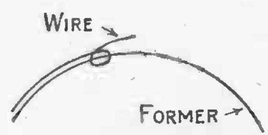


Fig. 179.—Finishing Off End of Winding

Some Alternative Constructional Details.—A drawback to a home-made variometer is that it is often difficult to connect the movable and fixed windings together. This difficulty can be overcome by the method shown in Fig. 178.

The outside former is wound in two halves, sufficient distance being allowed between for the width of the spindle. Finish off the four ends of the outside former and the two ends of the inside one, as shown in Fig. 179, to prevent the coil unwinding. If the

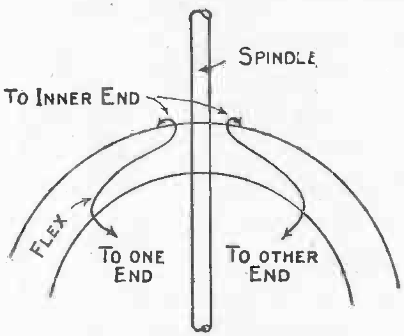


Fig 180.—Method of Making Connections

holes are slightly larger than the wire and shellac is dropped in, the insulation will be sufficient.

A soft, flexible rubber-covered flex is then fastened between the two inner ends of the outside former and the two ends of the inner coil, but the holes through the two formers must be copied as shown in Figs. 178 and 180; the rubber flex passes through both formers.

CHAPTER VI

Resistances or Rheostats

TYPES OF RHEOSTAT

Sliding Rheostat.—The sliding type is shown in Figs. 181 to 183. There are modifications of this type, as, for example, those with two cylindrical coils and those with one rectangular coil. This particular type has one cylindrical coil and is well suited to amateur construction, having no cast parts. The former (**A**) in this type is usually either solid slate, hollow porcelain, or enamelled iron tube, but any material with sufficient mechanical strength can be used, this having been determined in the design. The only material which has serious mechanical objections is wood, as it shrinks when the wire gets warm and the latter then comes loose.

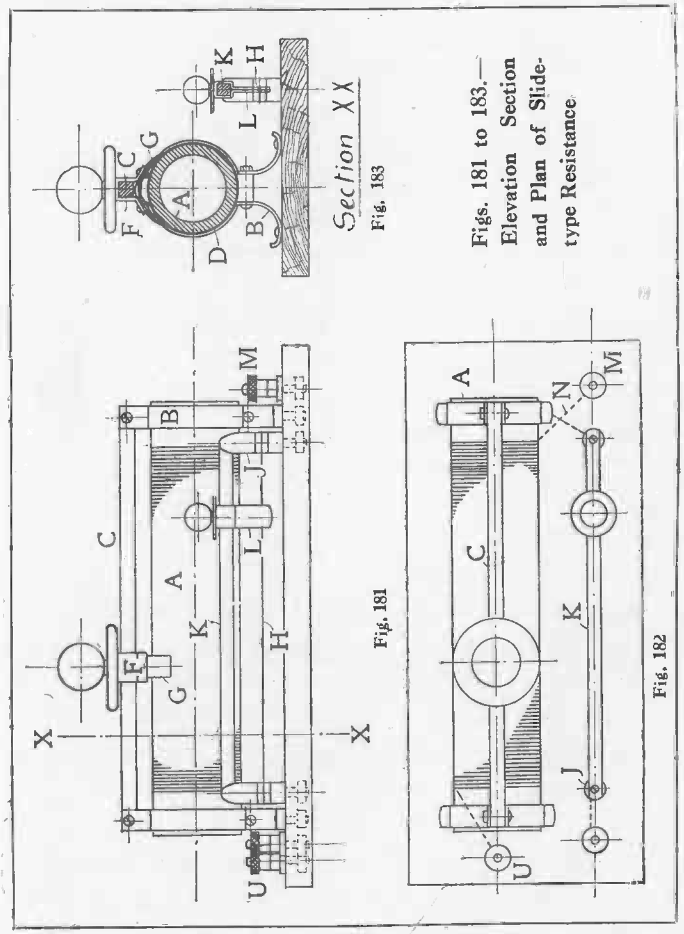
When bare wire, or in fact any wire larger than about No. 20 S.W.G., is used, as mentioned before, a space must be left of about half its diameter, and in this case the former must be threaded.

