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For Amateur & Experimenter

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CONDENSER UNIT
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SPECIAL THREE-FOLDER PLATE OF

SIMPLY-MADE CONDENSERS

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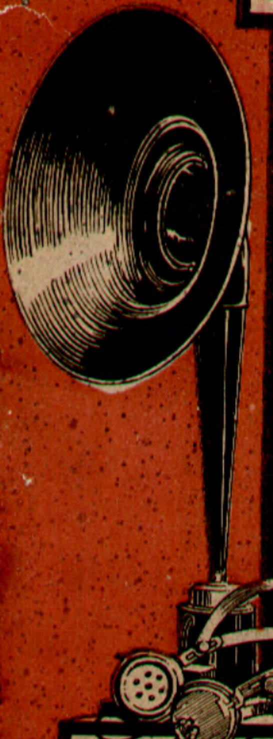

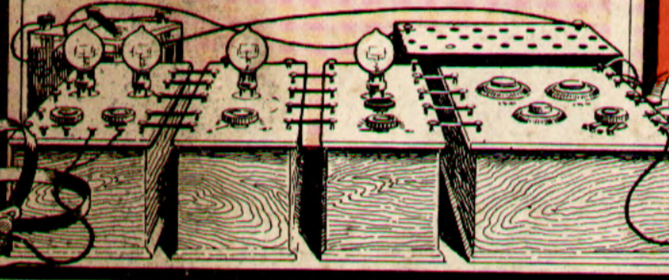

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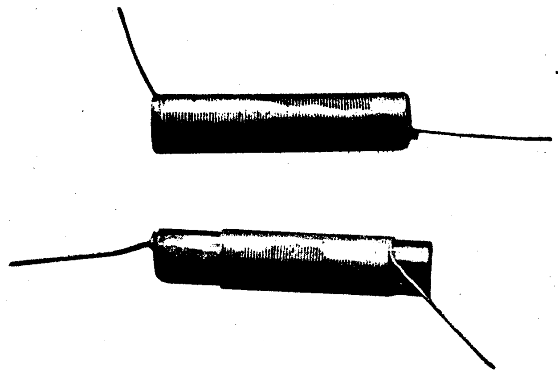

Fig. 24. Condenser made by wrapping mica round a brass tube, with outer winding of copper wire

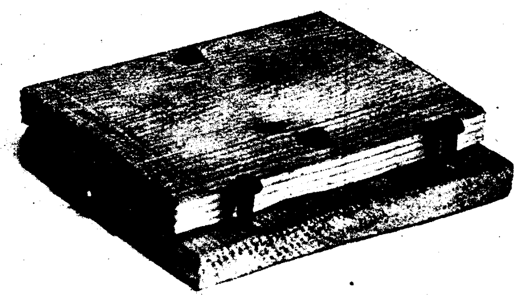

Fig. 25. Quickly-made fixed condenser for experimental purposes.

Fig. 26. Plates and insulating sheets for the fixed condenser. Holes at ends take terminal screws

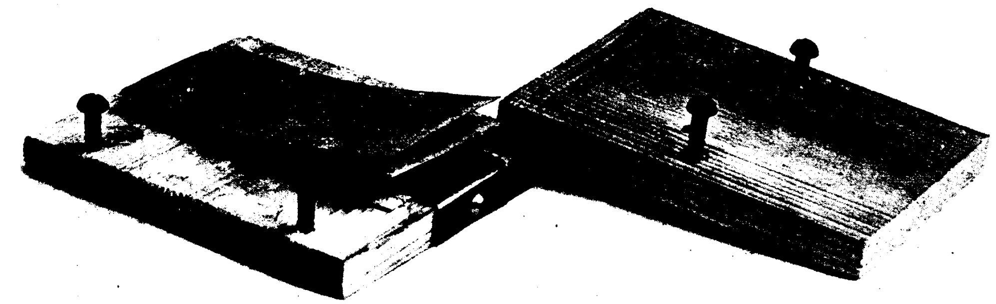

Fig. 27. How sheets of foil and insulation are assembled. Note method of turning foil over end of board, the screw being used as a terminal

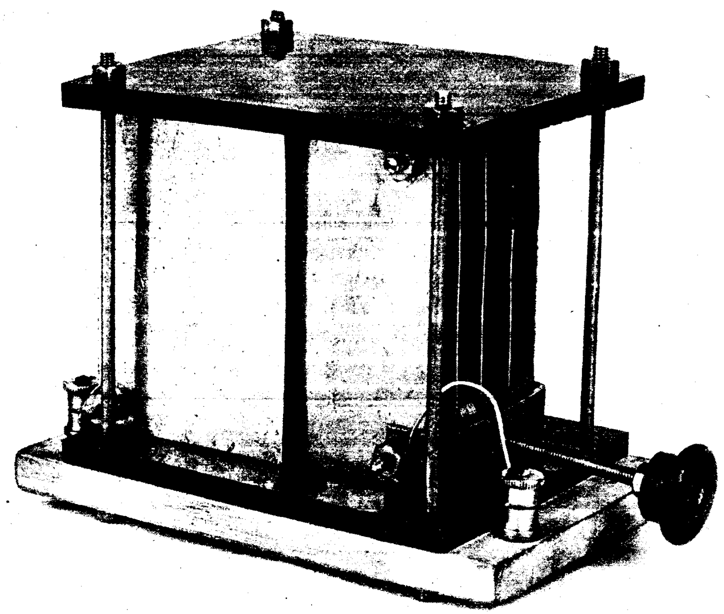

Fig. 28. Home-made variable condenser with vertical plates mounted on wooden base impregnated with paraffin wax

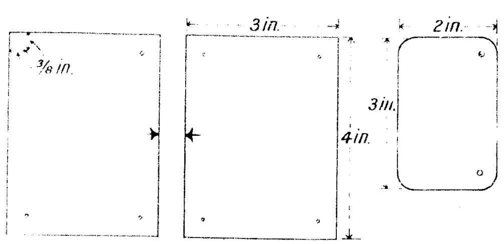

Fig. 29. Dimensions of top and bottom ebonite plates and (right) of fixed and moving plates

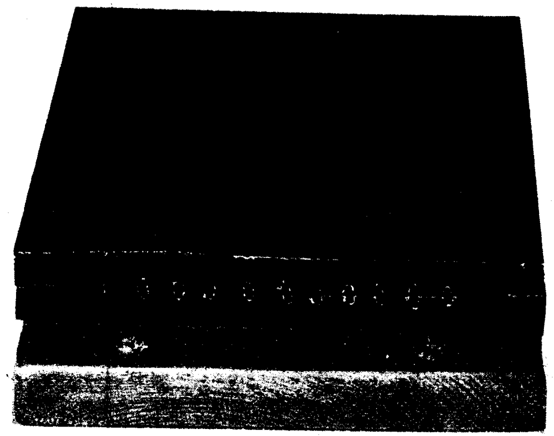

Fig. 30. Top and bottom ebonite plates, showing correct registering of slots for plates

Fig. 31. Cutting the slots in the ebonite plates by means of a hacksaw guided by saw blade

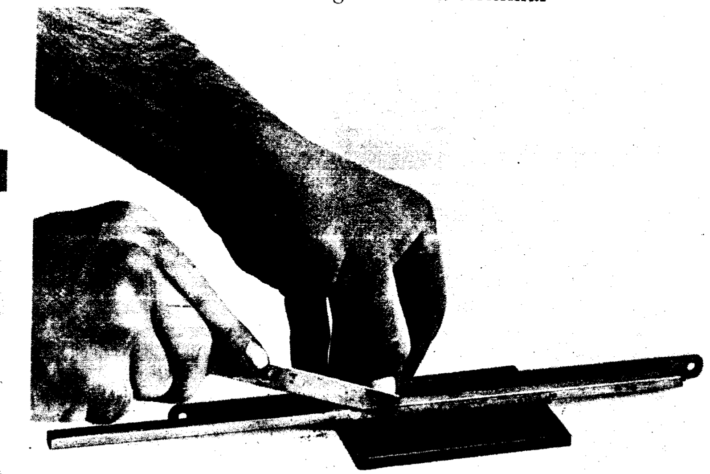

Fig. 32. Marking out the slots in ebonite plates with a hacksaw blade, a steel bar being used as a gauge

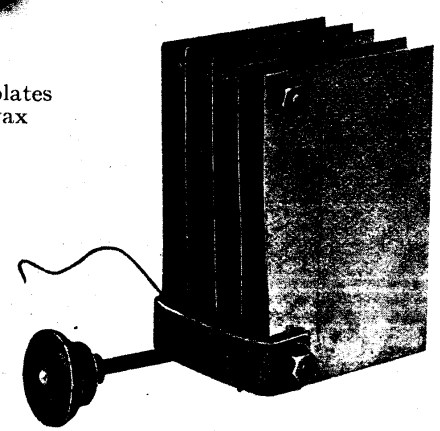

Fig. 33. Set of moving plates assembled with clamping piece

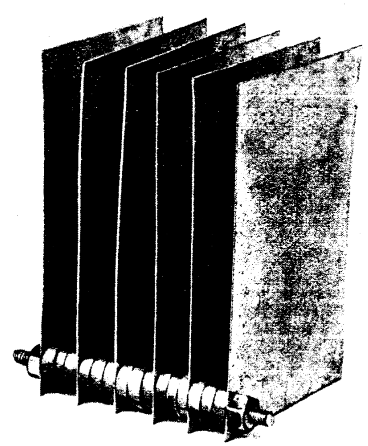

Fig. 34. Set of fixed plates held together by brass rods and washers

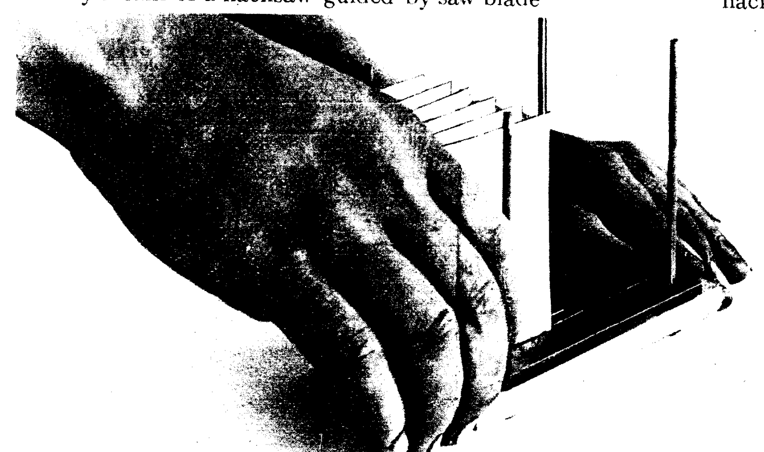

Fig. 35. Assembling the condenser. How the fixed plates are fitted into their grooves in the ebonite base

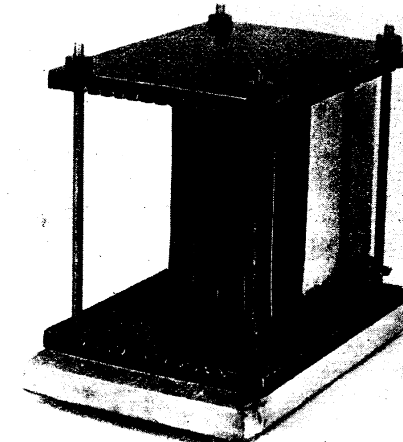

Fig. 36. Fixed plates set up and top and bottom panels bolted down

CONDENSER: HOW TO CONSTRUCT TWO TYPES OF SIMPLE FIXED CONDENSER AND A VARIABLE CONDENSER WITH VERTICAL PLATES

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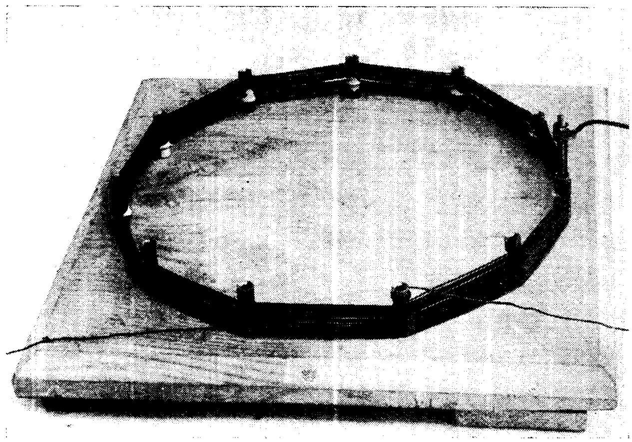
From photos specially taken for HARMSWORTH'S WIRELESS ENCYCLOPEDIA

application of this coil to a crystal set with a two-stage low-frequency amplifier, the aerial lead-in is connected to the commencement of the winding and the earth connexion effected by means of ordinary valve legs or wander plugs, which are simply pushed into the socket which gives the nearest wave-length, and the final tuning carried out with a condenser in the usual way.

Another way in which the same coil can be used is as an inductively coupled circuit. The two sets of plugs on the two separate circuits are plugged in as requisite, and as the plugs can be placed in any of the valve sockets, provided they are separated to suit the wave-length, the coupling can be varied, as the nearer the plugs of the secondary to the primary, the closer the coupling, and vice versa.



EXPERIMENTAL INDUCTANCE COIL

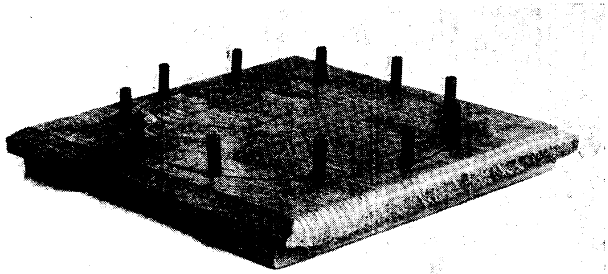
Fig. 6. This is an easily made inductance coil with great possibilities for the experimenter. The tappings are made by means of valve legs, round which the coil is wound

The construction of the coil is simplicity itself. All that has to be done is to cut a square baseboard from 9 in. wide hardwood or deal, fix cross battens to the underside, and bevel or chamfer the edges. A circle is then scribed on the upper side with a large pair of dividers, and the holes for the sockets drilled at regular intervals. Eleven of the sockets are used in the coil illustrated, but a greater number can be substituted to give any required number of tappings and as fine a tuning as may be wanted.

The holes should be small enough for the valve sockets to screw into the wood, and are secured with a nut on the underside.

Before the winding is started the sockets have to be polished with fine emery paper to ensure subsequent effective soldering. The appearance of the work at this stage is illustrated in Fig. 7. The wood can be varnished or stained and polished if it is desired to improve the appearance. The insulating value is benefited by impregnating the wood with boiling paraffin wax.

Winding this type of coil is a simple operation, and is one of the advantages of this type, as new coils can be very quickly assembled for experimental purposes. A start is made by scraping the insulation from the wire at a position about 6 in. from the end, turning it around the valve socket, and soldering. Two complete turns of the wire are taken, and a tapping is made to the socket next to the starting point by turning the wire once around the socket and taking another two turns right round the sockets and tapping off at the next socket, and so on, as shown in Fig. 8, until the whole is complete. The wire is turned evenly and closely, and with as even a tension as possible. The whole of the remaining tappings are then completed by scraping the insulation from the wire where it passes around the sockets, and soldering.



BASEBOARD FOR EXPERIMENTAL COIL

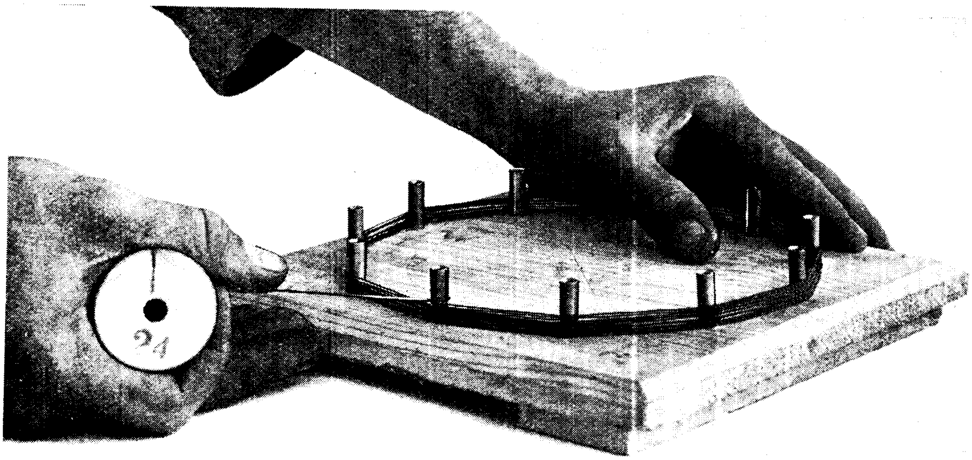
Fig. 7. Sockets are here shown in place on the baseboard, which is ready for winding on the coil seen in Fig. 6

The soldering process is simple, as all the tappings are exposed on the inner side of the coil, and are readily accessible. The last turn is soldered to the last of the sockets, and a length of wire left projecting so that it can be attached to any convenient terminal on the base or other piece of apparatus as desired.

A different kind of coil is illustrated in Fig. 9, and is suitable for panel mounting when a coupling or feed-back circuit is employed. In this case the coil is wound on a former constructed of wood with cardboard side pieces. The whole is mounted in the jaws of a brass holder shown in Fig. 10, which is attached to a long screwed rod with a bush piece and an ebonite knob of iron held in the vice. A hole is drilled in the centre of the end and tapped to screw to the rod. The fork part is drilled to take the screws which secure the former to the holder.

The bush is free to turn on the screwed spindle or rod, and is subsequently fixed to the panel in the usual way. An ebonite knob is screwed to the outer end of the spindle, and both this and the holder are further secured with a lock nut.

The effect of doing this is to permit the holder to rotate under the control of the knob. Sufficient length of spindle is left to allow for passing through the panel, any surplus being subsequently sawn off.



WINDING A COIL OF SPECIAL DESIGN FOR THE EXPERIMENTER

Fig. 8. When the required number of turns have been made round the circle of valve-leg sockets, a tapping is made by twisting the wire round the socket, as seen in the illustration. The metal socket then becomes a means of contact, as the wire at that point is soldered to it

Made in this way, it is possible to turn the coil about the centre line of the spindle, and thus it is applicable to many forms of coupled circuits when another coil of similar construction forms part of the circuit and has to be coupled to the primary.

The wood disk is sawn to shape, and the rim cleaned with a file and sandpaper. The side pieces are cut to shape with a penknife and glued and pinned to the wood. The whole is immersed in boiling paraffin wax, or well coated with an insulating varnish.

The holder, Fig. 10, is a length of brass strip $\frac{1}{2}$ in. wide and about 4 in. in length, this depending on the diameter of the coil. The strip is bent to a U shape with pliers or by hammering carefully on to a block

The coil is illustrated separately in Fig. 11, and can be bank wound as described under the heading Bank-wound Coils (*q.v.*). A start is made by passing one end of the wire through a hole in the side of the former, and finished in a similar way. The projecting ends of the wires are taken to terminals on the back of the panel or to any desired position. A simple way of arranging the wire during the winding process is shown in Fig. 12. A spindle is placed in the vice in an upright position and the spool fixed over it. The winding is carried out by hand, and the left is used to rotate the former while the right hand guides the wire into place.

The size and number of turns of the wire will be determined by the wave-length desired, or by the inductive value

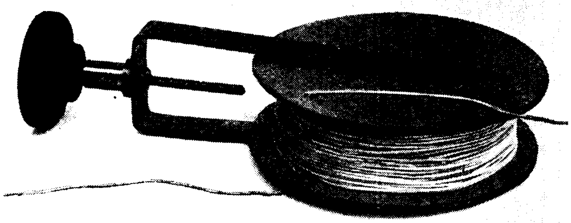


Fig. 9. A type of inductance coil for panel mounting when a coupling for feed-back circuit is employed

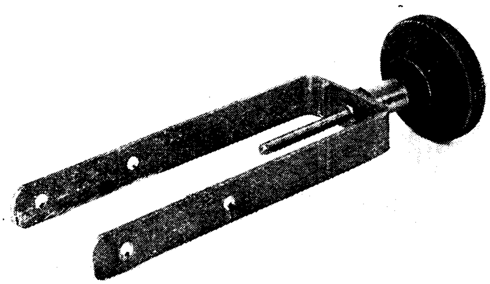


Fig. 10. Brass holder and bushing, with control knob

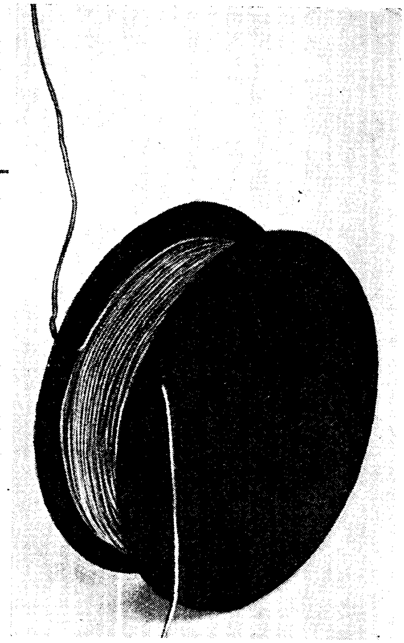


Fig. 11. Former showing how the wire is taken through a hole in the one side and out of the other

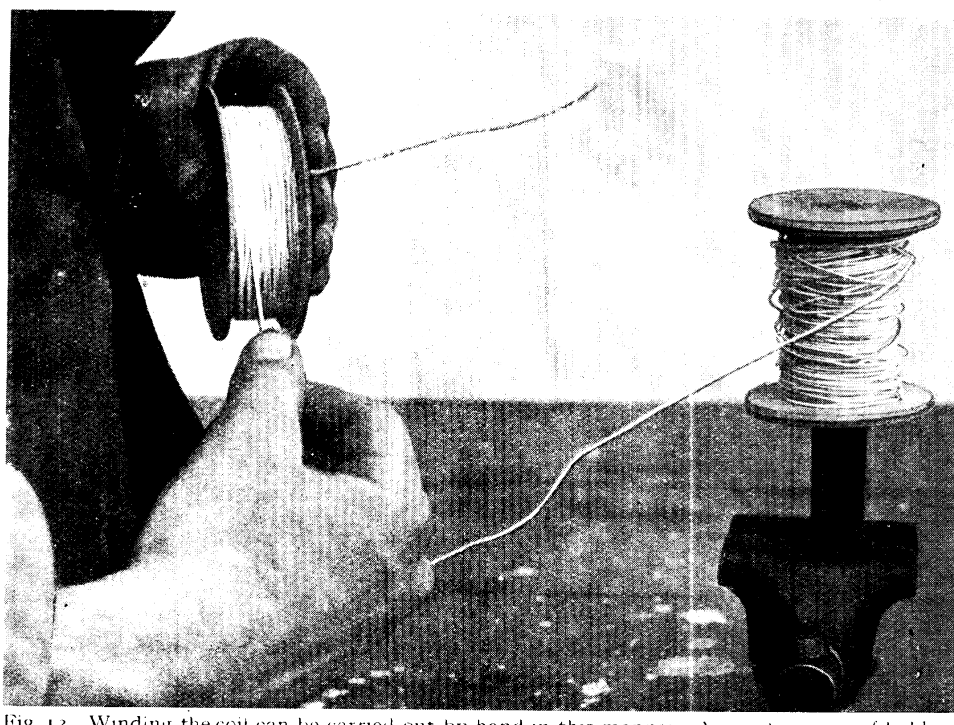
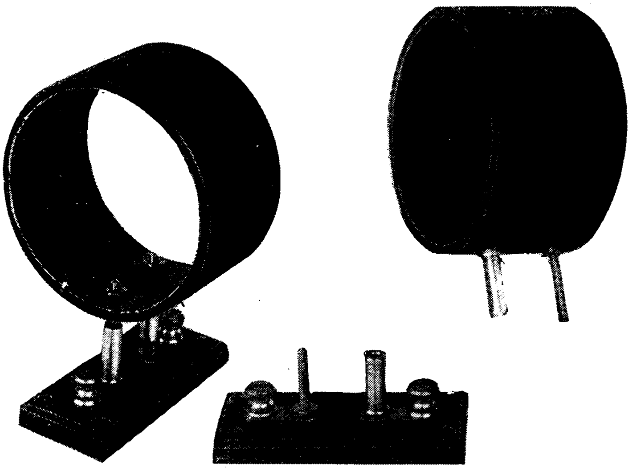


Fig. 12. Winding the coil can be carried out by hand in this manner. A simple means of holding the supply of wire is to fix a file or similar object in a vice and to mount the wire reel on it. Once the coil is started it should be finished without putting down the work. The reel should therefore be well mounted before commencing



HOME-MADE PLUG-IN COIL

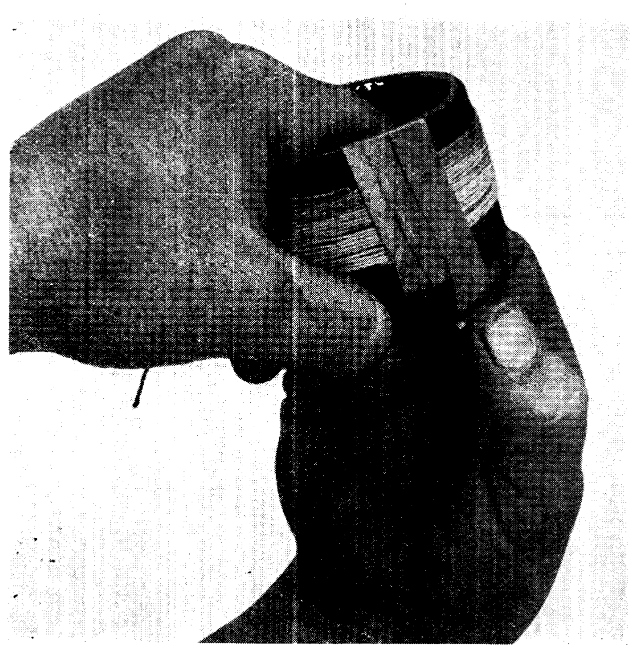
Fig. 13 (left). Plug-in coils can be made in this style by the amateur. It will be seen that the composition is of material used for many wireless purposes and construction is very simple. Fig. 14 (right). Valve legs and sockets are alternated on the holder and the coil former. An ebonite former is shown above, but waxed cardboard may be used if preferred

Interchangeable inductance coils are readily made on ebonite or cardboard tube formers, and can be mounted on ordinary valve legs and sockets fixed to a simple support, somewhat as shown in Fig. 13. The general procedure is to cut a short length of tube and fix a valve leg and a valve socket to it as shown in Figs. 13 and 14. These are merely passed through holes drilled in the ebonite and secured with nuts. The holder shown in Fig 14 consists of an ebonite base with a valve leg and socket fitted to it as for the former, and connexions made to terminals by means of copper contact strips.

The centres of the valve legs should be standardized to suit all the apparatus used by the experimenter. A convenient distance is $\frac{9}{16}$ in., but any other can be employed. All the windings should start from the valve leg and finish at the socket, so that all the windings will be in the same direction and the actual direction of winding will be easily remembered. There are several ways of winding this class of inductance coil, and they are dealt with in detail in the third part of this article, which begins on the next page.

After the coils have been wound, the ends of the wires are attached to the nuts on the valve legs and sockets, and the whole of the coil windings and the former are covered with Empire cloth or other insulating tape as illustrated in Fig. 15. The material is simply wound round and pressed into contact, and each layer should well overlap the next so that a sound job results. It should be wound round evenly, each layer overlapping the previous one by about a quarter of its width. If wound unevenly the insulation will peel off in handling.

The specific construction of various other coils is dealt with under their own headings in this Encyclopaedia and reference should be made to them.



BINDING WITH EMPIRE CLOTH

Fig. 15. Insulating tape is being wound round the former, the whole of which is to be covered. Empire cloth is frequently used as a protection for coils of this kind

COILS: (3) HOW TO WIND

Home-made Winders and Simple Methods of Winding

How the experimenter can contrive simple but efficient apparatus for winding his own inductance coils is described in this section and illustrated with a special plate. Reference should also be made to the two previous sections of this article, and to articles on winding particular coils such as Basket Coil, etc.

The winding of a length of wire on to a former seems to be an easy matter, but all experimenters know that there are numerous difficulties that arise when the actual work is taken in hand. Everyone, for example, who has tried to wind a coil has found how difficult it is to keep an even tension, for one thing, and, for another, to make the different turns of wire lie evenly with one another.

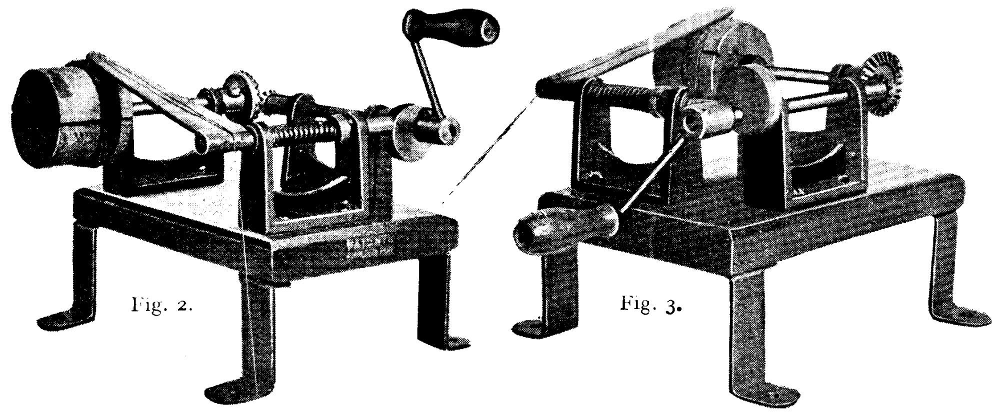
There are several aspects of the work and numerous ways of dealing with them. Several systems of winding are common, and are dealt with under their respective headings.

The following notes are directed to the solution of some of the everyday difficulties and ways of overcoming them that crop up when almost any type of coil has to be wound. In the industry the coils are usually wound by specially constructed machinery. An example from the Marconi wireless works at Chelmsford is shown in Fig. 1, but the experimenter has to adapt other methods as are most suited to the apparatus at command.

When any quantity of coils are to be wound it is desirable to obtain one of the ready-made coil-winding machines such as the Lokap, illustrated in Fig. 2 and Fig. 3, which are adapted particularly to the winding of duo-lateral and other forms of basket-weave coils and the like. They can, however, be adapted to a wide variety of uses, as the principle on which they function is that as the crank handle

COIL WINDING ON A LARGE SCALE AT THE MARCONI WORKS

Fig. 1. Coil winding on a commercial scale is carried out with rapidity and precision, large quantities being made daily. This is a scene at the Marconi Wireless Telegraph Company's works, where benches equipped with appropriate machinery are erected for the process

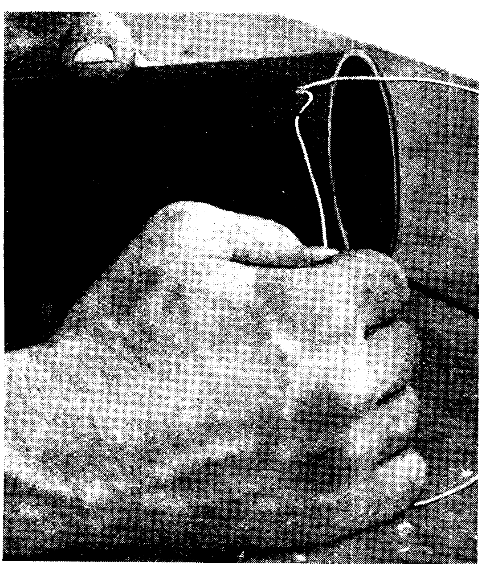


LOKAP COIL-WINDING MACHINES

Fig. 2. Lokap patent coil winders enable duo-lateral and other forms of basket-weave coils to be easily wound. Fig. 3. From this view it will be seen how the wire is run over a long wooden arm attached to a reciprocating shaft

is rotated a bobbin or former attached to a driven shaft is driven at a higher speed by means of the bevel gears, or, by changing the ratio of the gears, at the same speed or at a slower speed.

Another shaft at right angles to the crank shaft is driven backwards and forwards by a cam attached to the crank shaft. The shape and size of this cam regulates the path of travel of the wire from a spool to the former. This is effected by running the wire over a long wooden arm, notched at the outer end and attached to the reciprocating shaft at the other. The cams are interchangeable; and if a cam with a small throw be used, the travel of the wire across the former is limited, and with a long-throw cam the travel is increased. If the cam be omitted altogether, the wire can be wound directly on to a former in the usual way. That is, the wire will lie one turn against the other in regular order, and not in any kind of basket weave as is the case when a cam is used.



BEFORE WINDING A COIL

Fig. 4. When a coil is wound by hand one end of the wire is fixed to the cardboard tube through two holes

In the absence of a winding machine, and when only one or two coils are to be dealt with, the quickest way is to wind the wire by hand. To do this necessitates the starting end of the wire being attached to some kind of former, usually tubular, whereon to wind the wire. A commonly adopted plan, and one that gives satisfactory results, is to drill two small holes about $\frac{1}{2}$ in. apart and near to the edge of the former, or at such other place as it is desired the winding should start. The wire is then passed through one of these holes from the outside, taken inside the tube and brought out through the other hole, down again through the first hole, and up through the second as before and the wire drawn tight, as illustrated in Fig. 4. The outer or loose end of the wire should be left long enough to allow it to be connected to a terminal, or in any other manner, to the coil mounting or holder, as the case may be.

In some of the accompanying illustrations the wire shown is cotton-covered, in others enamelled. But it will be appreciated that the nature of the wire has little

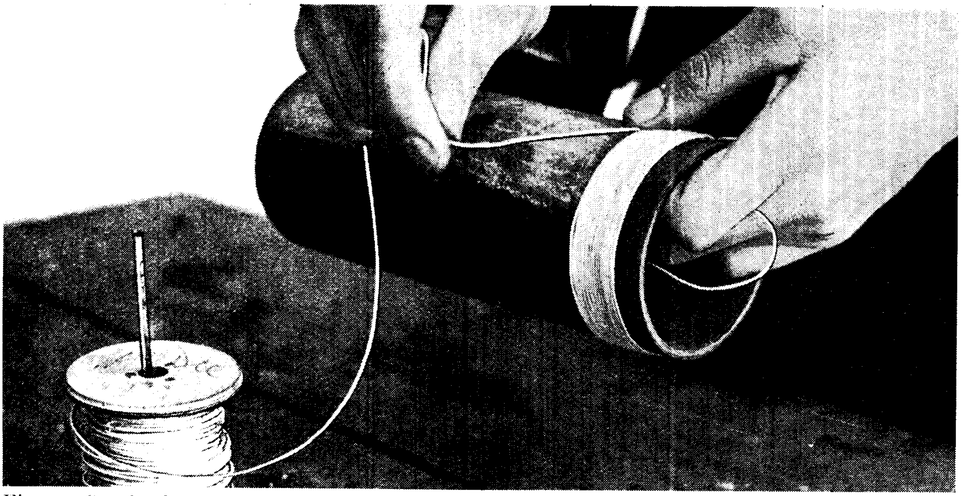


Fig. 5. On the bench will be seen a long nail, which supports the spool of wire; this enables the spool to rotate easily, and permits the wire to unwind evenly as the cardboard tube is rotated

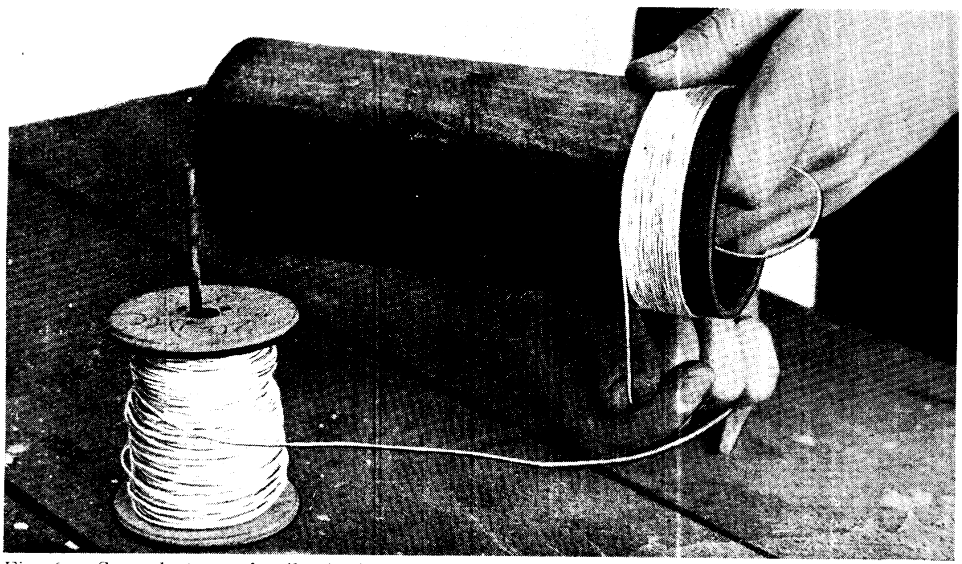


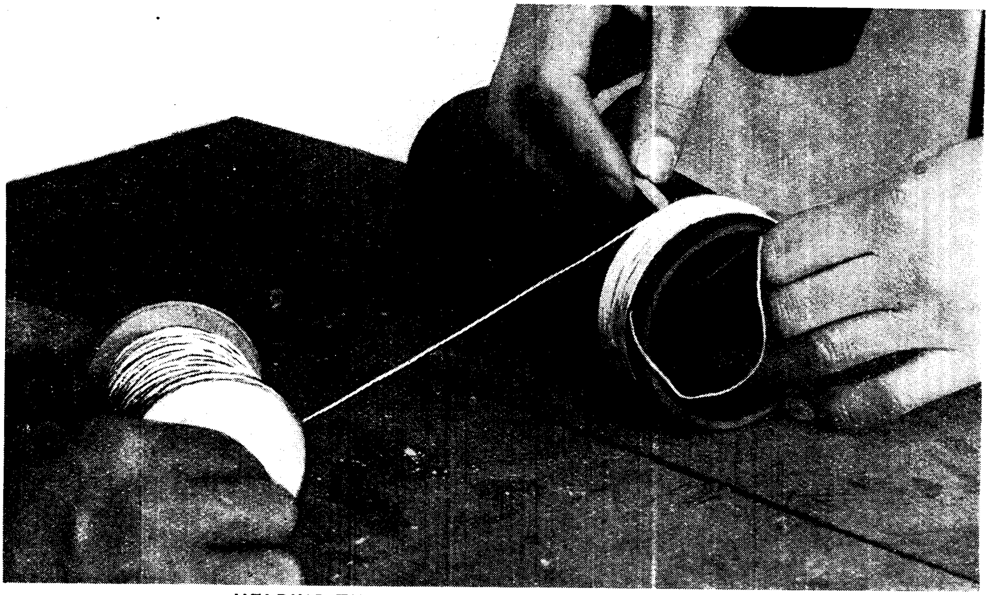
Fig. 6. Second stage of coil winding by hand. The right hand is under the tube, the left thumb on the coil to prevent it from being displaced

TWO STAGES OF WINDING A COIL BY HAND

bearing on the winding processes, and the same methods can be applied to either, or any class of wire customarily used on experimenters' coils.

The winding is continued from the stage shown in Fig. 4 by twisting the wire in a regular manner round and round the tube until sufficient has been wound on. In all coil winding it is very important that the wire be obtained ready for use on a spool, as a loose and tangled mass of wire cannot be satisfactorily wound on to a former. The first step is, therefore, to purchase supplies of the wire on spools of convenient size, usually in $\frac{1}{4}$ lb. to 1 lb. spools. Should this not be possible, the wire must be wound on to a spool by any of the methods described for the winding of coils.

Next fix the spool in an upright position on the work bench, and in such a manner that it can rotate easily, as



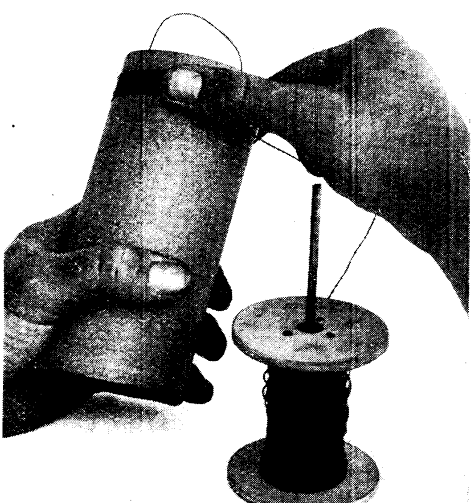
HELPING THE COIL WINDER IN HAND WINDING

Fig. 7. With the aid of an assistant to control the spool of wire, coil winding can be carried out with speed. The wire should be kept taut, and the winder, in this case, is using a piece of wood to guide the wire on to the tube

shown in Fig. 5. Having fixed the wire at the start as already described, take the tube in the left hand, and with the thumb on the upper part, as shown in Fig. 5, take the wire between the finger and thumb of the right hand and turn it round the tube as far as possible, and at the same time rotate the tube by turning the left hand towards the body. Tilt the free end of the tube upwards and away from the body, throw out the right arm and turn it downwards, thus bringing the right hand under the tube as shown in Fig. 6, and all the while keep the thumb of the left hand on the top of the tube so that the wire is not displaced.

A matter of importance is to keep the wire taut while winding it on to the tube, and one effective method of doing this is shown in Fig. 7. The tube rests on the bench and is rolled backwards and forwards under the control of the left hand. An assistant controls the spool of wire by holding the ends of a spindle passed through it, moving the spool in step with the tube, and all the while maintaining sufficient tension. With a little practice a coil can be wound very quickly by this method. To avoid the rubbing of the wire on the fingers a small piece of stick is used to guide the wire on to the tube, as is clearly visible in the illustration (Fig. 7).

Alternatively the method shown in Fig. 8 can be adopted, especially when winding with enamelled wire. The tube is in this case held in a vertical position in the left hand and the wire guided on to it



RAPID COIL WINDING

Fig. 8. Coil winding by hand may be done quickly in this way. The photograph is so arranged that the positions of the hands are as they appear to the winder himself. This method is useful when winding plain enamel wire

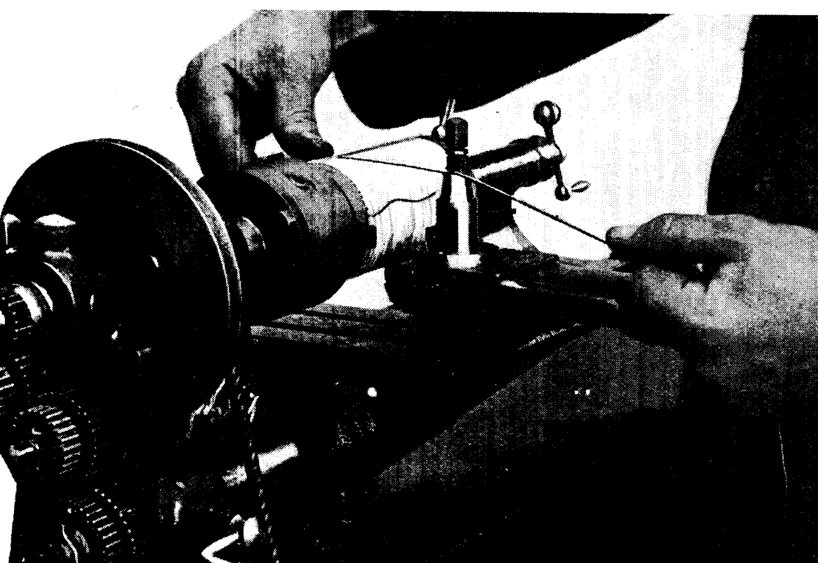
HOW TO MANIPULATE A SPOOL OF WIRE FOR COIL WINDING

Fig. 9. Photographed as the hands appear to the worker, the spool is being turned around the tube. By this means a much tighter and even coil is made than by turning the former

Fig. 10. Winding a coil on a curtain-ring former. A small spool should be used, the former held as here shown, and the spool turned round the outside and through the middle of the former

with the left hand by running the wire under the thumb as shown. The first finger acts as a steadier for the tube, and the other fingers loosely hold or guide the wire. If the tube be rotated by the left hand as quickly as possible, the wire can be laid quickly and neatly. To avoid a sore thumb, a finger stall may be used. Alternatively a piece of rag twisted round the ball of the thumb answers the purpose.

When a very tight winding is essential, the plan shown in Fig. 9 gives satisfactory results. The spool of wire is held in the right hand and the tube in the left, and the tube and the spool rotated in opposite directions simultaneously. The left thumb



WINDING A COIL ON A LATHE

Fig. 11. Efficient coil winding can be carried out with the aid of a lathe. The change wheels are set up for a corresponding number of threads per inch to the number of turns per inch of the winding

WINDING A RESISTANCE COIL

Fig. 12. In the chuck is a steel former tapered at one end. The resistance coil is wound on this by holding one end of the wire and rotating the lathe sufficiently slowly to enable the tension to be kept even and the winding regular

guides the wire into place, and the desired degree of pressure is easily maintained by the right hand, as the spool is a convenient way of controlling the wire.

For some purposes a small coil is all that is needed, and this can often be wound on a curtain ring, which makes an efficient former, as these rings are usually made of hardwood and varnished.

The wire should be used from a small spool so that it can be passed readily through the centre of the ring, as shown in Fig. 10, and can be wound in either direction, according to the needs of the case. The ends of the wire are fastened by passing them through a hole drilled through the ring or into a small notch cut in the side.

The experimenter fortunate enough to possess a screw-cutting lathe, such as the J. R., can make a rig up as shown in Fig. 11, and very quickly wind any number of coils. The method is to set up the lathe as for screw cutting, by choosing the number of threads suited to the gauge of wire. For example, when using No. 22 gauge enamelled wire, the number of turns that will have to be made per inch of length is 36. If the change wheels be set to cut 36 threads to the inch and the wire directed over a ring or pulley free to revolve on the tool post clamp screw, the wire is automatically and accurately fed on to the former. The latter is held in a chuck or mounted between centres, as may be most convenient. The spool is held in the right hand and the left used to guide the wire and keep it in close contact, especially when bank winding is in progress. The lathe can be treadled and the wire run on very quickly, or the headstock can be turned by hand, as desired.

Coils for resistances are generally wound with a well-known brand of special resistance wire, and a typical example of this aspect of the work is the winding of a resistance for a filament rheostat. To do this the wire is coiled on a steel former shaped at the end to a taper, held in a three-jaw chuck in the lathe. The resistance wire is held under one of the jaws of the chuck and manipulated as shown in Fig. 12. The lathe is rotated slowly and the wire coiled on to the former. The taper end is supported by a hollow centre in the tailstock. To prevent cutting the fingers with the wire a piece of leather should be held between the finger and thumb.

Simple Coil-Winding Machines. An easily made coil-winding machine is shown on the plate, Fig. 13, which can be made from odds and ends of material. The baseboard is of deal 6 in. wide and 18 in. long. Two uprights of the same material are roughly sawn to shape and screwed to the ends as shown, and a hole drilled through each to take the steel axle.

A convenient size for the uprights is 6 in. high, and this brings the centre of the axle 3 in. above the top of the base, sufficient for a tube 5 in. diameter. Should it be desired to wind a larger tube the axle hole can be drilled higher up the end pieces. The axle is made from a piece of $\frac{1}{4}$ in. diam. steel rod in a 24 in. length, and bent in a vice to the form of a crank handle, as shown in Fig. 14, and should be an easy fit in the axle holes. These may be slightly greased with vaseline to facilitate the movement of the axle. Two tapered supports have now to be made, as shown in Fig. 14, by cutting two large and two small disks and securing them together with connecting laths of thin wood about $\frac{3}{4}$ in. wide and $\frac{1}{4}$ in. thick.

The smaller end may be about $1\frac{1}{4}$ in. diam. and the larger 5 in. diam., and the two are spaced about 6 in. apart. Holes are drilled through the centre of all these pieces, and they are then placed on the axle and secured in any desired position with a set-screw. Ordinary round-headed wood screws with the points filed off will answer well, and are screwed through the disks. If the parts are a tight fit on the axle, a screw in each small disk will generally answer. Otherwise a long thin screw must be obtained and passed through the large disk as well. The machine ready for work is shown in Fig. 15. Tubes of various lengths are accommodated by sliding the supports along the axle until the tube is firmly held between them.

Coil Winder for All Purposes

Alternatively the coil winder shown in Fig. 16 may appeal to experimenters, as it has a somewhat wider scope of application. Essentially it comprises a baseboard with a fixed headstock at one end provided with a mandrel and crank handle. A movable head or tail stock is arranged to slide on the base and held in any position by means of a set-screw and fly nut. Cross-bars or drivers are fixed to each spindle, and have grooves cut across the faces into which is placed the tube on which the coil is to be wound. The spool of wire is supported on a peg raised to the centre height of the winder by a post attached at the left front of the base.

