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For Amateur & Experimenter

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SUPER-REGENERATIVE SET

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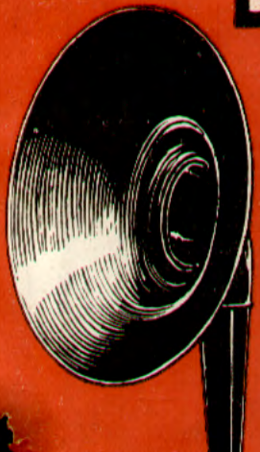

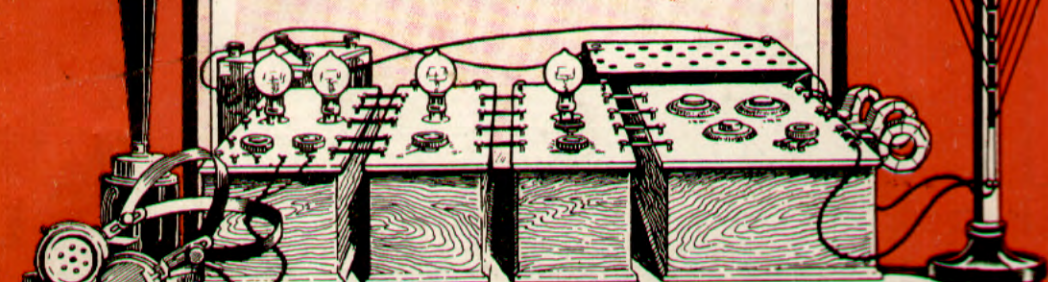

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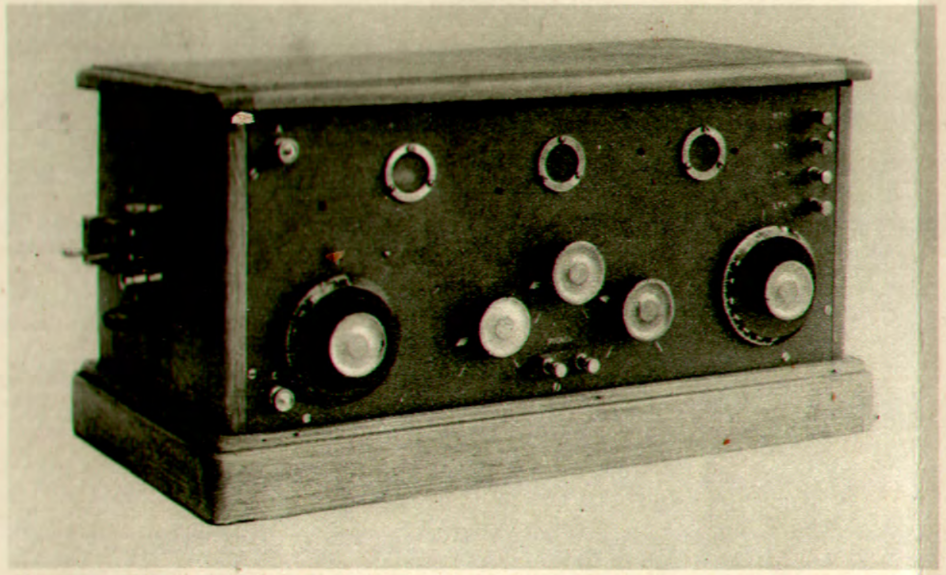


Fig. 27. Disconnected from batteries and aerial circuit the complete set appears as in this photograph. Except for outside coils all controls are on the panel

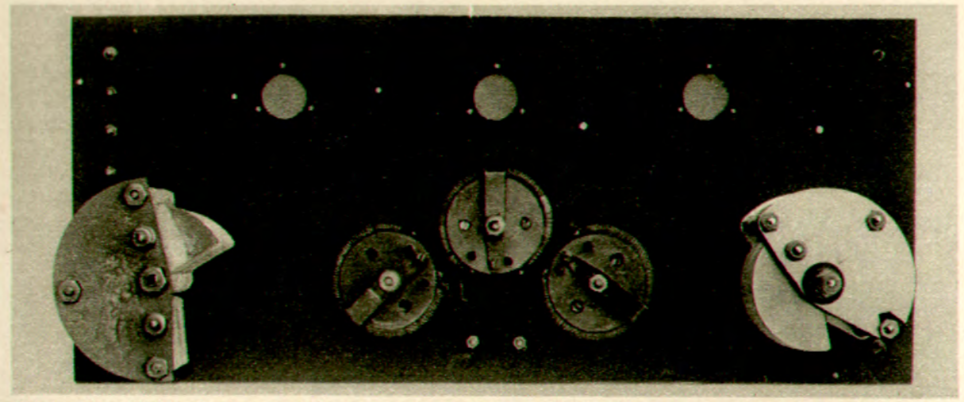


Fig. 28. Behind the panel are mounted the three filament resistances and two variable condensers. The relative positions of the terminals can be seen in this view

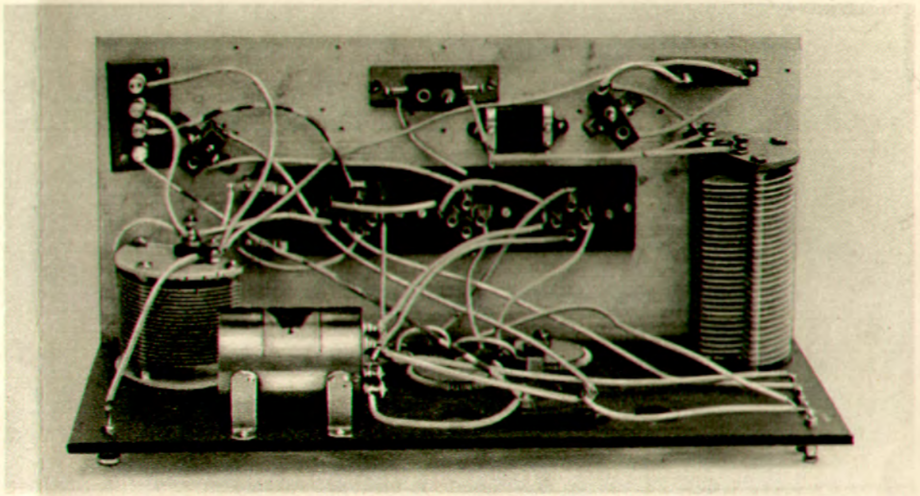


Fig. 29. This is a plan view of the completed wiring, and reference to it aids in connecting up. Each wire, as added, should be followed in this photograph

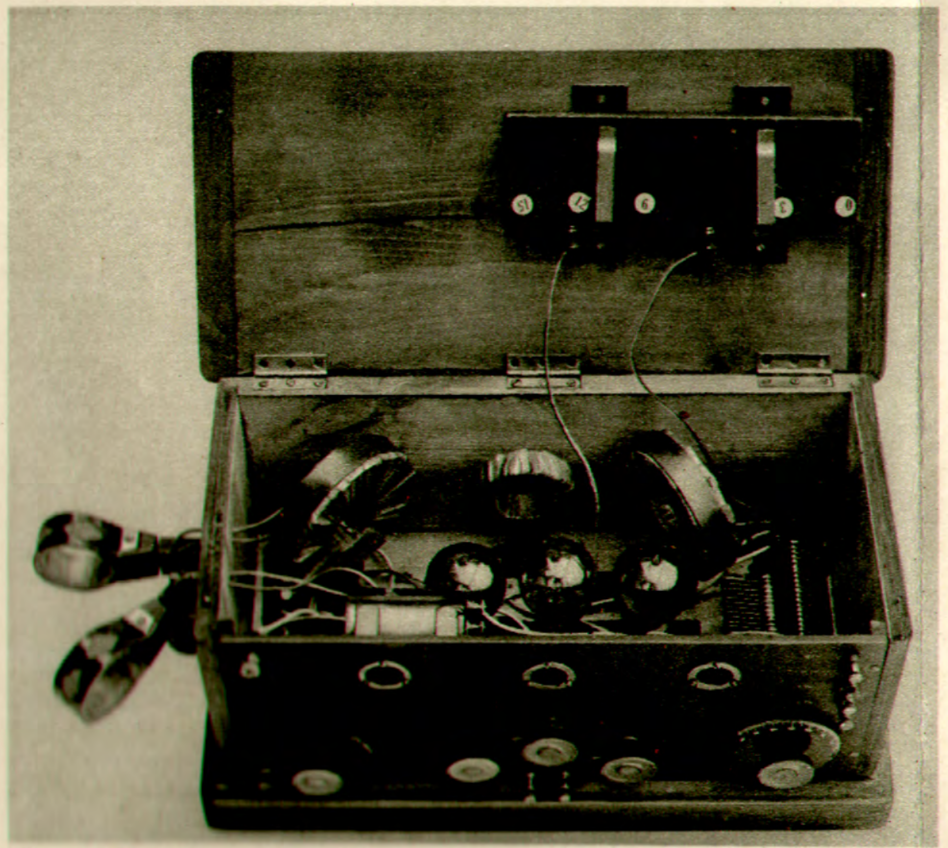


Fig. 30. Here the complete set is shown with the lid of the cabinet raised. The relative positions of the coils, valves, and grid battery may be clearly seen

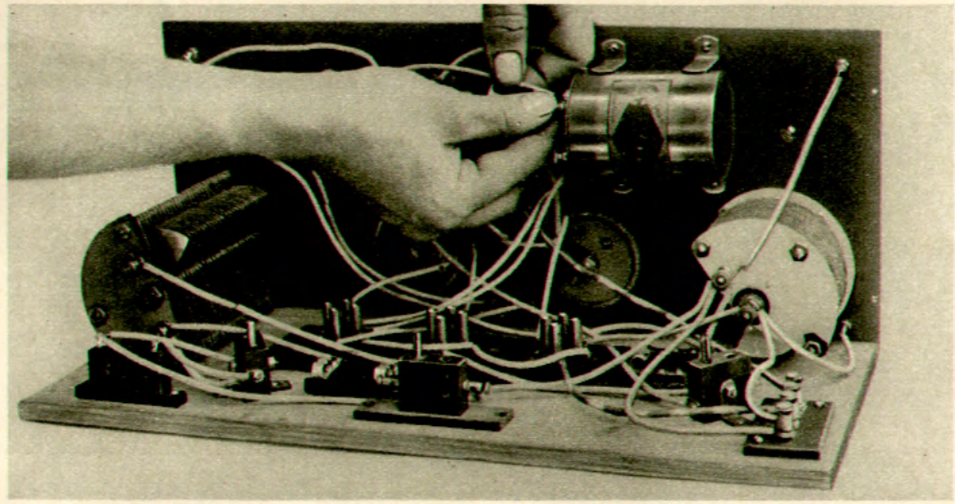


Fig. 31. After wiring all terminal connexions are tightened up securely to assure good electrical continuity. The operation is seen in progress in this illustration

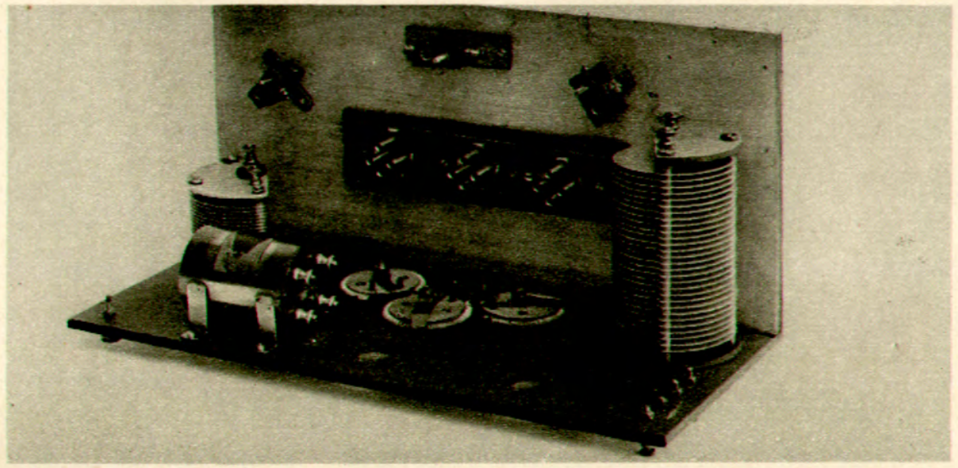


Fig. 32. Coil-holders are arranged as illustrated in order to obtain a minimum of interaction. A clear idea of the positions of the resistances and condensers is given

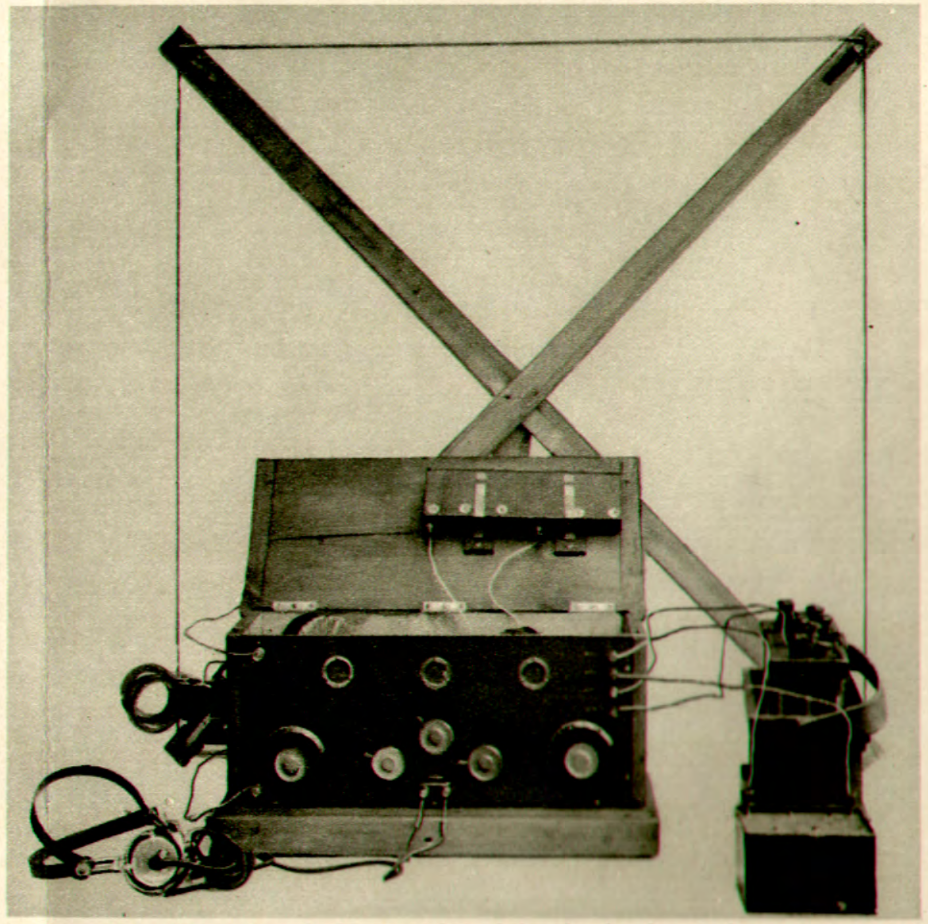


Fig. 33. Complete and ready for reception of signals, the three-valve super-regenerative set is shown connected up with a frame aerial and a pair of headphones

SUPER-REGENERATIVE SET: A COMPACT AND EASILY-MADE THREE-VALVE RECEIVER WHICH MAY BE OPERATED WITH A FRAME OR AN OUTDOOR AERIAL

To face page 1986

From photographs of a set specially designed for HARMSWORTH'S WIRELESS ENCYCLOPEDIA detector receiver, shown in Fig. 3, for the elimination of statics only involved the use of one crystal. A dry cell and potentiometer are connected in series, it will be noticed, the crystal detector being a carborundum crystal. A vario-coupler and variable condenser are used for tuning.

The De Groot static eliminator is based on the fact that when the current from the dry cell flows through the detector in a direction opposite to the ordinary one through the circuit, it increases the strength of weak signals in a ratio that is greater than in the case of strong signals. The direction of flow is, of course, controlled by the potentiometer.

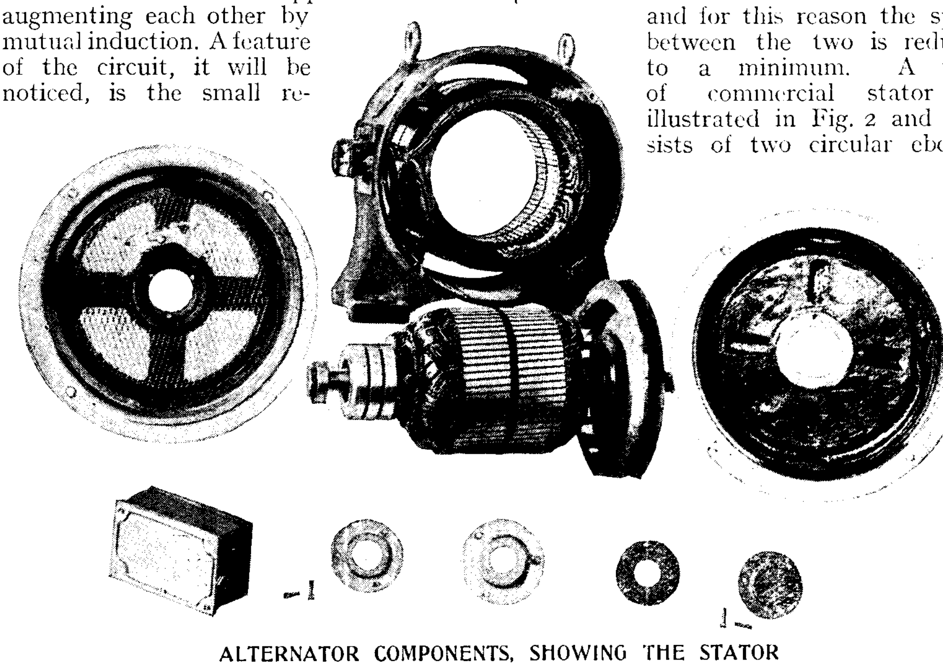
The heterodyne method of reception and the balanced valve method are both methods for those using valve sets which reduce very largely interference due to static. The heterodyne method of reception is described separately in this Encyclopedia.

Fig. 4 shows a balanced valve circuit which is very good for cutting out static. The two valve circuits are tuned to the same wave-length, but the current flow is in opposite directions. The transformer T is a special H.F. transformer in which the coils are wound to oppose instead of augmenting each other by mutual induction. A feature of the circuit, it will be noticed, is the small resistance placed in the aerial circuit. Since the two circuits are tuned alike, but are opposite in sense, the point where the aerial is connected is a node, and though it is not likely to affect the frequency of the oscillations in either circuit, the small resistance precludes any possibility in this direction. The resistance is chosen small enough not to affect to any great extent the energy of the oscillations set up by the incoming waves. *See* Atmospherics; Balanced Crystal; Filter Circuit; Interference Eliminator; Rejector Circuit.

STATOR. Name given to the fixed parts of certain electro-magnetic induction machines or instruments. It indicates the opposite part of the machine to the rotor, that is, that part which is capable of rotation.

Both terms are largely used in connexion with alternating current machinery, the stator of an alternator being seen to the back of the illustration in Fig. 1, which shows the main parts of an alternator disassembled. In wireless, the terms most often apply to the fixed and moving parts of a variometer or vario-coupler.

It is the object in most of these instruments to obtain as close a coupling as possible between the rotor and stator, and for this reason the space between the two is reduced to a minimum. A type of commercial stator is illustrated in Fig. 2 and consists of two circular ebonite

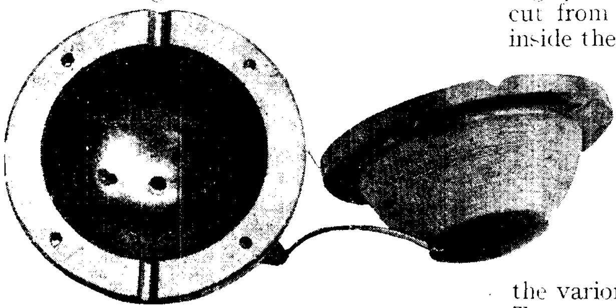


ALTERNATOR COMPONENTS, SHOWING THE STATOR

Fig. 1. The parts which make up an alternator are laid out here. The stator is seen at the back of the illustration, and is a ring-like casting. The rotor, which revolves within the stator, is immediately in front of the stator

Courtesy Crypto Electrical Co., Ltd

or composition mouldings, having flanges at their inner edges by which they may be bolted together. A ring-like flange is provided on the outside of each moulding and keeps the wire in place while the stator is being wound.



MOULDED STATOR

Fig. 2. Two mouldings of ebonite composition make up this commercial stator. The grooves enable the rotor spindle to be fixed in position

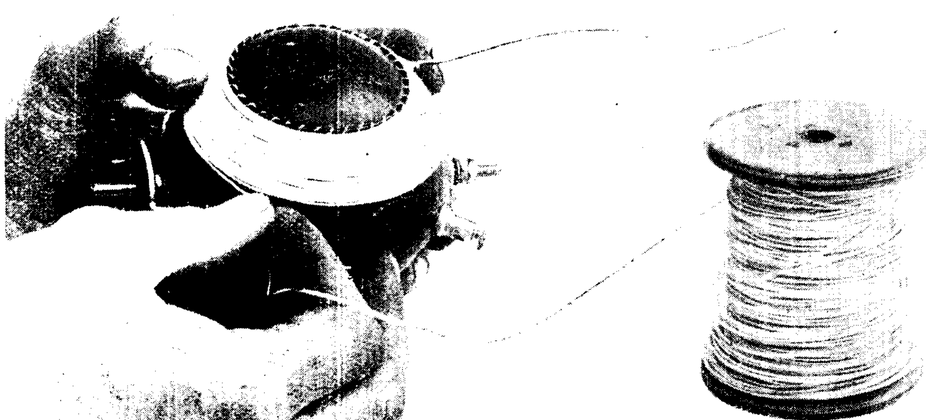
The rotor, which is also of composition construction, rotates inside the hollow cups of the stator, provision for the spindles of which is shown in Fig. 2.

An extremely efficient stator for a variometer may be made at very small expense from a rubber ball. A complete variometer constructed in this way is illustrated in Fig. 4. The size of the stator should first be determined, and should enable the rotor to be a good fit inside it. In purchasing the ball, it should be chosen for its stiffness and freedom from denting.

The ball is cut exactly in two, the seam by which the ball is joined up forming a guide in this operation, which is shown in Fig. 5. If the two halves do not appear to have sufficient rigidity, they may be further strengthened by painting their interiors with thick glue, as shown in Fig. 7. An ebonite ring ½ in. in width is cut from a piece of tubing, and fits just inside the two halves of the ball, as shown in Fig. 6. At this point the rotor is fitted inside the ebonite ring, as shown in Fig. 8.

A brass plate is cut and bent as shown in this illustration, and is attached to the ring over the projecting spindle of the rotor. This plate is drilled and tapped, and is used for mounting the variometer to a panel or other fixing. Two terminals are also screwed to the ring at the opposite end of the rotor. These parts should be left loose as shown in Fig. 8, as they serve to hold the two halves of the stator in position when screwed up tight.

In order to retain the insulated wire with which the stator is wound, a ring of stout wire is sewn in the centre of each half of the variometer stator. Strong thread is used for this operation, and care taken to keep the ring perfectly round. The method of securing the ring is shown in Fig. 9. One half of the stator with ring attached can just be seen to the right of the illustration. The two halves may now be assembled, a close fit being made by cutting away small slots at the edges of the two halves where the terminal stems and the



HOW TO WIND A VARIOMETER STATOR ON A RUBBER BALL

Fig. 3. Winding a variometer stator is accomplished by hand in the manner shown in this illustration. The stator is wound in two halves; one of these is shown almost finished

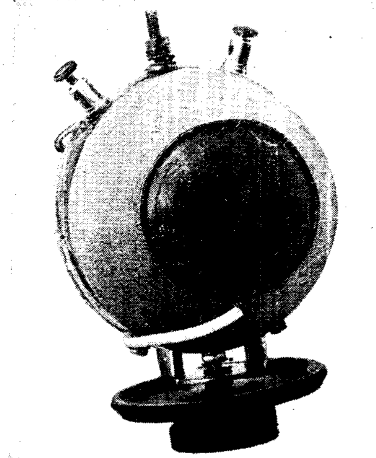


Fig. 4. In this photograph the variometer is complete, the stator being an ordinary rubber ball

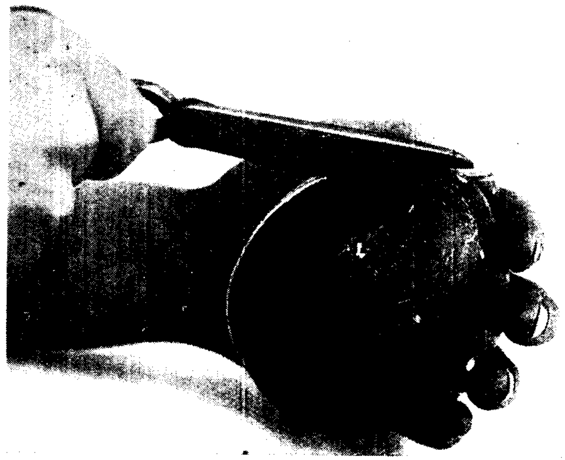


Fig. 5. An indiarubber ball is cut in half along the seams to construct the two halves of the stator as shown, and makes a really neat variometer stator

Fig. 6. Between the two halves of the stator an ebonite ring is attached. This must fit accurately

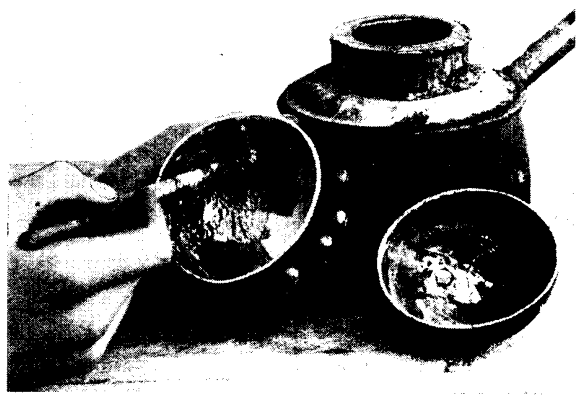


Fig. 7. Stiff glue is applied to the interiors of the two halves of the ball to strengthen them before the rotor is finally fixed in position

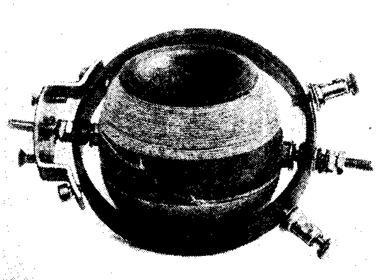


Fig. 8. The rotor terminals and brass plate are fitted to the ebonite ring ready for assembly in the stator

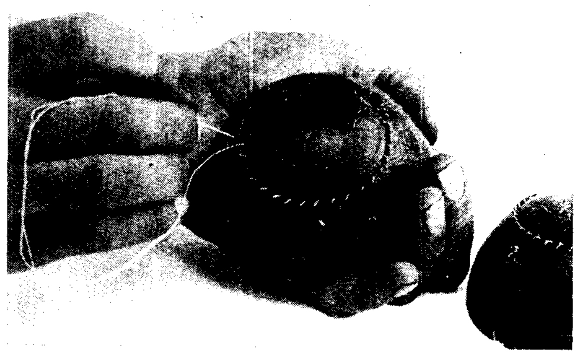


Fig. 9. Two wire retaining rings are sewn to the two halves of the stator to hold the windings in position, as shown more clearly in Fig. 3

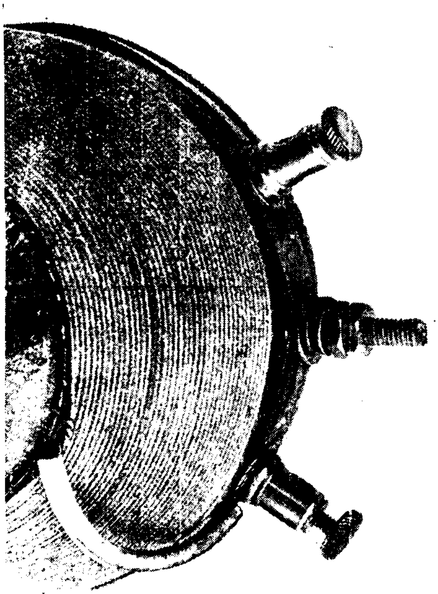
PROCESSES IN MAKING A VARIOMETER STATOR FROM A RUBBER BALL screws supporting the brass plate intervene.

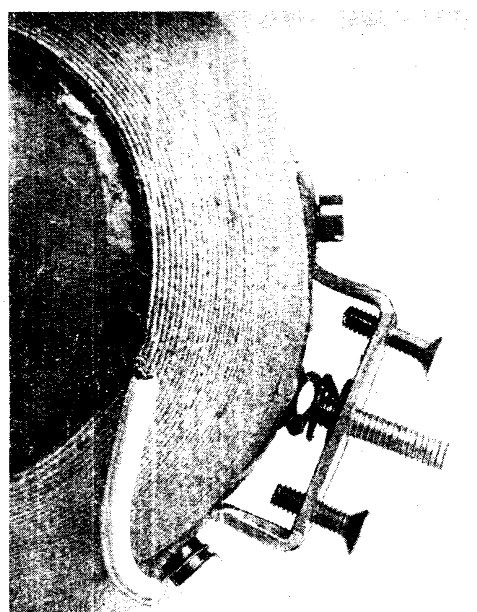
The spindle of the rotor should be rotated when the two halves are tightly clamped all round to assure that it does not touch the stator. Winding may now be commenced by taking a loop of wire round the ring and twisting it two or three times. Winding is begun as shown in Fig. 3, until the requisite amount of wire has been wound on. If difficulty is experienced in keeping the wire even and in position, the stator may first be painted on the outside with gold size or stiff shellac varnish. Further coatings may be applied to the wires as the winding progresses, but if self-capacity in the stator is an important consideration as little shellac as possible should be used. The free end is temporarily secured in one of the terminals while the other half of the stator is wound.

Care must be taken in winding the second half that the current flows in a continuous direction. The finishing ends of the two windings are now soldered together. One end of the stator winding is secured under one terminal, while the other terminal is connected by means of a short brass strip to the back end of the rotor spindle. A close-up of this connecting strip is illustrated in Fig. 10, which shows the arrangement of spring washer and lock nuts for making continuous contact. The other end of the stator winding is connected to the brass plate, from which contact is made to the front half of the rotor spindle. A close-up of the method of making contact is shown in Fig. 11. *See* Coil; Variometer.

STAY. Expression applied to a rigid support, used generally in wireless work to prevent a mast for an aerial buckling, or to keep it in an upright position. In general a stay may be any form of support for a structure. For example, it may be a cross-piece used to keep some part of apparatus in position during the course of erection, or it may be employed as a means of strengthening a work bench.

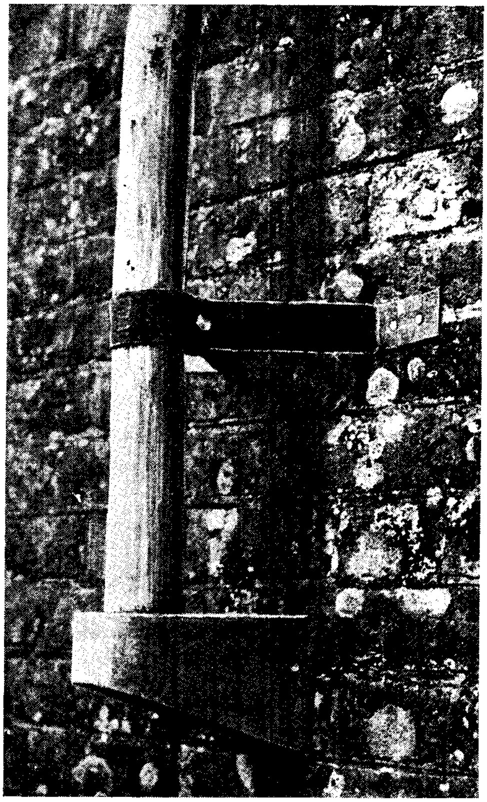
One application of iron stays in wireless work is illustrated in Fig. 1, which illustrates the base of a mast attached to the wall of a building. The foot of the mast rests on a stout wooden block let into the wall, the end of the mast being suitably shaped so that it may drop into the recess in the wooden block. This block merely carries the weight of the mast. To prevent the latter from shifting sideways, two iron stays may be employed. These are made from iron of a size appropriate to the length and weight of the mast. For





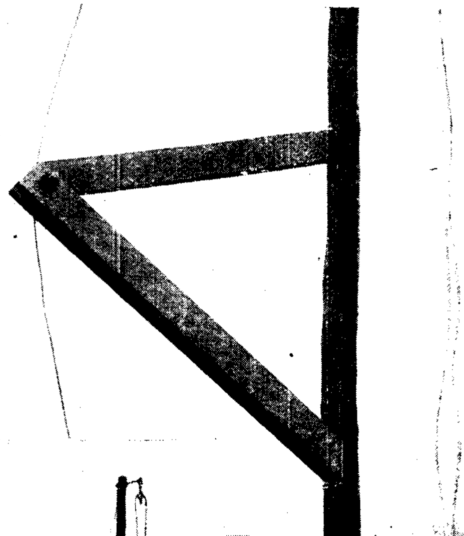
BACK AND FRONT END STATOR CONNEXIONS

Fig. 10 (left). How contact is obtained beween the back end of a rotor spindle and the stator is shown. Fig. 11 (right). This illustration gives a close-up view of the spindle and stator winding



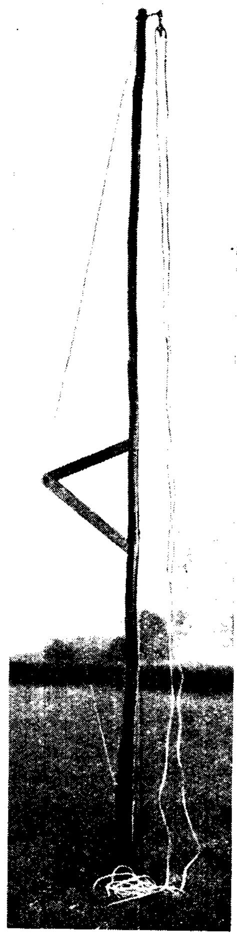
IRON STAY FOR MAST

Fig. 1. Fitted to the wall, an iron stay supports the butt of the mast a short distance above its base block and holds it firmly



WOODEN STAY

Fig. 2. Buckling is prevented in a single pole mast by a wooden stay of this kind



MAST WITH STAY

Fig. 3. Mast stays are attached about half-way up, and support a steel wire

example, they may be about 2 in. in width and $\frac{1}{4}$ in. in thickness.

They are forged to the shape of the letter A, and the feet are turned outwards to provide a means for fastening them to the wall, while the apex is rounded to embrace the mast, to which it is clamped by a bolt and nut. Two of these stays should be used on the lower part of the mast, as shown in the illustration, and another similar at some distance above it. The stays are secured to the wall with bolts or screws, or, alternatively, may be built into the brickwork.

Another form of stay or ring post is illustrated in Fig. 2. This is intended to prevent the mast buckling in the centre, and is of great value when for any reason it is impracticable to support the mast in the customary manner with guy-wires towards the back, as, for instance, when the aerial mast is to be placed in proximity to a garden wall or some other structure. In this case if three pieces of timber be disposed, as shown in Fig. 2, and a stay wire taken from the top of the mast over the end of the stay and then to the lower part of the mast, it will have the effect of greatly strengthening the mast against any tendency to buckle, due to the horizontal pull of the aerial upon it.

The size of the strips needed will be determined by the proportions and height of the mast, but for the average small amateur aerial, ordinary battens 2 in. wide and 1 in. thick will answer. They may be about 18 to 21 in. in length. The upper strip is a single piece, the lower is made of two pieces. The two outer ends are bolted together

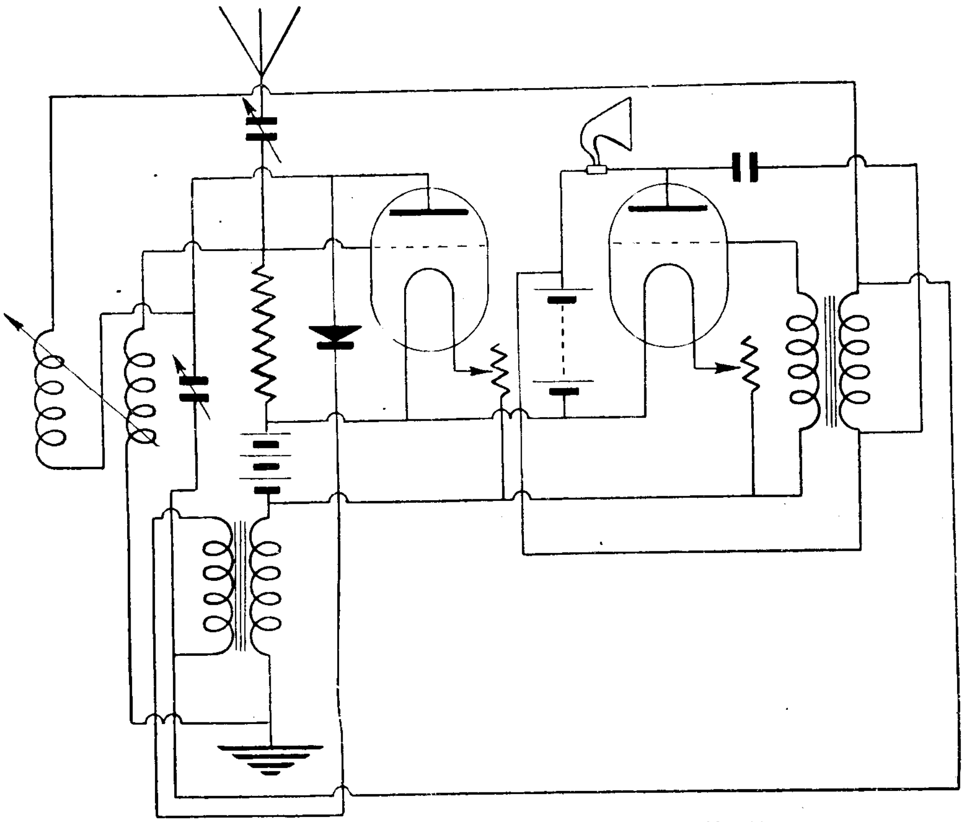


DIAGRAM OF THE CIRCUIT KNOWN AS THE S.T. 100

Fig. 1. Well known as the S.T. 100, this circuit is one of a group of such circuits. Many variations of the principle incorporated in this diagram have been made. This is the usual form of S.T. circuit having two valves employed for dual amplification

and the parts that come in contact with the mast are shaped to suit it, and the latter slightly flattened to provide an adequate bearing.

The stays can be secured to the mast with stout spikes or screws, which are only needed to support the stay itself, as there is no tendency for it to shift when the stay wire is tightened. The appearance of such a short mast when set in position is shown in Fig. 3. It is essential with such an arrangement that the stay wire be very tight. This can be accomplished either with the aid of a wire strainer or by tightening the wire with a lever or tourniquet and making it permanently fast by binding it around the mast with a number of turns of stout binding wire. The act of binding has the effect of further tightening the stay and making it secure. *See* Aerial; Guy; Mast.

S.T. CIRCUITS. Name given to a variety of circuits due to John Scott-Taggart, member of the Institute of Radio Engineers. Of the many circuits bearing the prefix S.T., probably the best known is the S.T. 100.

In its usual form the circuit is a two-valve dual amplifier having two stages of low-frequency amplification. A typical S.T. 100 circuit, of which many modifications have been made, is shown in circuit diagram form in Fig. 1. Among the modifications of this circuit is the addition of a grid-biasing battery, which when included is placed between the negative side of the filament-lighting battery and the filament end of the secondary coil of the first low-frequency transformer, the negative end of the biasing battery being towards the valve grids. The introduction of the grid battery regulates the operation of the valves and allows their operation on the middle point of their characteristic curves. The addition of the grid battery enables a higher anode voltage to be used, a suitable potential being obtained from a 100 volt high-tension battery.

The S.T. 100 is the outcome of considerable experiment with dual amplification or reflex circuits. Such circuits are not new, their general use being limited by the comparative inefficiency of the older types of wireless valves and transformers. At the present time the reason for the lack of popularity of the dual amplification circuit lies in its general instability and proneness to fall into oscillation, especially at audio-frequency. This trouble is particularly prevalent where double-stage low-frequency dual amplification is attempted.

In the S.T. 100 circuit howling is minimised, if not entirely eradicated, by the omission, or reduction in value, of certain fixed condensers from the circuit. It is common practice to shunt an inductance offering a large impedance to high-frequency currents with a fixed condenser which offers a path of low resistance to such currents. Such condensers, if not entirely omitted, are reduced in value to an extent which checks the tendency to oscillation.

The type of crystal used with this circuit appears to have considerable influence on the operation of the set, the crystal generally recommended being galena, used in conjunction with a fine metal point arranged to make a light contact with it.

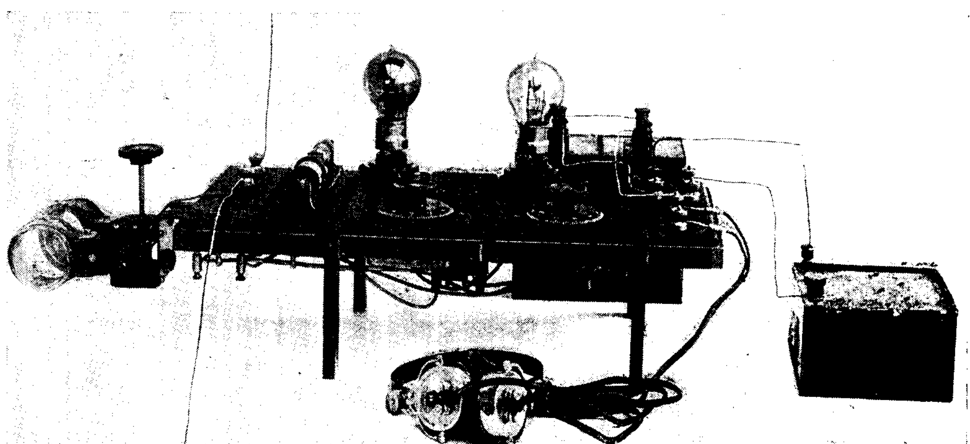
The originator of the circuit points out that apart from the properties of rectification enjoyed by the crystal, its impedance plays an important part in the functioning of the apparatus, in part affecting the tendency of the circuit to oscillate at radio-frequency, but influencing and governing the operation of the circuit generally.

An advantage claimed with the S.T. 100 is its adaptability and efficiency with most types of aerials, which advantage is not enjoyed with forms of super-regenerative circuits, such as that put forward by Armstrong.

For general experimental work the Polar Blok system of set construction is useful, and this method has been adopted in the construction of the S.T. 100 set shown in a completed form in Fig. 2. This system lends itself well to an exchange of condenser values or a rearrangement of components, at the same time preserving a well-finished appearance.

A plan view of the set showing the arrangements of the components is illustrated in Fig. 3, where a fixed resistance of 100,000 ohms is attached to the second panel from the left on the top set of panels. The two variable condensers seen in the lower set of panels each have a maximum capacity of ·0005 mfd. The pair of terminals seen to the right of these condensers in Fig. 3 are telephone terminals, while the four terminals just above them are for connexion of the high- and low-tension batteries. The terminals to the left of the set connect to aerial and earth.

Fig. 5 shows the back view of the set before assembly, and from the position of the coil holder it will be seen to be the plan view shown in Fig. 3 turned through 180 degrees. A chart is shown in Fig. 4 which



LAY-OUT OF S.T. 100 APPARATUS

Fig. 2. Built up from a set of Polar Blok parts is a complete S.T. 100 receiver ready for use. This photograph should be studied with the diagram of the circuit in Fig. 1

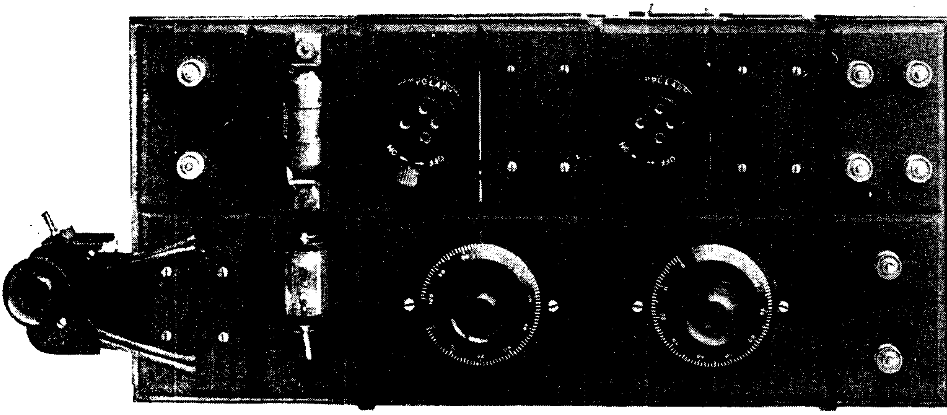


Fig. 3. This is a plan view of the Polar Blok panels which are assembled to make up the S.T. 100 circuit. It will be seen that Holderstats are used, combining valve holders with rheostats

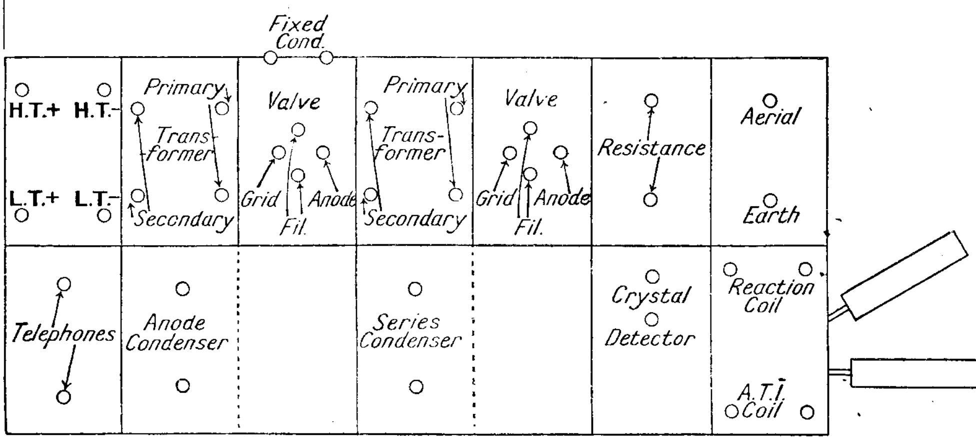


Fig. 4. Seen from the back, this diagram represents the panels in Fig. 5 (below), and forms a key to the Polar Blok system employed for the S.T. 100 set

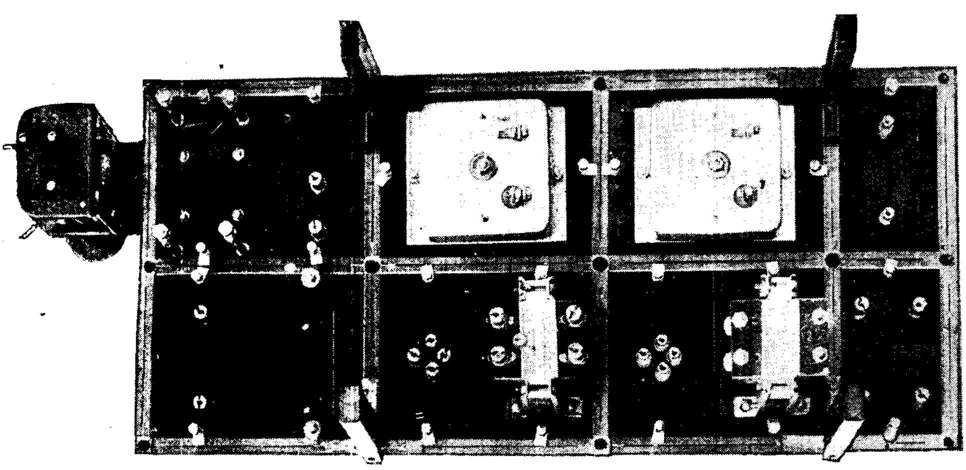


Fig. 5. Turned upside-down and photographed from above, the arrangement of the low-frequency transformers, condensers, and coil holders is clearly shown before the wiring is carried out. Note also the position of the terminals

HOW THE S.T. 100 SET IS BUILT UP

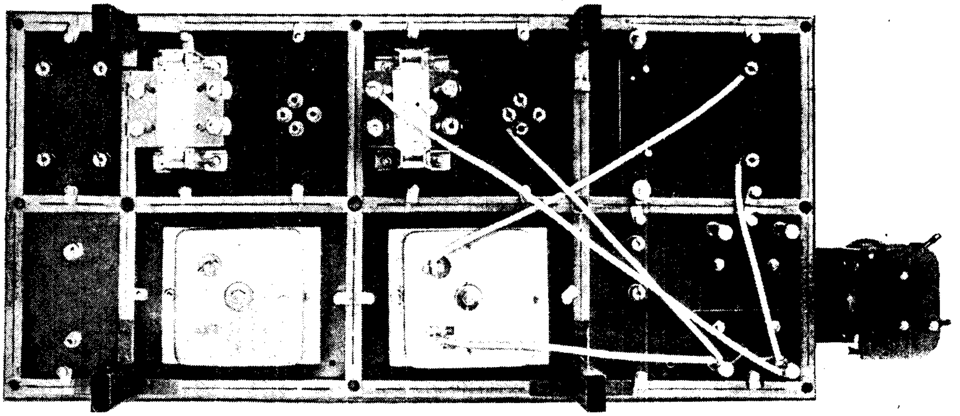


Fig. 6. On the underside of the panels wiring of the S.T. 100 set is carried out by first connecting up the aerial tuning coil and condenser. These connexions are shown in this photograph

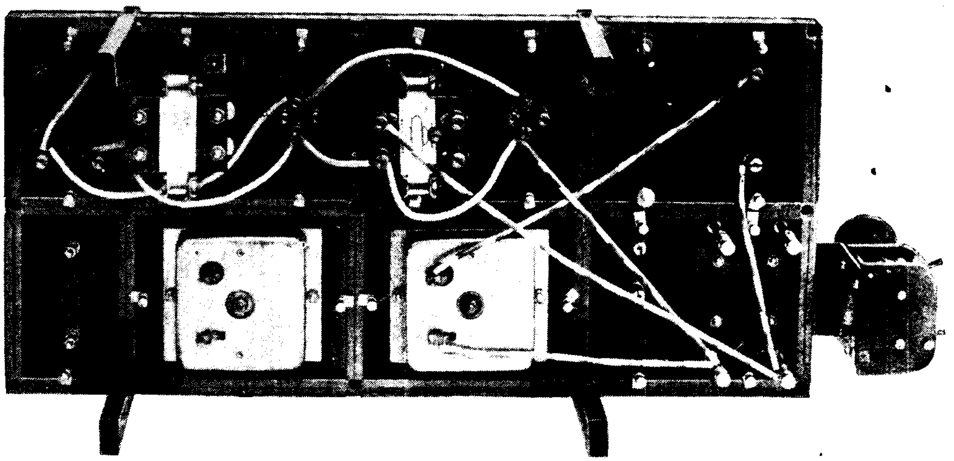


Fig. 7. Here the second stage in wiring is seen, and by comparing this illustration with the one above the additional wires are easily followed

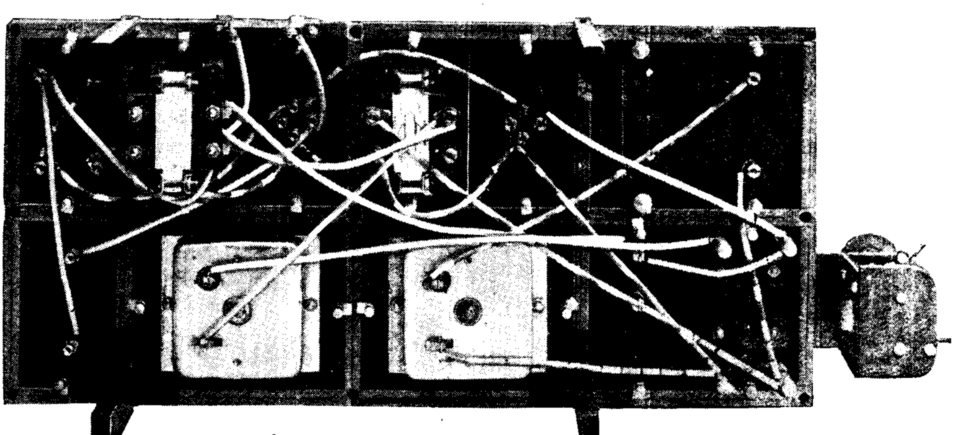
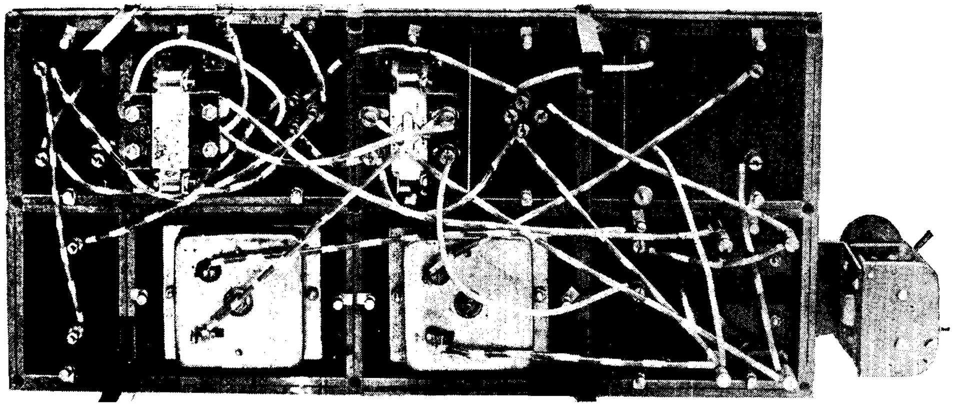


Fig. 8. Further connexions are now made, and the high-tension positive and anode wires are included. The additions may be seen by referring to Figs. 1 and 2. The wiring should be carried out in this sequence to avoid confusion

WIRING ARRANGEMENTS OF THE S.T. 100 RECEIVER

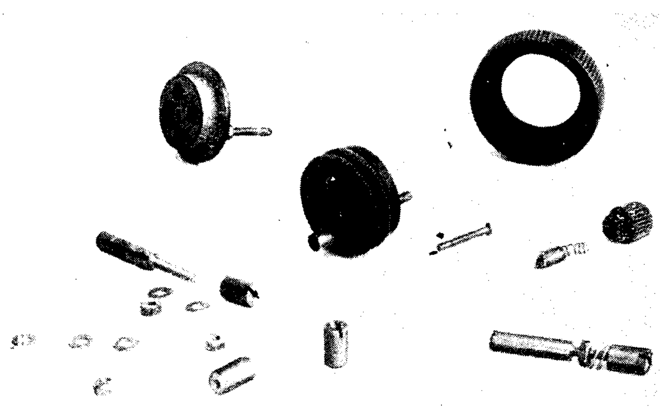


COMPLETED WIRING OF THE S.T. 100 SET

Fig. 9. Here the final stage of the wiring is shown, and this should be studied along with the preceding illustrations. The fixed condenser is clipped to the frame of the set, alongside the second valve holder

assists in the correct location of all the terminals used in the set, and this may be used in conjunction with all the illustrations of wiring which follow, in which connexion it will be found of use in tracing all the processes in the wiring.