When the former is made the wire is wound on and fixed at each end by being passed through a hole and soldered. A sufficient length is left blank at each end to accommodate the standards B, the former projecting slightly at each end. The standards are made in two halves, bent to shape from steel strips of a sufficient thickness to give the legs the necessary rigidity. The halves are clamped together round the former with bolts and nuts as shown. The guide C is clamped in the top, a spacing block D in the bottom. If the former is fragile a strip of fibre D is placed under the ring.

Substance	ρ	*Substance*	ρ
Advance	19.2×10^{-6}	Krupp Metal	33.4×10^{-6}
Argentan	11.2 ,, ,,	Lead	7.8 ,, ,,
Calido	39.3 ,, ,,	Manganin	16.5 ,, ,,
Climax	34.7 ,, ,,	Monel Metal	16.1 ,, ,,
Constantan	19.3 ,, ,,	Nichrome I	38.8 ,, ,,
Copper	0.63,, ,,	Nichrome II	42.6 ,, ,,
Eureka	18.5 ,, ,,	Nickel	3.9 ,, ,,
Excello	36.0 ,, ,,	Platinoid	18.4 ,, ,,
Ferro-Nickel	11.1 ,, ,,	Resista	29.9 ,, ,,
German Silver	13.0 ,, ,,	Rheostan	17.5 ,, ,,
Ideal	19.3 ,, ,,	Rheostine	29.9 ,, ,,
Ia Ia	18.9 ,, ,,	Rose's Metal	25.4 ,, ,,
Pure Iron	3.48,, ,,	Superior	34.3 ,, ,,
Soft Steel	4.6 ,, ,,	Therlo	18.4 ,, ,
Hard Steel	17.9 ,, ,,	Wood's Metal	22.2 ,, ,,
Soft Cast Iron	29.3 ,, ,,	Zinc	2.1 ,, ,,
Hard ,, ,,	38.9 ,, ,,		

The guide C is of square brass rod, and carries the slider, which is surmounted by an insulating disc and a knob. The bridge, or saddle, F fits on the guide, and has five or six layers of thin phosphor-bronze or hard brass strip G screwed to it. These form the contacts, and are bent round in the manner shown, so as to spring stiffly on to the surface of the coil. The top strip is bent up slightly in the centre, so as to act as a

spring, bearing against the under side of the guide as shown in the section.



Figs. 181 to 183.—Elevation Section and Plan of Slide-type Resistance

As the instrument is shown, it has an improvement in the form of a slide wire H for fine adjustment. It is fixed at each end to the brass pillars J which are fixed to the base by nuts from underneath, and which also carry the guide K. The wire is insulated from the pillars by small fibre bands, as shown. The slider in this case carries a clip L of brass or phosphor-bronze, which makes firm contact with the wire, the length of which should be at least a turn and a quarter of the coil. The connections of the instrument are as follows: The current enters at the terminal M, goes to the coil via the thick copper wire N, up through the slider to the guide C, back to the standard B, down a thick copper wire to the slide wire, up the slider to the guide, and to the other terminal via the pillar J. The connections are so arranged that to increase the resistance both the coarse and fine adjustment sliders are moved in the same direction to avoid confusion in use.

A third terminal U is provided, which is connected to the other end of the main coil so that the instrument may be used as a potentiometer. In this case the supply is connected across the main coil and a tapping of any desired fraction of the supply E.M.F. taken from one end of the coil and the slider. If it is desired to dispense with the fine-adjustment wire no wooden base is needed, two of the terminals in this case being fixed to brass bands clamped round the former at each end, and the third to any part of either standard, or one end of the guide. This is the more usual arrangement. The brass parts should be lacquered.

Rotary Rheostats.—The small rotary type of rheostat (Figs. 184 and 185) is of interest as being that most usually employed for the valve-filament current

regulator in wireless receiving sets. The actual construction of filament resistances is dealt with later in the chapter. The construction is fairly well explained by the figures. The only point which might not be quite lucid is the coil. The former is made from a circular section or ebonite or erinoid rod, which is screw-cut. The coil is first wound in the lathe on a mandrel slightly smaller than the former, and is then screwed on to the former, which has afterwards to be bent round into a circle by the application of boiling water. The coil, when made, is pressed into a groove turned or cut in the face of the ebonite panel, the ends being secured with small brass straps as shown. The latter is bushed with brass to take the spindle, which carries a brass or phosphor-bronze contact arm, springing stiffly on to the coil. The part which makes contact is bent up at each side so as to move smoothly over the turns of wire.