The dimensions can be adapted to individual requirements, but convenient sizes for the base are 9 in. wide and 14 in. long. The headstocks may have a height of $5\frac{1}{2}$ in. and be made from timber 3 in. wide and 1 in. thick. The cross-bars or drivers are 8 in. long, $1\frac{1}{4}$ in. wide and 1 in. thick. The base is cut to length from a piece of ordinary deal 9 in. wide and 1 in. thick. These sizes are nominal, as actually a 9 in. board only measures about $8\frac{3}{4}$ in. wide. Two battens are attached to the underside with screws to act as feet and to prevent the wood warping. The headstock is made by cutting a piece of the 3 in. stuff to a length of 7 in. and drilling a hole about $\frac{1}{2}$ in. diam. through it at a distance of $5\frac{1}{2}$ in. from the bottom. This hole is then bushed with brass tube and a steel bar cut to a length of about $2\frac{1}{2}$ in. and fitted with a crank made from wood with a separate handle as shown in Fig. 17, securing the crank to the shaft with a steel pin driven right through them.

The driver bar is attached in a similar way after the slots have been cut across them with a saw. Two cuts will have to be made and the material between them chipped out with a chisel or pocket-knife. The width of the slots should be the same as the thickness of the tubing to be used for the formers. In the event of the tube being a little thinner than the slot it can be secured by means of a wedge of wood driven crossways between the outside of the tube and the outer face of the slot. When the headstock is complete it is screwed to the base with two stout screws driven from the underside.

How the Adjustable Coil Winder is Used

The other arm used on the tailstock is made and fitted in the same way as for the headstock, but the support is made from a strip of brass or iron 1 in. wide and $\frac{3}{16}$ in. thick, bent to a right angle at the bottom and drilled for the holding-down bolt seen in Fig. 18. The slot in the base is easily cut by drilling a hole at each end of the slot and cutting out the material between with a keyhole saw.

The supporting arm for the spool is shown in Fig. 19, and is simply a piece of $1\frac{1}{2}$ in. square stuff notched at the bottom as in Fig. 19 and screwed to the front of the base. The upper end is fitted with a steel peg about $\frac{3}{16}$ in. diam. and 3 in. long to accommodate spools of different length. When a tube is to be wound the tailstock is adjusted to length and the tube fixed between it and the headstock by fitting it into the nearest groove, so that it runs as true as possible. Extra grooves can easily be cut to suit any particular dimensions. The spool of wire is then placed on the peg and a hole pierced in the tube near the end as shown in Fig. 20, and the wire fastened as previously described; the crank is then revolved and the wire guided on to the tube, as shown in Fig. 21, continuing until the winding is complete.

The winding of a narrow former such as that for a variometer is shown in Fig. 22, and is self-explanatory except to point out

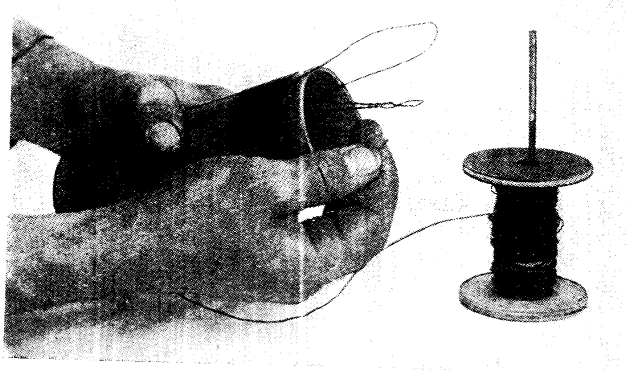
ATTACHING LEADS FOR TAPPINGS

Fig. 23. Tappings are made by soldering leads to the coil at specified numbers of turns of wire. At the turn which is to be tapped the single wire is isolated by means of pins, and the lead soldered on as shown in the photograph

that the headstock alone is needed and the tube is held firm with small wedges. The wire is conveniently guided with the left hand in the manner illustrated.

Tappings are an important part of coil winding, as the trend of modern design is to use tappings in preference to the plain type of coil with a sliding contact. By tappings is meant that at any predetermined point on the winding a loop or other arrangement of the wire allows a contact to be made to a terminal or series of terminals. The terminals or studs are so arranged that a contact arm can sweep across them and make a connexion with any desired point on the coil. The effect of this is that the virtual length of the coil winding is altered and tuning to various wave-lengths is possible.

There are many ways of making tappings. Perhaps the simplest is to complete the coil in the ordinary way as if it were a plain inductance, and then to separate one turn of the winding by holding it

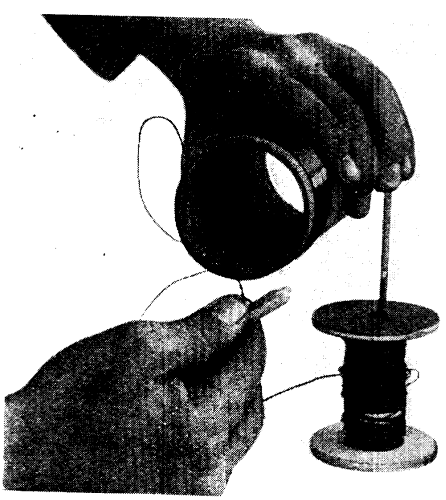


TAKING TAPPINGS INTERNALLY

Fig. 24. Tappings may be taken in this way, so that the leads are conducted through the former. As the coil is wound loops are made in the wire and holes made in the former, through which the loops are passed

apart with pins driven in at the sides of the winding in such a way that one of the turns is isolated, as in Fig. 23. The insulation is cleaned off and a short length of wire soldered to it. Any number of tappings are made in the same way.

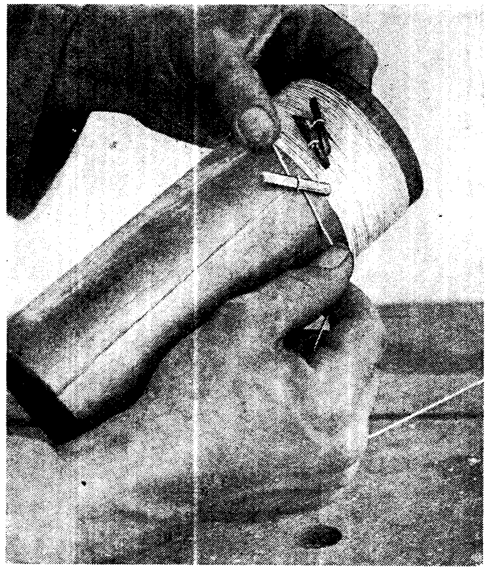
Alternatively the tappings can be taken internally by drilling a hole through the tube at the point where the tap is to be taken and making a loop in the wire, twisting the two parts together and passing them through the tube as shown in Fig. 24, and drawing them tight as in Fig. 25. The length of the tappings should be as nearly as possible such that they will reach to the terminals without excess of wire. The bight of the wire is subsequently cleaned of insulation and connected to the terminal.



INTERNAL COIL TAPPING

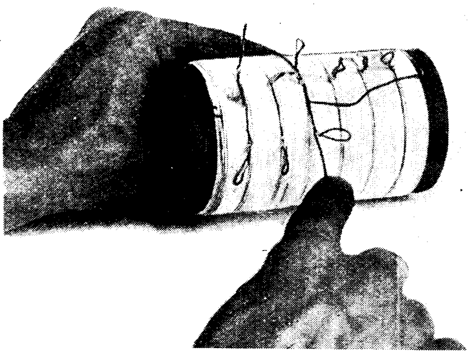
Fig. 25. When the loop of wire is passed through the former to make an internal tapping a piece of wood is held in the loop and the wire twisted, as in the coil illustrated

External tappings are made in a somewhat similar way by turning the wire round a small piece of match stick, as shown in Fig. 26, and continuing the winding. The loop thus formed is then twisted once to keep the turn firm, and then partly cleaned of insulation and another wire attached to it and taken to the terminal. In the case of a double-layer winding, as shown in Fig. 27, the taps taken off the first layer are passed through the turns of the second, and it is desirable to distinguish them in some way, or to take the tappings in some particular line to facilitate subsequent connexions.



COIL WOUND WITH EXTERNAL TAPS

Fig. 26. Match sticks may be used to hold the wire required for making external tappings. As the winding takes place small loops are made in the wire and the match sticks inserted



DOUBLE-LAYER TAPPED WINDING

Fig. 27. Tappings are taken in a double-layer coil by making the loops for the first winding at a different position from those of the second winding

In the foregoing notes it is of course apparent that the size of wire, number of turns, and so forth will have to be determined by requirements, also that a double-layer coil is wound by first winding the primary and continuing in the same way with the secondary.

A test of some sort should be made immediately the coil is wound to ascertain that the coil is continuous, and this may be done with instruments or with the simple rig-up shown in Fig. 28; these two dry cells have been wired in series and the leads taken from them to one side of a flash-lamp bulb, and to the commencement of the windings respectively. The bulb is secured to the wire by twisting the latter round it. If, therefore, the centre contact of the lamp be applied to any tapping or to the end of the winding, the lamp will light if the circuit is continuous and the resistance is not too high.

When all is satisfactory the coil is finished either by immersing it bodily in

TESTING FOR CONTINUITY OF WINDING

Fig. 28. Two dry cells are connected in circuit with a flash-lamp bulb and one end of the coil. If the resistance is not too great, and no fracture has been sustained in the wire during winding, when any one of the tappings or the far end of the coil is brought in contact the bulb should light up

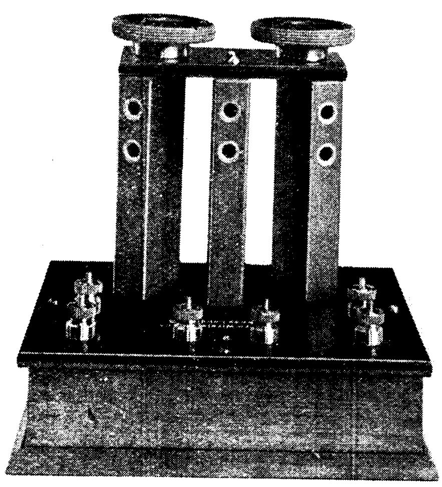
molten paraffin wax, or by coating the wire with insulating varnish or with a suitable paint, according to circumstances. As a rule, when a long winding has a sliding contact arrangement the best material is thick shellac varnish, known as stick varnish, as this is strong enough to hold the wire firmly against the friction of the contact device.—*E. W. Hobbs.*

COIL CONDENSER. Name applied to a condenser fitted to the case of a spark coil and used to store up the induced electro-motive force and increase the suddenness with which the spark jumps the gap. It also retards the current at the make, and reduces sparking at the points.

In a typical construction the condenser is composed of alternate layers of tinfoil and waxed paper amounting in all to some 140 layers for a condenser with a value of 2 mfd.

As the dielectric is very thin, and the area of the conductors large, a considerable capacity is obtained in a small space *See* Spark Coil.

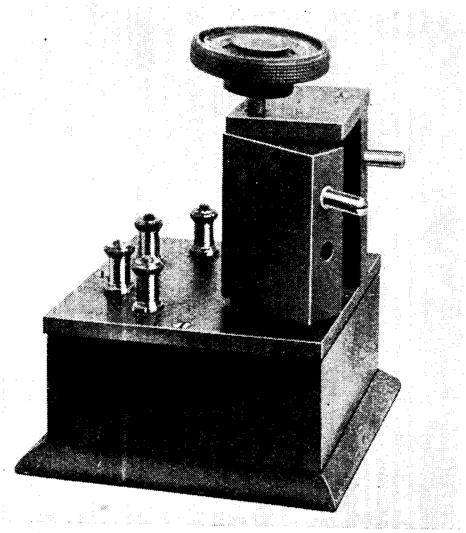
COIL HOLDER. General term for any support for a coil. It generally consists of an ebonite base piece with sockets for the reception of plugs attached to a part of the coil itself. Coil holders are mostly in demand for the many varieties of honeycomb and duo-lateral coils and others of similar type, such as the basket coil (*q.v.*).



TRIPLE COIL HOLDER

Fig. 2. Three coil holders, two of which are movable, are mounted on a cabinet base. This method is suitable for experimental sets. The holders are of the plug-in type

An example of the vertical type of two-coil holder is the pattern illustrated in Fig. 1, where the holder is in the form of a pillar, with a hinged portion which can be moved nearer to or farther



CABINET BASE FOR COIL HOLDERS

Fig. 1. Two coil holders with a cabinet base are shown. A vertical type of coil of this kind allows one coil to be moved nearer to or farther from the other for tuning purposes by means of the insulating knob

Courtesy Will Day, Ltd.

from the fixed portion by rotation of the knob at the top. In this and most of the coil holders connexion is made by means of plug contacts and internal wiring to terminals fixed to a base.

Two-coil holders are not so generally serviceable as three-coil holders, and an example of the latter is shown in Fig. 2 which is similar in essentials to the former example, but the two outer holders can both be moved independently. Both the foregoing are suitable for the experimenter, as the holders have a cabinet base, and can be placed on the table or in any handy place and wired to the apparatus with flexible wires.

A convenient pattern is illustrated in Fig. 4, and is intended for cabinet mounting. The coils plug into the sockets, which are free to move on bearings formed in the sides of the holder. Long handles make it easier to move the coils the small amount necessary for fine tuning.

One convenient way to mount this type of holder is shown in Fig. 6, where the holder is shown attached by screws to

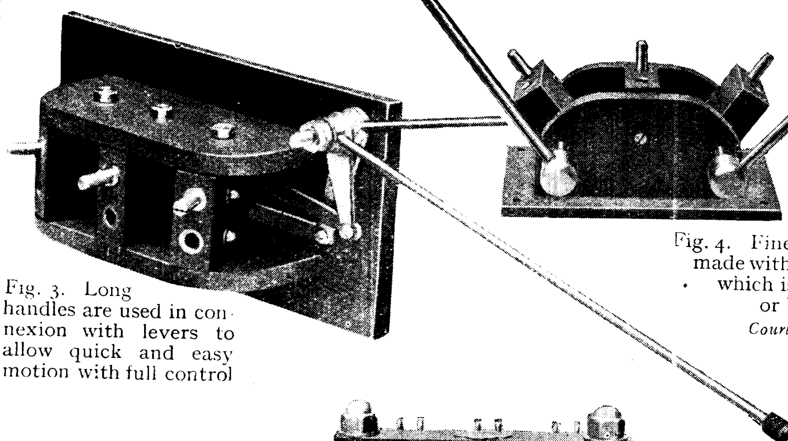


Fig. 3. Long handles are used in connexion with levers to allow quick and easy motion with full control

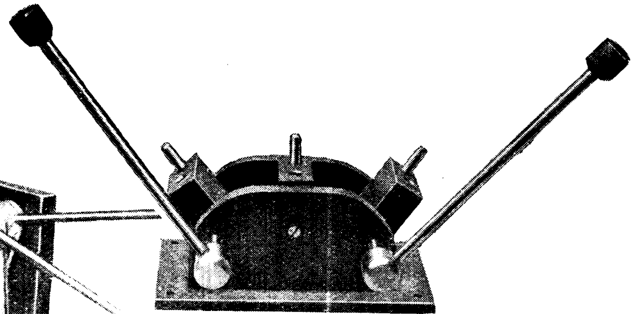


Fig. 4. Fine adjustment can be made with this type of holder, which is suitable for panel or base mounting

Courtesy Will Day, Ltd.

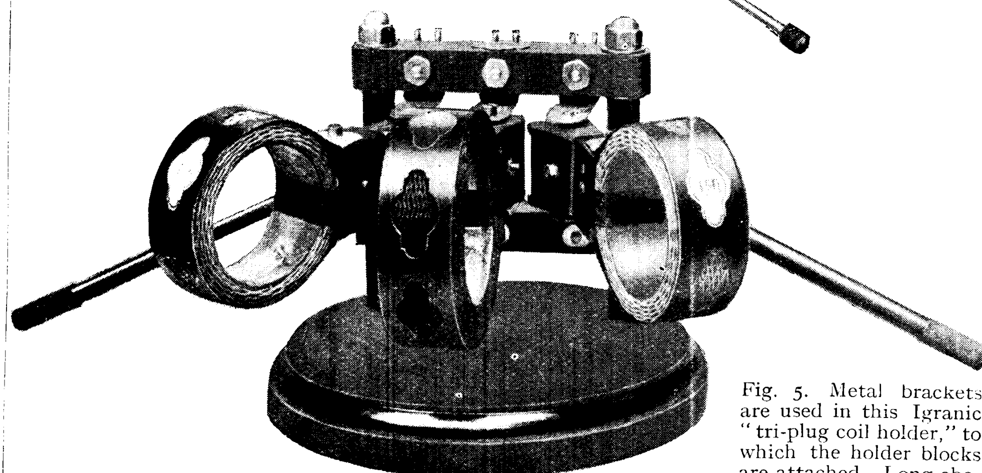


Fig. 5. Metal brackets are used in this Igranic "tri-plug coil holder," to which the holder blocks are attached. Long ebonite handles are provided for fine tuning

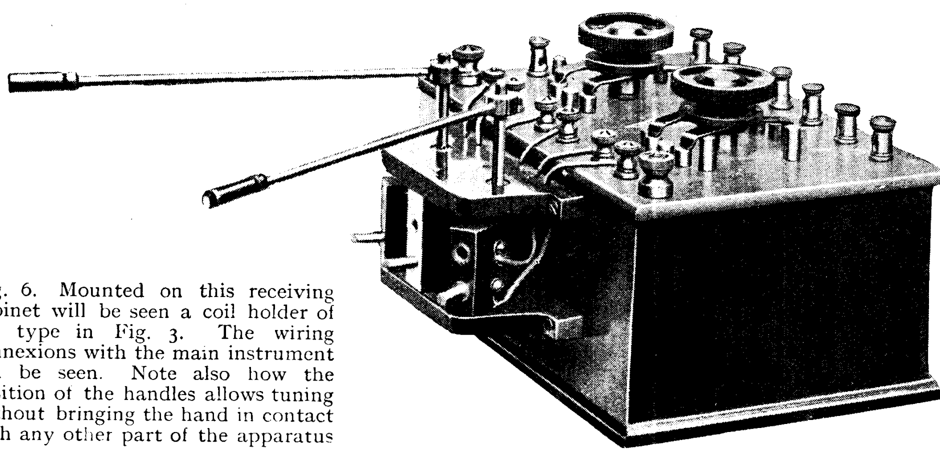
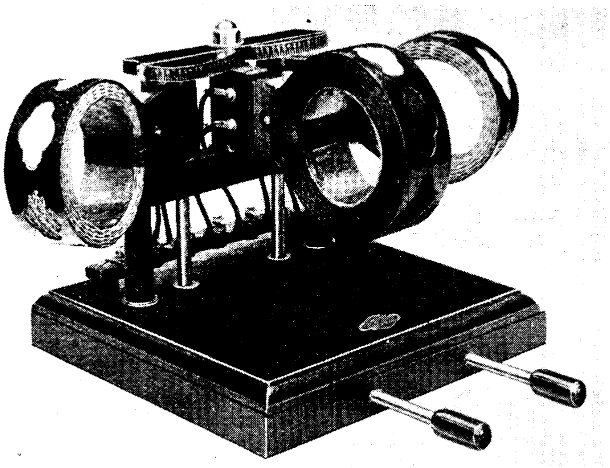


Fig. 6. Mounted on this receiving cabinet will be seen a coil holder of the type in Fig. 3. The wiring connexions with the main instrument can be seen. Note also how the position of the handles allows tuning without bringing the hand in contact with any other part of the apparatus

COIL HOLDERS WITH EXTENSION HANDLES FOR PLUG-IN TYPE COILS



IGRANIC MICRO-ADJUSTER HOLDER

Fig. 7. Calibrated dials are mounted on this holder at the top. The handles connect by gearing to the vertical rods to which the holders are attached

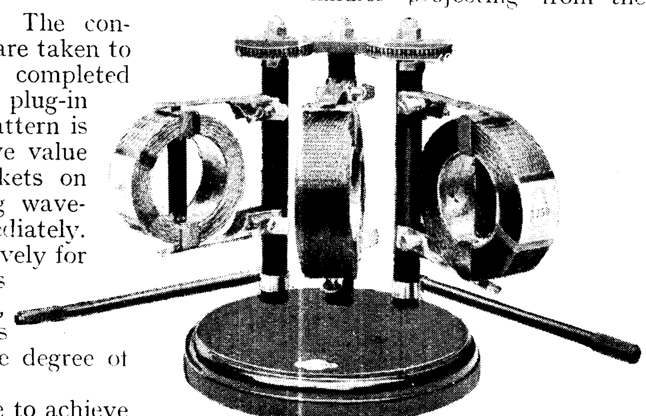
the side of a tuning panel. The connecting wires from the holder are taken to terminals on the panel and completed internally. The advantage of plug-in coil holders of this general pattern is that coils of varying inductive value can be plugged into the sockets on the holder, and the receiving wavelength of the set altered immediately. These holders are used extensively for reaction coils and other types of inductively coupled circuits, and a most important detail is that the means of varying the degree of coupling be sufficiently fine.

Various devices are available to achieve this, and one is shown in Fig. 3, where the handles are very long and are connected by links to the moving coil blocks; this allows of a quick but easy motion under full control of the experimenter.

The Igranic tri-plug coil holder, illustrated in Fig. 5, is an efficient pattern, and has long handles and a very easy movement, thanks to the metal brackets used as bearers for the holder blocks. Long ebonite handles provide fine tuning. The application of the coils is clearly shown in this illustration (Fig. 5).

A superior pattern is the Igranic micro-adjuster coil holder, which, as the name suggests, has a micrometer adjustment actuated by the handles projecting from the front of the base, as seen in Fig. 7. These handles connect by gearing to the vertical rods to which the holders are attached. The degree of coupling is calibrated, and the readings visible by inspection of the scale at the top of the stand.

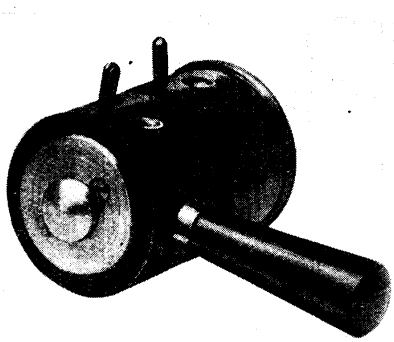
In all the foregoing the coils move radially away from each other and, for the best results, this is objectionable. To overcome this defect the Gimbolder, illustrated in Fig. 8, has much to commend it, as the coils are mounted on gimbals or pivots in such a way that the coils themselves can be moved on the



GIMBAL-MOUNTED COILS

Fig. 8. Gimbals on which the coils are mounted allow of swivelling in any way, either toward one another or through any angle to each other. Scales allow any adjustment to be noted for future use

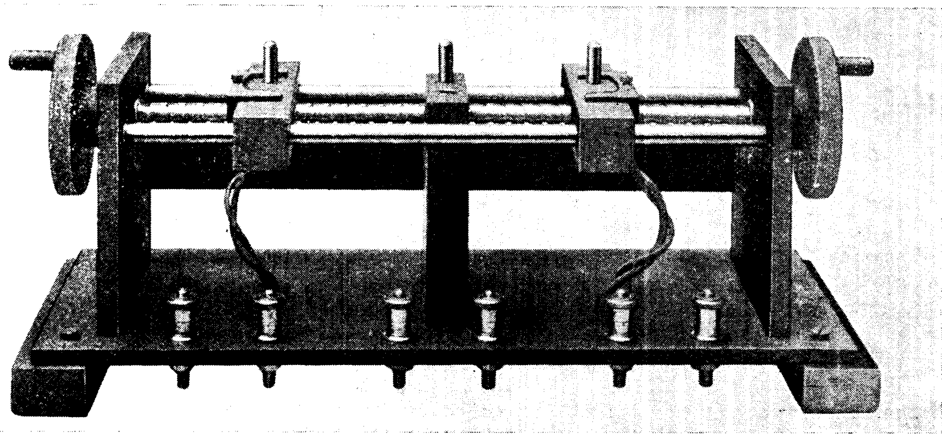
Courtesy Igranic Electric Co., Ltd.



CAPSTAN COIL HOLDER

Fig. 9. By means of this type of holder plugged-in coils may be turned in a plane parallel to themselves

Courtesy L. McMichael, Ltd.



MECHANICALLY OPERATED MOUNTS FOR COIL HOLDERS

Fig. 10. Two parallel guide bars act as supports for the holder blocks. These are separately moved by independent screws actuated by ebonite handles. Connexions are made by flexible wires

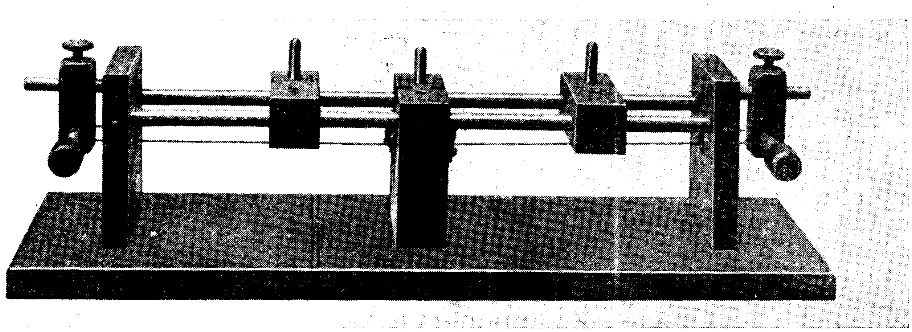
Courtesy L. McMichael, Ltd.

pivots and kept parallel to the centre coil, and the coils placed in the most advantageous relative positions. The stand is neat and simple, long ebonite handles provide for efficient tuning, and a calibrated scale enables the best setting to be recorded and the same degree of coupling reproduced at any time.

The McMichael capstan coil holder, shown in Fig. 9, is of altogether different type, and so arranged that the coils which plug into the holder in the usual way can be turned in a plane parallel to themselves, thus allowing of the finest degree of coupling. The robust construction makes them serviceable under the most strenuous conditions.

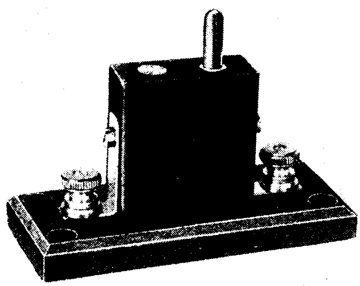
Circuits that call for a wide range in the coupling of coils are well supplied by the holder shown in Fig. 10, where two parallel guide bars act as supports for the holder blocks, which are propelled along by the action of independent screws, actuated by ebonite handles at each end of the device. Connexions are made by flexible wires to terminals at the front of the base, and the appliance is therefore particularly adapted to the needs of the experimenter. The screw movement allows of very fine coupling and control, and once a required degree of coupling has been attained there is no fear of the coils moving by the accidental shaking of the table or support on which the table is resting, as may be the case with some types of coil holder. This arrangement, too, lessens body capacity effects to a considerable degree.

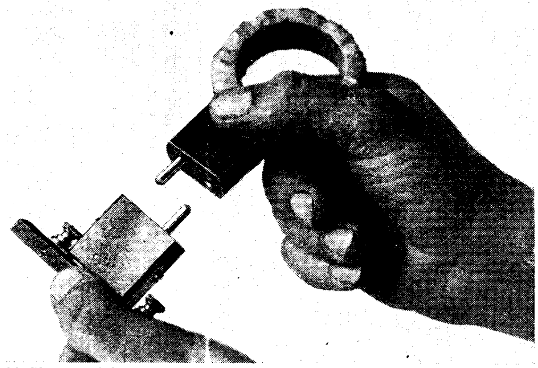
A variation of the same device is illustrated in Fig. 11, where the holders are propelled by turning a handle at either end of the stand. This winds the holder



COIL HOLDERS WITH A WIDE RANGE OF COUPLING

Fig. 11. Another pattern of the coil holder shown in Fig. 10 is shown above. Holders are moved along by means of wire controls passing over pulleys and actuated by ebonite handles. This type of coil holder is used when a wide range in the coupling of the coils is required



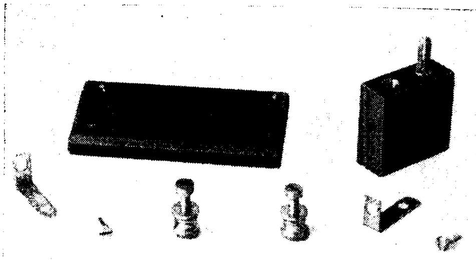


SIMPLE PLUG-IN TYPE COIL HOLDERS

Fig. 12. Amateurs will find this simple type of coil holder easy to make. It is intended for use with any of the standard plug-in coils. Fig. 13. Alternate legs and sockets are employed, and this photograph shows how they are engaged. By this means the coi can only be plugged in the right way according to its winding

along the guide bars, under the control of the wire or cord which runs over the guide pulleys on the stand.

The construction of simple coil holders is work well within the capabilities of the amateur, and a good type to commence with is shown in Fig. 12, a single holder with terminals on a base. The pattern is adaptable to a variety of circuits, and if several of these holders be made, any



DISSEMBLED COIL HOLDER

Fig. 14. Components of the coil holder, Fig. 12, are laid out. These comprise the ebonite stand, plug socket and plug, terminals, screws and brass angle pieces

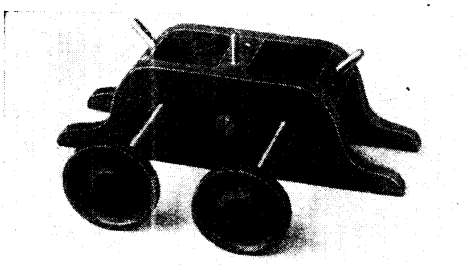
degree of coupling is possible by moving them about the table or on the base of the receiving set.

This holder is intended for use with any of the standard plug-in coils on the market, and as these have to interchange, as shown in Fig. 13, it is important that the centres of the plugs be accurate.

The component parts are illustrated in Fig. 14, and show at the top left the ebonite base, at the right the block with the plug socket and plug, and the metal parts at the front of the picture. The construction of a single or a multi-coil holder is essentially the same, and the following remarks on the construction of a three-coil holder apply equally to a two or a single holder with the obvious omission of the unwanted parts.

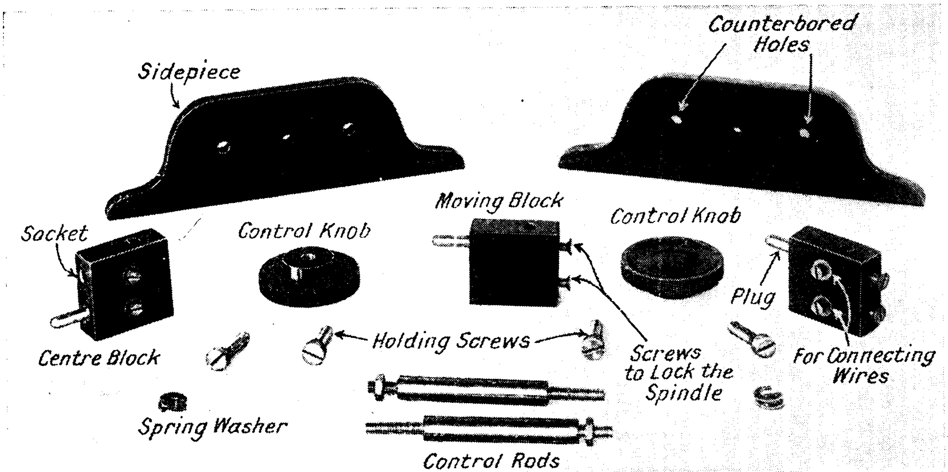
A three-coil holder for amateur construction is illustrated in Fig. 15. The central block is fixed to the side pieces, and the others are free to move under the action of the extension handles with ebonite knobs or long levers, as may be most convenient. The finished components appear in Fig. 16, and show the holder blocks, side frames, and control handles.

The first step is to obtain a piece of ebonite sheet $\frac{1}{4}$ in. thick for the side frames and another piece $\frac{1}{2}$ in. thick or a little over for the blocks, some brass rod $\frac{3}{16}$ in. diameter, and the two ebonite knobs, and a quantity of screws and washers of appropriate size. These small items are generally in the tool kit of the average experimenter, but if they have to be purchased separately the best plan is to



THREE-COIL HOLDER

Fig. 15. The coil holder here shown can be made by amateurs, and the method of construction is given on following pages



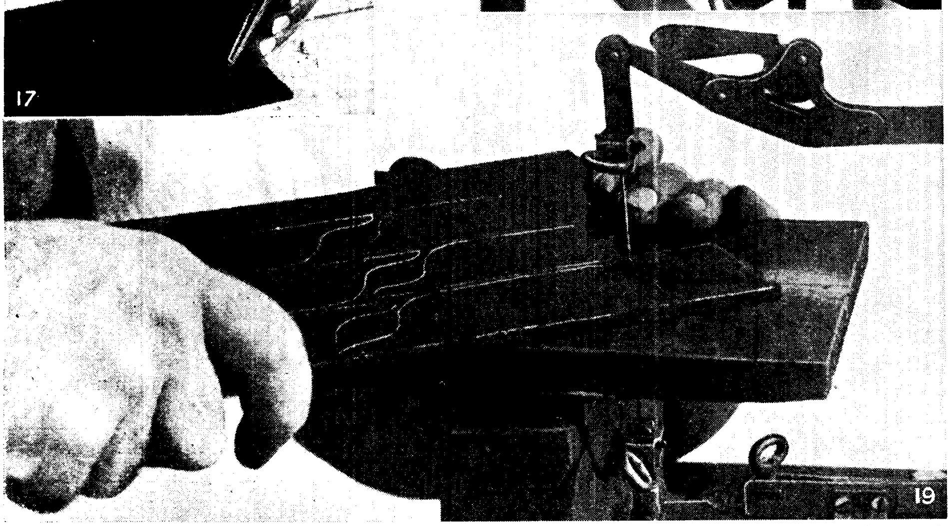


Fig. 16. All the parts necessary for the construction of the three-coil holder laid out and named. These should be made and collected together before assembling, checking over in order to have at hand every part. Fig. 17. Centres for the coil-mounting holes are marked with a centre punch. Fig. 18. Side pieces are filed accurately to shape in this manner. They are held in the vice with leather protecting pieces. Fig. 19. Shapes of the side pieces are marked out on the ebonite panel and sawn out with a treadle fretsaw or a hack-saw

STAGES IN MAKING AN AMATEUR'S THREE-COIL HOLDER

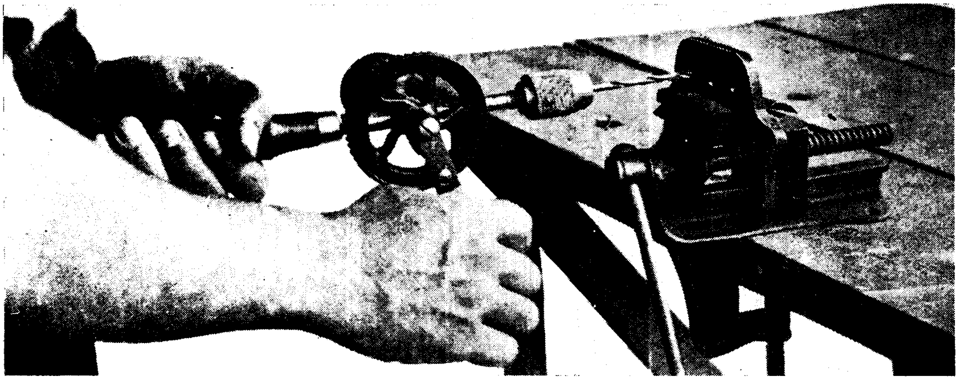


Fig. 20. Holes are being drilled for the control handles. A hand drill is used for this purpose, and the work is held in a vice and protected with leather

Fig. 21. Tapping is here taking place. Holes are tapped in the holding blocks to take set-screws to hold other screws from turning

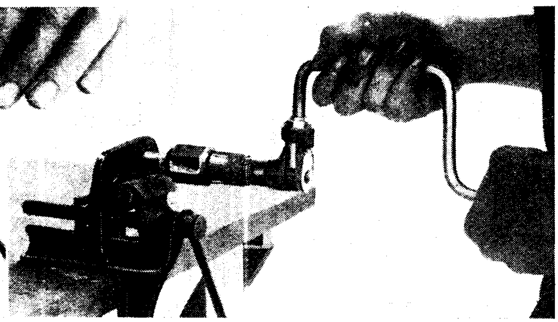


Fig. 22. Counterboring holes is necessary to take the spring washers which keep the holders in place when they have been set at the right degree of coupling

Fig. 23. One of the tapped holes is being fitted with a brass plug, another has a socket fitted

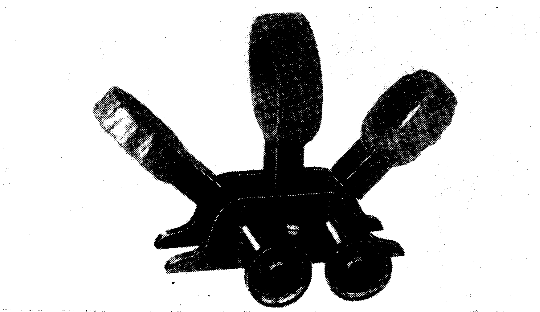


Fig. 24. When the components are assembled and the coils mounted the appearance should be as in this photograph

MAKING THE COMPONENT PARTS OF THE THREE-COIL HOLDER

get a selection of various sizes and lengths of B.A. screws and bronze spring washers, as they are always handy.

The next operation, one of the greatest importance, is to mark out the side plates. This must be done accurately or the coils will not move properly. Commence by scribing a line along the ebonite, and set off a length of 6 in., and scribe two parallel lines 1 in. and $1\frac{3}{4}$ in. from the first respectively. The middle line is the one on which the centres for the coil-mounting holes are marked, the first in the middle, and the others 1 in. each side of it.

These should be marked with a centre-punch in the manner illustrated in Fig. 17. The shape of the curved ends is then drawn and the ebonite sawn to shape with a treadle fretsaw, as shown in Fig. 19. In the absence of such a tool the ends are cut at an angle with a hacksaw.

The next step is to file the side pieces to shape with smooth files, as indicated in Fig. 18, using a lead or leather clamp or protection piece between the jaws of the vice and the work, to avoid bruises and scratches.

The holes for the control handles are drilled, as shown in Fig. 20, by holding the work in the vice and using a hand drill, by means of a drill press, or in the lathe, as may be most convenient. Smaller holes are drilled edgeways through the side pieces for the holding-down screws employed to secure the holder to the panel or other place where it is to be mounted.

Two side plates are prepared in the same way, and the outer two holes of one of them have then to be counterbored, as illustrated in Fig. 22. A pin type of counterbore (*q.v.*) is used for the purpose. The recess so formed is to take a spring washer, which exerts sufficient pressure to keep the holders in place when they have been set to the desired degree of coupling.

Three plug holders have now to be prepared by making three blocks of ebonite $\frac{1}{2}$ in. thick and $1\frac{1}{4}$ in. square. At a distance of $\frac{7}{8}$ in. from the top a hole is drilled and tapped through the ebonite and screwed No. 2 B.A. for the holding screws which keep the block in place between the side pieces.

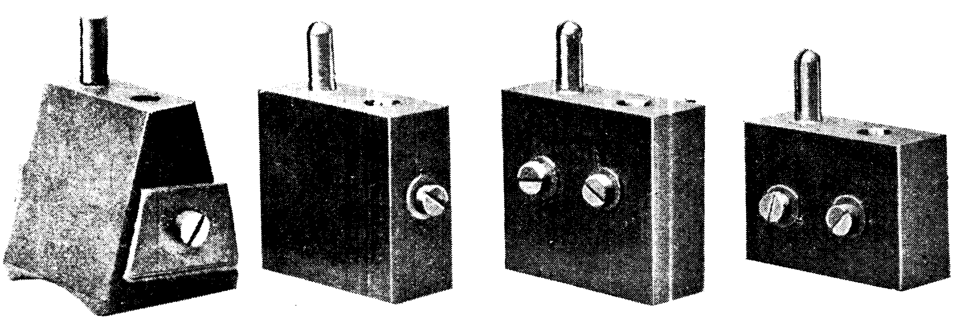
Two other holes are drilled through the block at $\frac{9}{16}$ in. centres, and tapped No. 4 B.A., as in Fig. 21, for set-screws to hold the other screws from turning. At the top part of the block these holes are enlarged to $\frac{1}{4}$ in. until the drill used for the purpose breaks through into the holding screw hole. A turned brass plug is then forced into one of these holes, as shown in Fig. 23, and a socket into the other.

As these should correspond with the plug and socket on the coils to be used in the holder, it is desirable to obtain one and work to it as a pattern to ensure the contacts being in alignment.

Finally, two other holes are drilled at right angles to the brass fittings and tapped No. 6 B.A., and provided with set-screws and washers to take the end of the connecting wires. These screws should pass well into the brass fittings, as they have to make good electrical contact therewith. The work is completed by turning the two brass rods for the control handle spindles, and screwing one end to suit the hole in the ebonite knobs, and the other to screw into the coil-holder block. These axles are fixed to the holder by the No. 4 B.A. screws, which are inserted into the tapped holes beneath the block. The whole is then assembled, and the coils put into place, as shown in Fig. 24.

COIL MOUNT. Name given to a variety of shaped pieces of ebonite or other insulating material used as a base or support for a coil. They are most extensively used in connexion with honeycomb coils, and others of a portable character, which are, as a rule, so arranged that they can be easily removed and replaced with others of different value.

Some typical examples are illustrated in Fig. 1, which shows from left to right a tapered holder for a honeycomb coil, which has a plug and socket type of connexion. It is arranged in this way to prevent the coil being inserted in any but the correct



SELECTION OF COIL MOUNTS FOR PLUG-IN COILS

Fig. 1. Various forms of coil mounts are used. These are four types of plug-in coil mounts. From left to right is a tapered holder for honeycomb coils, loading coil mount for panel, another loading coil mount with extra screw for connexions, and right type used in a multi-coil holder

way, as to do otherwise would make it difficult to be sure of the direction of the coil windings. The screws and side plates are provided to secure the ends of the protective covering of the coil.

The next example shows a single coil mount such as would be applied to a panel for a loading coil; it has the same characteristics as the former example. The next is similar, but has two small screws and washers for connecting the conducting wires from the mount to the apparatus. The last is a type for use in a multi-coil holder with moving mounts to permit of moving the coils to vary the coupling between them.

CONNEXIONS OF A BURNDEPT COIL

Fig. 2. How a Burndept coil is connected to the contact plug and socket of the coil mount may be seen in this partly dissembled coil

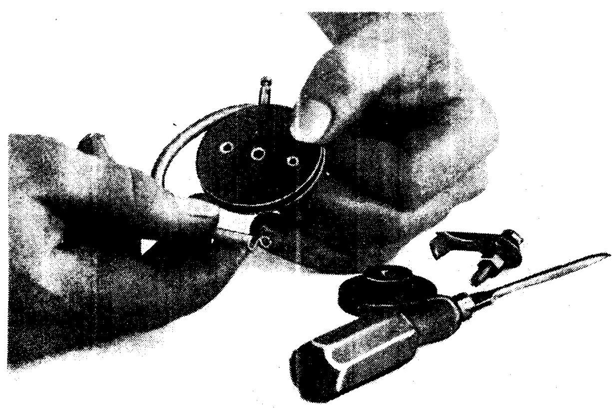
One method of mounting a coil is shown in Fig. 2, and clearly illustrates how the two ends of the coil winding are attached to the ends of the brass socket and plug respectively. To make a secure job of the coil it is attached to a fibre or ebonite slip, tapered at the ends and secured by screws to the top of the mount. The outside of the coil is wound with Empire cloth, or some similar insulating tape, and this keeps the coil closely in contact with the mount. The example illustrated shows Burndept practice.

Another example of a coil mount of an altogether different type is shown in Fig. 3, where a resistance coil is shown in progress of attachment to a circular mount, sometimes known as a former. This is used for the filament resistance of a rectifying valve, and the wire is first secured to one part of the mount by means of a small terminal, and then curved round the groove in the edge of the mount and secured at the opposite end of the coil by means of a set-screw. The end of the resistance coil is shaped in the form of an eye to allow of the passage of the screw. It is important that the coil be evenly spaced and equally extended through its length, and have sufficient tension to keep it firm and resist the friction of the moving contact arm. Another point in mounting this kind of coil is to keep the diameter of the resistance coil regular, as any variations will cause the contact arm to move erratically and adversely affect the control.

A variety of other coil mounts are dealt with under their respective headings, such as Basket Coil; Inductance Coil; Resistance Coil, etc.

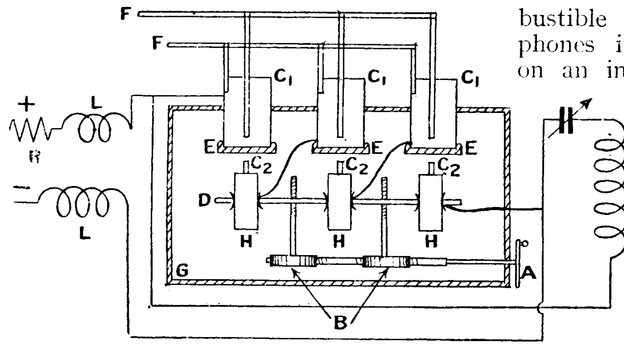
COLIN - JEANCE ARC. Well-known form of arc transmitter patented by V. Colin and M. Jeance. The arc is struck in an atmosphere which consists of a mixture of acetylene and hydrogen, or hydrogen and acetone. By burning the electrodes in such a mixture, the gases being carefully proportioned, the heat of the discharge causes carbon to be deposited on the carbon electrode just as fast as it is being eaten away by the arc. By this means the length of the arc is kept constant, and since the frequency of the oscillations is a function of the arc length, this arrangement ensures a constant frequency when transmitting, without mechanical arrangements being necessary to adjust the arc.

The electrodes in the Colin-Jeance arc generator are copper and carbon, a number



RESISTANCE COIL MOUNT

Fig. 3. Mounted on an ebonite disk with a grooved edge is a terminal from which the spiral resistance coil is taken which is being fitted to form a rheostat



COLIN-JEANCE ARC SYSTEM

Fig. 1. Copper electrodes, C_1, and carbons, C_2, of the Colin-Jeance arc transmitter are shown in this diagram

being joined up in series. In Fig. 1 the copper electrodes are shown diagrammatically at C_1 and the carbon at C_2. The carbon electrodes, which are thin carbon rods 0·04 to 0·08 in. diameter, are held on heavy metal holders, H. These metal holders are all mounted on a common framework or support, D, connected to gearing, B, so that they can be raised simultaneously by the handle A. The arcs are insulated from one another on this framework. The copper electrodes C_1 consist of large copper cylinders closed at E by copper caps and kept cool by water, paraffin, or other liquid circulating through the pipes F.

A gas-tight chamber, G, encloses the electrodes, and the current to the electrodes passes through the choking inductance coils, L, and is coupled to the transmitting aerial as shown in Fig. 2. The arcs are supplied with 500 volts, and in order to ensure purity of the transmitted wave and freedom from overtones the arc oscillating circuit is coupled to the aerial by an intermediate tuned circuit inductively coupled to the aerial.

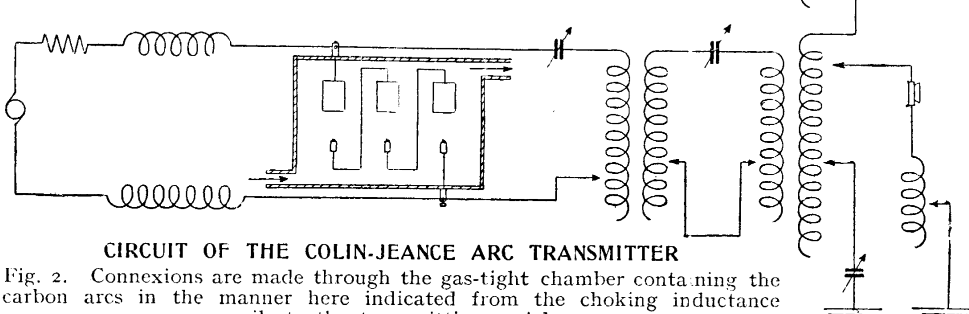
In the Colin-Jeance apparatus the microphone transmitters contain no combustible material. A number of microphones in series are employed, mounted on an insulating base and spoken into simultaneously. This arrangement reduces capacity currents of the microphone.

COLLET. A form of insulator for fixing twin conductors. One kind is made of porcelain, in the form of a tube having a collar at one end. It is held in place by a screw passing through the centre of the tube.