All wires should be as short as possible and parallel wires avoided. The first stage in wiring is shown in Fig. 6, and represents the completion of the aerial tuning cir-



HOLDERSTAT COMPONENTS

Fig. 10. These are the parts which go to make up the combined valve holder and filament resistance which is a feature of the Polar Blok system of construction

METHOD OF ASSEMBLING HOLDERSTAT

Fig. 11. The Holderstat calls for care in assembling. The centre ring rotates between the valve cap and the former, to which the valve legs and resistance coils are attached

cuit. The low-tension circuit is shown wired in Fig. 7, where the previous wiring is marked with black and white, to avoid confusion with the latest additions to the wiring. The H.T. and anode circuit is followed in Fig. 8, while in Fig. 9 the completed wiring is seen.

For broadcast wave-lengths a No. 50 Igranic coil will be found suitable for the average aerial, while a No. 75 coil of the same make is used for reaction. The value of the fixed condenser is ·002 mfd. capacity.

An interesting feature of the Polar Set is the combined filament resistance and valve holder, the parts for which are shown in Fig. 10. A double resistance spring is employed, contact to each being made with a wedge-shaped spring-loaded plunger. The method of assembling the main components is shown in Fig. 11, where the former, to which the resistance springs are attached, and the valve holder cap are fitted to the central ring from opposite sides. These parts are held together by the friction fit of the valve legs, and also by a screw fitting between the valve legs and screwing into the valve top.

STEINMETZ, CHARLES PROTENS. American-German scientist. Steinmetz was born in Germany in 1865, and studied mathematics, electrical engineering and chemistry at Breslau, Berlin and Zurich. He went to America in 1893, where he was appointed consulting engineer to the General Electric Company, a position he held until his death. In 1902 he was appointed professor of electro-physics in Union University, New York. He died at Schenectady, New York, October 26th, 1923.

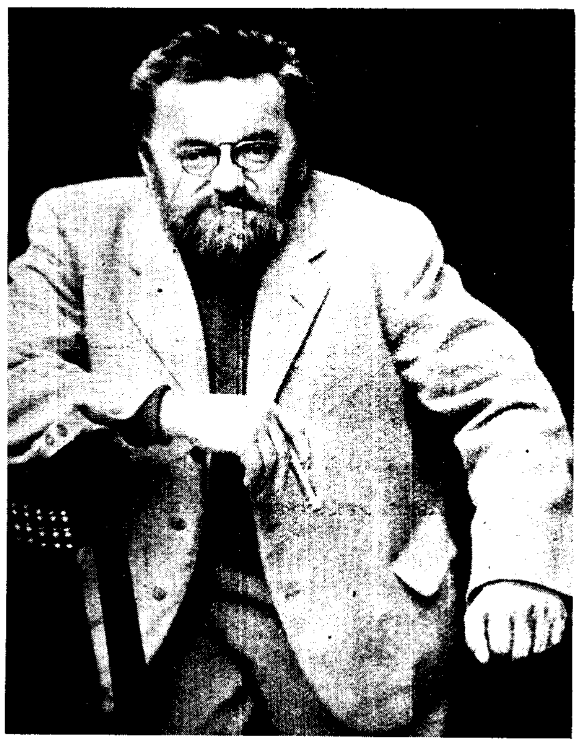
Dr. Steinmetz was one of the most remarkable figures in the electrical world. He was the chief exponent of the "No Ether" theory, and he carried out a series of remarkable researches in all branches of electricity, which are embodied in a series of books published by him between 1897 and 1917. He also published a large number of papers on magnetic and electrical phenomena. He was a past president of the American Institute of Electrical Engineers and the Illuminating Engineering Society, and was honoured by many scientific societies.

STEP-DOWN TRANSFORMER. Name given to a special form of transformer in which the primary is wound with a great many more turns than the secondary, this having the effect of increasing the amperage but decreasing the voltage which flows in the secondary circuit induced by a current flowing in the primary. Its chief use in wireless is in the telephone circuit of a receiving set permitting the use of low-resistance telephones. *See* Transformer.

STEP-UP TRANSFORMER. Name applied to a special pattern of transformer in which the secondary winding is composed of many more turns than that of the primary, this having the effect of decreasing the amperage but increasing the voltage in the secondary circuit, induced by a current flowing through the primary. It is used in wireless work for low-frequency amplification purposes. *See* Transformer.

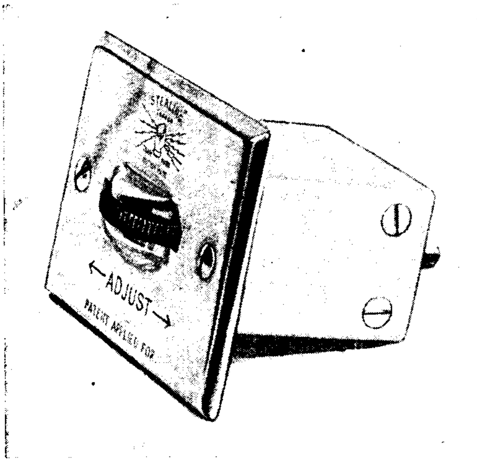
STERLING ACCESSORIES. A wide range of useful wireless accessories and components is manufactured by the Sterling Telephone and Electric Co., Ltd., which is admirably suited to the requirements of the professional and amateur constructor of wireless transmitting and receiving sets. In addition to the components, the Sterling Co. supply a variety of complete wireless receiving stations, and other apparatus of a similar character, examples of which are dealt with in this Encyclopedia under their respective headings.

One example of a Sterling production is illustrated in Fig. 1, which shows a Sterling enclosed crystal detector. This form is a feature of several of the Sterling



CHARLES PROTENS STEINMETZ

Steinmetz was born in Germany in 1865, and died in America in 1923. During his later years he propounded theories and conducted researches which opened up new channels of scientific investigation and earned him fame. He was the chief exponent of the "No Ether" theory



STERLING CRYSTAL DETECTOR

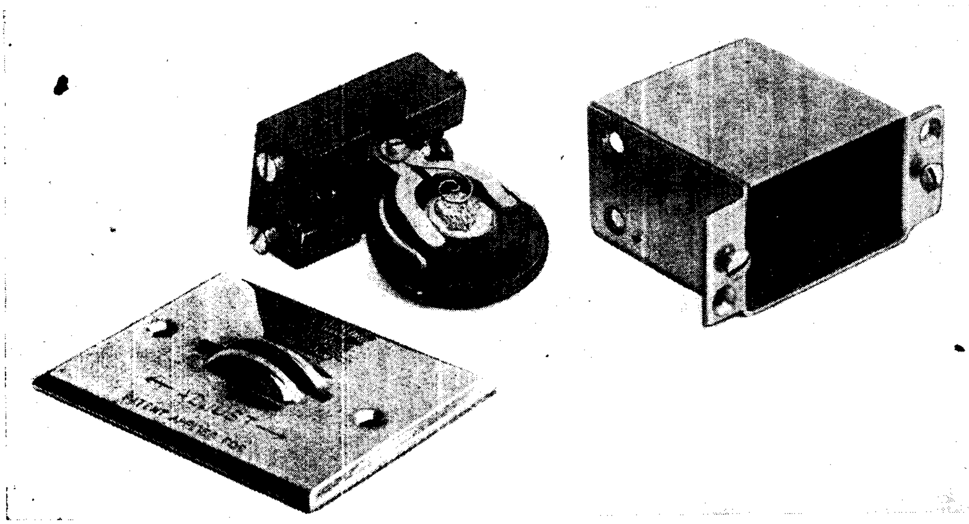
Fig. 1. Hertzite is used in this enclosed detector. Adjustment is made by a milled-edge ebonite wheel, which is rotated by the finger

sets, and is also available as a separate unit for the home constructor. The crystal is of the hertzite type, and is very sensitive. As can be seen from Fig. 1, this detector is entirely enclosed in a metal case, and is adjusted by means of a milled-edge ebonite wheel, which can be rotated by the thumb. It will be found to be stable in use.

The internal arrangement of this detector is clearly shown in Fig. 2, where the article has been taken apart to reveal the internal disposition of the components. On the left of Fig. 2 is a polished and plated cover plate. In the centre is an ebonite block supporting the Y-shaped prongs and other guide prongs which carry the circular ebonite disk, in the centre of which is mounted the crystal. The cat's-whisker is a very fine wire coiled to the shape of a flat spiral, and contact formed by bending the end of the wire upwards at right angles to the spiral, the result being a delicate pressure on the surface of the crystal.

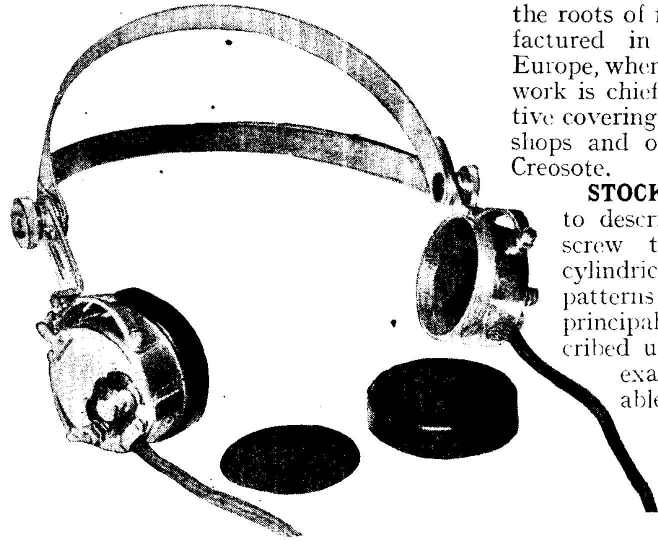
This contact point on the cat's-whisker is out of centre with the crystal, and consequently when the latter is rotated, further sensitive spots are quickly found, and the whole surface of the crystal can be accurately searched. This part of the device fits into the metal case on the right of the illustration. These contacts are sent out in perfect adjustment, and the experimenter is advised not to take them apart unless they fail to function properly, as the correct adjustment of the cat's-whisker is a difficult operation.

Another example of Sterling productions is shown in Fig. 3, which illustrates a standard Sterling headphone. One of the earpieces is shown partly disassembled to reveal the electro-magnets, diaphragm and ebonite cap. Adjustment is provided at the ends of the two aluminium head-bands and controlled by two knurled nuts. The earpieces are supported on a jointed Y-shaped piece which enables the



HOW THE STERLING CRYSTAL DETECTOR IS CONSTRUCTED

Fig. 2. When taken out of its case the Sterling crystal detector is seen to be an ingenious device whereby the cat's-whisker contact and the crystal may be adjusted by the rotation of the ebonite wheel-shaped mounting of the crystal cup



STERLING TELEPHONES

Fig. 3. One of the earpieces of the Sterling headphones shown above is partly disassembled to show the electro-magnets, diaphragm and ebonite cap. The headbands are of aluminium, and are adjustable

Courtesy Sterling Telephone and Electric Co., Ltd.

telephones to be adjusted comfortably over the head of the listener.

A great number of other accessories are also provided by the Sterling Co., many of them being described and illustrated in this Encyclopedia under their respective headings, to which reference should be made.

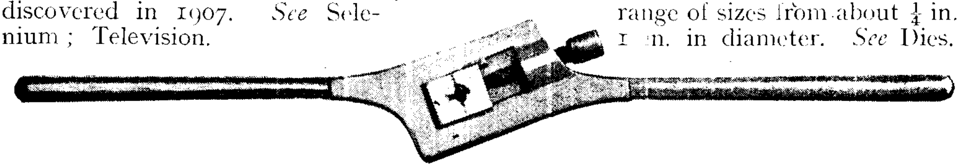
STIBNITE. Mineral consisting of antimony sulphide, Sb_2S_3, one of the important ores of antimony. It is lead grey in colour, with a metallic lustre. Stibnite is one of that group of substances, of which selenium, antimonite and silver iodide are the chief, whose electrical conductivity varies with the intensity of the light to which they are subjected. The sensitiveness of stibnite to light was discovered in 1907. *See* Selenium ; Television.

the roots of fir trees, and is chiefly manufactured in Scandinavia and Northern Europe, whence its name. Its use in wireless work is chiefly restricted to the preservative covering of aerial masts, timber workshops and other similar purposes. *See* Creosote.

STOCKS AND DIES. Term used to describe instruments for forming screw threads on the outside of cylindrical objects. There are many patterns of stocks and dies, the principal varieties of which are described under the heading Dies. One example of a stock for adjustable screwing dies is illustrated, and is known as the engineer's pattern. It comprises a strong wrought steel frame or body with a rectangular hole formed in it.

Part of the sides of this opening are shaped to a V section and act as guides or supports for the two dies. The latter are made of a good grade of cast steel and are in two halves. The lower is slipped into position and the upper, which is the adjustable half, is inserted into place and pressed home by means of a long set-screw. To introduce the die, this screw has to be turned back until the aperture is clear, when by pulling the die backwards it can be removed from the V guides, which terminate at a short distance from the end of the stock, and thereby permit of the die being removed.

In use the die is adjusted to the correct diameter and the stock rotated by hand. It is generally impracticable to cut a full thread with once screwing with such a stock and die, and consequently, after the work has been screwed for about half of its depth, the die is again adjusted and the work reduced to its full diameter. This pattern of stock and die is available in a range of sizes from about $\frac{1}{4}$ in. to 1 in. in diameter. *See* Dies.



ADJUSTABLE STOCK AND DIE FOR MAKING SCREW THREADS

Stocks and dies are made in various sizes suitable for particular kinds of work. In the above photograph is an engineer's pattern of stock made in wrought steel

STOCKHOLM TAR. Semi-liquid material used as a preservative for timber, and for other purposes. It is obtained after a heat treatment by extraction from

STONE, JOHN STONE. American wireless expert. Stone was educated at the Columbia and Johns Hopkins Universities, where he made a special study of chemistry, physics, mathematics and electricity. In 1890 he was appointed experimenter in the research laboratory of the American Bell Telephone Company, a post he held until 1899. During this time he made a number of investigations into wireless telephony. In 1899 he became consulting engineer on wireless matters to a number of firms, and brought out over a hundred patents in connexion with various sides of wireless. He made a special study of interference elimination, and has written a large number of papers on wireless matters. Stone is a member of many scientific societies. He is a fellow of the American Academy of Arts and Sciences, fellow and past president of the Institute of Radio Engineers, member of the Franklin Institute, etc.

STONE COHERER. Type of coherer once employed in some of the portable wireless sets used by the United States Army. The coherer in effect consisted of two small steel plugs, between which were placed loosely packed carbon granules. The coherer had the advantages of being self-decohering and of being able to withstand rough usage, but it had the disadvantage of not being so sensitive as other forms of coherer. *See* Coherer.

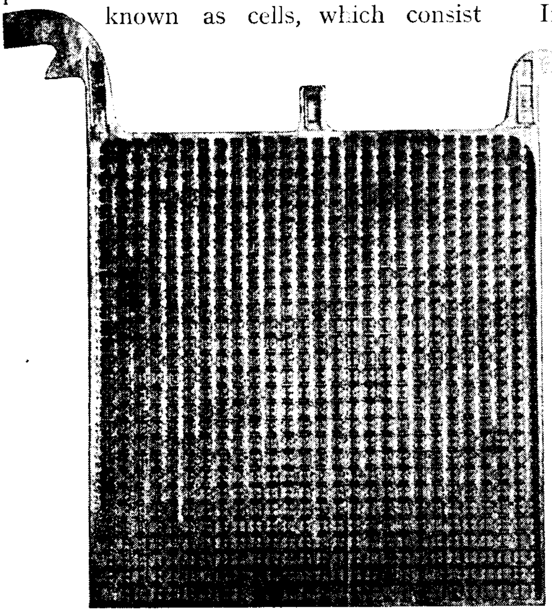
STORAGE BATTERIES: TYPES & APPLICATIONS IN WIRELESS

How Chemical Energy is Converted into Electrical Energy and Vice Versa

Here are described the principles of the storage battery, one of the most useful adjuncts for the wireless experimenter. This important article should be read with the articles under such headings as Accumulator; Battery; Dry Battery, etc.; reference should also be made to the various types of secondary cell described separately in this Encyclopedia, as Edison Cell; Hart Accumulator, etc.

A storage battery is a very well-known electrical appliance for the conversion of electrical energy into chemical energy during the process known as charging, and the reconversion of the latter into the former when discharging.

Practically all storage batteries are composed of a number of individual units known as cells, which consist essentially of a glass or other non-conducting container which holds a solution, usually of sulphuric acid and distilled water. This is known as the electrolyte, and acts upon a pair or number of plates made of lead, known respectively as the anode and cathode, or, more popularly, as the negative and positive.



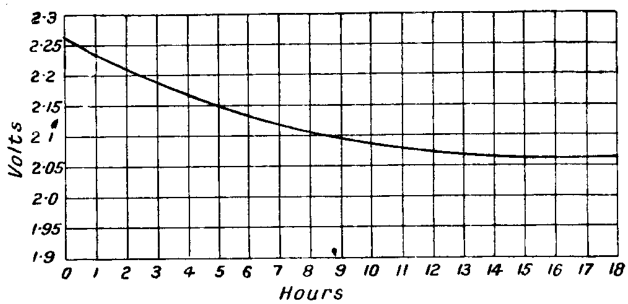
GRID TYPE NEGATIVE PLATE

Fig. 1. Lugs on the top of this plate are provided to afford support on the walls of the container and to act as contact pieces. The grids are clearly visible

Courtesy Hart Accumulator Co., Ltd.

In practice it is customary to employ a number of positive and negative plates, each group joined together, thus making a set of positives and a set of negatives, the purpose being to obtain as large a plate area exposed to the action of the electrolyte as possible. The plates are made of a framework of lead with a large number of apertures which are filled during the process of manufacture with the active material. The function of the plate framework is twofold. Firstly, it supports the active material, and, secondly, it acts as a conductor for the electrical current.

Different manufacturers adopt various methods for forming and shaping the plates. One pattern, as used by the Hart Accumulator Co., Ltd., for negative plates, is shown in Fig. 1, where the apertures or grids are clearly visible. At the top of these plates are lugs or projecting portions, which are provided to support the plates on the walls of the container, and also to act as a



STORAGE BATTERY VOLTS-HOURS CURVE

Fig. 2. Drop in voltage after a number of hours is shown in this curve. Fourteen to sixteen hours elapse before the voltage becomes normal

convenient means for the attachment of the connecting pieces which unite one plate to the others of which the cell is composed. In usual practice the negative plates are filled or pasted with spongy lead, that is, lead in the pure state. The positives are commonly filled with lead peroxide, a hard, brittle substance, chocolate brown in colour.

Before the plates can be used they have to undergo a process known as forming, which is carried out by the makers, and then the batteries appear in the familiar form as seen in shops and elsewhere when purchased. In this condition they are not of any service until they have been filled with acid and properly charged. Charging consists of passing a current of electricity through the cells for a sufficient time, and has the effect of converting the electrical energy from the current flow into chemical energy. When charged, the cell can be left for a time, amounting to perhaps several weeks, and the electrical energy taken from it at any time. The methods of forming and charging and the action of the electro-chemical reactions are dealt with under the heading Accumulators.

Exactly the same basic principles apply to a small cell fit only for the energization of a pocket flash-lamp bulb as to the huge batteries employed in a central station for supply of current to a town. The requirements of each case have to be dealt with on their merits and necessities, and this is perhaps the most difficult aspect for the wireless amateur—to select the type most suitable for a particular class of work.

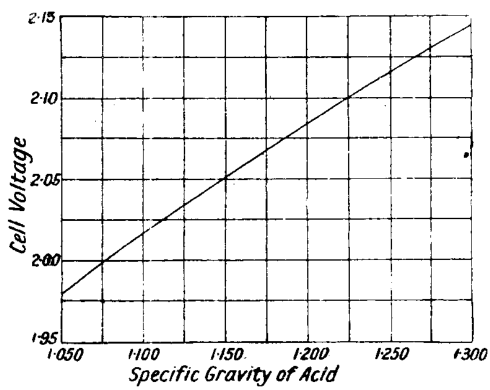
The most important features are perhaps the voltage, capacity and efficiency of a storage battery; and it has to be remembered that the voltage of a fully charged cell when neither discharging nor charging is about 2.1, but this is not a fixed quantity and is affected by many considerations.

The normal open circuit voltage is only attained some hours after charging, as immediately after charging the voltage is abnormally high, but falls rapidly to a normal, at which it will remain more or less constantly for an indefinite time, or until the energy has been utilized by the current demands made upon it. A characteristic voltage drop curve due to the lapse of time is given in Fig. 2, and is reproduced by the courtesy of the D.P. Battery Co., Ltd. This shows the rapid voltage drop for the first few hours, and indicates the necessity of careful adjustment of the filament resistances when a newly charged storage battery is connected to a receiving set.

If attention is not given to this point the valves may be overloaded and suffer.

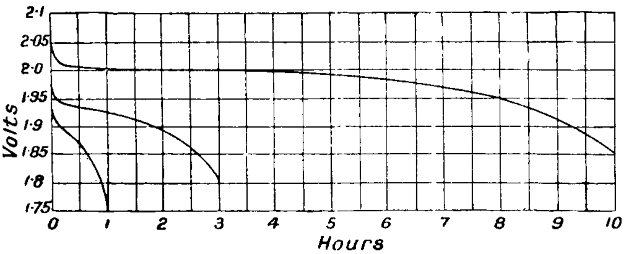
Another matter that bears on the voltage is the effect of acid density, and this is illustrated in Fig. 3 in the form of a curve from the same source. The curve emphasizes the need for the correct density of the acid, that is the proportion of sulphuric acid to water.

An increase in the density, that is the amount of sulphuric acid, increases the voltage, but this has to be considered in the light of other matters, especially the longevity of the cell. The makers always specify the correct density for the solution, and this should be scrupulously adhered to as it is a most important matter.



ACCUMULATOR CURVE

Fig. 3. How the voltage of an accumulator increases with the increase in the specific gravity of the liquid is shown by this curve



STORAGE BATTERY DISCHARGE

Fig. 4. This curve shows how the voltage drops for one-, three- and ten-hour rates of discharge

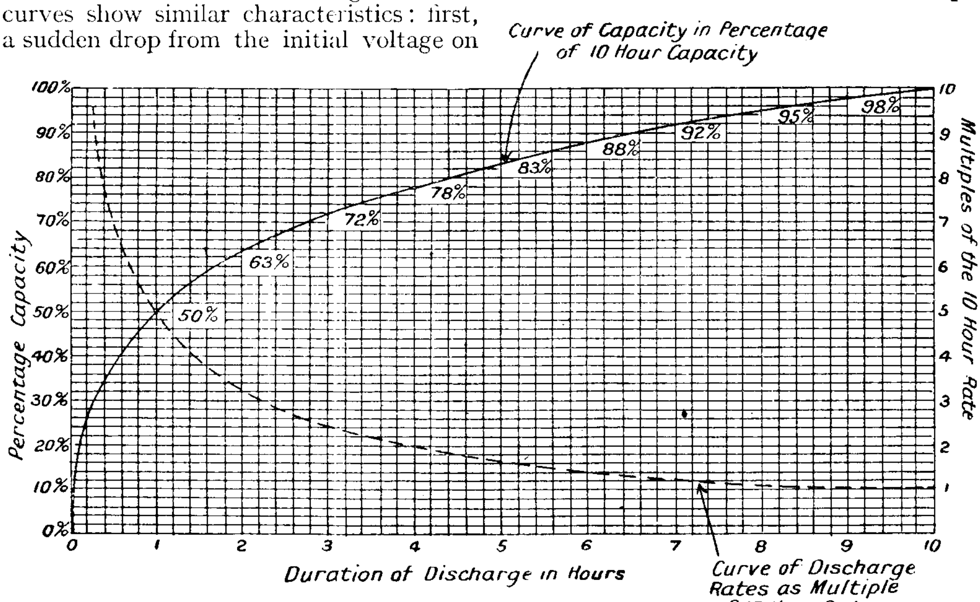
The temperature of the cell has an important bearing on the capacity, but as the amateur and experimenter generally use a storage battery in a comparatively warm room this point seldom need be considered, except to place the storage battery in an equable temperature.

The most important item from a practical point of view is the rate of discharge that can safely be taken from a storage battery, and also the rate of charging. The former is very important when reckoning the time that a battery will serve a particular set without detrimental voltage drop. This is also made readily apparent by a diagram such as that in Fig. 4, which shows the characteristic discharge voltage curves at the one-hour, three-hour and the normal ten-hour rate of discharge. All the curves show similar characteristics: first, a sudden drop from the initial voltage on open circuit, then a more gradual drop, and finally a sudden drop, when all discharge should be stopped and the cells be recharged as soon as possible.

This shows how important it is to use only those batteries that are fully up to their work, and as the voltage drops steadily, it indicates the reason why the filament resistance has to be turned up from time to time on a wireless set to maintain the correct voltage.

Particularly is this the case with sensitive sets, transmission and power-amplifier work with loud speakers, which demand a considerable current from a storage battery.

The capacity of a storage battery is measured in ampere-hours (A.H.), that is, the amount of electricity conveyed by a current of one ampere in one hour. For example, a cell with a capacity of 100 A.H. at the ten-hour rate is capable of sustaining a current of one ampere for 100 hours. It is most important to consider the capacity of any storage battery at some known hourly rate, which is customarily the normal ten-hour rate. This is because the rate of discharge is not strictly proportional to the current and to time. The above example



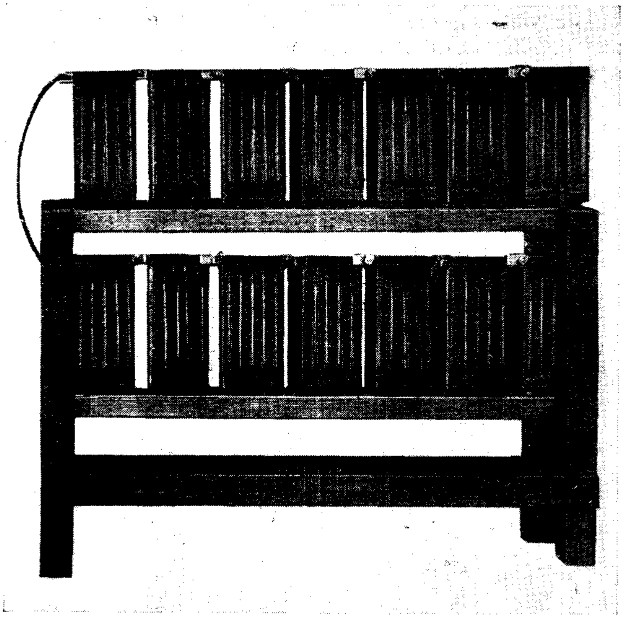
TIME-CAPACITY CURVE OF A STORAGE BATTERY

Fig. 5. Relation between the capacity of a cell and the rate of discharge is shown. Time-capacity is represented by the full-line curve at the top. The curve of discharge rate is dotted

of a 100 A.H. cell at 10 hours would not sustain 2 amperes for 50 hours, nor would it be capable of yielding 50 amperes for 2 hours.

The time-capacity curve, Fig. 5, shows the capacity of any cell and the rate of discharge. The full-line curve is a time-capacity curve applicable within limits to any size or type of lead storage cell, and is published by courtesy of the D.P. Battery Co. The full-line curve is plotted from the percentage capacity of a cell at a constant rate of discharge, against the number of hours during which that rate can be maintained without dropping below the permissible final voltage.

The capacity at the ten-hour rate is taken as the maximum, and the capacity at all other rates is taken as a percentage of this maximum. For example, at the two-hour rate the capacity of the cell is given by the height of the ordinate set up from the point marked 2 on the hour scale to the point of intersection with the curve, and is there shown to be 63 per cent. Thus this curve can be applied to ascertain the capacity of any cell at any rate, provided that its capacity at some one rate is specified. The dotted curve shows the relation between the rate of discharge and the duration of discharge, plotted as multiples of the ten-hour rate, which is taken as unity. For example to discharge a cell at three times the ten-hour rate would only require $2\frac{1}{4}$ hours.



CHLORIDE STORAGE BATTERY

Fig. 6. Made by the Chloride Electrical Company, this storage battery has 14 cells of 2 volts each. The last cell is usually divided from the remainder by a switch, so that it can be used as a stand-by

One of the reasons for this variation in capacity is the fact that at high rates of discharge the chemical action takes place chiefly on the surface of the active material, which speedily becomes exhausted, and the voltage falls in consequence, although there may still be plenty of untouched active material beneath the exhausted layer.

The rate of diffusion of the electrolyte through the active material has an important bearing on this point.

The internal resistance of a cell is composed of the resistances of the metallic plate, the active material, and the electrolyte. It is, however, a matter that is largely beyond the control of the experimenter. The best practical advice is to choose a reliable and reputable make of storage battery and one having good stout plates and ample space for electrolyte. The conductivity of the electrolyte is greatest at about 1·230 specific gravity. The best results are obtained in practice from acid with a specific gravity of 1·215, but when the space is limited the acid density may have to be raised to a considerable amount, probably in the neighbourhood of 1·280.

The stated specific gravity of a cell is therefore some indication of its efficiency, although it may be necessary to sacrifice some efficiency to gain other ends as, for example, in the case of a small portable battery, where weight and size are most important and any slight loss of efficiency not so particular. The best battery for any duty is therefore one that is large enough to provide the needed current at a normal or ten-hour rate of discharge. The plates will be thick enough to offer a minimum of internal resistance; the ample space for the electrolyte will allow of the use of a lower density; while the mechanical strength of the plates will ensure long life.

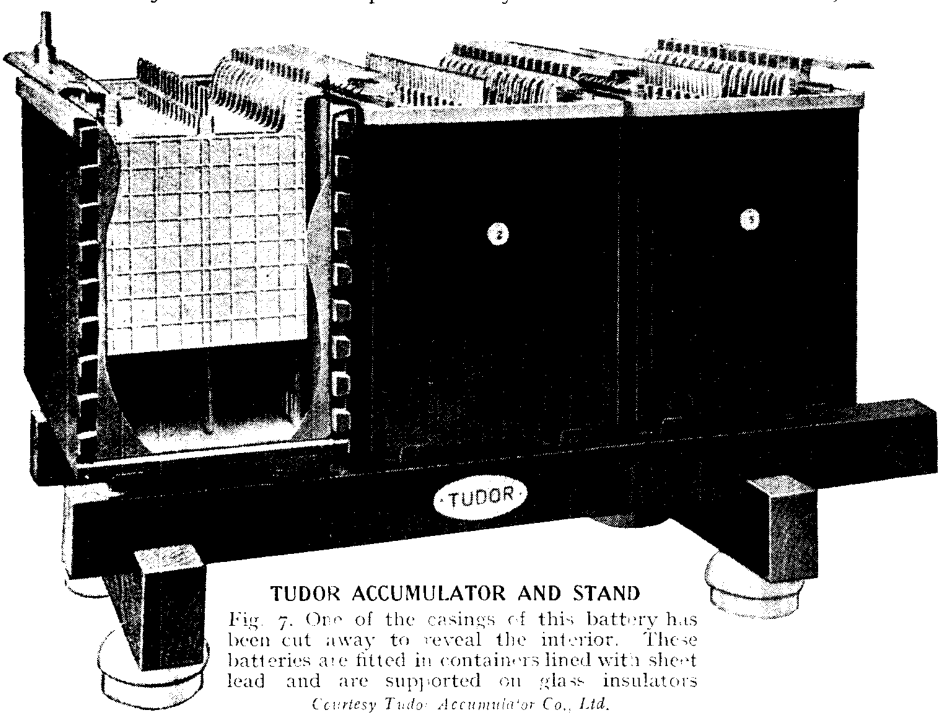
The various conditions of service have resulted in leading manufacturers evolving characteristic types, many of which are described under their proper headings in this Encyclopedia, as, for example, the Fuller Block, the Hart, and the D.P.

Fig. 6 is an excellent example of a storage battery by the Chloride Electrical Co., Ltd., suitable for a 25 volt circuit. There are 14 cells, each capable of delivering 2 volts, and therefore the total voltage from the battery would be 28. In practice there would be a switch in the circuit of the last cell, so that it could be used purely as a stand-by when the voltage of the others had become below normal after a prolonged discharge.

The cells are all of the glass-cased open-topped variety, and stand upon a heavily constructed open wooden framework. The latter is impregnated in order that the acid fumes shall not seriously affect it. Batteries of this description should be placed in a room by themselves, away from any machinery or other plant, for during charge considerable quantities of free acid are liberated from the open tops of the cells, and this is likely to prove injurious to adjacent apparatus.

When such batteries are installed in the house they are available for filament lighting if one or more of the cells be wired separately or tapped for the purpose, preferably the end cells. Alternatively a suitable resistance can be arranged to reduce the voltage to the requisite amount, and the current be taken from the nearest lighting point in the room. Either arrangement gives a practically never-failing source of energy for the filaments of a valve set.

Another type of open-top cell storage battery is the Tudor, shown in Fig. 7, by the Tudor Accumulator Co., Ltd.



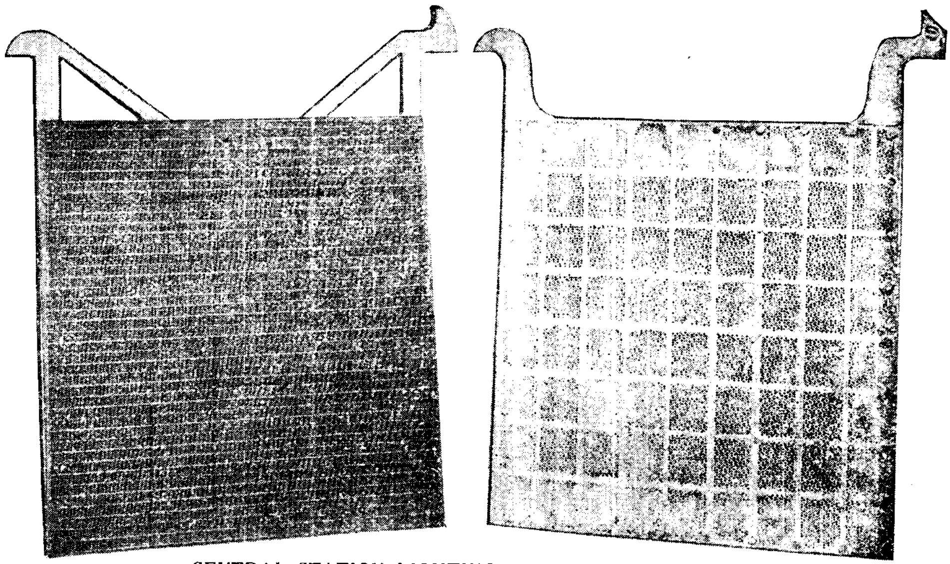
TUDOR ACCUMULATOR AND STAND

Fig. 7. One of the casings of this battery has been cut away to reveal the interior. These batteries are fitted in containers lined with sheet lead and are supported on glass insulators

Courtesy Tudor Accumulator Co., Ltd.

These batteries, which can be used as in the foregoing example, have wooden cases in the larger sizes lined with sheet lead, which is turned over at the top to form an external lip to prevent acid dripping or running down the sides of the box. Each box stands on glass insulators, and is coated with acid-proof paint. The plates rest on glass sheets placed at the inner sides of the box, as is shown in Fig. 7, and each plate is separated from the rest by wooden diaphragm separators.

Plates for most open-top cells have lugs cast on them, as shown in Fig. 8, which illustrates a positive and a negative D.P. plate. The set illustrated in Fig. 9 is of a pattern that is very useful for filament-lighting work or for loud-speaker work, providing ample reserves of electrical energy.



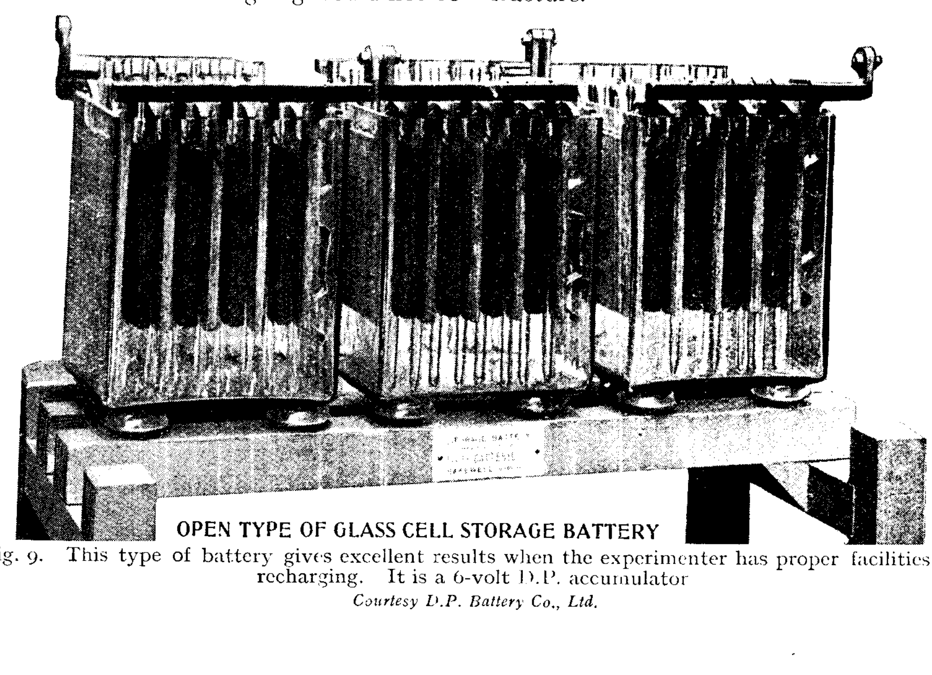
CENTRAL STATION LIGHTING ACCUMULATOR PLATES

Fig. 8. Positive and negative plates of a D.P. battery are illustrated, showing the grid formation and the lugs, which are for support and connexion

Courtesy D.P. Battery Co., Ltd.

Charging would have to be done on the spot, as the weight would render it impracticable to move this type of battery to a charging depot, but the use of a reliable battery homecharger overcomes this defect, and also does away with the annoyance of the failure of a battery due to exhaustion at a time when a broadcast programme of particular merit is to be heard.

Such cells as the foregoing would not be so serviceable on board ship for wireless purposes as those with ample space in the cells for the acid. To prevent the acid splashing over the top as the boat rolled a battery such as that in Fig. 10 has been evolved, and although it follows more or less the same lines as a deep cell, the well-strengthened plates have wide attachments to the lugs, as these are otherwise liable to fracture.



OPEN TYPE OF GLASS CELL STORAGE BATTERY

Fig. 9. This type of battery gives excellent results when the experimenter has proper facilities for recharging. It is a 6-volt D.P. accumulator

Courtesy D.P. Battery Co., Ltd.

Another method is shown in Fig. 11, illustrating the D.P. patent way of virtually building a set of plates into a compact whole by the use of spun glass felt with a wooden backing. This is placed between each pair of plates and the whole united by bands of non-conducting material. Thus all the plates are held firmly and prevented from chattering or moving.

In choosing a battery, therefore, the foregoing considerations should all be taken into account, but in general it will be found that for stationary use, when storage facilities are available, the open-top glass cells are the best. When good capacity is needed, with the means of transporting the exhausted cells to a charging station, the yacht or train lighting types with closed tops are more practical. For purely portable purposes the celluloid-cased small batteries should be chosen.

The size of the required cell can be ascertained if the maximum rate of discharge is known, and the total number of such cells found by reckoning each as 2 volts. Thus, suppose six valves would be in use, each consuming ·4 ampere, the total consumption would be 2·4 amperes, or allowing something for line voltage drops and other losses, a total of 3 amperes. —*E. W. Hobbs.*

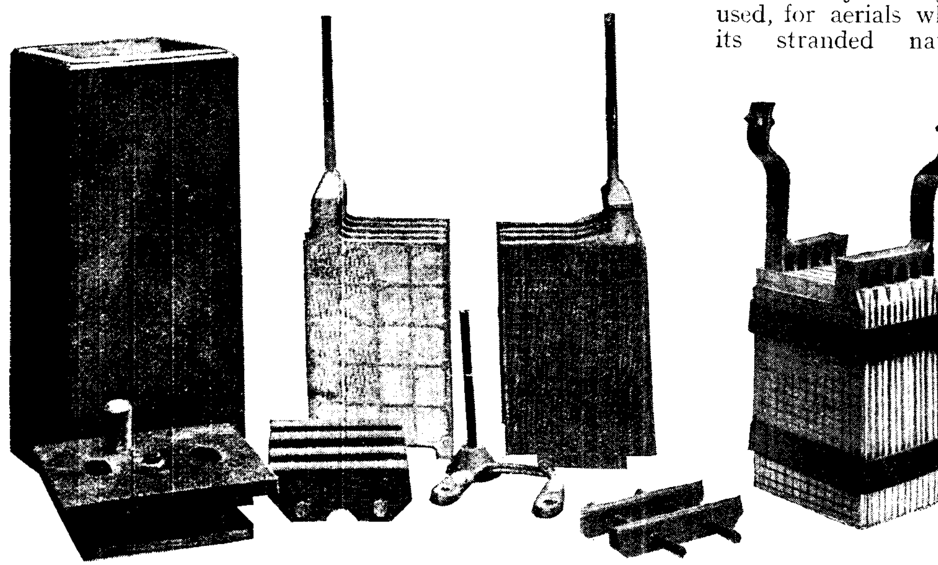
STRAIN ROD INSULATOR

Aerial mast stay wires are sometimes fitted with this kind of strain rod insulator to break electrical continuity

Courtesy Economic Electric Co., Ltd.

STRAIN ROD INSULATORS. The strain rod insulator is a form of insulator used for breaking the continuity of stays or guy-wires used for supporting a wireless mast. The object of the insulators is to break up the stays into a number of short lengths to prevent the loss of signal strength by inductive coupling of the aerial and stay wires. The illustration shows a strain rod insulator fitted with a galvanized iron ring at each end which is screwed in and forms a means of connexion of the stay wires. The strain rod insulator is of particularly robust construction, as it is subjected to the full strain of supporting the mast. Alternatively, porcelain egg insulators may be used. *See* Aerial; Guy.

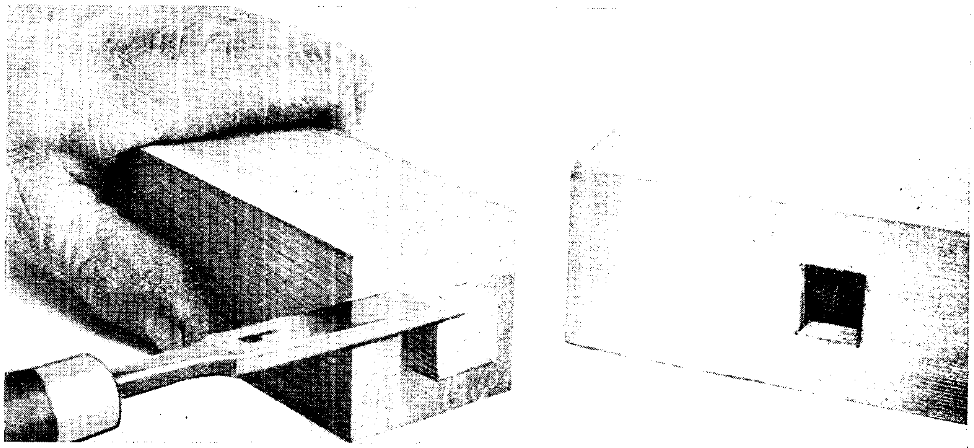
STRANDED CABLE. A form of electric wire consisting of a number of wires twisted round each other to form one conductor. Stranded cable may be insulated or bare, according to the use to which it will be put. An example of each type is illustrated. The bare variety is largely used, for aerials where its stranded nature



SPECIAL D.P. BATTERIES AND THEIR CONSTRUCTION

Fig. 10 (left). This is a special type of accumulator used on board ships. The cell is unusually deep to prevent the acid splashing over the sides as the ship rolls. Fig. 11 (right). Patent separators are used in this accumulator to prevent them from chattering or moving, the plates and separators being held by non-conducting bands

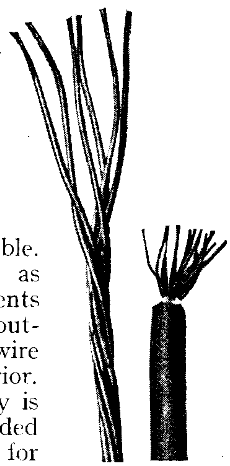
Courtesy D.P. Battery Co., Ltd.



CHISELLING OUT A STUB TENON

After the stub is roughly cut it must be finally fitted with care and precision in order to fit the mortise exactly. A tight fit should be made, and the two parts held together by glue, or alternatively, by both screwing and gluing

has a double advantage. In the first place, owing to the multiplicity of wires the possibility of sudden breakage is reduced, and secondly, greater efficiency is obtained owing to the greater surface area of the cable. This is of advantage, as high-frequency currents tend to travel on the outside, or surface, of a wire rather than its interior. Considerable flexibility is obtainable with a stranded cable, which accounts for its use in telephone leads and other applications where a flexible wire is required. *See* Cable ; Flex ; Litzendraht.