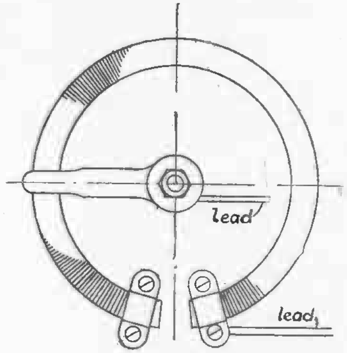


Fig. 184

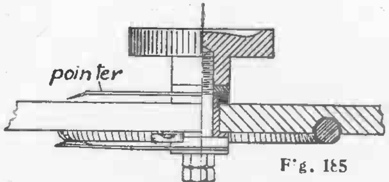


Fig. 185

Figs. 184 and 185.—Underneath Plan and Part Section of Rotary Resistance

Nowadays it is often the practice (not to be recommended) to omit the bent former altogether, using instead a disc with a groove round the edge into which the coil is sprung. This type is simpler, but the coil is liable to get pulled out, causing endless annoyance.

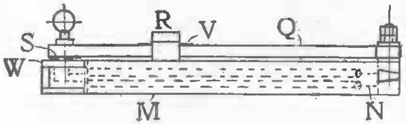


Fig. 186

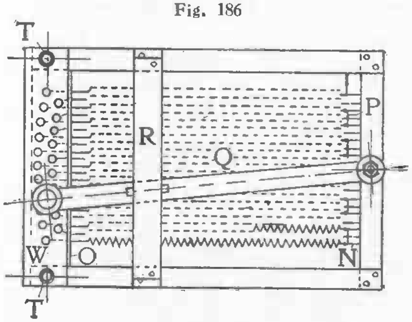


Fig. 187

Figs. 186 and 187.—Side Elevation and Plan of Open-coil Rheostat

Open-coil Rheostats.—One more type of wire rheostat is the old-fashioned open-coil type shown in Figs. 186 and 187. This is suitable for heavier loads than the preceding types.

In this case the great point to be observed is that all the coils must be kept at least 1½ in from any wood part. Beech is the best wood to use, but any fairly hard wood will do. The frame M is dovetailed and pinned together as shown. Two rows of coils are sprung between the screw-eyes N, which are fastened into the back bar of the frame, and the slate panel O, which is pierced with holes corresponding to the screw-eyes. Two coils are made together, with a straight piece P between them, which is passed through two adjacent screw-eyes. The two other ends are fastened, each with its neighbour from the next coil, through the

holes in the slate, to the two brass studs corresponding to the eyes. Thus there is one stud for every two coils. It is as well to line the under side of the stud panel W with asbestos sheeting. The arm Q is pivoted to the centre of the back bar, and is kept down to its work by the bridge R. A piece of thick copper wire conveys the current from the brass spring contact S, which bears on to the studs, through the arm to the spring contact V, which in its turn bears up against copper strip fitted along the bridge R.

The terminals T are screwed into the frame as shown, one being connected by thick copper wire to the end stud on the left-hand side and the other to the copper strip under the bridge R.

MAKING FILAMENT RESISTANCES

So far this chapter has explained the working principles of the various types. Space is now devoted to the making of filament resistances of orthodox types and various constructions.

Flat Type.—For this type (Figs. 188 and 189) a length of bare resistance wire is wound on to an ebonite or wood former and spaced by winding thin string on at the same time. A suitable size for the former is 1 in. by 2 in. by ¼ in. thick. Ebonite is best to work with.

A moving radial arm is arranged to traverse the resistance wire; one contact being made to this arm, the other to one end of the wire.

Using 28 S.W.G. resistance wire, twenty turns will be required on a former 1 in. wide, 2 in. long by ¼ in.

thick. This will allow a space at one end for the "off" position.