COMBINATION METER. An electrical measuring instrument having two sets of calibrations and used for measuring two different qualities of a current. The photograph shows a combined voltmeter and ammeter, useful for testing the current flowing through

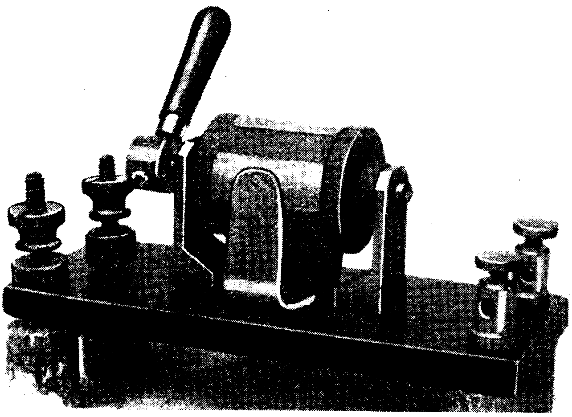
METER FOR CURRENT TESTING

Voltages and amperages can be measured by the same meter. It will be seen that double calibration is shown on the dial of the instrument, which is known as a combination meter



CIRCUIT OF THE COLIN-JEANCE ARC TRANSMITTER

Fig. 2. Connexions are made through the gas-tight chamber containing the carbon arcs in the manner here indicated from the choking inductance coils to the transmitting aerial



HAND-ACTUATED COMMUTATOR

Fig. 1. Polarity of the current supplied to a motor or other device is sometimes required to be reversed, when an instrument of this kind is used. This commutator is hand-actuated, and is sometimes known as a reversing switch

a filament circuit, or the charging rate when recharging a small battery.

The instrument is used by applying the point at the left to one side of the circuit when the voltage is to be measured, and completing the circuit by the contact point at the end of the flexible wire. The amperage is measured by using the other point on the right, and that at the end of the flexible wire.

Internal arrangements vary with different makes, but standard examples are given under the headings of Ammeter and Voltmeter (*q.v.*).

Such combination meters are very handy to the experimenter, as the one instrument is available for a wide range of uses, and as the expense of two instruments is greater there is a consequent economy.

COMMUTATION. As applied to electrical work the word is used to describe the reversal of one circuit in respect of a second, by some mechanical or electro-mechanical means. The instruments used to accomplish this are generally known as commutators when applied to dynamos and motors, and sometimes as reversing switches when applied to a circuit.

COMMUTATOR. Commuting an electric current is to change its direction of travel or polarity. The commutator is a device for doing this. It may be devised to operate by hand, and is then often termed a reversing switch. But every reversing switch is not a commutator in the generally accepted sense of the word. Because the commutator is a feature of all direct-current dynamos and electric motors, one usually associates the name with a rotary device.

The ordinary hand-lever commutator used on an experimental switchboard, for reversing the current supplied to a motor

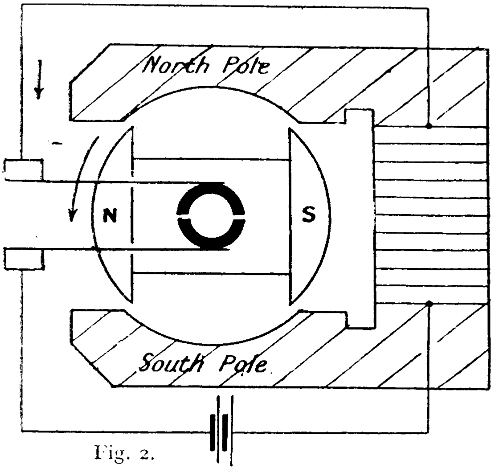


Fig. 2.

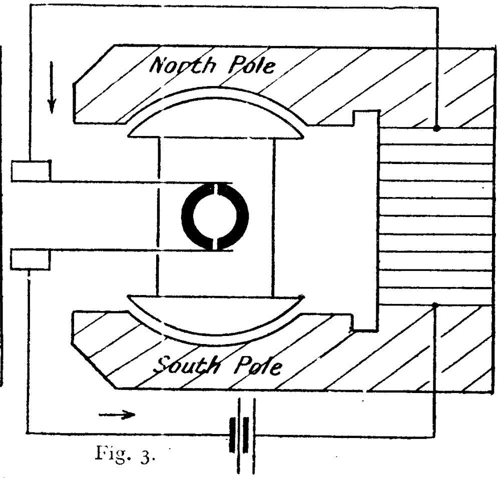


Fig. 3.

TWO STAGES IN CURRENT RECTIFICATION BY A COMMUTATOR

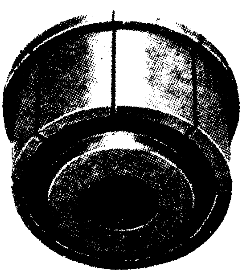
Fig. 2. At this stage the like poles repel and the unlike poles attract, and the conditions should be compared with Fig. 3. Here the armature poles are shown at the moment of short-circuiting. This stage is followed by a reversal of the armature polarity shown in Fig. 2, and rotation of the armature is thereby continued. The same cycle of operations is repeated while the machine is running

and many other purposes in electrical instrument work, may be made by mounting four contact strips on a cylinder of insulating material and connecting them alternately to the two incoming terminals. Two brushes which can only touch two of the contact strips at any one time lead the current away, as shown in Fig. 1. The disk form of commutator usually has only two contact strips, but has four spring brushes. The effect of a partial rotation of the disk through an angle of 90° is the same. By suitable connexions the polarity of the current is reversed.

In both of these types of commutator, as ordinarily used, it is essential that the brushes shall not bridge the gaps between the contacts. If the current is being supplied from an accumulator, there would be the danger of a short circuit if one brush touched two contacts during the operation of reversing.

This does not apply to the commutator of a dynamo or motor. Short-circuiting by slurring over from one contact to another is a necessary function. The slots between each segment are purposely made small so that the brushes can bridge them. In a dynamo the commutator produces a current of continuous direction from another which is an alternating current. In a motor it allows a continuous current to energize the revolving armature with an alternating polarity, so that when one of its poles is attracted to the poles of the field magnet by being magnetized by an opposite polarity, the current is commutated, the magnetism reversed, and the then like poles repel each other. In this way a unidirectional rotation is secured. This is illustrated in Figs. 2 and 3.

The simplest commutator is that fitted to a small tripolar motor. To make it, a piece of copper tube may be fitted on a stick of ebonite, secured by screws, by spinning over, or by recesses formed in the ebonite so that it may be split into three segments, and there wired to the three poles of the armature in proper sequence. To ensure an efficient short-circuiting during the period the brushes are crossing from one segment to another, it is a common practice to incline the slit to the axis of the armature shaft. A typical eight-pole commutator is illustrated in Fig. 4.

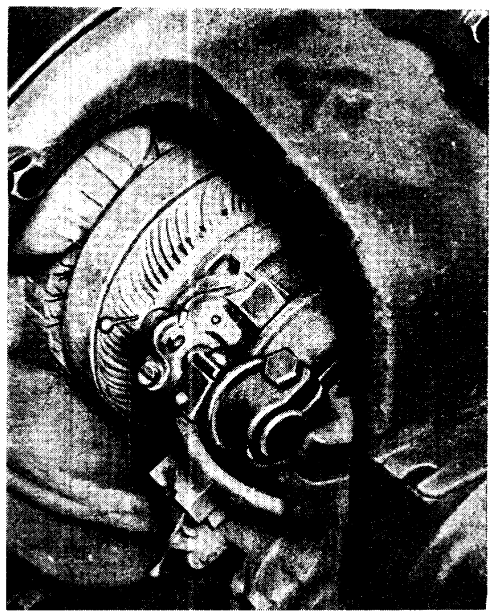


EIGHT-POLE COMMUTATOR

Fig. 4. Commutators of this kind are used on small power motors and dynamos

Disk commutators are made by fixing a disk of copper to another disk of insulating material and splitting up the metal one into segments. The screws should be out of brush contact and should be countersunk. In addition they must be fitted clear of the slits and so that at least two secure each segment. Commutators of this design are mostly employed in small motors of special types and in conjunction with "end-on" plunger brushes.

All these simple designs of commutators would fail in larger work because of the inflammable base on which they are mounted, and because of the open slots, which would fill up with metal dust from the continually abraded brushes. Therefore commutators for machines above 150 watts are made on a different principle. The commutator illustrated in Fig. 5 has segments which are solid V-section blocks of drawn-to-section copper or a cast bronze which is nearly all copper. These are secured to the armature shaft by end



COMMUTATOR IN SEMI-ENCLOSED MACHINE

Fig. 5. Segments of this commutator are solid V-section blocks of drawn-to-section copper secured to the armature shaft

washers of a shape which prevent the segments flying apart by centrifugal force, and, at the same time, gripping the segment insulation together tightly in a lateral direction. The segments and the securing washers are all insulated from each other by mica strips.

When the parts are all assembled, the projecting edges of the strips are trimmed off, and the whole commutator is trued up in the lathe perfectly cylindrical and in alinement with the armature shaft. There is often a little difficulty in getting a good face owing to the presence of the mica.

Finishing a commutator with emery cloth or powder is to be deprecated. The emery dust is difficult to get out of the copper once it is used. To obtain a high polish it is better to employ glass paper. Where the V-shaped drawn bars cannot be obtained or are not suited to the size of the commutator to be made, it will be possible to machine the whole out of a solid casting or bar of gun-metal or bronze. The casting would be machined to the final shape excepting the centre hole.

Filling Commutator Slots with Mica

This would not be bored out at all until after the commutator is completely sawn up into its segments. The centre stalk is necessary to keep the parts together during the sawing operation, which, by the way, would have to be done on a lathe fitted with a milling attachment or a regular milling machine. When the casting is divided radially, the slots may be filled with the mica and roughly turned up. It must then be held in a special chuck which will keep all the parts together and bored out rather larger than the shaft on which it runs—to provide for the necessary insulation. The shaped end washers which were screwed on to the stalk of the castings are then usable in their final position if insulated from the commutator segments by mica washers.

Where ordinary mica is employed, it is necessary to avoid pieces which are pierced, show red stains, or are otherwise obviously faulty. The red stains may indicate the presence of oxide of iron, which would affect the insulating value of the material.

Commutators should only be lubricated sparingly, using vaseline for the purpose. Oil of gummy resinous nature should not be applied to a commutator. *See* Dynamo.

COMPASSES, DRAWING. Instrument used for describing circles and arcs of circles. Compasses are also used to a limited extent as dividers or measuring instruments. The wireless experimenter should possess at least one pair of compasses complete with pen and pencil points, and some of the instruments now on the market are both inexpensive and efficient in use. The compasses should have what is known as a needle point—that is to say, the leg should terminate in a small steel needle which is held in a clamp or by means of a bolt and nut, the precise details varying with different maker's practice.

Another feature should be the provision of a knee joint, otherwise a form of hinged joint, permitting the leg to be bent from near the lower end or somewhere near the middle of its length. This is necessary to permit of the needle being kept in a perfectly vertical position, for the reason that in such a position the compasses may be rotated about the needle point without the latter making a large hole in the paper, as is the case if the legs are inclined to any considerable extent.

For much the same reason the pen or pencil point should similarly be jointed. It is general practice to provide a pen, pencil, and divider points which are interchangeable, and are secured in position by means of a small set-screw or some other convenient means. The pencil point comprises a small holder for a thin piece of black lead. The pen point comprises a pair of steel nibs, the width between the points being adjustable by means of a small set-screw. It is highly desirable that one of the nibs should be hinged so that it can be folded backwards to facilitate cleaning. The divider point is simply a sharp steel point which enables the compasses to be used as dividers for taking off accurate measurements.

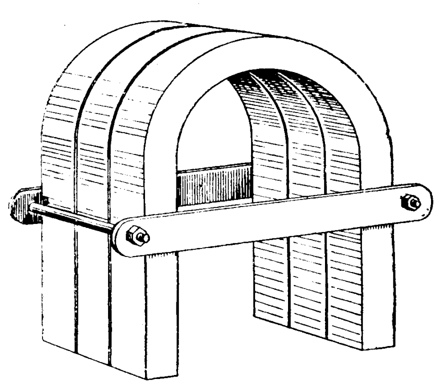
A convenient way in which to obtain this class of instrument is to purchase what is technically known as a half-set, which comprises the parts previously described, with the addition of a lengthening bar. For average work, compasses of the standard pattern will be found suitable, and may measure about $4\frac{1}{2}$ in. in length. A particularly good pattern, known as the Diamond, is now made in rustless steel, and this has the advantage that, even if the compasses are left lying about on the bench or drawing board, they neither rust nor tarnish, and are very delightful to use. The methods of use and their care and attention are dealt with under the heading Drawing Instruments.

COMPOUND DYNAMO. A direct current generator having two distinct sets of windings, and so arranged that the machine automatically tends to regulate its voltage under varying loads.

In a typical example the windings on the field magnet are a combination of a series and a shunt winding. The series winding is of low resistance and in series with the armature windings and the external circuit. The other is a separate winding of many turns of a fine wire having a high resistance to the passage of the current; this winding is shunted across the armature brushes. When the values are correctly proportioned, the effect is to regulate the voltage and keep it constant; for the series coils on the field magnet strengthen it as more current is demanded, while the exciting current in the shunt windings drops, depending on terminal voltage. *See* Dynamo.

COMPOUND MAGNETS. A compound permanent magnet is one made up of several separate magnets. It has been found that better results are obtained by splitting up a given weight of steel in a magnet into laminae. Magnet steel must be "dead hard" to obtain any degree of permanence in the applied magnetism. Soft steel loses magnetism almost as soon as the energizing current making it a magnet ceases to flow.

Therefore, where a compound magnet is to be made, all holes used for fixing it to its base or to another similar magnet alongside it must be drilled in the steel

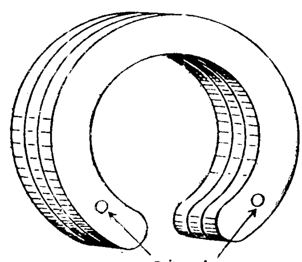


U-TYPE COMPOUND MAGNETS

Fig. 1. Three U-type magnets are joined by fastening with brass strips and bolts to avoid drilling

before it is hardened and magnetized. Where existing magnets are to be placed side by side for a single purpose, *i.e.* compounded, and it is not desired to drill holes in them because of the necessity for softening, rehardening, and magnetizing them, the magnets may be clamped together with bolts and clips as shown in Fig. 1.

The use of iron or steel for bolts or clips must be made with circumspection. Iron must not be allowed to bridge the poles of the magnet or their ultimate value may be upset. Presuming that a set of three magnets are being bolted together, as shown in Fig. 1, then the cross clips must be of brass or other non-magnetic material, but the bolts may be made of iron or steel so long as they are not too large in diameter. Fig. 2 shows another method of fixing magnets together to form a compound magnet by means of rivets.



COMPOUND HORSESHOE MAGNETS

Fig. 2. These horseshoe magnets are joined by rivets inserted near the ends of the magnets

Compounding a wire-wound electromagnet means only an alteration in the winding, not laminating the core iron. Compound winding is resorted to in dynamo field magnets. The main "series" winding is, in a compound-wound machine, supplemented by a secondary shunt winding. One winding in a compound-wound magnet may be made to augment or retard the magnetic effects of the other.

In a dynamo the compounded arrangement is employed to obtain an even voltage of output within large ranges of driving speed. Permanent magnets may be made out of ordinary tool steel (crucible cast steel), but is better to obtain the special tungsten steel, which also has no nickel in it, made for magneto magnets.

The magnetization may be performed by placing it across the poles of a strong electro-magnet. The energizing current should be cut off and applied many times, the permanent magnet being struck with a light hammer while it is energizing. *See* Magnet.

CONDENSERS: THEIR USE, CONSTRUCTION & THEORY

How to Make Eight Types, Fully Illustrated

Here are described all the functions of condensers in wireless circuits, the construction of several varieties with a special plate, and the general theory of condensers. Other condensers are described under their various headings, e.g., Air Condenser; Billi Condenser; Mansbridge Condenser. See also Capacity; Dielectric, etc.

In electricity a condenser is a piece of apparatus consisting of two or more conducting surfaces, usually approximately parallel, separated by a dielectric.

The condenser plays a most important part in wireless matters, and although one of the simplest pieces of apparatus to construct, it is not easy to explain concisely the way in which it functions.

Its utility is restricted to pulsating or alternating circuits, and its action may perhaps be best compared with that of a flat steel spring in mechanics; in the same way that inductance is sometimes likened to the inertia of a flywheel, making it difficult to start, stop, or change the value of a steady current flowing through any circuit possessing self-induction.

Imagine this flat spring at rest and in an unstressed state. On applying a force that will cause the spring to bend a certain opposition will be encountered, due to its stiffness or capacity for resisting bending stresses. These will increase as the spring is further bent until a condition is arrived at when the opposing force exerted by the spring balances the deflecting force applied to it, and the system of stresses is then in balance and motion ceases. If the force is now removed the spring returns to its normal position, if it has sufficient elasticity, and in unbending returns power to the system.

The Simplest Form of Condenser

The simplest form of condenser consists of two plates of metal, having as large a surface area as possible, placed close together and separated either by air or some other dielectric. To reduce the appliance to reasonable dimensions, each plate may be divided up into a number of units, that is cut into two, four, eight, or some other multiple, and all joined together electrically; at the same time, one set of plates is interleaved with the other set similarly subdivided and coupled up. The two groups of plates must be kept electrically separated, however, otherwise, of course, the apparatus ceases to act as a condenser. It is this accidental touching in air condensers, due to one of the moving plates being bent, that stops a wireless receiving circuit from functioning, and puzzles the amateur as to the cause of the trouble.

In actual practice the condenser plates usually consist of tinfoil, aluminium or brass sheets mounted on ebonite, glass or mica, and may be formed into various shapes of either tubular or rectangular section. In the electric circuit the driving force may be regarded as the potential or electromotive force, and the condenser plates as the springs which bend under pressure from the driving force. The movement of the springs, which are deflected until they balance the pressure, may be regarded as the flow of current into the condenser, and when no further motion takes place the condenser plates are said to be charged to the same potential as the circuit in much the same way as the opposing force of the springs balances the deflecting forces.

What the Capacity of a Condenser Is

If the electro-motive force which caused the charge is suddenly removed or reversed the condenser discharges, and returns to the circuit all the energy expended in charging it, provided there has been no leakage. The capacity of a condenser may be said to resemble that of a vessel holding liquid, and is measured by the time it takes for current to fill it to a certain level or potential. A condenser, for instance, with a large area would take a relatively long time to acquire a certain potential with current passing into it at a definite rate, just as a large tank or cistern would take longer for the water to rise to a certain level than one having a smaller area.

Condenser capacity is altered not only by the size of the metal plates, but also by the thickness of the dielectric between them, and the nature of the material forming the dielectric. A condenser with its plates simply separated by air would have a far less capacity than if ebonite, glass, or mica, were used as a dielectric, ebonite increasing the capacity by twice, glass five to ten times, according to its composition, and mica about eight times.

The measurement of condenser capacity is the quantity of electricity necessary to establish unit potential difference between its plates. Unit capacity is termed the farad, and represents such capacity as would attain a potential of one volt between its plates with a charge of one ampere flowing for one second, that is, one coulomb. In practice this unit is much too large to be convenient, and consequently the unit of one microfarad, or one millionth of a farad, has been taken.

Even the microfarad is a somewhat cumbersome unit in wireless work, and the electrostatic unit capacity of a sphere of one centimetre radius is sometimes used instead, which is $1/(9 \times 10^5)$ microfarads, from which it is clear that one absolute unit capacity $= 1/(9 \times 10^{11})$ farads, and one farad $= 9 \times 10^{11}$ absolute units.

The following relationship between quantity in coulombs, farads and volts is also important, namely $Q = CE$, that is, the charge, Q, introduced into a condenser is proportional to the capacity, C, of the condenser and the voltage, E, to which it is finally charged. The same law can be expressed as $E = Q/C$, and gives the potential difference between the plates of a condenser as being directly proportional to the charge introduced, and inversely proportional to its capacity.

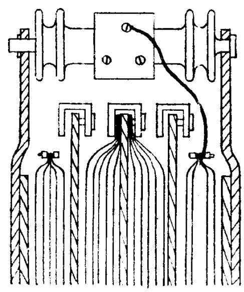
The total quantity of electricity in coulombs used in charging a condenser of C farads to a potential of E volts is as stated above, $Q = C \times E$, and assuming the condenser is charged at a uniform rate, its potential will rise uniformly from zero to the value represented by E, and the total work done during the time T taken to charge must equal the average potential. $\frac{1}{2}E$ multiplied by the rate of charge multiplied by the time $= \frac{1}{2}CE^2$ joules, the joule being the unit of electrical energy, or one volt multiplied by one ampere multiplied by one second.

Condensers in Parallel and in Series

The term $\frac{1}{2}CE^2$ represents the amount of energy expended in charging a condenser of C farads capacity to a maximum pressure of E volts, and it also represents the amount of energy when the same condenser discharges. If condensers are joined up in parallel and all are alike as to capacity, the combined capacity of the group is that of one condenser multiplied by the number in the group. If, however, they are coupled up in series, their joint capacity would be that of one condenser divided by the total number so joined together (see page 359).

Condensers for wireless transmission are made with strips or sheets of tinfoil interleaved either with paraffined paper, ebonite, or glass sheets. In some cases Leyden jars are used, and although fragile, they are very portable and convenient to handle and replace, and will stand heavy overloading. The oil condenser is made of strips of tinfoil between glass plates, and is immersed in paraffin oil contained in an iron case. This does away largely with brush discharge and internal leakage, but oil is apt to leak, and the apparatus is not free from drawbacks.

If internal sparking should occur, hydrocarbon gases are given off, which, being inflammable, may cause a serious explosion. Fig. 1 shows diagrammatically the internal construction of a standard transmitting condenser, so far as one element is concerned, and it is so arranged that by means of a switch any desired number of elements can be brought into circuit for various combinations.



TRANSMITTINC CONDENSER

Fig. 1. The internal construction of one element of a transmitting condenser is shown in this diagram

Condensers used in wireless work must have certain essential characteristics, which may be enumerated as follows:—

(1) Their capacity must be accurate, as stated.

(2) The dielectric must be of a very high order of insulation.

(3) Their capacity must not change during use, or, in the case of variable condensers, when once set.

(4) Dust and damp must not be allowed to affect them.

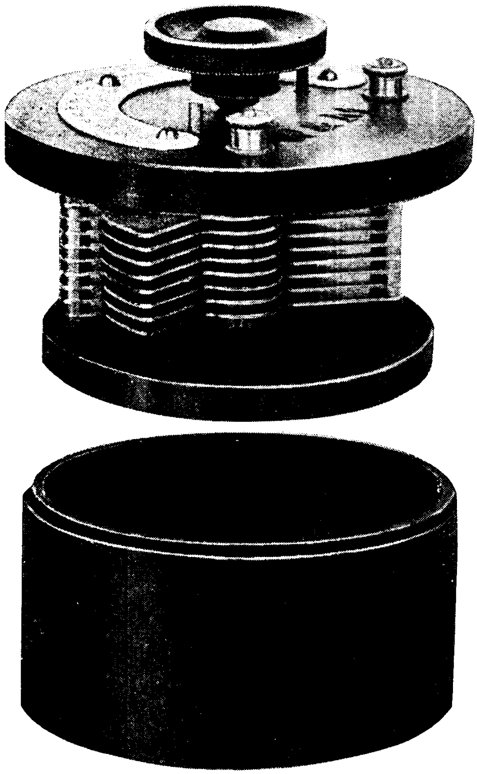
Taking (1) with small fixed condensers, even the most expensive may have 5 per cent variation either way, but this is not of much consequence. Some cheap makes often vary 100 per cent, and are not worth buying on that account.

(2) The use of really good ruby mica for fixed condensers ensures a sufficiently good dielectric.

(3) The natural springiness of copper foil and mica is sometimes sufficient to cause condensers to vary in capacity, but this can be avoided by mechanically clamping the plates firmly together.

(4) An ebonite container or wax surrounding will eliminate this trouble.

The most familiar type of variable condenser is the vane type (Fig. 2). Two sets of vanes, each of semicircular formation and usually made of aluminium, are used, separated by spacing washers. The fixed vanes are rigidly fixed to the top and bottom of the condenser. The top and bottom may be of ebonite or metal, and



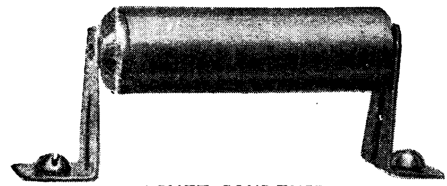
CONDENSER AND CASE

Fig. 2. Variable small capacity air condensers of the familiar type shown above may be furnished with an ebonite case or protective ebonite box. Connexions are made to terminals on the top

each contain a bearing half-way along the straight sides of the plates and accurately disposed in alinement with one another. Should the top and bottom plates be of metal the bearings must be insulated from them by an ebonite or other bushing.

Rotating in these bearings is a spindle having a square-sectioned centre, upon which the moving plates are threaded, being separated from one another by washers of identical thickness to those separating the fixed plates.

A knob and pointer, or knob and dial fixed securely to the projecting end of the condenser spindle, is used for controlling the dispositions of the moving vanes in relation to the fixed. Connexion to the moving vanes is made by a spring strip with a friction contact, or in better class



BRACKET CONDENSER

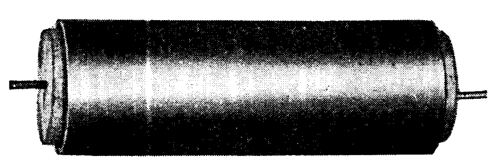
Fig. 3. A small fixed condenser with surfaces connected to brass end plates which fit holes in the brackets. This type is useful as a condenser where any change of capacity is wanted

condensers, by a coiled hair spring. If the latter type of connexion is used, provision must be made to prevent turning the spindle more than half a revolution.

Unless extreme care is taken in the construction of a vane type condenser, many defects are likely to creep in. Bad contact is the chief cause of trouble and causes clicking noises in the telephones, and it may be caused through either a weak or dirty spring contact to the moving vanes or by atmospheric action or damp causing oxidation between plates and spacer washers. Changes of capacity often occur through non-rigid plate supports.

There are many other types of variable condenser, some of which are described below.

Fig. 3 shows a small fixed condenser fitting in brass brackets. The condenser surfaces are connected to two brass end plates, conical in shape to fit two holes in the brackets. One plate of the condenser consists of a brass cylinder over which is wrapped a sheet of thin mica. This is surrounded either by a coil of tinned wire soldered along its whole length, or by another brass tube fitting over the mica. An ebonite tube surrounds the whole, making it dust and damp proof. This is a useful condenser when any rapid change



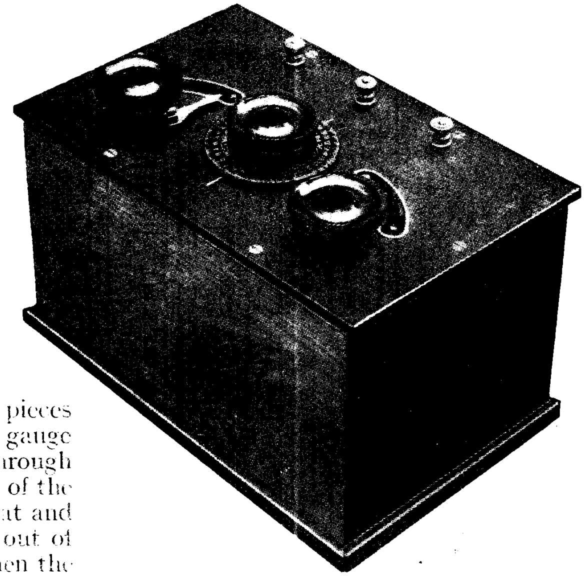
NEUTRODYNE CONDENSER

Fig. 4. Hazeltine neutrodyne circuit employs a condenser which consists of a copper tube in which is fitted an ebonite rod. Through a hole in the latter is passed two pieces of copper wire

is required, as the condenser can be very readily substituted for another of different capacity.

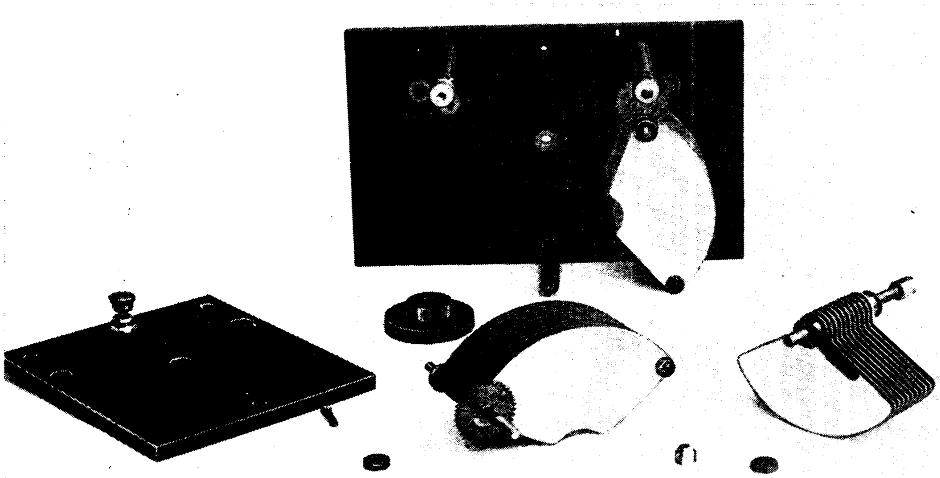
A condenser that is applicable to such circuits as the Hazeltine Neutrodyne (*q.v.*) is illustrated in Fig. 4, and can be quickly constructed from a piece of copper tube about ½ in. diameter and 2¾ in. long. The ends are cleaned up square and true, either in the lathe or by careful filing, and then rounded off with emery paper. The interior is cleaned in the same way and filled with a length of ebonite rod that fits tightly. Two separate pieces of stout copper wire about No. 14 gauge are then fitted into a hole drilled through the centre of the ebonite. The ends of the copper wires are separated somewhat and adjusted by sliding them into or out of the hole. A normal position is when the ends of the wires are about ½ in. apart. The finished condenser is then introduced into the circuit and held in place with a strip of ebonite or fibre in the form of a clip secured to the baseboard with a few screws.

The three-electrode condenser is a recent development that appears to have great possibilities to the experimenter, as it is claimed to reduce interference when properly applied to a circuit. It consists of three sets of moving blades which are separately adjustable in respect of each other. The whole are mounted in a case as a unit, and are illustrated in that form in Fig. 5; the components being shown separately in Fig. 6, where the three sets of moving plates are clearly visible and the gears that are employed to actuate the outer two banks of blades.



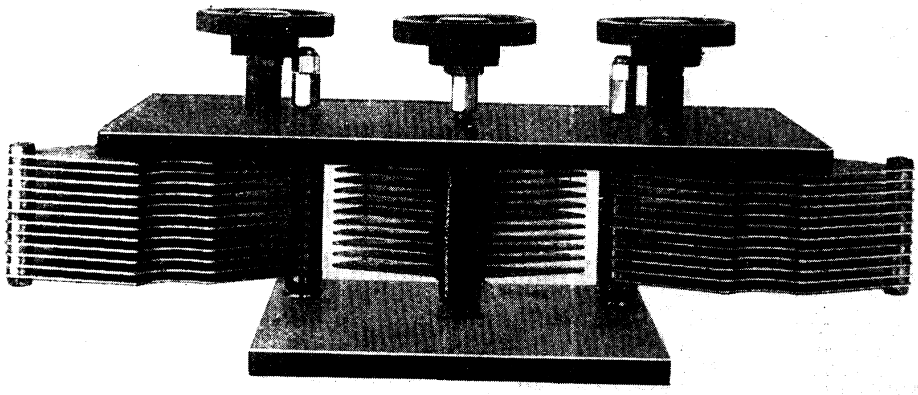
THREE-ELECTRODE CONDENSER

Fig. 5. Autoveyors' three-electrode variable condenser is in the form of a compact unit, as will be seen from the above photograph



COMPONENT PARTS OF THE THREE-ELECTRODE VARIABLE CONDENSER

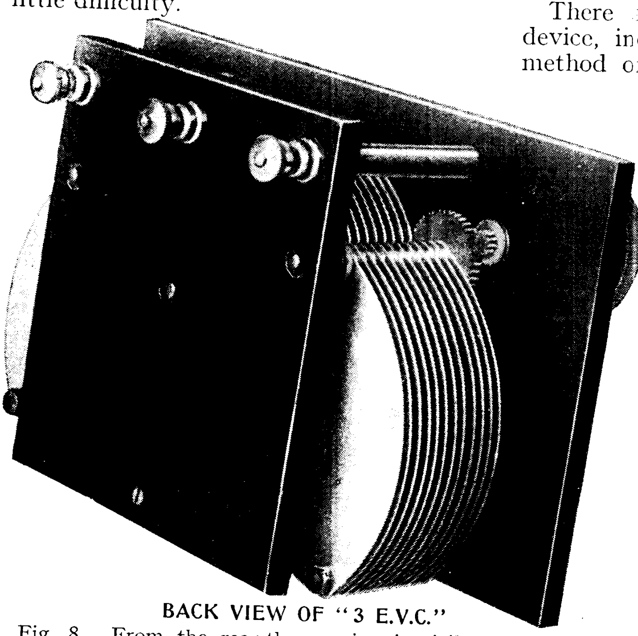
Fig. 6. Dissembled parts are laid out to show how the metal vanes or plates are shaped, and their cogwheels and spindles. The components are mounted between two ebonite panels. There are three sets of movable vanes, the two outside sets engaging independently with the centre set



THREE-ELECTRODE VARIABLE CONDENSER AT MAXIMUM SEPARATION

Fig. 7. This view of the assembled 3 E.V.C. condenser makes clear the method of operation. Three means of variation are provided, as the three units are movable. Very fine tuning can be effected by its use

The centre set is simply attached to a spindle in the usual way, but the outer sets are geared down and turned at a slow speed by the pinion wheels attached to the end of the operating spindle. This is a refinement that is conducive to fine tuning, apart from the other features of the 3 E.V.C. condenser, as it is named by the makers. It is claimed that by the device near-by stations may be tuned out with little difficulty.



BACK VIEW OF "3 E.V.C."

Fig. 8. From the rear the gearing is visible, which gives a slow motion to the moving vanes. The smaller cog is attached to the spindle of the turning knob, and the larger is attached to the set of vanes

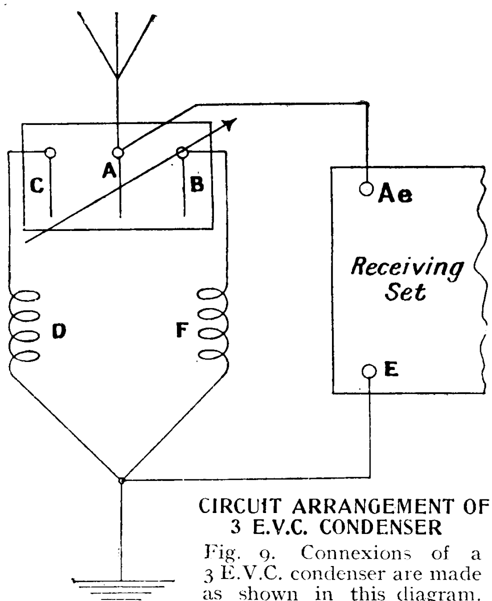
The appearance of the blades when they are all separated to the maximum is shown in Fig. 7, which illustrates a 0·0005 mfd. set for panel mounting. The back view of the same instrument, Fig. 8, shows clearly how the pinion on the actuating spindle gears with the gear wheel on the condenser plate spindle, and also the closeness of coupling that is possible with this device.

There are many applications for the device, including the bridge or balance method of utilizing capacity. To reduce or silence interruptions, the circuit may be as shown in the diagram Fig. 9. The 3 E.V.C. is shown at A, B, C, where each set of plates is, respectively, at A, the centre or aerial plates, B, the right-hand plates, and C, the left-hand plates.

The aerial lead-in is attached to the terminal at A, and thence by a wire from the terminal on the condenser to the aerial terminal on the receiving set. The right and left-hand sides of the condenser are attached to the coils F, D, respectively, as shown.

The other side of these coils are connected to earth, as is the earth terminal of the receiving set. The two coils act in conjunction with the condenser to form rejector circuits; and if interference is experienced both above and below the wave-length of the required station, such multiple interference is tuned out by first tuning the receiving set to the wave-length of the desired station and tuning the condenser C for the interference below the desired wave-length. To tune out the interference above the desired wave-length the other side of the condenser is separately tuned.

The Marconi disk variable condenser is one of the most compact types of variable condenser made. In construction it is very similar to two ordinary air dielectric condensers, save that the dielectric is thin ebonite sheet. One spindle operates a



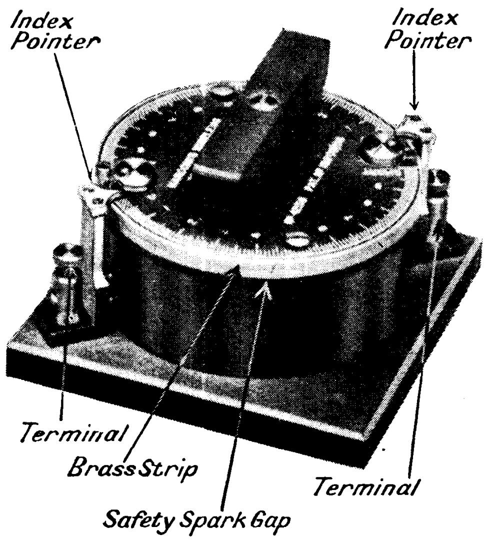
CIRCUIT ARRANGEMENT OF 3 E.V.C. CONDENSER

Fig. 9. Connexions of a 3 E.V.C. condenser are made as shown in this diagram. C, A, and B are the terminals of the condenser, from which leads are taken to aerial and two coils

double pair of moving sets of plates, also insulated from one another. The vanes of the condenser, shown in Fig. 10, are made of zinc. A safety spark gap is incorporated as shown to save the ebonite from an overload.

Fig. 11 shows the Dubilier Vanicon variable air condenser fitted into an ebonite case. An aluminium top shields the plates from body capacity.

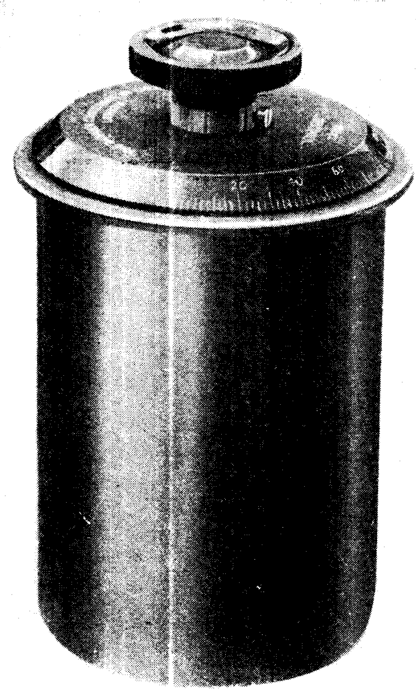
Fig. 12 shows a type of transmission condenser. It is one of a bank of four as used as a main condenser in a 5 kilowatt spark transmitter set. The dielectric consists



DISK CONDENSER

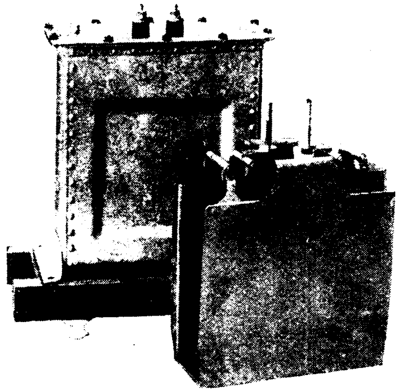
Fig. 10. Disk condensers are made in a similar way to an ordinary air condenser, the dielectric being ebonite and the vanes of zinc. Such condensers are, for their capacity, the most compact made

Courtesy Marconi Wireless Telegraph Co.



DUBILIER VARIABLE CONDENSER

Fig. 11. Dubilier "Vanicon" variable air condenser is here shown. An ebonite case is provided, and an aluminium top shields the plates from body capacity

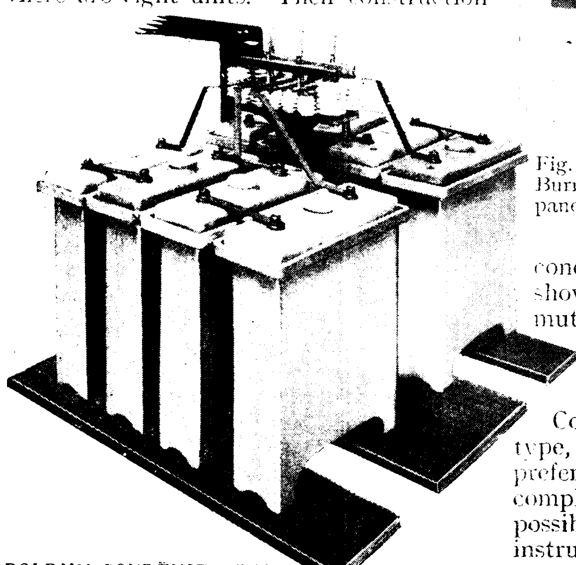


CONDENSER FOR 5 KW. TRANSMITTER

Fig. 12. Plates and container of a 5 kw. spark transmitter are shown above. This condenser has 36 glass plates and 17 zinc sheets, two plates separating each pair of sheets
Courtesy Marconi Wireless Telegraph Co.

of 36 glass plates, and there are 17 zinc sheets; so that there are two glass plates between each pair of zinc sheets. The whole assembly is immersed in high-flash insulating oil to prevent brush discharges. The tank is made of galvanized iron and supported on teak beams resting on porcelain insulators. Connexion to the plates is made by the two ebonite bushed terminals shown on the top.

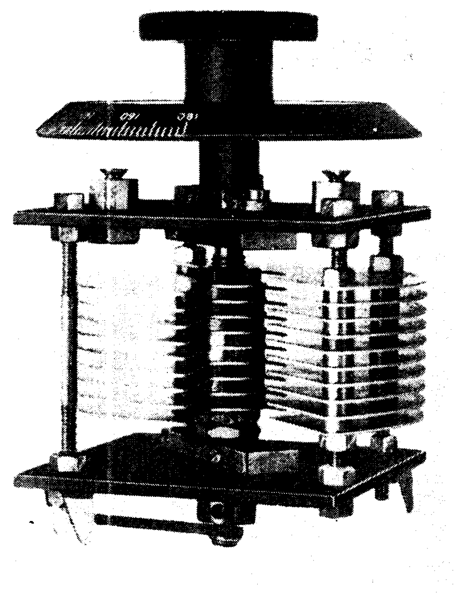
In the condenser bank shown in Fig. 13 there are eight units. Their construction



POLDHU CONDENSER BANK

Fig. 13. Poldhu condenser bank, such as is used with a 5 kw. transmitter. It is oil-sealed and provided with a controlling device known as a Swiss commutator, seen on top
Courtesy Marconi Wireless Telegraph Co.

is similar to the units of the condenser shown in Fig. 12, departing from that, however, in having glazed ironstone tanks. The feet are specially moulded to secure surface insulation between the bottom of the tanks and the ground. The tops of the tanks are moulded out to form a tray in which the lid is fitted. The trough thus made, when filled with oil, forms a trap and seals the tank. Only twenty glass plates are used, with one plate separating each pair of metal sheets. The

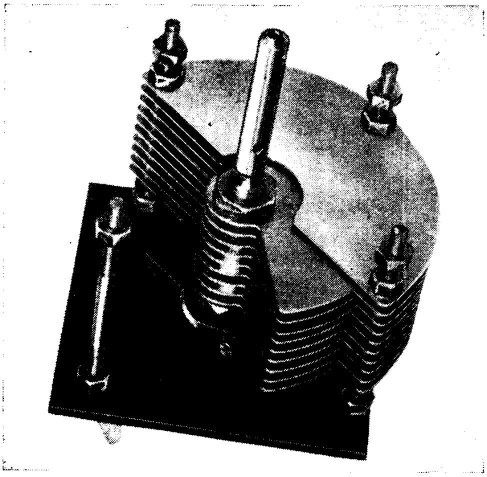


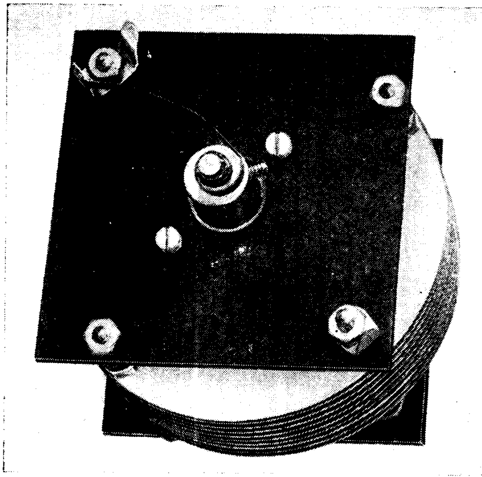
SELF-CONTAINED AIR CONDENSER

Fig. 14. Screws are seen below the dial of this Burndept condenser, which are provided for panel mounting. The condenser is complete and ready for use

condensers are placed in series in pairs, as shown in the photograph. The Swiss commutator mounted on the top of the bank is a condenser-controlling device resembling in principle and appearance a field telephone switch gear.

Condensers of the panel-mounting type, such as the example in Fig. 14, are preferably assembled in the form of a complete self-contained unit, as it is then possible to make all adjustments to the instrument before it is fixed to the panel. The pattern shown is a Burndept, and this can be attached to the panel by screws, seen beneath the dial. These screw into the brass pad pieces and pass through holes drilled in the panel for the purpose.





MECHANICAL ACTION OF A VARIABLE AIR CONDENSER

Fig. 15 (left). Moving vanes on a spindle pass between immovable vanes without any one touching another. When the two sets of vanes are covering each other they are separated by air. The ebonite top has been removed for the purpose of testing for truth and for adjustment. Fig. 16 (right). Contact is made between the moving spindle and the terminal by means of a coiled spring of phosphor-bronze, which tightens or loosens with sufficient play to permit rotation

A clearance hole is drilled in the panel to allow the spindle to pass without touching, as this is often a cause of partial failure.

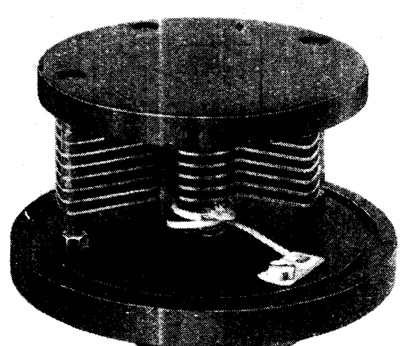
The dial is removed to fit the condenser to the panel, and the length of the spindle may have to be shortened to suit, as it is desirable that the dial fit closely to the face of the panel. It should, however, revolve without touching it at any point in its travel. Should it do so at one point only, the probability is that the unit is not square to the panel, which is remedied by adjusting the top and bottom plates.

Another most important point is to see that the moving plates always turn absolutely true and in the centre of the space between the fixed plates. On many condensers this may be tested by observing the position of the moving plates in respect of the others by removing the top ebonite plate and turning the plates from side to side and noting that they are equally spaced at each side as shown in Fig. 15. Adjustment is made by lengthening or shortening the distance between the top ebonite plate and the top fixed condenser plate. This usually has the effect of setting the plate true.

The connexion between the moving plates and the terminal is a matter that calls for particular attention. If the easy but inefficient method of allowing the contact to be completed through a bush and the spindle that passes through it is adhered to, there will be a serious loss of efficiency. It is seldom that such an arrangement is satisfactory.

A much better plan is that shown in Fig. 16, where a strip of phosphor-bronze is attached to a collar on the end of the spindle and taken to a terminal with a soldering tag. This ensures a perfect contact, as the strip is continuous. The coils at the spindle end of the strip enable it to turn with the spindle, the strip coiling and uncoiling slightly as the spindle is turned. Stops are essential to limit the travel of the spindle.

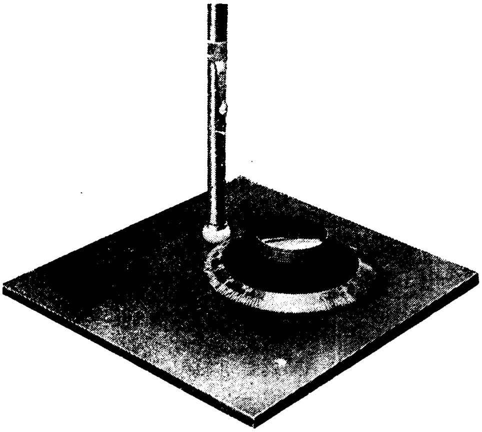
Another effective method is shown in Fig. 17, where a flexible wire is attached



CONNEXION OF CONDENSER ROTOR

Fig. 17. Another means of connecting the moving vanes of a condenser to the terminal is by the flexible insulated wire seen above

by soldering to the tag attached to the lower part of the spindle and the other end attached to a terminal plate with a knurled nut on the top. The illustration shows the underside of the condenser top plate and the method of attaching the wire. As in the former example, a soldered joint is made at each end of the conductor and stops provided to limit the travel of the spindle.