STRANDED CABLE

Two stranded cables are shown. That on the left is uninsulated and used for aerials. The right one is useful for many purposes

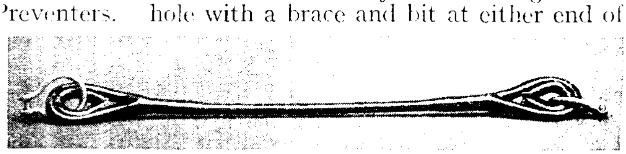
STRAYS. General name for the natural interference in a receiving set due to atmospherics or statics. Such interference is dealt with in this Encyclopedia under Atmospherics and Statics. *See* also Interference Preventers.

STROP INSULATOR. A special form of insulator largely used in ship's wireless installations for insulating the ends of the aerial from their points of attachment to the spreaders. The strop insulator is made of cord and is covered with rubber and vulcanized. A typical insulator of this pattern is shown in the illustration and is fitted with a galvanized thimble at either end. A shackle is provided through each thimble for attachment on one side to the aerial itself and on the other side to the spreader.

The strop insulator is also used to form part of a bridle of the spreader support. *See* Insulator.

STUB TENON. Name given to a particular form of mortise and tenon joint, examples of which are to be found in wireless cabinet work and other parts of the woodwork of a wireless outfit. Essentially, a stub tenon consists of a rectangular peg or projection formed on the end of a piece of timber which is to be jointed to another piece of timber at right angles, which for convenience may be called the framework.

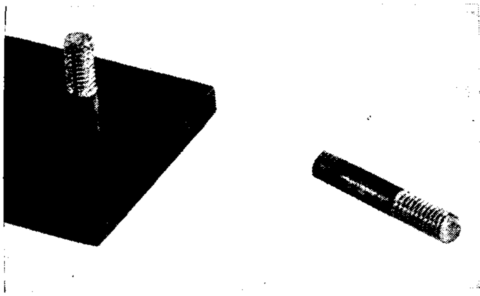
The disposition of the components of a stub tenon is shown in the illustration, from which it will be seen that the framework visible on the right has a rectangular hole, known as a mortise, cut in it. This hole is made by first making a drill hole with a brace and bit at either end of



STROP INSULATOR AS USED ON SHIPS

Insulators of the strop variety are used largely in ship installations. The one illustrated is 3 ft. in length

Courtesy Marconi's Wireless Telegraph Co., Ltd.



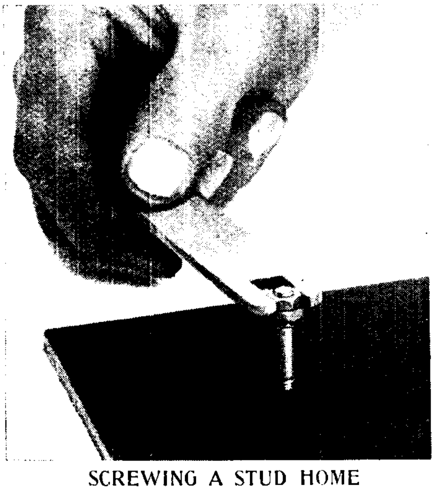
METAL STUD

Fig. 1. Screwed at both ends and used for uniting two or more parts of a structure is a cylindrical piece of metal or section of rod known as a stud

the required mortise, and then cutting out and finishing with a mortise or paring chisel. The size of the aperture is marked out before any work is done, while the end of the upright is similarly marked for the tenon.

The bulk of the wood around the tenon can be sawn away to form this part, but a perfect fit is best obtained by means of chisels, the end grain or shoulders being shaped by vertical paring and the walls of the tenon by horizontal paring in the manner illustrated.

A feature of the stub tenon is that the mortise does not penetrate right through the framework, and that the tenon is shouldered at right angles on all of its four faces. It may be employed in any part of a structure where it is not desired to reveal the end grain of the wood. It should be secured in its place with glue

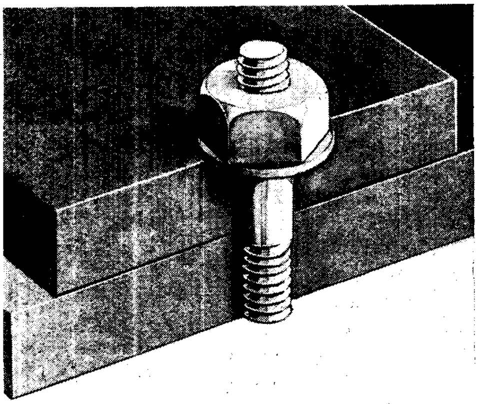


SCREWING A STUD HOME

Fig. 2. By using a pair of lock nuts and a spanner the stud is screwed into a panel when a stud box or key is not available

or screws, usually only with glue. The fit must be very accurate and firm, and the glue can then be relied upon to maintain perfect continuity and security. *See* Cabinet; Joints; Mortise and Tenon.

STUD. Studs are short metal cylinders or rods screwed at each end and used for uniting two or more parts of a structure. They are generally employed when it is impracticable to use a bolt and nut, as, for instance, in fixing some part of an apparatus to a stand or bed of such thickness that it would be undesirable to pass a long bolt through it. The arrangement of such a simple stud is clearly indicated in Fig. 1, where a separate stud is shown on the right, and also a similar stud screwed into its place in a piece of material.



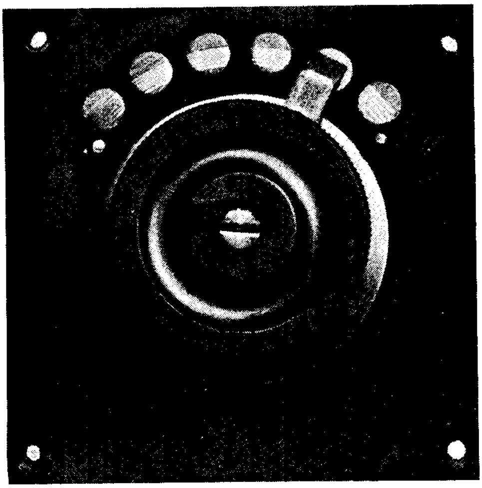
HOW A STUD IS USED

Fig. 3. This sectional illustration shows how the stud clips two pieces of ebonite together

The stud screws into a hole tapped into the material in the ordinary way, except that it is usually a blind hole, and the tapping operation must be performed with extra care. To introduce the stud and screw it up tightly into its place, a simple and practical plan is to employ a stud box or key. This is simply a cylindrical piece of material with a hole drilled through it which screws on to the end of the stud. A set-screw is passed through from the opposite end and tightened on to the head of the stud. The box may then be rotated with a spanner or wrench, and the stud screwed up tightly. The box is released by loosening the set-screw and unscrewing it from the end of the stud.

If this is not available, the plan illustrated in Fig. 2 can be followed. In this case, two nuts are screwed on to the end of the stud and are locked up tightly one against the other. This having been done, the stud is screwed into place with a small spanner, which bears upon both the lock nuts simultaneously. This enables the stud to be tightened up properly, and when this has been done the lock nuts are unfastened by the use of two spanners, rotating them simultaneously but in opposite directions. The studs are removed in a similar manner to that by which they are affixed.

A sectional view of a stud with its nut and washer is shown in Fig. 3, which shows clearly how the lower end of the stud is screwed into the plate. The shank of the stud passes through a clearance hole in the part to be bolted, while the nut and washer bear upon the upper surface of this part.



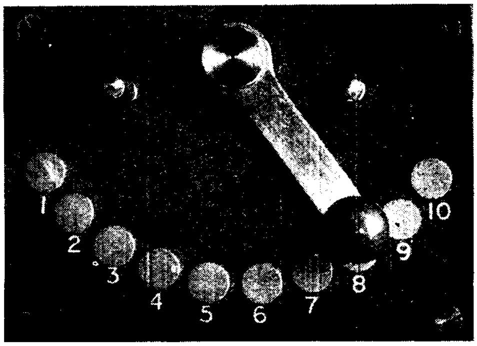
STUD SWITCH WITH LARGE KNOB

Fig. 2. Stop pegs are provided to confine the movement of the contact arm to the crescent containing the studs. A large ebonite knob is attached to the spindle

Courtesy Economic Electric Co., Ltd.

The use of studs is sometimes an advantage in the construction of wireless receiving sets for the attachment of various parts of apparatus, as by drilling blind holes into the back of a panel they obviate the presence and unsightly appearance of a bolt or screw head on the upper face of the panel or other parts of apparatus.

The expression stud is often used as an abbreviated form of the term contact stud, which refers to the studs used for inductance switches and other purposes. This class of stud is dealt with under the heading Contact Stud. *See* Coil; Switch.



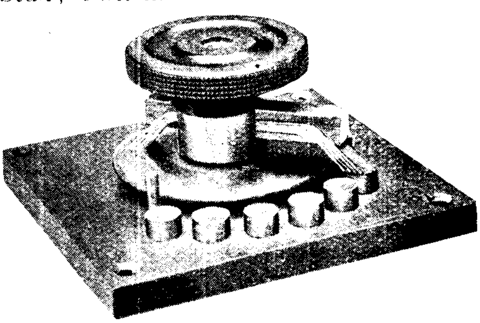
STUD SWITCH FOR PANEL MOUNTING

Fig. 1. An ebonite knob is fitted to the movable handle at the end where contact with the studs is made

Courtesy Economic Electric Co. Ltd.

STUD SWITCH. A form of switch largely used in wireless. It consists of a radial arm capable of movement over a number of flat-headed contacts or studs. A common type of stud switch is illustrated in Fig. 1, and has a brass arm pivoted at one end and fitted with an insulated handle at the other swinging over a range of ten studs. Stop pegs are provided at either end of the studs and limit the movement of the arm over the arc of studs.

A rather more elaborate type of stud switch is shown in Figs. 2 and 3, which give respectively a plan and side view of the switch. Six studs are provided, and stop pegs are provided to prevent the arm from overrunning the studs. The switch arm is made up of three pieces, the arm itself being composed of a series of copper laminations. Equal pressure is given to the spindle of the switch by means of a brass plate on which the back end of the contact arm presses. *See* Coil; Contact Stud; Switch.



SIDE VIEW OF SIX-STUD SWITCH

Fig. 3. Laminated contact arms are employed in this switch. Note the springy construction, which allows of the arm being properly balanced

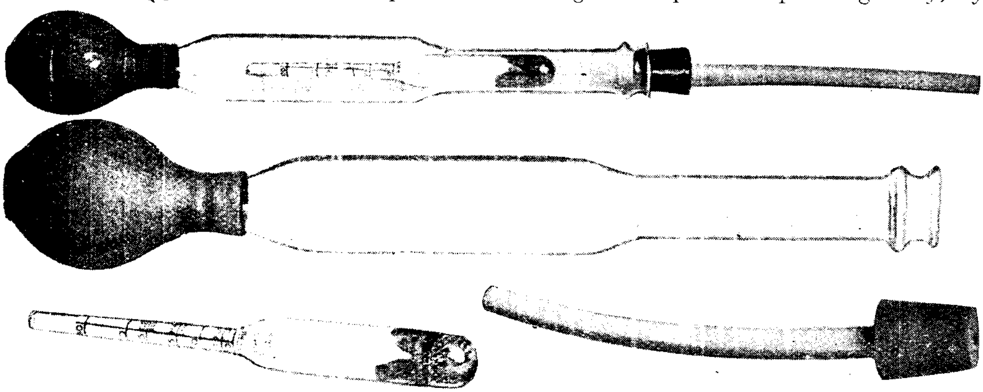
STUFFING BOX. Name given to the small circular container fitted to the outside of a compartment through which a rod projects for ensuring an air- or water-tight connexion between the rod and the compartment.

The most common application of the stuffing box is in connexion with steam engine practice, where the stuffing box is attached to the cover plate of a cylinder for making a steam-tight joint between the piston rod and the cylinder cover plate. Triple-expansion engines suitable for driving large alternators or other high power wireless generating plant are fitted with stuffing boxes.

The stuffing box of a Bradfield type marine insulator consists of a casting having a flanged base for fixing the stuffing box to the upper deck of the ship. The upper portion is a screwed sleeve, which may be screwed up or down by means of a proper gland key. The headings Bradfield Insulator and Gland Key in this Encyclopedia should be consulted.

Through the hole in the centre is passed the stem or lead of the insulator. Asbestos packing, in the form of rings, is used to fill the space between the stem of the insulator and the internal walls of the stuffing box. When the space has been filled to its utmost limit the upper flange is screwed down as far as it will go. The result of this is to compress the asbestos into one solid mass, which has the effect of preventing water penetrating between the box and the stem, and so into the cabin.

Another type of stuffing box is used with some types of accumulators for making an acid-tight joint at the point where the lugs of the plates project through the case. A flat rubber washer is placed over the lug, and lies flat on the case. A celluloid cap, very much resembling a thimble, having a hole at its upper end, is tightly filled with grease or vaseline and placed over the lug so that its lower end lies flat on the washer. A threaded metallic washer, better known as a round nut, is now screwed down on the celluloid cap, and when fully tightened up makes an extremely acid-tight joint. This type of stuffing box is often provided on better-class accumulators and permits them to be placed in a horizontal position without fear of leakage.



SUCTION HYDROMETER ASSEMBLED AND IN PARTS

Fig. 1 (above). Hydrometers of this kind are extremely useful for testing the specific gravity of accumulator acid or any liquid where an ordinary hydrometer could not be used. Fig. 2 (below). The hydrometer is made up of three chief components, as here illustrated

Courtesy Economic Electric Co., Ltd.

SUCTION HYDROMETER. A form of hydrometer which allows of the convenient testing of a liquid for specific gravity, by employing suction to cause the removal of a sufficient quantity of the liquid for test purposes.

It is frequently impossible to float a hydrometer in a liquid owing to lack of space in the container in which the liquid is normally housed. This difficulty obtains in all forms of portable accumulators and a great number of storage batteries. In the case of the former types the only access to the electrolyte is through a small filler hole in the top of the case, and in the latter type there is insufficient free acid round or between the plates.

For these reasons it is necessary to obtain a test sample of the acid without disturbing the battery, and the suction type of hydrometer fulfils this need.

In this type of instrument there is a tubular container in which the actual floating portion of the hydrometer is free to move. The tube has a rubber continuation at one end so that it may be inserted through a narrow opening, such as is found in the top of an accumulator, and at the other end is a rubber bulb which, when compressed by the fingers, causes a partial vacuum in the tube. Thus, when the open end of the latter is inserted in the electrolyte and the bulb is released, a portion of the liquid is drawn into the tube. This liquid surrounds the hydrometer, and the latter indicates the specific gravity by floating at a certain height relative to a scale.

An instrument of this type is shown complete in Fig. 1 and in parts in Fig. 2. Referring now to Fig. 1, it will be seen that the outer glass tube is narrowed at its lower portion so that the hydrometer may slide freely within it, but at the same time is given a certain amount of support to keep it upright in the tube. The top end of the tube is also narrowed about its neck, to receive the open end of a rubber bulb. A rubber cork attached to a length of tubing of the same material is fitted to the lower end of the glass tube.

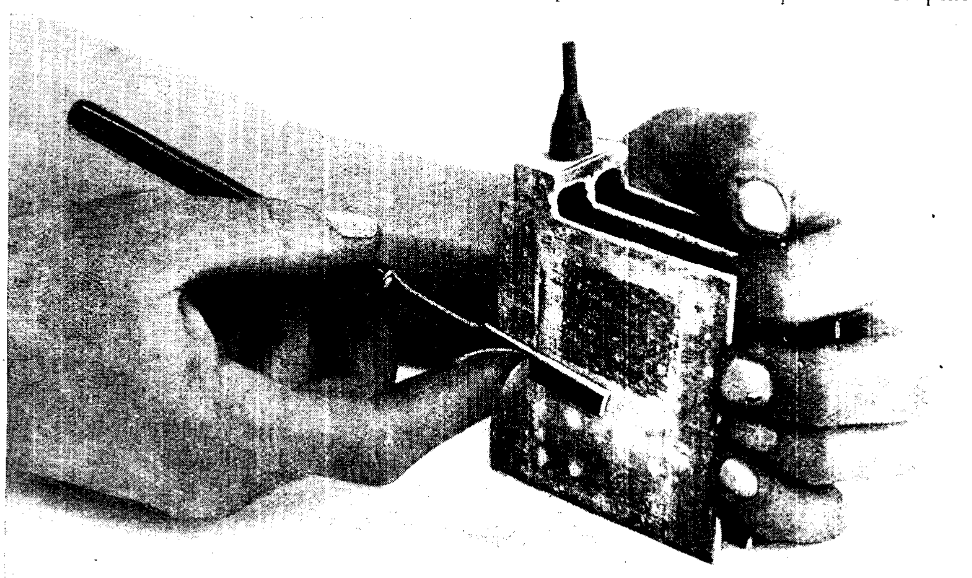
It is obvious that if the bulb is compressed in the hand and the rubber tube inserted in the electrolyte to a sufficient depth, a quantity of acid will be drawn into the tube when the bulb is released.

When this is accomplished, the whole instrument may be removed from the accumulator and the position of the hydrometer float ascertained. The latter contains a graduated scale which is marked with a red line at the position it should float if the specific gravity is correct, *i.e.* at 1·200.

Fig. 2 indicates the construction of the individual components more clearly. From this it will be seen that the float is weighted at its lower end. This weight is adjusted during manufacture, so that the instrument reads correctly. Lead shot is generally used for the weight, and in this case a quantity of cement has been added to prevent the shot from moving about inside the tube. It is convenient to have the rubber tube detachable, its removal facilitating the cleaning of the instrument. *See* Accumulator; Specific Gravity.

SULPHATING. Term used in connexion with lead sulphate working out of the surface of the plates of an accumulator in the form of almost insoluble crystals which are poor conductors of electricity and difficult to remove.

The conversion of the active material of the plates into lead sulphate takes place



REMOVING SULPHATE FROM ACCUMULATOR PLATE

Sulphating is a common occurrence in accumulators, and should be avoided by proper care and attention. The white sulphate should be carefully scraped off, as shown above, with a steel scraper during discharge of the accumulators and is the normal reaction which ordinarily causes no damage, as the sulphate is in a form that is easily soluble during the charging process under normal conditions. But when the cells are allowed to stand for any length of time in a discharged condition the sulphate not only increases in bulk, but becomes hard. An indication of the sulphating of the plates is given by the white spots on them. A sulphating cell, too, may be easily detected by the fact that the specific gravity of the acid at the end of a charge is less than it was at the end of the first charge, due to the fact that the plates have not liberated as much acid during charge as they took up during discharge. Part of the acid has been used to form the insoluble sulphate.

When sulphating has occurred and is not too deep-seated it may be remedied by long-continued charging at a low rate, say at half normal charging current, and when full gassing occurs, at quarter normal. When a cell is badly sulphated it will be cheaper to buy new plates.

To prevent sulphating the cells should not be allowed to stand for any length of time in a discharged condition. A cell may become sulphated by the addition of excess acid to the electrolyte; by an internal short circuit; or by drying out caused by failure to keep the electrolyte at its proper height, and all these points should be carefully watched. A too rapid discharge or an insufficient charge may also cause sulphating. *See* Accumulator.

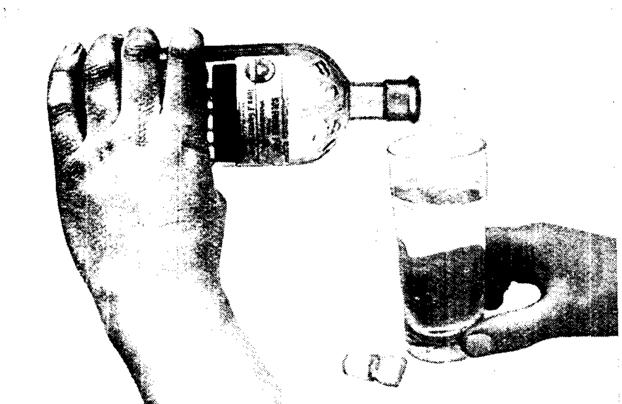
SULPHUR. One of the non-metallic elements. Its chemical symbol is S and its atomic weight 32·06.

Sulphur is only important in its combinations in wireless. It is a constituent of many crystal detectors, as iron pyrites, molybdenite, chalcopyrites and bornite. In itself it is a good insulator. *See* Crystal.

SULPHURIC ACID. One of the common and best known acids, sulphuric acid is a chemical compound containing two atoms of hydrogen, one atom of sulphur, and four atoms of oxygen in each molecule, or, in chemical symbols, H_2SO_4. Its use in wireless is as a chemical source of free electrons. The usual strength of battery acid, varying from 10 to 25 per cent of sulphuric acid, is a compromise between the need for quantity of acid and regard for good conductivity. Commercial sulphuric acid is used industrially mainly in a raw or impure state. For accumulator acid the acid should be free from impurities not ordinarily required in chemicals.

Accumulator acid is made by diluting pure, strong sulphuric acid with distilled water. Makers of batteries only use branded makes of accumulator acid guaranteed free from nitrates, chlorides, lead and other metals. Contamination with nitrates will cause lead from the plates to go into solution as lead nitrate. During each charge this is decomposed back into lead ions (and lead sulphate formed therefrom) and ionized nitric acid, which again attacks the lead plate. Thus this regenerative action will quickly lead to sulphation and deposit of lead sulphate on the plates of the battery and at the bottom of the storage cell. Chlorides will act in the same way, but more slowly, owing to the greatly diminished solubility of lead chloride. Arsenic and phosphorus will affect the spongy metal of the negative plate in like manner. Foreign metals are less harmful; in fact antimony is often added to the lead framework of accumulator grids.

Distilled water should be used for making accumulator acid, and not tap water, as is so often the case.



DILUTING SULPHURIC ACID

Sulphuric acid should be poured into water to form a dilute solution. It is dangerous to pour water into the acid to form a diluted solution, as the heat generated may break the vessel, the action being very violent between the water and the acid. The above illustration shows the correct method

Special regulations apply to the transport of sulphuric acid. A new accumulator is usually sent dry, but the purchaser should get the maker to send the necessary acid with it. When circumstances render preparation of accumulator acid a necessity, this should be made by adding gradually, and in small portions, strong sulphuric acid of specific gravity 1·840, two parts to eight parts of distilled water, as shown in the illustration. The water should never be added to the acid, as the heat generated may crack the containing vessel. The addition of water should give an acid of specific gravity about 1·225. A hydrometer should be used, testing when mixed solutions have become cold, as the strength of the strong acid is liable to vary owing to the absorption of water.

Strong sulphuric acid is a dangerous and corrosive chemical, and extreme care must be observed in handling it. Drops and drains must be removed at once. The more dilute accumulator acid has also a very destructive action on clothes and wood owing to gradual concentration by evaporation. When it is desired to counteract the effects of acid spilt upon clothes dilute solutions of ammonia or sodium bicarbonate should be used. Strong solutions may make matters worse by generating heat and immediately burning a hole in the material. *See* Accumulator.

SUPER-REGENERATION. Term used to designate the principle embodied in a class of wireless receiving sets that function at well over the normal oscillation point, where distortion appears in the usual circuits. Virtually a super-regenerative circuit is one that is adapted to enable reception to be heard satisfactorily under conditions of oscillation that in a normal type of set would only result in shrieks and howls. It is well known that when a simple detector valve set with reaction is tightly coupled the signal strength increases to a maximum, and then if the coupling be very slightly increased there will be a further increase in signal strength of a very high order for a small fraction of time, followed by the set breaking into violent oscillation. The purpose of the "super circuits" is to take advantage of this great increase of signal strength, and by suitable controls to allow the set to operate steadily under those conditions.

Much valuable work in this direction has been done by E. H. Armstrong, and his circuits are dealt with at length under the heading Armstrong Super-Regenerative Circuits in this Encyclopedia.

The outstanding feature of super circuits is the tremendous amplification they give; this is so great that it is not as a rule practicable to use these sets on an outdoor aerial, excellent results being achieved with a small indoor or frame aerial. This is a point that has to be studied by the experimenter, as these circuits are invariably difficult to tune, and usually require a certain amount of experiment to obtain the exact values of the components. When, however, the set is once mastered, the results are surprisingly good. A single-valve set functioning on a frame aerial will bring in a station about as loud as a normal two-valve set.

One of the advantages of such a set is that when properly used the circuit amplifies modulated transmissions, such as telephony, to a greater extent than it does spark or damped wave signals, thus tending to reduce the annoyance of interference. There is, however, a peculiar sound associated with super circuits when in proper operation that is difficult to describe, but which may be likened to an almost inaudible rushing or shrieking sound that gives the impression of the passage of enormous power.

This is not at all objectionable, and with a little experience is unnoticeable. In the practical use of the circuits by a novice the usual stages are: first, a good deal of trouble is encountered in picking up a station; this is followed by a period of distortion and then curious bubblings and screeches are heard; but this finally gives way to a wonderfully powerful reception. When the set is in proper operation all these objectionable noises cease and the reception is as pure and true as can be desired. The experimenter who tackles a super receiver will find it most fascinating, but must be prepared to give the time and patience to secure these results.

There are several ways of securing super-regeneration. The Armstrong and Flewelling methods are dealt with under their respective headings. Modifications of these circuits are numerous, and as a greater comprehension of the practical points in the design are more widely appreciated other circuits will probably be evolved. *See* Tuning.

SUPER-REGENERATIVE SET: HOW TO BUILD AND TUNE IT

A Wonderfully Efficient Set Built on the Flewelling Principle

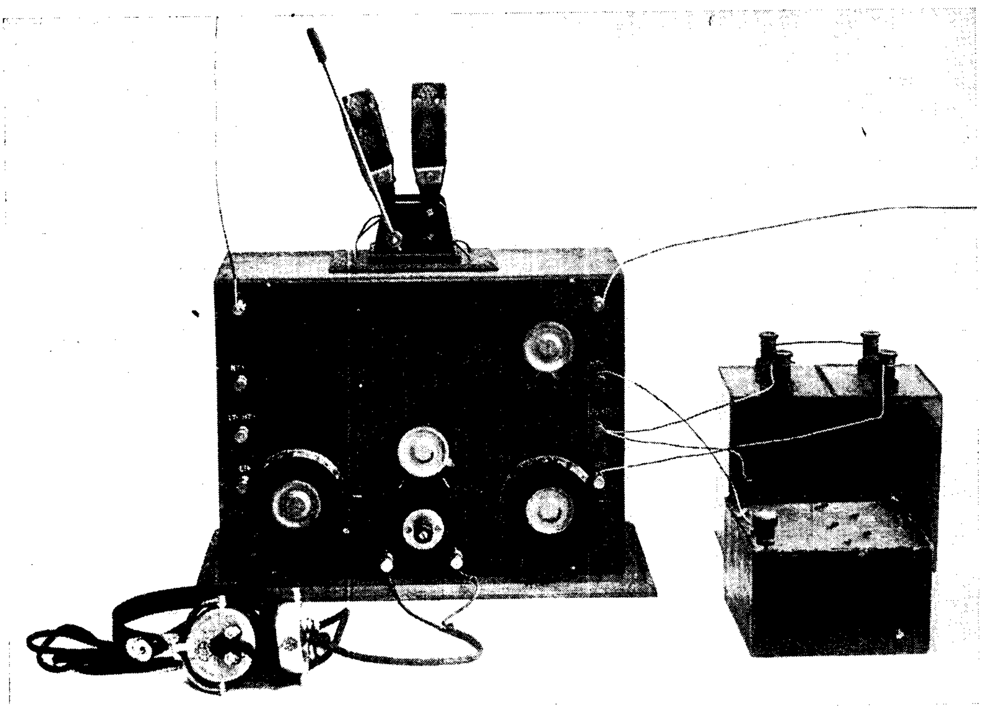
As it is being more widely understood, super-regeneration is steadily becoming more popular. Here the construction of a set on Flewelling's Principle is fully described and illustrated. The headings Armstrong Circuit; Flewelling Circuit, should be consulted; see also Amplification; High-frequency Amplification; Reaction; Regeneration

Super-regeneration is caused in many ways. The Armstrong and similar circuits utilize an oscillator for securing super-regeneration, while by other methods—for example, the Flewelling circuit—super-regeneration is obtained by condenser discharge ripples which act upon the grid of the valve. The theory of super-regeneration as obtained by this circuit is explained under the heading Flewelling Circuit.

A completed single-valve set embodying a modified form of the Flewelling circuit is shown in Fig. 1. This set may easily be constructed with the components usually present in a single-valve regenerative set, the only addition being a fixed condenser of ·005 mfd. capacity. In order to form a comparison between the Flewelling circuit and the ordinary detector valve circuit using reaction, a switch is incorporated in the set by which either of the two circuits may be used.

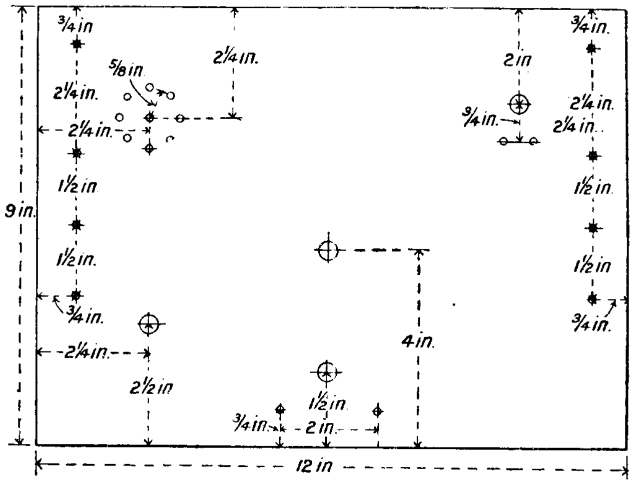
The switch is shown in Fig. 1 to the top right side of the set. At the bottom of the panel and on either side of a filament resistance and a variable grid leak are arranged two variable condensers. The variable condenser to the right is of .0005 mfd. capacity, and is used for tuning the aerial circuit, while the condenser to the left of the panel is of the vernier type, and is shunted for obtaining fine tuning across the larger one.

The panel is made from $\frac{3}{16}$ in. best quality ebonite and is cut and drilled to the instructions given under Ebonite in this Encyclopedia. Fig. 2 gives the



COMPLETED SINGLE-VALVE SUPER-REGENERATIVE SET

Fig. 1. In this super-regenerative set, easily constructed by the amateur at home, a form of Flewelling circuit, with modifications, is embodied. The only component not ordinarily found in single-valve receivers employing super-regeneration is the fixed condenser of ·005 mfd. capacity. The switch controlling the two circuits is at the top right-hand corner



DIMENSIONS OF THE PANEL

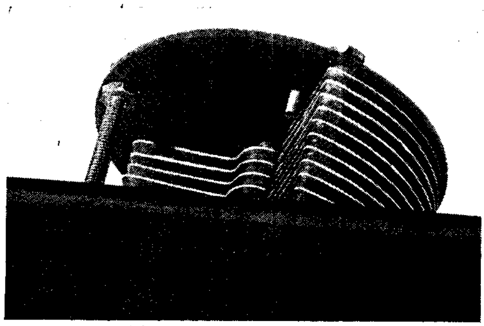
Fig. 2. Holes for the panel components of the super-regenerative set shown in Fig. 1 should be drilled in accordance with this diagrammatic lay-out

dimensions and positions of the principal holes required in the panel. Battery terminals are attached to both edges of the panel, which is useful where the addition of a low frequency amplifier may be required.

A feature of the aerial tuning condenser is the arrangement of a stop peg fitted at the back of this component which limits the scope of the moving plates to 180° from maximum to minimum capacity. The device may be adapted to the great majority of variable condensers of the air dielectric variety. A small piece is cut away towards the end of the outside moving vane, sufficiently wide to permit the entry of the stop peg. The stop peg, which consists of a rounded piece of ebonite, is driven through a hole in the end plate to register with the slot cut in the moving vane. The illustration of this feature seen in Fig. 3 shows the method quite clearly.

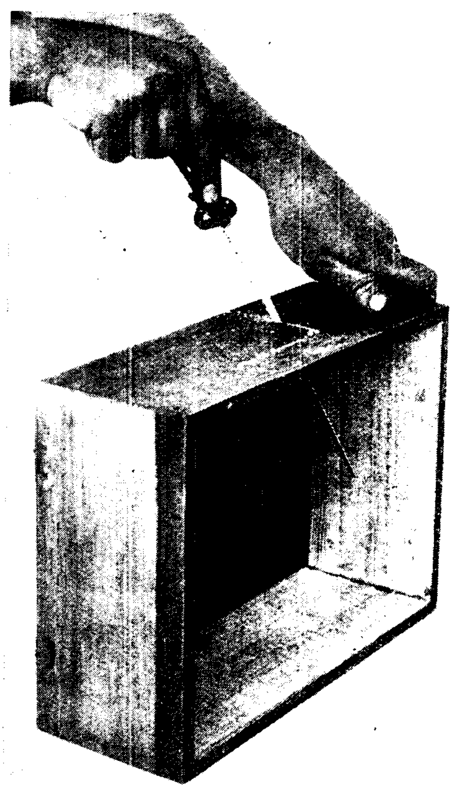
The case for the instrument is of simple box-like construction, having a depth from back to front of $4\frac{1}{2}$ in. The panel fits to the edges of the case as shown in Fig. 1. A small base with bevelled edges is attached, as shown, to the bottom side of the case.

A two-coil holder is fitted to the top of the case and is mounted to an oblong platform of ebonite. The connecting wires to the coil holder are carried through a square hole cut in the top



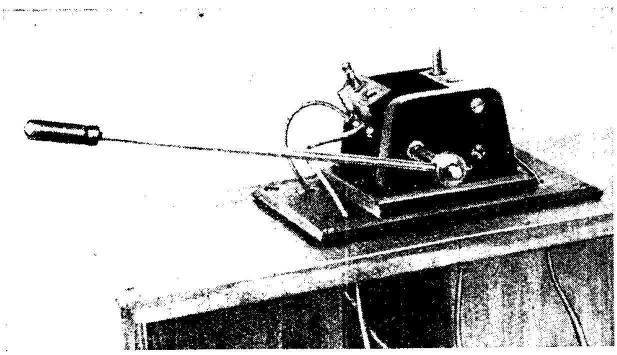
CONDENSER STOP PEG

Fig. 3. Ebonite (painted white here, for clearness) is the material from which the stop peg is made. It is driven through the end plate to register with the slot previously cut in the moving vane



CONSTRUCTING THE CABINET

Fig. 4. Connecting wires leading to the coil holders pass through an oblong hole cut in the top of the case by means of a keyhole saw



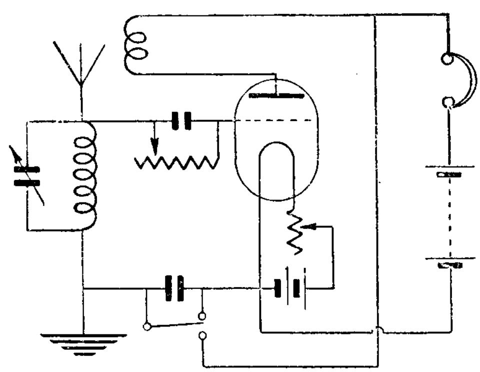
COIL HOLDER AND CONNECTING WIRES

Fig. 5. Led through the hole in the top of the cabinet, and through the coil-holder base, the connecting wires for the two coils are attached in the manner shown

of the case underneath the position of the coil holder. This hole is cut with a keyhole saw as shown in Fig. 4. A small hole is first drilled to permit the entry of the saw blade. The position of the coil holder on the top of the cabinet and method of attachment of the connecting wires to it is illustrated in Fig. 5.

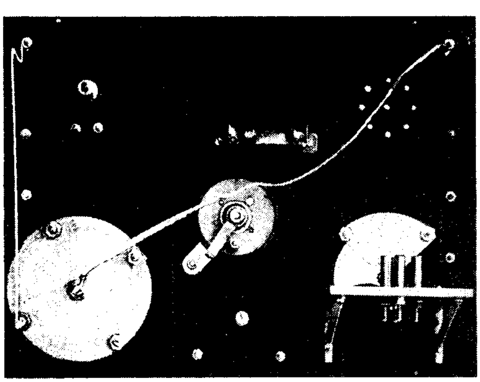
The valve is mounted to an ebonite platform attached to the back of the panel behind the vernier condenser. Valve sockets may be used in place of a valve holder. Fig. 6 gives a view of the back of the panel and shows the positions of the main components. The ·005 mfd. fixed condenser for obtaining the Flewelling effect is shown in this illustration just above the filament resistance, while below these components is seen the end view of the variable grid leak. The grid leak plays an important part in the operation of the receiver, and it is advisable when purchasing to secure a component of good quality. It should have a variable resistance from 1 to 5 megohms. In Fig. 6 the preliminary wiring is started, and shows the connexions of the variable condenser to aerial and earth terminals.

The wiring diagram is shown in Fig. 7. To assist the experimenter in the wiring, a number of illustrations are given of progressive stages of the wiring, where previous stages are shown dotted with black to enable the last addition of the wiring to be singled out. Fig. 8 shows the completion of the aerial tuning circuit, and also the connexion to the reaction coil. The next stage of wiring, shown in Fig. 9, gives the connexion from the grid to the grid leak and condenser and from there to the aerial.



THEORETICAL CIRCUIT DIAGRAM

Fig. 7. Though simple in appearance, the wiring of the set is not quite so easy as it looks, and the constructor should study carefully the illustrations that deal with this subject



REAR OF PANEL WITH FITTED COMPONENTS

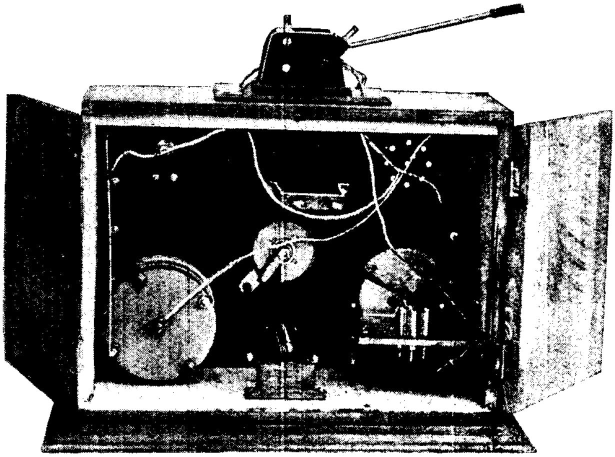
Fig. 6. Just above the filament resistance is the fixed condenser, and below is the variable grid leak. This first stage in the assembling shows the wiring of the tuning condenser

The low-tension circuit is completed in Fig. 10, where the terminals on the opposite sides of the panel are wired together. This illustration also shows the low-tension negative connexion wired to one side of the switch. The high-tension circuit, including the connexion to the other stud of the switch is shown in Fig. 11. Fig. 13, in which is shown the variable vernier condenser shunted across the larger condenser, gives the completed wiring. The switch arm is shown joined to one side of the large condenser and earth terminal in this illustration.

Before the set is put into operation all traces of foreign matter, such as sawdust or soldering flux, should be removed to avoid the possibility of electrical leakages.

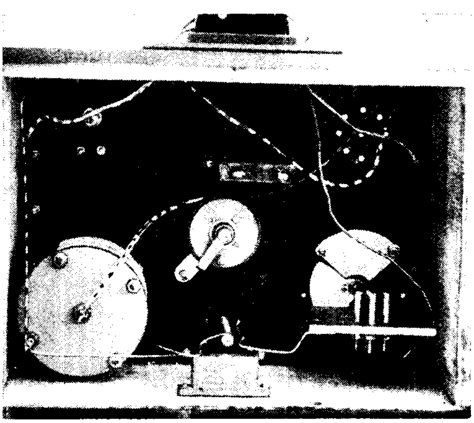
On a standard P.M.G. aerial a No. 50 duo-lateral coil will be found suitable for the aerial tuning inductance. The reaction coil may best be found by experiment, a No. 75 coil being the most useful. Any type of hard receiving valve may be used in connexion with suitable high- and low-tension batteries.

In operating the set the switch arm should first be placed on the stud where the set operates as a standard regenerative set. Having found the correct condenser settings for the station to be received, the switch may be changed over to the other stud.



EARLY STAGES IN THE WIRING

Fig. 8. Here the aerial tuning circuit is completely connected, and connexions with the reaction coil are also shown in position. Notice how the accessibility of the set from behind is assured by fitting hinged doors

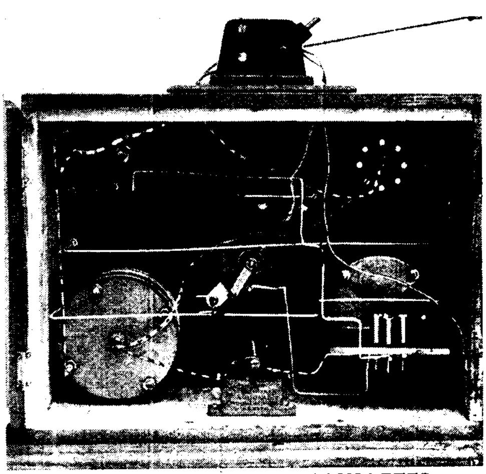


FURTHER STEPS IN THE CONNEXIONS

Fig. 9. The second stage in the wiring involves the connexion of grid and grid leak, and condenser to aerial. To avoid confusion different wires are dotted

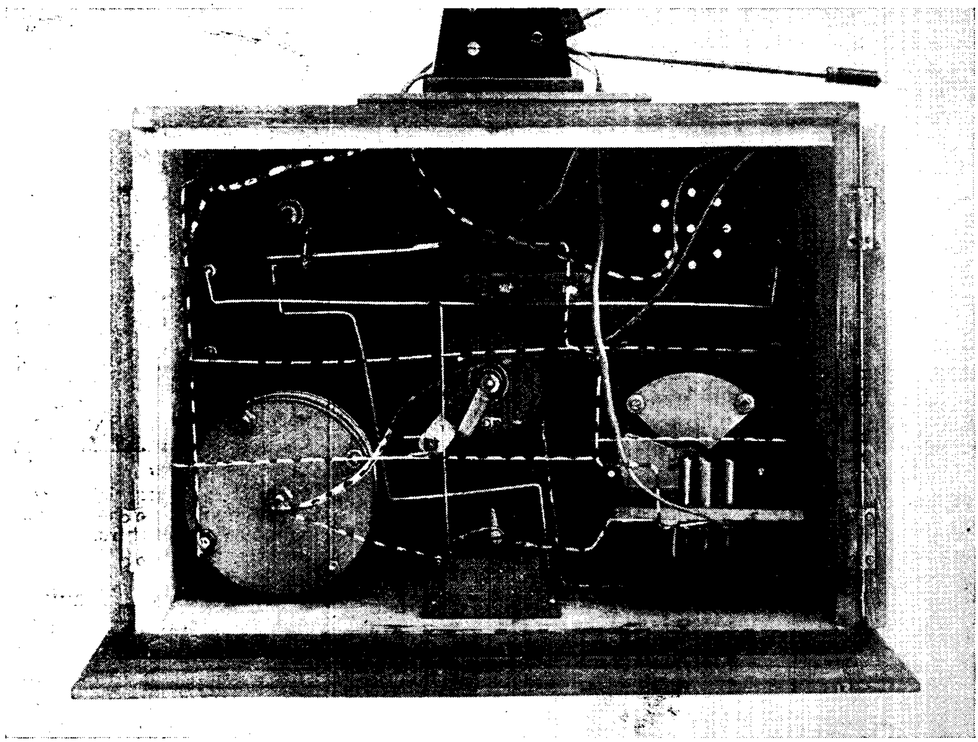
To obtain good results on the Flewelling circuit, a considerable amount of experimenting with the variable grid leak will probably be found necessary. The coupling of the reaction should be tightened until a high-pitched whistle is heard in the telephones. At this stage the set will probably be found to be extremely unstable and susceptible to body capacities. Advantage will be found in the use of long anti-capacity handles for the final adjustments of the grid leak and vernier condenser. At one setting of the grid leak a powerful throb may be heard in the telephones, and the value of the H.T. battery and filament voltage should be adjusted to eliminate this. The correct setting will be found just beyond this point, and may be finally tuned with a micrometer adjustment of the grid leak.

Another type of single-valve super-regenerative set is illustrated in Fig. 12. Super-regeneration is obtained in this set



LOW-TENSION CIRCUIT COMPLETED

Fig. 10. One stud of the switch is here shown connected to give the negative. The terminals on opposite sides of the panel, it will be observed, are wired together



HIGH-TENSION CIRCUIT COMPLETELY CONNECTED

Fig. 11. It will be observed in this illustration that the switch stud unoccupied by the low-tension circuit, as shown in Fig. 10, is here employed for high tension. Notice how the battery terminals of the set are carried right across the entire width of the panel

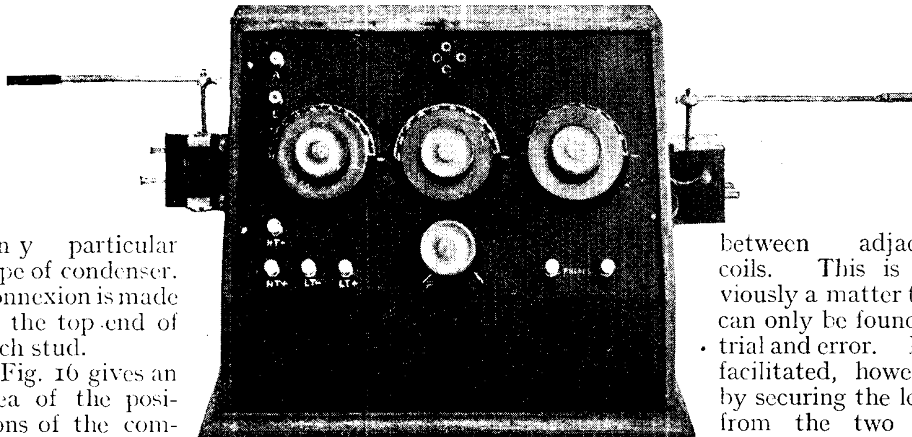
by means of two large value duo-lateral coils with suitable condensers, the frequency being adjusted to give the correct damping action to the grid of the valve.

When the frequencies of the large coils have been correctly adjusted results equal to many two- or even three-valve sets are obtainable. In common with the majority of super-regenerative sets, tuning is at first a tedious business, and the set is therefore more suited to the true experimenter than to one who merely requires a set for listening regularly to a broadcasting station. With this receiver broadcasting from a station well over 200 miles was received in the telephones at good strength.

In the construction of the set a panel is required measuring $11\frac{1}{2}$ in. by $7\frac{3}{8}$ in. This should be cut from the best quality ebonite of $\frac{3}{16}$ in. thickness. Dimensions for the principal holes in the panel are given in Fig. 15, which in conjunction with subsequent illustrations will enable the correct positions of the components to be ascertained. Three variable condensers are required, and are mounted in line along the centre of the panel. The condenser to the left in Fig. 12 is of ·0005 mfd. capacity, and tunes the aerial circuit. The central condenser is wired across the No. 1,250 coil, and has a value of ·00075 mfd. capacity.

The remaining variable capacity has a maximum of ·001 mfd. capacity, and is shunted across the No. 1,500 coil. It is of great importance that the value of all condensers mentioned in the construction of the set should be adhered to, as they play an important part in its functioning. For this reason, in order that fixed condensers of different values may be quickly changed, brass arms are arranged on the panel so that condensers of varying sizes and height may be substituted quickly. This feature is shown in Fig. 14.

Short studs of 4 B.A. screwed rod are screwed into the panel on either side of the condenser positions. A lock nut tightens each stud securely to the panel. A strip of springy brass having a hole at one end is slipped over the stud and a lock nut tightened down on the top of it. The arm may thus be turned to accommodate



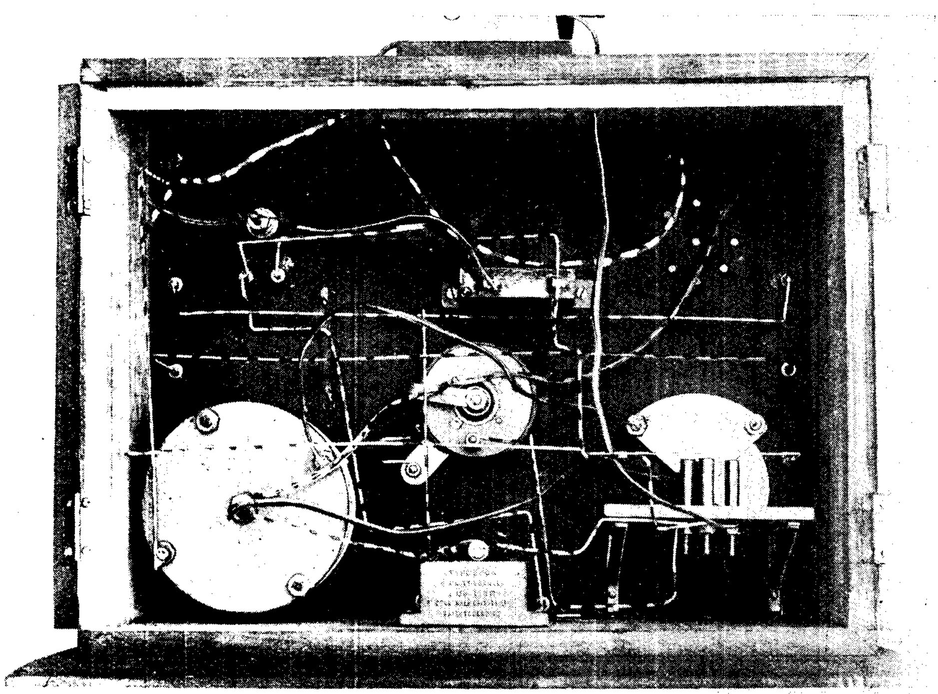
OSCILLATOR SINGLE-VALVE SET

Fig. 12. Another type of super-regenerative receiver that will give excellent results. This is the completed instrument before the reaction and tuning coils have been attached to the coil holders on either side

any particular type of condenser. Connexion is made to the top end of each stud.