While this arrangement is quite suitable for the filament of an amplifying or magnifying valve, the

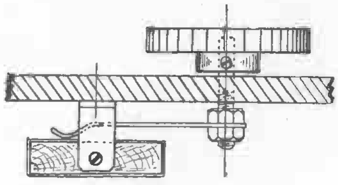


Fig. 188

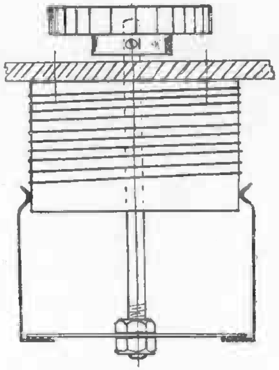


Fig. 190

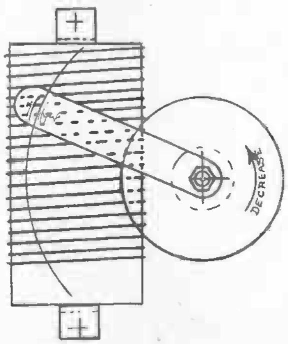


Fig. 189

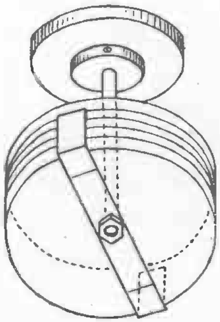


Fig. 191

Figs. 188 and 189.—Elevation and Plan of Flat-type Filament Resistance

Figs. 190 and 191.—Elevation and Under-side View of Rotary Resistance

objection is that there are really only twenty positions for the moving contact arm, and the difference between one position and the next is too large to give the fine adjustment required for a detecting valve.

Rotary Type.—The rotary type (see Figs. 190 and 191) overcomes this difficulty. Ten turns of wire are wound on to a former 1⅝ in. diameter and 1 in. long (using 28 S.W.G. uncovered resistance wire and spacing it with thin string, which is afterwards removed). This gives the required resistance of 5 ohms. A space is left at the bottom of the former for the off position.

A spindle passed down a hole exactly in the centre of the former has a knob on the upper end arranged to stick through the panel, on which the resistance is mounted. This spindle carries on its bottom end a cross-piece of the same length as the diameter of the coil. At each end of this horizontal cross-piece is fixed (soldered or bolted) a springy vertical contact arranged to rub on the resistance wire.

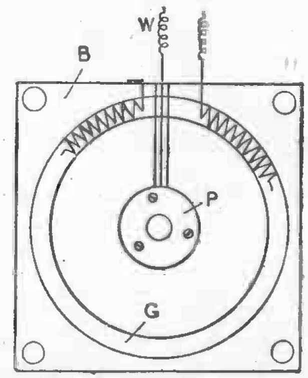


Fig. 192.—Details of Grooved Base of Filament Resistance showing Position of Coil

Another Type of Rotary Filament Resistance.—Figs. 192 to 194 give the constructional details of a rotary filament resistance.

The base B is set in the lathe and a hole $\frac{5}{16}$ in. in diameter is drilled in the centre of the base to take the plate P, which will be described later.

The groove G is now turned, using a round-nosed tool in the slide-rest and lubricating the work with turps to prevent the tool overheating.

The groove should be turned out to a depth of $\frac{3}{16}$ in., and must be kept as circular as possible to ensure the resistance coil being held firmly in position.

The fixing ring R, the purpose of which is to keep the resistance coil in place, is now turned up out of $\frac{1}{8}$ in. material. Three holes, to take countersunk screws, are drilled in the ring, while the edge of the ring is undercut. The ring, when placed on the base B, should have the undercut edge coincide exactly with the edge of the groove G, the two forming part of a circle in which lies the resistance coil. When the ring R is screwed down the resistance coil should be held firmly in position.

Fig. 193.—Section of Fixing Ring

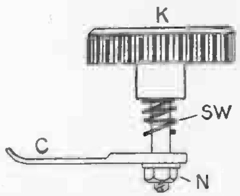


Fig. 194.—Details of Selector Switch

The Resistance Coil.—The resistance coil itself is made by coiling up a length of No. 20 S.W.G. resistance wire on a brass rod $\frac{5}{16}$ in. in diameter. A coil about 7 in. long is required, and after winding the coil should be stretched slightly to separate each turn.

A small hole should now be drilled through the side of the base B so as to break through into the groove G; one end of the resistance coil should be pushed through this hole as shown in Fig. 192. The end of the coil is cut off short, leaving just sufficient to bend over. The coil is then carefully laid in the groove G and cut off to length, the end being passed through a

second hole in the side of the base, sufficient wire being left to connect up to the rest of the apparatus.