LEVER FOR FINE ADJUSTMENT

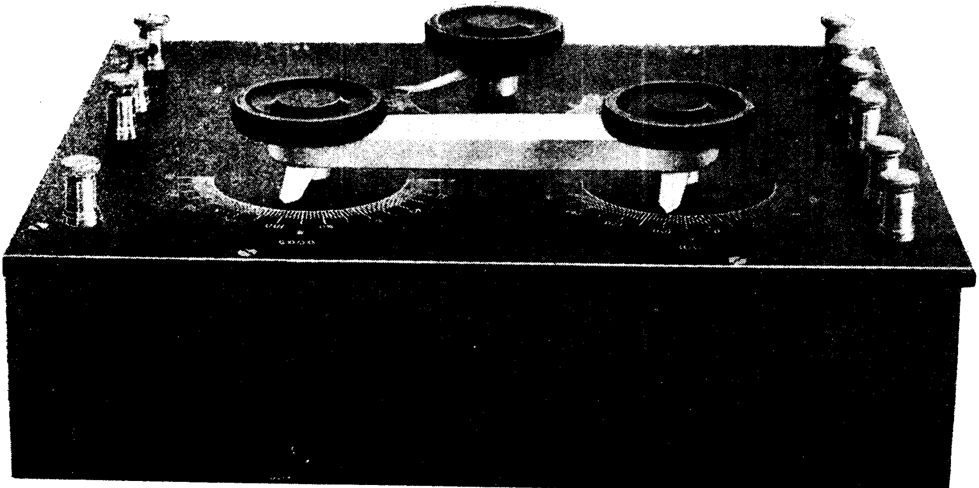
Fig. 18. Condensers are sometimes fitted with a long handle or lever as a means of fine adjustment. At the bottom of the lever, which is rotated between the finger and thumb, is a rubber wheel which engages the condenser dial

A difficulty in the use of some condensers, especially those without a vernier attachment, is to move the plates a sufficiently small amount for the finest tuning. One way to deal with this problem is illustrated in Fig. 18, where a long detachable handle is used to actuate the dial on the top of the condenser spindle by means of a small diameter rubber wheel attached to the lower part of the handle. This permits the dial to be moved a very small amount, as the reduction in the rate of turning is some five or six to one. The attachment is procurable at small cost and fitted by fixing a small bush to the panel at the side of the dial in such a position that the rubber wheel presses on the rim of the dial. The detachable handle fits into the bush, and when tuning is in progress the handle is inserted and turned as necessary.

The handle has a safety clip and can be carried in the pocket like a fountain pen, and is thus at hand when wanted. Another advantage is that the hands are kept well away from the condenser and body capacity effects are thereby minimized.

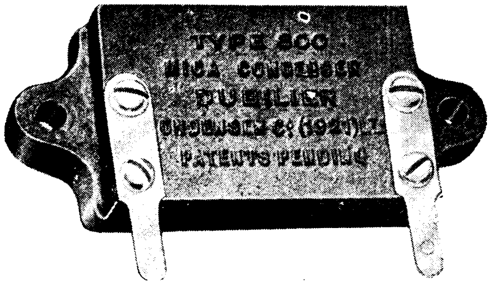
When two condensers have to be tuned simultaneously a useful way is to connect them with a stout rubber band passing over the knobs of the two condensers, as shown in Fig. 19. This plan is especially useful on a condenser panel or unit such as that illustrated. Should the condensers have to be turned in opposite directions the rubber band is reversed or crossed by twisting it before placing it on the knobs.

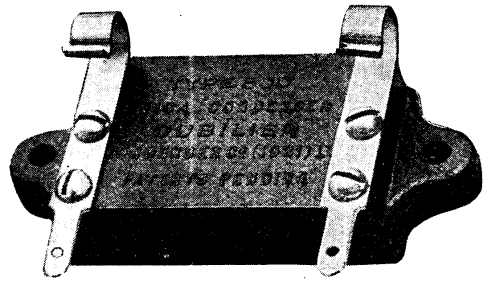
One of the most interesting types of condensers consists of two rollers side by



SYNCHRONIZED CONDENSERS FOR DUAL TUNING

Fig. 19. Two condensers which may be temporarily required to be synchronized during tuning can be connected with a rubber band placed as shown in the photograph. Simultaneous action is then possible by moving either knob



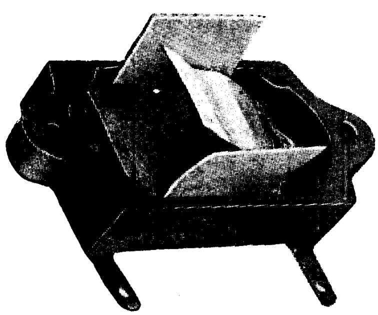


FIXED CONDENSERS AND GRID LEAK ATTACHMENT

Fig. 20. Dubilier condensers are of great use to amateurs who construct their own sets. This is a fixed condenser for screwing to back of panel. Fig. 21. With this condenser spring clips are attached for holding a grid leak. The dielectric is mica, with copper-foil plates

side, which rotate in bearings and are insulated from one another. One roller comprises a metal tube surrounded by an insulating medium, the other being quite plain. A metal ribbon is wound from the plain roller to the other one, and vice versa. Connexion is made to the metal of the tubular roller and to the ribbon; thus, as more ribbon is wound on, so more capacity is introduced.

A very simple, cheap, and effective type of condenser has merely two flat plates, one fixed and the other movable. Mica dielectric is placed between them. The movable plate is fixed to a screw-thread, and is capable of movement either toward or away from the fixed plate; as the capacity varies inversely in direct proportion to the distance between the plates, a truly representative dial reading can be obtained. The only drawback to this type of condenser is that it cannot be said to have a zero capacity when the plate is withdrawn to its fullest extent.



INTERIOR OF A DUBILIER CONDENSER

Fig. 22. Alteration in capacity by external bodies is prevented by the tin shroud, which is shown opened out. it surrounds the foil and mica plates. The whole is clamped together and the cavity filled with wax

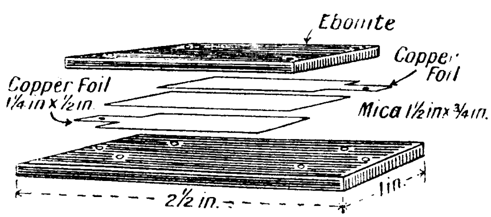
This renders it of little use in some circuits where it is sometimes required to cut down capacity to an absolute minimum, but for general work it is excellent. Moreover, it has the immense advantage of taking only about one-tenth of the space required for a vane-type condenser of the same maximum capacity. In the case of variable condensers used in transmission on fairly low powers, the vane spacing should not be less than $\frac{1}{8}$ in. between any two vanes.

Commercial fixed condensers sold for wireless purposes are invariably of the foil-mica type, as this is undoubtedly most efficient and comparatively cheap to manufacture. Condensers of this type can also be made up to fairly large capacities and still retain their small size and compactness.

Fig. 20 shows a type in general use. The foil and mica are cut to size and placed alternately, being clamped together by a metal clip. This has the excellent purpose of absolutely preventing changes of capacity due to the components of the condenser "springing." The ends of the plates, of like polarity, are connected to two screwed pillars. The whole condenser is now inserted inside a neat moulded block having a recess at the back, and generally the whole space is filled with wax or some similar composition.

The pillars project through the case, and terminal nuts or soldering tags are fixed to them. Fig. 21 shows tags also fitted for a grid leak. The result is really an ideal condenser, for it is dust-proof, its insulation is as perfect as it can be made commercially, and, moreover, its capacity cannot change under normal usage. The internal construction of such a condenser is shown in Fig. 22.

The construction of two useful types of fixed condenser is given. The number of plates and, in very small sizes, their dimensions will have to be left to the constructor, for it depends entirely upon the capacity which he desires to make. Reference to Fig. 23 will indicate general sizes to work to. First cut the two ebonite plates to size, square the ends and sides, and chamfer or radius all corners. Clamp the small plate midway over the large one in a vice in such a position that the screw holes can all be drilled together. Use the tapping size drill for the purpose. After drilling, tap the holes in the large plate and open out those in the small one to clearing size. This will ensure that the holes register truly. The clearing holes in the top plate should be countersunk to take the screw heads. The terminal holes should now be drilled, and countersunk from the underside to take the nut or head of the terminal screw, depending upon the type of terminal to be used. Holes for fixing the finished condenser to a panel must be drilled in the base, in the most convenient position for whatever purpose it is to be used.



HOW TO MAKE A FIXED CONDENSER

Fig. 23. Layers of copper coil and mica are here represented in their relative positions between the insulating plates. Dimensions being given, it is simple to construct this fixed condenser

The mica and copper foil may now be cut to size. Do not overlook the lugs at the ends of the foil, and be careful to see that the mica is free from holes and blemishes before using it. Even a small pinhole in the mica will ruin the condenser. Ruby mica is the best variety to use.

See that the mica is cut longer than the foil, as in Fig. 23, and for a condenser to be used for transmission, at least a quarter of an inch overlap all round, except at the lugs, must be allowed. Having prepared all the elements, lay the base upon the bench with a piece of foil placed centrally upon it. The lug should be over, say, the right-hand terminal hole. Now lay a piece of mica centrally over this, following with the next foil plate, but with the lug in the opposite direction. Proceed in this manner until the requisite number of plates and mica are fitted. The top plate may now be placed in position, the screws inserted and drawn up tight. It will next be necessary to drill the holes in the lugs to receive the terminals. Proceed very carefully here, otherwise the foil will be torn and the lug broken off. If a punch is available, it is better than drilling. The fitting of the terminals completes the condenser. Should the condenser be required in a position where damp is likely to affect it, run wax all round the open edges between the ebonite plates. This will effectively seal it without interfering with the excellence of the dielectric.

Home-made Condenser of Great Simplicity

A simple and useful type of condenser is shown in Fig. 24, on the plate facing page 488. It is made from a piece of brass tube ⅜ in. in diameter and 2 in. in length. Sufficient thin mica to wrap twice round the tube is required, and a few feet of No. 26 gauge tinned copper wire.

The tube should be thoroughly cleaned with a piece of emery paper, and a short length of wire should be soldered on the inside of it to make a connexion. The tube is then wrapped round with a strip of mica, which should go round twice, and come flush with the tube ends. For a condenser of the size ·0003 mfd., suitable for a grid condenser, start winding the wire about ¼ in. from the end and finish at ¼ in. from the other end. Hold the wire ends firmly and tin the wire along its entire length. One end of the wire is broken off, and the other, as shown in the figure, kept free for connecting purposes. This end is the end away from the wire soldered on the inside of the tube. A condenser of larger capacity may be obtained by winding the tube to the ends, but the greatest care must be taken to ensure perfect insulation between the tube and the wire.

The experimenter is always in need of a condenser of some particular value, and when a ready-made instrument is not at hand a substitute is easily made from hardwood or ebonite plates, with mica or paper insulation between the foil used as the condenser plates. The finished article, a particular example of the general form shown in Fig. 23, is shown in Fig. 25, and consists of a hardwood or ebonite baseboard, say, 3 in. wide and 2 in. long.

Another but narrower plate is prepared for the top plate, which is secured to the base with two screws. The base is held to the panel or instrument table with other screws which pass through the extended part of the base as shown in Fig. 25 It is in all cases preferable to use ebonite for all work of this character, but when the condenser is only wanted for an experiment or some temporary purpose, hardwood will answer very well, especially if it be well baked and dried, and impregnated with paraffin wax. The condenser plates are cut from thin copper foil, or from tinfoil, and are simply flat plates interleaved with waxed paper, or empire cloth, though mica is preferable.

The appearance of the plates and insulation sheets is shown in Fig. 26, which illustrates the holes drilled in the ends of the plates for the holding screws, which make contact with the foils and serve as terminals. The sheets, when prepared, are assembled as shown in Fig. 27, which indicates how the foil sheets are turned over at the ends and secured to the base by a round-headed brass screw. Each end is treated in the same way, and the top plate secured in position. Connexions are made to the screws at the side of the baseboard, or if a more elaborate pattern is required, a standard pattern of terminal can be fitted in place of the screws.

Vertical Plate Variable Condenser. Much has been written on the subject of variable condensers, but many of the constructional articles require the amateur to possess a lathe or special tools.

The condenser shown in Fig. 28, on the plate facing page 488, can be made successfully with the very simplest of tools. All that is strictly necessary is a drill brace, or a contrivance for drilling a few holes, and a hack-saw.

Procure two pieces of $\frac{3}{16}$ in. ebonite, each 4 in. by 3 in. These must be squared up quite true. If a vice is available, a good method of assuring that the edges are straight is to sandwich the ebonite between two straight edges of metal and tighten up in a vice so that the edge to be straightened just projects. Care must be taken to keep the tops of the straight edges in the same plane, that is—level with each other. If the ebonite is too high, knock it down a little with a hammer. A file is now run along the ebonite, keeping the file nearly parallel to the work. Pay special attention to those parts that project most.

When the edge is nearly down to the straight edges all the way along, wrap a fairly fine emery cloth tightly round the file and finish the edge off with it. If it is possible to keep the two straight edges level, two edges of ebonite may be clamped up and filed and papered together. Having made one edge of each piece of ebonite quite straight, it is comparatively easy to square the shorter sides in the same way. In finishing off the remaining long edge on each piece take care to get it parallel to the first. The care taken over this squaring up will be amply repaid by the appearance of the finished condenser, and the ease with which the components will drop into their right positions when the assembly stage arrives. Owing to the leakages on the glossy skin of ebonite, it is best to matt the two pieces.

Making the Top and Bottom Plates

Hold one piece in a vice, with a strip of cardboard over each vice-jaw to protect the papered edges of the ebonite. Fold a strip of emery paper around a piece of flat wood and rub along the ebonite in a direction parallel to the long sides. When all the skin has gone, repeat the rubbing process with a piece of old emery paper. This will give a smooth finish. Do not apply oil to darken the the colour, as is sometimes advised on matting ebonite, because, as the oil subsequently works out, dust will stick to it, giving rise to noises in the set resembling static discharges.

Four holes are now drilled in each ebonite plate, one at each corner. The position of each hole is $\frac{3}{8}$ in. from both adjacent edges, as in Fig. 29. The best way to get these holes drilled absolutely right is to drill the second ebonite panel through the holes already drilled in the first.

In order to keep the two plates in the same relative position throughout, after drilling the second series of holes, open the panels out on a table bookwise and scratch two arrow heads on each side of the two sides touching each other, as indicated in Fig. 29.

Eleven parallel slots must now be made in each plate. As was done in drilling, the second plate is copied from the first, the plates being placed together, as in Fig. 30. One plate only will be dealt with here. An old hack-saw blade is obtained and annealed by heating until nearly white hot, and then allowed to cool very slowly. It is then cut into two strips a little over 4 in. long. One piece is put in the vice, teeth side uppermost, and the teeth filed off until the strip is exactly $\frac{3}{8}$ in. in thickness. It is essential that both sides are quite straight and also parellel. This can be done in the same way that the ebonite panel was treated for ensuring straightness. The first slot is cut half an inch from the marked edge and parallel to it. To do this, put the panel in a vice with a straight edge on the line where the slot is to be cut. Take the broken piece of saw with the teeth intact and scrape a groove along the side of the straight edge, as in Fig. 31. Do not cut deeply, about $\frac{1}{16}$ in. will do. Having cut the first slot, put the panel on a flat table with a piece of saw in the slot. The $\frac{3}{8}$ in. strip is now pressed close to it and another shallow slot cut against the side of the strip. Another piece of saw will be required to do the scraping. Proceed in this way until six slots are cut. Fig. 32 shows the method of cutting the second slot.

Five intermediate slots are now required. With a pair of dividers carefully halve the distance between the first two slots, and with this divider setting scribe a line centrally between each of the other slots. These lines are cut into grooves by the method adopted in cutting the first slot.

Making the Slots for the Fixed Plates

For the cuts in the second panel place the two panels together mark to mark, and the positions of the slots can be immediately transferred to the second panel. These points are joined across the panel (on the marked side) and then slotted as the last five slots. All the slots are now made exactly the same depth. Take a new saw blade and fit a small nut and bolt through the hole in one end. Two small washers are put on each side so that a distance of $\frac{3}{32}$ in. separates them and the points of the teeth. This bolt is then screwed up tightly. The slots are now run over again until the washers slide on the ebonite. A uniform depth is thus absolutely assured.

Six fixed plates 3 in. by 2 in. are cut from 18 gauge flat aluminium sheet. The corners must be filed slightly round, as an electrical charge tends to dissipate itself from a sharp point. When the plates are exact to size they are clamped together, and a hole of $\frac{3}{16}$ in. in any one corner, $\frac{1}{4}$ in. from each adjacent side, is drilled through them all. A piece of 2 B.A. stemming $2\frac{1}{2}$ in. long is now cut. To assemble the plates screw a 2 B.A. lock nut just over the end of the stemming and thread on one plate. Three small washers are slipped on. Then follows another plate, washers, and so on, until all six are on. Another lock nut will clamp the fixed plates tightly. The set of fixed plates is shown in Fig. 34.

The five moving plates are exactly the same as the fixed plates, except that they have an extra $\frac{3}{16}$ in. hole on the same long side, also $\frac{1}{4}$ in. from each adjacent edge, as in Fig. 29.

How the Plates are Assembled

Bend up a strip of $\frac{1}{16}$ in. brass $2\frac{3}{4}$ in. long into a U shape, so that it will just fit over the outside of the moving plates. Two $\frac{3}{16}$ in. holes are drilled on the wings and a 4 B.A. tapping hole in the centre of the longer portion. This hole is tapped out 4 B.A., and a 2 in. length of 4 B.A. stemming screwed in. This is held to the brass with a 4 B.A. lock nut. A small ebonite knob is screwed on the other end. The assembly of these plates is exactly similar to the operation on the fixed plates. The brass strip and handle attached is bolted down under the lock nuts on the top spindle, as shown in Fig. 33.

Four rods, each $3\frac{3}{4}$ in. long, are cut from 4 B.A. stemming and held at one end by a 4 B.A. nut on the underside of the bottom ebonite panel, forming uprights.

The fixed plates are set into their grooves with the bolted-up side to the outside, as in Fig. 36. The top plate is now put on and the moving plates inserted into their slots with the handle at the bottom. When the plates are eased into the slots in the top panel it may be tightened down by four 4 B.A. nuts. The mounting of the instrument may be left to the choice of the constructor. If it is desired to mount it on a wooden base, as in the illustration, Fig. 28, four countersinks must be made to take the four screws under the ebonite base in order to improve the appearance and maintain ebonite insulation.

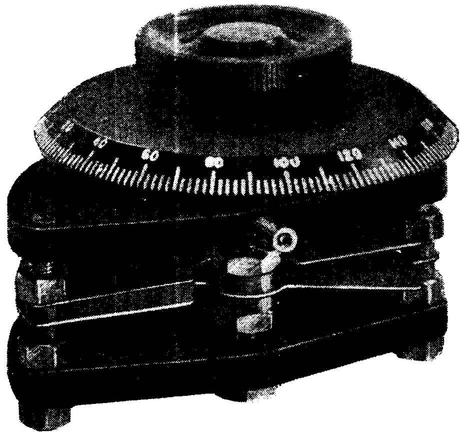
Electrical connexion to the moving plates is made by clamping a short length of flex wire under any convenient 2 B.A. nut, and the same applies to the fixed plates. If desired, these may be brought out to terminals mounted on the top of the instrument. The nuts on the top of the instrument will need careful adjustment to enable the moving plates to slide along with equal friction throughout its movement. When this has been done, the movement will be very smooth and even if the instructions are carried out.

Making a Vernier Condenser. The construction of a vernier condenser follows very much upon the lines of any other moving plate variable condenser, but it consists only of three plates, two fixed and one movable. Like other condensers of this type, it can either be arranged for panel mounting, fitted into a case to form a unit, or mounted direct upon the experimenter's instrument board. The pattern illustrated in Fig. 37 is suitable for either of the first two requirements.

To mount it on a panel a hole is drilled through the latter for the passage of the spindle, while the condenser is attached to the panel by means of two screws passed through from the front into holes drilled into the top part of the condenser frame.

Standard parts, such as those illustrated, can be purchased ready for use, or the condenser can easily be made up from spare parts. The necessary components are all shown in Fig. 38, and comprise a top and bottom plate of ebonite, the top plate fitted with a brass bush, a set screw, or small connector for attachment to the wire leading to the moving plate; the bottom plate may either have a set screw with a pointed end, as is the case in the example illustrated, or may have a plain bearing; spacing washers; three long screws with nuts; screwed spindle with the usual collar and lock nut; spindle washer; two fixed plates; one moving plate; a dial, and a knob.

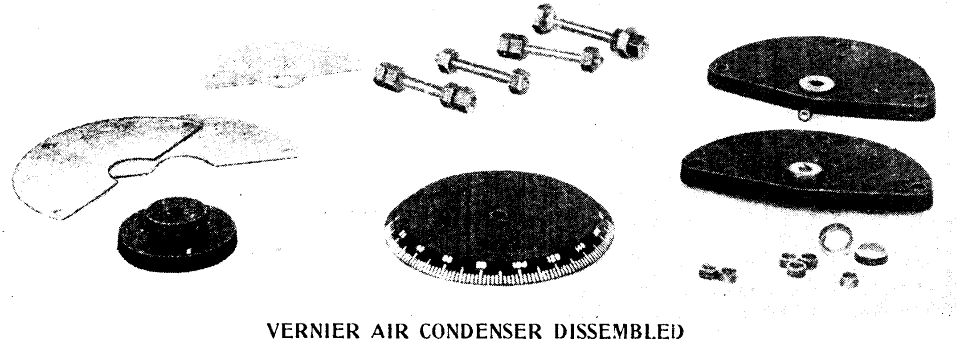
The first step is to assemble the moving plate, and to do this it should be fitted on to the square portion of the spindle, as illustrated in Fig. 39. Should the square hole in the plate not be a perfect fit on the square of the spindle, the best thing is to open it out with a square file in the manner



COMPLETE VERNIER CONDENSER

Fig. 37. There are two fixed plates and a movable plate in this vernier air condenser, which is constructed for panel mounting or for use direct on the instrument board

illustrated in Fig. 40; after which the dial, knob, and plate should be assembled as illustrated in Fig. 41, the procedure being to screw down the upper lock nut, slip the spacing washer over the flat part of the spindle, then fit the plate, following this by another spacing washer, and finally, the lower lock nut. Slight adjustment of these two nuts will allow of the plate being traversed up or down the spindle a small amount, and enables its position to be adjusted so that it will turn



VERNIER AIR CONDENSER DISSEMBLED

Fig. 38. Parts of the vernier air condenser shown in Fig. 37 are laid out. They can be obtained ready for assembly or made up from spare parts. The construction is on the same principle as the larger condensers, the turning knob operating the movable vane and the fixed vanes being held apart by spacing washers

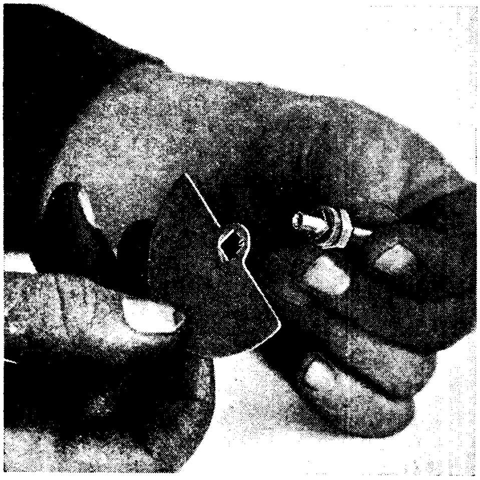


Fig. 39. Fitting the moving plate on the spindle by inserting a square portion of the spindle into the square hole in the plate

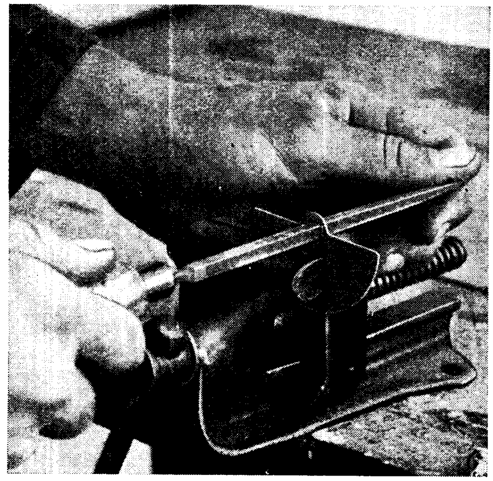


Fig. 40. By using a square file the hole in the movable vane is made a perfect fit on the spindle. The plate is held in a vice

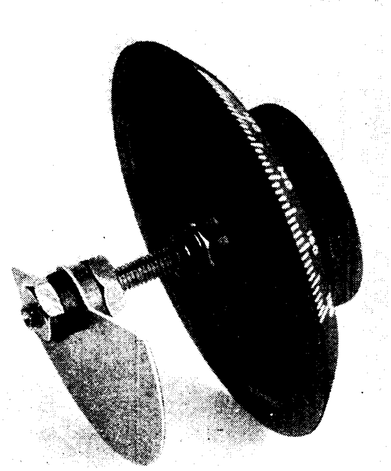


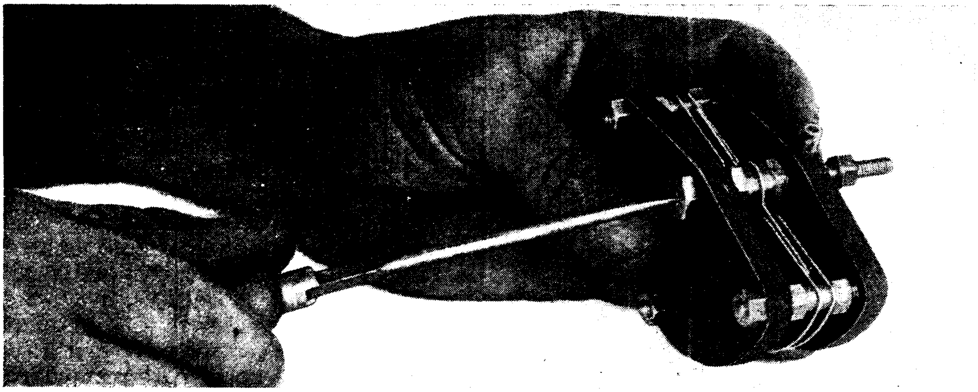
Fig. 41. Having made the vane, the movable portion of the condenser is assembled complete, as it appears in this photograph

Fig. 42. Two fixed plates are attached to the ebonite top. These are mounted on three upright posts and kept in position by spacers and nuts. The bottom ebonite plate is added when the movable part is attached

MAKING AND ASSEMBLING A VERNIER AIR CONDENSER

exactly between the two fixed plates. A spring washer is then slipped over the spindle, the nut screwed down, and the dial and knob screwed on to the spindle. It is best to assemble these at the commencement, and to see that they all fit properly; after which the dial, knob, nut, and washer are removed from the spindle and the plate is then ready for insertion into the condenser.

The three screwed rods which act as bases or supports between the top and bottom ebonite plates also serve to hold the two fixed condenser plates in their position. The rods are screwed into the top plates, a nut screwed on to each and tightened up, then a spacing washer on each rod, following this by the fixed plate, another spacing washer, and then the second fixed plate, and finally, the lock nuts. The bottom plate is slipped over the screwed rods and held in position with the remaining three nuts. Fig. 42 shows the top plate and the screwed rods in position.



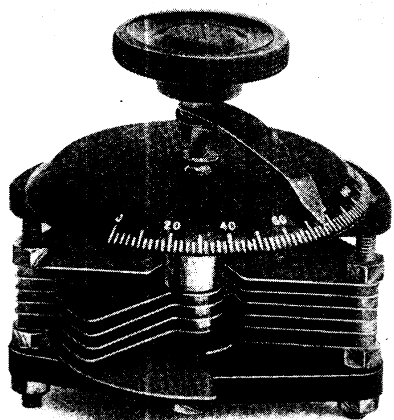
IMPORTANT STAGE IN CONSTRUCTING A VERNIER CONDENSER

Fig. 43. Unless the whole construction is trued up so that the fixed plates are rigid and the movable plate can rotate without touching the fixed plates at any part or angle, the condenser is practically useless. Here is seen the adjustment of the set-screw which allows slight variation of pressure on the spring washers holding the movable plate

The spindle is now inserted through the bearing in the top plate, the moving vane being slipped on and the set-screw adjusted by means of a screwdriver, as shown in Fig. 43, and any necessary adjustments to the fixed plate made by screwing all of the nuts on each of the pillars up or down, as the case may be, continuing until the moving plate is located exactly between the two fixed plates. Adjustment for the position of the moving plate is also made within small limits by increasing or decreasing the pressure exerted by the spring washers, this being accomplished by screwing up or slackening the set screw on the bottom plate. It is desirable to adjust them to give the desired degree of stiffness, so that when the dial is turned the plate will remain in its position and not have any tendency to move, as might happen if the bearings were too slack.

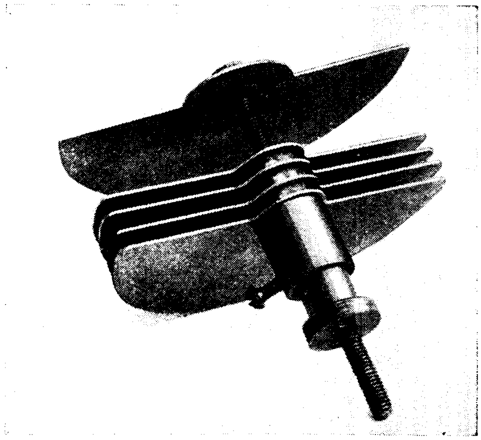
Individual methods of construction vary slightly with different makers and with the arrangement of the parts, but the erection of any variable condenser of this type can easily be made along the lines indicated. When the condenser has been assembled to the stage shown in Fig, 43, the dial and knob are fixed to the spindle and the condenser is ready for mounting in position. It should be noted when assembling the parts that the spring washer is located between the nut holding the fixed plate to the spindle and the inside of the ebonite top plate, as its function is to keep the spindle in close contact with the point set-screw forming the bottom bearing.

Condenser with Vernier Attachment. The advantage of a condenser in which one of the plates only can be rotated in relation to the others, is that it permits of exceedingly fine tuning, and there is no great difficulty in incorporating this feature into the ordinary type of variable air condenser. One method by which this is successfully accomplished is shown in the accompanying illustrations Figs. 44 to 46. The same method of application is adopted to any similar condenser. In this arrangement the dial is movable, and rotates the principal moving plates. The knob, which is provided with a pointer,



CONDENSER WITH VERNIER PLATE

Fig. 44. Very fine adjustment can be obtained with a condenser of the ordinary variable type to which is added a vernier plate. The dial of this condenser operates the main movable vanes, and the turning knob operates the vernier plate at the bottom



VERNIER AND MOVABLE PLATES

Fig. 45. Four movable plates are shown mounted together with the vernier plate on its spindle, which passes through the centre of the main plates spindle

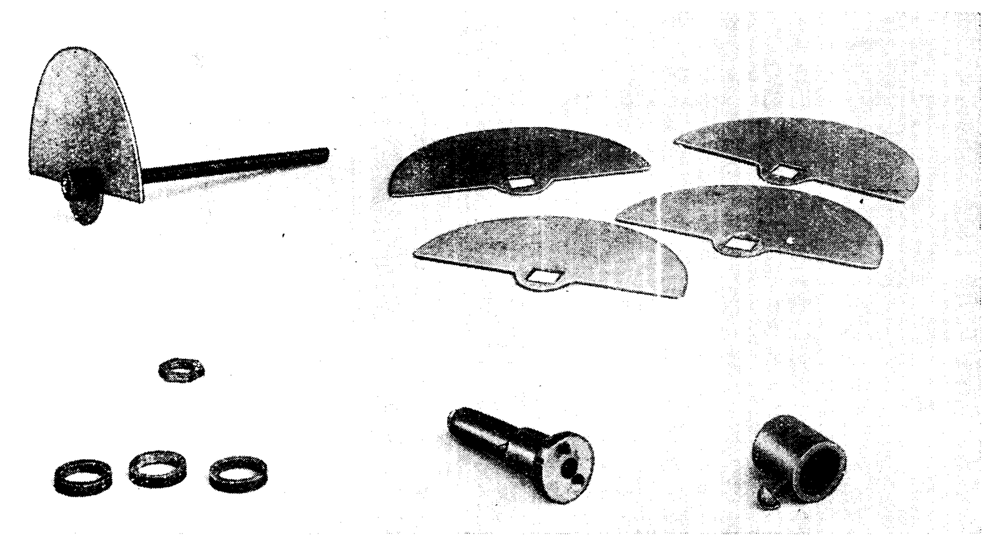
moves the single plate, which acts as a vernier. For coarse tuning, the dial and the knob may be turned simultaneously, by holding the knob between the thumb and second finger and pressing on the rim of the dial with the first finger. The final tuning is accomplished by gently moving the knob only.

To enable this to be done, the single, or vernier plate is attached to a long slender rod, the outer end of which is provided with an ebonite knob. The rod turns in a hollow, tubular-like member to which the principal moving plates are attached. This is clearly visible in Fig. 45.

The vernier plate and spindle consist simply of a length of screwed brass rod, to which an ordinary aluminium moving plate is secured by means of two lock nuts. This is clearly visible in Fig. 46, which shows the other parts referred to. The four principal moving plates are mounted on a sleeve seen in the lower part of Fig. 46. This sleeve may be turned from a piece of brass rod, and is of such a size that it will pass through the screw holes in the fixed plates. The upper part is provided with a collar, which acts as an abutment for the top plate. Spacing washers are then slipped over the sleeve between each of the plates and the whole secured with a thin nut on the bottom, thus following the ordinary practice adopted with this class of condenser.

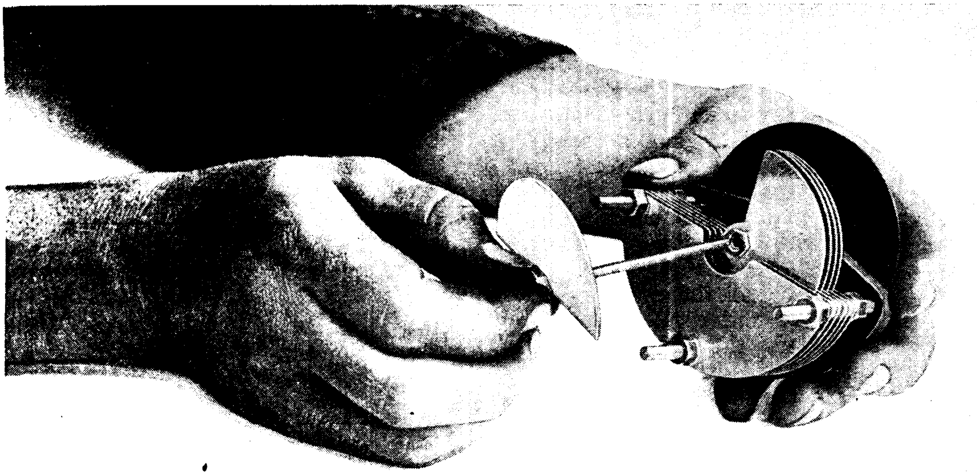
The upper part of the sleeve is formed with a flange drilled and tapped to take two screws, which secure the dial to it, and a loose collar and set-screw is also provided to fill the gap between the upper fixed plate and the underside of the ebonite top plate, the latter being bushed with brass in the ordinary way.

To assemble such a condenser, the fixed plates are secured in position by the side rods with their appropriate spacing washers and nuts in the customary manner. The



DETAILS OF PARTS OF CONDENSER WITH ADDED VERNIER PLATE

Fig. 46. One plate is seen mounted on the spindle. This is the single plate which is added to the condenser and is operated independently. The spindle turns in the bore of the sleeve seen in the foreground, on which is mounted the principal turning vanes



FITTING THE VERNIER PLATE TO A VARIABLE CONDENSER

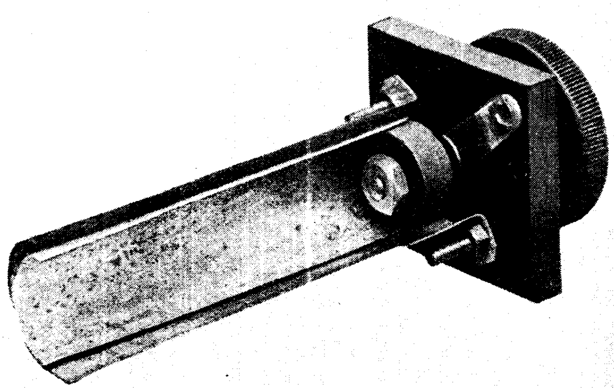
Fig. 47. Held in the operator's right hand is the vernier plate, mounted on a spindle which passes through the centre of the sleeve holding the other movable plates, and is surmounted with a turning knob. The condenser dial is in the operator's left hand, and by its means the four principal moving vanes are rotated

sleeve, with the moving plates attached to it, is then placed in position and the dial fixed to the upper side. The single vernier plate is then put into position by passing its rod through the hole in the centre of the sleeve in the manner illustrated in Fig. 47, after which the bottom plate and bearing is fitted in the usual way as already described for other condensers, and the work completed by fixing the knob and pointer, this latter being clearly visible in Fig. 44. Some amount of adjustment will be necessary to make the condenser to work smoothly.

How to Make a Tubular Vernier Condenser. The semicircular tubular variable vernier condenser shown in Fig. 48, besides being very simple to construct, has the added advantage of taking up very little panel room in a set. The only real disadvantage, which is not usually felt in vernier condensers, is that its minimum capacity is rather high. Without exception, it may be built up from materials at hand in any experimenter's scrap collection. The actual plates were cut from tin to the shapes and dimensions shown in Figs. 51 and 52.

After cutting, remove all the burrs, and bend on a piece of bright iron bar, the diameter of which is just under the required finished size, for the material will be found to spring slightly after being hammered. If bars of $\frac{7}{8}$ in. and $\frac{5}{8}$ in. respectively are used for the fixed and moving plates, the sizes will be found to come just right. After bending the fixed plate to its proper shape, the lugs should be turned over at right angles with pliers and the holes drilled in them.

This is one of the operations in making the condenser which requires great care.



SEMICIRCULAR CONDENSER

Fig. 48. Condensers of this kind are of advantage when space is limited. Construction is not difficult, and all dimensions are given on page 494

Pliers need not be used, but the plate may be laid on any suitable solid surface and the lugs tapped over. Accuracy of adjustment of the plates of a tubular condenser is just as important as with the plates of the flat vane variable condenser. A slight bend or buckling may easily render the condenser useless.

The base is a piece of ¼ in. ebonite sheet, 1¾ in. square, with fixing holes and centre hole drilled as shown in Fig. 50 (c). Care must be taken to drill the centre spindle hole quite square and dead to size, for upon this depends the correct rotation and disposition of the moving plate. Before drilling the holes for fixing the fixed plate, the ebonite insulator shown in Fig. 50 (d) should be made.

After turning and drilling the centre hole it should be held in the vice and the No. 6 B.A. tapped holes marked off from the plate itself. These may be drilled right through to the centre if required, for by doing this the tapping will be facilitated. The holes drilled and tapped, the plate may now be attached by two countersunk screws. These must be screwed up very tightly and the screw heads filed off nearly flush with the plate itself, otherwise they will foul the fixed plate when the former is rotated.

The spindle is 1¾ in. of No. 2 B.A. screwed rod. It now remains to drill the holes for fixing the stationary plate. Grip the base plate in the vice horizontally. Thread the spindle in the hole and stand the moving plate upon it, using the spindle as a guide to hold it in position. Now stand the fixed plate in position, so that the gap between the plates is equidistant. Hold the fixed plate firmly in the left hand, whilst with the right mark off the fixing holes, to correspond with the holes in the lugs. A scriber should be used to do this. When this is accomplished the holes may be drilled. The size of the holes is No. 6 B.A. clearing, and they should be countersunk on the panel side of the ebonite sufficiently deep to clear completely the screw heads.

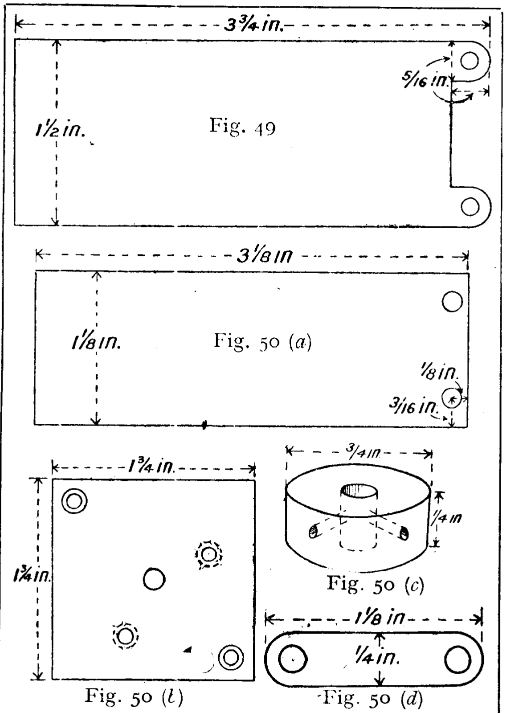
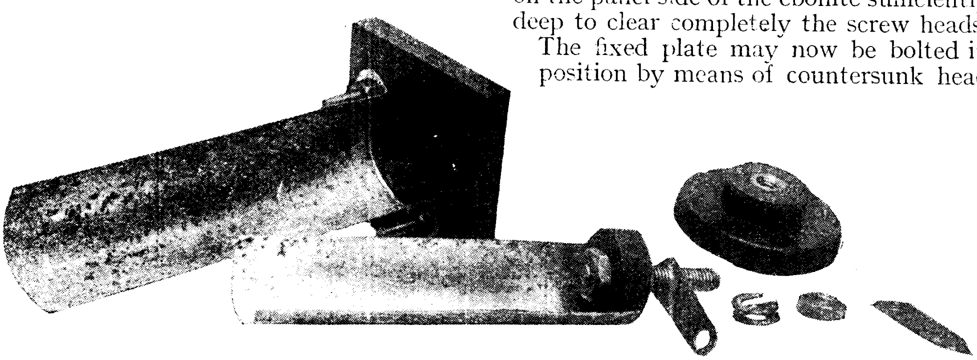


Fig. 49. Dimensions for the fixed plate. Fig. 50 (a). Dimensions of the moving plate. Fig. 50 (b) is an ebonite sheet, bored, Fig. 50 (c) the ebonite insulating base, and Fig. 50 (d) the contact strip

DETAILS OF SEMICIRCULAR CONDENSER

The fixed plate may now be bolted in position by means of countersunk head

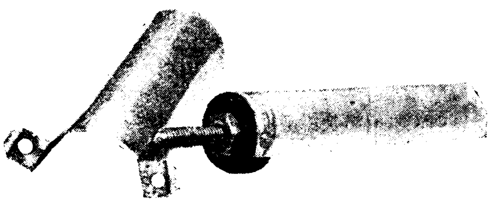


COMPONENTS OF SEMICIRCULAR VERNIER AIR CONDENSER

Fig. 51. From the parts of the semicircular condenser shown above it will be seen that no difficulty will be found by the amateur experimenter in obtaining the material for construction. Note the shape of the plates; they are cut from tin sheet

No. 6 B.A. screws and nuts, the nuts themselves clamping down on to the plate lugs.

The assembly of the spindle on to the moving plate may now be undertaken. Thread a No. 2 B.A. nut upon the spindle rod, leaving one end of the rod flush with one side of the nut. Push the rod through the insulator piece, and clamp this down with another nut on to the reverse side. A thackeray or spring washer is now slipped on, followed by the contact strip,



VANES OF SEMICIRCULAR CONDENSER

Fig. 52. On the left is the fixed vane, with its brackets for attachment to the ebonite top, and on the right the moving vane, with insulator piece and spindle

dimensions of which are given in Fig. 50 (*d*). This is a piece of thin brass, and takes the thrust of the spring washer, and conducts the current from the moving plate to one of the screws which fix the condenser to the panel.

The moving plate assembly may now be pushed into the hole in the ebonite base plate. This done, the correct compression is put upon the spring washer by another No. 2 B.A. nut, followed by a pointer, or dial, and a knob. The action of screwing the knob and No. 2 B.A. nut together will lock the spindle correctly.

Attachment to the panel is quite a simple matter and the connexions are taken from any convenient part on the fixed plate, such as the holding-down screw, and from the contact screw for the moving plate.

The Construction of a Tubular Condenser. The tubular condenser is a variable condenser, in which one tube slides in or out of another in order to vary the capacity. This type of condenser has the disadvantage of taking up more space than the more common moving-vane type, and is difficult to mount on a panel. Where space is plentiful the tubular condenser has its advantages, among which are its comparative ease of construction, and the fact that it is not easily damaged or deranged.

Materials required:

Baseboard of hardwood—oak, beech, or mahogany—14 in. by 4 in. by $\frac{3}{8}$ in.

2 wooden uprights 5 in. by 4 in. by $\frac{3}{8}$ in.

2 wood blocks 3 in. by 2 in. by $\frac{3}{4}$ in.

1 brass tube 6 in. by $2\frac{5}{8}$ in. outside diameter and $\frac{1}{16}$ in. thick.

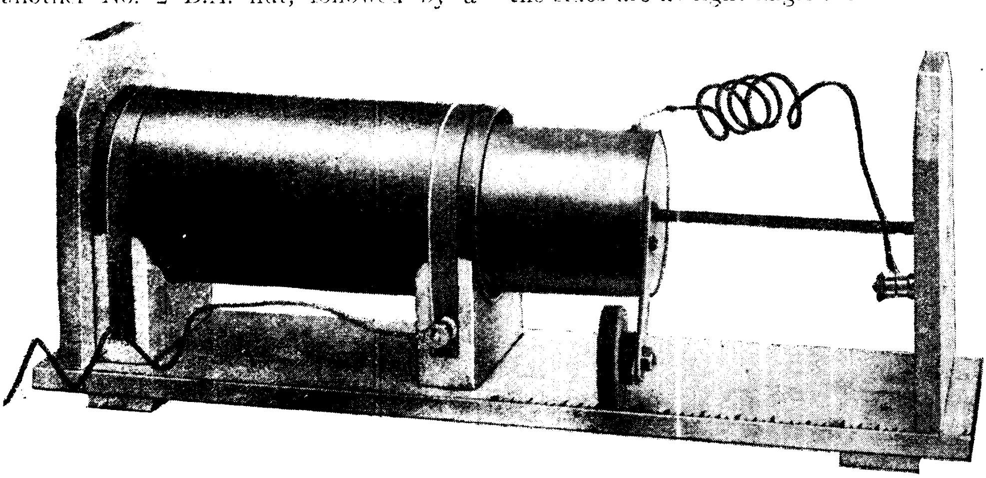
1 brass tube 6 in. by 3 in.

1 ebonite or wooden rod 13 in. by $\frac{1}{4}$ in. diameter.

2 brass strips 9 in. by $\frac{3}{8}$ in. by $\frac{1}{16}$ in.

2 terminals.

Starting with the baseboard, cut this to the size stated, taking particular care that the sides are at right angles. Two wooden



HOW TO MAKE A VARIABLE TUBULAR CONDENSER

Fig. 53. Simplicity, and the ease with which this type of condenser is made, recommend its use in certain cases. It is easily adjusted, the small tube sliding in or out of the larger tube, but takes up a larger space for a given capacity than other types of condensers

uprights, which can be cut from the same wood, also require squaring up. In cutting the uprights care should be taken to see that the grain is vertical when the uprights are in position. This will minimize any tendency to warping or splitting.