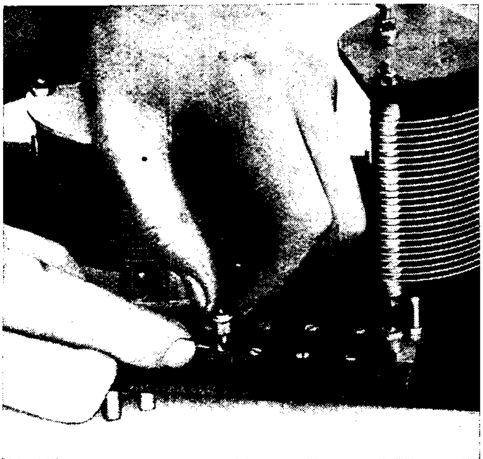
Fig. 16 gives an idea of the positions of the components, and in this illustration a part of the wiring is shown. Some amount of experimenting is required to ascertain the correct way of connecting up the aerial tuning coil with the reaction coil, and also the two large coils, in order to get magnetic coupling between adjacent coils. This is obviously a matter that can only be found by trial and error. It is facilitated, however, by securing the leads from the two coil holders, into which the four coils are plugged, to terminals arranged in double pairs at the back of the panel.

Appropriate connexions to other parts of the apparatus are made by securely fastening the wires under the terminals. The terminal holes are thus left clear, and



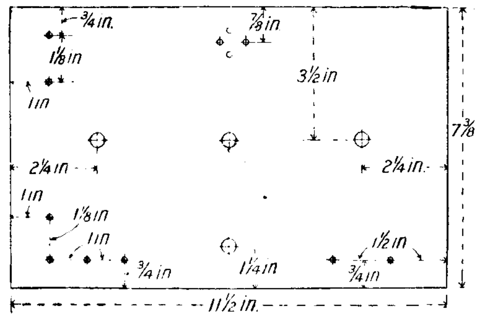
COMPLETED WIRING OF THE FLEWELLING SINGLE-VALVE RECEIVER

Fig. 13. This illustration completes the series in pages 1916–1920. Observe how the variable vernier condenser is shunted across the larger one. To one side of the latter the switch arm is joined, connecting thus with the earth terminal. Dotted wires show the paths of different connexions



CONSTRUCTIONAL DETAILS

Fig. 14. Special brass clips are made to support the condensers, so that others of different value may be substituted if necessary



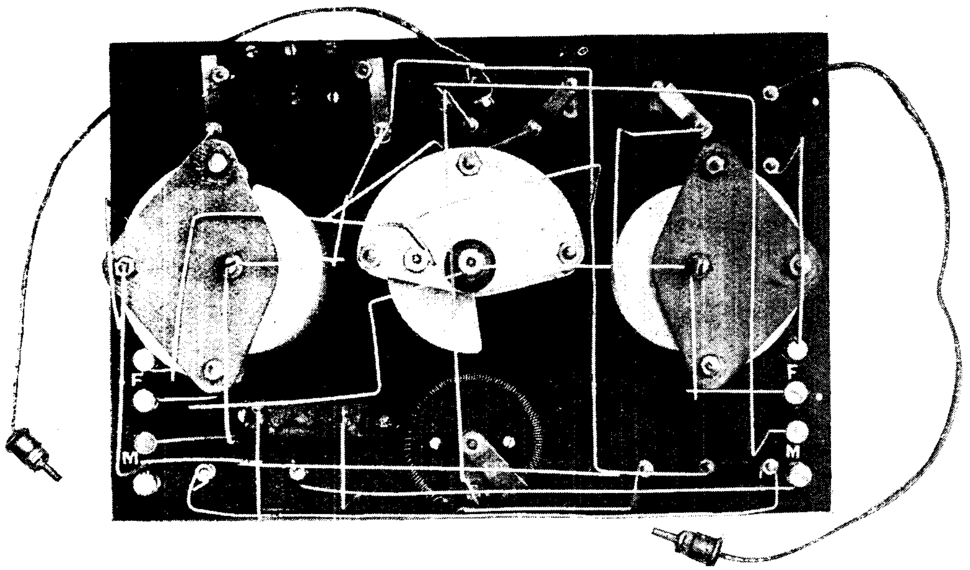
LAY-OUT OF THE PANEL

Fig. 15. Before the construction of the single-valve oscillator set is begun the panel should be marked out in accordance with these dimensions

allow for easily changing over the leads to the coil holders. This feature is seen in Fig. 16, where each pair of terminals is marked "M" and "F," representing the moving and fixed plugs of the coil holder.

As provision is made for connecting the inductances at a later stage, the wiring of the panel may be made before it is assembled to the case. The wiring diagram is given in Fig. 18. Wiring is carried out with $\frac{1}{16}$ in. square tinned wire, and forms a ready means of connexion of terminals. If this wire is not straight it may be straightened by clamping one end in a vice while a convenient length is pulled out.

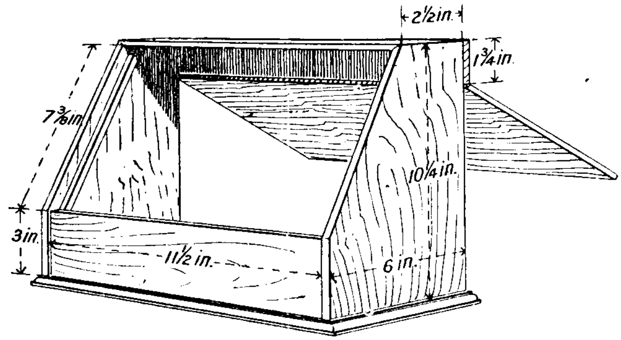
Connexion to the aerial terminal and grid is made with two lengths of insulated flex wire which terminate in wander plugs. From the wiring diagram it will be seen that these connexions are taken to a battery arranged in the grid circuit. The grid battery is secured to the base of the case, and will be more fully described after the case has been constructed.



SINGLE-VALVE OSCILLATOR SET: THE PANEL BEFORE FITTING IN THE CASE

Fig. 16. An excellent idea of the positions of the components upon the panel may be gathered from this view of the rear of the panel, taken just before the latter was fitted into the case. As much of the wiring as could be effected at this stage has been carried out

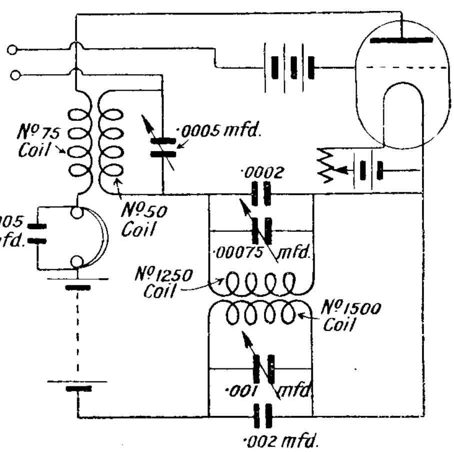
Dimensions for the case are given in Fig. 17. It is of the sloping panel type, and is fitted with a hinged back, by which easy access to the grid battery and connexions can be made. Fillets of wood are attached to the inside edges of the front of the case, and form a means of attachment of the panel. A moulded base is provided which overlaps the sides of the case slightly.



DIMENSIONS OF THE CABINET

Fig. 17. These are the measurements for the case of the single-valve super regenerative set illustrated in Fig. 12. Notice the hinged flap at the back of the cabinet, for inspection purposes

For the attachment of the grid battery to the base two platforms of ebonite are required, measuring 5 in. by $1\frac{1}{2}$ in. Towards one end a stout brass clip is bolted to each platform, so that the battery is a tight fit inside the clip. Each platform is then secured by means of countersunk wood screws. The operation of fitting the grid battery inside its clips is shown in Fig. 19.



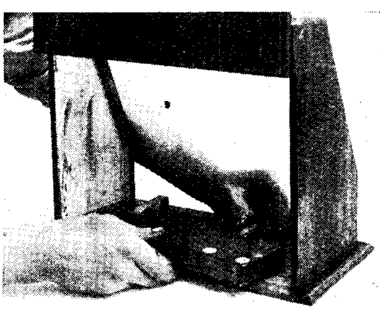
OSCILLATOR CIRCUIT DIAGRAM

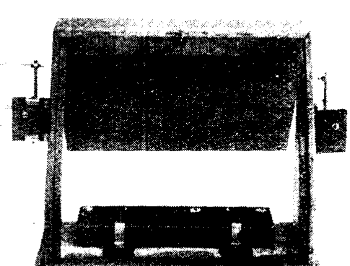
Fig. 18. The theoretical circuit of the oscillator set. Wiring is accomplished with $\frac{1}{16}$ in. square section tinned copper wire, which gives a neat appearance to soldered connexions

Two coil holders, preferably fitted with long extension handles, are attached to the outside of the case in the positions indicated in Fig. 20. The panel may now be fitted to the case. Owing to the angle of the sides to the top, difficulty may be experienced in fitting the panel. The top edge of the panel should first be brought near to the top of the case in the manner shown in Fig. 21. The lower edge of the panel can be eased into position, after which two wood screws at either side secure it in position.

The loose connexions from the two coil holders are attached to their respective terminals, after which the set is ready for the preliminary test.

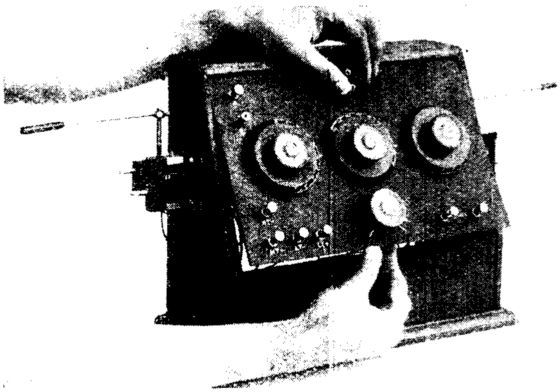
Fig. 22 gives a back view of the completed set, and shows the grid and aerial plug





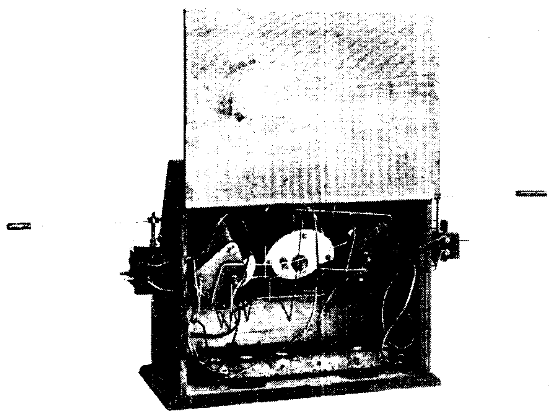
FITTING THE GRID BATTERIES TO THE BASE OF THE CABINET

Fig. 19 (left). Special clips are employed to hold the grid-biasing batteries in position; these are easily made at home. Fig. 20 (right). The coil holders have now been attached to the sides of the case and the grid batteries are here shown fitted in position on the base



HOW THE PANEL IS FITTED

Fig. 21. As difficulty may be experienced in fitting, it is advisable to proceed as shown, approaching the top of the panel first to the top of the case



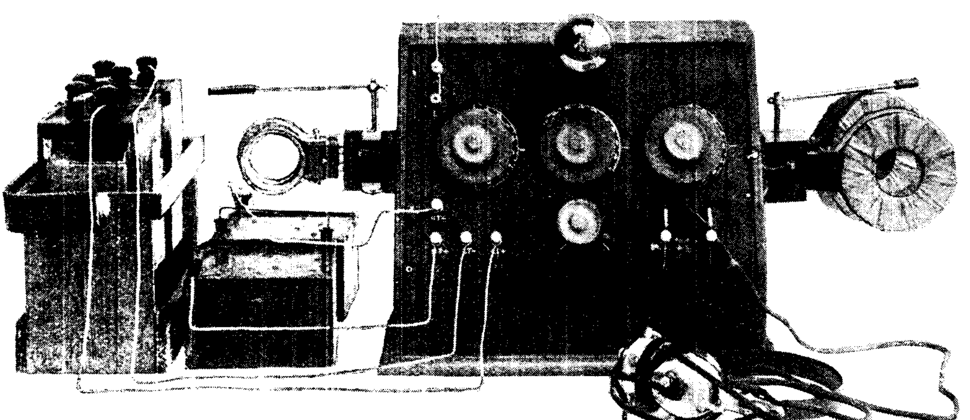
BACK VIEW OF THE COMPLETE SET

Fig. 22. The hinged flap at the rear is raised to show the wiring of the oscillator set. The wander plugs are shown attached to the grid-biasing battery on the base of cabinet

inserted into the grid battery sockets. The grid battery shown has a capacity of 15 volts, but the probability is that this amount will not be required. The 15 volt battery is a common commercial article, and forms a useful and compact unit. A tap of 6 volts will form a useful base for the first test.

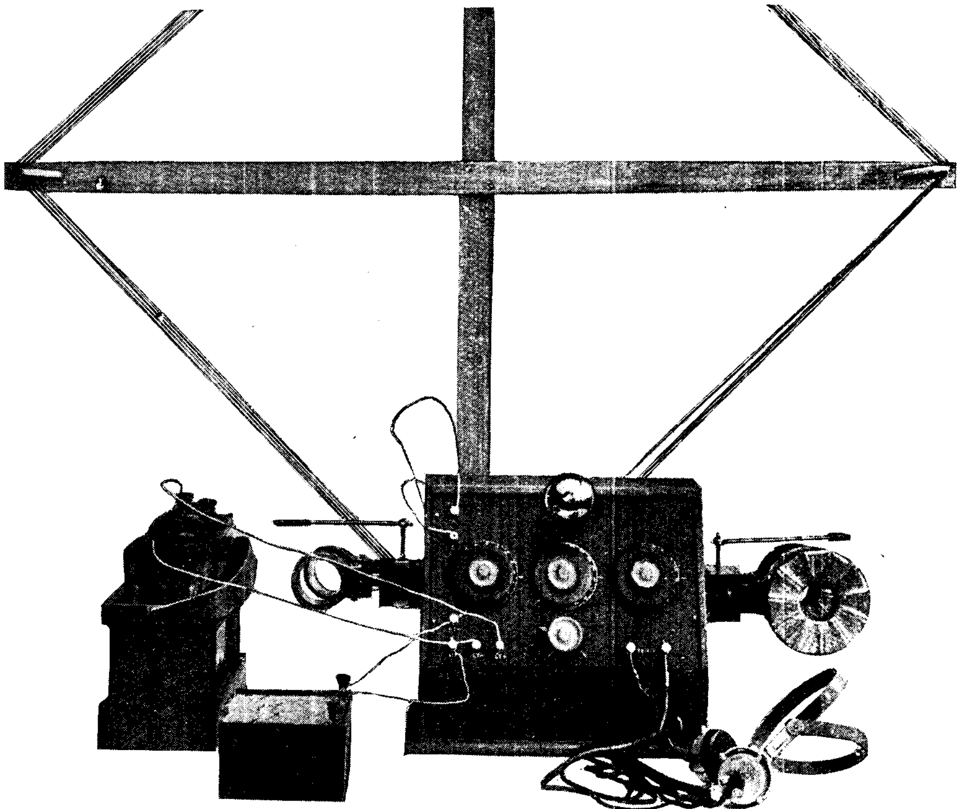
The set works extremely well on a frame aerial, which is connected to the aerial and earth terminals. It is inadvisable to make the first test with an outdoor aerial, owing to the violent oscillations of the set before it is properly tuned. An alternative, where a frame cannot be used, is to join the aerial and earth terminals and connect them to the earth lead. This arrangement is quite sufficient to bring in signals. This method of connecting the set is illustrated in Fig. 23, while in Fig. 24 is shown the method of connecting the frame aerial.

In tuning the set, both pairs of coils should be tightly coupled, and the variable condensers given a medium value. If the value of coil and condenser for the reception of any particular station is known, time will be saved in arranging these values in the aerial tuning circuit. The two oscillator condensers are rotated very slowly until an extremely high-pitched whistle is heard in the telephones.



OSCILLATOR SET READY FOR USE

Fig. 23. Where a frame aerial cannot be used, the aerial and earth terminals are connected as shown here, and joined thus to the earth lead. Quite satisfactory signals are obtained in this way



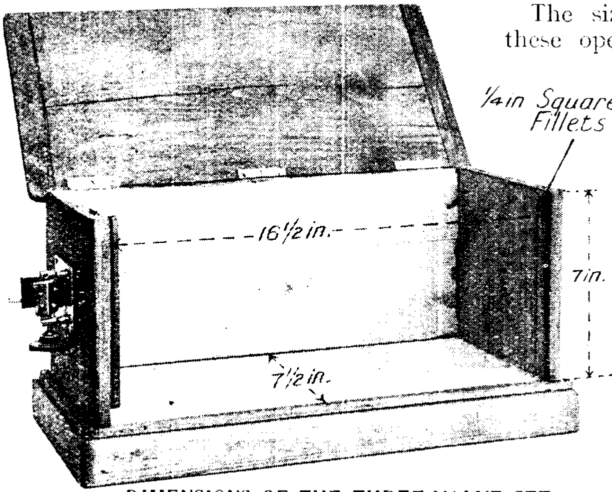
SINGLE-VALVE OSCILLATOR SET WITH FRAME AERIAL

Fig. 24. When, as in the case illustrated above, a frame aerial can conveniently be employed, the aerial and earth terminals may be connected to the frame in the ordinary way. Until the tuning of the set is thoroughly understood it should not be connected to the outdoor aerial

Further rotation of the condensers at this point results in a fairly low-pitched squeak. If this is experienced the condensers should be rotated back until the whistle stage is heard. The movable oscillator coil is moved farther away from the fixed coil until the whistle gives way to a continuous rushing noise. At this stage great magnification of signals is experienced, but the probability is that they will be distorted. Further movement of the coil will cause the rushing sounds to terminate with a sudden flopping sound, and the set will be found to be absolutely silent.

The coil must again be tightly coupled, when the whistle will again be heard. The position of the coil where the built-up oscillations suddenly fail should be avoided in the second and subsequent adjustments. If tightly coupling the oscillator coils fails to bring back the whistle, a slight rotation of any of the condensers will bring it back. Experiments conducted in this way will enable the constructor to learn the method of operating the set, after which the adjustment of the reaction coupling and filament resistance may be made to secure maximum amplification with freedom from distortion. A feature of the reproduction of music with this set is its extremely mellow and pure tone. It is also free from capacity effects when the set is properly tuned. If the set fails to function in the manner described, and it is certain that the wiring is correct, the trouble may very probably be traced to unsuitable fixed condensers, which should be replaced with others of slightly different value until the effects described are experienced.

Three-valve Super-regenerative Set. A three-valve super-regenerative set is illustrated in Fig. 27 on the special photogravure plate facing page 1926, which gives remarkably good results either with a frame aerial or any other form of aerial obtainable.



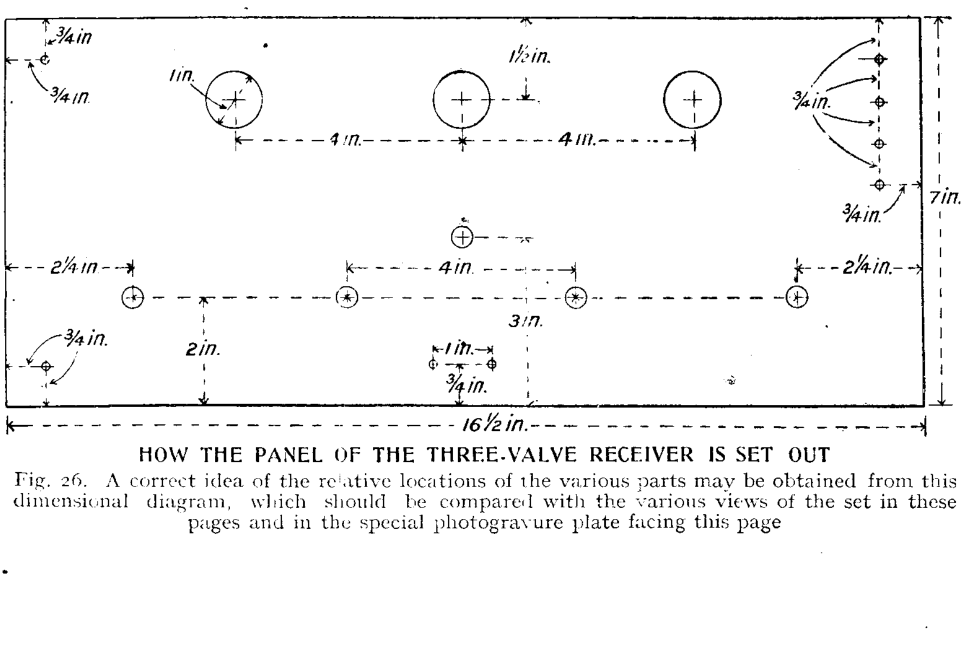
DIMENSIONS OF THE THREE-VALVE SET

Fig. 25. The experimenter may employ such wood as accords with his taste in constructing the cabinet, whose leading dimensions appear here

The dimensioned case is shown in Fig. 25, and may be constructed to the tastes and ability of the experimenter. A hinged lid should be provided by which access to the interior may be made. Another feature of the case construction is a false bottom which entirely fits the interior. This bottom may be made from ⅜ in. well-seasoned wood, having the front edge coming flush with the outside edge of the panel-retaining fillets, which are attached to the sides of the case. After completing the case, it may be stained or polished, and then left to harden while the panel is cut and drilled.

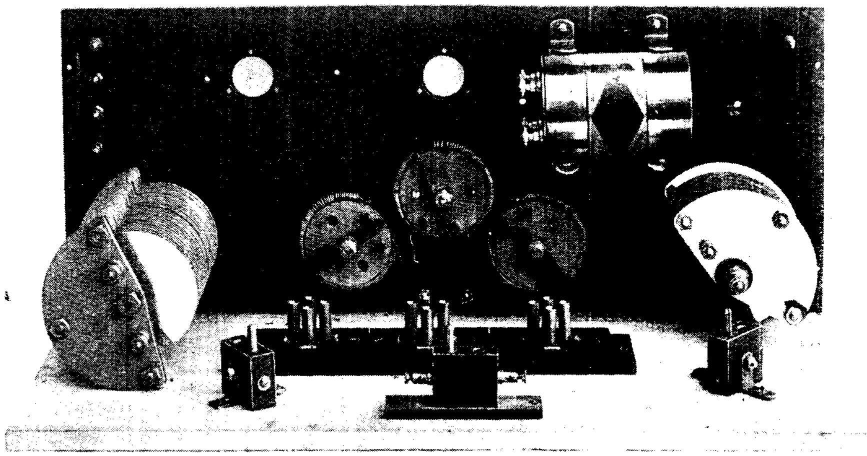
The size and leading dimensions for these operations are shown in Fig. 26. The panel, if not of the matt surface variety, should be matted on both sides in the manner described under the heading Ebonite in this Encyclopedia. It should be of good quality, and $\frac{3}{16}$ or ¼ in. in thickness. Three filament resistances are mounted centrally, and to the left of the panel, viewed from the front, a variable condenser of ·0005 mfd. capacity is attached for aerial tuning. The variable condenser to the other side of the filament resistance is of ·0001 mfd. capacity, and in wiring is shunted across the fixed condenser E. These are together in series with the coils Q and A shown in the theoretical circuit diagram in Fig. 26.

Four battery terminals are fitted to the top right side of the panel, while the telephones are connected to a pair of terminals below the centre filament resistance. Aerial and earth terminals are placed to the top and bottom of the left side of the panel. The three 1 in. holes shown in Fig. 26 in line towards the top of the panel form a means of viewing the valves, and their appearance is improved by covering them with a fine copper gauze held in position with brightly polished brass rings. A back view of the panel at this stage is shown in Fig. 28.



HOW THE PANEL OF THE THREE-VALVE RECEIVER IS SET OUT

Fig. 26. A correct idea of the relative locations of the various parts may be obtained from this dimensional diagram, which should be compared with the various views of the set in these pages and in the special photogravure plate facing this page



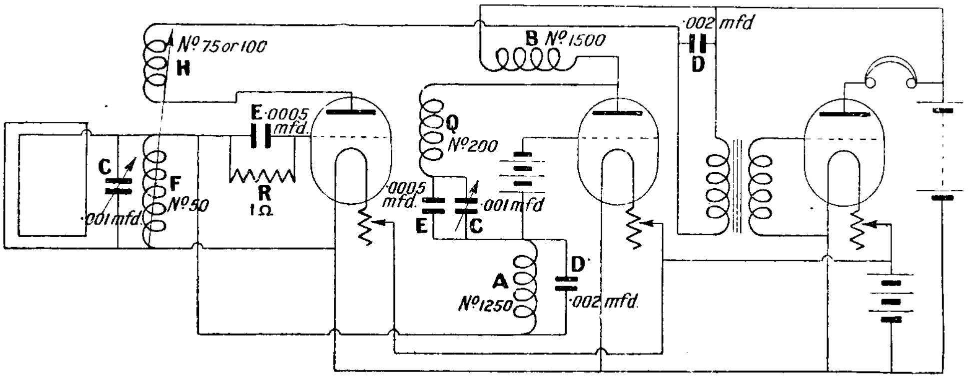
REAR VIEW OF THE PANEL OF THE THREE-VALVE SET

Fig. 34. Several of the principal components are now fitted behind the panel. Notice the special ebonite panel, mounted on the base, upon which the valve holders are fitted. The appearance of the valve-inspection holes is improved by the fitting of fine wire gauze

The loose bottom is attached to the lower edge of the panel, when the coil holders and valve holders may be fitted. The latter consist of three small ebonite bases, to which are screwed four valve sockets, thus forming a valve holder. Each of these valve holders is secured to a common base consisting of a long strip of ebonite, which makes a platform of three valve holders. The platform is screwed to the base behind the filament resistances.

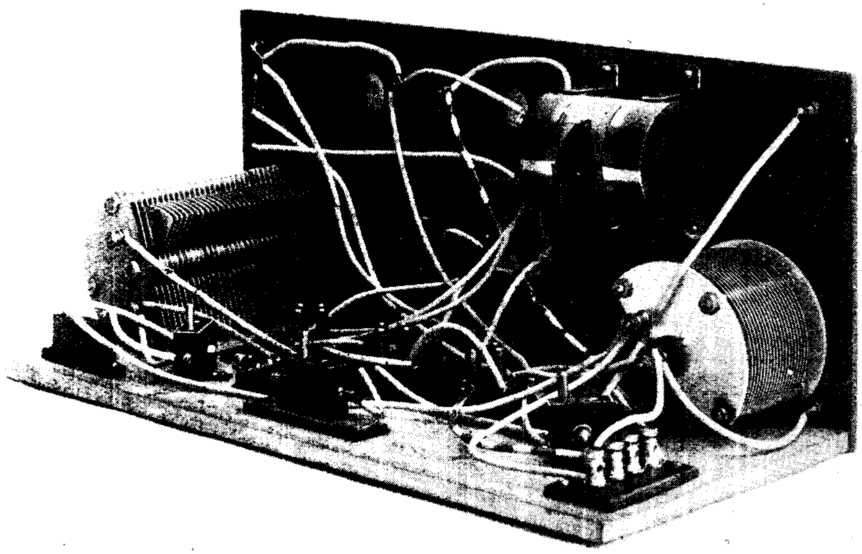
Any good quality low-frequency transformer may be used for the low-frequency amplifier valve, and is attached to the panel in any convenient position. Fig. 36 shows a back view of the set at this stage of completion. This illustration is useful in showing the relative positions of the single coil holders, where the two outside ones are seen at an angle to the central one. This feature is more clearly shown in Fig. 36, which gives a plan of the set viewed from the right-hand side.

All the components now being assembled, the wiring may be commenced according to the wiring diagram given in Fig. 35. The diagram gives the values of the fixed condensers used on the set, and these should be placed where they assure the shortest of connexions. Wiring is carried out with No. 20 gauge tinned wire, covered with valve rubber or insulated sleeving.



THEORETICAL CIRCUIT DIAGRAM

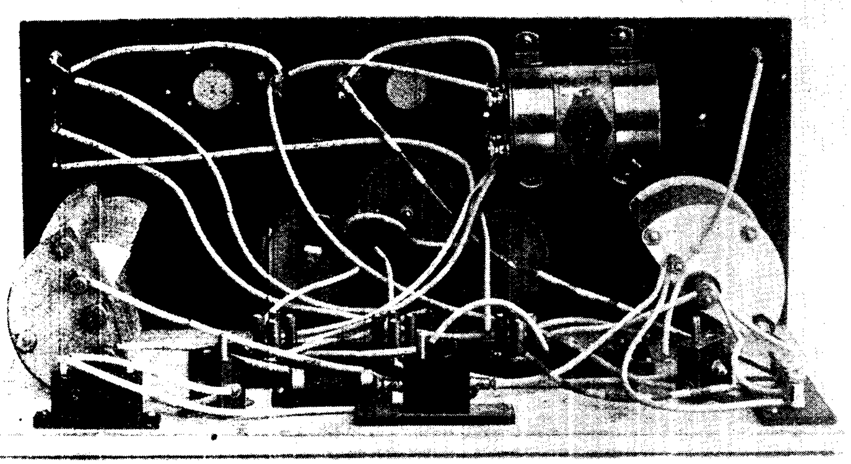
Fig. 35. All the components having been assembled, as in Fig. 34, the wiring may be carried out according to this diagram. No. 20 gauge tinned wire covered with sleeving is employed for this purpose. All connexions should be soldered



COMPLETE WIRING OF THE THREE-VALVE SUPER-REGENERATIVE SET

Fig. 36. Seen from the right-hand side, the rear view of the panel presents a somewhat involved appearance, but in actual practice the wiring is simple. Note the terminal board, to which leads from the two-coil holder are subsequently attached

As far as possible all connexions should be soldered, but where terminals are provided, as on the low-frequency transformer and on one of the condensers used in this set, care should be taken in assuring that these connexions are electrically perfect. Fig. 31 shows the operation of testing the terminal connexion after the wiring has been completed. One view of the completed wiring is shown in Fig. 36, where the back of the set is viewed from the right-hand side. A plan view of the wiring, which is useful in showing the connexions to the coil holders, is given in Fig. 29. A third view of the completed wiring representing a dead-on back



PANEL OF THE THREE-VALVE SET FROM THE REAR

Fig. 37. Another view of the wiring after its completion. This illustration gives an excellent idea of the situations of the fixed condensers, seen here on the platform of the set

elevation is shown in Fig. 37, which illustration shows the wiring of the battery terminals and the low-frequency transformer with fixed condenser attached.

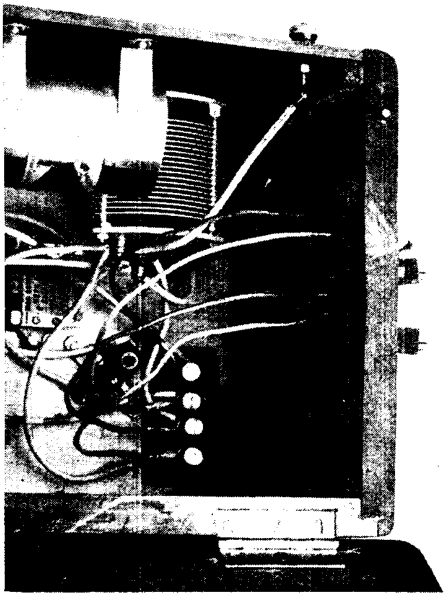
A two-coil holder, into which the aerial tuning coil and the reaction coil are plugged, is attached to the left side of the case, as shown in several of the illustrations. In order to facilitate connecting up the leads from these coils the right way round, a terminal board is fastened to the interior of the set. This terminal board is fitted with four terminals corresponding to the leads from the coil holder, and is clearly seen in the illustrations of the completed wiring in Figs. 31 and 37. This arrangement is also useful in enabling the wiring to be completed before the set is fitted into its case. A close-up is given in Fig. 38 where the leads from the coil are shown connected to the terminals.

The grid biasing battery is a dry battery of 15 volts, and fits into springy brass clips mounted to small bases of ebonite, which are in turn screwed to the inside of the lid. This feature is shown in Fig. 30 in the plate, which gives a semi-plan view of the completed set with the lid open. This illustration gives a good idea of the position of the oscillator coils.

The complete set in use with a frame aerial is illustrated in Fig. 33. The set will probably be found somewhat easier to operate than the single valve oscillator set previously described. The grid battery should first be set to give a negative grid potential of 4 volts. The anodes of the valves are given a positive potential of about 60 volts for a start.

After signals are received, adjustment of the anode and grid voltages is made to secure the best results. The coupling of the reaction coil to the aerial tuning coil should at first be fairly loose, and afterwards tightened until a loud rushing sound is heard in the telephones. The aerial tuning condenser is then slowly rotated until a signal is heard and brought to its maximum strength. The variable oscillator condenser is then rotated to secure the best adjustment.—*W. W. Whiffin.*

SUPERSONIC HETERODYNE. Type of heterodyne receiving circuit due to Major E. H. Armstrong. It is particularly suitable for the reception of the shorter ranges of wave-lengths from 200 metres downwards. At the extremely high frequencies which obtain on the shorter wave-lengths efficient radio-frequency amplification



INTERNAL DETAILS

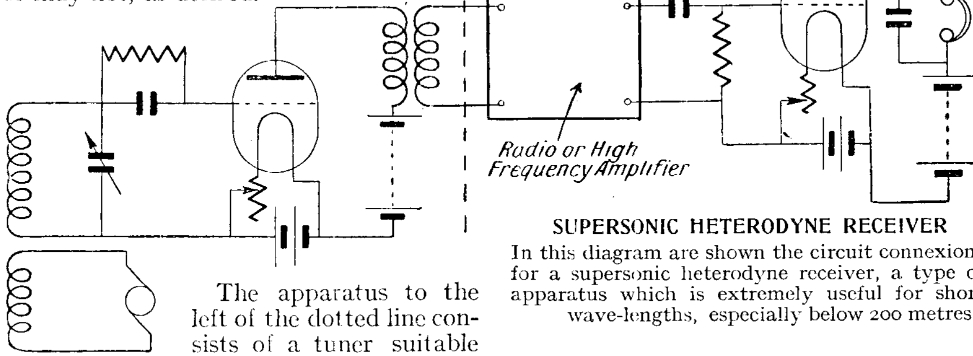
Fig. 38. A close-up view of the terminal board, showing how the connecting wires are led in from the coil holder outside the cabinet

becomes a very difficult problem owing to the losses produced by high capacities.

In the supersonic heterodyne receiver a super-audible beat note is obtained when the signals are first rectified. For instance, if 100 metre (3,000,000 cycles) signals were being received on a supersonic heterodyne instrument, the heterodyne would be tuned to, say, 2,900,000 cycles. The resultant note-beat will be 3,000,000 minus 2,900,000, which is 100,000 cycles. This frequency is then amplified by ordinary radio-frequency methods, such as by resistance or tuned air-cored transformers.

Rectification is again carried out subsequently to this amplification at the super-audible frequency, and the signals may then be heard in the telephone, or put through low-frequency amplifiers and a loud speaker in the usual manner.

While this system may appear at first sight to be very involved, as a matter of fact it is not so, and reference to the figure, which is a typical circuit diagram of a supersonic heterodyne receiver, will indicate that very little additional apparatus has to be used. The instrument just to the right of the dotted line may be an ordinary radio-frequency amplifier using transformer, tuned anode or resistance coupling, and suitable for wave-lengths of the order of 3,000 metres. Any standard instrument will do for this purpose, and it may include within itself the rectifier shown further to the right, or may not, as desired.



SUPERSONIC HETERODYNE RECEIVER

In this diagram are shown the circuit connexions for a supersonic heterodyne receiver, a type of apparatus which is extremely useful for short wave-lengths, especially below 200 metres

The apparatus to the left of the dotted line consists of a tuner suitable for short-wave reception and a standard rectifying circuit. To this is coupled an ordinary separate heterodyne employing any standard arrangement. Self-heterodyne, or autodyne, systems may be employed, but are not recommended, as their use entails a certain amount of mistuning, with consequent reduction of efficiency.

Supersonic heterodyne systems will be found of extreme value in short-wave work and are very selective in character. Further, they are perfectly stable in operation. It is interesting to note that the B.B.C. transmissions from the Old Vic Theatre, London, are received on a supersonic heterodyne receiver before being re-radiated from 2 L O or relayed to the other stations. This will serve to indicate that the system is thoroughly reliable and stable, and that it does not produce any serious amount of distortion. *See* Autodyne; Beat Reception; Heterodyne; Oscillation; Short-wave Receiver.

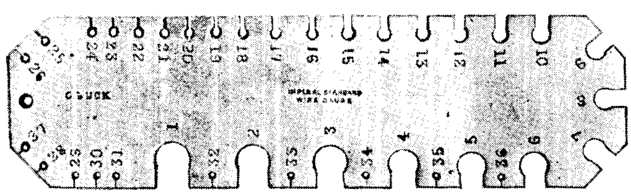
SUSTAINED WAVES. This is another term, occasionally used in wireless, for continuous waves (*q.v.*).

S.W.G. This is the usual abbreviation for the British standard wire gauge, the only legal standard wire gauge in the United Kingdom.

The photograph shows the usual imperial standard wire gauge tool for finding thicknesses of metal or diameters of wires from 36 gauge to 1 gauge, *i.e.* from ·0076 of an inch to ·3 of an inch in thickness. This gauge is extremely useful to the wireless experimenter, and is a tool he should have in his workshop. The table below gives the sizes in thousandths of an inch of the gauges shown :—

STANDARD WIRE GAUGE			
Gauge No.	Thickness or diameter; thousandths of an inch.	Gauge No.	Thickness or diameter; thousandths of an inch.
36	7·6	18	48·0
35	8·4	17	56·0
34	9·2	16	64·0
33	10·0	15	72·0
32	10·8	14	80·0
31	11·6	13	92·0
30	12·4	12	104·0
29	13·6	11	116·0
28	14·8	10	128·0
27	16·4	9	144·0
26	18·0	8	160·0
25	20·0	7	176·0
24	22·0	6	192·0
23	24·0	5	212·0
22	28·0	4	232·0
21	32·0	3	252·0
20	36·0	2	276·0
19	40·0	1	300·0

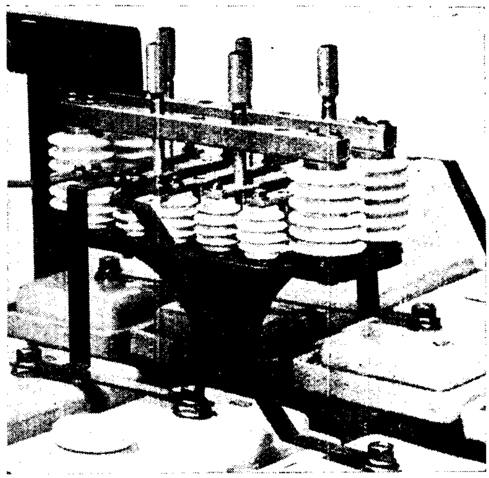
SWISS COMMUTATOR. A device used in high-powered transmitting stations, by means of which individual units of a bank of condensers may be conveniently and



STANDARD WIRE GAUGE

An imperial standard flat wire gauge used for measuring the thickness of sheet metal from 7·6 mils to 300 mils. Mil is the standard abbreviation for one-thousandth of an inch readily connected in series or parallel, as desired. An example of such a device is illustrated. The photograph shows the tops of a number of oil-filled condensers, together with their heavy strip connecting leads. The latter are all connected to further horizontal strips supported on the shorter ribbed insulators.

Two heavy square-section copper bars are arranged transversely above the connecting strips. These are supported on larger insulators in order that plenty of vertical clearance between both sets of conductors may be obtained. A series of holes is drilled in both series of conductors, those in the upper series registering exactly with those in the lower. A number of pins, a tight fit in any hole, are fitted so that connexion is made between both sets of strips. By different arrangements of the pins in the various holes it is possible to connect the various condensers in any series-parallel arrangement desired. *See* Condenser.



SWISS COMMUTATOR

By means of the commutator device fitted to this bank of condensers used in high-power wireless transmitting stations a number of condensers can be connected in series or parallel, as desired, with great speed

SWITCHES: THEIR VARIETIES, USES AND CONSTRUCTION

One of the Most Useful Wireless Accessories Fully Explained

The switch is one of the most useful components in a wireless set—one, indeed, that cannot be dispensed with. It is therefore fitting that this description should cover a wide range of different types: those suitable for light currents, those that control heavy currents, and the many others for special purposes. The reader is also referred to such headings as Anti-capacity Switch; Knife Switch; Jacks and Plugs

A switch is an electro-mechanical device adapted to sever, or complete, an electrical circuit. There are innumerable switches used in electrical work, which vary likewise in size, shape and purpose. Many of them are employed in wireless work, and of them the greater number are dealt with under their respective titles. The designation of the switch is to a large extent an indication of its purpose, or of a particular feature of the construction. Examples include the tumbler switches, so named from the action of the control handles, inductance switches, which control the value of the inductance in a coil, reversing switches or commutators, which reverse the current flow in a circuit.

The size of a switch or of its component parts must first conform to the requirements of the current that is to be passed, as it is obvious the sectional area of the metallic parts must be appropriate to the area of the conductor and the amount of current that will flow through the switch. The base or stand has generally to be of insulating material, and this must of necessity be adequate to secure the safety of other adjacent apparatus, and to restrain the passage of the current except through its appointed paths.

Another important matter is the speed at which the contact is made between the moving and fixed member, as this has a bearing on the presence of an arc and its duration when dealing with heavy currents. The current capacity is a convenient means of classifying switches, those for currents over, say, 10 amperes being treated as for heavy currents, those from 10 amperes to 1 ampere as medium, and those for lower currents as low-current switches.

A type of switch suitable for heavy current work is illustrated in Fig. 1. In appearance the switch is similar to the ordinary knife switch and is of simple construction. In order to break the circuit with a minimum of sparking, the end contacts on both the base and the moving arm are of carbon. They are arranged to be the first contacts to "make" when the switch is being closed, and are the last to open when contact is broken. The moving arm is supported in bearings in a cast-iron support screwed to

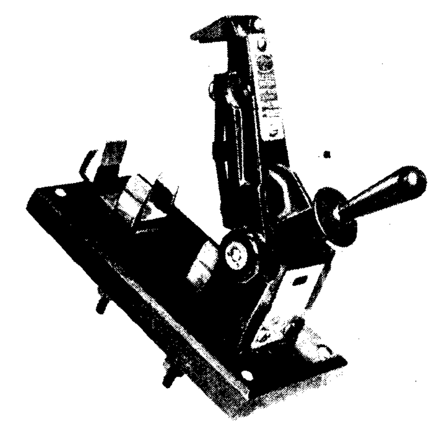


Fig. 1. This switch, similar to the usual knife switch, makes or breaks heavy currents

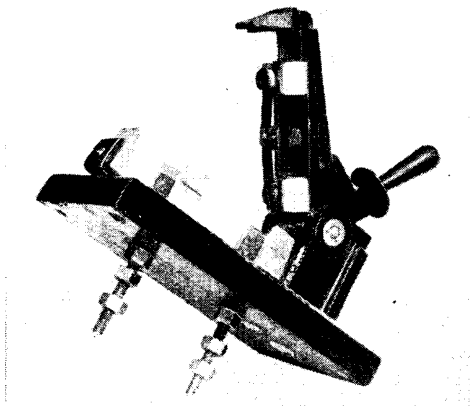


Fig. 2. Another view of the switch in Fig. 1. Here the underside of the moving arm is visible

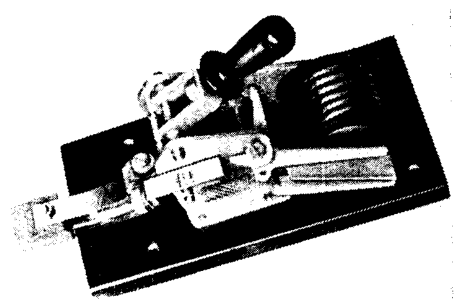


Fig. 3. An automatic overload release which throws the switch arm out when the current becomes too heavy

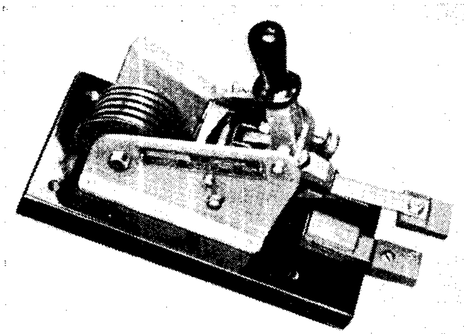


Fig. 4. Carbon contacts are used in this, the same switch as in Fig. 3. Here they are in the "break" position

Courtesy General Electric Co., Ltd.

TWO TYPES OF KNIFE SWITCH SUITABLE FOR HEAVY CURRENTS

the base of the switch. Another view of the switch is given in Fig. 2, where the underside of the moving arm is seen.

Many of the larger switches are fitted with mechanism whereby the circuit is automatically broken when the voltage or current fails to fulfil certain required conditions. The switch illustrated in Fig. 3 is of this type. It is fitted with an overload release which throws the switch arm out when the current rises above a definite value. Another view of this switch is given in Fig. 4.

Switches of the above types which serve to control heavy currents have special provision made for the prevention of arcing when the circuit is broken. For this reason the great majority of large current switches have a moving arm with contacts attached towards one end. A well insulated handle is fitted, by which the arm may rapidly be withdrawn from the fixed contacts. It is important also that there should be considerable air space between the fixed and moving contacts, as the arc, once started, will extend for a long way. To prevent this drawing of the arc the larger of the heavy switches are oil-immersed, while others are electro-magnetically operated from a distance. In the switch shown in Fig. 3 carbon is used throughout for making electrical connexion. Carbon has the advantage in being better able to stand up to the heat of an arc should it occur.

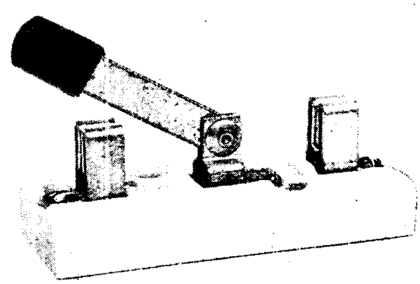
Switches for medium currents fall largely into two classes, the tumbler and the knife switch. An example of the tumbler switch is illustrated in Fig. 7, and is used in small sets for transmission and reception. The two switches at the left are coupled together, and are employed to either connect the circuit for transmission, or by altering the position of the handle opposite to that shown for reception.

A separate stop and start switch is located at the right-hand side. The switches have china bases mounted on an ebonite panel, and this in turn is attached to stout oak wall plates. The tumbler switch is somewhat similar to the knife switch in its action, but is operated by a lever movement in the "on" position and is often fitted with a spring return.

In the tumbler switch also the moving arm is of a U-shape, and either end fits into springy fixed contacts. A typical medium power switch suitable for carrying 5 amperes is illustrated in Fig. 5. The movable portion or knife of the switch consists of a straight strip of copper pivoted at one end to a clip-like bearing. On either side of this bearing a fixed contact is secured close to the handle of the switch arm. Springy contact is assured by making a double bend on each side of the fixed contacts. The base is of stout porcelain, having a hole on either side for fixing the switch in position.

Switches in general may be divided into five broad classes. The tumbler or rocking arm switch has the advantage of keeping its contact surfaces clean by means of the wiping action that takes place when the switch is put in or out. Owing also to the springy arrangements of the fixed contacts, good electrical connexion is assured.

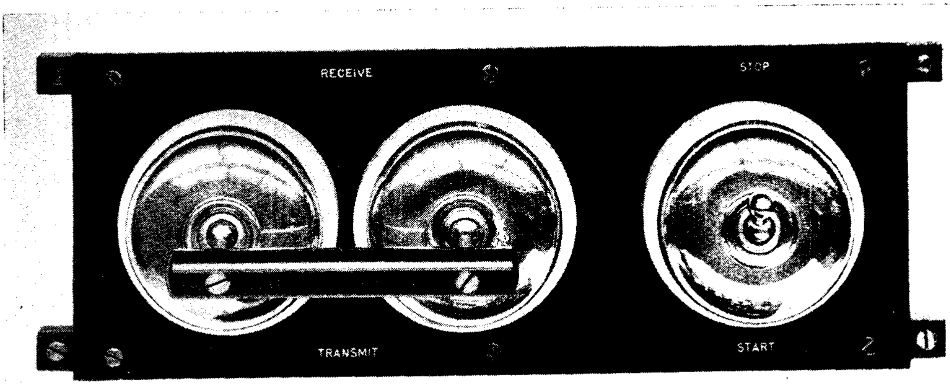
The circular arm type, which is capable of moving over a number of studs placed radially with the pivoting point of the moving arm, is less suitable for heavy or medium current work owing to its tendency to arcing. For wireless purposes it is extremely useful in performing the work of a number of switches and occupying a very small space.