The ring R is then screwed down to fix the coil permanently in position.

A small boss P with a flat shoulder is turned in the lathe to form a bearing surface for the contact shown in Fig. 192. Three holes are drilled in the flange for the purpose of securing the plate to the base B, while the centre of the boss is drilled out to $\frac{3}{16}$ in., in which the spindle of the contact rotates.

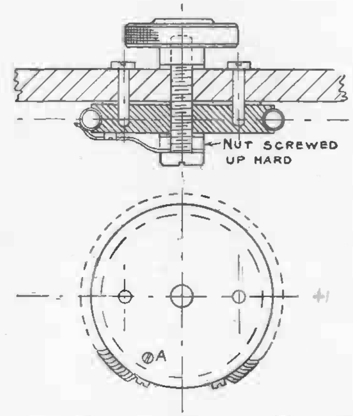


Fig. 195.—Section and Plan of Filament Rheostat

The contact or selector arm is shown in detail in Fig. 194, K being an ebonite knob into which is screwed a spindle, on the end of which is fitted the contact finger C. A small square shoulder is filed on the spindle to fit into a corresponding square hole in the contact C, which is held firmly in position by the nut N. A spring washer S W serves to keep the contact C always firmly against the resistance coil.

The contact C is curved slightly at the end to provide a large surface for contact with the resistance coil; it is also filed thin three parts of its length, as shown in Fig. 194, to make it more springy. A variation of this form of construction is given in Fig. 195.

CHAPTER VII

Transformers

For an explanation as to the function of various transformers, reference should be made to Chapter I. There are several forms of construction, but there is no need to detail all of them. The telephone transformer will be described first, and then high- and low-frequency intervalve transformers.

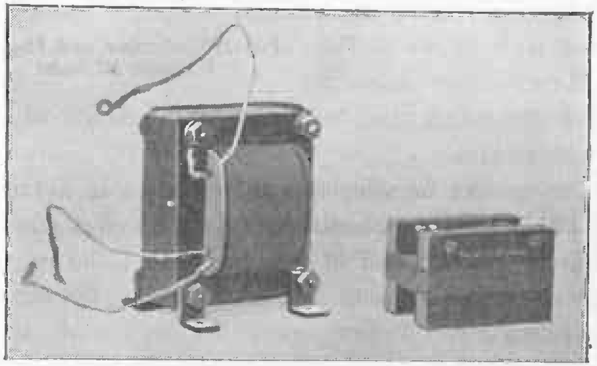


Fig. 196.—Two Patterns of Intervalve Transformer.

A TELEPHONE TRANSFORMER

Its Elements.— The telephone transformer consists of an iron core, closed or open, on which is wound two separate coils, well insulated from one another. They may be wound side by side or one over the other. If the telephones are of high-resistance, say 4,000 ohms,

the windings may each have the same number of turns, but there is no reason why low-resistance phones should not be used, in which case the ratio of the number of turns on primary and secondary should be between 5 and 20 to one.

The following notes describe a telephone transformer for a pair of 300-ohm phones, but of course the information, with modifications, is generally applicable. It includes a condenser across the primary, so that there is no need to use an external condenser.

The Iron Core.—The core is made of a bundle of iron wires; about $\frac{1}{4}$ lb. No. 20 S.W.G. is ample. The wire is straightened out and cut into 10-in. lengths. A piece of $\frac{1}{2}$-in. diameter fibre tube 3 in. long and two pieces of ebonite $1\frac{1}{2}$ in. square and $\frac{1}{4}$ in. thick should then be obtained. Holes $\frac{1}{2}$ in. in diameter are to be drilled in the centre of each end, and they are driven over the ends of the tube to make a bobbin.

The bundle should be $\frac{3}{8}$ in. in diameter.

The Windings.—The secondary winding is wound first. It should be noted that in a step-down transformer the high-resistance winding will be the primary and the low-resistance the secondary. It is more convenient to wind the secondary on first.

Single-cotton-covered 32 S.W.G. wire will serve. This makes about 1,000 turns. The ends of the wire are brought out through little holes in the cheeks of the bobbin, and two layers of paraffin-waxed paper are put over the winding. The covering round the secondary is well smoothed down with a piece of warm brass strip.