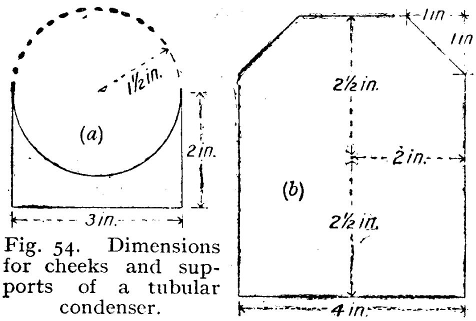


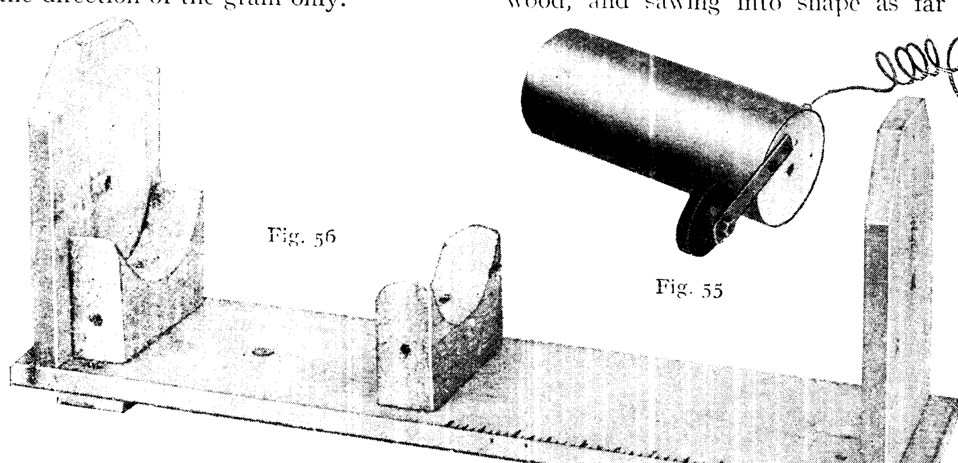
Fig. 54. Dimensions for cheeks and supports of a tubular condenser.

To improve the appearance of the uprights saw off two corners on each, by drawing a line diagonally across from points 1 in. from the corner on the top and side respectively. If it is required to polish the instrument, all the woodwork must be planed up and the corners finished with a paring chisel before papering. To do this wrap a sheet of Oakey's No. 1 glasspaper round a piece of wood about 3 in. square, and hold the glass-paper tightly around it. Clamping the wood to be papered securely to a bench, rub the glasspaper pad fairly slowly along the wood, taking care to rub in the direction of the grain only.

When papering the edges, put a piece of wood against the papered face where it would meet the vice jaws. This will prevent bruising it. The holes in the upright to take the $\frac{1}{4}$ in. ebonite rod must be marked out and drilled $\frac{1}{4}$ in. as in Figs. 54 (*b*) and 56. The uprights can now be screwed on at the ends of the base-board. Two screws $1\frac{1}{2}$ in. long will be required. The sides of the uprights must come $\frac{1}{2}$ in. from the ends of the baseboard. It should now be varnished. Pour a little white hard varnish into an eggcup, and with a soft brush apply the varnish. This is put on in the direction of the grain of the wood, using long strokes finishing at the ends of the board. Wait until the first coat is quite dry before applying a second.

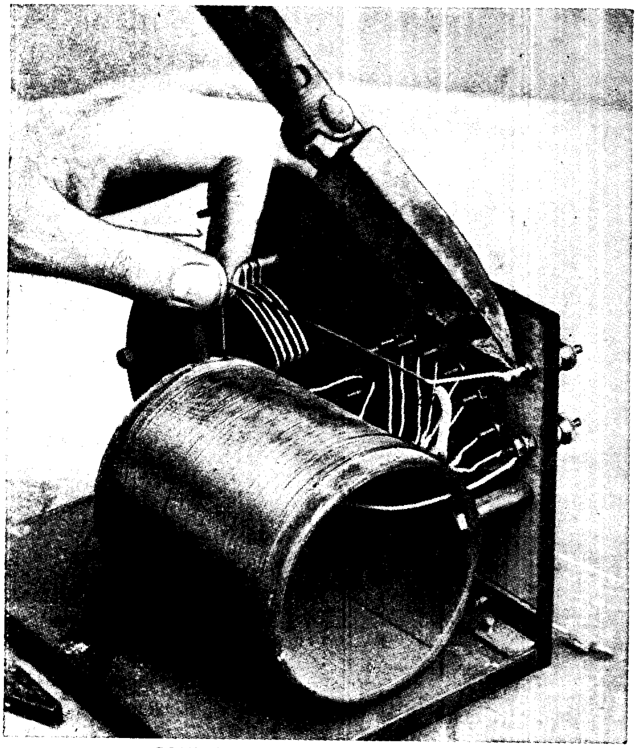
Three coats will give a very good finish, especially if the first and second coats be rubbed down with fine old sandpaper. The ends of the two brass tubes must be made square, and if a lathe is available, turn them, failing which they must be filed. In order to improve the finish of the instrument, both the tubes should be well polished and lacquered.

The smaller tube slides centrally on the $\frac{1}{4}$ in. ebonite rod. For this purpose two wooden disks having central holes of $\frac{1}{4}$ in. diameter are pressed into the ends, so that the outer faces come flush with the edge of the tube. This is really a turning job, but if facilities for this are not available they must be made by hand by making a circle of $2\frac{1}{2}$ in. diam. in a stout piece of wood, and sawing into shape as far as



INNER TUBE AND SUPPORTS OF THE HOME-MADE TUBULAR CONDENSER

Fig. 55 (above). At the side of the inner tube, which is complete and ready for assembly, is a brass strip and knob to move the tube and mark its position along the scale. Fig. 56. The supporting chocks and end pieces are here seen mounted in position ready to take the tube



CONNECTING-UP WITH SOLDER

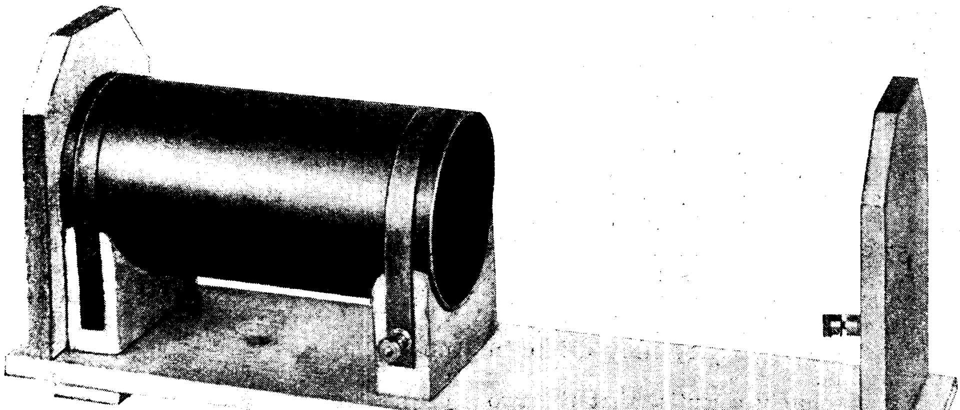
Fig. 2. Wireless receiving sets should have their connexions soldered to ensure best results. The metal should be thoroughly cleaned before applying the solder and a minimum amount of flux applied

corners are to be avoided, as the current appears to flow more readily around a gradual bend than it does when it has to make an abrupt turn. The variations in the molecular disposition of the metal at the sharp bends possibly set up a discharge at the apex of the angle, with resulting loss in signal strength.

One method of carrying out the connecting-up stage of the work is to prepare the wires and place them in position temporarily, then to remove them and make all the joints perfect by soldering. When such a plan is possible, it is often beneficial, as it is then seen that a few alterations to the path of some of the wires will give much better results and a more equable distribution of the wiring. After all the wires are in their place, the connexions ought to be carefully checked with the wiring diagram to ascertain that all is correct. The wires are then removed and all the joints soldered, the wires replaced and soldered to the terminals. This is done step by step, working first at the joints that would be most difficult to get at later on when other wires are placed. The art of soldering is not difficult to acquire, and is well worth while to do well. The process is described in detail in the article on soldering, but briefly the stages are first to clean thoroughly the places to be soldered, apply a trace of flux, heat the soldering-iron to just below a red heat, tin the point and touch it on the stick of solder, and at once apply the point of the iron to the work, as shown in Fig. 2, where the conductor is in the act of being soldered to the terminal end.

Too much care cannot be taken to get a perfectly soldered joint at every connexion. The advantages include more silent operation of the set, due to the absence of condenser effects, or of noises in the telephones occasioned by wires loosely attached to a terminal. When the amateur is unable to make a soldered joint, the connexions will have to be made with terminals having lock nuts, the wire being gripped between the two. The ends of the wire ought to be coiled to form an eye and in the direction in which the nut is turned to tighten it, that is, generally the same direction as that in which the hands of a clock turn. The tendency is then for the wire to tighten up under the nut. If the wire is turned the opposite way the joint will tend to open. Two wires ought not to be attached between the same nuts, but always be separately connected with a nut. The terminals are, as a rule, long enough to allow of several nuts being screwed on for this purpose. The reason is that two wires cannot be persuaded to remain in perfect contact when placed on top of each other.

CONNECTOR. Term used generally for a conductor employed to convey current from one point to another, and particularly between the units of wireless apparatus. There are numerous examples of this class of wireless fitting, and some are illustrated. The simplest comprises a plain brass bar



FIXED TUBE OF THE TUBULAR CONDENSER MOUNTED

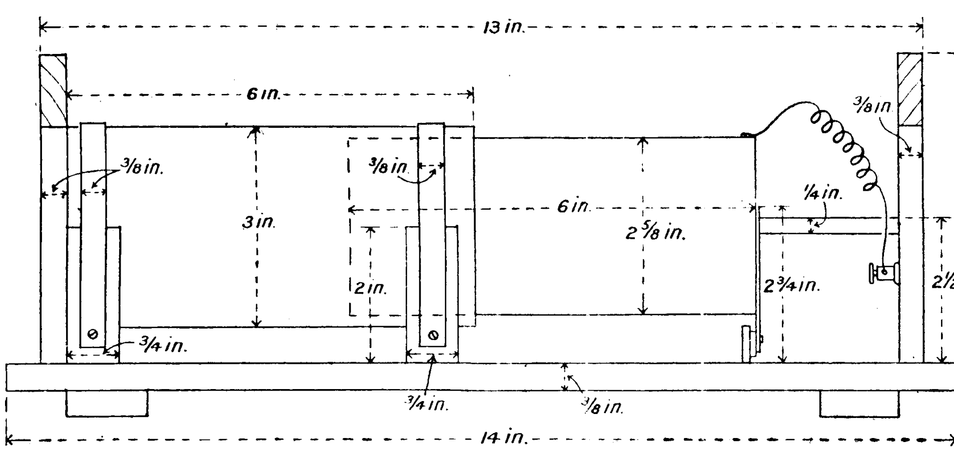
Fig. 57. Attached to the wooden supports is the fixed tube of the condenser, which is held down by two brass bands. On the right of the base a scale is marked so that adjustments may be recorded

possible. Final trueing up to the circle inscribed can be done with a file. Particular care must be taken to ensure the $\frac{1}{4}$ in. hole being central. If the fit of the disks is too slack they may be packed with insulation tape.

One screw will be required to hold down a connecting wire to one end of the tube. The free end of this wire is held down under a terminal screwed to one upright. This is clearly shown in Fig. 57. Before assembly, a strip of brass $2\frac{3}{4}$ in. long and $\frac{3}{8}$ in. wide, to one end of which is attached an ebonite knob, is screwed on to the wooden disk nearest the wire connexion. This is shown in Fig. 55 and in the photograph of the completed instrument, Fig. 53, and needs no further comment.

The scale on the baseboard is purely arbitrary and may consist of a piece of rule tacked down to the base. For the chocks two pieces of wood, 3 in. by 2 in. by $\frac{3}{4}$ in., are sawn, and filed out on one side to an arc of a circle of 3 in. diameter, as in Fig. 54 (*a*) These pieces should be finished to match the rest of the work.

They are now fixed in position as shown in Fig. 56. Both are screwed centrally to the sides of the base, one being placed close to one upright, the other $5\frac{1}{4}$ in. from the first, measuring from centre to centre.



SIDE ELEVATION AND DIMENSIONS OF TUBULAR CONDENSER

Fig. 58. Constructors may use this diagram for working measurements when making the tubular condenser. The method of wiring is very simple, and the inner tube is shown connected to a terminal on the cheek on the right. The fixed tube is connected by a terminal which also holds the brass band to the wooden support in the middle

The outer tube now requires mounting. It is held in position on the chocks by two brass bands, bent over the tube, and the ends screwed to the sides of the chocks. One screw at the forward end is dispensed with by using a terminal which serves the double purpose of making electrical connexion with the tube as well as holding down the brass strip on one side. Fig. 57 illustrates the instrument at this stage. The assembly is now completed by mounting the smaller tube on the ¼ in. ebonite rod, which is itself made a friction fit in the ¼ in. holes previously drilled in the uprights.

It is absolutely essential that the two tubes shall not touch, and in this direction the following test will be of service. Connect a battery and lamp in series with the two terminals. If the tubes are making contact with each other the lamp will light. A buzzer bell or galvanometer may be used instead of the lamp by connecting up in the same way. If the instrument requires adjustment a little paper packing between the chocks and the outer tube will probably put it right.

Fig. 58 shows a side elevation of the condenser, with all the necessary dimensions, both for the two tubes of which it consists and for the wooden framework. The capacity of such a condenser may be calculated from the formula given on page 503 for Tubular Condensers. —*A. H. Avery and E. W. Hobbs.*

Use of Condensers in Circuits. The construction and characteristics of the condenser having been described, its operation in some typical circuits may now be examined. The functions which the condenser is called upon to perform in wireless are so various that they cannot all be satisfactorily explained by mechanical analogy. But for most purposes it will be found convenient to consider the condenser as being the equivalent of an enlarged pipe in a water circuit. This enlargement of the pipe may be supposed to have stretched across it an elastic diaphragm or membrane.

This membrane will prevent any steady flow of the water unless it bursts, due to too great a pressure of the water. But such a membrane will readily allow alternating flow, and even assist it by its flexibility and elasticity. When driving forces cease to be supplied to the water, the recoil of the membrane drives it back.

In the *variable* condenser we have the equivalent of the ability to alter the stiffness of the membrane and so vary its capacity. The analogy is by no means complete, but it helps to explain most of the functions of the condenser in wireless circuits, more especially those for the purpose of reception. In the case of the *fixed* condenser the membrane cannot be so altered, as it were, and its effect remains constant on the water flow.

The condenser lies at the root of all wireless transmission, since the simplest of all methods of setting up a train of electro-magnetic waves is by making use of the discharge of a condenser through a coil of wire to produce a closed oscillatory circuit as shown in Fig. 59.

The condenser is first "charged" by causing a quantity of the electricity supplied from a battery or other source to its positive plate, A, to be removed and accumulated on the negative plate, B. When a conducting path in the shape of the coiled wire, C, is provided between the two plates, the displaced electricity flows back, the potentials or electrical pressures of the plates are equalized, and the condenser is discharged. Since, however, the coil possesses inductance (*q.v.*), the current does not stop immediately but for a time continues to flow and charge up the condenser in the reverse direction, with the result that the condenser also discharges in the reverse direction.

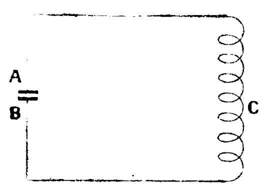


Fig. 59. Closed oscillatory circuit used for setting up a train of electro-magnetic waves

This oscillatory discharge goes on until, owing to the gradual conversion of the original energy in the condenser into heat by the electrical friction or "resistance" of the wire, the oscillations are "damped out" and stop. If it is required to set up trains of ether waves it is necessary to recharge the condenser as in the first instance, and it is upon the succession of charges, discharges, and recharges of a large condenser that the process of spark transmission is largely based.

In continuous wave transmission energy is supplied continuously to the system to make up for that which is lost, and accordingly the oscillations are not "damped out," but are continuous, and the consequent waves are of uniform amplitude. The condenser, however, remains an important factor, and in commercial transmitting sets a "smoothing" condenser is often employed in order to render the unidirectional pulses of current from the rectifying valves continuous.

The action of the smoothing condenser in the latter case has been described as similar to that produced by a long length of rubber hose when pulses of water are forced into one from a pump. Each pulse is partly spent in stretching the rubber, while, during the intervals between the pulses the stretched hose contracts and helps to keep the water flowing. Thus the irregularities in the supply are smoothed out, and a steady jet is obtained at the other end of the hose.

But in transmission—and in reception also—we have another condenser to consider besides that or those in the closed oscillatory circuit. By suspending a length of wire in the air, and insulating it from the earth, as in the case of an ordinary wireless aerial, we produce, in fact, a giant condenser in which the wire acts as one plate, the air as the dielectric, and the earth as the other plate. By joining the lower end of the aerial through a coil of wire to the earth an "open oscillatory circuit" is formed.

If this open oscillatory circuit is coupled to a closed oscillatory circuit made up of an ordinary condenser and inductance, Fig. 60, and it is arranged that the natural frequency of the two circuits is the same, the oscillations in the closed circuit will set up oscillations in the open circuit. This is very useful, because a closed oscillatory circuit produces waves of a very small amplitude, and is consequently a very bad radiator, while an open oscillatory circuit is just the reverse. Incidentally, there is an important difference in the composition as well as in the properties of the two circuits. In the case of the closed oscillatory circuit the two are mixed up and distributed along the whole length of the aerial, since the aerial wire is acting simultaneously as one plate of the "condenser" and also as an inductance.

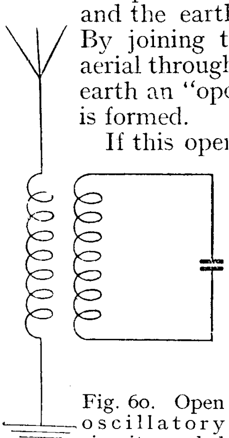


Fig. 60. Open oscillatory circuit coupled to closed circuit with a condenser

We have now to consider the functions of condensers in receiving sets, and for this purpose reference should be made to Figs. 61 to 71, in which a variety of such functions are shown diagrammatically.

In Fig. 61 the condenser connected across the telephones is operating as a reservoir, and not as a smoother or steadier of current, since, if the current rectified by the crystal as shown in Fig. 62 were too much smoothed at this stage, we should not get the spurts necessary to set the diaphragms of the telephones vibrating and so producing audible sounds. What the condenser does here is to collect the spurting current passed by the crystal and, after storing enough of it to raise the potential slightly, to discharge it through the shunt circuit of the telephones. The result is to alter the resonant note a little, and in many cases a notable improvement can be effected by this means in the performance of high-resistance telephones and loud speakers. The capacity of condensers for this purpose may be ·001 or ·002 mfd. In specially designed sets it is regulated to make the rate of discharge about 800 times per second, if that rate produces an audible note in the telephones. It should, however, be added that not infrequently a condenser in this position is, practically speaking, superfluous.

CONDENSER FUNCTIONS

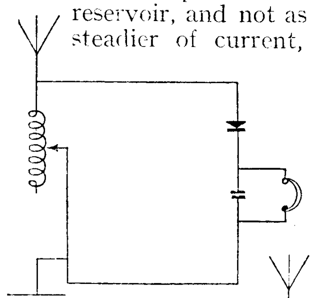


Fig. 61. Across the telephone is a condenser which holds or contains the current after it has passed the crystal and to a certain extent acts as a reservoir.

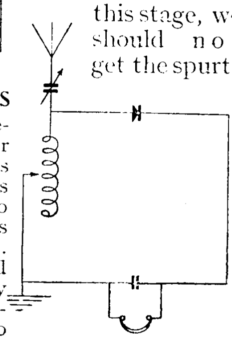
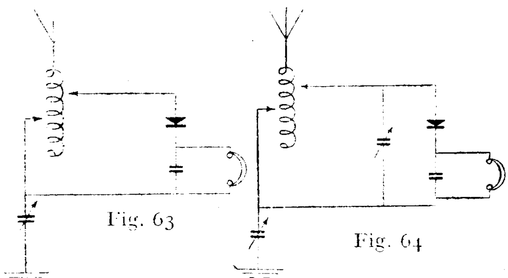


Fig. 62. Placed in the aerial lead is a variable condenser by which the desired wavelength can be tuned into the circuit

In Figs. 62 and 63 we have a condenser introduced in the aerial circuit and earth lead respectively. In both these cases the condenser can, if variable as shown, be used for tuning; but a more interesting effect of its presence is the reduction or increase of the wave-length by increasing or reducing the capacity in the aerial or earth, as the case may be. It has already been explained that the aerial wire, the earth, and the intervening air form a great condenser. The capacity of this



TUNING BY VARIABLE CONDENSER

Fig. 63. Capacity of the aerial circuit is varied by the condenser in the earth lead. Fig. 64. Another variable condenser is now added by which the receiving circuit is tuned

can be measured if suitable means are adopted, but cannot be calculated by the usual method, owing to the fact mentioned above that the aerial wire acts not only as one plate of the condenser, but as inductance as well. By adding an ordinary condenser in series to this great aerial-air-earth condenser, we decrease the reservoir capacity of the former, and thereby reduce the wave-length to which the aerial is naturally tuned.

The resultant capacity of condensers in series is shown by the formula

$$C = 1/(1/C_1 + 1/C_2 + 1/C_3 + \ . \ . \ .)$$

and, accordingly, if the effective capacity of the aerial is measured by one or other of the approved methods, the capacity of the condenser in series required for a given wave-length can be calculated with accuracy. A variable condenser renders calculation unnecessary.

For short wave-lengths one having a capacity of ·0005 mfd. will be found sufficient, but for very long wave-lengths ·0015 is needed. A useful medium is ·001. In practice the correct capacity is the smallest that can be used without loss of signal strength.

Where a condenser is put in parallel directly between the aerial and earth the wave-length is increased, and in practice it will be found that an increase of about three times can be attained in this way, but that beyond this inductance must be added. Within the limits mentioned the necessary additional capacity can be calculated from the formula for the total capacity of condensers in parallel, viz.,

$$C = C_1 + C_2 + C_3 + \ . \ . \ .$$

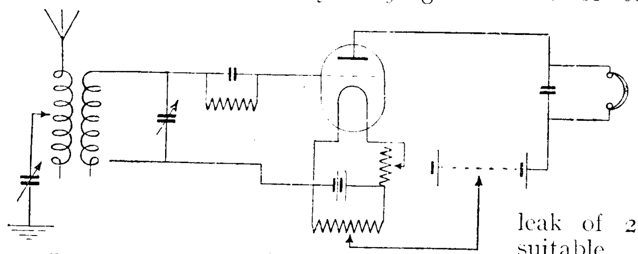
In Fig. 64 we have a second variable condenser introduced for the specific purpose of tuning the circuit to a definite frequency. In dealing alone with the performance of a condenser in a closed oscillatory circuit, it was explained that in the process of charging the condenser a reversal of the pressure takes place. But before this can happen the pressure on each of the two plates of which the condenser is supposed to consist increases from a minimum to a maximum and then decreases to a minimum. The action has been compared to that in the case of a shunting engine which gathers speed, slackens speed, stops, and then reverses its direction of motion. However quickly the pressure varies in magnitude or direction, the charge of electricity in the condenser will try to vary immediately in step with the applied pressure, for the current flow is presumed to consist of electrons, which move with great velocity and have practically no inertia.

But unless the breakdown voltage is reached these electrons cannot pass through the dielectric as an electric current. They must therefore pass through the connecting wire, in the case of Fig. 64 the coil, as shown. This they can only do when the applied pressure in the coil is decreasing and is, therefore, for an infinitely short space of time less than the back pressure of the condenser. In the first quarter-cycle of operations, then, the condenser will be accumulating a greater and greater charge of electricity, and in the second quarter-cycle it will discharge this electricity along the coil. And when the applied electric pressure, having fallen to zero, begins to increase in the opposite direction, electricity will begin to flow into the condenser in that direction, only to be discharged in the last quarter-cycle.

It follows that the greater the frequency at which the electric pressure changes direction, the more nearly the circuit behaves as if there were a "straight through" connexion; that is to say, the smaller is the impedance of the condenser. The impedance, on the other hand, of a coil, such as that shown in

Fig. 64, increases with the frequency at which the electrical pressure applied to its ends changes direction.

When, therefore, we wish to tune the aerial or closed circuit to a definite frequency corresponding with the wave-length of any particular transmitting station, we can do so by varying the



FOUR CONDENSERS IN A RECEIVER

Fig. 65. Two variable and two fixed condensers are employed in conjunction with a valve. Aerial circuit capacity is regulated by the condenser in the earth lead, tuning is carried out by the variable condenser in the closed circuit. A fixed condenser is placed across the phones, as in Fig. 61, and another across the grid leak as an arrester of frequency

capacity of the condenser until its effect on the circuit exactly counterbalances the opposite effect of the inductance coil. The whole circuit is then most sensitive to alternating electrical potentials of that particular frequency, and is therefore tuned to the corresponding wave-length.

In Fig. 65 we have an ordinary single-valve circuit with four condensers, the functions of three of which — that, namely, in the aerial circuit, the tuning condenser in the closed circuit, and that across the telephones—have already been explained. But in regard to the first two a new feature is introduced in the shape of a secondary coil, with the help of which the aerial circuit is coupled inductively to the closed circuit. In a case of this kind the primary and secondary coils have to be tuned separately, and the two variable condensers have separate tuning functions accordingly.

The fourth condenser, a fixed one, shown for the first time in this circuit, is the grid condenser, with which is associated the grid leak, the two really forming part of the grid system of the valve. The function of a grid condenser is that of an arrester of frequency. The frequency per second in the case of a 400-metre wave-length is 750,000, and with waves arriving at this rate the grid of the valve would become, so to speak, congested. The grid condenser performs the useful function of slowing down the frequency, and in practice is usually of the fixed variety, with a capacity of from ·0001 mfd. to ·0004 mfd., the first being used with a leak of high, and the second with one of correspondingly low resistance. When receiving very weak signals a ·0001 grid condenser can be used with advantage, and one of ·0004 mfd. when the signals are strong or atmospherics are troublesome. For all-round work a grid condenser with a capacity of ·0003 mfd., with a leak of 2 megohms resistance, is very suitable.

In Fig. 66 we have an example of an inductively coupled crystal circuit in which, again, variable condensers are used to tune the aerial and closed circuits separately. The idea is carried a step further in Fig. 67, in which, in addition to the ordinary tuning condenser for the aerial circuit, there is a second variable condenser in parallel with the aerial tuning inductance for the purpose of increasing the wave-length for long wave reception. The condenser in the earth lead can, as shown, be short-circuited when not required.

Fig. 68 is an example of a simple regenerative set employing a two-slider tuner, a variable condenser being introduced for the purpose of enabling the amount of the reaction to be controlled.

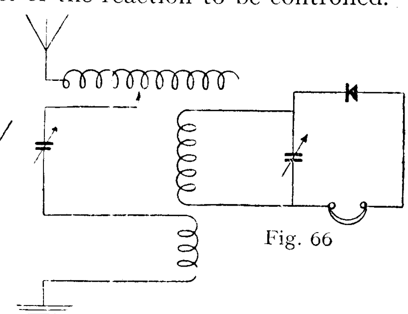


Fig. 66

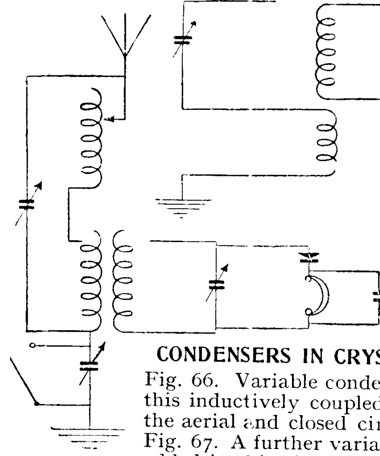
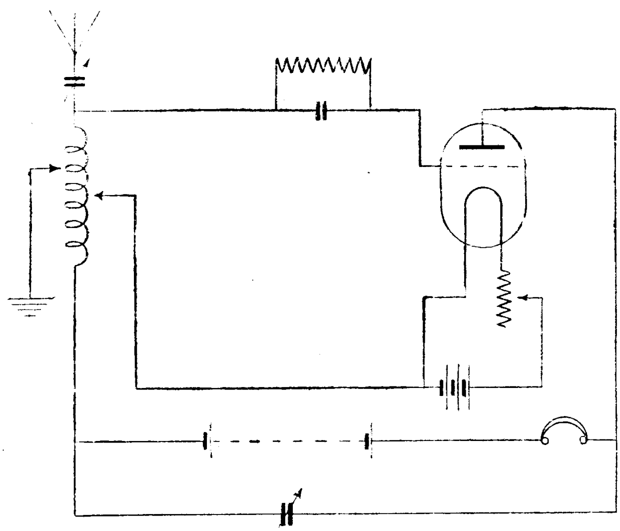


Fig. 67

CONDENSERS IN CRYSTAL CIRCUITS

Fig. 66. Variable condensers are used in this inductively coupled circuit to tune the aerial and closed circuits separately. Fig. 67. A further variable condenser is added in this circuit in parallel with the A.T.I. for reception of longer wave-lengths



CONDENSERS IN A REGENERATIVE CIRCUIT

Fig. 68. Reaction is controlled in this simple form of regenerative circuit by a variable condenser. Tuning in this case is carried out by double sliders

Fig. 69 illustrates the interesting neutrodyne circuit invented by Professor Hazeltine, of America, in which the capacity effects between the grid and the plate and between other parts of the valve are neutralized by very small condensers between grid and grid. The condensers, as shown in the smaller diagram, Fig. 70, are simply two pieces of bare copper wire enclosed in an insulating sleeve, with their ends about $\frac{3}{4}$ in. apart. Over the insulating sleeve is placed a copper tube, $2\frac{3}{4}$ in. long. The wire and the tubing thus act as two very small condensers in series. Such condensers are very easy to construct, and will be found useful in many circuits beside the Hazeltine. A photograph of one appears on page 478.

Another important use of a condenser in a receiving circuit is indicated in Fig. 71, where one of the fixed variety, usually of the value of ·001 mfd., is shown across the primaries of the low-frequency transformer. In addition to the rectified current from the rectifying valve there is usually a small high-frequency current, and a condenser can usefully be employed for the purpose of preventing this from passing through the primary winding of the transformer. This condenser is not needed in subsequent stages of low-frequency amplification.

Finally, mention should be made of the condenser, also fixed, placed by many workers across the H.T. battery. In this case advantage is taken of the fact that a condenser, while presenting practically infinite impedance to direct currents, provides a path of low impedance to high-frequency currents. The result of its use in the connexion mentioned is to shunt the high internal resistance of the battery by providing a path for all the current in the circuit and so preventing it from entering the battery itself. The capacity of the condenser should be about 2 mfd.—*O. Wheeler.*

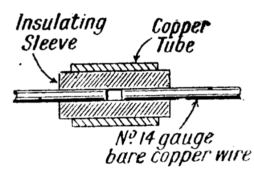
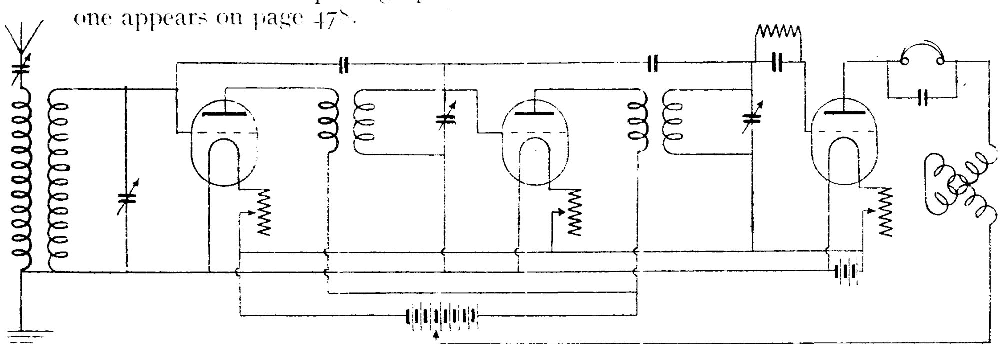


Fig. 70. Condenser used in the Hazeltine circuit shown below



PROFESSOR HAZELTINE'S NEUTRODYNE CIRCUIT

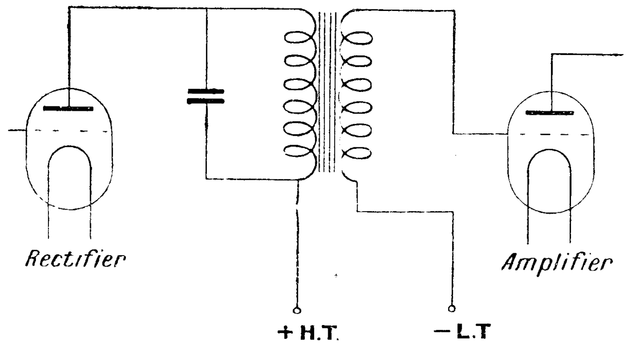
Fig. 69. Very small condensers are used between the grids in the Hazeltine neutrodyne circuit. These condensers are of simple construction, and a sectional diagram of one of them is shown in Fig. 70. It will be noticed that no fewer than eight condensers are required in this circuit

Calculating the Capacity of Condensers. The calculation of the capacity of a condenser is not usually a difficult matter within the limits of accuracy required by the average amateur and experimenter.

The usual form of condenser is the parallel plate condenser. If n be the number of plates in such a condenser, a the area of one side of each plate, k the dielectric constant of the material between the plates, C the capacity of the condenser, and t the distance between the plates

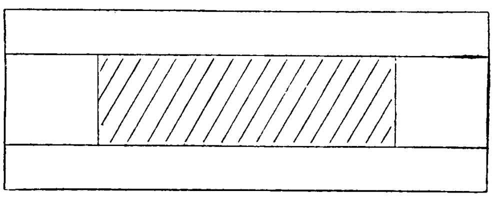
$$C = \frac{ka(n-1)}{36\pi t \times 10^5}$$

C is given by this formula in micro-farads, a in square centimetres and t in centimetres. The area of the plates considered is, of course, only that part of the area which is opposite to or covered by another plate, the shaded portion in Figure 72, for example.



CONDENSER USED WITH TRANSFORMER

Fig. 71. Across the primaries of the low-frequency transformer is a fixed condenser, the function of which is to prevent the high-frequency current reaching the transformer primary winding



CALCULATION OF CONDENSER CAPACITY

Fig. 72. When the capacity of a parallel plate condenser is calculated only that portion of the area of the plate is taken into consideration which is covered by another plate, as indicated by the shaded portion of this diagram

In the case of the ordinary moving vane type of variable condenser the area a is the area of one side of the moving vanes, less, of course, the central cut-away portion of the plate for the spindle. The cut-away portion is neglected and the overlapping area of one plate is

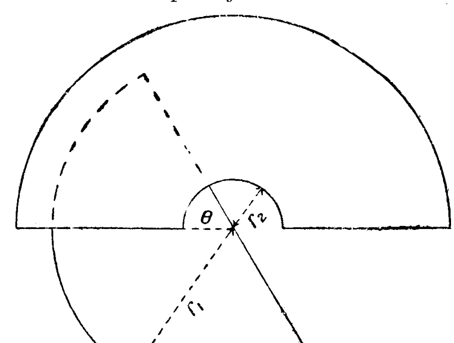
$$\frac{\theta\pi(r_1^2 - r_2^2)}{360}$$

where r_1 is the radius of the moving plate, r_2 the radius of the cut-away portion in the fixed plate, and θ the angle of rotation as shown in Fig 73. The capacity of a condenser with a total number of n plates is therefore

$$\frac{k\theta(n-1)(r_1^2 - r_2^2)}{36 \times 360 \times t \times 10^5}$$

where t is the distance between the plates.

These formulae neglect the edge effect, and to make them correct the condenser should have a metal ring or rim round the outside edge of each plate and separated from it by a small gap. The formulae, too, may vary considerably from the actual measured result if the dielectric is solid, since pressure on the dielectric during the course of manufacture has an effect on the capacity of the condenser.



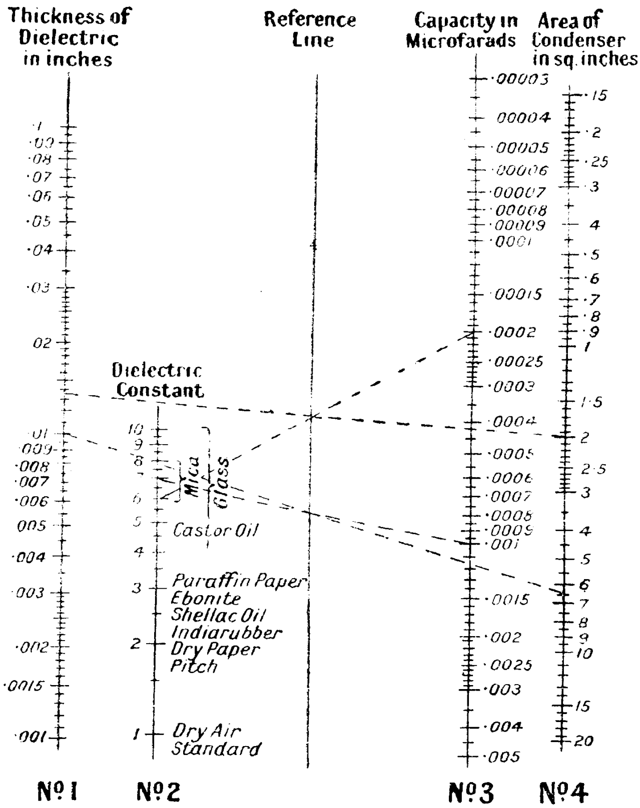
ROTATING VANE CONDENSER CAPACITY

Fig. 73. Calculation of the capacity of a movable vane condenser is made by considering the area of one side of the moving vanes, less the central portion cut away for the spindle

The capacity of a tubular condenser may be calculated from the formula

$$C = \frac{l}{4{\cdot}6052 \log (r_2/r_1) \times 9 \times 10^5}$$

Where r_1 is the outside radius of the inner cylinder, r_2 the inside radius of the outer cylinder and l the length of the covering part. It is assumed that air is the dielectric



HOFFMAN'S CHART FOR CALCULATING CAPACITY

Fig. 74. Capacities of condensers can be readily calculated from this chart, devised by Prof. Hoffman. Two examples of the way in which the chart is used are shown. The chart also gives the areas of plates required to make a condenser of specific capacity

Fig. 74 shows a useful chart, due to Hoffman, for calculating the capacity of a condenser.

The left-hand graduated line gives the thickness of the dielectric, the next the material of the dielectric, the third line is the reference line, the fourth the line on which the capacity in microfarads is measured, and the right-hand line gives the effective area of the condenser plates for the given capacity.

Examples of the way to use the chart are as follow: Suppose it is required to find the effective area of the two copper foils of a fixed condenser of ·001 mfd. capacity, separated by a piece of mica $\frac{1}{100}$ in. in thickness.

On the capacity line, No. 3, find ·001, and join this with the dielectric constant for mica, 7, on line No. 2. Note the point where this cuts the reference line. Join this last point with the point ·01 ($\frac{1}{100}$ in.) on the line No. 1, which gives the thickness of the dielectric, and produce the line until it meets line No. 4, which gives the effective area of the plates as 7 sq. in. The effective area is the overlapping area of the plates.

As another example the lines have been drawn for a condenser of ·0002 mfd. capacity, with an area of plates of 2 sq. in., using a sheet of mica ·0135 in. thick, taking the dielectric constant of its particular sheet of mica as 6, and, similarly, any combination may be quickly calculated. —*J. L. Pritchard.*

CONDENSER DIAL. Disks of ebonite or other insulating material adapted to rotate the moving plates of a variable condenser. They are usually calibrated to indicate the degree of coupling between the plates.

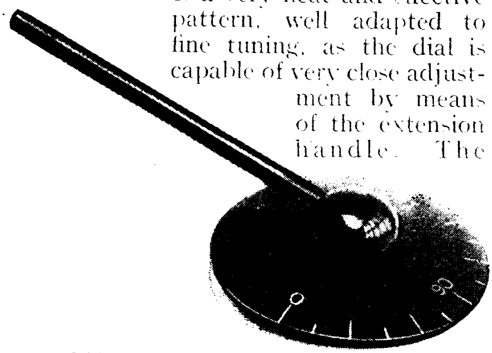
A typical example is combined with a knob as shown in Fig. 1, and comprises a dial about $2\frac{3}{4}$ in. diameter, having a bevelled edge calibrated from 0° to 180°. The knob is formed in one with the dial in the moulding process during manufacture, and is thus an integral part of the whole, entirely eliminating chances of the knob slipping. This type of dial is usually attached to the spindle by means of a set-screw, or by screwing to the spindle and making it secure with a lock nut. The former is

MOULDED CONDENSER DIAL

Fig. 1. Both the knob and dial in this type are moulded in ebonite as one piece. The spindle is held by a set-screw through the neck beneath the knob

the better plan, especially when a flat is formed on the spindle for the screw to bear against.

Another type is illustrated in Fig. 2, and consists of a dial and an extension handle. This is a very neat and effective pattern, well adapted to fine tuning, as the dial is capable of very close adjustment by means of the extension handle. The



DIAL WITH EXTENSION HANDLE

Fig. 2. Condenser dials having a long-adjustment handle reduce hand capacity effects. Very neat appearance can be combined with a convenient means of fine adjustment in this type

absence of any metal work on the exterior is an advantage, as there is little likelihood of surface losses. The general neatness and the smooth contours are other points in its favour. There are numerous types of dial and handle, but detailed consideration and hints on making are given under the heading Dial.

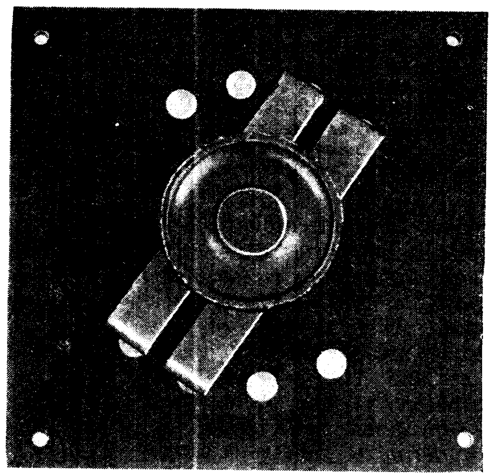
CONDENSER MICROPHONE. The combination of a microphone and a condenser, notably that developed by Fessenden. The apparatus is arranged in series in the aerial circuit of a transmitting set, and as the diaphragm is set in motion by the action of the speaker's voice the capacity of the condenser is varied and modulates the radiated energy. *See* Microphone.

CONDENSER PAPER. Name applied to a variety of prepared papers specially adapted to act as the dielectric between the plates of a condenser. The paper may be any good quality, impregnated with paraffin wax, shellac, resin, or other insulating materials. Homogeneity is an important item, as the slightest suggestion of a puncture is most detrimental in a condenser. The papers are cut with scissors or with a sharp knife to any desired size, but are purchased in sheets measuring about 10 in. by 8 in. or 12 in. by 10 in. It is desirable that such material be stored flat and in an equable temperature, as if the paper be rolled the surface may crack and tend to split.

CONDENSER SWITCH. Name applied to a type of series-parallel switch adapted to vary the circuit connexions to a condenser.

In the typical example illustrated this is accomplished by throwing the switch arm from one side to the other of the pairs of contacts. For example, when in the position illustrated the condenser might be in series with the aerial tuning inductance, but when the contact arms were over the other studs the condenser would be in parallel. By this simple action the range of a single inductance coil is considerably extended.

The construction is easily within the capability of the experimenter, and consists of cutting a piece of ebonite about 3/16 in. thick to a rectangular form and drilling holes in the corners for the holding down screws. The centre hole is then marked off and a circle scribed from it. On this circle the positions for the studs are marked and holes drilled for them. The studs are fixed in the usual way with a nut on the underside of the panel.



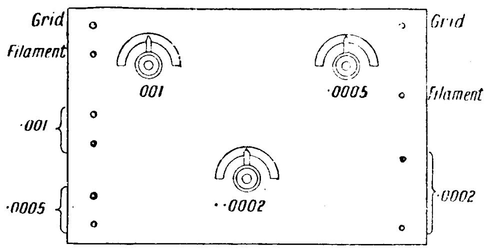
SERIES PARALLEL CONDENSER SWITCH

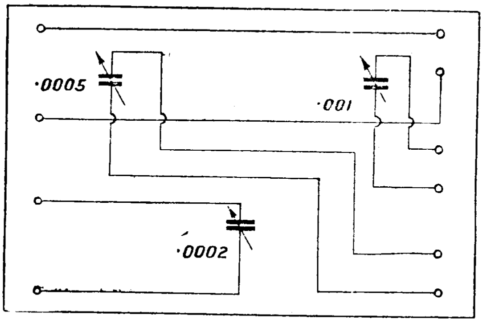
When it is desired to vary the circuit connexions to a condenser, a switch is used as shown in this photograph

The central hole is then drilled and bushed with brass and the spindle, made from screwed brass rod, fitted to it. The ebonite knob is slotted on the underside for the two contact arms, which are cut from strip copper or phosphor-bronze and spaced to contact with two studs on each side of the centre as shown.

They are attached to the knob with screws and the whole fixed to the spindle with a lock nut in the customary manner. The contact arms are bent over at the ends to act as contact points and should bear evenly and smoothly on the studs. To ensure a good contact a spring washer is placed beneath the panel on the spindle and tightened as requisite with a nut and a lock nut. The corners of the studs are preferably rounded off and the contact arms treated in the same way. Connexions are made by soldering to the studs where they protrude below the surface at the back of the panel. If desired, the whole can be mounted on a shallow case and used as a separate switch, or can be wired and attached to the panel of the receiving set.

In the latter case the studs and contact arm could be erected directly on the ebonite panel. *See* Anti-capacity Switch; Series-parallel Switch; Switches, etc.





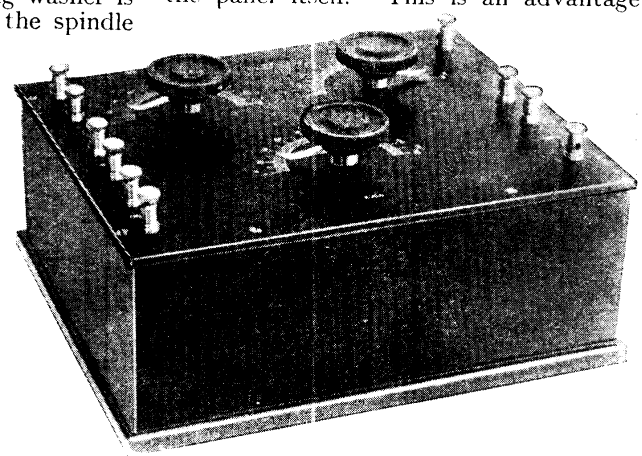
ARRANGEMENT OF CONDENSER UNIT

Fig. 1 (above). Panel lay-out of a condenser unit. It will be seen any of the three condensers may be introduced in a circuit by connecting to the appropriate terminals. Fig. 2 (below). Wiring is carried out as here shown. By comparing with Fig. 1 the many uses of a condenser unit will be apparent, each condenser being wired independently

CONDENSER UNIT. An instrument containing one or more suitably housed condensers of variable capacity, conveniently connected to terminals so that they may be attached to any apparatus, such as a tuner unit with the minimum of trouble. This unit of condensers is very useful in a wireless set in which all stages of amplification and the rectifier and tuner are made up in boxes or cabinets of the same depth and width. In each unit, including the condenser unit, terminals are placed and connected on both sides of the panel in order that connexion may be made through each unit to the next.

The condenser unit shown in Fig. 3 has three variable condensers of different capacities. The largest, a ·001 mfd., is connected to terminals on the left-hand panel edge and in the centre of it. Two terminals connecting a ·0005 mfd. condenser are placed on the same edge at the bottom corner. A smaller condenser of ·0002 mfd. capacity is brought out to terminals on the right-hand bottom corner of the panel. This condenser is for tuning the primary winding of a high-frequency transformer, if a radio-frequency amplifying unit is in use. If not, it may be conveniently used across the reaction coil. The lay-out of the panel is shown in Fig. 1.