KNIFE SWITCH

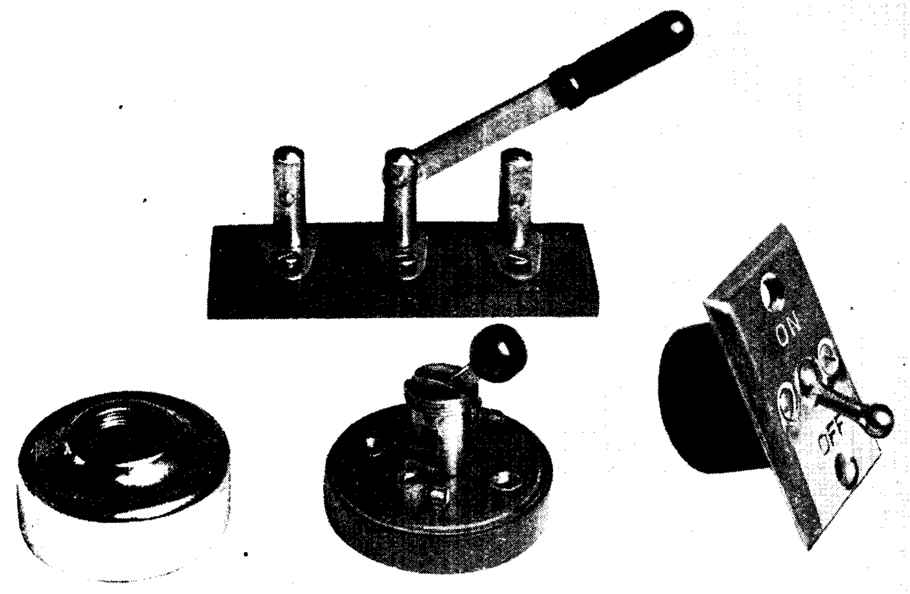
Fig. 5. When low currents are employed this switch is quite efficient. It is often used to connect aerial to earth, or for similar purposes, and is mounted on a porcelain base

With the exception of transmission circuits, practically all wireless work is done with small power. Where this type of switch is used for adding or cutting out cells in a high-tension battery, care must be taken to ensure that the moving contact arm is not able to span two studs at once, as if it does the cells joined to two adjacent studs will be short-circuited every time the switch is moved. In many cases, however, this feature is not detrimental. For instance, in an aerial tuning



MOUNTED AND COUPLED SWITCHES

Fig. 6. An ebonite panel mounted with three switches, by Marconi's Wireless Telegraph Co., Ltd. The two switches on the left are coupled together to form a double-pole change-over switch shown in the "transmit" position. In the opposite position the switch is used for reception



SELECTION OF COMMON TYPES OF SWITCHES USEFUL IN WIRELESS WORK

Fig. 7. In the background of the photograph is shown a single-pole change-over switch. In the left foreground appears an ordinary tumbler switch with the cover removed, while to the right is shown a special type of tumbler switch suitable for panel mounting

switch or tapped reaction coil the bridging of adjacent contact studs when the switch arm is moved is an advantage, as the circuit is not broken at every stud change.

Sliding types of contacts are not used to any great extent, but in many patterns they are suitable for panel mounting owing to the small superficial space they occupy.

Plug-in types of switch are largely used in wireless, and take the form of plugs and jacks in the most common types.

The Dewar and anti-capacity switch (*q.v.*) belong to the pressure type of switch.

In selecting the type of switch for any particular purpose, the various factors of each should be considered before decision is made. Where high-frequency currents are to be controlled the switch selected for the operation should have a minimum of capacity. If only one or two wires are concerned, the plug-in switch made with valve sockets spaced well apart, and a valve pin plug insulated with an ebonite top, is suitable.

A group of three different types of switch is illustrated in Fig. 7. At the top is a single-pole double-throw switch of a very simple type. It will be seen that the pillars which are attached to the ebonite base are all of the same design, and all have flanged bases to which terminal screws are fitted. The centre pillar carries the switch blade, and the other two are slotted to receive the blade when it is desired to make contact. A long ebonite handle is fitted, enabling the switch to be used with safety on fairly high pressures.

Below this knife switch is a simple and neat pattern of miniature tumbler switch. Contact is broken or made by moving the little ball-ended handle projecting from the slotted centre-piece. A spun brass cover, which is screwed to fit the centre-piece, is fitted to the switch and completely encloses the internal mechanism. Tumbler switches of this sort generally have a quick-breaking action which is useful in preventing arcing, and thus renders them of utility even for comparatively heavy currents.

The switch on the right may be considered to be an adaptation of a tumbler switch to render it suitable for panel mounting. The movement is substantially the same, but the case is different and is fitted with a large rectangular nickel-plated flange which looks very well on the front of a panel. Such switches are very suitable and useful for battery switching, but are not recommended for anything else on a wireless receiver on account of their inherently high self-capacity.

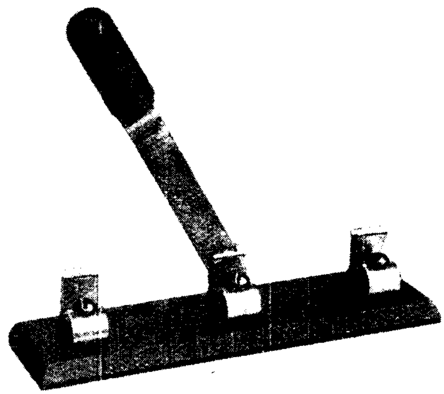
A simple form of change-over knife switch is illustrated in Fig. 8. This switch is more or less self-explanatory, and can be constructed from odds and ends to be found in the average experimenter's scrap-box. A double-pole change-over switch is shown in Fig. 9. This is of a type suitable for panel mounting, screwed stems being provided on the underside of the contacts by which they may be readily attached to the panel. The application of this panel mounting switch is shown in Fig. 10, where a single-pole change-over switch is shown.

A type of stud switch for panel mounting is shown in Fig. 11. This switch is of rather unusual form in that the arm and studs are fitted to the back of the panel. The position of the arm is indicated by the graduated dial seen to the right of the illustration, which is attached to the outside of the panel.

It is important in fitting up a rotary switch arm to place the locking nuts and washers in the correct order. Unless this is done trouble may afterwards be experienced with the operating knob or the switch arm coming loose.

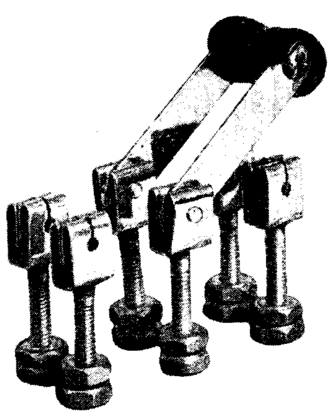
Fig. 15 shows a typical switch arm with a collection of parts making the completed arm. The parts are arranged in their correct order of assembly. The knob is first fixed to the screwed rod forming the spindle of the switch. The contact arm is now fitted and tightened up securely by means of the round nut. The next fitting to the right is a brass bush, which is secured to the panel. Following this and at the back of the panel a flat brass washer is slipped over the spindle and then a spring washer and another flat washer. When the correct tension is obtained by screwing up the nut that follows next, a second nut is locked securely to the first. The spring washer should be quite firmly held between the two flat washers, and not loosely.

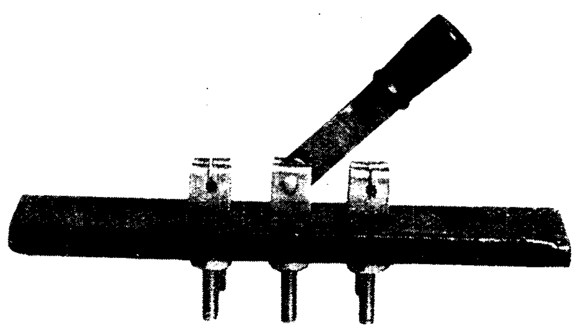
A high-grade type of commercial sliding switch is illustrated in Fig. 12. The switch is suitable for panel mounting, having a means for central fixing. The operation of the switch is easily understood from the illustration.



HOME-CONSTRUCTED KNIFE SWITCH

Fig. 8. An easily made single-pole change-over switch, mounted on ebonite, that is very efficient in use





SWITCHES ASSEMBLED AND IN PARTS

Fig. 9 (left). Here is shown a set of parts for a change-over switch, ready for mounting. Fig. 10 (right). A switch assembled from parts of a panel-mounting switch

Photo (left) courtesy Will Day, Ltd.

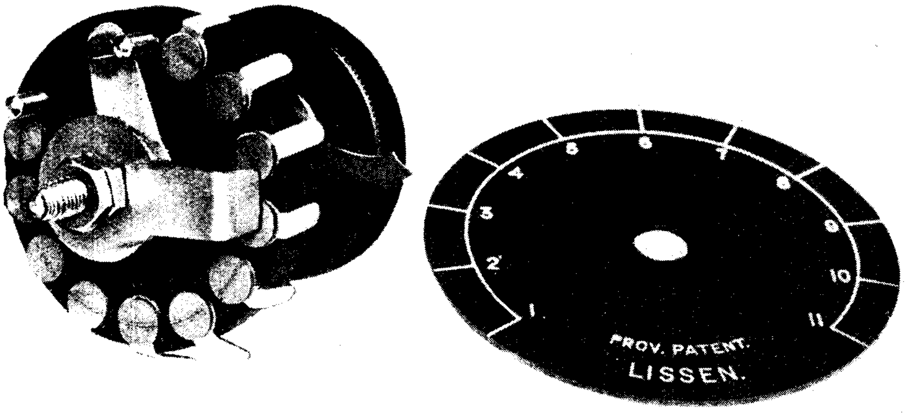


Fig. 11. This novel type of switch has the studs and contact arm assembled for mounting to the inside of a panel, the knob and marked dial being on the outside

Courtesy Lissen, Ltd.

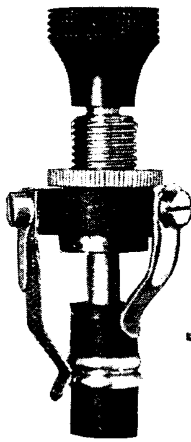


Fig. 12. This is a high-grade type of sliding switch for panel mounting

Courtesy Lissen, Ltd.

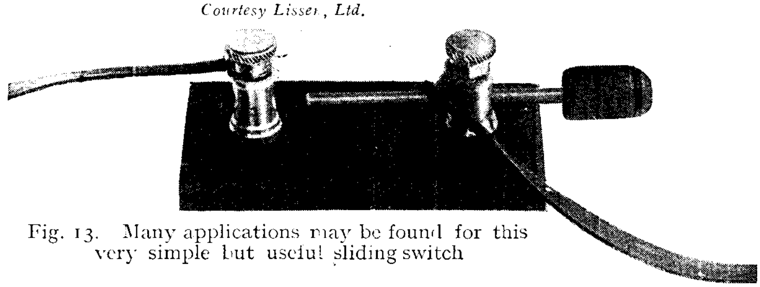


Fig. 13. Many applications may be found for this very simple but useful sliding switch

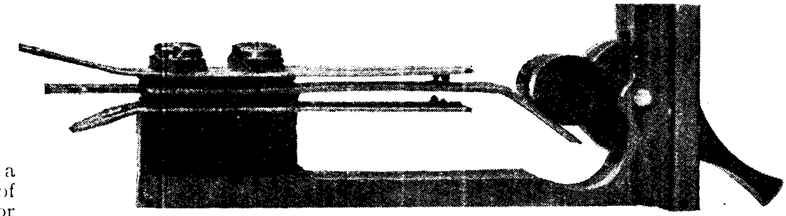


Fig. 14. This type of Dewar switch is worked by pressure exerted by a knob which operates a cam

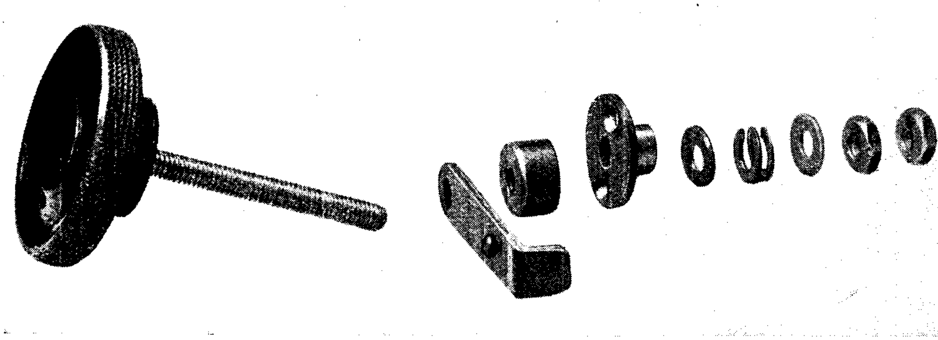
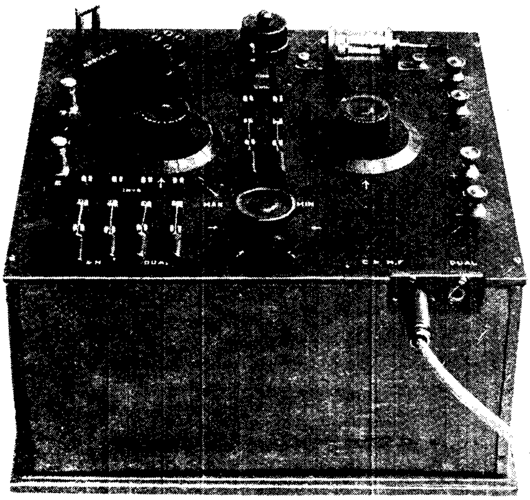
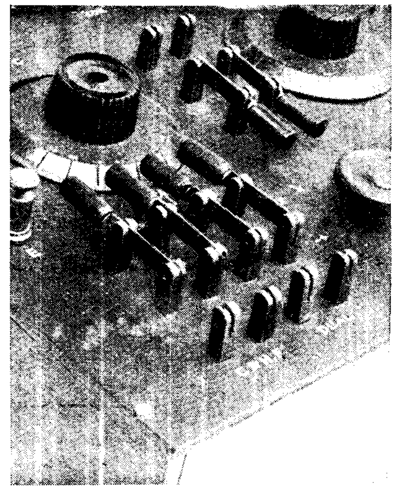


Fig. 15. A set of parts which go to make up a switch arm, in their order of assembly

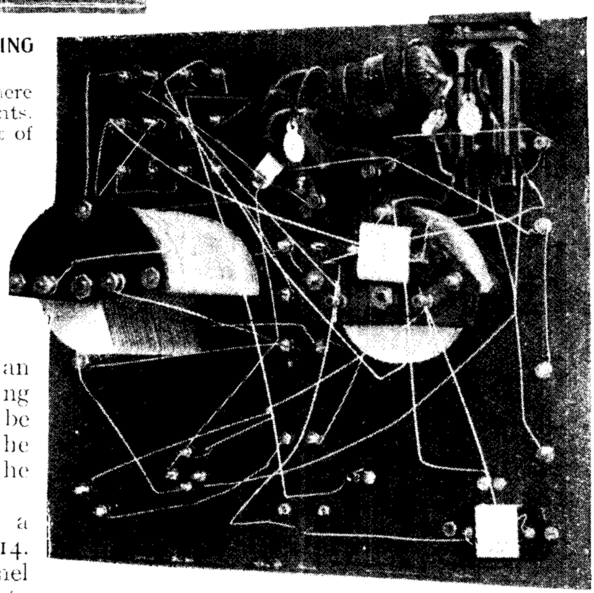
CONSTRUCTIONAL DETAILS OF VARIOUS TYPES OF SWITCHES





RECEIVER WITH SEVERAL SWITCHING SYSTEMS

Fig. 16 (left). Many switches are used here for obtaining different circuit arrangements. Fig. 17 (right). Closer view of the set of knife switches seen in Fig. 16



BACK VIEW OF THE RECEIVER

Fig. 18. How the circuit systems in Figs. 16 and 17 are wired. Note the switch connexions

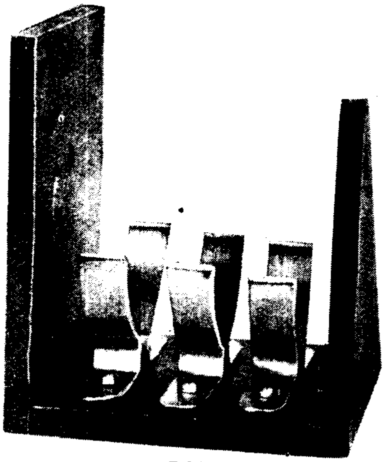
An extremely simple type of home-made sliding switch is shown in Fig. 13. Two terminals of the telephone type are attached to a small ebonite base so that their holes fall in line. brass rod fitted at one end with an insulating handle is capable of sliding through both holes, when it may be tightened up by means of the knurled screws on the top of the terminals.

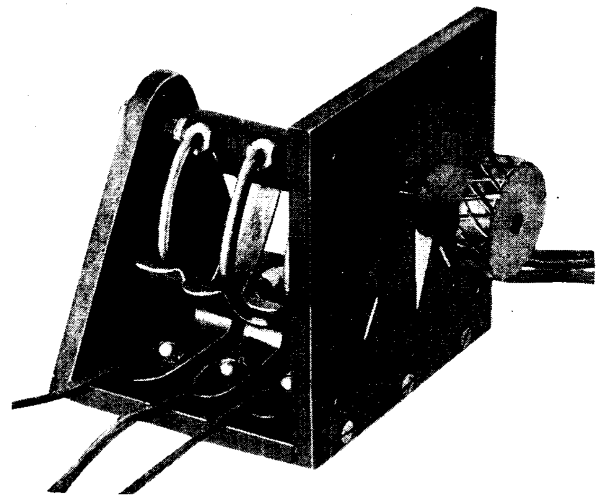
Of the pressure type of switch, a Dewar switch is illustrated in Fig. 14. This type lends itself well to panel mounting, and is made to operate a number of circuits in some patterns.

The application of switches to a home-made set is illustrated in Fig. 16. This shows a complete set where the switches enable either a crystal, high-frequency valve and crystal, or dual-amplification circuit to be used as desired without altering the wiring in any way. Three different types of switch are in use.

The small tumbler switch seen to the back of the set short circuits a loading coil in the aerial tuning circuit when not required. The plug and jack type of switch is used for the telephone connexions, where they may be inserted either into the high-frequency and crystal circuit or the dual-amplification circuit. Centrally placed and to the left of the set single-pole change-over switches are fitted.

A close view of these switches is shown in Fig. 17. They may easily be constructed from $\frac{1}{4}$ in. square brass rods shouldered and tapped at their lower ends for attachment to the panel. The top ends are rounded off and slots are cut to permit the entry of the switch arm. The latter is supported in a similar pillar, through which a rod is fitted and on which the moving arm rotates.

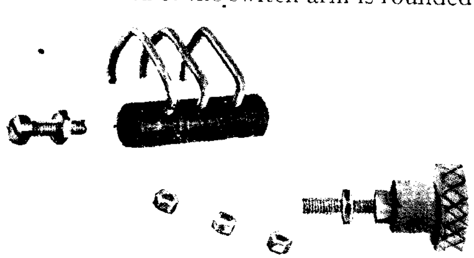




ROCKER SWITCH, A TYPE ADAPTABLE FOR MANY CIRCUITS

Fig. 19 (left). Three pairs of contact brushes are employed, and these are shown in position. Base, front and back plates are also shown assembled. Fig. 20 (right). The completed rocker switch

The moving arm consists of a straight strip of copper or brass filed down at one end and fitted with an insulated handle. The other end of the switch arm is rounded



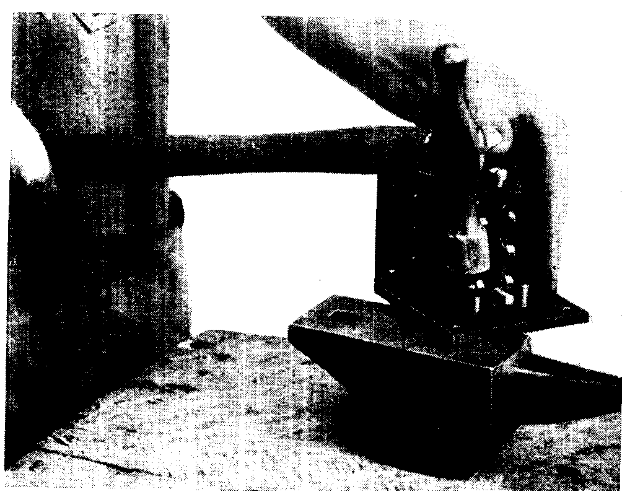
SPINDLE DETAIL

Fig. 21. Ebonite is used for the knob and the seating of the contacts, which are shown ready for mounting to the arm

and drilled to take the pivoting pin. The wiring of this receiver, showing the connexions to the various switches, is illustrated in Fig. 18.

The construction of switches of many patterns has been described under their respective headings in this Encyclopedia, and reference should be made thereto for other details. One method of making a rocking switch is illustrated in Figs. 19 to 22, Fig. 20 showing the finished article. The feature of the switch is the high insulation value and the low self-capacity due to a minimum of metal in the construction. The base, front and back plates are made from ebonite about $\frac{3}{16}$ in. thick, and will measure according to the number of desired contacts. In the present example three are employed, and the base measures 3 in. by $2\frac{1}{2}$ in. The front panel is 3 in. square.

The contacts shown in Fig. 19 are bent to shape from thin springy brass strip, and secured to the base with a screw with a



FITTING THE STOP-PEGS

Fig. 22. The stop-pegs are driven into the front panel by hammering lightly and firmly in this manner. The anvil makes a firm rest for the ebonite

round head, which thus serves to hold the contact blade and also to act as a terminal for the connecting wires. The shape of the contacts is semicircular and the contacts are set radially, but with the curved faces concentric with the spindle. The spindle, as shown in Fig. 21, is made from a piece of $\frac{1}{2}$ in. diameter ebonite rod with a piece of standard screwed rod screwed into each end and secured with a lock nut. A small knob and pointer are attached to the front spindle, which should be sufficiently long to pass through the panel if the switch is mounted to the back of it. The moving contact members are made from $\frac{1}{8}$ in. diameter brass rod screwed at one end and passed through holes tapped into the ebonite rod. These contacts are secured with a lock nut, and should fit tightly to avoid any chance of their turning or shifting in position.

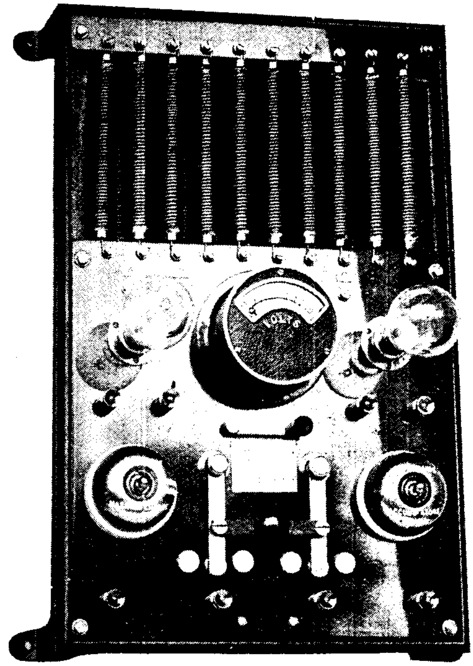
The shape of these arms or contact brushes is that of a spoke with a semicircular shoe piece at the outer end. This has to bear on the contact blades with sufficient pressure to make good contact.

A slight adjustment will enable this to be done with certainty. The switch, as illustrated, operates as a single pole, and makes contact and closes the circuits when the swinging arms touch both pairs of the contact brushes. Movement of the spindle is limited by stop pegs driven into the front panel, as shown in Fig. 22, and these should be of ebonite slightly tapered and driven hard into the front panel.—*E. W. Hobbs*

SWITCHBOARD. The term switchboard is applied to a species of apparatus characterized by the use of a switch or switches for the control of a circuit or circuits. Switchboards, as far as they apply to wireless, can be classified under two headings: those that are used for the control of the charging current and the output from a battery, and those that are used for the distribution of electrical currents to desired locations. The former are often known as charging switchboards, the latter as distribution boards.

The essential requirements of a switchboard are a sound substantial base of insulating material, with convenient means for supporting it from a base or from the wall. There should be some independent insulating material between the baseboard and the place of support to reduce any chances of earthing to a minimum.

Upon the board must be conveniently mounted all the requisites for the control of the current and the operation of the instrument. These usually comprise the actual switches, safety fuses and instruments such as a voltmeter and ammeter. On the face of a distributing switchboard the requisite connecting point or contacts are needed, with a multi-plug or other means of effecting the connexions.



MARINE TYPE OF SWITCHBOARD

Fig. 1. Accumulators may be charged and current regulated for the induction coil of the ship's transmitter by means of the switch-board shown above

Courtesy Marconi's Wireless Telegraph Co., Ltd.

Suitable materials for the baseboard are slate for the higher voltage currents, ebonite for lower voltages, and occasionally hardwood for small charging boards. All the components ought to be substantial and well over the minimum size for the work they have to perform.

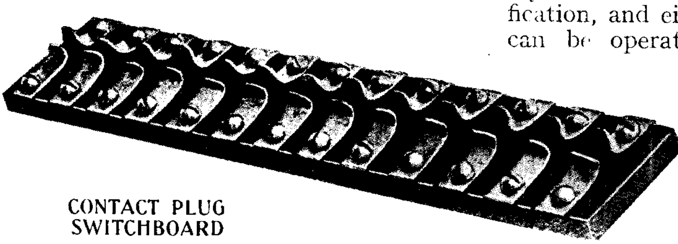
A type of marine switchboard suitable for use when charging accumulators or regulating the current of the induction coil of a ship's spark transmitting apparatus is illustrated in Fig. 1. The whole apparatus is contained in a cast-iron framework having legs at each corner for attachment to a wall or other place of permanent fixing. The switch panel occupies the lower portion of the framework, while at the top a strip of slate is attached, to which a double row of spiral resistance coils are attached. The resistances are wound on circular formers of a heat-resisting material and are attached at their lower ends to the top side of the switch panel.

A voltmeter reading up to 50 volts is centrally mounted on the panel, a key switch being fitted below the meter to effect a reading. On either side of the voltmeter a charging lamp is placed that, when switched into the circuit, gives a charging rate of 2 amperes. Seven combinations of charging or discharging through the induction coil are possible, and are brought about by the three switches fitted to the bottom of the panel. The mains at 60 to 120 volts pressure enter the switchboard at the binding posts just below the two charging lamps.

Quite a different pattern of switchboard is illustrated in Fig. 2, and is intended for use on the panel of a wireless set for speedily altering the connexions to allow of the set functioning on different circuit arrangements by the removal of one or more contact plugs.

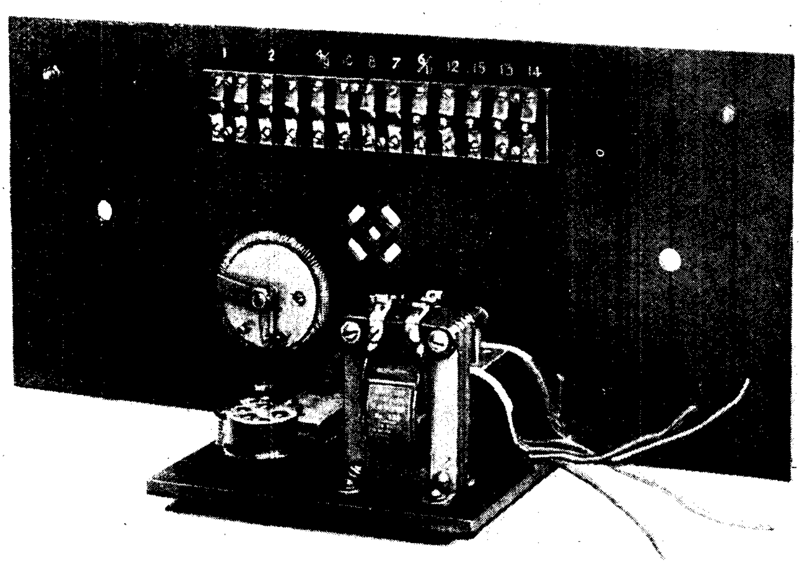
The base is a plate of ebonite about $\frac{3}{16}$ in. thick, and of such length and width as may be needed to accommodate the requisite number of contacts. In this example there are 13 separate pairs of contacts mounted on a plate measuring $1\frac{1}{2}$ in. wide and 7 in. long. In one application the plate is mounted at the top back of the panel, as shown in Fig. 3, and ultimately the contacts are connected to the various pieces of apparatus according to the desired wiring. For example, the circuits shown in Fig. 5 are suitable for a crystal detector with H.F. or L.F. amplification, and either of these three circuits can be operated as desired by merely altering the position of a single plug-in switch.

The contacts are numbered 1 to 15, but two are left blank, as they are not needed except as balances to maintain equality of pressure on the prongs of the plug contacts. The



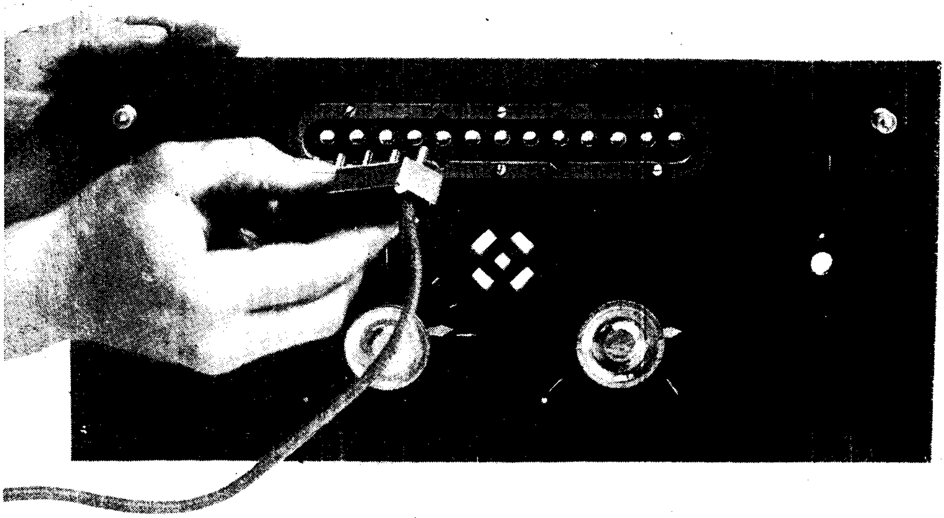
CONTACT PLUG SWITCHBOARD

Fig. 2. Contact plugs are used on this switchboard, a type particularly suited to panel mounting on a wireless set



CONTACT PLUG SWITCHBOARD MOUNTED ON A PANEL

Fig. 3. Here the switchboard shown above is seen mounted on a panel. The valve and other components can be connected up to the switch in order to vary the circuit connexions of the set in such a manner as may be desired by the experimenter

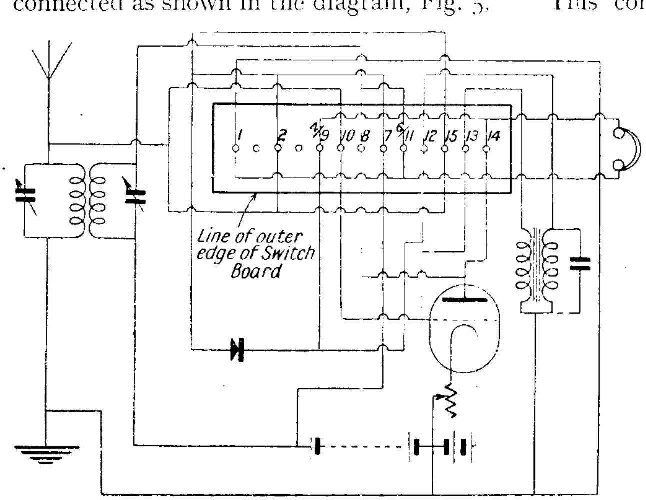


HOW THE SWITCHBOARD CONTACTS ARE EFFECTED

Fig. 4. Five contacts are obtained by means of a five-prong push-in plug made of ebonite. In this manner fresh connexions are made on the switchboard and different circuits are brought into use, in the manner shown in Fig. 5

principle adopted in this case is to employ five consecutive contacts to control each circuit.

To do this necessitates making the telephone connexions to the first, fifth, ninth and thirteenth contacts, counting from the left as seen from the back of the panel. Arranged in this way the telephones can be connected as shown in the diagram, Fig. 5.



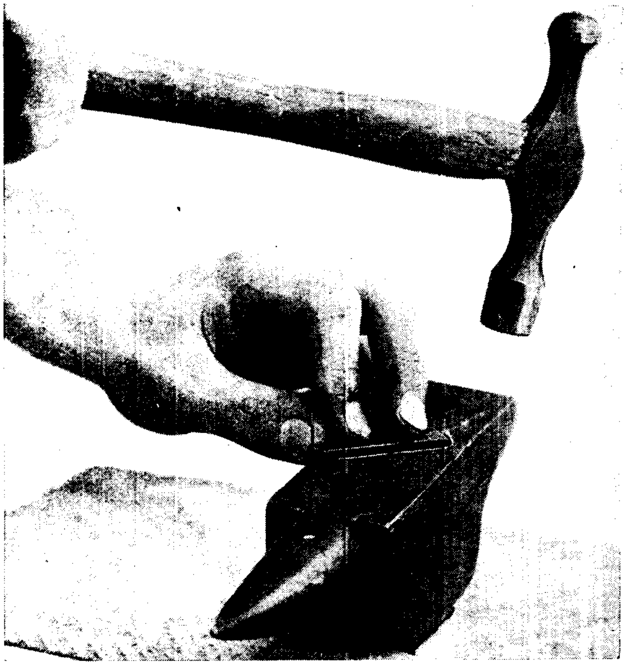
WIRING DIAGRAM OF CIRCUITS CONTROLLED BY SWITCHBOARD

Fig. 5. Contacts are numbered from one to fifteen, with two blanks for balance. A choice of three circuits is provided, and these are varied merely by altering the position of the plug

and simply a five-prong plug used to make the connexions; or the telephone leads can be attached directly to the outer contacts on the plug. This method is shown in operation in Fig. 4 where the plug so equipped is seen being inserted into the left-hand set of contacts from the front part of the panel.

This completes the circuits controlled by contacts numbered 6/11, 12, 15, 13, 14 on the diagram, Fig. 5. This is the crystal with L.F. amplification circuit. The crystal only is used in the opposite set of contacts numbered 1, 2, 4/9. The centre set of contacts controls the circuits for H.F. amplification with crystal detector.

When the telephones are connected to the plug as shown in Fig. 4 it is necessary to have a simple guard device to prevent risk of inserting the plug in any but the correct position. One way of doing this is shown in Fig. 4, and comprises a slotted ebonite plate with notches in it. Similarly shaped projections are worked on the plug, and thus keep the whole in register and prevent any mistake in plugging in.

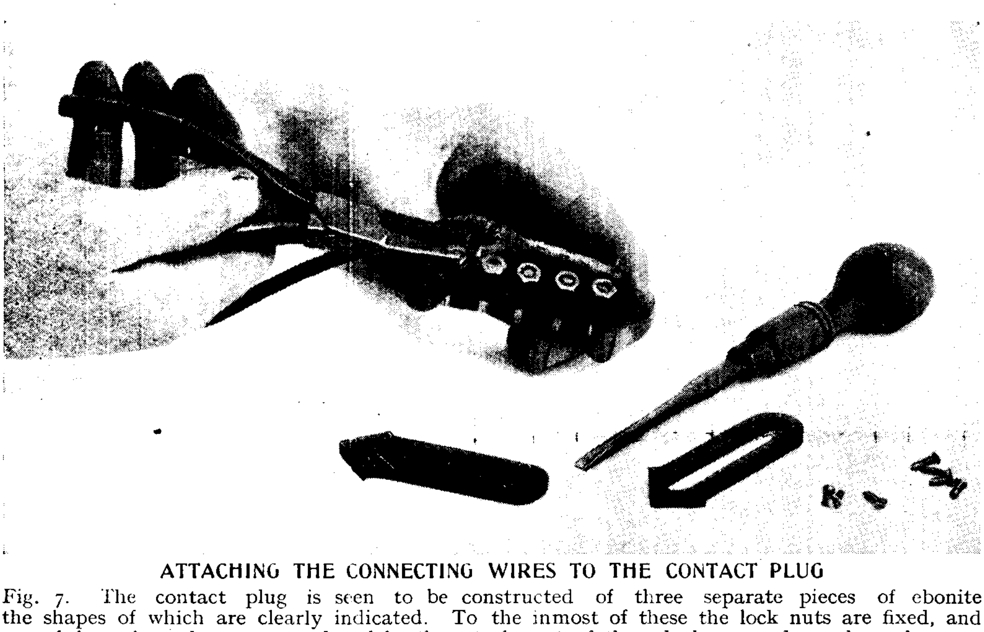


SHAPING THE CONTACTS

Fig. 6. By hammering the metal blade of the contact over a steel plate on an anvil the contact for the switchboard is easily and properly shaped prior to mounting

The construction is not a difficult matter, but calls for care in the making of the contact pieces, and particularly of the spacing of the plug holes. These must all be exactly the same spacing, as the plug prongs have to fit into any of the combinations with equal facility and certainty. To ensure effective contact, the contact blades on the ebonite plate must be of springy metal, and must be firmly attached to the plate, having neatly rounded ends slightly overlapping the plug holes. The blades can be made of copper or preferably brass or phosphor-bronze, and laminated.

They are shaped by cutting to uniform length, and with the aid of a specially shaped steel plate are hammered over at the top end, as shown in Fig. 6. The blade is held firmly in contact with the steel piece, and the blade allowed to overlap the end a trifle. It is wiped across the surface of the bench anvil, thus turning the end up somewhat. The rounding is completed by gently hammering, as shown, until the end of the blade is rolled over to a half-circular shape. The screw holes should be drilled with a template or jig as a guide to ensure perfect alinement.



ATTACHING THE CONNECTING WIRES TO THE CONTACT PLUG

Fig. 7. The contact plug is seen to be constructed of three separate pieces of ebonite the shapes of which are clearly indicated. To the inmost of these the lock nuts are fixed, and of these the end two are employed for the attachment of the telephone cords, as shown here

The construction of the plug is simplified by the use of three pieces of ebonite about $\frac{1}{4}$ in. thick, all cut to the same external profile. One of these plates is used to support the five plugs, which are made from brass rod about $\frac{3}{16}$ in. diameter and screwed to the plate.

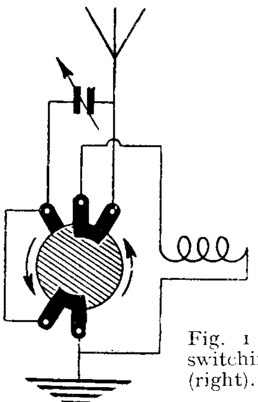
They are further secured by lock nuts screwed on the ends of the plugs and well tightened. The end two are used for the attachment of the telephone cords, if preferred, and their mode of attachment is shown in Fig. 7, which also illustrates how the parts are shaped.

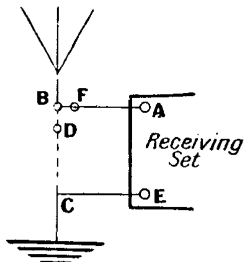
The second plate is slotted to clear the nuts on the plugs, and the top plate hollowed to make room for the telephone cords, which pass through an aperture in it. With switchboards of this type it is highly important to check over the circuit very carefully before switching on the high-tension or the low-tension batteries, to avoid a disastrous short circuit. When planning the circuit arrangements it will be found that several of the connexions will be common to more than one of the circuits, and when the position of the contacts can be suitably arranged, one will serve for these multiple duties. In the present example contacts numbered 4/9 and 6/11 are common respectively, Nos. 4 and 9 being alike, and 6 and 11 also similar, and performing the same purpose. *See* Accumulator; Charging Board; Jack; Switch.

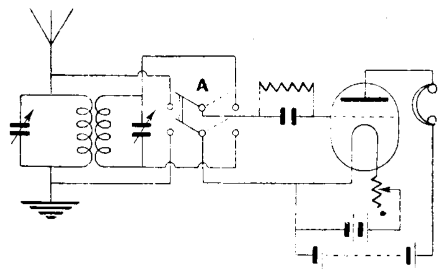
SWITCHING SYSTEMS. Term applied to the disposition and arrangement of switches in an electrical circuit to enable it to be adequately controlled.

In wireless work there is a great scope for ingenuity in the design of switching systems, and there is the practical benefit that when switches are properly disposed in a set it is possible to operate certain parts of it and to cut out others. This is often an economy, as, for instance, in the case of a crystal set used near a broadcasting station.

For ordinary headphone reception from such a station the crystal will answer well, but if a loud speaker is used a low-frequency amplifier will probably be needed. This can be built into the set and controlled by a switch or switches, and thus when the extra strength is needed can be brought into operation. Normally, however, reception can be obtained without it, and the battery power thus economized.







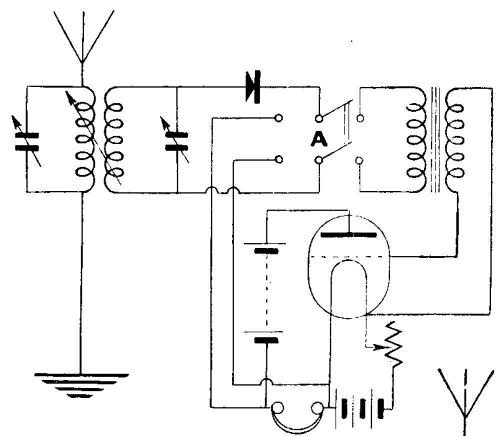
COMMONLY EMPLOYED SWITCHING SYSTEMS

Fig. 1 (left). Rotating type of multi-contact switch for series-parallel aerial switching. Fig. 2 (centre). Simple aerial to earth switch connexion. Fig. 3 (right). Conventional arrangement of tune and stand-by switch of the double-pole, double-throw type

Similar applications are employed for the control of parts of a multi-valve set, as the cutting-in of stages of high-frequency or low-frequency amplification, or the control of a loud-speaker circuit.

The simplest switching arrangement is that for the aerial and earth connexions. It is very easily followed, and is diagrammatically illustrated in Fig. 2, showing at A the aerial terminal of a set, and at E the earth terminal. The aerial lead-in is attached to one side of a simple switch at B, and the switch arm is arranged so that it can make contact with either of the terminals F D at will. When on terminal F the set is capable of receiving signals, but when at D is directly connected to earth, as a branch wire is taken to C, both to E and to the earth.

Another commonly used arrangement is pictured in Fig. 1, showing a series-parallel switching device. In this example a rotary type of multi-contact switch is used, which when turned to the right or to the left puts the variable condenser in



CRYSTAL AND AMPLIFIER SYSTEM

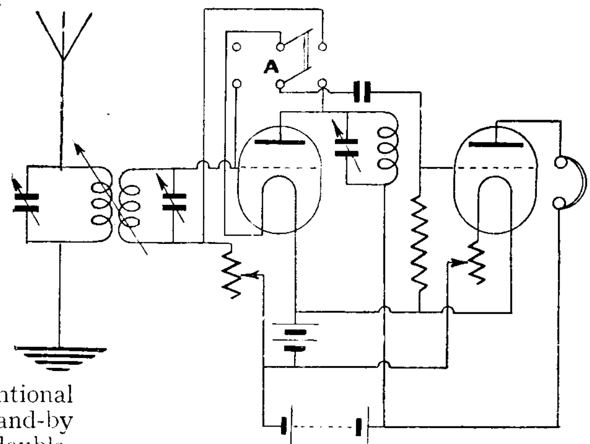
Fig. 4. A is the switch, which, when thrown to the right, puts the crystal in series with the telephones, eliminating the amplifier circuit

series or in parallel with the inductance, thereby giving a wider range of wave-length reception.

The experimenter sometimes finds it difficult to pick up signals quickly on a multi-circuit tuner, and one way of dealing with this matter is illustrated in Fig. 3, showing a conventional method of arranging a tune and stand-by switching system. A double-pole double-throw switch is located as shown at A. When thrown to the left it puts the aerial tuning inductance and condenser in direct connexion with the grid and filament circuits of the detector valve, facilitating tuning. When the station has been picked up the secondary circuit is brought into play by throwing the switch to the right, completing the secondary connexions to the grid and filament and severing those from the aerial and earth.

The usually adopted method of switching a crystal and low-frequency amplifier is shown in Fig. 4, by means of the switch shown at A, which when thrown to the left puts the crystal in series with the telephones.

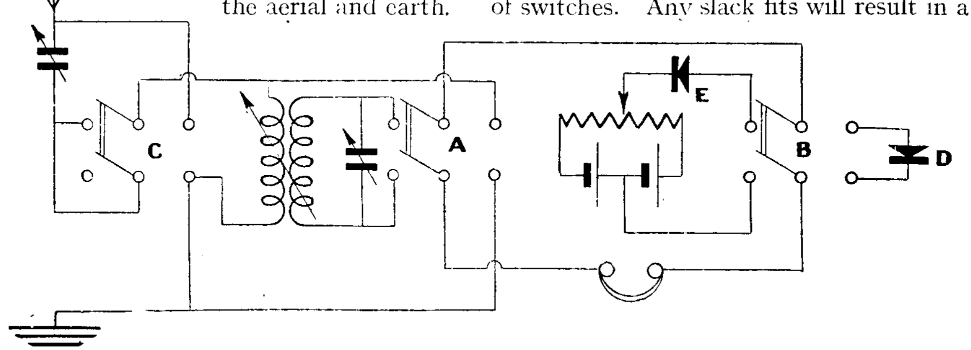
When the low-frequency amplifier is needed the switch is thrown to the right and the filament switched on. The crystal is then in the primary circuit of the transformer, and the latter is brought into play, with a consequent increase of signal strength.



CONTROL OF TWO VALVES

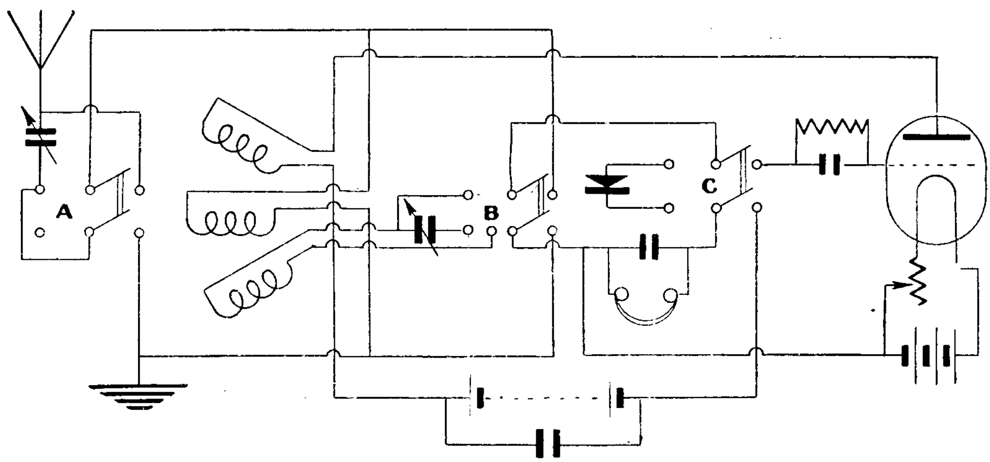
Fig. 5. Shown at A, the double-pole, double-throw switch connects the A.T.I. and condenser directly with grid and filament circuits of the detector valve

The switching of high-frequency circuits is a matter that calls for some additional care, owing to the nature of the electrical pulsations that have to be handled. All contact faces must be perfectly clean, and capacity effects reduced to a minimum by the use of the best design of switches. Any slack fits will result in a



SWITCHING WITH A CHOICE OF CRYSTALS

Fig. 6. Several systems are embodied in one set above. A is the tune and stand-by switch; C the series-parallel switch in the aerial circuit. B is a selector switch giving a choice of two crystals



CIRCUIT ARRANGEMENTS FOR CRYSTAL OR VALVE RECEPTION

Fig. 7. Here the choice is akin to Fig. 6, only a choice is given this time of crystal or valve circuits. This arrangement is very suitable in cases where valve reception is only occasionally called for

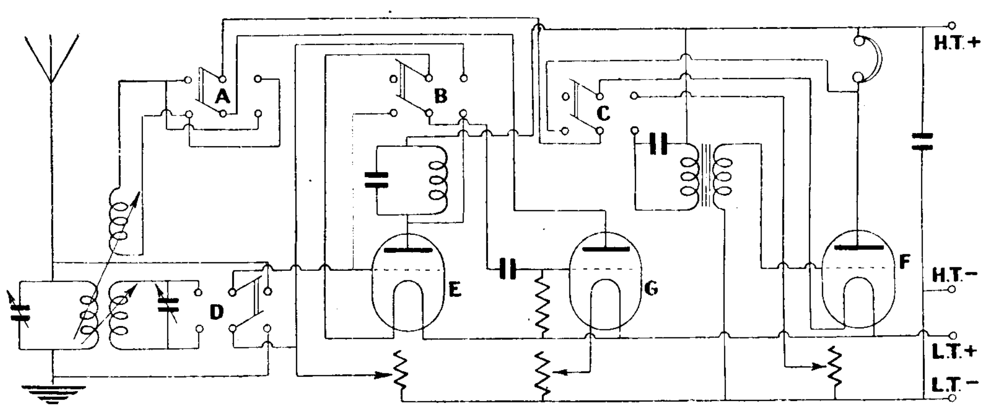
certain amount of parasitic noise in the set, especially when several valves are used, and these effects must be studiously guarded against. The application of a switch to a two-valve circuit is where the first valve, which acts as a high-frequency amplifier, can be switched in or out of circuit at will by the switch at A. This may be any reputable type of low-capacity pattern, as shown in Fig. 5.

The switch, when thrown to the left, puts the high-frequency valve into the circuit, but when to the right the detector valve alone functions.

With this arrangement the set can be tuned accurately to the station, and afterwards the high-frequency valve is switched in and the signal strength increased. Tuning of the high-frequency valve is thereby simplified.

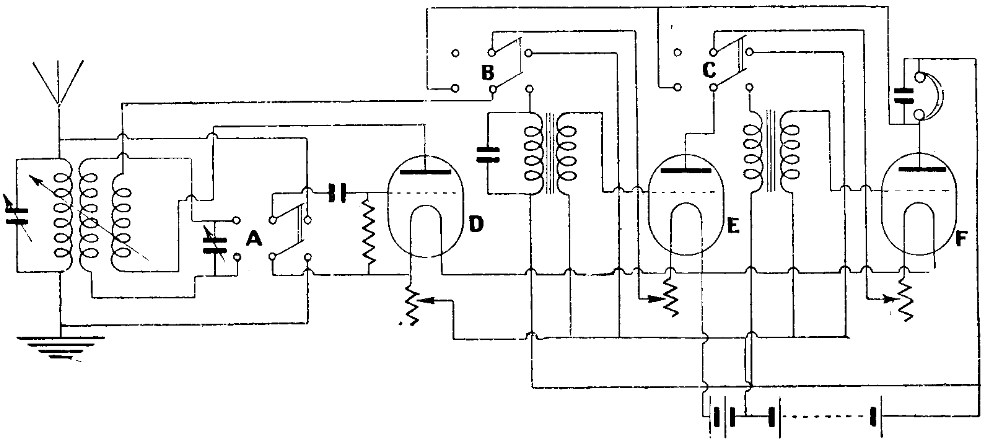
Several switch systems can be incorporated into one receiving set, such as the arrangement in Fig. 6, where the switch at A is an ordinary tune and stand-by device. A series-parallel switch is shown in the aerial circuit at C, and a selector switch at B, enabling either of two crystals to be put into the circuit. For instance, suppose it were desired to have a sensitive crystal for loudest reception, or for test purposes, and to have a stable one for quickly picking up the signals.