The primary winding consists of about 14,000 turns of No. 42 s.w.g. single-silk-covered wire (weight about 1½ oz.) or 2 oz. of No. 40. The ends of the wire are soldered to pieces of No. 26-gauge wire to make strong leads. About 2 ft. of wire should be used for the inside end. When this has been soldered it should be wound once or twice round the bobbin and then another piece of paper laid on. The end can be brought out through a hole in the cheek of the bobbin or between two cut paper washers, which are slipped on the core and pressed against the cheek as shown in Fig. 197. The wire is then wound on the core evenly and carefully from end to end.

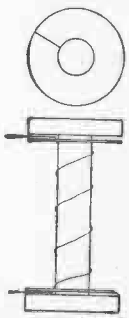


Fig. 197.—Method of Bringing Out Wire Between Paper Washers

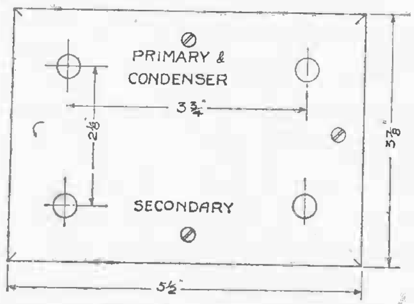


Fig. 198.—Plan of Lid

When finished, the end of the wire is joined to a piece of No. 26 as before and the whole covered with a layer of paraffined paper. The coil wires are then placed in position and bent round the sides of the bobbin to overlap. They can either be spread out evenly all round, umbrella fashion, or all kept together. If they are bent round all in the same direction, they can be tied together and bound round with tape to make them tight.

Testing the Transformer.—The transformer is now complete, and the windings should be tested for continuity. To do this each winding is connected in series with a telephone and a dry cell. When the circuit is made and broken a loud click should be heard in the telephone. Both primary and secondary should be tested this way. This is done by connecting one lead from the telephone to the cell, the other to an end of the secondary, and the other terminal of the cell to the primary. No noise should now be heard. The condenser, which is connected across the primary, consists of twenty sheets of tinfoil 3 in. by 1½ in. and twenty sheets of thin white paper 2½ in. by 2 in. Typing paper is convenient for this purpose. It is cut up into strips 2 in. wide and soaked in wax. The strips are then hung up to cool and cut into 3-in. lengths. The condenser is built up to allow ¼ in. space for the paper to overlap the foil.

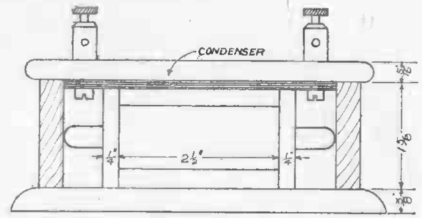


Fig. 199.—Sectional Elevation of Transformer

The Connecting Wires.—The connecting wires are cut to about 4 in. long, and pieces of rubber tubing are slipped over them. The condenser is fastened under the lid of the box and clamped down with the primary terminals as shown in the drawing, Fig. 199. The rest of the wires can then be connected up. The diagrams (Figs. 198 and 200) are self-explanatory.

INTERVALVE TRANSFORMERS

H.F. Transformer.—For a high-frequency air-core intervalve transformer one piece of ebonite $1\frac{3}{4}$ in. in diameter by 2 in. long will be required for the bobbin, sixteen No. 9 B.A. brass screws each $\frac{3}{8}$ in. long for the connecting pins, and for the windings approximately 2 oz. of No. 40 S.W.G. d.s.c. copper wire or, alternatively, $2\frac{1}{2}$ oz. of No. 38 S.W.G. d.s.c. wire; but in this case the ebonite bobbin should be 2 in. in diameter. Two pieces of soft brass strip each $1\frac{1}{4}$ in. long by $\frac{5}{8}$ in. wide and $\frac{1}{16}$ in. thick and four No. 4 B.A. brass screws will be necessary for the brackets.