A few points in which these condensers will be found to differ slightly in construction from other types are worth noting. Each condenser is assembled on the panel itself. This is an advantage

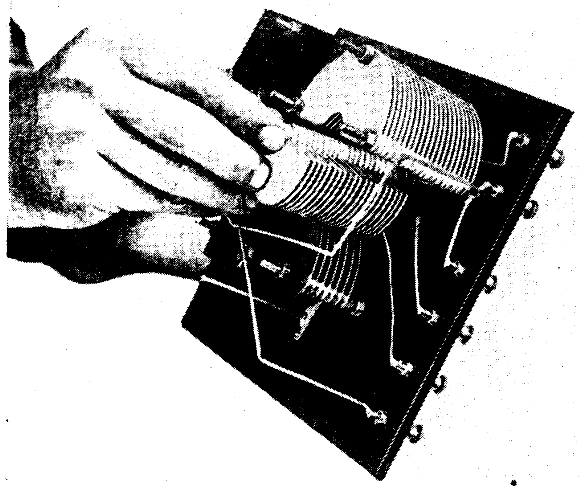


CONDENSERS MOUNTED AS A UNIT

Fig. 3. Three variable condensers of different capacities are mounted as a unit for inclusion in wireless circuits. They are interchangeable for experimental purposes. The cabinet may be of dimensions and design consistent with the remainder of the set with which it is connected

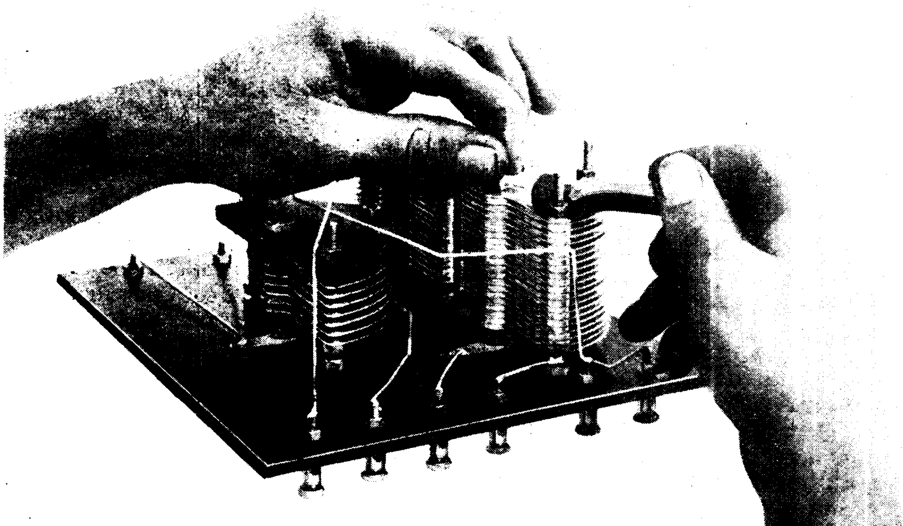
where space is limited, as room is saved by having no top plate. Contact to the moving plate is made in every case by the pressure of a spring washer upon a brass strip held under a brass bush and locked by a small screw. In mounting the moving plate spindle, the contact strip is pushed over the brass bush fitting the hole in the ebonite. A flat washer is first put on the moving plate spindle. This is followed by a spring washer, which presses against the bush and is illustrated in Figs. 4 and 6. Adjustment of the fixed plates is made by nuts touching the outer fixed plates. This is shown in Fig. 5. The bearing at the back end of the moving vane spindle consists of a hollow, slot-ended grub screw to which the spindle is turned down to fit. Fairly easy movement is made on the spindle, after which the locking nut on the grub screw is tightened. Adjustment of movement can easily be made at any time by slackening the lock nut and giving the grub screw a slight turn. The fixing of the knob and pointer follows standard practice. The pointer should be at the 180 degree mark when the condenser is at its maximum capacity.

In soldering the condensers to their respective terminals, keep the work clear of



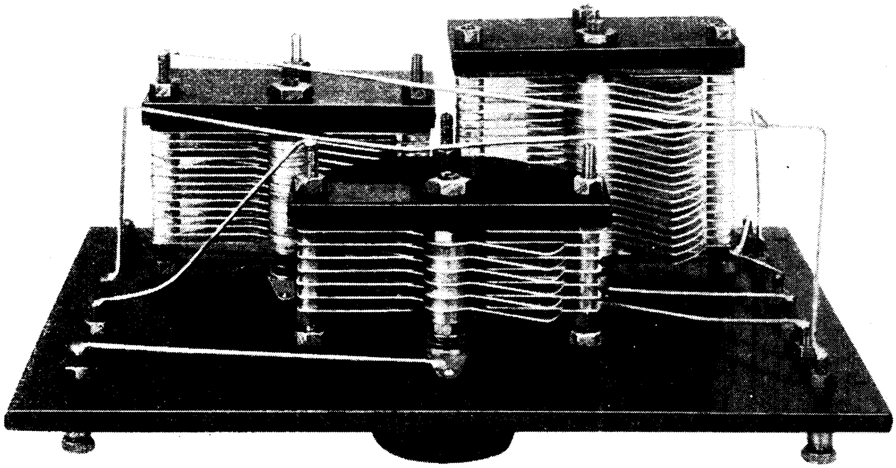
BUILDING UP THE CONDENSER UNIT

Fig. 4. Connexions of the condenser unit and the variable condensers themselves are the same as when variable condensers are mounted separately. Here the moving vanes of one of the condensers are being placed in position



HOW TO TRUE UP THE PLATES OF A CONDENSER UNIT

Fig. 5. The three variable condensers of the unit are mounted on the back of the panel. The operator is adjusting the nuts by which the plates are made to sit square and true on the upright posts and spacers. This is an important part of construction, and must be carried out with considerable care to ensure efficiency



INTERNAL WIRING OF THE CONDENSER UNIT COMPLETE

Fig. 6. This photograph shows the connexions between the three variable condensers of this unit and the terminals. The condensers are attached to the panel, which, when lifted off the cabinet, removes the whole apparatus. Connecting wires are neatly soldered to the bottoms of the terminals

unnecessary fluxite or soldering paste. All wires should be as short and straight as possible, and no two wires should be allowed to run closely parallel to each other. Do not solder on to the screw of the contact strip, but to the strip itself. Wiring connexions are shown diagrammatically in Fig. 2, and Fig. 6 shows the completed condenser from the underside, making clear the connexions of the wires.

CONDENSITE. Hard substance used as an insulating material. Its chief constituent is a resinous gum made from phenol and formaldehyde. Condensite is non-inflammable, cannot be fused except at very high temperatures, is insoluble in oil and most of the usual solvents, and is not attacked by acids. The material may be moulded, so that it adapts itself readily in the construction of insulating knobs, condenser dials, and the like. It may also be used to impregnate other substances, as wood, cardboard, etc. A still further use of condensite is as an insulating cement for sealing terminals in position. At normal atmospheric temperatures a $\frac{3}{16}$ in. sheet of condensite has a puncturing voltage of 12,000 volts, reduced to about 5,000 volts at 170° F.

CONDUCTANCE. That property which a body has for conducting electricity. The term conductivity is also used. Good conductors have large conductance and insulators have small conductance. Conductance is the converse of resistance, and is measured by its reciprocal. Thus a wire with a resistance of R ohms has a conducting power of 1/R units of conductance.

The unit of conductance is the mho. A body which has a resistance of one ohm has a conducting power of one mho. The mho is the conductance of a column of mercury 106·3 cm. long, 1 sq. mm. in cross section, and of mass 14·4521 grm. at 0° C. *See* Conductor; Resistance.

CONDUCTION CURRENT. An electric current which will flow in a conductor which forms a closed circuit if some source of electro-motive force is inserted in that circuit. *See* Current.

CONDUCTIVE COUPLING. Another name for direct coupling, in which there is a metallic connexion between the circuits being coupled. *See* Direct Coupling.

CONDUCTOR. Substance of such small resistance that it readily allows electricity to flow through it or to pass from it to other bodies. There is no definite dividing line between conductors and insulators, or substances offering a high resistance to the passage of electricity. All conductors offer some resistance to the passage of an electric current, and all insulators will pass an electric current of sufficiently high voltage. The voltage required, however, is so high, in the case of some insulators, that for all normal purposes, particularly in wireless, their insulating properties may be considered almost perfect.

Most metals are good conductors, and nearly all transparent substances, as well as many opaque ones, as ebonite, are good insulators and poor conductors. The following table gives a list of conductors in the order of their conductance, the best conducting material coming first.

Silver (annealed).	Lead.
Copper (annealed).	German silver.
Copper (hard-drawn)	Platinum silver.
Silver (hard-drawn).	Platinoid.
Brass.	Manganin.
Telegraphic silicon-bronze.	Mercury.
Gold.	Gas coke.
Aluminium.	Charcoal.
Zinc.	Graphite.
Platinum.	Acids.
Iron.	Metallic salts.
Nickel.	Impure water.
Tin.	The human body.

The conducting or insulating powers of most bodies are influenced by temperature. The resistance of metals increases as their temperature is raised, and the resistance of insulators decreases with increase of temperature. Alloys do not follow this law. Manganin, German silver, and platinoid, for example, are affected to a far less extent by change in temperature than a pure metal, as, say, copper, and such substances are largely used as standards for testing. Carbon becomes a better conductor as it is heated, but after a certain temperature the resistance begins to increase again.

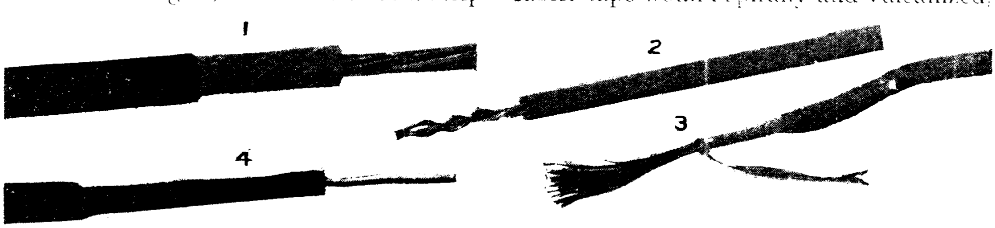
In actual practice a conductor in electrical engineering is used chiefly as a wire, or combination of wires, suitable for carrying an electric current. A lightning conductor may consist of a copper or other metallic strip. Such a conductor is shown in Fig. 1, and consists of a strip of copper $\frac{3}{4}$ in. by $\frac{1}{16}$ in. fixed by hook nails to the side of a house. No insulation is necessary or desirable in such a conductor.

Fig. 2 shows a number of conductors such as are used in wireless. No. 1 is a large-stranded conductor consisting of seven strands of No. 18-gauge tinned copper wire. Surrounding this is an insulation of rubber and cotton tape, the whole being vulcanized to form one solid insulation. The outer casing is a cotton braid, impregnated with paraffin wax. This form of conductor is used for heavy lighting mains or small motor leads, and should not be used on voltages above 600. In describing stranded conductors it is usual to denote the number of strands first, followed by the gauge, *e.g.* 7/18 means seven strands of No. 18 S.W.G. copper; 3/22 denotes three strands of No. 22. Where the insulation next to the actual conductor is of a rubber composition, the copper is invariably tinned, thus preventing any chemical action on the copper from the vulcanizing process.

CONDUCTOR

Fig. 1. Flat against the wall is a copper strip lightning conductor or earth lead

The single conductor shown at 4 is a piece of single 18-gauge lighting wire. Here, again, the copper is tinned and surrounded by a vulcanized rubber tube. This rubber tube is again covered with a fabric tape wound spirally and vulcanized.



CONDUCTORS USED FOR WIRELESS PURPOSES

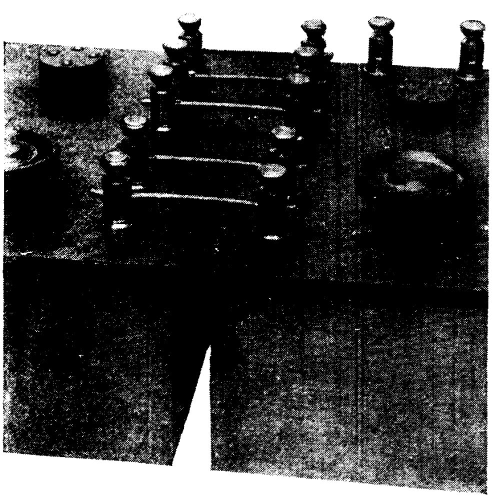
Fig. 2. Four types of conductor are shown. No. 1 is a cable containing 7 strands of No. 18-gauge tinned copper wire; No. 2 is a 3-strand 18-gauge conductor with braided insulation; No. 3 is a 35-strand No. 40 S.W.G. wire covered with rubber, and No. 4 is a single-strand 18-gauge copper wire, heavily insulated. In each case the insulation is partly removed

the final covering being braided cotton immersed in wax.

The conductor shown at No. 2 is a three-strand 18-gauge conductor with a braided-formation insulation of impregnated cotton. No rubber is used in this case. Such a wire may be used for low-voltage lighting where a comparatively long line exists and fairly heavy currents must be carried. The flexible conductor shown at 3 has 35 strands of No. 40 S.W.G. wire. The insulation is merely a fairly loose rubber tube surrounded by a loose silk braid, the whole being wound in such a manner that it provides maximum flexibility combined with the ability to withstand mechanical fracture.

Connecting strips, bus-bars, and so on are all forms of conductors, and are described under their own headings in this Encyclopedia. *See* Carrying Capacity; Insulator; Wire.

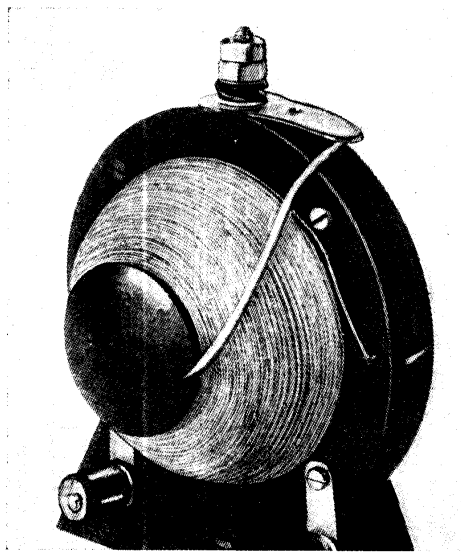
CONNECTING STRIPS. Name used in wireless to describe an electrical conductor, usually short in length and sufficiently stiff to be self-supporting. One typical application is illustrated in Fig. 1, and is an example of the use of short strips of wire employed to connect the terminals between two units. In such a case the strips are passed through holes in the telephone terminals and pinched tightly by means of the set-screws on the top. It is important with such a connexion that a good, sound metallic joint is made, for which reason the connecting strips should be thick enough to fit closely in the holes in the terminals.



UNITS JOINED BY CONNECTING STRIPS

Fig. 1. Short strips of stout wire or brass rod are used in this way for connecting the terminals of two units of a receiving set together

Another example of the use of connecting strips is given in Fig. 2, which illustrates a variometer. In this case several strips are used, notably one at the top which conducts the current to the rotor and stator windings. The support or holder, which is attached to the panel, is itself secured to the stator former by means of two pairs of connecting strips, the upper ends bolted together through the stator windings, the lower ends similarly bolted to the holder, with the ends of the bolts equipped with terminals. Consequently, these strips serve two purposes. They hold the former securely to the panel mounting and are also used as the conductors for the aerial and earth wires, being connected internally to the variometer windings.

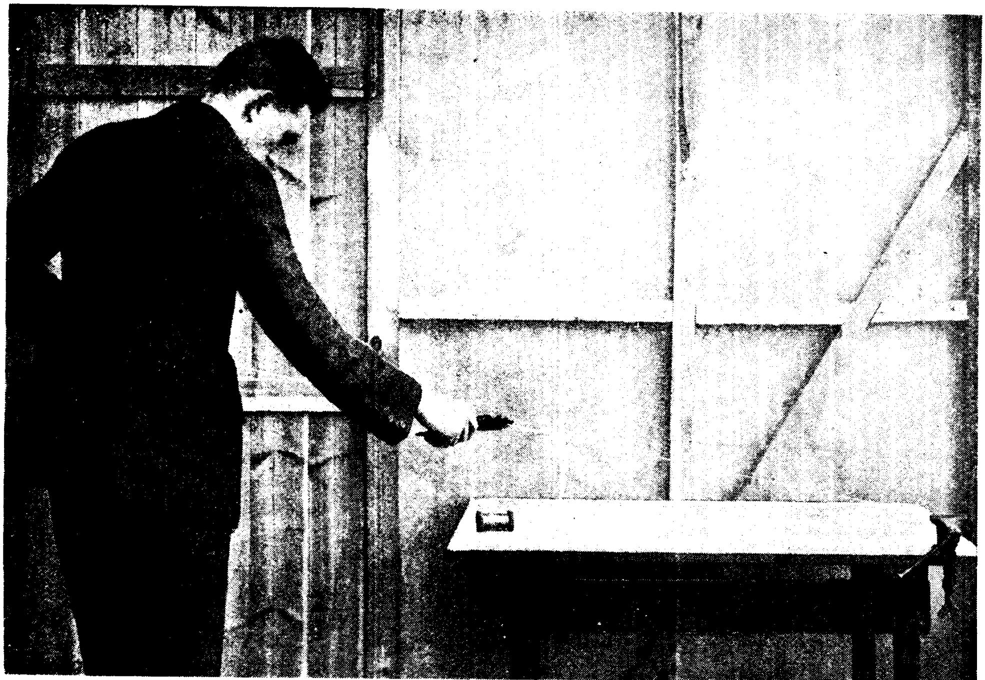


CONNECTING STRIPS IN A VARIOMETER

Fig. 2. This variometer has its stator and rotor connected by means of the strip at the top of the photograph. Connecting strips are also seen at the bottom, making contact with the terminals

In general, brass, copper, and phosphor-bronze are the most useful materials for the experimenter to use for connecting strips of all kinds.

CONNECTING-UP. In wireless work means the joining of the various parts of the apparatus in proper order by means of a suitable conductor. The work is one of the most important items in wireless construction, as the whole success of the



STRAIGHTENING HEAVY-GAUGE WIRE TO BE USED FOR CONNECTING-UP

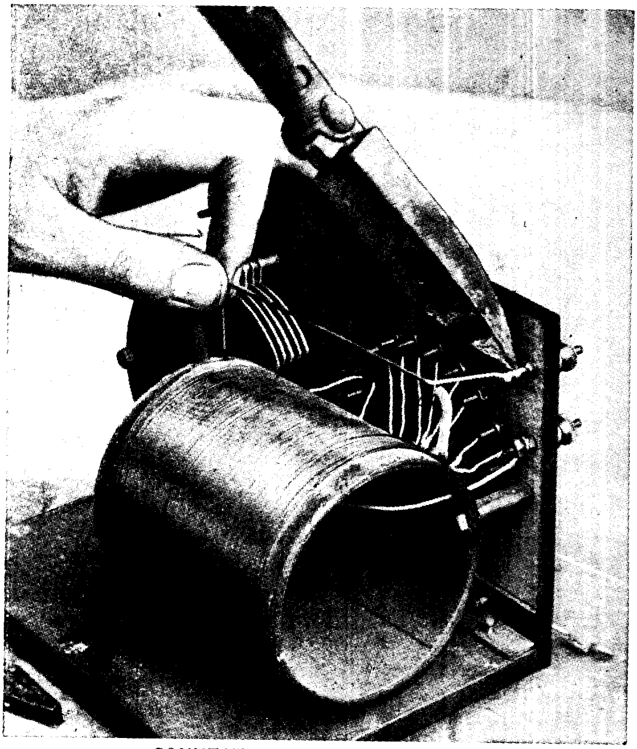
Fig. 1. Kinks and twists have to be taken out of a wire which is used for connecting-up. An effective means of doing this is to hold the wire in a vice while straining it with a pair of pliers. It is then cut into convenient lengths and kept flat until required for connecting-up

apparatus depends on the quality of the connexions, apart from the correct design and arrangement of the component parts of the set. There is little use in having first-class apparatus and bad connexions, as the connexions have to act as paths for the current and, consequently, must be electrically perfect.

One difficulty is that normally a current of electricity is invisible, and any leakage is consequently not detected by the eye; but unless the connexions are perfect, there will be a considerable loss in efficiency. Possibly the set will work if the connexions are simply made by twisting the wires around the terminals, but such a method is very bad practice and the results are generally poor. The experimenter will be astonished at the improvements which will follow when genuine care is taken in connecting-up.

The first step in the connecting-up of an amateur receiving set is to straighten the wire that will be used. This is accomplished as shown in Fig. 1, by fixing one end of the wire in the vice and holding the spool in the left hand, while the right is employed in bringing tension on the wire at about the middle of its length. This pulling has the effect of straightening out any kinks, and the wire is then cut off into convenient lengths.

Most of the connexions can be made with No. 18-gauge tinned copper wire, although sometimes a thicker wire is used, and some experimenters prefer a square copper wire. On occasion it is necessary to use flexible wire and other insulated conductors, especially for the lead-in from the aerial. The connexions of the set can best be carried out with bare wire, provided a sufficient air gap is left between all adjacent conductors to obviate any chance of interference. The wires should be arranged so that there is as much space between them and the back of the panel as possible, and all of them should be as widely spaced as feasible. The appearance of a set with regularly arranged wires is better than one in which the wires are taken at all manner of different angles and directions, but the former is a method that is more likely to give trouble with inductive effects than is the case when the wires are not arranged parallel to one another. Square



CONNECTING-UP WITH SOLDER

Fig. 2. Wireless receiving sets should have their connexions soldered to ensure best results. The metal should be thoroughly cleaned before applying the solder and a minimum amount of flux applied

at the joints that would be most difficult to get at later on when other wires are placed. The art of soldering is not difficult to acquire, and is well worth while to do well. The process is described in detail in the article on soldering, but briefly the stages are first to clean thoroughly the places to be soldered, apply a trace of flux, heat the soldering-iron to just below a red heat, tin the point and touch it on the stick of solder, and at once apply the point of the iron to the work, as shown in Fig. 2, where the conductor is in the act of being soldered to the terminal end.

Too much care cannot be taken to get a perfectly soldered joint at every connexion. The advantages include more silent operation of the set, due to the absence of condenser effects, or of noises in the telephones occasioned by wires loosely attached to a terminal. When the amateur is unable to make a soldered joint, the connexions will have to be made with terminals having

corners are to be avoided, as the current appears to flow more readily around a gradual bend than it does when it has to make an abrupt turn. The variations in the molecular disposition of the metal at the sharp bends possibly set up a discharge at the apex of the angle, with resulting loss in signal strength.

One method of carrying out the connecting-up stage of the work is to prepare the wires and place them in position temporarily, then to remove them and make all the joints perfect by soldering. When such a plan is possible, it is often beneficial, as it is then seen that a few alterations to the path of some of the wires will give much better results and a more equable distribution of the wiring. After all the wires are in their place, the connexions ought to be carefully checked with the wiring diagram to ascertain that all is correct. The wires are then removed and all the joints soldered, the wires replaced and soldered to the terminals. This is done step by step, working first

lock nuts, the wire being gripped between the two. The ends of the wire ought to be coiled to form an eye and in the direction in which the nut is turned to tighten it, that is, generally the same direction as that in which the hands of a clock turn. The tendency is then for the wire to tighten up under the nut. If the wire is turned the opposite way the joint will tend to open. Two wires ought not to be attached between the same nuts, but always be separately connected with a nut. The terminals are, as a rule, long enough to allow of several nuts being screwed on for this purpose. The reason is that two wires cannot be persuaded to remain in perfect contact when placed on top of each other.

CONNECTOR. Term used generally for a conductor employed to convey current from one point to another, and particularly between the units of wireless apparatus. There are numerous examples of this class of wireless fitting, and some are illustrated. The simplest comprises a plain brass bar drilled through the centre and provided with two set-screws, Fig. 1, which are fitted at right angles to the central hole. The wires to be joined are placed one in each end of the central hole, and the screws tightened to grasp them tightly. Another type has a flat plate for attachment to an object, such as a carbon plate in a battery. In this case the wire is attached by the pinching screw and makes contact through the whole of the fitting.

The experimenter who uses the electricity supply for charging purposes or other work, as, for example, the supply of high-tension current to the valves, can make extensive use of the connectors of the types illustrated in Fig. 2, all of which are of the plug-in pattern. They are used in pairs, and one of them is fitted with projecting pegs or prongs, the other with sockets. The conducting wires are insulated from each other, and attached to these terminals by means of set screws or by soldering. The internal construction is clearly shown in Fig. 3, which illustrates a miniature and other types of plug connexion suitable for the low-tension battery leads.

Connectors of this type are generally made with ebonite or china bodies and brass contacts. When required for high voltages the china pattern is preferable, but for low voltages the ebonite is sufficient and is more durable and less liable to accidents from rough or careless handling.

With these types of connectors it is important to mark the polarity of the contacts and to take precautions against accidentally crossing the wires and reversing the connexions. This is overcome by the combination of clearly marked terminals, or by making the plugs with one plug contact and one socket contact on each element of the pair. The use of plug-in connectors for the attachment of the telephone leads, to extend the length thereof, or to attach the leads from the battery to the receiving set, is one to be commended, as it tends to neatness on the instrument panel, and the absence of projecting fittings is a distinct advantage.

A good example of this type is shown in Fig. 4, comprising a stout, well-insulated and braided twin flexible conductor, with plug-in terminals at each end. The

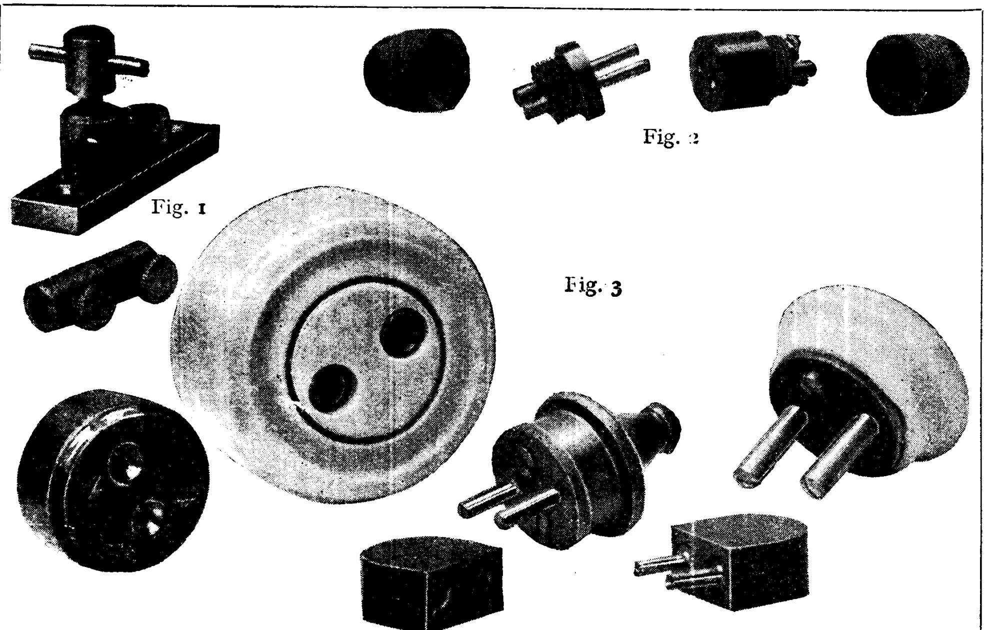
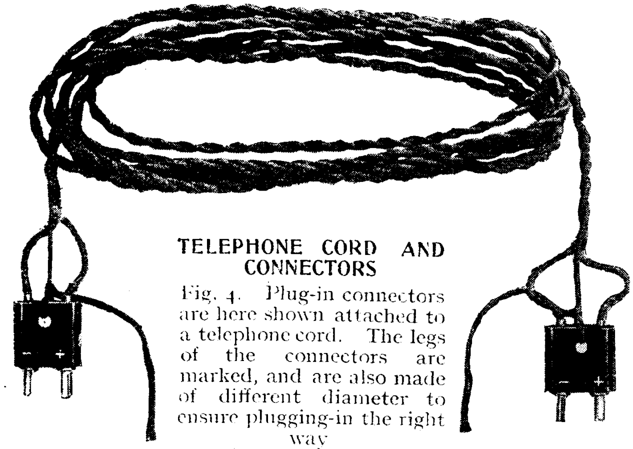


Fig. 1. Two of the simplest types of connectors used in wireless are here shown. The ends of wire or contact rods are gripped by means of set screws. Fig. 2. Miniature plug-in connectors of this kind are very useful. This one has been taken to pieces to show construction. Fig. 3. Other plug-in types are here shown. These connectors are always used in pairs, one being fitted with projecting pegs or prongs, and the other with corresponding sockets into which they are plugged

CONNECTORS IN COMMON USE WITH WIRELESS SETS



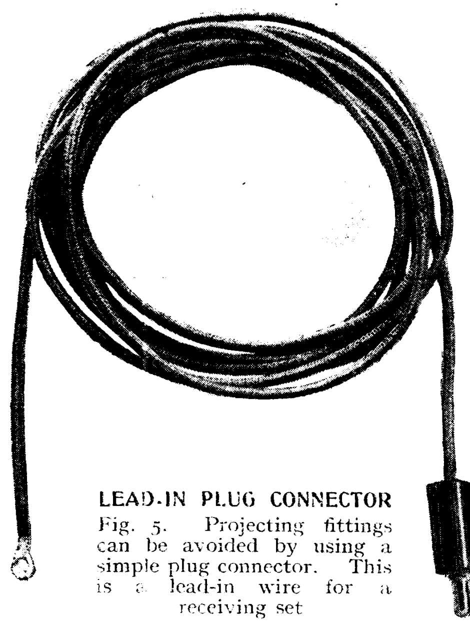
TELEPHONE CORD AND CONNECTORS

Fig. 4. Plug-in connectors are here shown attached to a telephone cord. The legs of the connectors are marked, and are also made of different diameter to ensure plugging-in the right way

polarity is marked, and to further guard against accidents the plugs are made of different diameters. The larger is used for the positive connexion, and the thinner for the negative. Both plugs are mounted in an ebonite block, and the tension is removed from the flexible wire by the use of a cord tied to the top part of the block through a hole provided for the purpose.

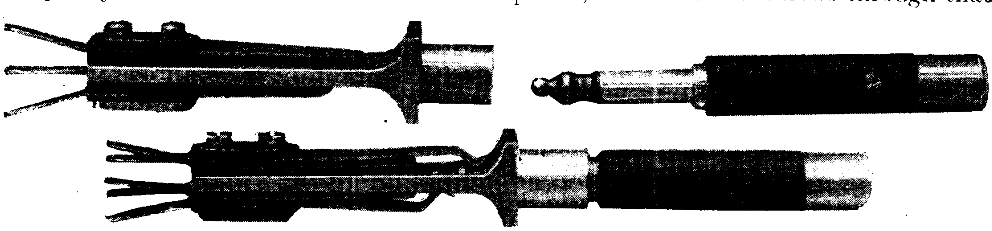
A somewhat similar arrangement to the foregoing, also manufactured by the General Electric Co., is the one shown in Fig. 5, but is a single conductor, and has a plug at one end and a terminal tag at the other. Such a connector is very useful for such work as plugging in the lead-in wire from the aerial to the set, and if a separate socket is provided and connected to the earth lead, the aerial can be disconnected from the set and connected direct to earth by the simple act of removing the plug from one socket and inserting it in the other.

Quite a different type of connector, shown in Figs. 6 and 7, is known as a plug and jack, and extensively employed in telephony. It combines the functions of a plug connector and a switch, and in one example the telephone leads are connected to the plug, which has two insulated contacts of circular or tubular form. The internal connexions of the instrument are terminated at the jack, which is attached to the panel or cabinet. When the plug and jack are separated, as shown in Fig. 6, the connexions are broken and the current cannot flow through the circuit controlled by the jack. But when the plug is inserted, as shown in Fig. 7, the springy contact arms are forced outwards and make contact with the contact points, and the current flows through that



LEAD-IN PLUG CONNECTOR

Fig. 5. Projecting fittings can be avoided by using a simple plug connector. This is a lead-in wire for a receiving set

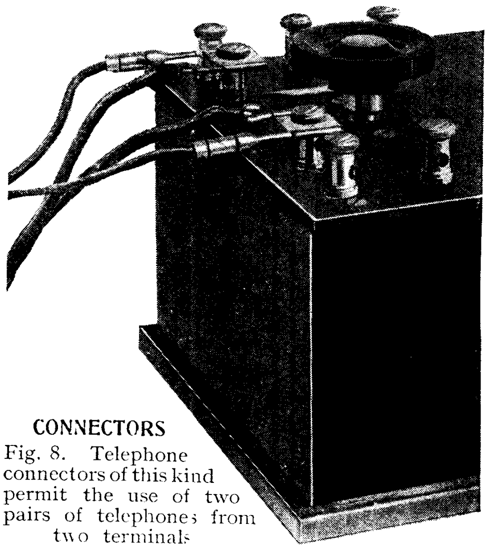


JACK AND PLUG CONNECTORS AND AUTOMATIC SWITCHES

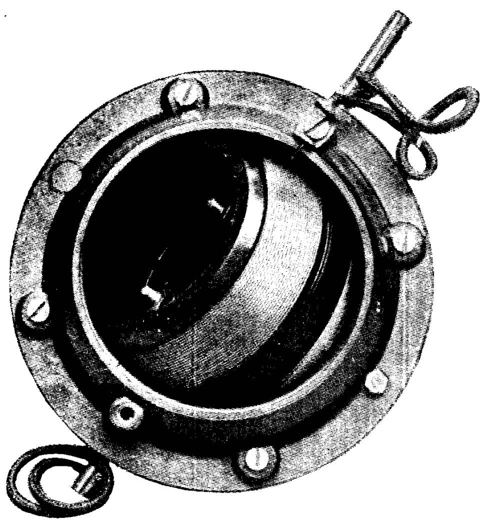
Fig. 6 (top). Many amateurs making their own apparatus prefer the jack and plug method of connecting. Here is a jack and plug, disengaged, and when so removed disconnects the circuit it controls. Fig. 7 (below). The same jack engaged in its plug, forcing the springy contact arms outward by the plug contacts, permitting the current to flow through the circuit, and also through the leads to which the plug is attached circuit. Thus the simple act of putting the plug into the jack connects the telephones and likewise completes the circuit.

The experimenter often desires to use two sets of headphones on a receiving set, and the use of one of the numerous patent connectors is recommended. The pattern shown in Fig. 8 is suitable for two sets of telephones. It comprises a flat plate of metal with two ends rolled to form a springy, tube-like member, into which the telephone tags are pressed.

The connector can be placed on the terminals as shown, or the telephones can be connected in series by attaching the connector between the two pairs of telephones, the tag of one attached to one side of the connector and that of the other telephone to the opposite side of the connector. Another device, arranged to take up to six telephones, is shown in Fig. 9, and comprises a square brass bar drilled with a series of holes, each with a pinching screw at right angles. The telephone tags are passed through the hole and secured with the screws. —*E. W. Hobbs.*



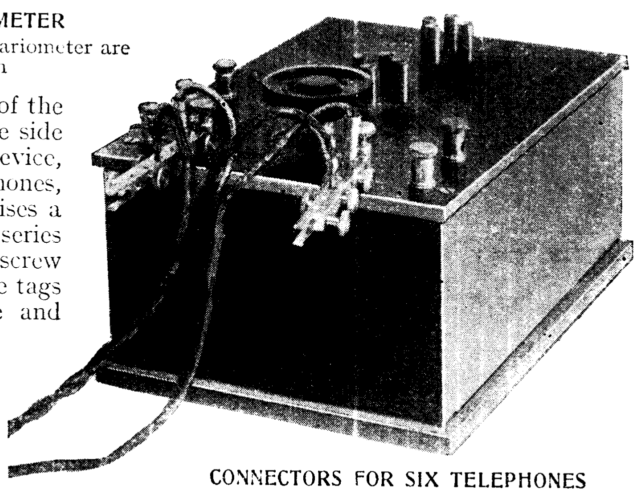
CONNECTORS
Fig. 8. Telephone connectors of this kind permit the use of two pairs of telephones from two terminals



CONNEXIONS OF A VARIOMETER
Rotor and stator connexions of a variometer are seen in this photograph

CONNEXIONS. Electrical conductors between two or more parts of a circuit or piece of apparatus. There are numerous types of connexion. Generally, in wireless work, the connexions are intended to conduct the current from one moving part to some other part of a piece of apparatus. The example illustrated shows how the current is taken from or to the rotor and stator of a variometer.

This is a case where the connexion must be efficient and also of a flexible character. These conditions are met by the use of a short length of flexible wire. One end is attached to the bush in which the spindle turns, the other to the soldering tag which is attached to the end of the stator winding. The other end of the spindle is similarly treated, and as the spindle is in



CONNECTORS FOR SIX TELEPHONES
Fig. 9. By the attachment of these connectors to the telephone terminals of a receiving set, six pairs of telephones can be used at one time

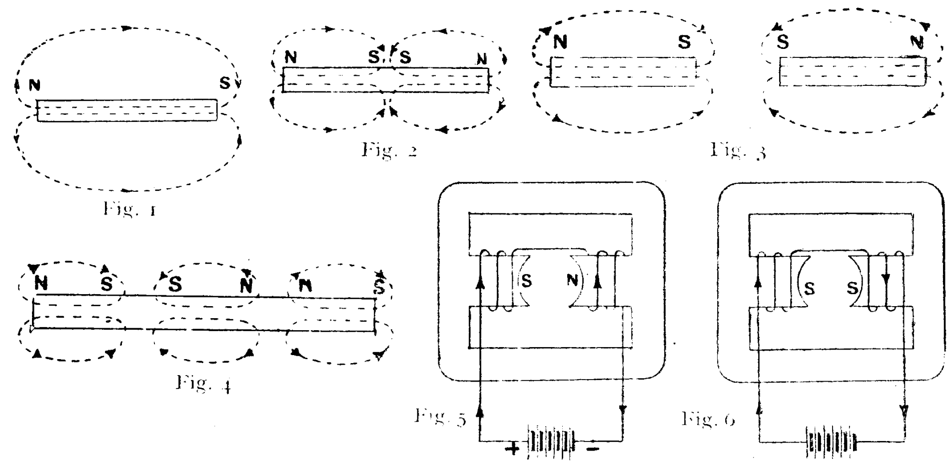


Fig. 1. Dotted lines represent the field of magnetic force and arrows the direction in which a free magnetic north pole might be supposed to be impelled. Fig. 2. Similar pairs of poles of a magnet. Fig. 3. The same magnet as in Fig. 2 divided, making two independent magnets with consecutive north and south poles. Fig. 4. Resultant magnetic field of a magnet having more than one pair of consequent poles. Fig. 5. Normal arrangement of north and south poles of an electro-magnet. Fig. 6. In this case consequent poles result from an error in connecting, and the apparatus would not work

THEORY OF LINES OF MAGNETIC FORCE APPLIED TO CONSEQUENT POLES

two parts, the current flows through the whole of the rotor windings and via the connexions to the stator windings. The use of the flexible insulated wire thus allows the rotor to turn, and the insulation avoids risk of short circuits, as might be the case were the wire bare. All connexions ought to be well soldered to make perfect electrical connexion between the parts concerned. Detachable connexions are generally known as connectors. *See* Connecting Strips; Connecting-up.

CONSEQUENT POLES. When a steel bar magnet, instead of exhibiting a north pole at one end and a south pole at the other end, is found to show similar polarity at both ends, this condition is known as consequent poles. In the normal magnet, whether permanent or electrically excited, the polar conditions are as shown in Fig. 1, the dotted line representing the field of magnetic force, and the arrows the direction in which by convention a free magnetic north pole would be impelled if such a thing as a single pole could be supposed to exist.

A magnet may, however, have a similar pair of poles formed at its equator, as shown in Fig. 2, which leaves its extremities also similarly magnetized, a condition of affairs which results in a redistribution of magnetic lines, as shown in the same figure. If the same magnet were divided as shown in Fig. 3, it would become virtually two independent magnets with two ordinary consecutive north and south poles. It is even possible that a magnet may have more than one pair of consequent poles, as in Fig. 4, which depicts the magnetic field arising from it.

What has been said of permanent magnets is true of electro-magnets, the poles of which may be either consecutively north and south, or consequent, according to the connexions of the exciting coils. Thus in Fig. 5 the normal arrangement of successive north and south poles is shown such as would exist in a two-pole field magnet of a dynamo or electric motor. If the field coils were connected up by error as in Fig. 6, however, the result would be a field magnet having consequent poles, and the machine would refuse to work. The same principles apply equally to the case of open and closed magnetic circuits, only the latter have no air gaps at which the polarity would be exhibited.

CONSTANT CURRENT MODULATION. Speech transmission in wireless telephony is brought about by changes wrought in the amplitude of the aerial current by what is commonly known as modulation. The range and quality of transmission does not depend so much upon the actual maximum amount of current in the aerial as upon the *change* in value of this current, which is brought about by modulation between its minimum and maximum values. In practice the wave train would never be modulated to its minimum or zero value, but a figure round about 50 per cent modulation would be aimed at.

In speaking into the telephone transmitter an effect is produced which is equivalent to changing the resistance of the aerial circuit, and when correctly designed the resistance of the telephone transmitter should be such that if transferred to the aerial circuit it will be equal to the resistance of the latter. If, for instance, the idle resistance of the tele-

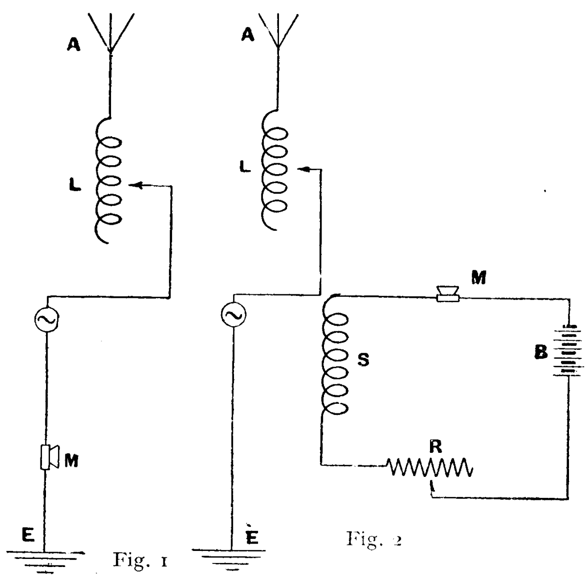


Fig. 1 Fig. 2

CONSTANT CURRENT MODULATION

Fig. 1 (left). Modulation of high-frequency alternating currents by microphone in series with the aerial. Fig. 2 (right). Modulation by introduction of a microphone in the exciting circuit of an alternator

phone transmitter were much lower than that of the rest of the circuit, any change in the former could have but very little effect on the total circuit resistance; hence the modulation would be more or less ineffective.

On the other hand, if the reverse conditions were present the radiation of power from the aerial would be very small, since so large a percentage would be absorbed by the transmitter; consequently, there is a correct relationship between the telephone transmitter resistance and that of the balance of the aerial circuit, which relationship is best obtained by making them equal to one another.

Various schemes are adopted for modulation. For instance, in Fig. 1 is shown a simple method of modulation by introducing the microphone, M, directly in series with some form of high-frequency alternating current, V, and a loading inductance, L, A representing the aerial and E the earth.

The microphone is of the ordinary carbon granule type, and the carbon granules are in contact with an elastic metallic diaphragm which forms part of the aerial circuit. When the microphone diaphragm is stationary the pressure between it and the carbon granules is constant and the resistance of this part of the circuit is also constant. When set in vibration by the human voice or other sound waves which cause it to oscillate, the varying pressure between the carbon and the diaphragm results in a varying circuit resistance, and therefore in the amplitudes of current derived from any constant potential source of supply, or from an alternator. In other words, the vibrating microphone diaphragm acts as a variable series resistance in the circuit responding in sympathy with the sound waves which reach it and passing these on as current vibrations in the electric circuit. There are several other ways in which modulation may be obtained. The one just described is in series with the main aerial circuit, and directly affects the current flowing in it. Modulation can also be derived from variations introduced into the direct current circuit which excites the high-frequency alternator, and a diagram representing constant current modulation obtained by such means appears in Fig. 2. A battery, B, is here shown supplying direct current to the exciting coils of the alternator, S, with a variable resistance, R, and the microphone M, all in series in the same circuit. Changes in the resistance of the transmitter circuit now result in certain changes in the alternator excitation, which consequently modifies its electromotive force, and therefore the aerial current. But unless the self-induction of the exciting circuit is low, and the alternator field far from being saturated magnetically, the amplitude of the aerial currents may not respond very closely to those in the transmitter circuit. *See* Modulation; Transmitter.

CONSTANTON. Alloy consisting of about 60 per cent of copper and 40 per cent of nickel. It is used as a resistance

Fig. 1

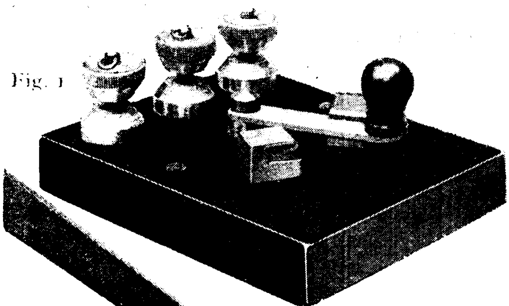
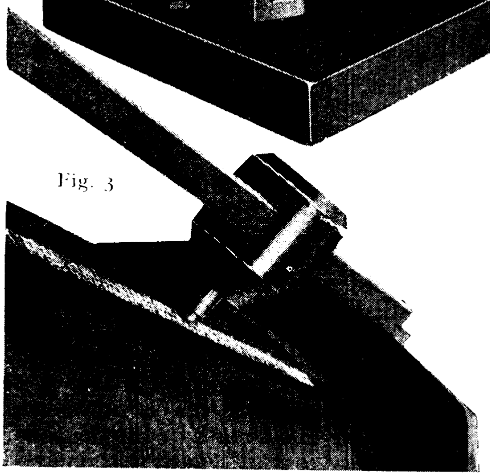


Fig. 3



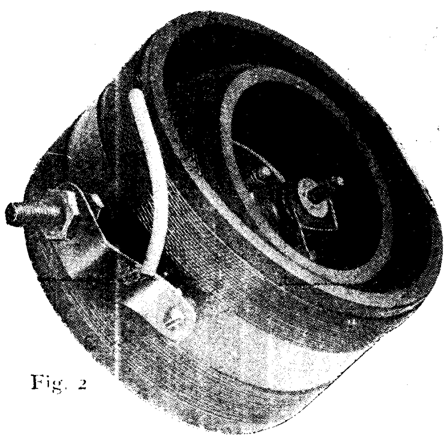


Fig. 2

PRINCIPAL TYPES OF CONTACT IN RECEIVING SETS

Fig. 1. Spring grip contacts on a two-way switch may be seen in this photograph. The pressure exerted by the spring clips ensures a good contact, and holds the contact arm in place. Fig. 2. Contact is made between the rotor and stator of a variometer by means of the contact blade, to which is soldered the flexible wire. Fig. 3. Sliding contact is made in this case by a spring plunger, being held in position so that it rests on the face of a coil, but can be moved along a slider bar

wire in electrical instruments, and also to form one element in base metal thermo-couples. Its electrical conductivity, compared with that of copper as unit, is only about ·033. Constanton is restricted in use for resistance standards mainly to coils of high value, where the thermo-electro-motive force is small compared with the volts required to make measurements with the coil.

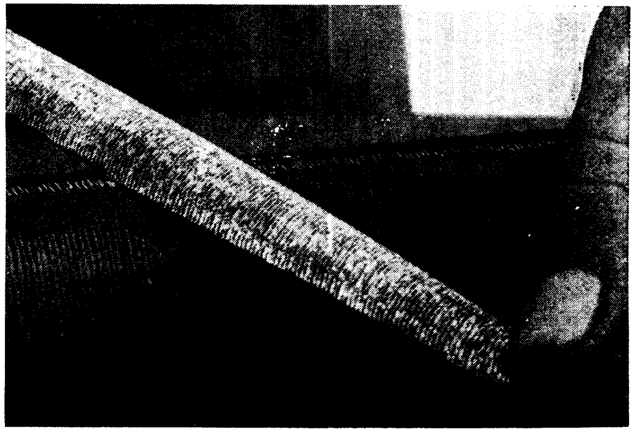
CONTACT. The point where one electrically-conducting member touches another and effects an electrical connexion between them in a circuit.

A simple form of contact is illustrated in Fig. 1, and takes the current from a movable arm to a fixed contact block, with springy metal jaws, into which the contact arm enters. This type is a good one for low-voltage work, as the contact is effected by a wiping movement that tends to keep the surfaces clean. The pressure exerted by the contacts ensures good electrical connexion, and the grip is sufficient to hold the arm firmly in place, and avoids any chance of current fluctuations due to the arm vibrating.

To effect a contact between a moving and a fixed member calls for another type of contact arrangement, and one way of dealing with the problem is illustrated in Fig. 2, and shows how the rotor spindle of a variometer is connected electrically to the stator windings by means of a contact blade attached at one end to the stator.

At the other end contact is made by means of a hole through which the rotor spindle passes. The spindle has two nuts screwed to it, one on each side of the blade. A pressure is exerted on the blade by means of a spring washer located between the blade and one of the nuts. The nuts are locked to the spindle after the spring pressure has been adjusted. The current flowing through the rotor windings is taken by the blade and passed on, through a wire soldered to it, to the stator windings. The rubbing contact thus formed between the spindle and the blade is effective.