The latter might be of the carborundum pattern, as shown at E, and brought into circuit by throwing the switch B to the left. As soon as signals are tuned in



THREE-VALVE SWITCHING SYSTEM

Fig. 8. Various combinations are obtainable by alternative switching in this circuit. D is the tune and stand-by; the switches B and C control the valves E and F, and A reverses the direction of the current flow through the reaction coil



SECOND SWITCH-CONTROLLED THREE-VALVE CIRCUIT

Fig. 9. This system allows of the use of the detector valve alone or of one or two stages of low-frequency amplification; A, the tune and stand-by; B controls the first stage of low-frequency amplification, and C the second

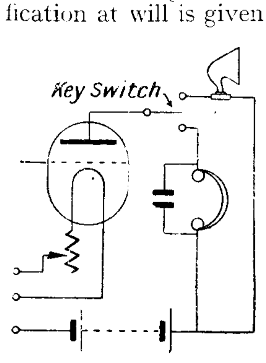
the switch is thrown to the right and the test or other crystal at D is put into the circuit and the carborundum crystal cut out of it. Used in this way, it is an easy matter to adjust the test crystal, as it is known that the set is properly tuned, and that speech or music is heard.

The circuit arrangement shown in Fig. 7 and the purpose of the switches is somewhat akin to the foregoing example, but in this case the choice is between a crystal and a valve for reception purposes. This arrangement is a good one for those who only use a valve occasionally, as by the use of the switches it is possible to have a crystal for detection purposes and a simple tuning arrangement consisting of a condenser and inductance, or to change over at will to a three-circuit arrangement of a valve with reaction. The former combination is used when the switch A is in either of its positions, the switch B to the right, and the selector switch C to the left. Reversing the positions of the latter switches cuts out the crystal and brings into the circuit the secondary circuit for tuning and the valve with reaction.

Switching arrangements for a three-valve set are given in Fig. 8, whereby various combinations are obtainable at will. The switch at D is the customary tune and stand-by switch, switches B and C respectively control the valves E and F, and the switch A reverses the direction of flow through the reaction coil.

In the circuit shown in Fig. 8 the first valve is a high-frequency amplifier on the tuned anode principle, valve G the detector, and valve F a low-frequency amplifier valve.

Loud speakers require a considerable amount of low-frequency amplification for proper operation, and it is not always desired to use them, or to have some convenient means for controlling the volume of sound. A switching system that allows of the use of the detector valve alone or of one or two stages of low-frequency amplification at will is given in Fig. 9, where A is the tune and stand-by switch, B a switch controlling the first stage of low-frequency amplification and switch C the second stage.



LOUD-SPEAKER SWITCH

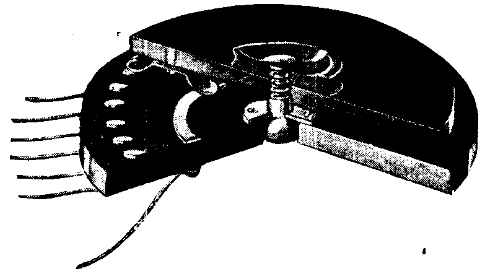
Fig. 10. How the key switch is arranged to control the switching of telephones or loud speaker

D is the detector valve, E the first and F the second low-frequency valves. When the switch B is to the right and switch C to the left one stage of low-frequency is in circuit. With B to the left and C to the right, only the detector is in circuit. When both stages of low-frequency are needed. switch B is to the right and C to the right, The switch A is used when tuning in the usual way. A switching refinement is illustrated in Fig. 10, which shows pictorially the arrangement of an anti-capacity switch to control the switching of telephones or loud speaker. The telephones are used for the tuning, and when the signals are properly heard the switch is thrown and the telephones cut out of the circuit and the loud speaker brought into it.

Switching to control the inductances in a multi-valve high-frequency amplifier is by no means commonly used, but an application is illustrated in Fig. 12, where one special switch, D, of a rotary type, is used to vary simultaneously the inductance values of the three coils, A, B, C, the first being the aerial tuning inductance and the others the anode reactance coils.

The values of these coils and the proportions of their windings are correctly arranged at the start; but, apart from this, all the coils are similarly tapped and the tappings taken to stud contacts on the switch D. The general arrangement of such a switch is shown sectionally in Fig. 11, and comprises a base with the contact studs disposed near the rim and the second contact in the form of a quadrant-shaped contact plate. There are three separate sets of these studs and plates, and each is bridged by a balancing brush, which spans the space between the studs and the quadrant plate.

Each of these sets must be regarded as separate and distinct from the others. One set is wired to the aerial inductance, as shown at E in Fig. 12, the first anode coil to F, and the second anode coil to G. The connexions from the quadrant plate in the last two, F, G, are to the lower side of



COIL-TAPPING CONTACTS

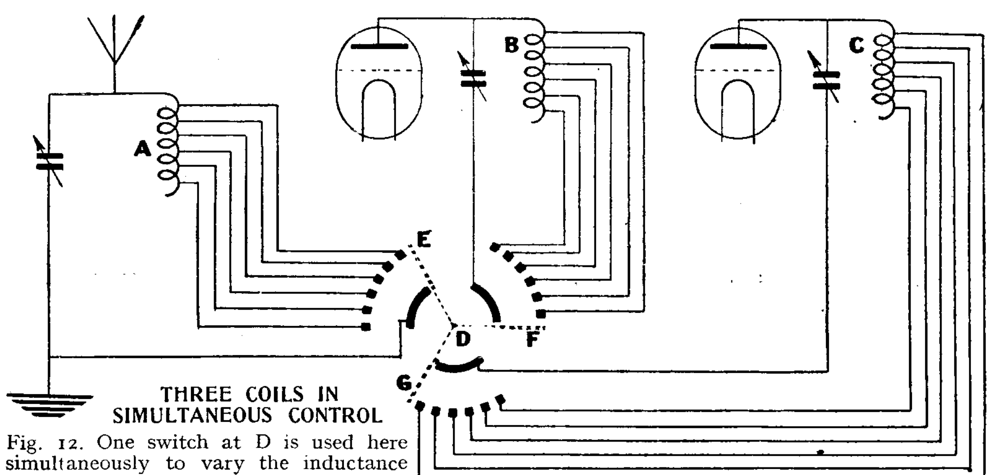
Fig. 11. This switch is the one shown at the point D in Fig. 12, and is cut in section to show how contacts with coil tappings are effected

the tuning condensers across the reactance coil in the usual way.

The lead from the quadrant plate at E is to earth; thus the aerial inductance is shunted at all times by the aerial tuning condenser, but the value of the aerial coil can be varied in step with the variations of the high-frequency coils. For simplicity the remainder of the circuits are not shown, but follow conventional lines, and may or may not include other switches, such as the tune and stand-by or separate valve controls and reversing switches. *See* Anti-capacity Switch; Dewar Switch; Knife Switch; Jacks and Plugs; Switches.

SWIVEL SWITCH. An extremely useful and ingenious switch, in which the moving arm is capable of rotation in a ball and socket joint to make connexion with any number or arrangement of switch contacts, arranged radially round the swivelling point of the switch arm.

One form of the swivel switch is illustrated in Fig. 1. It consists of a circular



THREE COILS IN SIMULTANEOUS CONTROL

Fig. 12. One switch at D is used here simultaneously to vary the inductance values of the three coils A, B and C

base of ebonite, to the centre of which a rounded brass knob is screwed. A flat brass strip secured under the ball makes connexion to a terminal screwed towards the circumference of the base. The switch arm is made from two lengths of brass strip drilled at one end to form a depression into which the ball is fitted.

Towards the end of the two brass strips which fit over the central ball two holes are drilled, and a bolt is fitted through by which continual pressure is made between the strips and the ball. A handle of $\frac{1}{4}$ in. ebonite is fitted between the brass strips at the outer end, and provides a means of moving the switch arm to any desired contacts. The contacts are right-angle strips of springy brass having a double bend at the side where they make contact with the arm. Holes are drilled in their bottom sides by which they are screwed to the base. The fixing of the contacts is illustrated in Fig. 2.

In the switch shown three pairs of contacts are fitted, but, if desired, any number consistent with room to place them may be used. Correct tension to the moving switch arm is given by tightening the screw in the arm. This operation is shown in Fig. 3.

In wiring up, the switch connexion is taken to the terminal joined to the switch arm and any of the pairs of contacts. A switch of this description is useful for switching in extra high-tension voltage, in which case the terminal would connect to the high-tension positive terminal and the fixed contacts to progressive tappings from the high-tension battery. High-tension negative is not controlled by the switch and runs straight to its terminal.

An even more useful type of switch, having great possibilities in switching arrangements, is shown completed in Fig. 4. This switch is of somewhat similar principle. Connexion is not, however, made to the moving arm, which bears three U-shaped contacts, spaced at equal distances. These contacts are arranged to plug in to pairs of fixed contacts, the wires of any one circuit being taken to opposite sides of a pair of fixed contacts.

When the plug on the moving arm is inserted between the contacts the gap between them is bridged and current is allowed to flow. Within the limits of construction any number of circuits may thus be controlled with the single arm. In the switch illustrated four switching arrangements are provided. One is a three-way switch while two have double pairs of fixed contacts and thus can operate two different circuits requiring two make and break positions.

The third is a single switch. The construction of the switch is very simple. The moving arm rotates on a ball and socket joint to give it a universal action. It is made from a piece of square ebonite, and at its pivoting end is drilled out to receive a small brass knob attached to a screwed rod. A hole is drilled at the centre of the depression and a spring is fitted into it. The ball is kept in position inside the depression by two square washers screwed to the moving arm on either side of the ball. In order to build up the moving arm to the required height the ball is fitted to an ebonite collar and is then tightened to the base by a nut from underneath. The contacts on the moving arm are cut from thin sheet brass and are screwed to the sides of the arm in the manner shown in Fig. 5. This illustration also shows the method of fitting the ball and socket movement. The fixed contacts shown in Fig. 6 are arranged in line with the pivoting point of the moving arm and are sufficiently close to form a good connexion when the plugs of the moving arm are inserted. *See* Switch; Switch Systems.

SYKES'S MICROPHONE. This is a form of liquid microphone due to A. F. Sykes. In most liquid microphones a stream of conducting liquid is caused to flow so that its cross-section is varied between the electrodes and the resistance is thereby varied. The cross-section of the liquid is varied by the voice or other sound, by suitable mechanical means.

In the Sykes liquid microphone the variation of resistance is effected by varying the concentration of salt or other conducting material in the stream passing between the electrodes. The diaphragm of the microphone controls the volume of a concentrated salt solution which flows into another stream of pure water or non-conducting liquid. The conductivity of the combined solution is thereby varied as the sound waves falling on the microphone diaphragm varies the vibration of the latter. Special jets are used to obtain the necessary modulation. *See* Liquid Microphone; Majorana's Microphone.

SYLVANITE. Mineral which consists of gold and silver telluride. It is tin-white

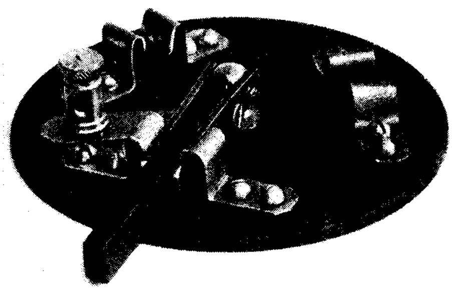


Fig. 1. In the complete swivel switch a ball and socket joint gives quickly any of three desired contacts

Fig. 2. Fixed contacts are secured to the base with screws driven into tapped holes in the base, which is of ebonite

Fig. 3. Adjustment of the ball and socket is effected by tightening the screw holding the two brass strips

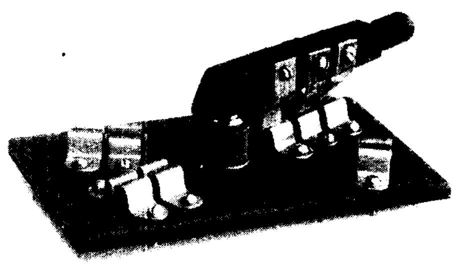


Fig. 4. Another swivel switch, in which connexions may be made to a one-, two-, or three-way switch at will

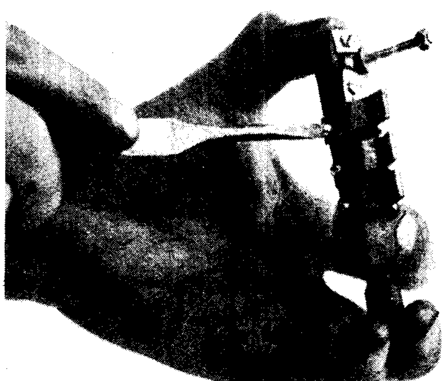


Fig. 5. Details of ball-and-socket movement and method of attaching the U-shaped plugs

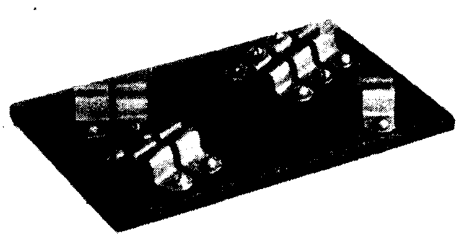


Fig. 6. Ebonite base of the switch, showing the fixed contacts assembled in position

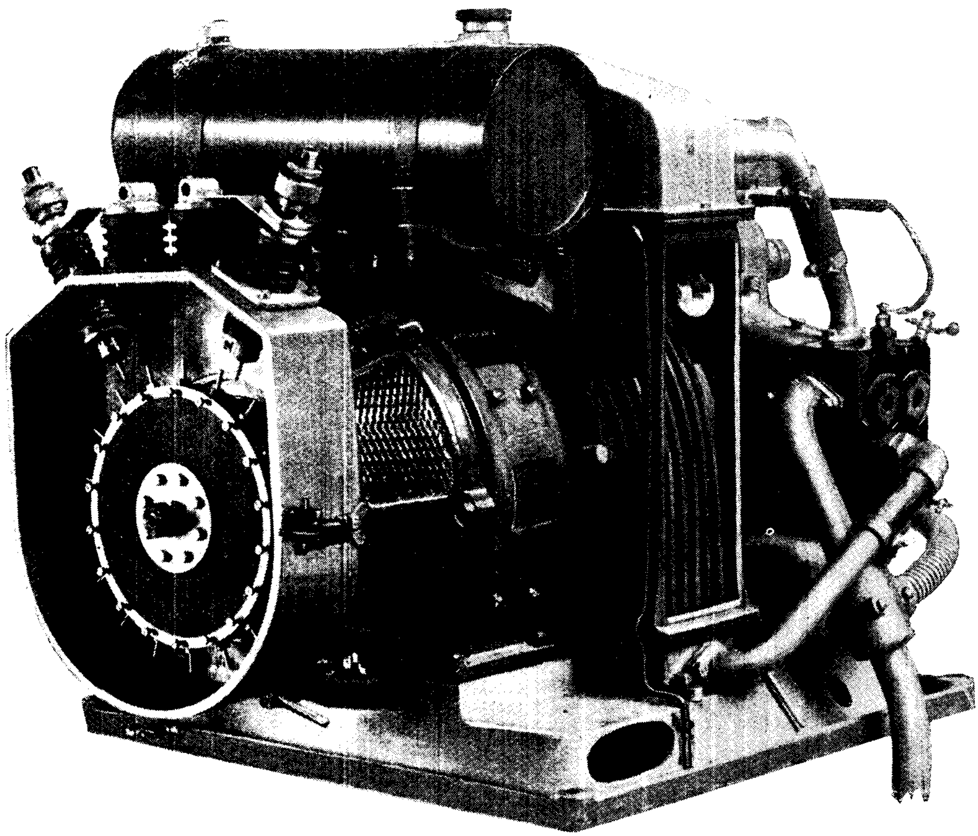
TWO NOVEL AND EASILY CONSTRUCTED SWIVEL SWITCHES in colour with a brilliant lustre, and is often known as graphic gold or graphic tellurium. It is found in Transylvania, Colorado and Western Australia, and has been used as a crystal detector. *See* Crystal.

SYMBOLS. In wireless the pictorial or other form of representation of wireless objects. The term is also used for the abbreviated representation by means of simple pictorial objects, characters, letters or other marks of any idea, or operation, or quantity in mathematics, chemistry and other sciences. The wireless amateur is chiefly concerned with the symbols as used in circuit diagrams, and these are given under the heading Abbreviations and Symbols in this Encyclopedia.

SYNCHRONOUS DISK DISCHARGER. A synchronous discharger is a rotary spark gap which is so arranged that discharge takes place in synchronism with alternations in the generator.

The photograph, Fig. 1, shows a synchronous discharger attached to the generator with which it is used. This machine is fitted with eighteen rotary discharge rods, arranged in a similar manner to those shown in Fig. 2. The construction of the insulators attached to the fixed rods is clear in this illustration. It will be seen that outside the casing there are further heavy ribbed insulators, at the top of which are the terminals for the leads.

The machine illustrated is a complete engine-generator unit. The engine is a water-cooled, horizontally opposed twin-cylinder machine of the familiar Douglas type, and is fitted with a radiator built over the generator body. Behind the radiator is a circular petrol tank. Engine, generator and discharger are all directly coupled, and therefore run at the same speed. The whole machine is bolted to a cast bed-plate of box formation.



SYNCHRONOUS DISK DISCHARGER ATTACHED TO GENERATOR UNIT

Fig. 1. This apparatus is a form of rotary spark gap. The discharger is attached to the generator with which it is used. There are eighteen rotary discharge rods and two fixed electrodes

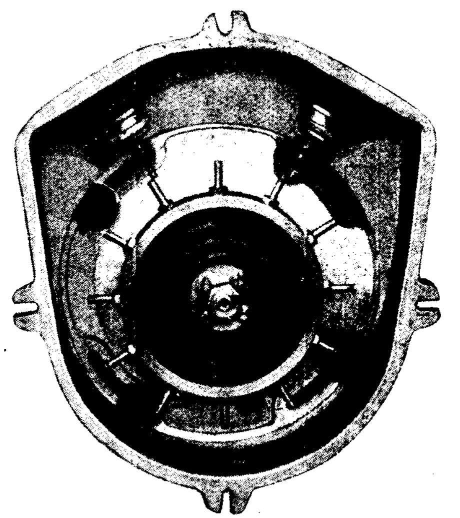
Courtesy Marconi's Wireless Telegraph Co., Ltd.

In Fig. 2 is shown a synchronous discharger for small powers by Marconi's Wireless Telegraph Company. This device is attached to the end of the shaft of a high-frequency alternator, and therefore must, as a whole, run synchronously with it. From the photograph it will be seen that the rotor is fitted with a number of projections or poles, which form the rotating discharge rods. Their number is one for every pair of poles in the machine.

The fixed rods, two in number, are inclined towards the centre of the shaft, and are attached to the outer casing. Ebonite bushes of heavy section are used to insulate the conductors to the fixed rods.

The outer casing is entirely separate from the generator body, and is bolted to it. It is capable of adjustment around the centre. The illustration shows that there are four slots equally spaced about the circumference of a circle concentric with the spindle. In these slots bolts are fitted, which allow the whole case to be rotated within the limits of the slots. By this means the relationship between the fixed and rotating discharge rods may be varied in order that when the machine is installed the points of discharge may be made in phase with the current.

Subsequent adjustment may be necessary some time after the machine has been in use, for constant arcing between the discharger tends to burn one side of the tips of the rods, with the result that they tend to lag behind the current. When this happens it is necessary to readjust the position of the fixed rods with respect to the rotary ones. *See* Rotary Spark Gap; Spark Gap.



SMALL POWER DISCHARGER

Fig. 2. Only twelve discharge rods and two electrodes appear here; there is one discharge rod for every pair of alternator poles, on the end of the shaft on which the discharger is fixed

Courtesy Marconi's Wireless Telegraph Co., Ltd.

SYNCHRONOUS MOTOR. An alternating current motor which runs always in step, phase or synchronism with the supply current.

Any single or polyphase alternator may be run as a motor in precisely the same manner that a direct current dynamo may be so applied.

In the case of an alternator the frequency of the current generated is the number of pairs of poles multiplied by the number of revolutions per second, and when that alternator is run as a motor it will only be able to run at that speed, and must first be speeded up to that number of revolutions per second by external means before it will run as a motor. When that speed is reached it will continue to function as a motor, provided it is not overloaded or put out of step in some other manner.

Should this happen, the motor will stop, and will have to be brought up to synchronous speed again before it may again be used. Despite this disadvantage, synchronous motors have many uses, one of the principal of which is for the driving side of a motor-generator set. In this instance the alternating current motor may be started from the D.C. side of the machine by applying current to the dynamo and running that as a motor until the whole plant has attained synchronous speed. When that is reached, the alternating current mains may be applied, and the set will function as a motor-generator.

Some forms of polyphase synchronous motors may be started by opening the field circuit and applying the polyphase supply direct to the armature. By means of eddy currents set up in the poles of the field magnets a driving torque is produced, and the rotor will start to rotate. When synchronism is attained the fields may be closed and the load applied to the motor. *See* Generator; Phase; Sine Curve.

SYNCHRONOUS SPARK GAP. A rotary spark arranged to give a fixed number of sparks to each cycle of an alternating current supply, the sparks occurring at points of the same phase in successive cycles. *See* Gap ; Rotary Spark Gap ; Spark Gap ; Synchronous Disk Discharger.

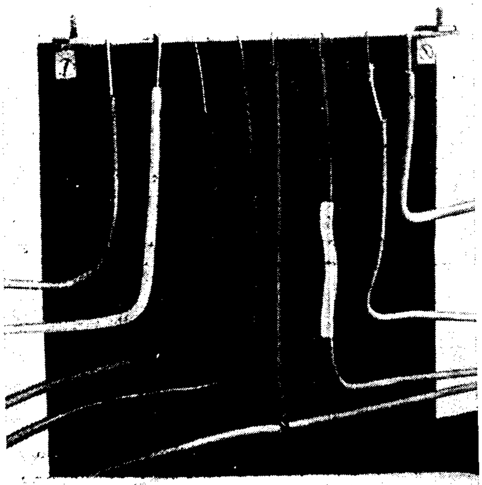
SYNTONY. In wireless the adjustment of one circuit to another, so that their time periods are the same. Two or more circuits are said to be syntonized when they have been adjusted to the same frequency. A simple syntonizing experiment is the syntonic Leyden jar experiment.

This is an experiment, due to Sir Oliver Lodge, to illustrate the essential principle of all tuning. The same plan is now used in wave measurers. Two Leyden-jar circuits are arranged so that they can be tuned so as to have the same frequency of vibration, and then one will respond to the other : on the analogy of two tuning-forks, one of which may be loaded until they are either in or out of tune. The first jar has a spark gap in its circuit, and is charged and discharged in the ordinary way. The second jar has a complete metallic circuit of approximately the same dimensions as the other ; but the circuit is completed through a metallic slider, which must make good contact, and which, by being moved about, alters the inductance of this circuit.

To demonstrate the surgings, an overflow or shunt gap is provided between the coatings, the best plan being a strip of tinfoil bent over the lip of the jar to connect the two coatings, except for the space of $\frac{1}{8}$ in. or $\frac{7}{16}$ of an inch. Instead of this strip of tinfoil, wires may be used, leaving a small gap between them ; though the longer path thus provided is less quickly responsive to overflow than is the strip of tinfoil. The essential thing in this second or resonant Leyden jar circuit is that it shall be metallically complete, that is to say, the coatings shall be short-circuited through it. Otherwise the surgings cannot work up from the necessary small beginnings. This is a necessary feature of all tuning arrangements. Good joints are essential, because the initial E.M.F. is very feeble, and only works up to a considerable amount by resonance. By moving the slider the jar can easily be put out of tune with the other, and then there is no response. In wave-measurers the maximum response is indicated by various instruments, but in this experiment by an overflow spark. The detector has to be in shunt with the main circuit, not in series, or it will prevent the oscillations from the beginning.

The same plan was applied by Lodge to an aerial, after he had introduced inductance into it ; and the coherer, the crystal, or other detector, works by overflow from the two capacity areas at each end of this inductance, or—what is the same thing—from the upper part of the aerial and the earth. The surgings may, however, be detected by magnetic coupling, though this would not be suitable in the Leyden-jar experiment.

The tuning of one circuit in resonance with another is dealt with in many articles in this Encyclopedia. The reader should consult such articles as Frequency ; Lodge Syntonic Jars ; Oscillation ; Tuning, etc.



SYSTOFLEX INSULATION

This very useful insulating sleeving of flexible tubing is made in different colours so that the paths of different circuits may be distinguished without difficulty

SYSTOFLEX. Trade name given to a particular insulated sleeving, which is slipped over a wire to prevent accidental contact with any metallic substance. Systoflex is manufactured in a variety of colours, and so is of assistance in differentiating between different circuits.

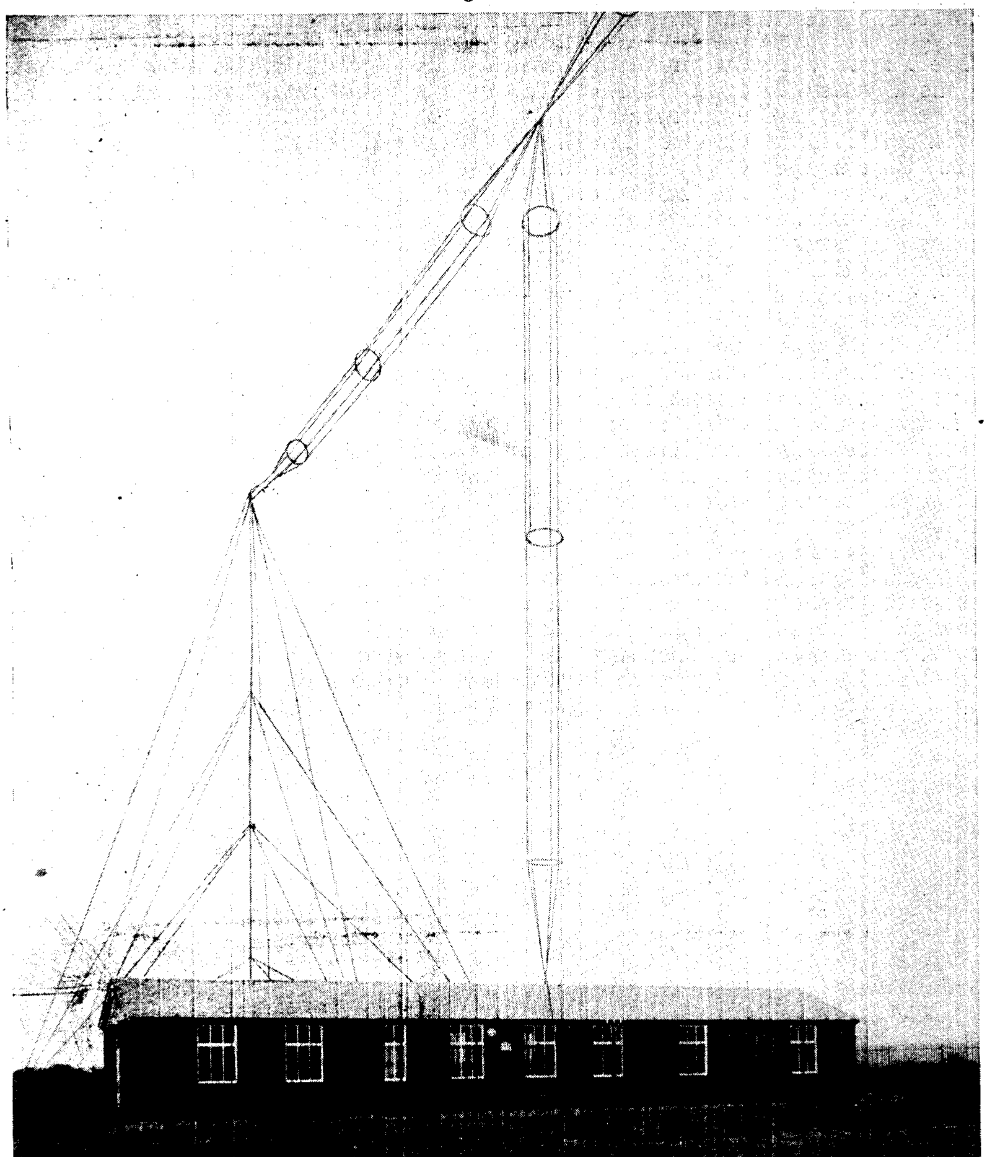
Three sizes of Systoflex are commonly used by the wireless experimenter, ranging from 1 mm. to 3 mm. Systoflex is covered with a flexible insulating varnish or enamel, which is shown in the illustration, and has a shiny exterior. When a wire is to be pushed through a length of Systoflex the operation is often assisted if the wire is run through the fingers first of all to free it from bends and kinks. Where two pieces of Systoflex are fitted on the same wire the joint can be covered with a short length of Systoflex of a larger diameter.

The advantage of any form of insulated sleeving is that bare tinned wire may be used for making connexions which obviates the stripping of the insulation if an insulated wire is used. *See* Insulation ; Wiring.

T

Ta. This is the chemical symbol for the rare metallic element tantalum (*q.v.*).

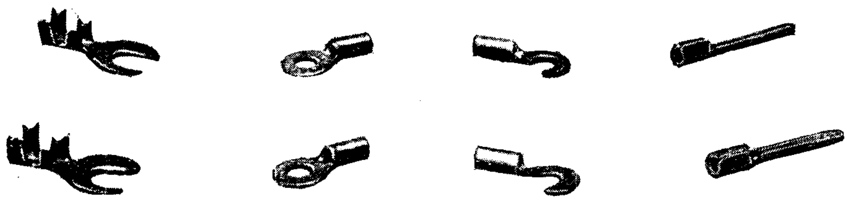
T AERIAL. Name given to a type of aerial in which the lead- or leads-in are attached to the middle of the horizontal wire or wires.



T AERIAL OF THE BOURNEMOUTH BROADCASTING STATION

The characteristic feature of the T aerial is that its lead-in wires are attached to the centre of the horizontal wires. This type is by no means in such general use as the inverted L type of aerial. The illustration is of the aerial of 6 BM, the Bournemouth station

Courtesy Marconi's Wireless Telegraph Co., Ltd.



VARIOUS TYPES OF TAGS, INDISPENSABLE WIRELESS FITMENTS

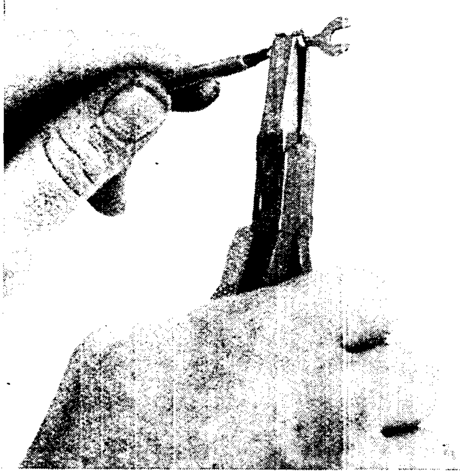
Fig. 1. From left to right the different specimens are: spade terminals or tags; eye tags for soldering on the ends of wires; hook tags for terminal connexions; telephone tags

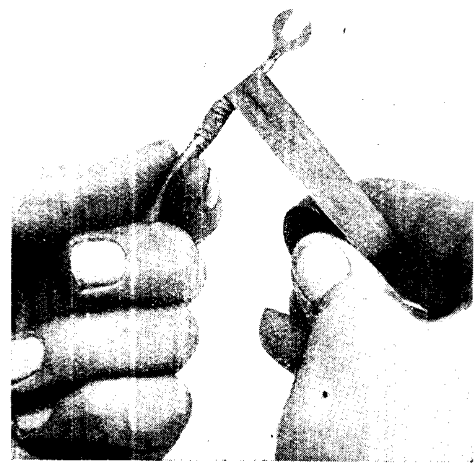
The T aerial is not so generally in use as the inverted L type. One of the reasons for this is that its natural wave-length is shorter for a given length of aerial than in the case of the inverted L type, since the two halves of the horizontal wire are converted into two inductances in parallel and their combined value is less than either taken separately. By reducing the inductance the wave-length is reduced, other things being equal, as wave-length depends on inductance and capacity. The inductance can be increased by using a number of wires in parallel. It is important that the lead-in of a T aerial should be taken from the exact centre of the horizontal span.

It is very often more convenient to use a T type of aerial rather than the inverted L. This is particularly the case on board ships, where the distance between the masts is so great that an inverted L aerial would give a wave-length in excess of 600 metres. A short-wave condenser (*q.v.*) may be used to decrease the wave-length, but the objection to this is that the use of such a condenser decreases the radiation efficiency of the aerial. A condenser in series with the aerial in any case would not reduce the wave-length below one half its natural wave-length, so that with the inverted L aerial of great length a 300 metre wave could not be reached. The difficulty is overcome, especially where a T aerial gives an unusually long lead-in, by using insulators to shorten the length of the L aerial.

The illustration shows the T aerial employed by the Bournemouth Broadcasting Station. The aerial is of the cage type, and the main horizontal portion of the cage is divided in the centre, where the lead-in is attached. The latter is also of the cage type, of the same diameter as the main aerial. *See* Aerial.

TAGS. Term generally applied to small terminals or connectors which are attached to the ends of flexible or other connecting wires. A typical selection is illustrated, and shows four different varieties. On the

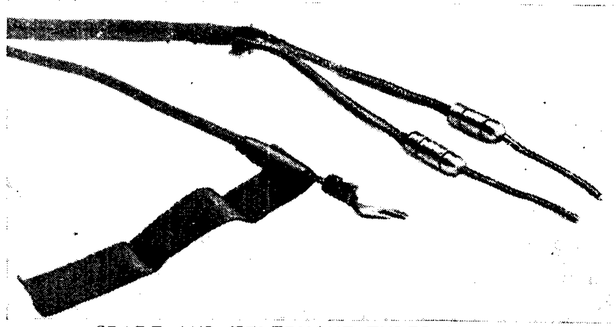




METHOD OF ATTACHING TAGS TO THE ENDS OF WIRES

Fig. 2 (left). The end of the tag is inserted in the bared end of the stranded wire, which is twisted round the end of the tag. Fig. 3 (right). Insulating tape is applied to effect a neat and sound joint between tag and wire left are two examples of the pattern of tag sometimes known as spade terminals. These have projecting prongs which when bent over and around the conductor make good contact therewith.

The second pattern is for soldering directly to the ends of tinned copper bus bar, or similar types of wires, and has an eye formed for direct attachment to a terminal or binding post. The third pattern is similar to the foregoing, but has a hook-shaped end instead of an eye, and is more appropriate when the connexions are likely to be removed at frequent intervals. Both are fixed to the wires by soldering. The lowest one shown on the right is the familiar telephone tag, and is suitable for attachment to the ends of telephone wires, or for any other connecting wires which may be used in conjunction with conductors employed for connexion to terminals of the type generally known as telephone terminals.



SPADE AND TELEPHONE TYPES OF TAGS

Fig. 4. A contrast in appearances is presented here. Notice the neatness of the telephone tags as compared with the single spade whose insulation is shown partly unwound

The method of fixing these tags is illustrated in Fig. 2, which shows how the end of the insulation should be bared, and the stranded wire inserted between the prongs of the tag. These prongs are then bent over with a pair of flat nose pliers and well compressed on to the wire. To complete the work the bared end of the conductor should be taped with insulating tape, as shown in Fig. 3, commencing the binding about 1 in. from the end of the insulation, and giving several turns around the bared part. This not only acts as a good insulator, but also strengthens the fitting and minimises the risk of the wires becoming frayed or broken. The use of tags in this way adds to the neatness and workmanlike appearance of the set, ensures good contact, and when used in conjunction with the lock nuts usually found on contact studs, valve sockets, and similar fittings, ensures a good and reliable electrical connexion.

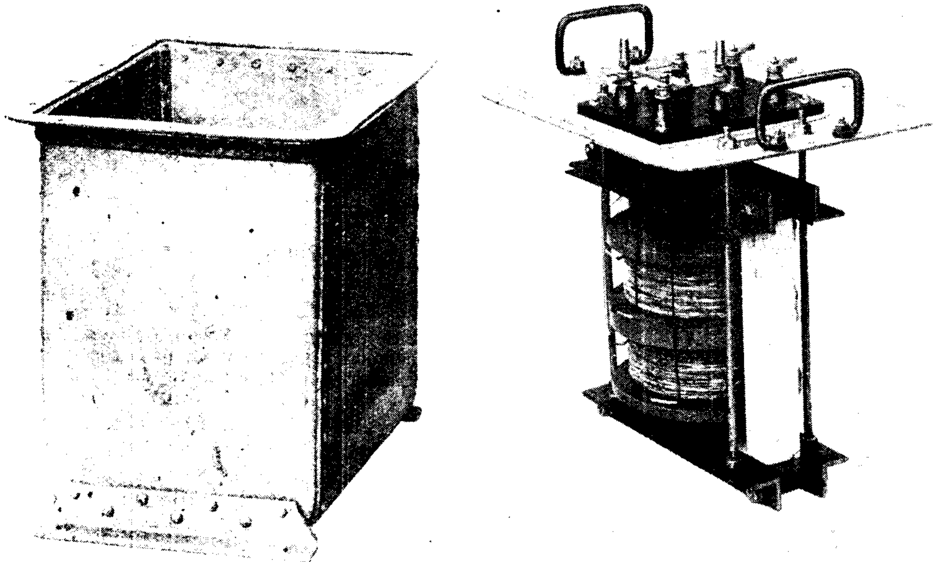
In selecting the types of tags to be used for a particular purpose, reference to Fig. 4 will show that the spade type of tag is much shorter than the telephone pattern, and in restricted places is generally preferable. The ordinary telephone tag shown in Fig. 4 is made with a long shank to enable it to be inserted through the hole in the telephone terminal. Should they be too long, the tags can be cut back to any desired length. *See* Terminals.

TANGENT GALVANOMETER. Variety of galvanometer. It is so called because the strength of the currents passed through its coil is proportional to the tangent of the angle of deflection of the magnetic needle in the centre of the coil.

Essentially the tangent galvanometer consists of a circular coil of a few turns of insulated wire with a small magnetic needle suspended at the centre. A light aluminium pointer is attached to the needle and enables the deflection to be read on a horizontal scale graduated in degrees. The needle is small enough to justify the assumption that the magnetic field due to the current in the coil is uniform throughout the space occupied by the needle and equal to the field at the centre of the coil.

The coil is set in the magnetic meridian so that the needle and the coil are in the same plane. The current is then passed through the coil, and the angle of deflection read off from the scale. If the angle of deflection is θ, and C the current in absolute units, then $C = 10\ K \tan \theta$ amperes, where K is a constant known as the reduction factor of the galvanometer. *See* Galvanometer.

TANK TRANSFORMER. One having its windings immersed in oil contained in a tank. The illustration is a photograph of a $1\frac{1}{2}$ kilowatt tank transformer by Marconi's Wireless Telegraph Co., Ltd. The tank is shown empty on the left, while the transformer may be seen on the right. Galvanized iron is the material used for the tank, and it is heavily constructed to enable it to withstand rough sea usage. A



ONE AND A HALF KILOWATT TRANSFORMER AND ITS CASING

Oil of a very high flash-point surrounds this transformer, seen on the right, when it has been immersed within the containing tank which appears on the left. The apparatus is very solidly constructed to withstand rough sea usage

Courtesy Marconi's Wireless Telegraph Co., Ltd.

flange is fitted to the top, and on to this flange the top plate of the transformer is bolted. Packing is interposed between the top plate and the flange, in order to prevent any possibility of the contents leaking.

The transformer is of the closed-core type, and has one primary and two secondaries. The latter are wound over the primary, and consist of two equal portions. On top of the transformer is an ebonite panel into which are fitted the terminals and switching arrangements for the secondary. By means of the latter it is possible to arrange conveniently for the two windings of the secondary to be in series or parallel as desired.

The transformer is lowered into the tank after it has been filled with oil of a very high flash-point. Handles are provided to the top plate of the transformer in order that it may be easily carried about if desired. Two flanges are attached to the bottom of the case so that it may be screwed down to the deck when once installed in position. *See* Transformer.

TANTALUM. One of the rare metallic elements. Its chemical symbol is Ta, and atomic weight 181. Tantalum is a silver-white metal, very ductile, which has the property of becoming so hard when hammered that it is almost unaffected by a diamond drill. Tantalum is largely used in the filaments of electric lamps.

TAPPED INDUCTANCES IN CONSTRUCTION AND USE

A Valuable Tuning Agent in Many Wireless Receivers

Here various types of tapped inductances are described in detail, and full instructions for the construction of one at home are also incorporated. The reader will find helpful references to this subject in the articles under such headings as Bank Winding; Coils; Duolateral Coils; Honeycomb Coil; Inductance; Induction Coil; and also under the related headings, Switch; Wiring, etc.

The term tapped inductance is used to describe all forms of inductance coils provided with leads or connexions at intervals along the length of the coil. The leads are known as tappings, and consist of short wires attached to the run of the inductance windings in such a way that the continuity of the windings is not interrupted, while permitting any or all of the tapped portions to be brought into the circuit at will. There are numerous types of tapped inductances.

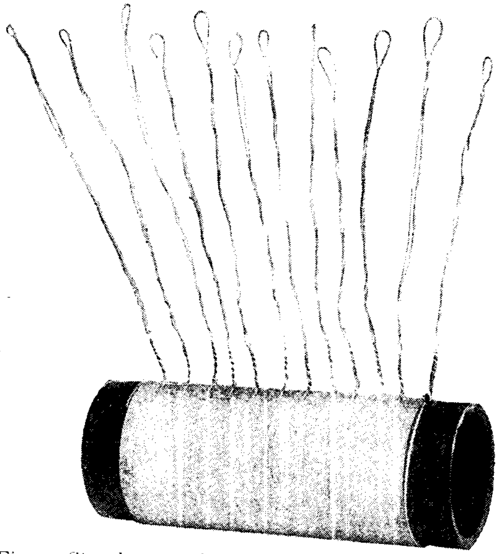


Fig. 1. Simple tapped coil with twelve uniformly spaced tappings made by twisting the wire into loops

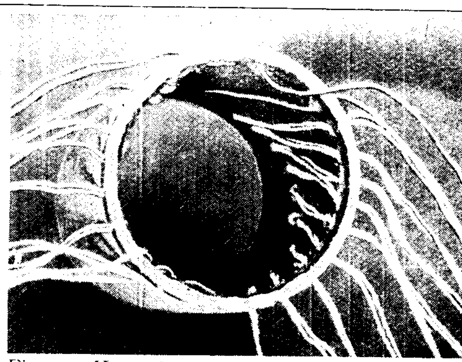


Fig. 2. How the tappings of coil in Fig. 3 appear viewed from the end. Note how the wires come through the former

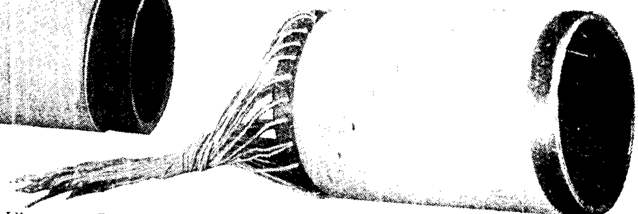


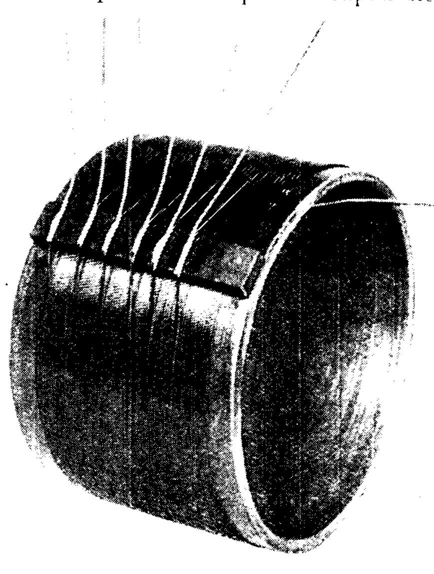
Fig. 3. In this pattern the tappings are led through the former as above and brought out to one end

EXTERNAL AND INTERNAL DETAILS OF SIMPLE TAPPED INDUCTANCES

A simple pattern of tapped inductance is shown in Fig. 1, and comprises a plain winding around a cardboard or ebonite tubular former. The tappings are taken by making a loop into the wire as the winding proceeds, twisting the wire together, and continuing the winding to the next tapping point, and so on.

Another method shown in Fig. 3 is to turn the tappings into the centre of the former tube and bring them all out at the end. This is accomplished by making holes through the former at the requisite places and passing the wire through the holes after the wire has been twisted. When done in this way the tappings appear on the inside of the former, as shown in Fig. 2, and this method has the advantage that the wires are readily attached to an inductance or stud switch.

The foregoing methods are particularly applicable to tappings made in insulated wires covered with cotton or silk, but when the popular enamelled wires are employed the method pictured in Fig. 4 has many advantages. In this case the turns of wire that are to be tapped are taken over a strip of ebonite which rests on the top of the windings. This strip should be about $\frac{3}{16}$ in. wide and $\frac{1}{8}$ in. thick, or thereabouts, and is worked across the windings as they are coiled around the former. When the winding is completed the turns of wire on the top of the strip are scraped clean



SIMPLE MANNER OF TAPPING

Fig. 4. Tappings are quickly effected on this coil of enamelled wire. An ebonite bridge isolates the tapping points

and quite free of insulating enamel, and wires are then soldered to them.

This ensures complete electrical continuity in the windings. There is a minimum of capacity effect, and the soldered joints are readily accessible. Consequently good joints can be made with the minimum of trouble.

The construction of a tapped inductance for experimental use is not a difficult matter, and one way in which it can be carried out is here described The same methods can be applied to inductances with other tuning ranges, but the pattern illustrated in Fig. 5 is intended for use with a variable condenser with a value of ·001 mfd., and should then tune over a range of 200 to 2,800 metres on the average aerial. The feature of this inductance is that it can be applied to a panel by means of the customary central fixing, as in Fig. 5, or for experimental purposes can be simply placed in a vertical position on the wireless table, as in Fig. 6. The contacts are located within the end of the tubular former.

A Novel Type of Control Handle

The control handle is of somewhat unorthodox shape but proves very handy in use, as it is sufficiently large to be moved without trouble. The handle is attached to a long central spindle passing through the former to the opposite end, where it actuates the laminated contact arm seen in Fig. 5, and makes contact with any of six tapping points.

The windings are supported on an ordinary circular former which may be ebonite or cardboard tube 3 in. in diameter and 5½ in. long. Two hardwood or ebonite disks are needed to fit closely into the former, and are best turned to shape in a lathe. This is done by cutting a sheet of ebonite to a rectangular shape, drilling a central hole, and plugging it with a shouldered peg of ebonite or metal.

This peg is then mounted in a chuck in the lathe and the disk turned as shown in Fig. 7, using an ordinary parting tool clamped in the tool post and parallel with the lathe bed. The shapes of the disks and the former are seen in Fig. 8. They are securely fixed by small screws passed through the former into holes tapped into the rim of the disks.

Another disk is needed, but this must have the centre turned out to form a ring as seen in Fig. 9, with a width of about ⅜ in. Two holes are drilled and countersunk on a diameter of the ring, and are used to attach the ring to the lower ebonite disk. The next step is shown in progress in Fig. 9, and consists of marking out the six contact stud holes and opposite them a series of similarly spaced holes to take the opposite end of the contact arm.

The latter set of holes is simply a series of depressions in the surface. The first set is drilled out to clear the stud part of the contact studs. The screwed part of the studs screws into the lower ebonite disk, which should be drilled and tapped to suit the studs. This is best effected by screwing the ring to the end disk and drilling through the stud holes in the ring. The studs should then be fitted and any surplus filed away flush with the surface of the ring.

The purpose is to provide a flat surface for the contact arm to move across. The contact arm is located at the other end to the contact studs, falling into one of the depressions.

The lower disk is then fixed to the former tube at a distance of ½ in. from the bottom. Its proper position is so marked that it can be replaced in the same position, and is then removed. Then the lower disk is fitted with a central brass bush to suit the long spindle, and a No. 4 B.A. round-headed brass screw is fitted at a distance of ¾ in. from the edge.

Winding the Tapped Inductance

The upper disk has a screwed centre-fitting bush attached to the centre, and the disk is secured in place with round-headed brass screws passed through the side of the former as shown in Fig. 11.