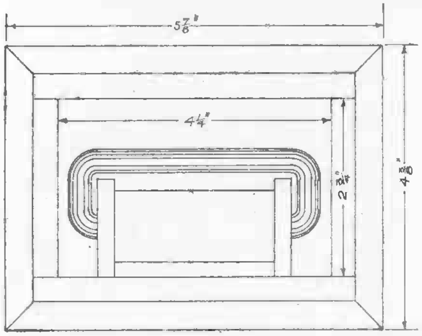


Fig. 200.—Diagram showing Position of Transformer in Case

A $\frac{1}{4}$-in. hole is bored through the centre of the bobbin, and eight parallel grooves are cut in it, each groove being $\frac{3}{32}$ in. wide by $\frac{1}{2}$ in. deep ($\frac{5}{8}$ in. deep in the case of the 2-in. bobbin). The thickness of ebonite between adjacent grooves is to be $\frac{1}{32}$ in. and $\frac{1}{4}$ in. at each end. Small holes are to be carefully drilled and

tapped, and the sixteen small brass screws (with heads cut off) are to be screwed in place as shown in Fig. 201, having first had their points dipped in shellac varnish to prevent any tendency of the screws to work loose later.

Bend and drill the soft brass strips to make the two securing brackets. The necessary holes for these should also be drilled in the ends of the bobbin and tapped for No. 4 B.A. screws; but the brackets themselves should not be fixed in place until after the winding is completed.

Before commencing to wind the transformer carefully "tin" the projecting portion of each connecting pin. The use of separate pairs of pins enables the winding in each groove to be tested for continuity, thus facilitating the locating and repairing of any fault which may occur.

In each of the eight grooves are to be wound 400 turns of wire, the commencing and finishing ends of each section being temporarily wound round the respective connecting pins as the winding proceeds. All sections are to be wound in the same direction, and particular care must be exercised when connecting sections in series to preserve this correct direction.

Sections 1, 3, 5 and 7 are to be connected in series to form the primary winding, and sections 2, 4, 6 and 8 similarly to form the secondary. The ends of each section are to be carefully freed of insulation and soldered to respective connecting pins, and each section tested for continuity by means of a single dry-cell and telephone receiver, after which the sections may be connected together by short pieces of bare copper wire (say No. 26 S.W.G.) as shown in Fig. 201.

When these connections are all made the continuity of each complete winding and the insulation between windings should be tested with cell and telephone, as before, and if found correct the completed transformer may be fitted in the containing box.

L.F. Transformer.—A simpler type of transformer may be made in accordance with the following particulars. Core: $\frac{3}{8}$ in. in diameter by $5\frac{1}{2}$ in. long of soft Swedish iron wires, say No. 30 or No. 32 S.W.G., carefully bundled together and tightly bound for $1\frac{1}{2}$ in. in the centre with silk tape and dipped in molten paraffin wax, subsequently being drained and hung up to set. The foundation-tube is $1\frac{1}{2}$ in. long by $\frac{3}{8}$-in. bore made by wrapping stout drawing-paper of correct width three or four times round the taped portion of the iron core, securing with shellac varnish applied during the wrapping process, and when set removing from the core. The winder or coil former should consist of two brass discs, each $\frac{1}{8}$ in. or $\frac{3}{16}$ in. thick and $1\frac{1}{2}$ in. in diameter with separating bush of brass, $\frac{3}{8}$ in. outside diameter by $1\frac{1}{2}$ in. long, the whole being secured on a $\frac{3}{16}$-in. spindle by means of $\frac{3}{16}$-in. brass nuts. The spindle is to be cranked to form a handle by means of which the complete former may be rotated.

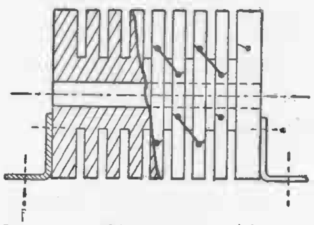


Fig. 201.—Former for Air-core Transformer

When assembling the former ready for the winding, two discs of drawing-paper, each $1\frac{1}{2}$ in. in diameter, are to be placed in position, one against the inner face of each brass disc, with the paper foundation-tube on the brass bush between them.

Primary winding consists of about twelve layers, approximately 2,500 turns, and occupying a depth of about $\frac{3}{16}$ in. of No. 38 S.W.G. d.s.c. copper wire. Approximate weight of wire $1\frac{1}{4}$ oz. insulation between windings: Two layers of thin silk tape $1\frac{1}{2}$ in. wide, previously dipped in molten paraffin wax and pressed between blotting-paper. Secondary winding consists of about 10,000 turns of No. 42 S.W.G. d.s.c. copper wire, to fill remaining space on former up to $\frac{1}{16}$ in. of the edge of the brass discs. Approximate weight of the wire is 2 oz. For the outer insulation four layers of silk tape (waxed as before) or two layers of empire cloth, the lap-joint being secured with a little Chatterton's compound, are required. A further alternative is to wrap carefully with ordinary sticky tape as used by electricians.