A popular type of sliding contact, seen in Fig. 3, comprises a square slider-bar that spans the supports of the inductance coil. An ebonite knob is arranged to slide on this bar, and attached to the knob is a brass spring plunger, one part of which makes contact with the bar, and the other part with a bared path on the coils. The act of sliding the knob on the bar propels the plunger along, wipes the contact clean, and allows any one of the coils of the winding to be selected as the contact point. This device is simple and effective, but has the



MAKING A CONTACT PATH

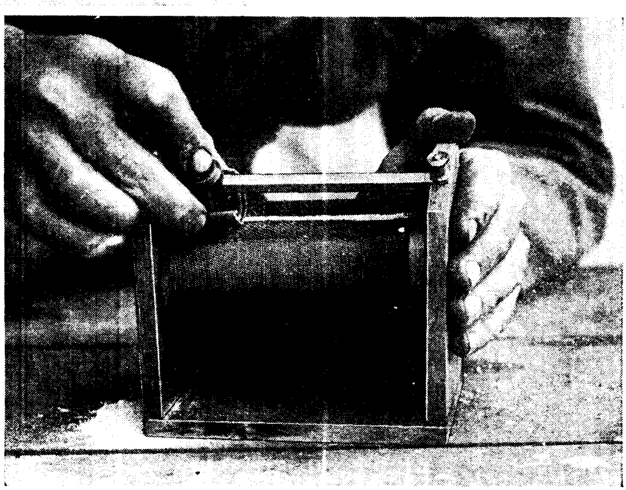
Fig. 4. Insulation is removed from an inductance coil to make a path for a slider contact by using a file in this way

REMOVING ENAMEL INSULATION

Fig. 5. Parallel to the path of the slider contact a straight edge is held to guide a piece of wood around which fine emery paper is wrapped. By this means insulation is removed from the wire

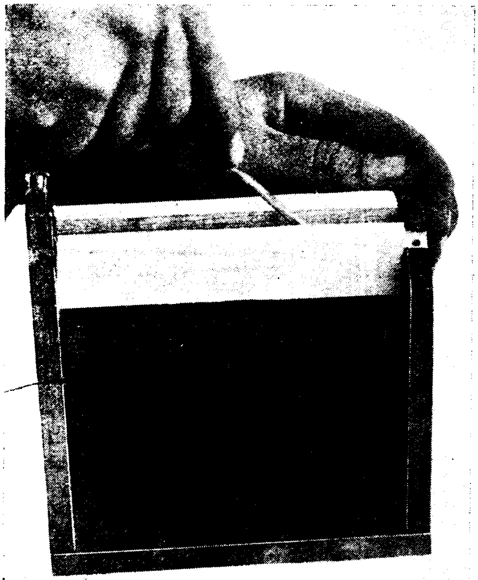
defect that the friction on the contact part of the coil speedily wears away the surface. The device is satisfactory when the slider is not likely to be altered much, but when it is in constant use a series of tappings and contact studs (*q.v.*) are preferable.

The method of clearing the insulation from a coil to enable a sliding contact to function is shown in Fig. 4, where a file is seen in use filing the top of the insulation. Provided the insulation has been well shellacked or varnished to make it stiff, there is no great difficulty in filing the upper part of the insulation so that a narrow bare path is formed on the coil. To make this path straight and smooth, a piece of emery paper is folded around a narrow stick of wood and rubbed too and fro along the coil, guiding the emery as shown in Fig. 5, with a stick or batten of wood. This keeps the path straight and results in a workmanlike job.



USING THE SLIDER TO MAKE CONTACT

Fig. 6. Fine emery paper is here seen folded round the slider knob, which, being moved up and down along its path, clears the insulation where it is to make contact



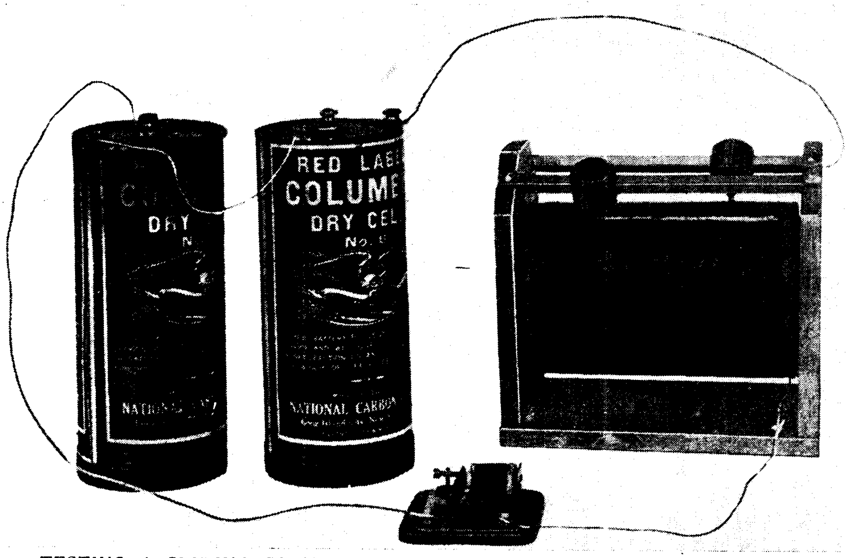
GUIDING THE CONTACT SCRAPER

Fig. 7. A neat contact path can be made with this simple device. Two pieces of wood are used as a guide for the chisel employed for scraping away the insulation, and the result is a clean path of even width

The final touches are, however, best given by assembling the coil in the mount and fixing the bar and slider in place, and at such a height that the plunger will make good contact with the wire. The emery paper is then folded around the point of the plunger, Fig. 6, and the knob moved steadily up and down the bar, the emery paper thus forming a clean, smooth path just at the point of contact.

Enamelled copper wire is cleared for a similar purpose by making up a jig or guide from two odd pieces of wood, separated by packing a piece of the same thickness as the desired width of the contact path, Fig. 7. The jig is located between the ends of the coil mount, and a chisel or scraper worked up and down between the wooden strips, thus clearing the insulation at the desired point only.

Whenever a contact path has been formed in any way, it is very desirable to test the continuity by means of a buzzer or small circuit-testing lamp. The arrangement of a buzzer and battery for such work is shown in Fig. 8, where a two-slider coil is undergoing a continuity test. A wire from the battery is connected to one side of the buzzer, and the other wire from the buzzer is attached to one end of the coil winding. The other wire from the battery is attached to a terminal on the slider-bar. The knob is then moved steadily along the bar, and if the contact is perfect the buzzer will sound steadily the whole time,

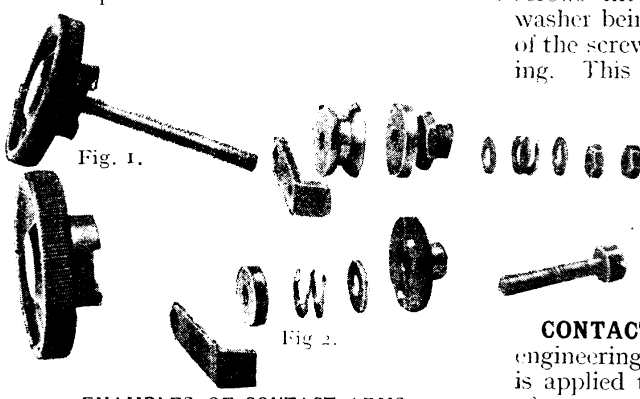


TESTING A SLIDING CONTACT PATH FOR CONTINUITY WITH A BUZZER

Fig. 8. After the insulation has been removed from an inductance coil to allow the slider knobs to make contact, the test shown in progress above is carried out to ascertain whether at any point in the path defects occur. Should the path permit perfect contact the buzzer will sound continuously; but the sound will cease if in moving the sliding knob a point is found where there is a defect

any bad places being indicated by a diminution in the sound or a total cessation of the buzzer. The insulation will have to be cleared at the indicated points, and the test repeated until perfect results are obtained. Such a test is quickly carried out, and the time so spent is well repaid, because the contacts are then known to be correct.—*E. W. Hobbs.*

CONTACT ARM. A movable metallic conductor, used for the purpose of making connexions in electrical circuits. Examples include the contact arm of the ordinary type of throw-over switch and arms used on inductance switches and for many other purposes in wireless. In the latter connexion they are generally employed as a means of effecting contact between studs or contact plates, and the arm is used to conduct the current from any one of them to the centre spindle or some other contact point.



EXAMPLES OF CONTACT ARMS

Fig. 1. Dissembled to show the construction is a contact arm with a spindle mounted on the turning knob. Fig. 2. Another contact arm is shown, the spindle in this case being a screw upon which the knob is mounted when the other parts have been assembled

The experimenter uses a great many contact arms, of which a simple pattern is illustrated in Fig. 1. This comprises a central spindle made from screwed brass rod, to the upper end of which is attached an ebonite knob. This may be secured to the spindle with a set-screw or lock nut, or may be moulded into place when the knob is being made. The boss on the knob is slotted diametrically, and used as a housing for the contact arm itself, which is made up from three or four laminae of copper, phosphor-bronze, or brass, these being riveted together and turned over at the upper end, where they are rounded off and polished perfectly smooth.

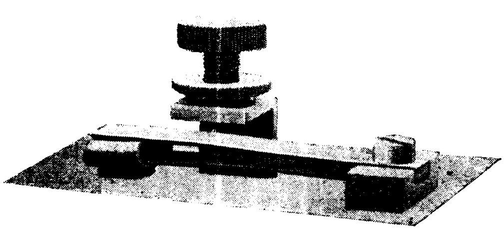
A circular brass member, known as a contact collar, is then screwed to the spindle, and holds the contact arm firmly in slots in the knob and also makes good electrical contact with it. The spindle turns in simple bearings or a bush, while a spring washer, two plain washers, and two lock nuts are fixed to the end of the spindle in such a manner that the spring washer can exert constant pressure and keep the contact arm in firm contact with the studs. The contact bush is used so that the brush (*q.v.*) can bear upon it, thereby enabling the current to be conducted to any desired point.

In the variation illustrated in Fig. 2 the contact arm is similarly attached to the knob, but in this case a simple screw passes through the bearing bush and screws into the knob itself, the spring washer being interposed between the head of the screw and the underside of the bearing. This shorter pattern is particularly suitable for panel mountings in restricted spaces.

Numerous other detailed patterns of contact arm are made, their application and purpose being dealt with in the various sets described throughout this Encyclopedia.

CONTACT BREAKER. In electrical engineering the expression contact breaker is applied to a variety of different pieces of apparatus, but its general application in wireless work is in the form of an automatic device in conjunction with spark coils.

A standard example is illustrated and shows the essentials of this type of contact breaker. The whole piece of apparatus is usually mounted on an ebonite or other



SPARK COIL CONTACT BREAKER

Various forms of contact breakers are made. The type shown above is used in conjunction with a spark coil insulating post, at one end of which is a small block to which are attached two or more strong metal arms. To one of them is attached a soft iron plate which is attracted by the core of the spark coil, which thereby constrains the arm to move through a very short distance. A second arm is loosely connected to the first, and is also constrained to move in a similar manner, but in this case a contact point is provided opposite to another contact point on the outer end of a short screw, adjustably mounted in an angle-shaped bracket, insulated from the blades.

When suitably adjusted the natural springiness of the contact blades brings the contact points into engagement and the primary circuit is thereby completed. This magnetizes the core, which attracts the moving blades and forces connexion between the contact points, thereby interrupting the flow of current. This, in turn, causes the magnetism of the core to cease and the springiness of the contact blades again forces them into contact with the contact screw.

The current is again passed through the primary winding, and the same cycle of operations continued. The number of times this may happen per second is dependent upon various conditions, including the various adjustments to the contact breaker itself.

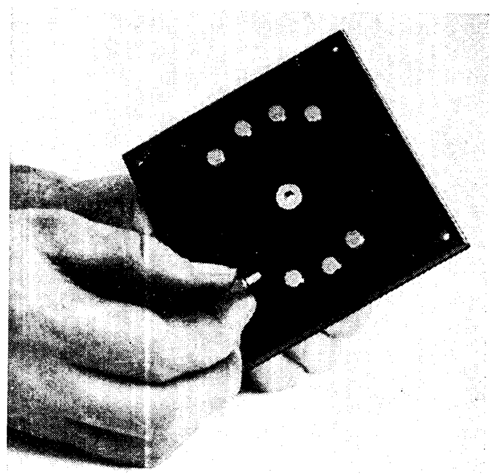
To avoid excessive sparking between the contact points, a condenser of suitable capacity should form part of the spark coil circuit. Practical attentions that should be given to the contact breaker to ensure it functioning properly are to keep the contact points perfectly clean and flat and separated by just the right amount to allow of the quick break with the minimum travel of the blades, and to see that all connexions are perfectly sound.

CONTACT STUD. Brass fitting, in the form of a large-headed screw, used as a terminal at the ends of a tapping from an inductance coil or other apparatus. The usual type of contact stud is machined from round brass rod, with a smooth-topped head. The shank is screwed, generally on the B.A. system.

The appearance of contact studs is greatly improved if they are protected from oxidation by lacquering. Usually, the finish is sufficiently good to enable them to be polished with a piece of old emery paper, but care should be taken not to round the parallel sides. If a lathe is not available the stud may be held in the chuck of a hand brace, the latter being screwed up in a vice for the purpose. Trouble may develop from uneven, loose studs, and in many cases this may lead to the dismantling of the set before it is possible to cure the faults.

Contact studs should not be placed too close together, as dust or even small metallic filings may collect between them and cause shorting of current. If the ebonite is a poor insulator, the smaller the space between studs the greater will be the leakage.

Fig. 1 shows a double set of contact studs in process of assembly. The spacing shown in this illustration will admit of very little leakage from any source. A long contact arm should be used to allow ample spacing between studs.

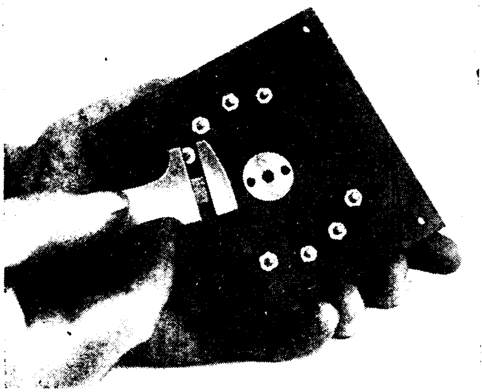


FIXING CONTACT STUDS IN THE PANEL

Fig. 1. Two sets of contact studs are being fitted to the panel of a switch. Wide spacing has been allowed to avoid leakage of high-frequency currents

In marking a radial line for the disposition of the studs, avoid pencil lines and distinct divider-leg scratches. Lead pencil is a conductor, and deep scratches may collect small amounts of conducting materials.

In assembly the stud should be gripped with a pair of pliers, the jaws being covered with a wad of paper to prevent marking. An alternative method of clamping up the studs is shown in Fig. 2, where a small adjustable spanner is used. This method may be used when the nuts are a loose fit on the shanks. If the panel is of a soft



HOW THE CONTACT STUDS ARE FIXED

Fig. 2. On the underside of the switch panel the contact studs are provided with nuts, one of which is being screwed up tightly with a spanner

material and the surface of the tightening nuts small, it is an advantage to place a brass washer against the ebonite on the inside to prevent the nut sinking in.

When soldering or connecting wires to the contact stud shanks, the iron should be very hot, and the job done as quickly as possible to avoid undue heating of the stud. This is an important point, as a perfectly tight stud will become quite loose after being heated, owing to the partial melting of the ebonite.

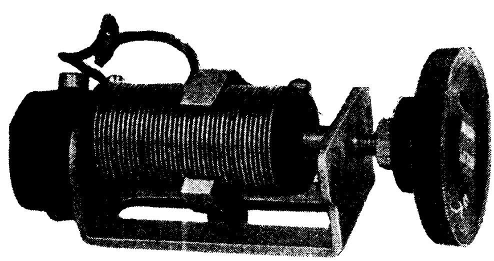
When all the connexions have been made to the studs and they have been properly tightened up, the tops must be rubbed down level. A fine 8 in. flat file, without a handle, is laid over on the studs, and a forward and backward movement is made by the right hand, while the fingers of the left hand "feel" that the file is sliding flatly across the tops. This filing is done from both ends in order to minimize the tendency to file one end lower than the other. When all depressions are filed out, a single layer of fine emery paper is wrapped round the file, and the process continued until the studs are perfectly smooth.

An important point to remember is to brush thoroughly away all traces of filings from the stud tops and soldering paste on the outside. A little petrol is useful for removing this. Fluxite itself is a good insulator, but in time its surface will be coated with dust, giving rise to noises in the telephones resembling static discharges. Dust will collect in time between the studs, and should be removed by periodic brushing. *See* Tapping.

CONTINUOUS CURRENT. An electrical current constantly and regularly flowing in one direction. Such a unidirectional current is a practically non-pulsating direct current (*q.v.*).

CONTINUOUSLY VARIABLE RESISTANCE. A resistance in which the amount of the resistance in circuit can be varied by extremely small amounts, and without breaking the circuit at any point in the travel of the regulating device. The pattern illustrated is applicable to a filament lighting rheostat, and in this form the resistance wire is wound on a movable ebonite former This is rotated by the knob at the right hand, and can also be drawn out bodily a small amount by pulling the knob outward.

When the resistance is rotated it propels a half nut along the resistance. This nut is screwed the same number of turns per inch as the spacing of the resistance winding. The nut is prevented from moving by a spring contact that presses on the top of the windings and thereby makes perfect contact between the nut and the wire. The nut is prevented from rotating by a slot in the framework, in which runs a small wheel made of ebonite. A flexible



BLAXLEY VARIABLE RHEOSTAT

Continuously variable resistance is provided by this instrument, known as the Blaxley patent micro-switch. A sliding contact moves along the wire as it is rotated, thus permitting very small variations

wire connects the movable nut with the switch device incorporated at the rear of the frame. This is actuated by pulling out or pushing in the knob. *See* Resistance; Rheostat.

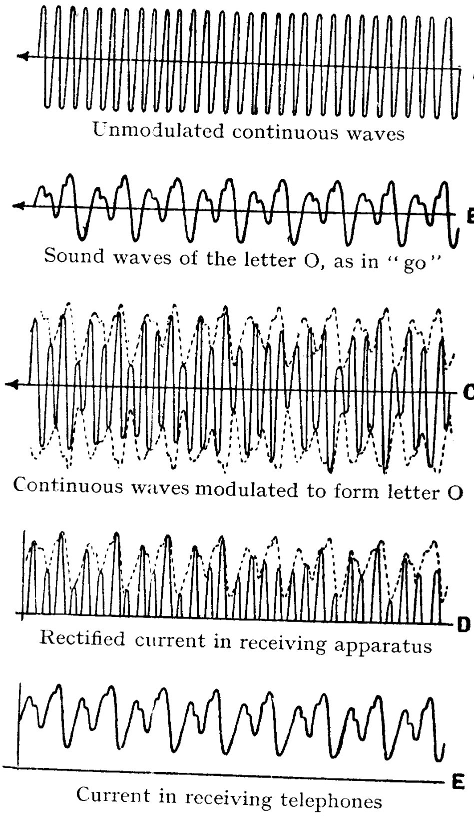
CONTINUOUS WAVES or Type A Waves. A sequence of waves produced without interruption or variation. Waves which, after reaching the steady state, are periodic, *i.e.* the successive oscillations are identical.

They are, in other words, electromagnetic waves of uniform amplitude, now commonly used in wireless telegraphy, and essential for the transmission of wireless telephony signals. In "spark" transmission trains are set up of waves the amplitude or bigness of which gradually diminishes, necessitating special arrangements in the shape of successive condenser discharges for the production of fresh trains. In continuous wave transmission (C.W.), a steady oscillatory current flows in the aerial as long as the key is pressed.

The system has important advantages. Much sharper tuning is possible than with spark transmitters, thus lessening the interference at the receiving end from signals on other and nearly related wavelengths. Again, at the receiving end the pitch of the note of C.W. signals can be controlled, which is not the case with the "damped" waves radiated on a spark system, where the pitch of the note heard depends on the number of complete trains of waves per second. Thirdly, C.W. is well adapted to high-speed transmission by automatic machinery. Finally, it is practicable with C.W. to transmit signals over very much longer ranges than with "spark."

In wireless telephony continuous waves take the place of the steady electric current flowing in an ordinary land line telephone wire. A telephone transmitter or microphone is associated with the C.W. generating apparatus, and when speech or music passes into the former, it causes the amplitude of the waves radiated from the aerial to be moulded or modulated in correspondence with the variations in the speech or music that is being dealt with. The process of modulation has been best described by Addey, with the help of the diagram, Fig. 1. In the figure, A represents a stream of unmodulated continuous ether waves, B the sound waves created by speaking the letter o as in "go," and C the continuous ether waves as modulated by the sound waves to form the letter o. In D and E the results at the receiving end are shown diagrammatically, E being identical with B.

In practice the frequency of the wireless waves would be much greater relatively to that of the sound waves than is shown in the diagram, and consequently very small ripples of speech are impressed on the ether waves. The moulded C.W. waves, as they pass the receiving station, set up in the receiving aerial oscillating currents the amplitude of which varies in



MODULATION OF CONTINUOUS WAVES IN SPEECH TRANSMISSION

exactly the same manner as the amplitude of the waves. These oscillatory currents are detected at the receiving station by a rectifying detector which only allows the current pulses in one direction to pass.

In D the current pulses corresponding to the portions of the curve below the zero line in C are supposed to be suppressed. The current pulses which pass the rectifier are caused to blend together and produce a comparatively slowly varying current which varies in exactly the same way as the amplitude of the continuous ether waves, and therefore reproduces the form of the speech waves E. This current is sent through the receiving telephones, with the final result that the diaphragms of the latter are set into vibration and produce sound waves of exactly the same form as the speech waves at the transmitting station.

The use of continuous waves in wireless originated in the discovery made in Great

Britain by W. Duddell and published in 1900, that if a condenser and an inductance of suitable magnitude are connected in series as a shunt across an arc, the direct current supply to which is taken through two other inductances, a steady alternating current will be set up in the shunt path, the value of the inductance and capacity in that path determining the frequency of the current. On this discovery Dr. Poulsen of Denmark based an improved system of generating continuous waves which he patented in 1903 and demonstrated in London three years later. In this system, as in the case of Duddell's so-called "musical arc," an arc provides the continuous oscillations. It is maintained in an atmosphere of hydrogen between a cathode of carbon and a water-cooled metallic anode, and in a transverse magnetic field.

Powerful Arc Transmitting Stations

In 1911 Dr. Goldschmidt, in Germany, used a high-speed generator for the production of continuous wireless waves, and subsequently other alternator systems were designed by Alexanderson, Latour and others, which, with the Elwell-Poulsen arc system, have been freely used in Europe and America. The alternator is regarded as radiating a purer wave, and as consequently better adapted to telephony transmission. But the arc is so simple in its manner of working, and enables changes in the wave-length to be so readily made, that, previous to the great improvements in the thermionic valve, it was the most popular system for long-distance work. In this country several large stations have been equipped with powerful arc installations, that at Leafield in Oxfordshire, which communicates directly with the similarly equipped Abu Zabal station near Cairo, being a typical example. Each of the Elwell-Poulsen arc units at these stations are of 250 kw. capacity, and the power developed is such that C.W. signals from Leafield have frequently been received in Australia.

Later a tendency developed to substitute thermionic valves for arcs and alternators in C.W. transmission even over the longest distances, and in the great stations under construction by the Marconi Company for purposes of Imperial communication valves are used exclusively. The valves in this case, which are about 18 in. in length, are of glass, but valves the walls of which are of clear fused silica have also been used successfully, notably by the Royal Navy, in the production of continuous waves.

In the article on valves (*q.v.*) the relative functions of the filament, grid, and plate are described in detail. For the purposes of the present sketch it is sufficient to emphasize the fact that by applying electrical pressure to the grid the strength of the current passing from plate to filament can be varied, the valve consequently becoming a sort of electrical tap, the extent of the opening in which is regulated by the grid potential.

A minute change in grid potential causes a corresponding and larger change in the amount of current flowing from the plate to the filament. If oscillatory currents are started in the aerial with the help of a valve to which a direct current of high voltage has been applied, and these oscillatory currents are arranged to vary the electrical pressure on the grid, they can be made to strengthen the current flowing from the plate to the filament, from which, again, energy can be transferred to the aerial, thus rendering the oscillatory currents in the latter also stronger. A repetition of this series of actions causes the oscillations not only to surge in the closed circuits, but also to run to and fro in the aerial, from which their energy is radiated in the form of continuous electro-magnetic waves. For the transmission of Morse signals the oscillations can be varied, and the waves moulded or modulated, by means of a telegraph key placed in the grid circuit.

Use of Control Valves

In wireless telephony a closed oscillating circuit, instead of the aerial circuit, may be excited from the oscillating valve, and the oscillations in this closed circuit may be made to excite the aerial through an oscillation transformer. A "control" valve joined across the secondary coil of the oscillation transformer will enable speech or music modulations to be impressed—by means of a microphone with which amplifying valves are associated—first on the grid of the control valve, and later on the radiated continuous waves themselves. For, by causing the grid potential of the control valve to vary in accordance with the sound waves, the resistance of the valve is made to vary in the same degree, and the amplitude of the oscillations is similarly modulated, with the result that identical modulated oscillations are set up in the distant receiving aerial.

Alternatively, the microphone transmitter may be placed in the aerial circuit itself so as to modulate the currents in the latter directly.

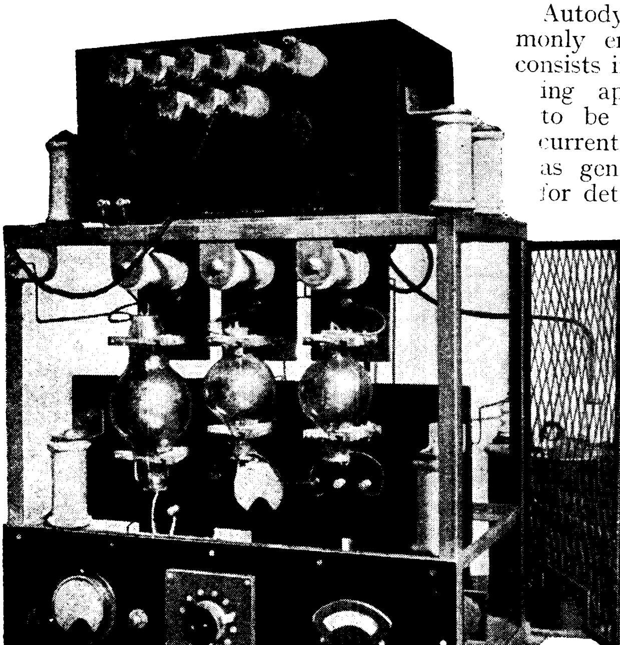
Interrupted continuous waves (I.C.W.) are occasionally employed in cases where a C.W. station wishes to communicate with a station arranged only for the reception of spark signals. This is done by breaking up the continuous train of waves, and in cases where, as in many commercial transmitting sets, the current pulses are made continuous by the use of a smoothing condenser, it can be very simply effected by disconnecting the latter.

Morse signals transmitted by C.W. are not audible in the telephones of crystal receivers unless some special device is adopted at the receiving end for breaking up the oscillations into groups at audio-frequency. But in the case of wireless telephony the process of modulation provides the necessary breaking up, and consequently crystals can be effectively employed for reception.

For the reception of C.W. Morse, where a valve is used as detector, advantage is taken of the principle of "beats" produced by the interaction of two oscillations differing slightly in frequency, as exemplified by the "beat" that is heard when two organ pipes differing slightly in "pitch" are sounded simultaneously. There are two methods in C.W. reception, the independent heterodyne and the autodyne. The former is the more scientific method, and greatly superior to autodyning where long wave-lengths are concerned. It consists in generating in a separate single valve provided with coupled grid and anode circuits continuous oscillations at a frequency slightly different from that of the incoming signals, and superimposing these upon the received currents. The resultant beats are rectified and so made to affect the telephones, a musical note being produced which corresponds with the beat frequency.

Autodyning, which is the method commonly employed in amateur reception, consists in generating in the valve receiving apparatus itself the oscillations to be superimposed on the received currents, the same valve being used as generator of local oscillations and for detecting purposes. What happens in this case is that the receiving set is slightly de-tuned from true resonance with the incoming signals, and the necessary beats are set up accordingly. A practical layout for this method of reception is illustrated in Figs. 3 and 4 on page 171.

The various forms of transmitters are separately described in detail in this Encyclopedia under such headings as Poulsen Arc. Fig. 2 shows a 1½ kw. ship transmitter and tuner worked upon an A.C. generator delivering 200 volts at a frequency of 500. This current is connected to transformers inside the base of the instrument which step up the voltage to 10,000. The rectifying valves are on the right, the third being the transmitter.



CONTINUOUS WAVE TRANSMITTER

Fig. 2. Atlantic liners use a 1½ kw. ship transmitter of this kind with oscillating valves for the routine business of wireless message transmission

Courtesy Siemens Bros. & Co., Ltd.

The A.C. voltmeter, filament transformer, rheostat and ammeter are fitted to the lower panel. The tuner is fitted on the top of the framework, and the inductance tapping shown varies the wave-length from 1,800 to 2,500 metres. A variable condenser and variometer are fitted for fine tuning. The hot-wire ammeter, showing the radiated current, can be seen immediately beneath the central valve. This set is identical with the one fitted to the Cunard liner Berengaria. *See* Autodyne; Heterodyne; Poulsen Arc; Transmission; Valve; Wave, etc.

THE CONTROL OF MACHINES BY WIRELESS WAVES

By Major Raymond Phillips, I.O.M.

Here our contributor, who has invented many methods of controlling mechanisms such as airships and model railway trains at a distance by wireless waves, describes his apparatus and how it is used successfully. He also discusses the larger questions of the uses of wireless control in warfare. Related articles such as Coherer; Detector; Relay, etc., should also be referred to

The control and operation of mechanism by wireless opens up an unlimited field for research, more particularly from a naval and military point of view.

Numerous experiments have from time to time been carried out in connexion with the wireless control of battleships, torpedoes, and other craft. Such feats naturally make a weird and impressive spectacle to non-scientific observers, but there is a great deal to be done before these experiments assume a serious aspect. It is pretty well known that "jamming" (*i.e.*, interference from other transmitting stations) is at present an unsolved problem. Its solution would undoubtedly open up a new era in warfare.

"Tuning" does not entirely eliminate "jamming," because although two, or more stations may be "tuned" to a desired wave-length, other similarly "tuned" stations might transmit signals, and thus upset the wireless control of mechanism from another transmitting station.

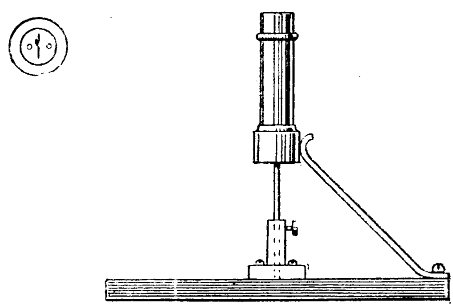
The wireless control of a battleship or airship presents an entirely different problem from wireless telegraphy or wireless telephony. It will be apparent that control at great distances is at present impracticable, purely from a "visibility" point of view, as once the distance separating such a craft from a transmitting station became sufficiently great to render the former invisible, it is obvious (quite apart from the risk of "jamming") that perfect wireless control would cease, because it is impossible to allow for various air or under-water currents affecting an invisible object.

For "short range" work a coherer possesses many advantages over other forms of detectors for wireless control.

Great care should be exercised in the design and manufacture of a coherer. Large contact surfaces tend to make such a detector very sensitive, but sometimes "sluggish" in decohering. The latter would be a source of annoyance on account of its tendency to develop "pumping" in a relay connected with a coherer.

The smallest current possible (consistent with efficient working) should pass through the contacts and filings of a coherer.

A vertical type of coherer (which proved superior to a horizontal type) as shown in Fig. 1, was fitted to the selective controller attached to the wireless-controlled airship

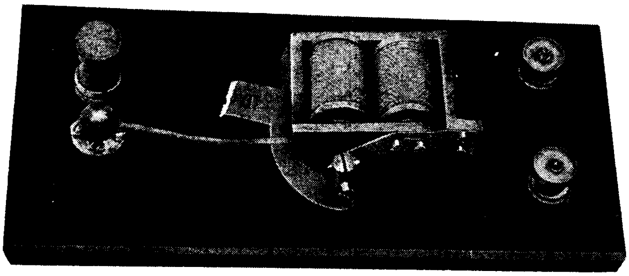


VERTICAL COHERER OF CONTROL APPARATUS
Fig. 1. In practice it was found that this coherer was superior to the horizontal type for use with a selective controller for a wireless controlled airship. Above, at the left, is represented the operating relay electrically connected to the coherer

as described in the specification of my British Patent No. 6316 of 1910. The sum of the total length of the two outer contacts in the base of the coherer equalled the length of the centre contact. The latter was attached to the supporting rod. The former to the brass cap encasing the glass tube as shown in Fig 1.

A decohering device usually takes the form of an ordinary electric bell movement. The "conductor" resistance of the windings of the electro-magnets of such devices should not be too high, as rapid action is essential, and is attained (having regard to the efficient lightness of moving parts and the low E.M.F. employed) by arranging the number of ampere turns so that a moderate current density is involved in preference to a very large number of turns offering a high conductor resistance, and thus only admitting infinitesimal currents.

A coherer which I have designed, together with a decohering device, is shown in Fig. 2. This instrument, when inserted in suitable circuits, has proved very efficient over fairly long distances.



COHERER AND DECOHERER

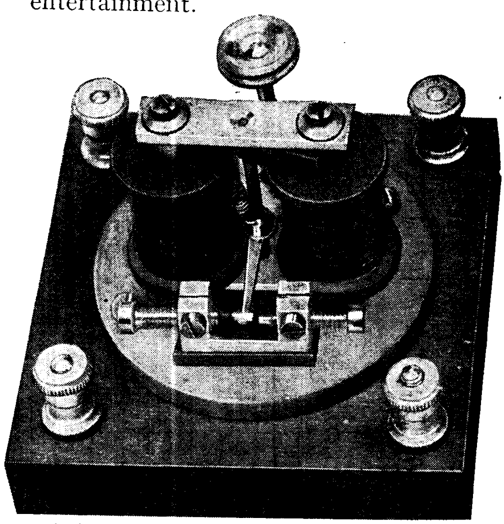
Fig. 2. Decohering was carried out by this device, and in apparatus suitably designed was very efficient for long-distance work

The reliability of a coherer greatly depends upon a good quality relay being connected with the detector circuit, and for fine adjustment (in order to obtain extreme sensitiveness for working over long distances) it is necessary to insert a suitable potentiometer between the local battery, connected in series with a coherer, and the windings of the electro-magnets of a relay. It has already been explained that the wireless control of a boat, or airship, is effective only if such craft is operated at a visible range. It will, therefore, be apparent that receiving apparatus should be so reliable in its action, that once a craft has left the immediate vicinity of a transmitting station, no further adjustment of the receiver should be necessary, otherwise perfect control would cease. For that reason I am of the opinion that for the limited distances involved with the wireless control of mechanism fitted to boats, airships, torpedoes, and such-like craft, the use of valves as detectors and amplifiers would introduce complications which are not only undesirable, but unnecessary. The risk of valve filaments "burning out" at a critical period of control is extremely serious.

A type of relay is shown in Fig. 3 which has proved very effective for receivers designed to have a maximum range of 500 yards only. The electro-magnets of such a relay are wound to a conductor resistance of 100 ohms. For longer ranges a polarized relay is a useful type to adopt. Its action is as follows: A permanent steel magnet (forming part of the instrument) is mounted in such a position that it magnetizes the extremities of the iron cores on which the bobbins are wound. A thin "tongue" of soft iron is mounted and free to move between these polar extremities, and becomes magnetized in a contrary sense to the cores. When the windings of such a relay are traversed by an electric current, the magnetization of one core is increased and that of the other decreased, so that the soft iron "tongue," finding itself in a kind of unstable equilibrium between the two polar extremities, becomes attracted by one pole, and the "tongue," being fitted with a suitable contact, is arranged to open or close a circuit connected with a local battery.

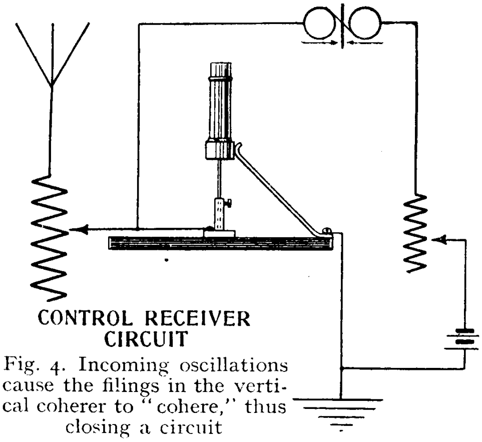
A "polarized" type of relay is a somewhat costly instrument to purchase, and its construction should only be attempted by a skilled mechanic.

For experimental work the relay shown in Fig. 3 will be found quite effective. A similar type was fitted to my well-known wireless controlled airship, which was successfully exhibited at various places of entertainment.



RELAY FOR SHORT-DISTANCE CONTROL

Fig. 3. For distances of less than 500 yards the above relay proved very effective in radio-control apparatus. Relays of this type are wound to a conductor resistance of 100 ohms



CONTROL RECEIVER CIRCUIT

Fig. 4. Incoming oscillations cause the filings in the vertical coherer to "cohere," thus closing a circuit

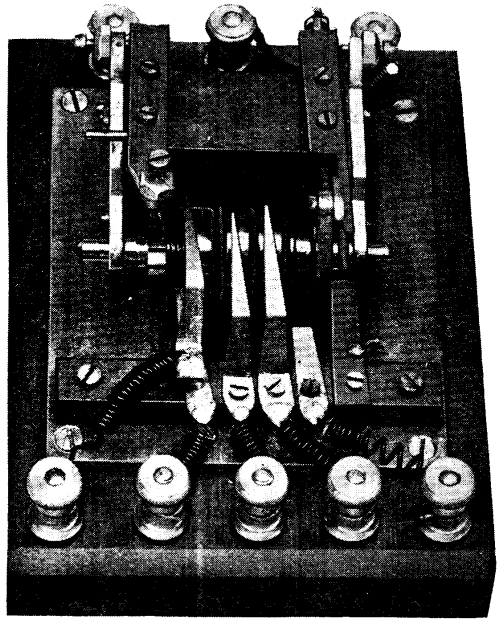
A simple receiving circuit is shown in Fig. 4. The theory is that incoming oscillations cause the filings (normally offering a high resistance) contained in a coherer to cohere, and thus allow electric current to flow through the coherer from a local battery connected with a relay and potentiometer.

It will be apparent that the action of a coherer is quite different from that of a valve, as in the former incoming oscillations are not rectified, but merely "surge" through the filings and contacts contained in a coherer, and such contacts remain in a short-circuited condition until a decohering device (as shown in Fig. 2) is caused to tap the coherer. and thus shake up the filings contained therein, which has the peculiar property of restoring the normally high resistance of the filings.

It will be apparent that some method is necessary for the selection of various electric circuits it may be desired to control by wireless waves; in fact, selectivity is the crux of the whole problem.

Simple selection (*i.e.* selection by sequence) involves a "step by step" movement electro-magnetically operated.

If a drum (suitably studded with contact pins) be attached to a ratchet wheel, and the latter caused to revolve in desired stages by means of impulses from a pawl attached to an armature attracted by the polar extremities of an electro-magnet, and the source of electrical energy for energizing the latter be wirelessly controlled, it will be apparent that if the whole device is mounted in a suitable manner and the drum caused to revolve in desired stages, various electric circuits could be opened or closed at will. It will be seen that such a system might cause considerable confusion if it became necessary to control independently a number of electric motors. A "simple" selector is shown in Fig. 5. This device has proved very effective for controlling model electric trains, small boats, etc. A somewhat similar type of selector was



SIMPLE SEQUENCE SELECTOR

Fig. 5. Selection by sequence causes confusion when it is necessary to control a number of electric motors independently. This simple device is very effective for controlling models such as boats

fitted to the controller attached to my well-known wireless-controlled airship, although in the latter craft a more complicated system of circuits was involved. The contact drum of the selector shown in Fig. 5 is fitted with two slip rings (each insulated from the other) connected with outer contacts, which form an efficient current reverser. Other contacts can be fitted according to the number of circuits it is desired to control, one contact being arranged to close a decoherer circuit.

In 1911-12 I invented a system of "direct selection." This involved the fitting of continuously revolving synchronized drums in the transmitting and receiving apparatus. The contact pins fitted to the drums were arranged and connected as shown in Figs. 6 and 7. A dashpot (not shown) was fitted to the supplementary relay, S.R., causing a lag in the upward movement of the armature, A, so that, synchronously with a transmitted wireless wave, selected circuits were instantaneously closed in the receiving apparatus, and remained in that condition until the cessation of electric oscillations in the transmitting apparatus.

This system permitted the control of a large number of circuits by wireless waves transmitted on a fixed wave-length. I later invented a secret device which enabled the wave-length to be synchronously varied in the transmitting and receiving instruments as desired. The two systems introduced complications which

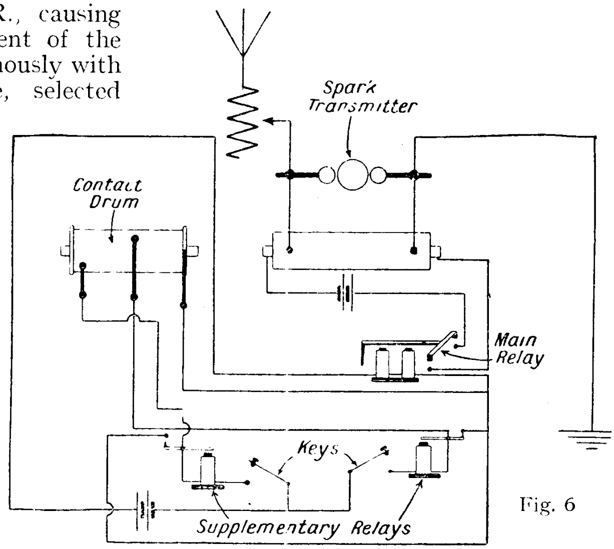


Fig. 6

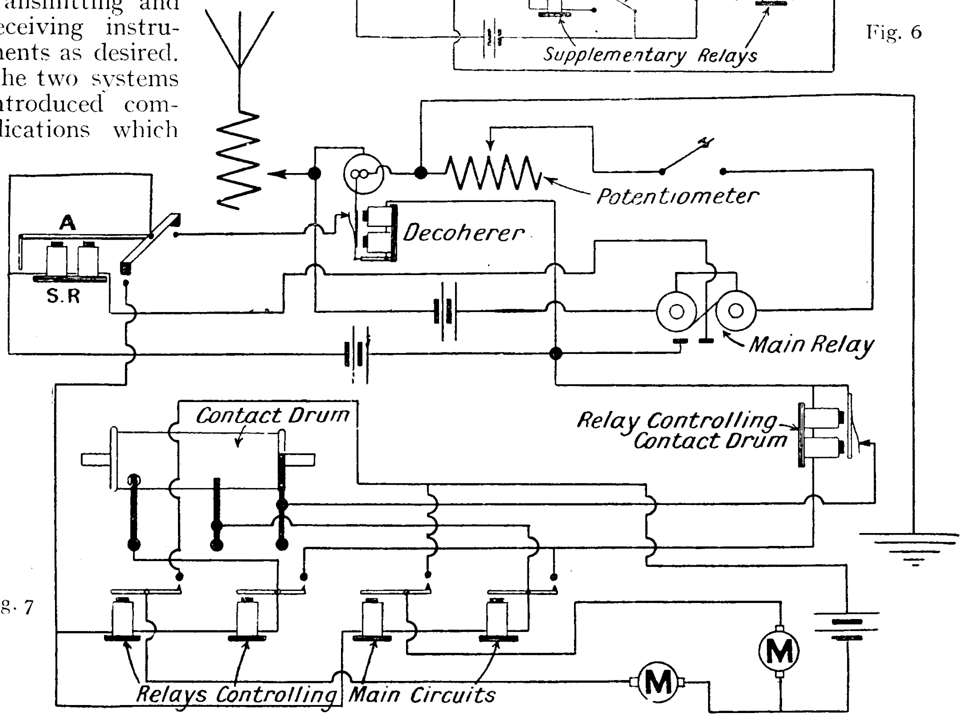


Fig. 7

CONTROL APPARATUS DESIGNED FOR DIRECT SELECTION

Fig. 6 (above). On the left of this diagram will be seen a revolving synchronized drum, the contact pins of which are connected in an arrangement which allows of direct selection. Fig. 7. (below). Selected wave-lengths having been determined, this system permits of control of a large number of circuits. This is made possible by the circuits being closed on the reception of oscillations of their particular wave-length

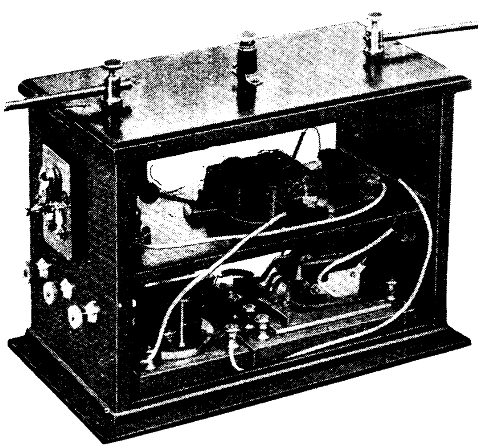
reduced jamming to rather fine limits, but did not completely render wireless-controlled craft, such as airships, etc., immune from interference which might be caused by other transmitting stations.

Prominence has been given to reports that a method had been discovered to arrest aeroplanes in flight by wireless, this presumably being another form of wireless control arranged to so affect the magneto fitted to an aeroplane engine that the latter would be put out of action.

It was discovered years ago that with an enormous expenditure of electrical energy it was possible (at a fairly considerable distance from a transmitting station) to burn out the armatures of dynamos, and no doubt the rumour originated as a result of similar experiments conducted with a view to ascertaining the effect on magnetos.

In 1911 I conducted experiments with very large high-frequency apparatus which proved that with an impracticable expenditure of electrical energy such effects could be produced.

The complete wireless receiver shown in Figs. 8 and 9 is one designed specially for controlling scale-model electric trains. The coherer, with decohering device, is shown

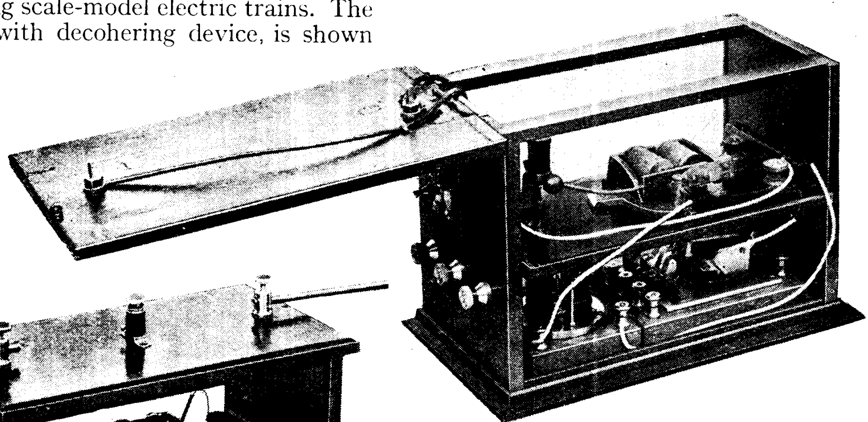


MODEL TRAIN CONTROLLER

Fig. 8. Model trains made to scale were controlled by this wireless apparatus. In the upper part of the instrument is the coherer and decoherer

fitted in the upper part of the instrument. In the lower portion is fitted the selector and relay. The antenna is fitted on the lid, secured by two terminals. A small signal lamp is also fitted, and is illuminated by electric current controlled by the selector, thus indicating if the latter is functioning correctly, or otherwise. The instrument is also arranged to be connected to a valve receiver, if desired, but for that purpose a supplementary, and much more sensitive, relay is required, and the coherer, with decohering device, is not required. The receiver was arranged in the manner described purely for experimental purposes, for, as already explained, the risk of valve filaments burning out at a critical period of control is extremely serious.

It will be recognized that although the possibilities of wireless control cannot be overrated, it must be admitted that at present there are limitations to its application for the control of mechanism. There would be no difficulty in firing a big gun by wireless, and producing other equally awe-inspiring spectacles, but



ANTENNA CONNEXION OF TRAIN CONTROLLER

Fig. 9. Terminals on the lid, here seen on the underside, connect the antenna to the wireless apparatus for the control of model trains. The vertical coherer can be clearly seen in this photograph.

there is a good deal of research work ahead and many problems to be solved before the dream of a real "wireless battle" becomes a reality.

CONVECTIVE DISCHARGE. When a body is charged to a higher potential than that of adjacent matter, it is found that the charge gradually leaks away.

This leakage of charge is not all due to pure conduction but is caused by the charge being used up in charging smaller bodies, such as particles of dust and moisture.

An aerial wire suspended above the earth on good insulators may at one period become highly charged due to charged rain falling upon it, in which case each drop gives up its charge to the wire, until the wire is at the same potential as the raindrops. Later on another rainstorm may come, the drops of which are at a far lower potential than the wire. In this case each drop will become charged as it passes near the wire, and will pass on to the earth, where it gives up the charge.