The winding in the next part of the work is carried out with No. 24 D.C.C. wire wound on the bank-wound principle, details of which are given under the heading Bank Wound Coils (*q.v.*). Taps are taken at various stages in the winding, each tapping point being counted according to the total number of turns, commencing from one end, preferably the top of the former. These taps are taken as follows:

The first tap at the seventh turn, corresponding to about 260 metres, the second at the seventeenth turn, corresponding to about 420 metres, is shown in Fig. 12. The third tap is taken off at the thirty-third turn, equal to about 700 metres, the fourth at sixty-one turns, corresponding with about 1,100 metres, the fifth tap at the

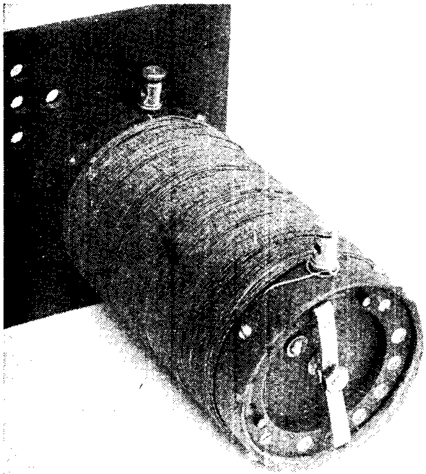


Fig. 5. Either mounted on the panel or in a vertical position this type of tapped inductance coil gives very good results

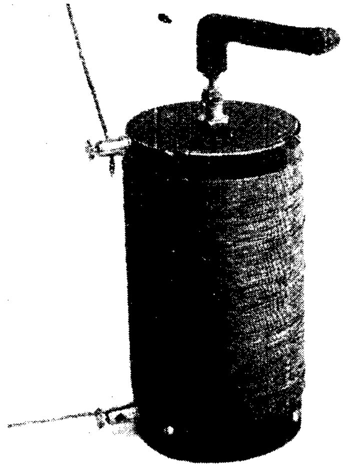


Fig. 6. The home-made tapped inductance is very suitable for experimental work. Note the novel type of control handle

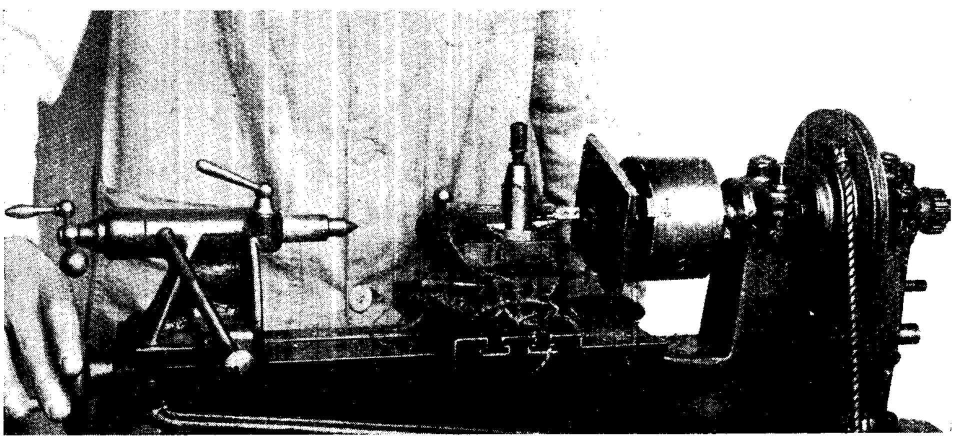


Fig. 7. Tight fitting of the ebonite end disks in the cardboard former of the tapped coil is ensured by turning in a lathe, which gives greater accuracy more quickly than other methods

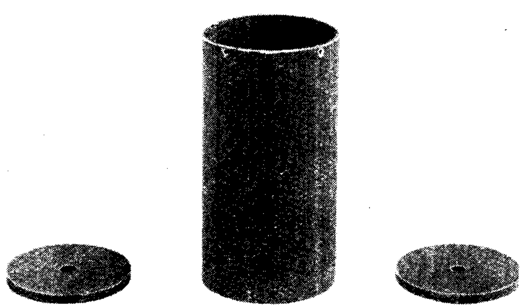


Fig. 8. Two ebonite pieces form the end disks for the cardboard former of the tapped inductance

Fig. 9. Marking the ring for positions of the contact studs leading to tappings

STAGES IN THE CONSTRUCTION OF THE HOME-MADE TAPPED INDUCTANCE

121st turn for 2,000 metres, and the sixth tap at the 235th turn corresponding with 3,000 metres.

Each tap is arranged slightly to overlap the next sets above and below and, with the tuning condenser, cover the intermediate wave-lengths. The theoretical wiring of this inductance is shown in Fig. 10, and from this it will be seen that a dead-end switch device is incorporated.

This is simply a short-circuiting switch arranged to connect the end turns to earth and is operated by screwing up the single screw in the end disk. This screw bites into a nut soldered to a small brass contact plate, the outer end of which is shaped to bear on the centre bush or on to a brass plate attached to it.

The other side of the contact blade is connected to earth. When not required, the screw is slackened and the contact is thereby broken. This contact blade is clearly shown in Fig. 16, and is easily made from thin springy strip brass or copper.

At every tapping point and at the last turn the windings are finished in the usual way by passing the wire through a hole in the former as shown in Fig. 14, thus bringing all the ends of the taps and the start and finish of the windings to the inner part of the former.

The tappings are attached to the studs on the bottom disk as shown in Fig. 15. Contacts are made by the lock nuts, thus saving the mess of soldering in a restricted space. The commencement of the winding is attached to the aerial terminal at the top of the former tube. The earth terminal is connected to the centre spindle at the lower part of the bushing and to one side of the shorting switch. The last turn of the inductance winding is attached to the other contact of the shorting switch.

The next step after completing the connexions is to prepare an ebonite or cardboard tube long enough to reach from one disk to the other. This is placed inside the windings and is intended to prevent the tappings touching the centre spindle and thus setting up a short circuit. This tube is simply slipped in place over the centre spindle, and may be of any reasonable diameter.

The lower disk is fixed in place and the centre spindle fitted through the bushings. The upper end has a nut screwed to it to act temporarily as a stop. The lower end is attached to the double-ended contact arm, which is made as described under the heading Contact Arms. The general form is shown in Fig. 16, which also illustrates the handle and the inner tube made of ebonite and cut away at the bottom to clear the shorting switch.

When the contact arm is fitted the nut is removed from the top of the spindle and a spring washer and lock nuts fitted in the usual way to draw the contact blade into contact with the faces of the studs.

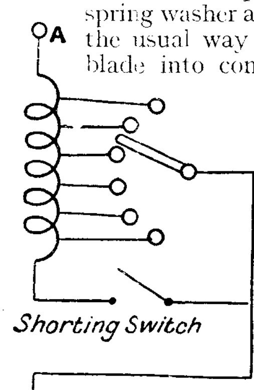
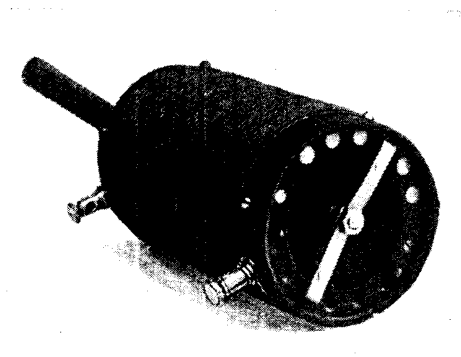


Fig. 10. Theoretical diagram or construction of the tapped inductance coil

The handle, spindle and contact arm are separately shown in Fig. 16. The spindle is a length of No. 2 B.A. screwed rod, or, if preferred, can be plain brass rod $\frac{3}{16}$ in. in diameter, screwed at each end.

The handle is sawn from a block of ebonite $\frac{1}{2}$ in. thick, 1 in. wide, and $2\frac{1}{2}$ in. long, and is finished by mounting in the lathe, as shown in Fig. 17, and turning the boss and drilling the hole for the spindle. The hand grip is shaped by filing and finished by polishing.

After all the work is finished, the windings are coated with shellac or celluloid varnish and the continuity of the windings tested. The working of the shorting switch should also be tested at the same time, and when all is correct the appliance is ready for use.



UNDERSIDE OF THE COMPLETE INDUCTANCE

Fig. 11. In this position a clear view is given of the details of contact arms and studs

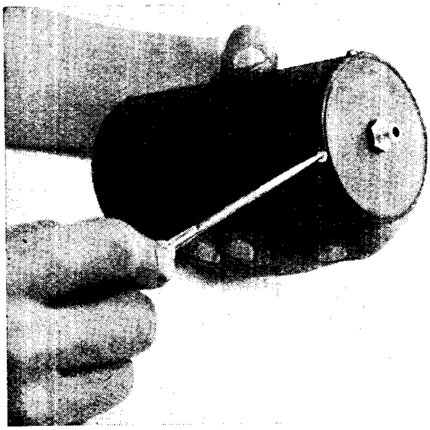


Fig. 12. Fixing the top ebonite disk to the cardboard former by means of round-headed screws. Tappings are taken at the other end

Fig. 13. Wiring here is at the second tapping point, showing how the bank winding is carried out for this kind of coil

Fig. 14. Winding is completed by taking the wire through the former after the last turn

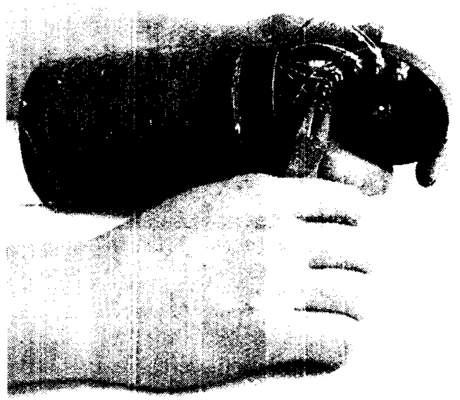


Fig. 15. Connecting the tappings to the contact studs. This saves soldering in restricted space

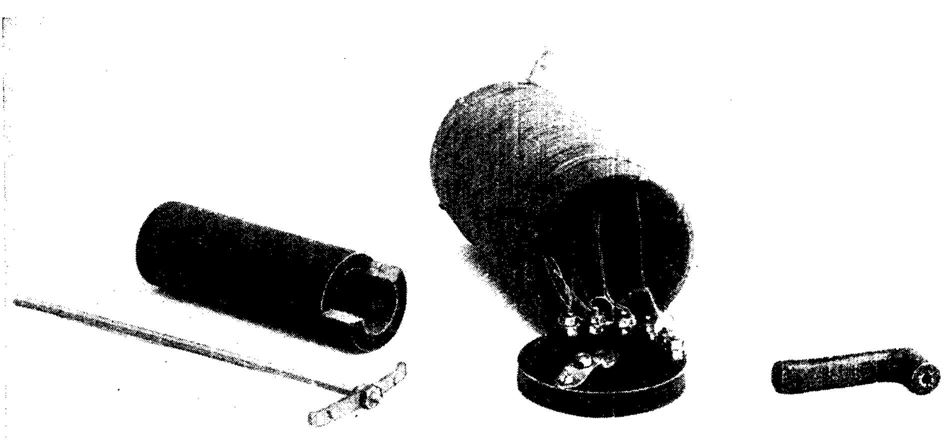
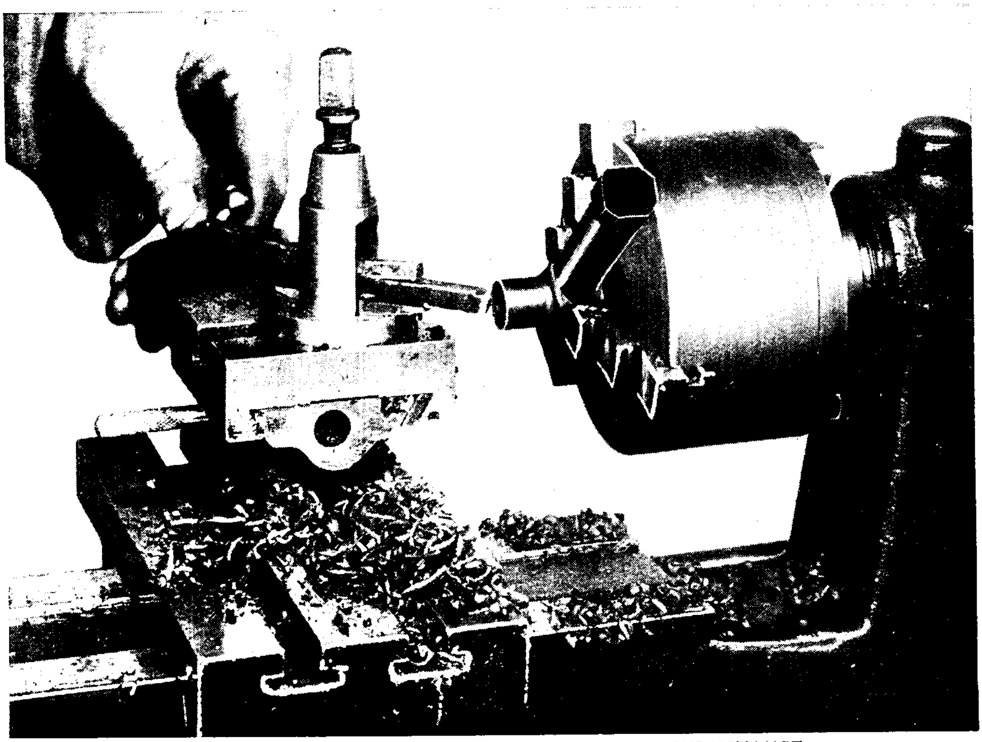


Fig. 16. Components of the home-made tapped inductance; the spindle and contact arm have been removed and tappings are shown

FINAL STAGES IN BUILDING UP THE TAPPED INDUCTANCE



FINISHING THE HANDLE OF THE TAPPED INDUCTANCE

Fig. 17. By mounting the roughly-shaped handle in the lathe and turning carefully, a good finish is imparted. The boss is rounded off and the spindle hole drilled also. The illustration shows how the rough ebonite is chucked in the lathe

A view of the underside of the lower part is shown in Fig. 11, and this should make the arrangement of the parts quite clear.

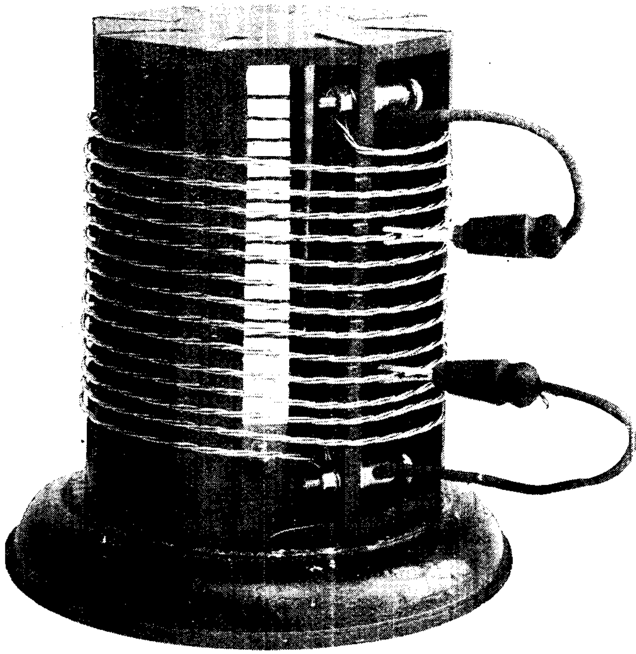
Another pattern of tapped inductance suitable for the ordinary amateur broadcasting band of wave-lengths is illustrated in Fig. 18, and takes the form of a tuning helix as used for transmission purposes.

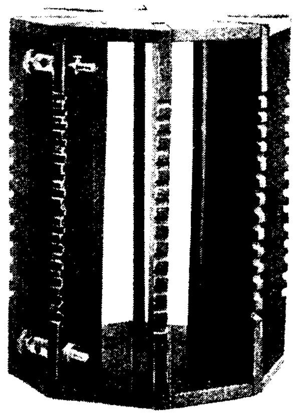
The value of the inductance is determined by the gauge and length of the wire with which it is wound. In the example illustrated this is intended for the lower wave-lengths of 100 metres or less to about 200 metres. By the use of a thinner gauge of wire of greater length the inductance can be used for the B.B.C. broadcast band of wave-lengths. The advantage of this pattern is the ample air spaces around the windings and the low value of capacity. The use of ebonite in strips as a former is advantageous, as it adds to the value of the insulation, and, unlike wood, is not greatly affected by atmospheric changes.

The wire used in this case is ordinary aerial wire consisting of three strands of No. 22 gauge copper wire, and thus there is a minimum of resistance loss in reception. The stand or former is shown completed in Fig. 19, and is composed of top and bottom plates of ebonite $\frac{3}{16}$ in. thick. These plates are octagonal in shape, and are sawn to shape with a hack-saw and the edges filed true.

They are most readily made from two pieces 4 in. square, the corners then only having to be cut away to form the eight sides. The top and bottom plates are connected together by eight strips of ebonite 1 in. wide and $5\frac{1}{2}$ in. long, which are fitted into slots cut radially at the corners. The slots are cut by first drilling a hole at the termination of the slot on the inner side, and then sawing with a hack-saw from the outside to the hole.

The slots are filed true, as shown in Fig. 20, taking care to keep them in line and of exactly the proper thickness. The whole set of eight pieces, after they have been fitted, is then held in a vice, as shown in Fig. 21, and fourteen slots cut across the face with a hack-saw.





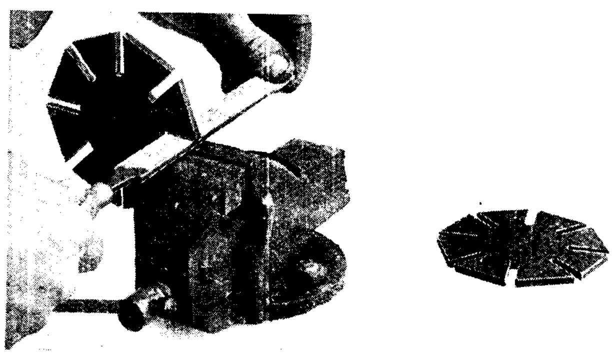
HELICAL TAPPED INDUCTANCE

Fig. 18 (left). Tappings in this inductance are effected by special wander plugs. Fig. 19 (right). Note the grooves in the ebonite former to hold the wires in position

The first slot is cut at a distance of 1 in. from the end, and the others are spaced $\frac{1}{4}$ in. apart. Two holes are drilled in one of the strips to take the two terminals for the beginning and end of the windings, and telephone pattern terminals are fitted to these holes.

The wiring is commenced by attaching one end of the wire to a terminal, and carefully turning the wire around the outside of the strips and inserting it into the slots in each strip. The wire should be drawn tight and wound as evenly as possible, and is finished by attaching it to the other terminal. The tappings are taken off, as shown in Fig. 18, by means of flexible wires attached one to each terminal and having at the other ends a form of spring contact plug shaped like a long wander plug. These plugs have ebonite handles, and can be clipped on to the wire at any point, and thus allow of the finest tuning possible.

The centre portion of the



CONSTRUCTING THE END PLATES

Fig. 20. How the slots are cut in the end plates. To ensure trueness the edges are filed

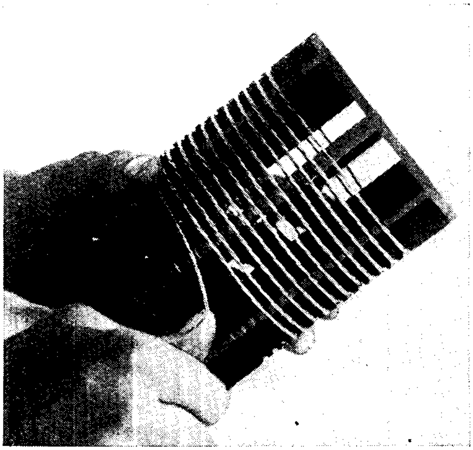
SLOTTING THE FORMER STRIPS

Fig. 21. All the slots are made at one time so that the spacing between the slots may register accurately when the former is assembled

inductance is normally used, and by sliding the contact plugs along the wire a delicate adjustment is possible, as the tapping point can be adjusted to the very best advantage. When completed the ebonite former is mounted on the top of a turned wooden base plate, to which it is attached by screws passed through the bottom plate into the base.

This general type of tapped inductance has been developed to meet the requirements of large transmitting stations, and is then a most imposing and important piece of apparatus.

One of the latest forms of Marconi tapped inductance of this type is shown in Fig. 23. There are really three series of coils in this piece of apparatus, two being for the aerial tuning inductance--for coarse and fine tuning—and the other for the anode tuning of the transmitting valve.



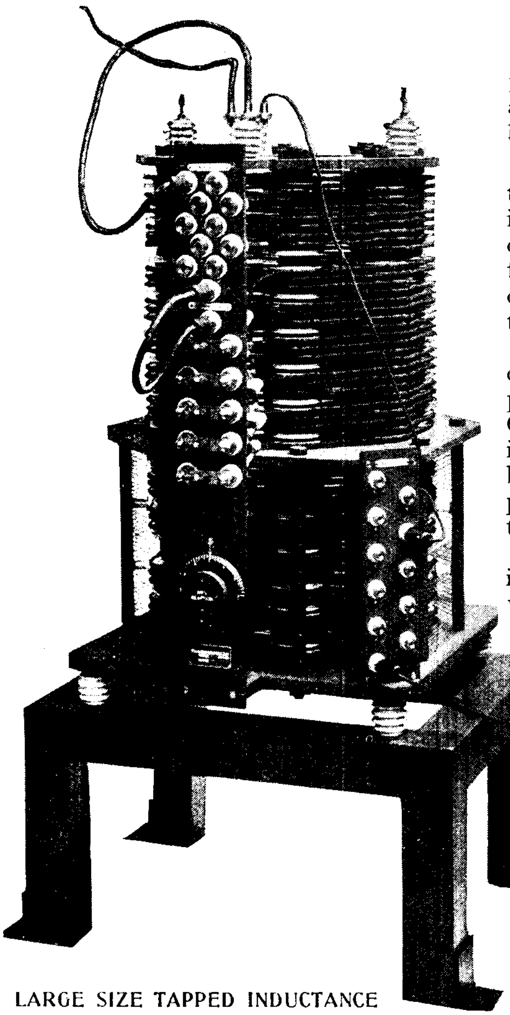
HOW THE WIRING IS CARRIED OUT

Fig. 22. It is a matter of considerable importance that the winding should be as tight as possible. Here the stranded wire is shown in the process of winding

Connexions from the tappings in all cases are effected by means of a wander plug attached to the end of a flexible lead. On the fine tuning tap of the aerial tuning inductance some of the connexions are brought to terminals to which bridging pieces are attached, thus short-circuiting the terminals when desired.

Within the lower coil, which is the anode inductance, is a further rotary coil, to which the knob and dial shown in the foreground are attached.

The wire of which this inductance is composed is a form of Litzendraht, each conductor being separately insulated. The whole apparatus is mounted on four insulators, and is brought up to a convenient operating height by being placed upon a wooden framework.—*E. W. Hobbs.*

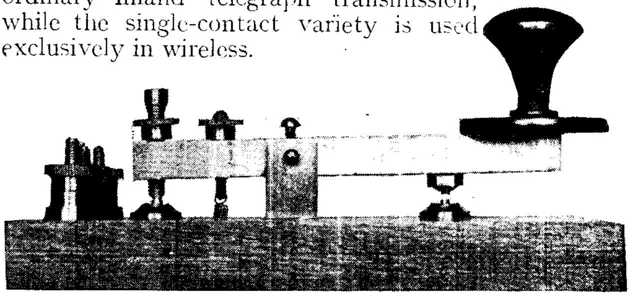


LARGE SIZE TAPPED INDUCTANCE

Fig. 23. Three series of coils are incorporated in this modern apparatus, two for aerial tuning inductance for coarse and fine tuning, and the other for the anode tuning of the transmitting valve

Courtesy Marconi's Wireless Telegraph Co., Ltd.

TAPPER. An instrument for interrupting the continuity of a circuit for the conveyance of signals or messages by a predetermined code. Tappers are divided, broadly, into two classes. In one pattern a single pair of contacts is arranged so that when the tapper is in a state of rest the circuit is permanently broken. In the other variety double pairs of contacts are employed, one on either side of the pivoting point, contact being broken only when the arm of the tapper is moving from one set of contacts to the other. This type of tapper is largely used in the Post Office in ordinary inland telegraph transmission, while the single-contact variety is used exclusively in wireless.



DOUBLE-CONTACT TAPPER

In this double click tapper, as largely used in the Post Office, the back contact and spring return are adjustable. The arm is pivoted about a centre bearing

Essentially, the tapper consists of a pivoted arm fitted at one end with a spring which enables the arm normally to break contact. A knob is fitted to the other end by which the pivoted arm may be moved. In many spark transmitting sets the knob of the tapper is fitted with a large insulating ring to prevent injury to the operator from the high potentials existing in the metalwork of the tapper. In transmitters dealing with large and dangerous potentials the tapper is included in a low-tension circuit which operates the main current in the manner of a relay.

A typical double-click tapper is illustrated, and shows the arrangements of contacts and spring return fitted to the arm. The back contact and also the spring are adjustable, the former for the amount of movement to the arm and the latter for the degree of tension.

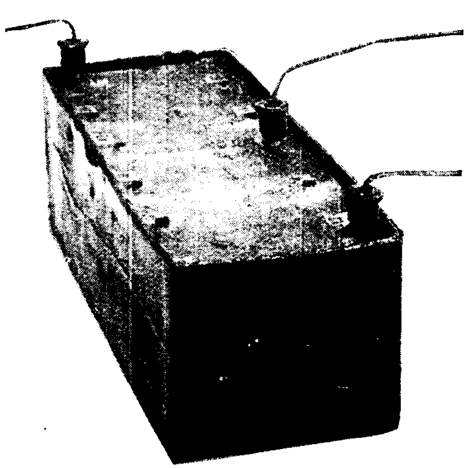
The contacts of tappers are made of a non-pitting anti-corrosive metal, and of these platinum is the best and the most expensive.

See Morse Code; Omnigraph; Telegraph Sounder.

TAPPING. Term used in several senses. In wireless work as practised by the amateur, a tapping is virtually a connexion to some source of E.M.F. whereby a portion is by-passed or utilized. In the case of an inductance coil, for instance, tappings are short connecting leads attached to various parts of the coil so that any desired section may be used as occasion requires.

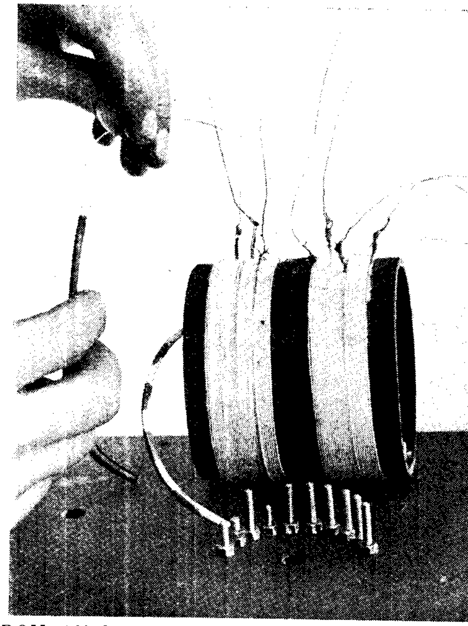
Another commonly used example of tapping, illustrated in Fig. 1, is such as is used in a high-tension battery to vary the voltage applied to the anode. In this case contact is effected by means of wander plugs which fit into sockets in the high-tension battery, connecting wires being taken from the wander plugs to the various parts of the circuit. One application is to have a wander plug on the negative terminal, another at, say, 36 volts positive, and a second at, for example, 54 volts positive. There are therefore two tappings on the high-tension battery, each of which has a different voltage value.

The methods of taking tappings from an inductance coil are many and varied, and a number of different systems are described under the headings Coils and Tapped Inductances (*q.v.*). One of the simplest methods is illustrated in Fig. 2, and consists of forming a short loop in the wire during the process of winding. This loop is then twisted around after the insulation has been bared, when the wire is twisted tightly together with a pair of pliers. Connexions are made to different points by soldering the wires to them.



HIGH-TENSION BATTERY TAPPINGS

Fig. 1. Wander plugs are the most common form of tappings employed for obtaining different voltages from a high-tension battery



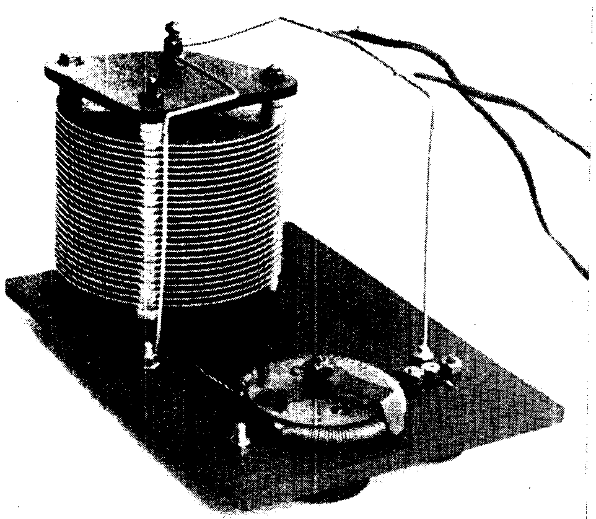
HOW TAPPINGS ARE TAKEN FROM AN INDUCTANCE COIL

Fig. 2 (left). By twisting the turn of the coil a quick tapping is easily obtained. Fig. 3 (right). How the taps are carried out to contacts; the tapping wires are covered with sleeving

Another example of tapping is illustrated in Fig. 4, which shows a small panel with a variable condenser, filament resistance and terminals attached to it. One wire goes from the centre contact of the variable condenser to terminals on the panel, and taps are taken from this wire to flexible insulated wires which are soldered to the main wire, these tappings being connected to other parts of the apparatus.

Tappings of this nature are usually made to the negative or earth side of the apparatus, and often facilitate wiring and shorten the length of the connecting wires. The tappings from an inductance are usually made with tinned copper wire, and, to avoid any chance of their short-circuiting, they should be covered with a piece of systoflex or thin rubber tubing as in Fig. 3. This protects the wires, and, if desired, the sleeving may be marked to indicate the order of the tapping, a little point which often saves trouble later, when completing the wiring of the set.

A useful method of tapping, especially applicable for experimental purposes, shown in Fig. 6, consists of a combination of a wander plug and an ordinary valve socket or sockets. The wander plug is connected to the flexible



TAPPINGS FROM A COMMON LEAD

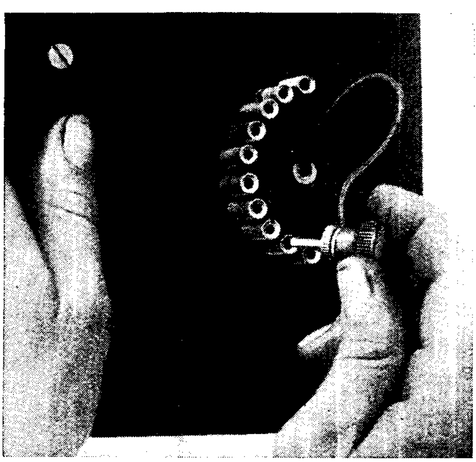
Fig. 4. Tappings from the wire leading from the condenser to the panel contact are made by flexible insulated wire

wire, the other end of which may be attached to a terminal, as, for instance, the aerial terminal. Each of the sockets is connected to separate taps taken from the inductance coil, details of which are shown in Fig. 5. Consequently, to utilize any portion of the inductance it is merely necessary to plug into the desired socket. The remaining connexions of the set are effected in the usual manner, according to the requirements of the circuit.

When tuning is effected by means of a tapped inductance, the tappings should be taken off in unequal amounts, in two separate sets, if possible, commencing from either end of the winding. One end would be tapped off in comparatively wide spaces, with perhaps 10 to 15 turns between each, while the other tappings should be taken off one at each turn, so that a suitable combination allowing of tuning within the limit of one turn of the inductance is formed.

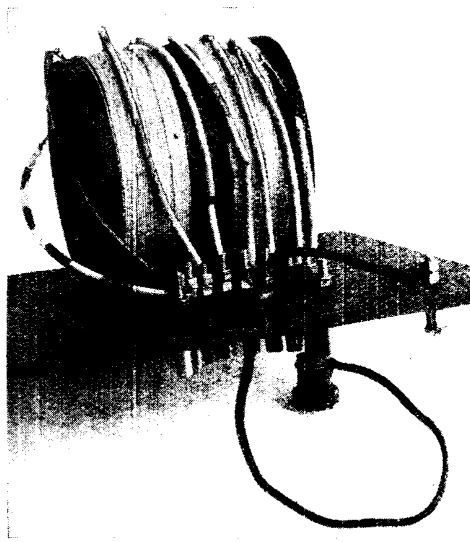
Another point to consider when the inductance is to be used in conjunction with a variable tuning condenser is to arrange the tappings so that the whole of the capacity of the circuit of a number of tappings reaches the desired signal or wave-length of the next set, or the combination of sets brings in the same signal with the capacity at its minimum value. By this means complete tuning over the whole range of the inductance is possible.

TAPS. Term applied to a number of small hand tools used for the purpose of



WANDER PLUG AND VALVE SOCKETS

Fig. 6. Contacts are effected here by valve sockets leading to separate taps and these are used in conjunction with a wander plug



INTERNAL DETAILS

Fig. 5. Here is shown the detail of the connexions of the valve sockets by means of flexible wire to the tappings of the inductance

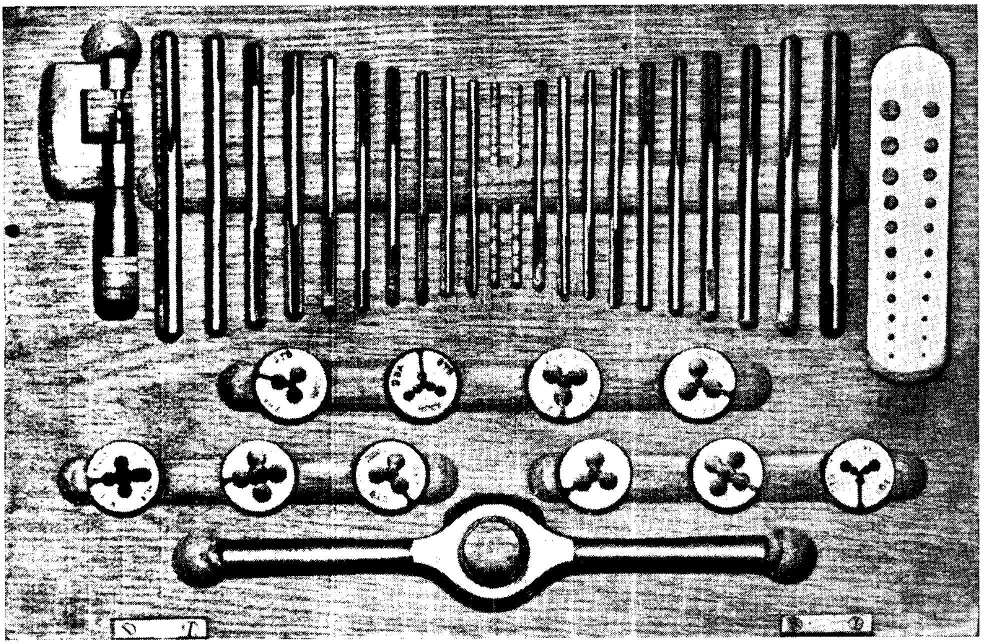
cutting screw threads on cylindrical metal objects. Taps and dies are used for cutting screws on other materials, such as ebonite, but their chief use is in the making of screw threads in holes drilled in metal, and on the surface of cylindrical pieces intended to screw into those holes.

The terms taps and dies refer generally to a set of such tools, and a suitable outfit is illustrated as indicative of a set applicable to wireless work. This comprises a set of taper and plug taps, a tapping or drill gauge for determining the size of drill to use with any of the taps, a micrometer for gauging the diameter of material to be screwed, a die stock and set of dies.

Those shown are for the B.A. system of screw threads as used almost exclusively on wireless work for the smaller sizes of screws, bolts and nuts. Such a set, or some other of similar description, is essential to the wireless constructor, as without these tools it is impossible to cut the screw threads in a practical and satisfactory manner. The actual methods of cutting screws with dies or taps are dealt with in this Encyclopedia under the heading Dies and Taps (*q.v.*).

Te. This is the chemical symbol for the metallic element tellurium, one of the crystal rectifiers. *See* Tellurium.

TELEFUNKEN. Name used for trading purposes, and also the popular name of the Gesellschaft für Drahtlose Telegraphie



BRITISH ASSOCIATION TAPS AND DIES

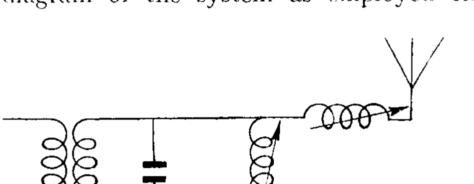
Such a set of taps and dies as this, mounted in a wooden case is a most useful piece of apparatus for the wireless constructor. It covers a wide range of gauges

Courtesy George Buck

m.b.H., a German wireless company. The Telefunken Company is well known, not only for its manufactured products, but also for its commercial development of wireless. The company holds a large number of important patents, and was formed in 1903 to exploit the patents of Professors Slaby and Braun, and of Count von Arco. The company has its headquarters in Berlin, and has subsidiary companies in many parts of the world.

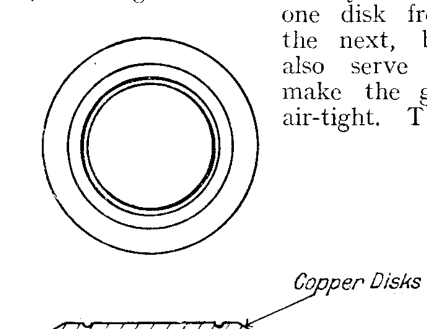
The Telefunken systems have been used widely by the German military and naval and air forces, and in the United States army and navy. Fig. 1 shows the circuit diagram of the system as employed on ships. It uses a quenched gap, and for maximum transference of energy from the quenched gap circuit to the aerial circuit the two must be accurately tuned with respect to each other.

Fig. 2 shows the method of construction of the spark gap used, an extremely efficient form of quenched spark gap. Copper disks about 8 in. in diameter are used, and rings of mica not only insulate one disk from the next, but also serve to make the gap air-tight. The



TELEFUNKEN CIRCUIT

Fig. 1. Circuit diagram of the well-known Telefunken transmitting system as employed in their wireless system on ships



CONSTRUCTION OF SPARK GAP

Fig. 2. Here is shown the type of spark gap employed in the Telefunken system; it is an extremely efficient form of quenched spark gap

mica rings are about one-hundredth of an inch in thickness, which gives the length of the spark. Between each pair of disks a groove is cut on each side of the surface of the disks to restrict the sparking surface to the centre of the plate and keep the sparking away from the mica rings. Cooling flanges or fins are provided, and the central parts of the disks are often silvered over to reduce the resistance to the spark and improve the cooling of the arc.

Another example of the work of the Telefunken Company is illustrated in Fig. 3, and shows a pair of crystal detectors. These are of the carborundum pattern, and are particularly well made. The pattern on the right is made with an ebonite base adapted to fit rapidly into a socket specially designed for the purpose, so that a new crystal can be exchanged for one that may be slightly out of adjustment almost without stopping reception. By having a spare crystal in perfect adjustment always available any slight failings due to imperfect contact, or other cause, can be instantly remedied by removing the faulty pattern and replacing it with the other.

The one removed can be tested and adjusted as soon as is expedient. The connexions to the set are made through contact pieces on the base. The pattern on the right is similar in general functions, but of slightly different design, having a two-pin plug-in contact formed on the lower part of the base. Both patterns are turned out with a metal cover to exclude dirt and dust, thereby tending to keep the crystal in good condition. When used with the customary battery and potentiometer, these crystals give loud and stable signals, and were widely used during the Great War on account of their ability to withstand rough usage. *See* Carborundum ; Crystal Sets.

TELEGRAPH SOUNDER. A telegraph receiving instrument by which Morse signals are indicated by a series of clicks. It is an electro-magnetically operated device in which the magnets are connected through a suitable relay to operate directly from the receiver. At the beginning of a signal the magnets cause a bar of metal to fall suddenly and give a sharp click or tap. On the completion of the Morse signal the bar is released by the magnet, and is returned by a spring, when it causes another click. Thus there are two clicks for each Morse signal, and a dot or dash may be distinguished by the time interval between two successive clicks.

The signals are transmitted by means of suitable apparatus, and under the agency of a tapper (*q.v.*), this instrument being illustrated at the right of Fig. 1, and next to it the telegraph sounder. The positions of the bar and the magnets are clearly shown, as well as the means for adjusting the bar ; these take the form of adjustable set-screws held in place by lock nuts. The sounder is constructed on an ebonite base and mounted on a polished

TELEFUNKEN CRYSTAL DETECTORS

Fig. 3. Two different types of carborundum crystal detectors manufactured by the Telefunken Company. They are very efficient, being particularly stable and are specially adapted for constant and rough usage under all conditions

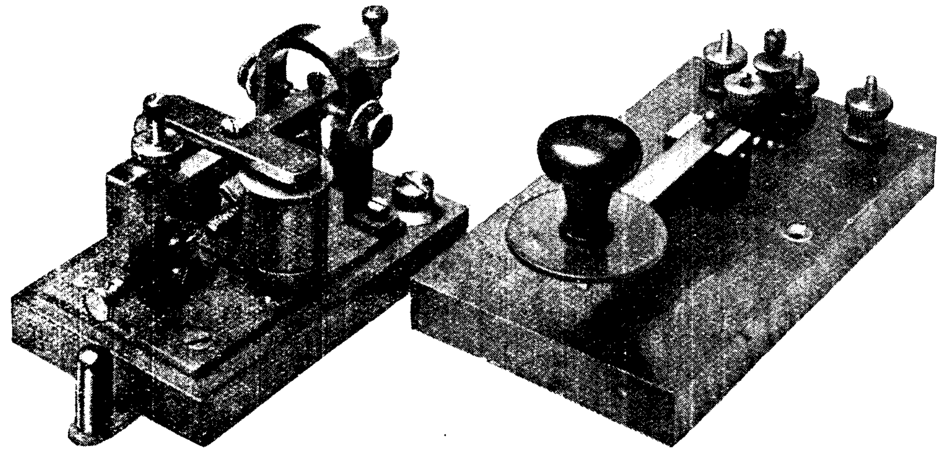


Fig. 1 (left). An electro-magnetically operated telegraph sounder. Fig. 2 (right). A common type of Morse tapping key. These sturdy instruments are very efficient in use

Courtesy A. W. Gamage, Ltd.

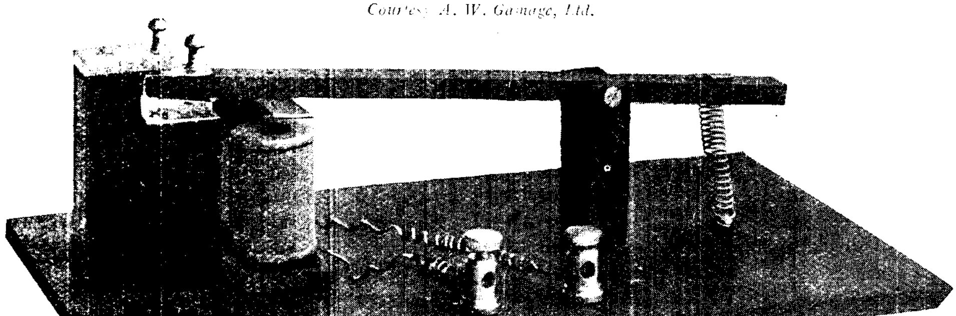


Fig. 3. Home-made telegraph sounder; it is exceedingly simple in construction and efficient in use. The amateur will find this sounder useful for practising Morse

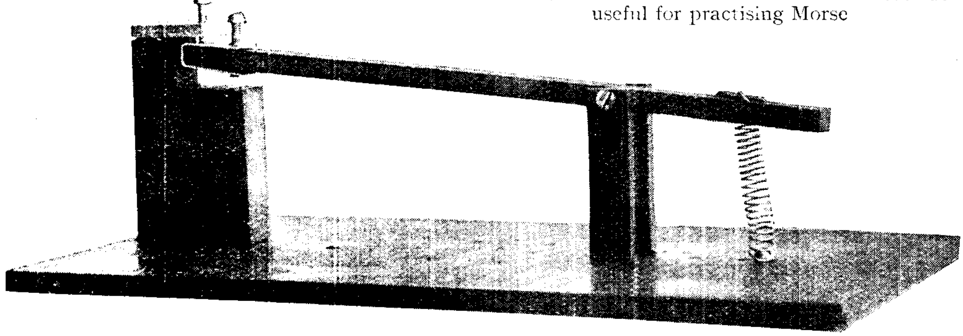
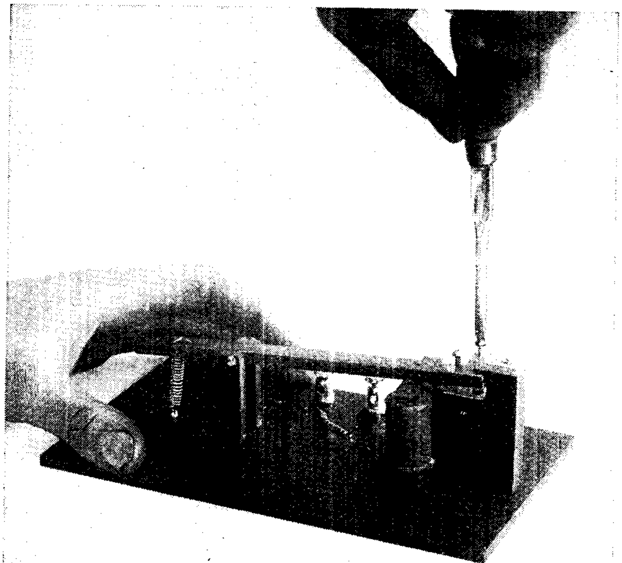


Fig. 4. How the main moving bar of a telegraph sounder is pivoted; the spring is made of piano wire and is strong enough to make the bar return quickly when released by the magnets

HOME-CONSTRUCTED AND COMMERCIAL TELEGRAPH SOUNDERS

oak sub-base, this combination ensuring good electrical insulation and solidity of construction. These are features of importance in any sounder, as the vibration, when working, would speedily upset the adjustment of an instrument unless it were well and sturdily made. Repeated tappings have a tendency to loosen the set-screws, unless the lock nuts be properly tightened, a matter that should be looked to when it is desired that the instrument should work for any length of time.



FINAL ADJUSTMENTS OF THE COMPLETE SOUNDER

Fig. 5. Stop screws are used to regulate the gap to make the instrument respond to different speeds of transmission

A simple form of telegraph sounder suitable for most amateur requirements may be made at home from scrap materials which are likely to be to hand in any amateur's workshop. It may be worked off any receiver capable of giving reasonably strong signals, providing a suitable relay and local battery are placed in circuit with it.

Such an instrument is shown complete in Fig. 3. The chief item in its construction is the electro-magnet which operates the moving armature. This type of magnet is always found in any ordinary household electric bell, and should a disused bell be available considerable time will be saved.

On the size of the magnet selected depends the height of the main bracket, shown at the extreme left-hand side of the illustration.

This bracket is made of hardwood, and it is faced at the top and on the surface below the moving bar with brass strip. The latter should be at least $\frac{1}{16}$ in. in thickness, as on its weight depends to some extent the loudness of the clicks. It will also be noticed that the end of the moving bar is faced with light-gauge sheet brass, a factor which is also responsible for louder reception.

When the moving bar rises owing to the spring, it hits the upper projecting piece of brass, while when it is pulled down by the magnet it strikes the brass face on the portion of the end bracket beneath it. In this manner it gives a click whichever way it moves, and by the interval between these clicks the operator is able to distinguish a dot or a dash.

The actual moving bar is made of wood, and it has a light but stiff piece of iron attached beneath it and at right angles to it, at a point just above the magnet poles as shown in Figs. 3 and 5.

It is this bar or armature which is pulled down by the magnets when they are energized by the local battery, which is itself put in circuit by the relay operated by the receiver.

The main moving bar is pivoted at a point about a third of the way along from the end opposite to the magnets, as shown in Fig. 4. The pivots are carried on two vertical pieces of wood attached to the base, and consist of ordinary countersunk wood screws, which are of such a length that they do not meet in the middle of the bar.

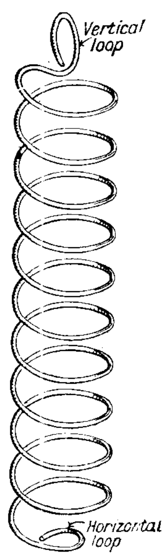


Fig. 6. Enlargement of the contact spring showing how the ends are looped at right angles to each other

Between the pivot and that end of the bar is a spring, which is of piano wire, that should be about $\frac{5}{16}$ in. in diameter, and sufficiently strong to make the bar return quickly after the magnets have released it. The ends should be bent with pliers to the shapes shown in Fig. 6. The upper end of the spring is formed into a vertical loop, which is threaded through a narrow slot cut in the moving bar, and is finally held by inserting a short piece of wire between the spring and the bar, as shown in Fig. 4. The natural tension of the spring will prevent the short wire from slipping out sideways.

Electrical connexion from the magnets is taken to the terminals, which are in turn connected to the relay and battery circuit.

Final adjustment of the instrument is effected by rotating the stop-screws, as indicated in Fig. 5. It will be readily understood that shortening the projection of these screws will limit the movement of the bar and so make it respond to different speeds of transmission. *See* Key; Morse Code; Omnigraph.

TELEGRAPHY, WIRELESS. General term applied to any system of transmission and reception of telegraphic signals by the use of ether waves propagated by electrical means.

Under this heading is given a brief survey of the chief systems which are in use at the present time, and a review of the stages by which wireless telegraphy has progressed since its early inception.

Wireless communication generally has been evolved from the original experimental work of Hertz in the propagation and measurement of electro-magnetic waves through space. Hertz discovered that if the ether was disturbed by a discharge of electricity at a high potential, a series of electro-magnetic waves was propagated in all directions. His experiments showed that these waves were similar in character to light waves in that they travelled in the same medium and at the same velocity. The Hertzian oscillator which he used consisted merely of a spark gap connected to an induction coil, while he used two metal plates, each connected to one side of the gap, from which the waves were radiated.

These experiments of Hertz followed the theories on electro-magnetic waves which were deduced by Clerk-Maxwell, and it is on these theories that modern wireless science has been developed.

Reception by Lodge's Coherer

From the above it is evident that a means of transmission of waves became a possibility, and if these waves were sent out in a series of long and short periods, Morse signals could be transmitted also by their aid.

The next step in the practical development of electro-magnetic waves was the invention of a receiving device called by Lodge the "coherer."

The coherer consisted of a small glass tube containing loose metal filings, which normally, owing to their high resistance due to loose contact, formed a bad electrical conductor. It was found that connexion of this device to a suitable means for the "collection" of ether waves resulted in the metal filings adhering together and forming a conducting medium of reasonable value. Thus in effect the coherer became a form of relay whereby a local battery was brought into play. This local battery was utilized to cause an electric bell or other device to function, thus indicating the presence of the waves.

Amongst the scientists interested in these experiments was Marconi, who also saw the commercial possibilities of wireless signalling. In his experimental work he used an earthed system and discovered that the transmission and detection of electro-magnetic waves over comparatively long distances was a possibility.

Marconi eventually dropped the coherer in favour of an invention of his own called the magnetic detector, photographs and a description of which appear under that heading in page 1363. The magnetic detector was for a very long period the most stable device for the detection of electro-magnetic waves known, and the early Marconi apparatus used it extensively, particularly for marine work.