Avoid the use of shellac varnish in the body of the windings, but use it on the foundation-tube and first layer of the primary, on the first layer of the secondary, and liberally throughout on the inner faces of the two paper discs and adjacent turns of wire.

When the winding and insulation are complete, the brass winder is taken apart and the windings removed and placed in position on the iron core.

Fig. 196 shows two patterns of intervalve transformer.

CHAPTER VIII

Making a Test Buzzer

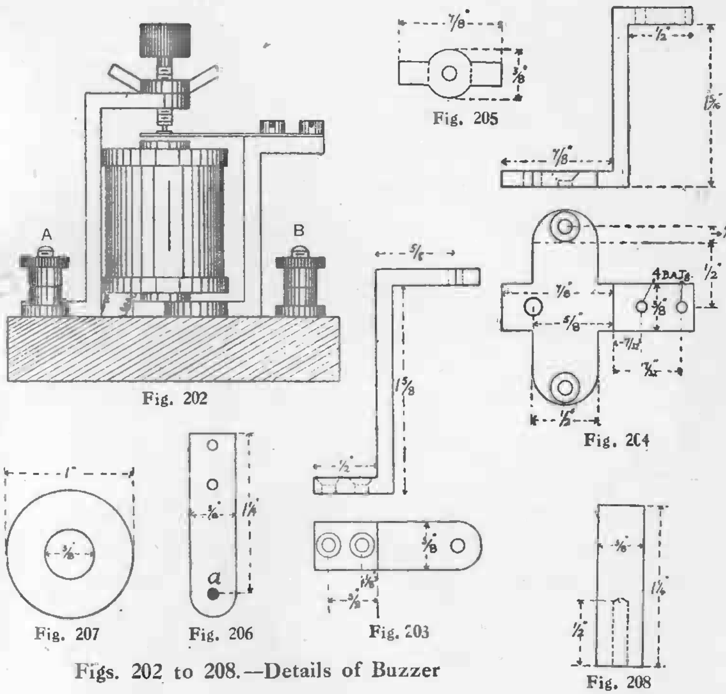
FIG. 202 on the next page shows a side elevation of a test buzzer. The contact-screw standard (Fig. 203) is made from $\frac{1}{8}$-in. sheet brass, and the magnet frame (Fig. 204) is made of $\frac{1}{8}$-in. soft sheet iron. The wing-nut (Fig. 205) is of $\frac{1}{8}$-in. sheet brass. When cut to the shape and dimensions of Fig. 205 bend up the wings as shown in Fig. 202.

The Armature.—Thin clock-spring is used for the armature (Fig. 206). The fixing-screw holes are 4 B.A. clearance, and should be drilled to correspond with their associating holes in the magnet frame. A hole is drilled at *a*, and a piece of platinum wire is driven into it.

The Coil Cheeks and Core.—Ebonite $\frac{1}{8}$-in. thick is preferable for the coil-cheeks (Fig. 207). Make the core of the coil (Fig. 208) of soft iron. The lower end is drilled and tapped 2 B.A. for the purpose of affixing the coil to the magnet frame. The cheeks are affixed with shellac varnish so that the ends of the core project for a distance of $\frac{1}{16}$ in. That portion of the core between the cheeks is covered with waxed paper.

Winding.—The wire used is No. 30 silk-covered. The contact screw is 4 B.A., and is fitted at one end with a platinum contact and at the other with a small knurled ebonite knob.

Fasten the coil to the magnet frame with a $\frac{5}{8}$-in. 2 B.A. screw, and then screw the armature spring into place with two $\frac{1}{8}$-in. 4 B.A. screws. Fit the contact screw and wing-nut to the standard and then screw these portions on to the base. One end of the winding



Figs. 202 to 208.—Details of Buzzer

is taken to A, the other end is soldered on to the base of the contact-screw standard, the magnet frame is connected to the other terminals and is connected to the contact-screw standard.

A and B are connected to a battery of two dry cells with a tapping key in circuit.

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