In dry weather dust particles will act in a similar way, the dust particles nearest the wire becoming highly charged, and passing this charge on to others farther from the wire which are at a lower potential.

When the potential of a wire is raised to higher values, the next form of discharge which takes place is the glow discharge, which is a silent, faintly luminous discharge. At higher potentials still the glow fringes out into visible pointed and irregular blue-green tendrils, which produce a hissing noise, and produce ozone from the surrounding air. This discharge is called a brush discharge. A further increase in potential will convert this brush discharge into a spark jumping from the wire to some adjacent object at earth potential, or at a potential different from that of the wire.

CONVERTER, ROTARY. Converters are of many types, and in general any mechanical or electrical contrivance which will convert one form of electrical energy into another may be termed a converter. The name, however, is now most generally applied to:

(1) The direct current rotary converter, which is a motor having a separate winding on its armature and two commutators, usually one at each end of the armature. Such machines are employed for changing one direct current voltage to another.

(2) The rotary converter, which is the most general application of this principle. The machine consists of a field system and armature, the latter having a commutator at one end and slip-rings at the other. It is run either for converting alternating current into direct, or for changing direct current into alternating.

In all direct current generators the current which is produced in the windings of the armature is an alternating one. For as each armature coil comes towards a magnetic north field pole, a current will build up in that coil in one sense, whilst when the same coil approaches a magnetic south pole the current will be in the opposite sense. The commutator of the generator is in effect an automatic switch which connects up the armature coils in such a way that the current taken out from the brushes is unidirectional. It is therefore apparent that if the current is taken from the armature without first passing through the commutator, then this current will be an alternating one, and its maximum voltage will be equal to the direct current voltage supplied to the armature. But as on the commutator side the current is a steady direct current, and on the other side an alternating one, the effective voltage on the alternating side will be

$$V = \frac{E}{\sqrt{2}} = \cdot 707\, E$$

where

V = the alternating current voltage, and
E = the direct current voltage.

The frequency of the alternating current supply from all converters depends upon the number of poles and the number of revolutions of the armature. As the frequency is the number of cycles per second, and as in a bipolar machine there is one complete cycle per revolution, it follows that the frequency will be

$$\sim = \frac{N}{2} \times R$$

where

N = number of poles,
R = revolutions per second,
$\sim$ = frequency.

The alternating current will be

$$C_1 \times \sqrt{2} = 1\cdot 414\, C_2.$$

In place of the tapping being taken to the slip-rings from two points which are equidistant on the armature winding, they may be taken in such a manner that the armature winding is divided into three equal parts, these three points being joined to three slip-rings. The resulting current will then be three-phase alternating current.

The voltage in this case relative to the direct current voltage of input will be

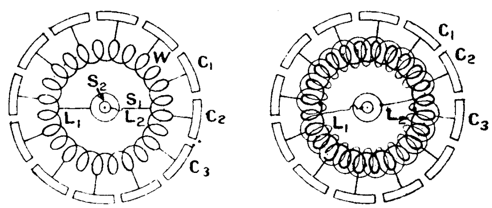
$$V = \frac{E\sqrt{3}}{2\sqrt{2}} = \cdot 612\, E$$

and the current

$$= \frac{2C\sqrt{2}}{3} = \cdot 943\, C.$$

Other connexions may be taken for four-phase, six-phase, etc., but these are not in such general use.

Up to this point the ordinary form of rotary converter has been considered, that is, the form in which all the wire on the armature or rotor carries current which is separated out, at the one end by slip-rings, where it is available as alternating current, and at the other by a commutator which rectifies it into direct current. This type of winding is shown diagrammatically by Fig. 1, where W is the armature winding, which—although shown in the now obsolete Gramme ring form for clearness—may be arranged in any of the other more modern methods. This winding is tapped at equal points, and taken to the commutator sections, C_1, C_2, C_3, etc., whilst two equidistant points are also tapped and connected to the slip-rings, S_1, S_2 for the alternating current supply. This is the form of converter



WINDINGS OF A ROTARY CONVERTER

Fig. 1 (left). Winding of an ordinary form of rotary converter armature is shown at W, in the Gramme ring form for clearness. Fig. 2 (right). Much higher alternating current voltages are obtained by extending the leads, L_1 L_2, so as to form another continuous winding, which is wound over the first

which gives the fixed ratio of alternating current to direct current voltage represented by the formula

$$V = \frac{E}{\sqrt{2}}$$

If, however, instead of connecting the winding direct to the slip-rings S_1, S_2 the leads L_1, L_2 are extended so that they form another continuous winding which is wound over the first (Fig. 2) on the same armature, whilst the ends of this second winding are taken to the slip-rings, then it is possible to get an alternating current voltage of much higher value than the original direct current voltage.

This method of construction is sometimes extended, so that various points of this second winding may be joined at will to the slip-rings, thus making the converter capable of adjustment as to the ratio of direct current and alternating current.

COPPER. One of the metallic elements. The chemical symbol is Cu, the atomic weight 63·6. Copper is one of the most important of the metals used in wireless work. It is most extensively used in the form of wire, either plain, enamelled or covered with a composite insulation as described in the article on copper wire. Other uses are in the form of sheets for earth plates and strips for contacts and conductors. This is chiefly because copper has a great electrical conductivity, equalled only by silver. In comparison with the latter metal copper has an electrical resistance in the neighbourhood of 1·07, assuming silver to be 1.

The heat conductivity is about 73·5 per cent of silver, varying somewhat according to its composition. The characteristics of copper are given in the article on copper wire (*q.v.*).

The specific gravity varies between 8·91 and 8·95, according to its treatment, increasing when the metal is compacted, as by hammering. It is a very ductile material and to a certain extent easily worked, especially in the form of wire and strip. Copper is easily soldered in the same general way as brass, if it be previously tinned. It can be turned in a lathe with the aid of a very keen tool, is usually sawn with a hack-saw, and filed with good new files. There is a tendency for the tool to choke, that is, for the cutting edge to become clogged with copper, which adheres to it very tenaciously; this tendency is reduced by using paraffin oil as a lubricant. French chalk is generally used when filing copper, for the same reason. Finishing processes include polishing and lacquering, which keep the surface from becoming oxidized or corroded by atmospheric action.

COPPER FOIL. A thin sheet copper much used for condenser plates and other purposes in wireless apparatus making. It is obtainable in small flat sheets or in the form of rolls about 12 in. wide. This grade of very thin sheet copper can be cut to shape with a stout pair of scissors, is flattened readily with a hammer or mallet, and bent to various shapes with broad flat-faced pliers. Thin copper is very useful for making many forms of contact strips and for such purposes as the laminations of a contact arm. It can be soldered if the surface is previously tinned. *See* Soldering.

COPPER GAUZE. A manufactured article composed of copper wires woven into the form of a wire mesh. Copper gauze is obtainable in many degrees of fineness.

The finest meshes will not permit the passage of water, but allow a light spirit such as petrol to pass, consequently the copper gauze is most valuable as a filter. It is also employed in the manufacture of contact brushes (*q.v.*). The material is obtainable in sheet or roll, and is readily cut with stout scissors or with tinman's snips. If the surface is tinned, it can be soldered without any difficulty.

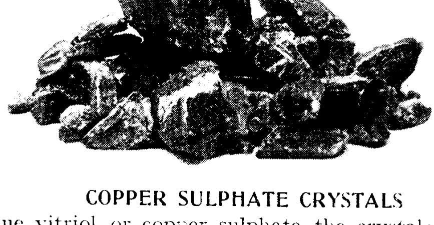
COPPER PYRITES, or Chalcopyrite. Copper-iron sulphide used as a low-potential rectifier crystal, usually in conjunction with zincite and tellurium. It has a brilliant brass-yellow colour, and is one of the copper ores. The photograph shows a specimen of copper pyrites. *See* Chalcopyrites; Perikon.

COPPER PYRITES SPECIMEN

This crystal is used largely in conjunction with zincite and tellurium as a rectifier. It is of a brilliant brass yellow colour

Courtesy Will Day, Ltd.

COPPER SULPHATE. An important salt of copper, also known as blue vitriol. It is the residue from the action of sulphuric acid on copper. The chemical equation is represented by $Cu + H_2SO_4 = CuSO_4 + H_2$. In appearance the copper sulphate crystals are a bright blue, possessing hard, shiny facets. They form a good preservative for wood, and are often used instead of creosote for the preservation of aerial masts. The crystals are added to water sufficient to cover the purpose required until a saturated solution is made. This is then applied to the mast with an old brush and allowed to sink well in.



COPPER SULPHATE CRYSTALS

Blue vitriol, or copper sulphate, the crystals of which are shown above, is bright blue in colour. This substance is used as a wood preservative, and is useful for preserving aerial masts

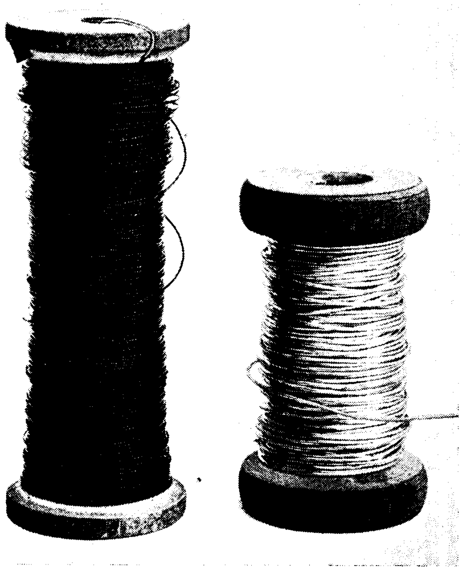
COPPER WIRE. Copper wire is one of the chief materials of electrical engineering. Copper is very ductile, has a tensile strength only a little inferior to iron, is a good conductor of heat and electricity, and does not corrode easily. The most important characteristic, viz., its relatively high electrical conductivity, is likely to be challenged in practice only by aluminium. The latter, however, cannot be satisfactorily soldered and is more liable to disintegration by oxidation.

Copper wire can be drawn to an extremely small diameter, No. 40 wire, only $\frac{1}{200}$ in., not being an uncommon size. The metal of the wire is hardened in the process of drawing, and if it has to be worked subsequently in any way, it may be required to be annealed by heating to red heat and quenching in water.

CHARACTERISTICS OF COPPER

Specific Gravity. Water = 1.	Tensile Strength, pounds per sq. in. (soft).	Melting Point, deg. Fahr.
8·85	36,000	1940
Relative Heat Conduction. Gold = 1,000	Relative Electrical Resistance. Silver = 1.	Coefficient of Expansion per deg. Fahr.
898	1·07	·00000887

Copper, although it weighs about three times the weight per unit volume of aluminium, is half the cost and is twice as good a conductor of electricity. Copper wire is therefore the best conductor per unit of cost, at present. For wireless aerials, weight has to be considered as well as resistance to corrosion. An iron or steel wire would have to be seven times the area and weight of a copper wire of given conductivity and would rust. While aluminium is lighter and per unit of weight is a better conductor of electricity, impurities in the atmosphere and in rain water



TINNED AND PLAIN COPPER WIRE

Copper wire for wireless purposes is supplied on reels in somewhat like manner to cotton, and usually sold by weight. On the left is a reel of plain copper wire, and on the right a reel of tinned copper wire

reduce its life compared with copper. In oxidizing on the surface the inside of the copper wire is to some extent protected from further corrosion.

The following table is used by practical electricians to determine the amount of copper wire required to carry a given current. Copper wire is sold by weight, and it is also necessary to know the weight and electrical resistance offered by a given length of wire. The largest size included in the table is No. 8 gauge, about $\frac{5}{32}$ in. diameter. Thicker wires are made, but do not come within the requirements of the average experimenter.

CHARACTERISTICS OF COPPER WIRES (BARE)			
Imperial Standard Wire Gauge	Diameter in Inches.	Yards per lb.	Electrical Resistance.
			Ohms per lb.
8	·16	4·3	·005
9	·144	5·3	·0078
10	·128	6·7	·0125
11	·116	8·18	·0186
12	·104	10·18	·0288
13	·092	13·01	·047
14	·08	17·2	·083
15	·072	21·2	·125
16	·064	26·8	·201
18	·048	47·8	·635
20	·036	84·9	2·07
22	·028	140·00	5·48
24	·022	227·00	14·40
26	·018	340·00	32·10
28	·0148	502·00	70·00
30	·0124	716·00	143·00
32	·0108	950·00	248·00
36	·0076	1900·00	1010·00
40	·0048	4780·00	6260·00
50	·001	110000·00	3 Million

For instrument work, where insulation is required, as in the winding of coils, copper wires are covered in three ways—

(1) Enamelling with a flexible enamel;

(2) Wrapping with cotton thread, either in single or double layers;

(3) Wrapping with silk in the same way, singly or doubly.

For conducting currents, cables of copper wire are made. The wires in a cable may be each covered with rubber so that they can carry separate circuits or parts of a circuit, the whole being braided together, or, as in the bell and electric wire, several strands of bare copper wire are twisted together inside the insulating covering. Such cables are termed flexible wires. The following are the standard sizes of such cables. The wires are lapped with cotton, insulated with rubber strip and braided

SIZES OF WIRES IN CABLES.							
	No. 40	No. 38	No. 36	No. 32	No. 30	No. 28	No. 26
Number	25	16	10				
	34	22	14				
of wires	44	29	18	10			
	56	36	22	13			
in	70	45	28	16	10		
	100	64	40	23	15	11	
Cable.	136	87	54	31	21	14	10
	178	114	71	41	27	19	13

Reverting to the consideration of wires for coils, single silk-covered wires in small gauges are usually ·004 (four thousandths) larger in diameter than the bare wire. To provide a better insulation a duplex silk covering is used, the increase in diameter then being ·006 in. Small enamelled wires may be calculated on the same basis as single covered wires. Double cotton covered wires should always be used in small dynamos, motors and transformers. For small wires, below No. 16 S.W.G., add ·012 to the size of the wire, *e.g.* No. 16 S.W.G. = ·064, + ·012 = ·076 in. diameter. In larger diameter wires the extra diameter due to the thickness of the covering is ·015 in. The question of the thickness of the covering is an extremely important one when considering the amount and resistance of a wire in a coil of given size.

For ordinary work it is usual to limit the strength of a current passing through a conductor to about 1,000 amperes per square inch of cross-section. A No. 16 S.W.G. wire, ·064 in. in diameter, would therefore be safe to 1000 × area of ·064 diameter wire = 3·2 amperes. Twice the amount is allowable in coils of instruments. If a wire is impressed with too strong a current, it will rise in temperature, and may burn off the covering, breaking down the insulation. It must also be remembered that copper and other metals show a greater resistance to current as the temperature rises, which makes matters worse in the case of an overcharge.

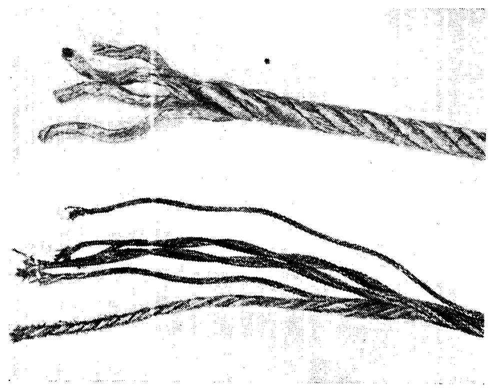
Insulated electric light wires are usually plated with tin, *i.e.* tinned. This simplifies the soldering of joints in wires. It is essential that wires which are to be joined should be soft-soldered or twisted together. The bared joints in insulated wires should be taped over with adhesive tape after the wires are soldered together and have been wiped quite clean. For large wires, one of the paste fluxes may be used, as there is greater danger of subsequent failure at the soldered joint if any of the corrosive fluxes are used. Where a lot of joints have to be made, they can be dipped in a bath of molten solder.

All cables and covered wires are made up of annealed wire, and will stand a certain amount of twisting up. In removing the insulating covering, in baring the end of a wire or cable, the cutting of the insulation should be carefully done. None of the wires should be cut or nicked. If carelessly done, the wires or conductors will not only be weakened at each side of the stiff, strong joint, but the electrical resistance will be increased locally, and the value of the whole conductor wire impaired.

To overcome this difficulty the experimenter can burn off the insulation of most small insulated wires by holding the end of the insulation in the flame of a match. This sets the insulation on fire, and when it has burned for a moment or two it can be blown out and the charred insulation scraped off with a knife blade, the wire brightened with a piece of fine emery paper, and the joint made as already described. *See* Cable; Coil; Wire.

CORDAGE. Name applied in wireless work to a thin rope, which may be of hemp, wire, or other material. It is most extensively used for the halyards of a wireless mast, and to some extent as a guy rope.

One variety, composed of four strands twisted together, and suitable for halyards, is shown in Fig. 1, and is generally typical of the ordinary non-metallic cordage. Another pattern specially suitable for outdoor work, as, for example, the stays of an aerial mast, is illustrated in Fig. 2, and is composed of a hemp core with a number of strands of steel wire



CORDAGE FOR WIRELESS PURPOSES

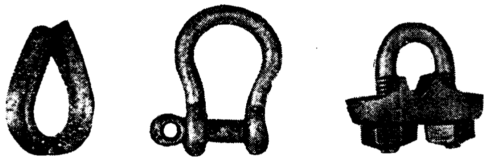
Fig. 1 (above). Four-stranded cord is commonly used, the four strands being simply twisted together in the manufacture. Halyards used in aerial construction are often made with this cord. Fig. 2.(below). Hemp cord wound with a number of steel wire strands is a suitable material for the stays of an aerial mast. The wire strands have been untwisted to show the construction

wound on the outside. This gives strength and flexibility, and at the same time the material is very durable.

Appropriate fittings that are employed with cordage are illustrated in Fig. 3, and show, from left to right, a heart thimble, shackle, and a clip. The former is used to work into the end of a cord to prevent it fraying or being severed by the local load imposed on it at the point of its attachment. The shackle is used to connect the thimble to the standing part of a rigging, as, for example, the strainer at the foot of a mast guy rope. The clip is used to secure the ends of the wire and to prevent the end pulling out.

The method of application is shown in Fig. 4, which makes clear how the cord is looped and secured by passing the two parts through the staple on the clip, and, tightening the nuts, draws the whole tightly together.

The way to turn the end of a cord around the thimble is illustrated in Fig. 5. The cord is placed around the groove in the outside of the thimble, and the ends bound

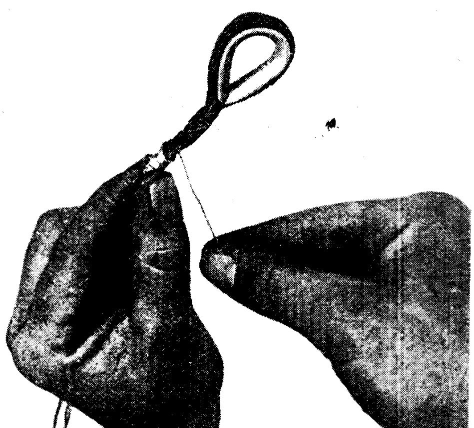


HEART THIMBLE, SHACKLE AND CLIP

Fig. 3. Fittings for cordage are shown here. On the left is a heart thimble used to prevent fraying and to help to take up a local load. The shackle in the centre connects the thimble to the standing part of a rigging, and the clip on the right is used to secure the end of a wire to prevent it being pulled out

tightly with copper wire to bind them together and keep the cord firmly in place. The thimble thus distributes the pressure on the end of the rope over a wide area and prevents chafing.

CORE. Expression used in electrical work to describe the insulated conducting wires of an electric cable. It is also



ATTACHING A HEART THIMBLE

Fig. 5. Bent round the heart thimble is a cord end, and the operator is binding wire round the doubled cord to hold the thimble tightly in the loop

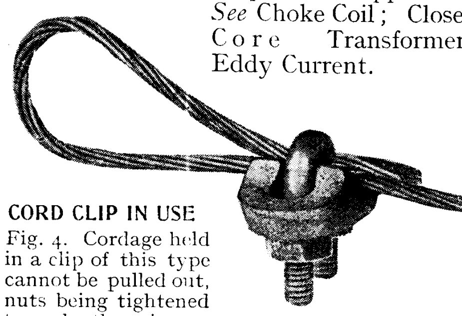
applied to the insulated bundle of iron wires around which the conductor is wound. An example of this type of core is illustrated, showing the ends of the iron wires protruding from the insulation.

In an armature the core is built up of laminations of soft or annealed iron wire (*q.v.*), lightly insulated from one another and riveted or bolted together to form a solid mass. The object of laminations is to reduce eddy currents and to increase the rapidity with which the core may be magnetized and demagnetized.

Another reason for laminations is that they aid the construction of such appliances as a closed core transformer.

In some types of coil, such as an air-core choke coil, the core is simply an air space or gap surrounded by the wire winding.

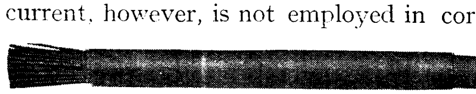
In general the word is applied to the central portion of a piece of apparatus. *See* Choke Coil; Closed Core Transformer; Eddy Current.



CORD CLIP IN USE

Fig. 4. Cordage held in a clip of this type cannot be pulled out, nuts being tightened to make the grip secure

CORE LOSSES. A loss of efficiency occasioned by the setting up of stray currents in an iron core while under the influence of a magnetic field. For example, when a coil of copper wire is placed around an iron core in the form of a bundle of wires, and a current of electricity is passed around it, a magnetic field is generated, and this sets up a magnetic state in the core. The whole of the current, however, is not employed in core



CORE OF A CABLE

Iron wire forms the core of this cable, a number of strands being bunched together and coated with insulation. Part of the insulation has been removed to show the core

magnetizing the core, and the amount expended in generating waste currents in the core itself is one of the chief core losses. Eddy currents (*q.v.*) are generated in the same way and are most undesirable features in an electro-magnetic machine, as their production requires current which would be better used in the generation of currents for the purpose for which the machine is designed.

When the current is generated or transformed in quantity, the eddies or strays, as they are sometimes called, tend to heat the core, reduce its permeability and result in a loss of magnetic flux.

Core losses are minimized by making the core laminations of soft iron, each piece lightly insulated from its neighbours. This prevents the eddy currents building up, and restricts them to each individual stamping of the armature or core. This system is used in the manufacture of cores for transformers, particularly the low-frequency type used in wireless receiving sets. Telephone transformers and induction coils are also made in the same way or on the same principles. Core losses may be reduced by electrically connecting the cores to earth, thus preventing them accumulating. *See* Eddy Currents ; Magnetism ; Transformer.

CORONA. Under the heading Brush Discharge, certain effects are described attributable to highly electrified particles of dust, air, or other matter being driven off from a charged conductor by the self-repulsion which exists between two similarly charged bodies. If one highly charged body is approached by another oppositely charged, the brush discharge is accentuated by reason of the mutual attraction of the charges, and although the separation between the two may be so great as to prevent an actual disruptive discharge or spark taking place, a continuous silent glow may be present if the potential difference is high enough, and this is termed the corona effect.

If this silent discharge is very pronounced it leads to a considerable loss of energy, and care has to be taken in designing circuits which are carrying high-voltage currents, so that the corona loss is minimized as much as possible. Many things contribute towards a high or low corona loss, such as the absolute temperature of the air, as well as the size and spacing of the conductors. Between parallel conductors the maximum voltage, E, which may exist without any serious corona loss can be ascertained by the following calculation :

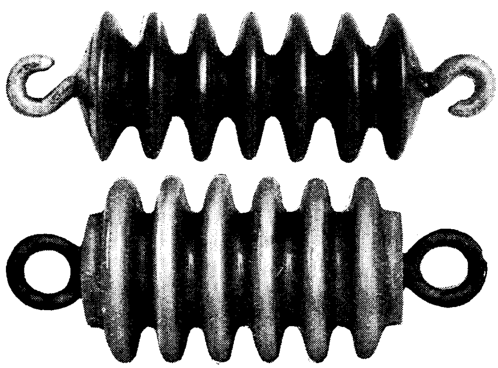
$$E = \frac{17{\cdot}9h}{T} \times 2{\cdot}055\, r^1 \log_{10}\left(\frac{l}{r}\right) \times Bd \times 10^{13}$$

volts, or in simpler form:

$$E = 36{,}800\, \frac{hr^1}{T} \log_{10}\left(\frac{l}{r}\right) \times Bd\ 10^{10} \text{ volts.}$$

In these expressions h = the height of the barometer in inches ; T = the absolute temperature in degrees F., that is, actual temperature plus 459·2 r^1 = the effective radius of the conductor, that is, the radius of the conductor plus the depth of the weakest zone of atmosphere surrounding it ; r = the radius of the conductor in inches ; and l = the distance apart of the conductors in inches.

CORRUGATED INSULATOR. Name given to a type of insulator in which the barrel is made with several disk-like portions of large diameter relative to the connecting part between them. A typical example, illustrated in Fig. 1, is made from ebonite or similar moulded composition, into which is embedded at each end



CHINA AND EBONITE CORRUGATED INSULATORS

Fig. 1 (above). Embedded at each end of this ebonite corrugated barrel insulator are strong brass hooks for attachment to the aerial wire or halyard. Fig. 2 (below). Galvanized iron eyes are attached to the china barrel corrugated insulator

a strong brass wire hook for attachment to the aerial wire and halyard. A variation of the same idea is shown in Fig. 2, but in this case the insulator is made of china or porcelain, with galvanized iron eyes embedded therein.

The claims for this class of insulator include the very long path presented to any current that might have a tendency to leak. The shape is one that naturally drains and keeps clean in wet weather. They are, however, rather heavy for amateur's aerials. When purchasing note that the insulation is perfect and the hook or eye very secure, as the whole pull of the aerial will be borne by it.

COSSOR VALVE. Three-electrode valve made by the Cossor valve company.

The Cossor valve differs in constructional details from the standard type of three-electrode valve. Fig. 1 shows the general appearance of the valve and Fig. 2 diagrammatic details of the anode, filament and grid.

COSSOR VALVE

Fig. 1. Pink top Cossor valves are also known as P2 valves. The anode covers the filament like a dome. Below the anode can be seen part of the grid

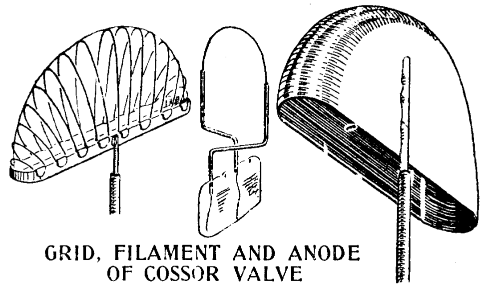
The anode consists of a flattened hemispherical hood which almost completely shrouds the grid. The latter is semicircular in shape. A metal band forms the outer edge of the grid, and the winding is secured to this band by a lashing wire as well as being secured to the band on each side, to ensure absolute rigidity. The filament follows the general shape of the grid, which extends well below the filament and the anode, so enabling the whole of the filament electron emission to be thoroughly under the grid control.

The shape of the three electrodes obviates the accumulation of electrostatic charges on the glass bulb, and so does away with one of the causes of parasitic noises in valve reception which are often wrongly attributed to atmospherics.

The dome shape of the anode has the additional advantage of shielding the eyes of the operator from the brilliancy of the glowing filament.

Fig. 1 shows the Pink Top Cossor valve or P2 valve, a development of the P1 valve, constructed on similar lines. The valve is more specially intended for use with high-frequency amplifiers. According to the makers, the filament voltage for normal working purposes is 3·5 to 4 volts. The anode voltage is given as 20–80 volts, and the amplification factor is 11. *See* Valve.

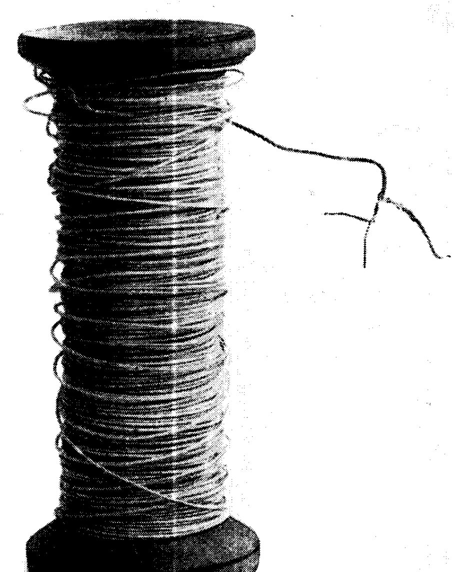
COTTON-COVERED WIRE. Name given to an insulated conductor, generally consisting of a relatively thin, single copper wire covered on the exterior with



GRID, FILAMENT AND ANODE OF COSSOR VALVE

Fig. 2. On the left of this diagram, which should be compared with the photograph, Fig. 1, is the grid, in the centre the filament, and on the right the anode, or dome-shaped plate, of the Cossor valve seen in Fig. 1

cotton. It is obtainable in many gauges, that is, the thickness of the copper conductor; and is generally supplied in the form illustrated, coiled up on a wooden spool or reel. It is sold by weight, and the



COTTON-COVERED WIRE

Single cotton-covered (S.C.C.) and double cotton-covered (D.C.C.) copper wire is commonly used in wireless sets. It is sold on reels, and when coils are to be wound, retailers can usually supply an approximate weight of wire for a given dimension of coil The tables on the next page will assist approximate number of yards per pound of several commonly-used gauges are given in the following table.

Gauge.	Yards per lb.
20	87
22	142
24	233
26	345
28	520
30	720

The cotton covering is either single or double. The former consists of a single layer or winding, and is abbreviated to S.C.C. The latter has an inner covering of cotton laid approximately in the direction of the wire, with an outer covering of cotton wound around it. Double cotton-covered wire is abbreviated to D.C.C., and is more thoroughly insulated than the former.

The approximate number of turns of wire that can be wound closely together per one inch length of any diameter of former are given in the table below.

Gauge.	Turns per inch.	
	S.C.C.	D.C.C.
20	22	21
22	27	25
24	34	30
26	40	35
28	48	40
30	56	45

To improve further the insulating qualities of the covering it is in some cases impregnated with paraffin wax, or the copper wire may be covered with india-rubber and then covered with the cotton. It is then known as indiarubber and cotton-covered wire, and abbreviated as I.R.C.C. This class of wire is extensively used for the connexions in bell and buzzer circuits. The former for all classes of inductance coil and other windings.

COULOMB. Name given to the unit of electrical quantity on the practical C.G.S. system of units. It is the quantity of electricity conveyed per second by a current of one ampere. The coulomb is sometimes known as the ampere-second. If C is the current strength in amperes, t the time in seconds, Q the total quantity which has passed in coulombs, then $Q = Ct$.

The coulomb is also defined as that quantity of electricity which liberates ·001118 gramme of silver from a solution of silver nitrate in one second. The coulomb is equivalent to 3×10^9 electrostatic units of quantity. *See* Ampere ; Units.

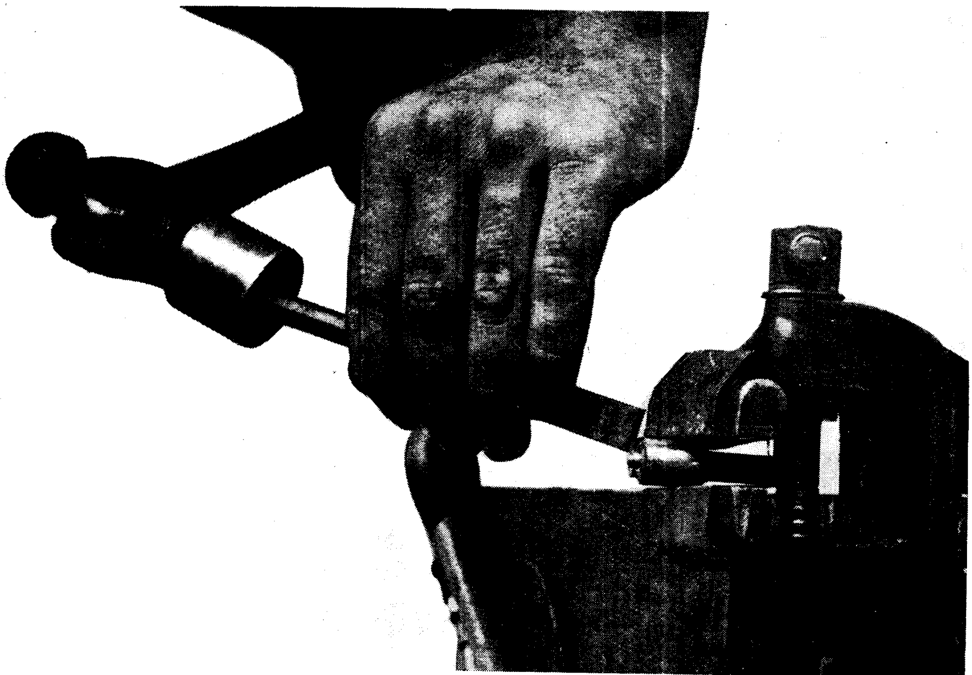
COUNTERBORE. Concentric recess formed about a screw hole. Generally the name is also applied to the tool that produces the counterbore. A good example of the tool as made by an amateur is seen in Fig. 1, and comprises a shank with four cutting edges, or teeth, in the outer end.

AMATEUR-MADE COUNTERBORE TOOL

Fig. 1. Holes are counterbored with an instrument which can be made by the amateur, as in this case. Many instances occur in the construction of wireless apparatus where counterboring is necessary

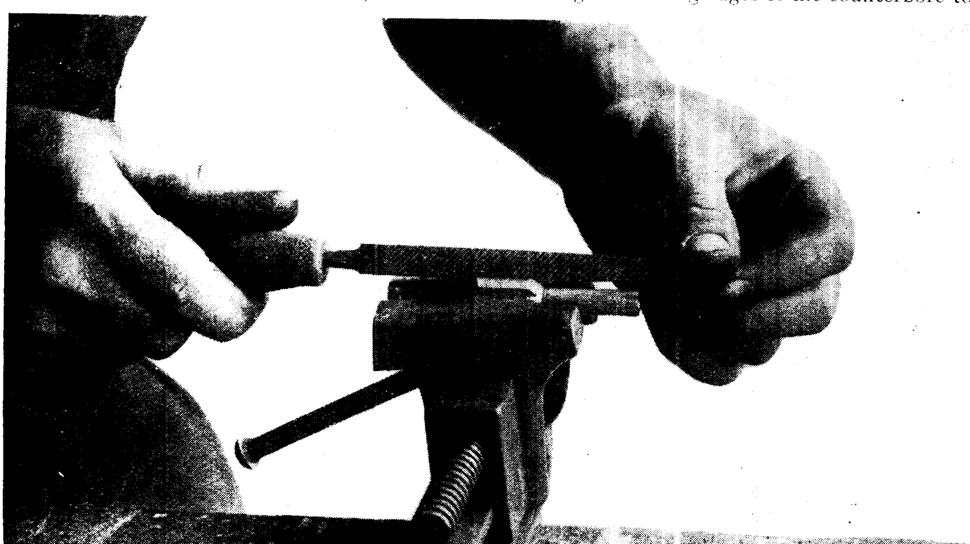
A central peg or pilot is formed in the centre of the cutting end, and is used to guide the path of the cutter. In use, a small hole is drilled to suit the pilot and the cutter revolved under great pressure. The recess is speedily formed, and is intended to act as a space to receive a spring washer, as, for example, in a three-coil tuning stand.

The making of an efficient counterbore is shown in Figs. 2 and 3. The cutter is first machined to shape from cast steel and the teeth marked out accurately. The next step is to cut back the jaws to form the cutting edges, as shown in Fig. 2, where the chisel is seen in use chipping out the teeth. This stage is followed by careful filing, as shown in Fig. 3. Grooves are cut in the sides of the counterbore to allow the cut away material to clear itself during counterboring. The great object is to construct four or other number of equidistant jaws with keen cutting edges. When the cutter is complete, it is hardened and tempered in the customary manner for drills and similar tools. It is rotated by a brace or in the lathe, the latter for preference, although any sufficiently powerful drive will answer the purpose.



MAKING A COUNTERBORE TOOL

Fig. 2. Counterboring, or the process of cutting a recess about a hole for the accommodation of a screw head, requires a special instrument which acts in the same way as a chisel, except that it is confined to a very limited space, and the cutting direction is circular. A counterbore, such as is being made in the above photograph, has four chisel-like cutting edges which, being rotated, take off shavings of the material worked upon, thus leaving a sunken circular groove about a hole previously made. Above the operator is seen making the cutting edges of the counterbore tool



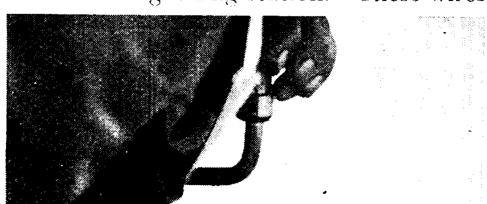
FILING THE GROOVES OF A COUNTERBORE TOOL

Fig. 3. Shavings cut by this type of counterbore tool cannot escape by way of the hole about which the cutting edges rotate. Grooves are therefore cut in the sides of the instrument, and these form channels by way of which the cut-away material finds egress from the counterbored hole. As will be seen in Fig. 2, the counterbore tool has a nose or projecting part on its face which fits into the hole which is to be counterbored. The operator is seen in this illustration cutting the grooves with a file

COUNTERPOISE. It is frequently thought that the best position for a wireless station is upon high ground with the minimum number of obstacles and buildings in the immediate vicinity. This is by no means the case, as such positions are usually dry, if not actually rocky, and a good earth is difficult to obtain. The ideal conditions for a wireless site are level, grassy, or marshy ground, with wide open valleys in the direction of the desired communication. Springs, wells, and watercourses are of far more frequent occurrence here than on high ground, and even if not actually available, the ground is easy to turn up for sinking the necessary length of earth wires.

When it is entirely impossible to arrange for an ordinary earth, an artificial earth, called a counterpoise, is substituted. This consists of a large network of wires laid radially if possible, or else in a rectangular area. If directive signalling is desired the longer portion of the rectangular system should point away from the direction of the signalling station. These wires will have a large capacity, and in some respects offer advantages over the watercourse earth, which is susceptible to considerable variations, being influenced more by the seasons and the temperature; the counterpoise earth has more constant electrical properties. Earth mats, consisting of copper gauze rolls, can be used as counterpoise earths, and in this respect they resemble the capacity earth elsewhere described.

In dry weather these gauze mats no doubt act by capacity effect almost entirely, the few points of contact with the ground being insufficient to make a proper connexion to the earth. In wet weather, however, they become more or less a true earth, or may even be converted into one in dry weather by intentionally spraying them with water. A number of gauze mats are generally employed, their spacing and direction relative to the aerial being determined by the best results which are found attainable, and each mat is connected with the others and the central point by means of flexible copper cables. *See* Capacity; Earth.



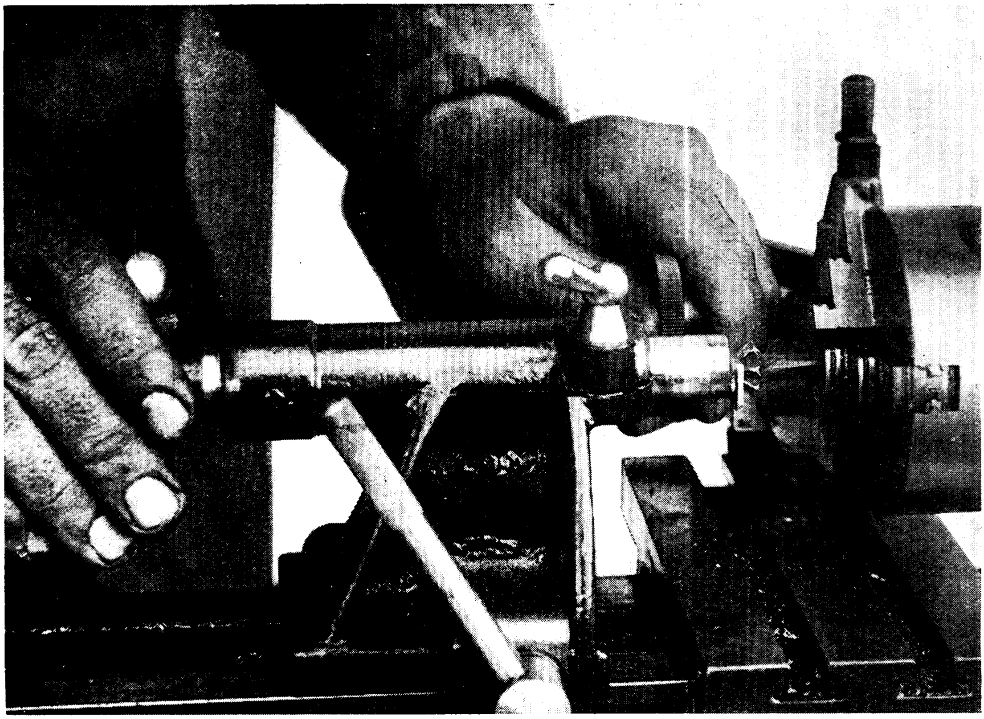
USING A COUNTERSINKING BIT

Fig. 1. Countersinking with a brace and rose-head or other countersinking bit is an operation, as the photograph illustrates, similar to the use of an ordinary brace and bit. Here the material worked upon is wood

COUNTERSINKING. The act of making a shallow, conical depression in wood or metal or other material. Such a depression is usually made to receive the head of a wood screw, so that it shall be flush with the surface of the work. This should be done regularly by amateurs who wish to have a neat finish to their sets. Practically speaking, all countersinking by amateurs is best carried out either with a brace and countersink bit as shown in Fig. 1, or by the use of the lathe. The latter tool is shown in Fig. 2, with a countersink held firmly in the chuck. The work to be countersunk is supported by the tail stock, and when the lead screw thereon is rotated, the tooth is forced against the revolving countersink and the depression is rapidly formed.

As a general rule the hole for the screw is drilled first and the corners tapered with the countersink afterwards This saves much time and labour, as a large proportion of the metal has already been removed. Sometimes the hole is formed by making the recess first and drilling out later. This method is effective in starting the drill at the proper point and obviates much centre-punch work.

Ebonite can be dealt with in the same way, and all panels to be fitted with conical-shaped screw heads should be countersunk so that the heads will finish flush with the



COUNTERSINKING IN METAL WITH THE AID OF A LATHE

Fig. 2. Metal or other material can be countersunk, as here shown, by employing a suitable tool, which is held in the chuck of a lathe. The work is supported by the tail stock. The operator is holding a turning knob, to which is attached a brass strip pierced with holes, which are being countersunk

surface. On some woodwork an efficient countersinking is made by holding a gouge in a vertical position and rotating it. This cuts away a tapered piece from the edge of the screw hole. There are several forms of countersink bit (*see* Brace Bit), but the amateur will do very well with a small "rose head" countersink for metal, another kept exclusively for ebonite, and a "snail" pattern for woodwork.

COUPLER PANEL. In wireless work, an expression used to describe a unit, or a panel fitted up with either a vario-coupler or other forms of coupling for tuning purposes. It is a convenient means for defining the purpose of a unit in a receiving set, and one type, illustrated in the photograph, is an aerial tuning device known as the No. 15 Elwell. It comprises a vario-coupler with tapped primary windings. These are controlled by seven taps and a contact arm moving over the face of the studs. The rotor is controlled by the knob at the upper part of the ebonite panel. The whole is enclosed in a mahogany cabinet.

ELWELL AERIAL TUNING PANEL

This coupling unit is an Elwell No. 15 aerial tuning panel, comprising a vario-coupler with tapped primary windings

COUPLING : THEORY AND PRACTICE

How Circuits are Electrically Coupled, with Photographic Demonstrations

Here are discussed and fully explained the inductive, electrostatic and direct forms of coupling and their combinations for receiving circuits, with ingenious photographic illustrations of the various degrees of coupling. See also such headings as Close Coupling ; Coil ; Reaction ; Regeneration

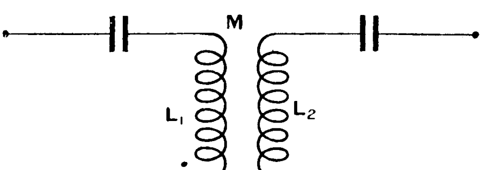
Coupling is the connexion between two circuits by means of which energy from one circuit is transferred completely or in part to the other. The connexion may be by inductive, electrostatic, or direct coupling, or by any combination of these.

Direct or Conductive Coupling simply comprises a metallic connexion between the two circuits.

Inductive Coupling, the form most commonly met with in wireless, comprehends the arrangement of an open and a closed oscillatory circuit, or of two closed oscillatory circuits, in such a way that their respective inductances are in close approximation, with the result that energy is transferred from one circuit to the other by electro-magnetic induction. In such cases the coupling is commonly termed "loose" or "tight," according to the degree of approximation and consequent amount of energy transferred.

Incidentally, the description "loose coupler" is applied to a useful form of inductance for short wave-lengths, in which the secondary coil is made to slide telescope-tubewise inside the primary, the amount of energy inductively transferred depending on the extent to which the inner tube is pulled out. The more closely the inner tube is pushed in, the "tighter" the coupling, and vice versa.

A simple form of inductive coupling is illustrated in Fig. 1.

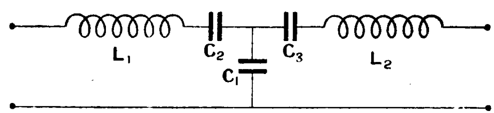


MUTUAL INDUCTANCE OR COIL COUPLING

Fig. 1. Inductive coupling of two coils is represented here. The coils are equal in size, and so placed in relation to each other as to produce mutual induction

For explanation of lettering, see below under Coefficient of Coupling.

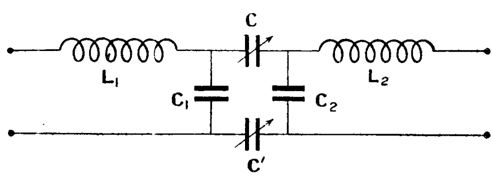
Electrostatic Coupling comprises any method depending on the use of condensers by which some proportion of the voltage in one circuit is impressed on the other. The examples in Figs. 2 and 3 of electrostatic coupling are taken from Part II. of Coursey's "Radio Experimenter's Handbook."



COMMON CAPACITY COUPLING

Fig. 2. Two circuits are here shown coupled, each circuit containing a coil and condenser, with a common coupling condenser between the two circuits

In Fig. 3 the two condensers, C and C′, provide the coupling between the two circuits L_1 C_1 and L_2 C_2.



ELECTROSTATIC COUPLING

Fig. 3. Inserted between two circuits coupled are two variable condensers. Oscillations in one circuit can be excited in the other by this capacity coupling

Coefficient of Coupling. At this point reference may be made to the term "coefficient of coupling," which is used to denote the influence of one circuit upon another when the two are coupled otherwise than directly. It is expressed as the ratio between the existing coupling and the maximum influence possible, loose coupling being indicated by a small coefficient, and vice versa. The ordinary symbol is k.

In the examples given above the coefficients of coupling are as follows :

In Fig. 1, where M = the mutual inductance between the two circuits in microhenries, L_1 = the total inductance of the primary circuit in microhenries, and L_2 = the total inductance of the secondary circuit in microhenries.

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

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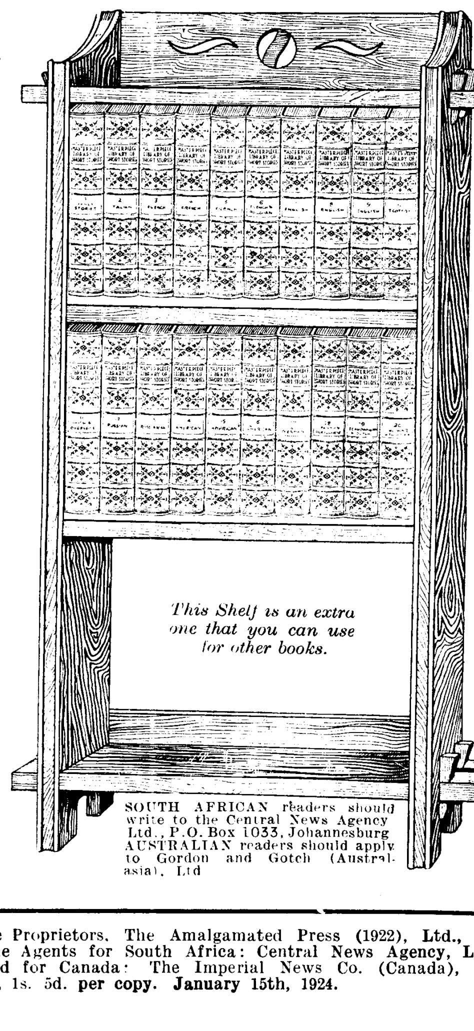

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