Progress in Transmission

During this period of transition the Marconi Company was founded, and vast strides in the successful propagation and reception of these waves over great distances were made. These advances were achieved principally by the use of larger power for transmission and the use of longer wave-lengths. It is interesting to note at this stage that the very short reflected waves which are being greatly experimented with at the present time were dropped at this early stage in favour of the longer variety, owing entirely to the comparative ease with which successful signalling was accomplished by long waves.

So far, the waves most commonly in use were of the damped variety, *i.e.* their amplitude constantly diminished, although, of course, their length remained a constant factor. Further, it became evident that if many stations were erected difficulties in reception would be experienced due to "jamming." Thus experiments were necessarily conducted with a view to restricting the wave-lengths upon which a signal was transmitted, by the use of loose coupling both in transmitters and receivers. As at the present time, the function in wireless apparatus known as "tuning" was becoming of increasing importance, for thus only could selectivity in reception be accomplished.

A great improvement in transmission was now evolved. This was the introduction of continuous waves, which were found to possess advantages in both the distance over which they were effective and their capacity for keeping within reasonable limits as regards wave-length. The original C.W. systems were carried out by means of arc transmitters.

The arc system was in almost universal use for high-powered work, and amongst the chief commercial exponents of this type of transmitter were Poulsen, Elwell, Alexanderson and the Telefunken Company.

In the meantime, the crystal detector was being developed and becoming more and more in evidence. The coherer became an instrument of the past, and the magnetic detector was rapidly being supplanted in favour of the crystal. Carborundum, under the influence of a suitable electrical potential, was found to be an excellent detector and, moreover, one of remarkable stability.

Fleming's Invention of the Valve

Attention was now to be diverted along quite different channels by the introduction of the Fleming two-electrode valve. This was stated to be the outcome of a series of observations by Edison upon his invention, the incandescent electric lamp. He made the discovery that the blackening within the lamp globe was largely due to the disintegration of the filament in the form of electrons, an effect known as the Edison effect.

Fleming, acting upon this theory, evolved the two-electrode valve, in which the electrodes consisted of a filament surrounded by a cylinder of metal called the sheath, plate or anode and which were contained within an evacuated glass vessel. The filament was heated by a low-tension current, while the anode was impressed with a potential of considerably higher value.

The sole function of this valve was detecting or rectifying, and it became a rival of the crystal dector for this purpose. Despite its drawbacks, in that it required two separate batteries for its working, it was quite the best detector known.

Subsequently to these discoveries of Fleming, attention was given to a development of this invention by Lee de Forest, in America. De Forest was responsible for the addition of the third electrode in the valve, known as the grid. This development became of enormous importance, for it was soon found that the product of this invention could be made to produce electrical oscillations, to rectify high-frequency currents with a hitherto unheard-of efficiency, and to amplify such currents, while at the same time preserving faithfully their characteristics.

Thus the valve receiver, and also the valve transmitter, developed. The arc system of producing continuous waves was gradually being supplanted by this new device, while for serious commercial receiving the crystal detector and its predecessors themselves were obsolescent. All these developments were undoubtedly accelerated by the Great War, and inventors became engaged in producing valves which would operate with less and less current, thus leading the way to the dull emitter valve.

During the whole of this period the number of transmitting stations was becoming greatly increased, and the attention of designers of wireless apparatus was continually engaged in attempting to produce receivers which were absolutely selective. Great strides in this direction have been made, and, with skilled operators, the commercial wireless receiver of to-day is marvellously selective.

High-speed Wireless Telegraphy

With the advances that were made in the reliability of wireless apparatus, its use for commercial trans-continental and transatlantic intercommunication, as well as for Press services, became apparent. To this end rapid advances were made in the development of high-speed telegraphic apparatus. The Wheatstone high-speed land-line telegraphic system was adapted for wireless purposes, and business and other long-distance communications were made as reliable and even more speedy than the older cable systems.

Further, as far as Britain is concerned, the Marconi Company developed centrally-operated remote-control systems whereby stations situated in different parts of the country could all be operated from one central office in London.

There was, however, one aspect of the transmission of telegraphic signals by wireless which still remained to be considerably improved. This was secrecy of communication. All the transmitters in use radiated their signals in all directions, and anybody in possession of suitable apparatus could pick them up at will. Attention was therefore given to short waves, using reflectors as a means of projection along a narrow beam in a similar manner to the way light is projected by a search-light.

It has been previously mentioned that Marconi had already experimented in this direction. In fact, he demonstrated this system to the British Post Office in the year 1896. Owing to the fact that such great strides were made with comparative ease using long waves and high powers, the subject was apparently dropped for some years. The latest experiments in this direction have proved beyond question that this system will prove practically secret, even without the use of any special codes, and that, owing to the reflectors and resultant concentration of energy, great economy of power is effected. Illustrations of the apparatus used in this system, and a description, appear under the heading Short Wave.—*R. B. Hurton.*

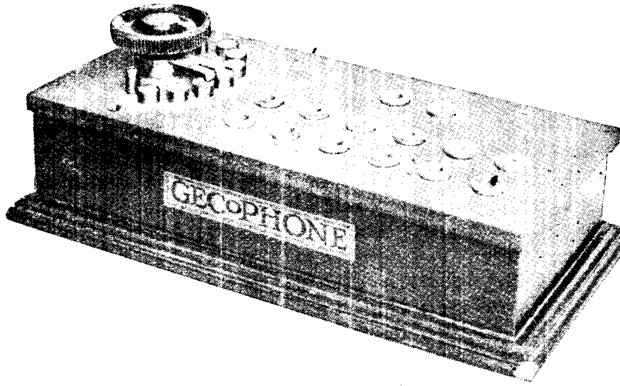
TELEPHONE CONDENSER. Fixed condenser shunted across the telephones of a receiving set or across the telephones and high-tension battery wired in series. The windings of the telephones offer a high resistance to radio-frequency and to speech-modulated currents, and for this reason the telephone condenser is often of advantage where the telephones are in the anode circuit of the detector valve.

Particular advantage is often found where a reaction coil is employed, as the effect of the telephone condenser is to offer a path of low resistance to the radio-frequency currents. Body capacity effects are also diminished as, owing to the direct path for the radio-frequency currents, the additional capacity introduced by the presence of the hand is not noticeable. When used in this connexion, a suitable condenser capacity would be from ·001 to ·003 mfd. It is sometimes found, especially where the telephone condenser is used with telephones in the anode of the detector valve and no reaction coil is employed, that the introduction of a telephone condenser results in a diminution of signal strength. This is because the stray capacities of the receiver, which give a certain amount of reaction effect, are minimised. Although signal strength may be slightly minimised, the receiver is made more stable, and the tone of music or speech made more pure by the addition of the telephone condenser.

The beneficial effects of the telephone condenser are more pronounced in a multi-valve circuit, where its presence prevents overloading of the telephones and provides a more even and steady current flow. Suitable capacities for shunting across the telephones vary between ·001 and ·005 mfd. *See* By-pass Condenser; Condenser.

TELEPHONE DISTRIBUTION BOARD. Name applied to an instrument used for connecting several telephones to one common circuit. The use of a distribution board enables several listeners to have the use of individual telephones, all of which are energized from a single point connected to the receiver set circuit. One pattern is illustrated in Fig. 1, and is that adopted by the General Electric Co., intended for use with apparatus of the well-known Gecophone brand. The current from the receiving set is taken to the distribution board through flexible leads which plug into the two sockets at the back of the instrument.

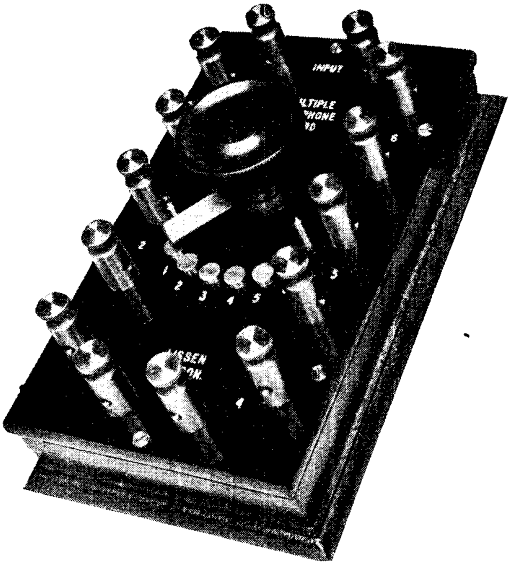
The telephones plug into the series of holes in the front, and any or all can be brought into action by operation of the stud switch at the left of the board. Another type, as made by the Lissen Co., is shown in Fig. 2, and is provided with



TELEPHONE DISTRIBUTION BOX

Fig. 1. A number of listeners-in can use the same wireless receiving set at one time by connecting their headphones to the sockets on the panel

Courtesy General Electric Co., Ltd.



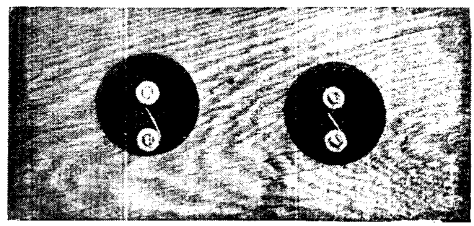
LISSEN DISTRIBUTION BOARD

Fig. 2. A series of telephone terminals is used in this type and control is effected by the selector switch shown in the centre

a series of telephone terminals. This board can be used with any type of receiver able to actuate several telephones simultaneously, and is controlled by the numbered selector switch which is shown in the centre of the panel.

The latter is of ebonite, mounted on a polished wood case, making the whole into a compact and useful unit. A simple type is shown in Fig. 4 in use with the Oracle crystal set, and suitable for two pairs of telephones. This consists of a wooden base with an ebonite panel attached to the upper part, and provided with two sets of telephone terminals. These are suitably connected to a pair of spring contact pieces, to which the telephone tags are attached. An underside view of the baseboard is shown in Fig. 3, and illustrates the simplicity and efficiency of this device. There is no difficulty whatever in the wiring, which, as is clearly shown, is held by means of nuts. If preferred, soldering may be employed for this purpose.

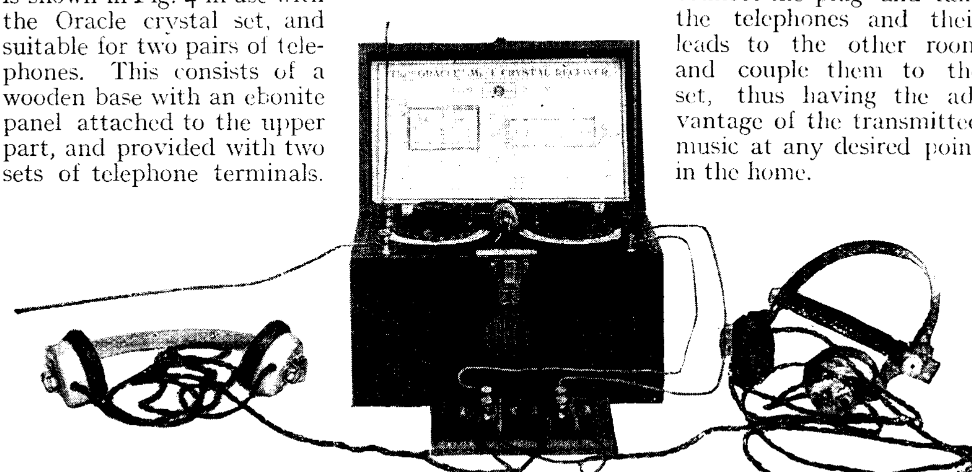
Apart from their uses as mere distributing boards, these appliances can



UNDERSIDE VIEW

Fig. 3. How the contacts of the simple distribution board in Fig. 4 are made

be usefully employed to connect the telephones to some other room than that in which the set is located. All that need be done is to run a pair of well-insulated wires from the set to the desired location, and then to attach the telephones to the distribution board. When the latter is of the plug-in variety it is but the work of a moment to disconnect the plug and take the telephones and their leads to the other room and couple them to the set, thus having the advantage of the transmitted music at any desired point in the home.



EASILY CONSTRUCTED TELEPHONE DISTRIBUTION BOARD

Fig. 4. Two pairs of telephones can be connected to the simply made distribution board seen in the foreground. The average crystal set will give quite good reception results for two telephones, though the volume of sound is thus necessarily reduced

TELEPHONE RECEIVERS: HOW THEY ARE MADE AND USED

An Important Component of Wireless Receiving Sets Fully Described

Here the reader will find a full description of the construction of the various modern types of headphones as used in wireless. He will find further illuminating references to this subject under such headings as Headphone and Microphone, as well as in the text throughout this Encyclopedia dealing with proprietary types, as Ericsson Headphones. See also Loud Speaker; Resistance; Telephone Transformer

The telephone receiver is a device which converts modulated electric currents into audible sound waves. In its standard form it is a very simple piece of apparatus, remarkably efficient and reliable in service, and it is probably on the latter account that the finer details of its operation are not known to the extent that they should be.

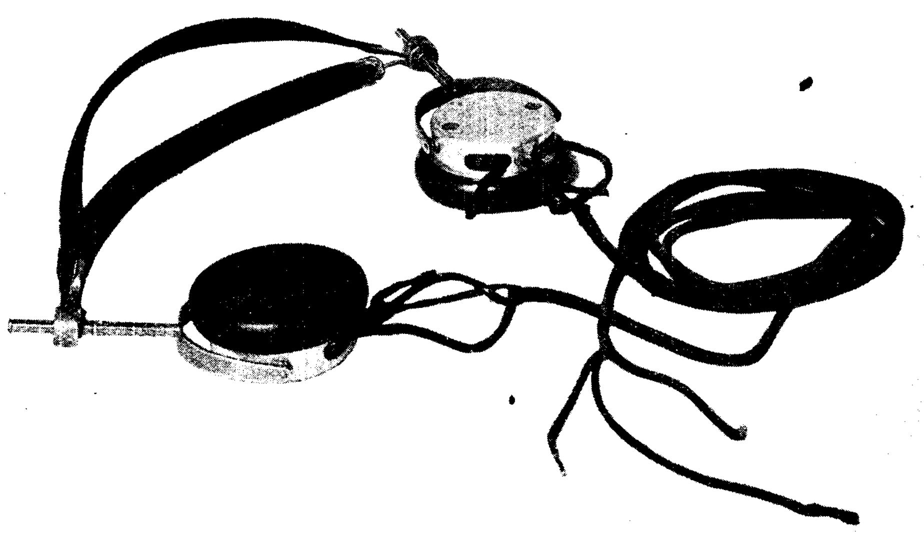
The essential features of a telephone receiver are an electro-magnet and a diaphragm, held in some convenient form of case. Current from the receiver is taken to the electro-magnet, which it energizes in a strength proportional to the strength of the current. The diaphragm is supported by its rim at a short distance from the magnet faces, and thus it is attracted by the magnet when it is energized.

It follows that as the magnetic flux varies, so the pull on the diaphragm varies, and thus the latter will respond to every difference in current strength and reproduce mechanically every electrical variation. As the diaphragm moves it causes corresponding air waves or vibrations, which are detected by the ear in the form of sound.

That, in simple language, is the action of the telephone; but it has taken many years of research to reach the state of perfection in tone reproduction which exists in the modern instrument.

So reliable in this respect are the higher-class makes of telephone that the user, when he hears bad or distorted speech or music in his receivers, may, without hesitation, lay the blame on the transmission quality or, more likely, on his receiving set, and not to the telephones.

The appearance of the internal construction of a modern earpiece of conventional design may be gathered from the Federal telephones, illustrated in Figs. 1 and 2. Inside the aluminium casing is a form of horseshoe magnet. This has its main portion bent into the form of a circle, but its poles are bent up at right angles so that their extreme edges face



FEDERAL TELEPHONES FOR BROADCAST RECEPTION

Fig. 1. Aluminium is used in the making of the light casing of the magnets in these well-known instruments. The external appearance of these telephones is handsome and they are efficient in use. The headbands are constructed of pliable material

Courtesy Pettigrew and Merriman, Ltd.

outwards, as shown in Fig. 2. The magnet is of the permanent type, and thus exerts a constant pull on the diaphragm. The latter is therefore permanently in a state of tension. It has been proved that while in this state it is more susceptible to minute variations in tension than if it were normally perfectly flat.

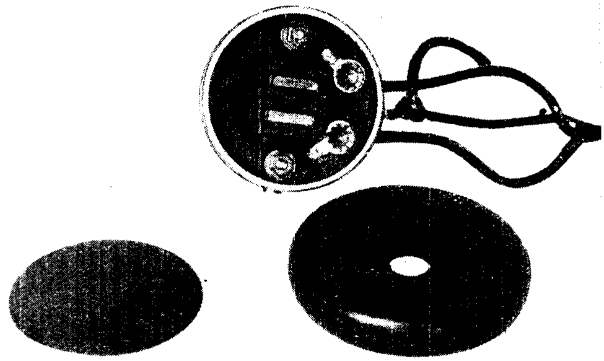
On each limb of the permanent magnet is a bobbin containing the windings, and it is thus of great importance that the direction of the current put through the windings should be such that it assists the permanent magnet. Should the reverse happen it is more than probable that the permanent magnet will become demagnetized and the efficiency of the receivers lowered a considerable degree.

The cords attached to the receivers are sometimes marked positive and negative, usually by the weaving of red and black cotton into the braiding, and the red-coloured or positive lead should always be connected to the positive side of the set. This does not of course, apply in the case of crystal sets.

The electrical design and construction of the Siemens telephones, illustrated in Fig. 3, is substantially the same as for those in Fig. 1, the main difference lying in the type of headband and the attachment of the cords.

Fig. 4 is a general view of the well-known Brown type A reed telephone, and the construction of this instrument is a radical departure from all accepted standards. It is claimed that the special construction employed is responsible for a considerable increase in sensitivity.

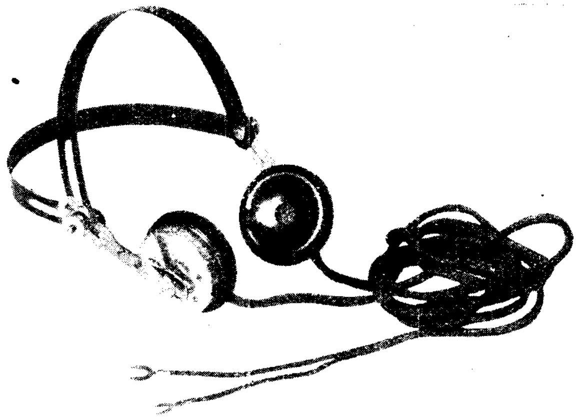
The chief difference of this type of telephone lies in the substitution of a non-magnetic diaphragm of thin aluminium,



INTERIOR OF FEDERAL TELEPHONE EARPIECE

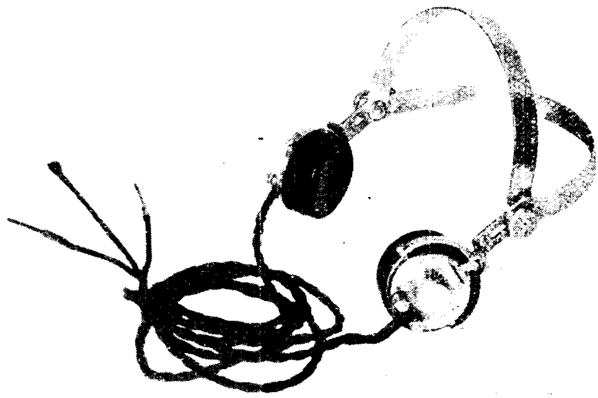
Fig. 2. Diaphragm, protective ebonite and magnets of the telephones shown in Fig. 1 are shown here

Courtesy Pettigrew and Merriman, Ltd.



SIEMENS TELEPHONES

Fig. 3. In these telephones a universal ball-bearing joint allows the earpiece to be adjusted easily. In construction this instrument closely resembles the Federal type



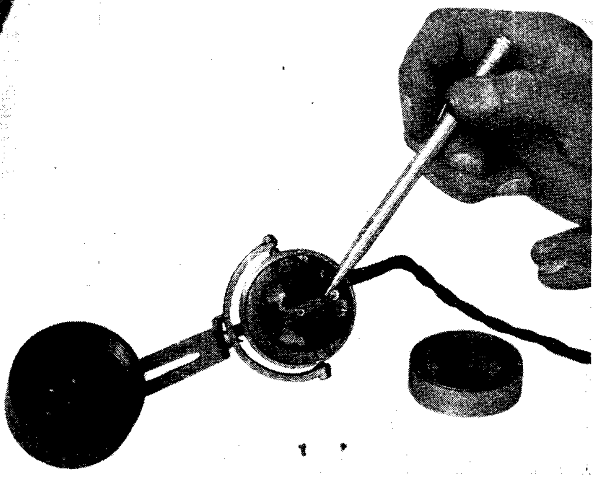
BROWN TYPE A REED TELEPHONES

Fig. 4. The construction of this type of instrument differs very essentially from most kinds and, it is claimed, affords more sensitive reception

Courtesy S. G. Brown, Ltd.

the form of a semicircular horseshoe, having its poles arranged in the form of a diameter. It is between these poles that the free end of the reed vibrates, the back being rigidly attached to the outer casing.

The magnets are fixed to a kind of sub-frame within the outer casing, and the relative positions of the magnet faces with respect to the reed may be varied by the milled screw at the back of the earpiece. This movement is useful, for it allows the



BROWN TELEPHONES IN USE

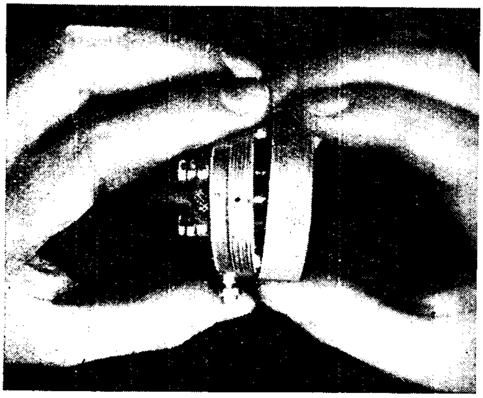
Fig. 5 (above). A milled screw adjusts the position of the vibrating reed relatively to the magnet. Fig. 6 (right). Internal construction showing aluminium reed, to which the pencil is pointing

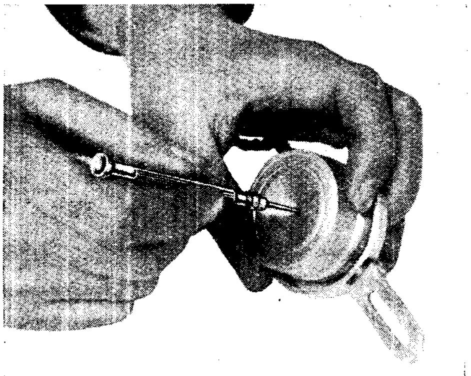
Courtesy S. G. Brown, Ltd

which is in the form of a cone having its apex facing the magnets. The movement of this diaphragm is derived from a metal reed vibrating between two opposite magnet faces. This reed is clearly shown in Fig. 6, where it is indicated by the point of a pencil. It is also clear from this illustration that the permanent magnet is in

full sensitivity to be used for weak signals, while " chatter " on strong signals can be eliminated by increasing the air-gap.

It is not necessary to remove the telephones from the head for this operation, as reference to Fig. 5 will show. When the most sensitive adjustment is required it is necessary to turn the screw





CONSTRUCTIONAL DETAILS OF THE VIBRATING REED HEADPHONE

Fig. 7 (left). How the aluminium shell is fitted on the Brown telephone. Fig. 8 (right). Great care must be used in adjusting the screw in the centre of the diaphragm until a click is heard, and then to turn back about one turn of a revolution.

Fig. 6 also shows the component parts of the Brown reed telephone disassembled, from which it is clear that the diaphragm is mounted in a circular aluminium shell. The latter fits round the base of the aluminium casing, and when fitting it is important that a special indentation in the diaphragm support registers with a slot cut in the outer casing. A glance at Fig. 7 illustrates the procedure to be adopted in this operation.

When this is done it is necessary to insert the small screw in the centre of the diaphragm. This is used to attach the diaphragm to the reed, and the greatest care is necessary in this operation, for a slight slip of the screwdriver on to the diaphragm will cause the latter to be ruined by a large slit or dent. The method of fixing this screw is illustrated in Fig. 8.

Adequate protection for the fragile diaphragm is provided by the special type of ebonite ear-cap fitted. Instead of the usual large hole in the centre it has a series of small holes arranged in the form of a circle. From the delicate construction of the telephones it might be thought that they are not suitable for rough handling. That this is not so was proved during the Great War, when they were in almost universal use under active service conditions.

The headbands with which wireless telephone receivers are fitted are a most important feature, and on them depends to a large extent their comfort in use. Generally speaking, English manufacturers favour the type illustrated in Fig. 3. Here the bands themselves are of spring steel strip, which is Coslettised or enamelled to give protection against rust. One end of each strip is fitted with a long slot, while the other end has a circular hole punched in it. Through these slots and holes are threaded the screws which carry the nickel-plated brass pieces which support the actual telephones. The telephone supports are fitted at their extremity with a simple form of ball and socket joint, which allows the telephones to assume a natural flat position against the ear.

Fittings of this type must first be adjusted to suit requirements of individual comfort by a suitable spacing of the steel bands and the correct length adjustment of the clamping screws in the slotted holes. Once set in the correct position, and the screws clamped tightly, it should not be necessary to give any subsequent adjustment for the same person.

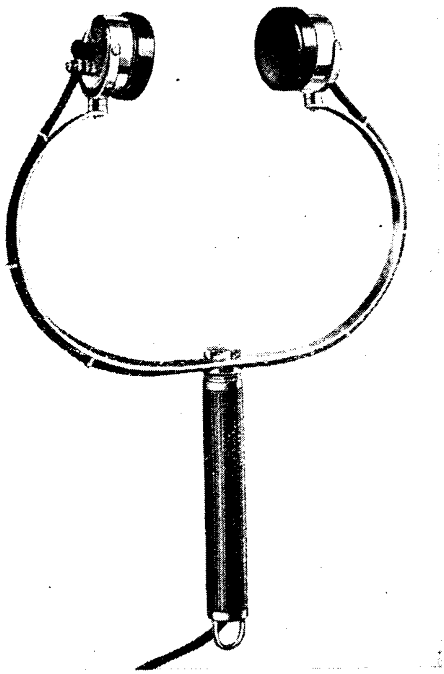
A type of headband which is in universal use in America, and which is becoming increasingly popular in England, is shown attached to the Federal telephones illustrated in Fig. 1. The great advantages of this type of headband lie in the fact that they may be readily adjusted to suit the wearer when actually on the head. Again, owing to the entire absence of screws and slots, they are not so likely to become entangled in the wearer's hair.

It will be found that while actually on the head the spring nut will permanently retain any position in which it is placed. These headbands are very comfortable to wear, and their natural spring tends always to keep the earpieces pressed flat against the ears.

Quick detachability of the separate earpieces is a desirable feature, as by its use it is possible to allow a second person to hear occasionally without the delay of purchasing of a second pair of telephones. Both the Federal and Siemens types possess this feature. In the former it is necessary to expand the stirrup spring which holds the earpiece, and in the latter to slide the ball attached to the earpiece casing along the slot in the brass support. The slot terminates in a hole which allows the ball to fall through, and the band to be disconnected with ease.

FRENCH TYPE OF TELEPHONE

Fig. 9. Adjustable fittings and double headbands are employed in these very useful instruments



FOR LADIES' USE

Fig. 10. By the use of this telephone the inconvenience of a disarranged coiffure is avoided. It is mounted on a double arm with a centrally-fitted grip

Courtesy Sterling Telephone & Electric Co., Ltd.

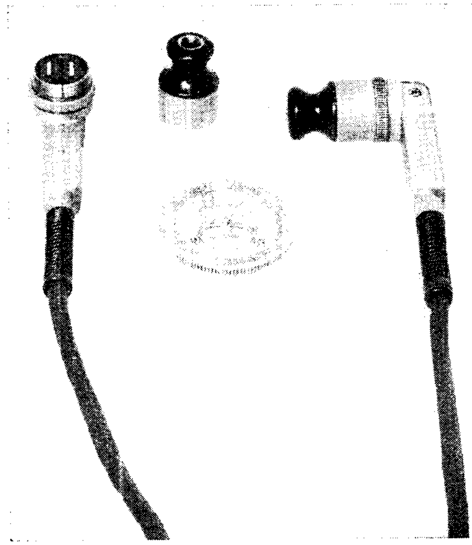
An example of French manufacture is shown in Fig. 9, the well-known Sidpe telephones. These are provided with dual headbands and neat adjustable side supports for the earpieces; circular magnets are used, and the earcaps are corrugated.

Ladies will appreciate the merits of the Sterling handphones illustrated in Fig. 10, these having a handle wherewith to hold the telephones, and thereby overcome all chances of disarranging the hair. The instruments are light to handle and effective as regards their tonal qualities. For those very hard of hearing the miniature telephones shown in Fig. 11 will appeal, as they fit right into the ear. The small size of these instruments, made by F. Charles Rein & Co., can be appreciated by reference to the shilling shown beside them.

Notwithstanding their small size these telephones have properly wound magnets and a diaphragm, the action and construction in general following accepted practice for the full-size instruments.

Telephone cords occasionally give trouble, particularly where they terminate in metal tags, either at the telephone end or the end which is connected to the set. This trouble usually takes the form of the tags pulling off and exposing the bare strands of the flex. To obviate this annoyance many manufacturers adopt the features shown in Figs. 1 and 4. If the ends of the cords in these pictures are examined it will be found that a continuation of the cord covering exists between the terminations of the wires. These cords should be tied round any convenient terminal on the set, and adjusted so that any tension resulting from an inadvertent pull on the cords affects this centre string only. If this procedure is carried out it is impossible to put any tension on the actual leads, and thus the metal tags cannot possibly be pulled out.—*R. B. Hurton.*

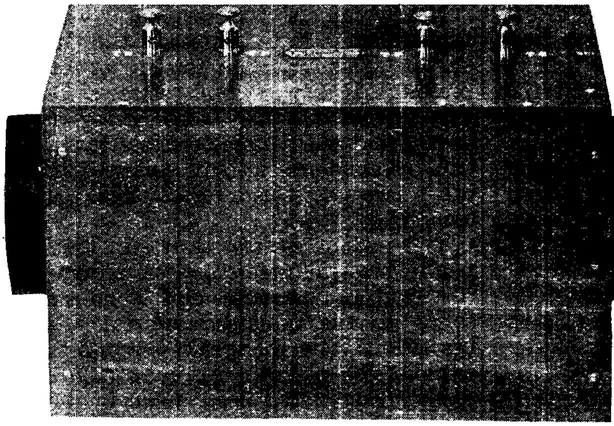
TELEPHONE TRANSFORMER. An iron-cored transformer of either the open or closed core variety used for inductively coupling the telephones instead of directly connecting them in a circuit. In construction the telephone transformer is very similar to the low-frequency transformer. It has this big difference, however. The latter is wired to give a step up of voltage, while the telephone transformer reduces the voltage to a lower potential.



SMALL-SIZE TELEPHONES

Fig. 11. For deaf people this special type has been evolved for insertion in the cavity of the ear. Compare the size of the earpiece with the shilling

Courtesy F. Charles Rein & Sons.



COMMON TYPE OF TELEPHONE TRANSFORMER

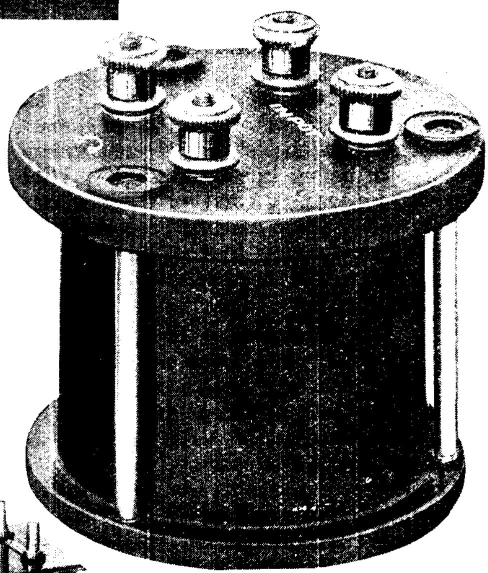
Fig. 1. A protective wooden box covers this telephone transformer. Connexions to the coils are made from the terminals on the top

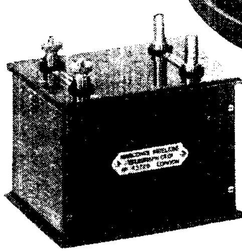
Courtesy Marconi's Wireless Telegraph Co., Ltd.

For this reason the windings of the telephone transformer placed in the circuit in the position normally occupied by high-resistance telephones have a greater number of turns of wire than the coil connected directly to the telephones. The use of the telephone transformer safeguards the telephones from the high potentials of the high-tension battery, and thus the risk of an insulation breakdown or the possibility of the telephones being burned out is avoided. The resistances of the coils used in telephone transformers are commonly about 4,000 ohms and 120 ohms, the coil having the lesser resistance being connected to the telephones.

Two types of telephone transformer are illustrated in Figs. 1 and 2. These are mounted in small boxes, the input and output terminals being arranged in pairs on the top of the cases.

Another type of telephone transformer is illustrated in Fig. 3. In this transformer the windings are protected by large circular plates fitting at the top and bottom of the instrument, and are kept in position by means of three rods screwed to the plates near their circumference. Terminals are arranged to the top plate. *See* Intervalve Transformer; Transformer.





EFFICIENT TELEPHONE TRANSFORMERS

Fig. 2 (left). A Marconi telephone transformer. Fig. 3 (above). Solid top and bottom plates protect the coils in this neat and compact instrument by the Fuller's United Electric Works, Ltd.

TELEPHONY IN WIRELESS: A SURVEY OF ITS PROGRESS

Developments in Theory and Practice of Transmission and Reception

This necessarily brief, but reasonably complete, survey of that branch of wireless science which embraces the transmission and reception of telephony covers its theory and evolution from the early experiments of Marconi and other pioneers. The reader will find further references pertinent to the subject under Broadcasting; Transmission; Valves, etc.

Telephony is the term applied to the transmission of the human voice or music by means of electro-magnetic (ether) waves propagated by wireless apparatus. The first experiments of any practical or commercial importance were made upon the introduction of continuous wave transmitting apparatus, but it was not until the advent of the valve as a means of transmitting that great strides were made in its development.

In wireless telephony the radiated waves may be considered to consist of two distinct groups. In the first place, there is the carrier wave, which forms the direct means of communication, and which may be said to take the place of the line in ordinary wired telephony; then there is the modulated wave, which actually conveys the modulations of the voice or music. The carrier wave is identical with the waves which are transmitted by a telegraphic transmitter, except that it is unbroken from one end of the message to the other. The modulated wave is superimposed on the carrier by a separate circuit embodied in the transmitter, and generally by another valve, known as the modulator valve.

The actual speech modulation is primarily obtained by means of an instrument known as a microphone, details of which are given under that heading. Up to a quite recent date the microphones in use for wireless work were identical in general principles with the standard instrument used for ordinary line telephony. While these are reasonably good for speech, they are by no means faithful recorders of music, chiefly owing to the loose carbon contact between the granules and the inertia of the diaphragm.

The Microphone of To-day

The modern microphone at present in use for broadcasting in this country is an electro-dynamic instrument, having a light coil of wire instead of a diaphragm. In the earlier forms of telephony transmitter it was a general practice to insert the microphone in the earth lead of the instrument. Thus the radiation current had perforce to pass through the microphone, and when the resistance of the latter was continually varied by the operator's speech, the current was modulated in accordance with the sounds which the speaker made. In this system the aerial and earth connexion was not metallically connected to the transmitter proper, but was loosely coupled.

A development of this system was the introduction of the grid control circuit, in which the microphone was fed with low-tension current from the filament battery, with the primary of a transformer in series with it. This transformer, known as the microphone or modulation transformer, had its secondary connected in the grid circuit of the valve. The grid therefore received the modulated impulses and transferred them to the anode circuit. For the method adopted to effect this, the heading Valve should be referred to.

Nearly all of the original telephony transmitting sets adopted the Round valve. This was the forerunner of the present R types of three-electrode valve, and all the transmitting types were fitted with three separate filaments, one being in use at any time, while the other two acted as stand-bys in case of emergency.

The advent of practical wireless telephony brought many new inventors into the field of research, and it is largely owing to the romantic interest aroused by the ability to speak through space without the use of wires that such enormous strides have been made in the art during the last few years. Telegraphy must always be a purely utilitarian system of communication, but as a means of entertainment it is of no value, and does not, therefore, appeal to the laity. From the transmission of human speech to music is only a very small step, and wireless communication as a means of conveying lectures, concerts and entertainments generally soon became a practical development.

America, the Pioneer of Broadcasting

It is to America that the world is indebted for the introduction of the broadcasting (*q.v.*) of wireless speech and music. This undoubtedly was largely due to the ease with which citizens in the U.S.A. may obtain licences for using wireless transmitting apparatus, and the absence of restrictions on the kind of matter transmitted. It soon became evident that broadcasting was a splendid medium for advertising, and in a very short space of time hundreds of stations came into existence chiefly for this purpose, being owned and controlled by large commercial enterprises.

This naturally led to the entry of new brains into the field of research, both in transmission and reception, and rapid strides were made in the efficiency of both classes of instrument, and more particularly in the selectivity of receivers. Further, the dull emitter valve was evolved, and became a commercial possibility.

Events in America developed with such rapidity that it soon became a matter of the greatest difficulty to be able to select any one broadcasting station, for there was no control of any serious nature over the number of stations to transmit at any one time, and no great care was exercised in keeping to the particular allotted wave-lengths. This resulted in a chaotic state of affairs, and legislation soon became a matter of extreme urgency. To this end the wave-lengths were rigorously enforced and the hours at which different stations were allowed to transmit became a subject of careful legislation.

A study of the conditions obtaining in America was made by interested firms in Britain, the outcome of which was the formation of the British Broadcasting Company, an amalgamation of wireless firms to form one central broadcasting authority. Previously to this event the only really high powered transmissions were made by the Marconi Company from their experimental station 2 M T at Writtle, near Chelmsford. These consisted of half-hour transmissions of speech and music on every Tuesday evening.

Soon after the inauguration of the B.B.C., regular evening transmissions were made from the original London station 2 L O. Following this, other stations were erected in different parts of the country, and regular afternoon and evening programmes of speech and music were transmitted.

One of the greatest events in the development of broadcasting in this country was the relaying of opera from Covent Garden Opera House, London, and, following this, relaying by land-line and radiation simultaneously from all stations of the one subject was accomplished. A later development of this system was the relaying of American transmissions, picked up originally by wireless, relayed by land-line to all stations, and finally re-radiated so that anyone might receive them at will, in a manner similar to the ordinary transmissions.

As a result of the commercial possibilities of broadcasting and the public interest aroused, both in Europe and America, new ideas and improved methods became universally applied. The standard transmitting apparatus of the B.B.C. is remarkable for its stability and efficiency. The circuits involved in the actual transmitter include the control and sub-control systems. On the receiving side the adaption of regeneration and super-regeneration to telephony apparatus as a means of increasing range and signal strength with reduced numbers of valves was effected. Dual amplification systems were likewise developed, both in pure valve receivers and in valve and crystal combinations, with improved results.

High-frequency amplification as a means of increasing range, and low-frequency amplification for enabling loud-speakers to be operated, were vastly improved. Receiving apparatus embodying these functions are fully described in this Encyclopedia under their respective titles.

A development of wireless telephony whereby proper conversation is possible has been developed, a description of which is given under the heading Duplex Telephony.

TELEVISION, OR ELECTRIC VISION AT A DISTANCE

By E. E. Fournier d'Albe, D.Sc., F.Inst.P.

The problem of transmitting light images to distances beyond ordinary vision is one whose complete solution will in all probability depend upon an application of wireless methods. Here Dr. Fournier d'Albe, who is well known for his work on this subject, describes all the important methods that have been proposed. See also such related headings as Photography by Wireless; Selenium.

The transmission of sight along a wire or through the ether beyond the range of ordinary vision is a problem still awaiting solution.

The luminosity of a single lamp can be transmitted already by either wire or wireless. All that is necessary is to allow the lamp to shine on a selenium cell (*q.v.*) in circuit with a battery. As the resistance of the selenium diminishes with increasing illumination, any variation of brightness in the lamp will cause variations of current in the circuit, and these variations may be used to actuate a great variety of devices, all capable of exhibiting and recording the original variations of the lamp at any distance.

Television, however, involves much more than this. It involves the independent transmission of as many different points or patches as constitute the original view or scene to be transmitted.

The number of such points or patches is very large. A human face seen from a distance of 20 ft. consists of some 10,000 luminous points, each covering a separate element of the retina or sensitive layer of the human eye. The retina consists of millions of separate receivers, each dealing with a separate position in space, and it is this fact which makes television the formidable problem it is.

If a rapidly moving or changing face is to be seen by wireless, 10,000 signals must be transmitted at least 16 times per second, so as to follow the changes as rapidly as the eye can follow them. And since not only the presence, but the brightness of each point must be indicated, this television problem involves the transmission of some 300,000 signals per second.

The problem is somewhat simpler from another aspect. A face on a small scale, say, a postage stamp, can just be recognized if it consists of only some 400 separate patches, and if that number of selenium cells could be used simultaneously and each made to follow the variations of one of the constituent patches, we should obtain a crude form of television which might be quite useful for some purposes.

For the translation of light into electric impulses, only two devices can be considered, viz. the selenium cell and the photo-electric cell, a vacuum bulb with a negative electrode covered with an alkaline metal such as potassium or rubidium in a colloidal state. Of these two cells the latter is the more rapid in its action, while the former gives a far stronger current.

In 1880 Professors Ayrton and Parry proposed to obtain television by means of a number of selenium cells, but Shelford Bidwell pointed out that their apparatus would have 90,000 working parts, and would cost over a million pounds.

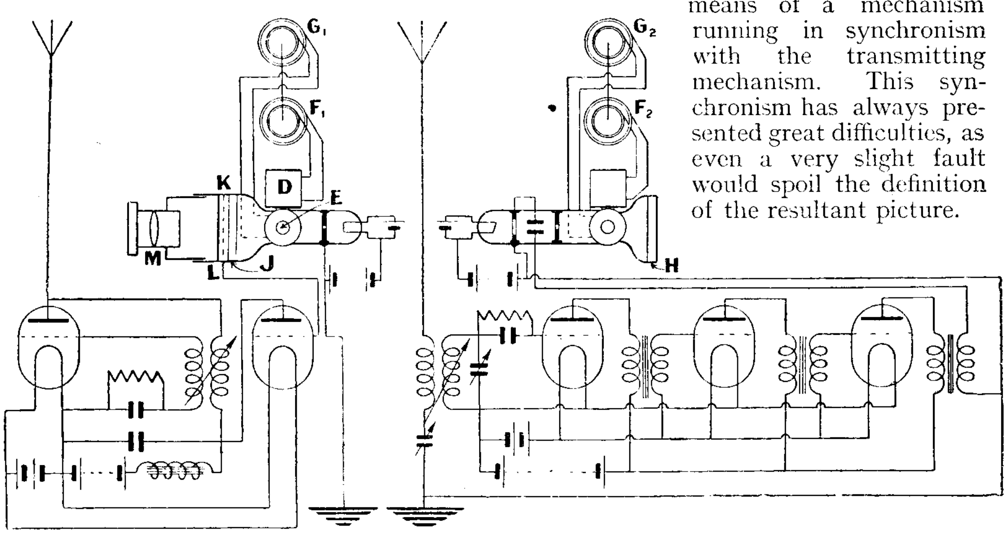
In 1913 Ernst Ruhmer succeeded in transmitting a few simple geometrical figures by means of a number of selenium cells.

Some other workers, notably Dosai and Nisco, also attempted to use a number of selenium cells simultaneously.

But the objection to this method is that no two selenium cells will behave in a similar manner, and it is impossible to attain an exact reproduction.

The remedy for this difficulty would be to use the principle of the "persistence of vision," which enables the eye to bridge gaps between successive flickers, as in the cinematograph. Many systems of television have been based upon this principle.

Rosing, in 1910, used revolving polygonal mirrors to analyse the picture into its constituent elements. Andersen used a perforated strip or ribbon which made every patch of the picture flash upon a screen in turn. In both cases the light was made to fall on a single selenium cell. At the receiving station it was necessary to analyse the currents transmitted by means of a mechanism running in synchronism with the transmitting mechanism. This synchronism has always presented great difficulties, as even a very slight fault would spoil the definition of the resultant picture.



TRANSMITTER AND RECEIVER IN CAMPBELL SWINTON'S METHOD OF TELEVISION

Fig. 1. Rubidium blocks make up the screen J on which the image is thrown. Each block is electrically charged by a cathode beam falling on it from the other side; it is discharged by light and produces an electrical impulse in the transmitter. At the receiver a synchronous cathode beam traces out the original sent out by the transmitter

Courtesy "Wireless World and Radio Review"

SELECTED PROGRAMMES FOR THE AMATEUR

British and Continental Wireless Transmissions

Below is given a list of some of the principal stations whose transmissions can be tuned in on apparatus described in this Encyclopedia. These include public stations in Great Britain and the Continent; but the list is not intended to be complete. Times of transmission by the British Broadcasting Company vary, but these may be found in the daily press. Post Office, Marconi and Aviation transmissions take place at all hours

BRITISH BROADCASTING COMPANY

CALL	STATION	WAVE-LENGTH	CALL	STATION	WAVE-LENGTH
2 LO	LONDON..	365	6 FL	SHEFFIELD	303
6 BM	BOURNEMOUTH ..	385	5 NO	NEWCASTLE.. ..	400
5 PY	PLYMOUTH	330	5 SC	GLASGOW	420
5 WA	CARDIFF	353	2 EH	EDINBURGH.. ..	325
2 ZY	MANCHESTER ..	375	2 BD	ABERDEEN	495
5 IT	BIRMINGHAM ..	475	6 LV	LIVERPOOL	318

CONTINENTAL STATIONS

Transmissions from these stations are chiefly of popular interest, but time signals, commercial information and financial intelligence are included. Times are given in British Summer Time

CALL	STATION	WAVE-LENGTH	TIME	SERVICE
PCFF	Amsterdam	2,000	07.50	Daily
—	Berlin (Vox Haus)	430	13.55	Time Signals
—	"	"	17.40	Music
BAV	Brussels ..	1,100	14.00	Reports
"	"	"	18.50	"
—	(Radio Elect.)	265	18.00	Music
—	"	"	21.00	"
—	Eberswalde	2,930	13.00	"
HB 1	Geneva ..	1,100	20.00	"
PCGG	Hague ..	1,070	19.00	Irregular; Music
PCKK	"	"	21.40	Fri. Music
PCMM	"	1,050	21.10	Sat. Music
PCUU	"	"	20.45	Thurs. Irregular
"	"	"	21.40	Sun. Irregular
LP	Königswusterhausen	3,700	08.00	Financial News
"	"	"	09.00	Reports
"	"	"	10.00	"
"	"	2,700	11.00	Not Sun. Music
"	"	4,000	12.00	Music
"	"	2,700	16.00	Irreg. Music
HB 2	Lausanne	1,000	19.00	Wed & Fri. Music
"	"	780	16.00	Irregular; Music
OXE	Lyngby ..	2,400	20.30	Not Sun. Music
YN	Lyons ..	470	11.45	Music
—	Madrid ..	392	19.00	Irregular; Music
PTT	"	400–700	17.00	"

CALL	STATION	WAVE-LENGTH	TIME	SERVICE
POZ	Nauen ..	4,700	00.57	Time Signals
"	"	"	12.57	"
FL	Paris (Eiffel Tower)	2,600	07.50	Weather
"	"	"	10.58	Time Signals
"	"	"	11.05	" "
"	"	"	11.34	" "
"	"	"	12.15	Weather
"	"	"	20.00	"
"	"	"	22.58	Time Signals
"	"	"	23.20	Weather
"	"	"	23.44	Time Signals
—	Paris (Radiola)	1,780	13.00	Markets
—	"	"	13.45	Music
—	"	"	14.45	Financial News
—	"	"	17.30	" "
—	"	"	17.45	Music
—	"	"	18.45	Racing News
—	"	"	22.30	Reports; Music
—	"	"	23.00	Thurs. and Sun. Music
—	Paris (Ecole Supérieure)	450	15.30	Sat. Music
—	"	"	20.45	Daily; Music
PRG	Prague ..	1,800	08.00	News
"	"	"	16.00	Irregular; Music
KBEL	"	1,150	22.00	Music
ICD	Rome ..	3,200	12.00	"
"	"	1,800	16.00	"
"	"	"	20.30	"

AVIATION AND OTHER SERVICE TRANSMISSIONS

CALL	STATION	WAVE-LENGTH	SERVICE
GFA	Air Ministry (London)	900–4,100	
BYB	Cleethorpes (Radio)	3,000–5,200	Aviation. Gale Warnings
GED	Croydon.. ..	900	Civil Aviation
GEM	Didsbury ..	"	" "
GEP	Pulham ..	"	" "
GER	Renfrew Radio		" "
BYP	Plymouth ..	220	Aircraft
MUU	Carnarvon ..	14,200	Marconi
MZX	Chelmsford	3,800	"
GLA	North Weald Essex	3,800	"
GLB	" "	2,900	"
GLO	" "	4,350	"
GLA	Ongar Radio	2,400	"
GLB	" "	3,950	"
GLO	" "	4,350	"
2 MT	Writtle ..	400	Marconi Scientific Inst. Co.

CALL	STATION	WAVE-LENGTH	SERVICE
GCS	Caister-on-Sea	1,750	Post Office
GXO	Crookhaven ..		" "
GCC	Cullercoats ..	600	" "
GRL	Fishguard	600	" "
GBL	Leafield ..	8,750–9,400	" "
GKB	Northolt Radio	6,890	" "
GBL	Oxford Radio	8,750–12,300	" "
GPK	Port-Patrick Radio	600	" "
GLV	Seaforth Radio	"	" "
GSW	Stonehaven Radio	3,000–5,000	" "
GCA	Tobermory Radio	300	" "
GCK	Valentia ..	600	" "
GKR	Wick	600	" "

THE

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