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For Amateur & Experimenter

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Special Series of Articles on

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Part II by William Le Queux, M.Inst.R.E.
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6RJ, THE WELL-KNOWN AMATEUR TRANSMITTING STATION

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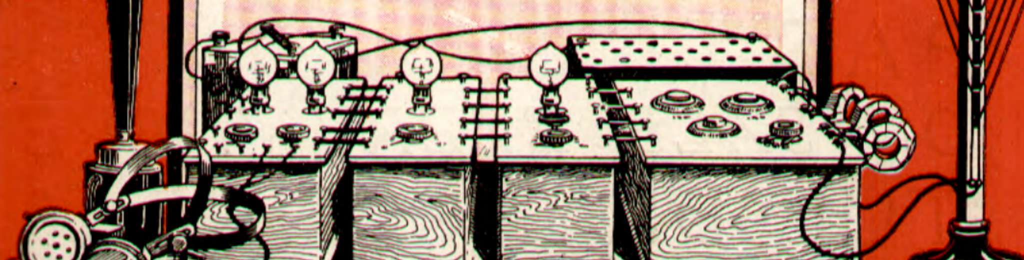

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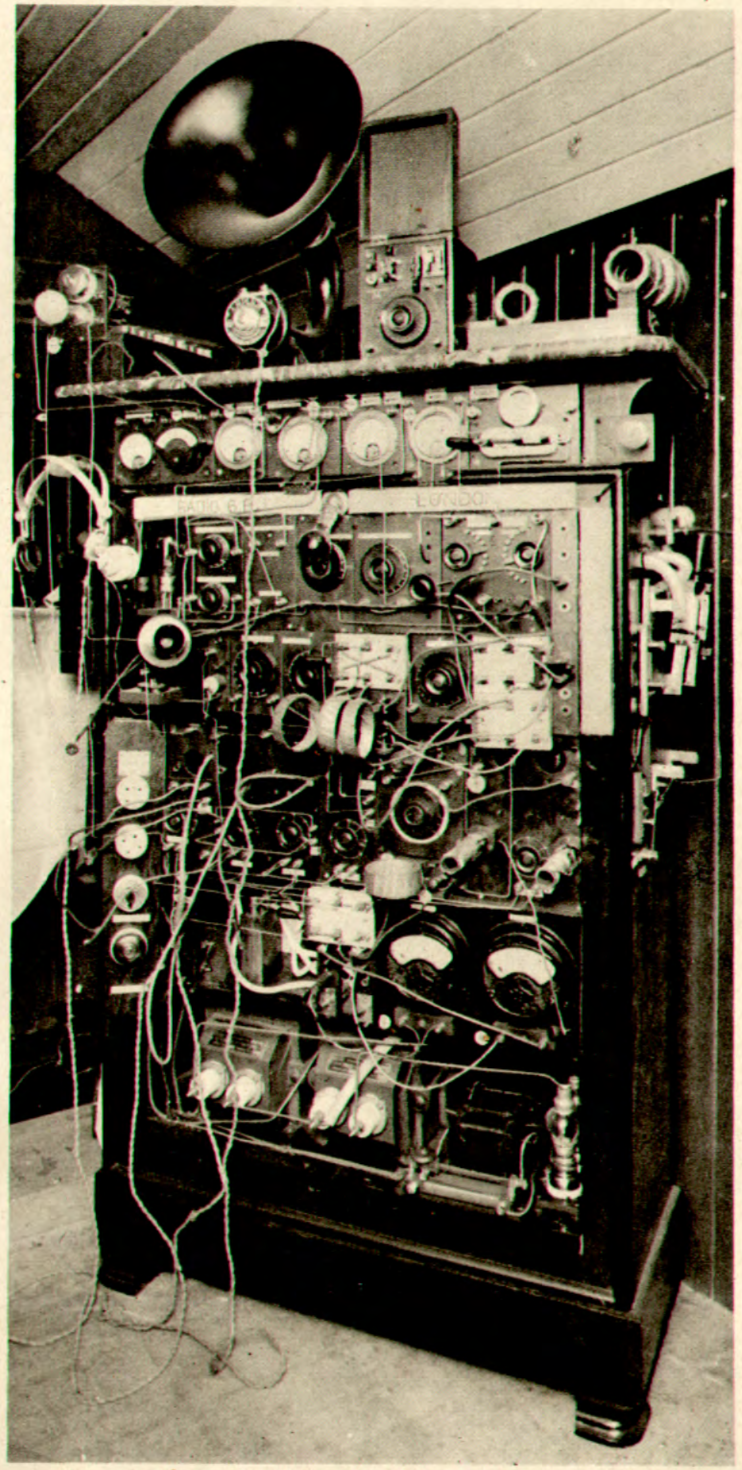


Fig. 7. General view of 6RJ amateur transmission station which is entirely enclosed within one single cabinet

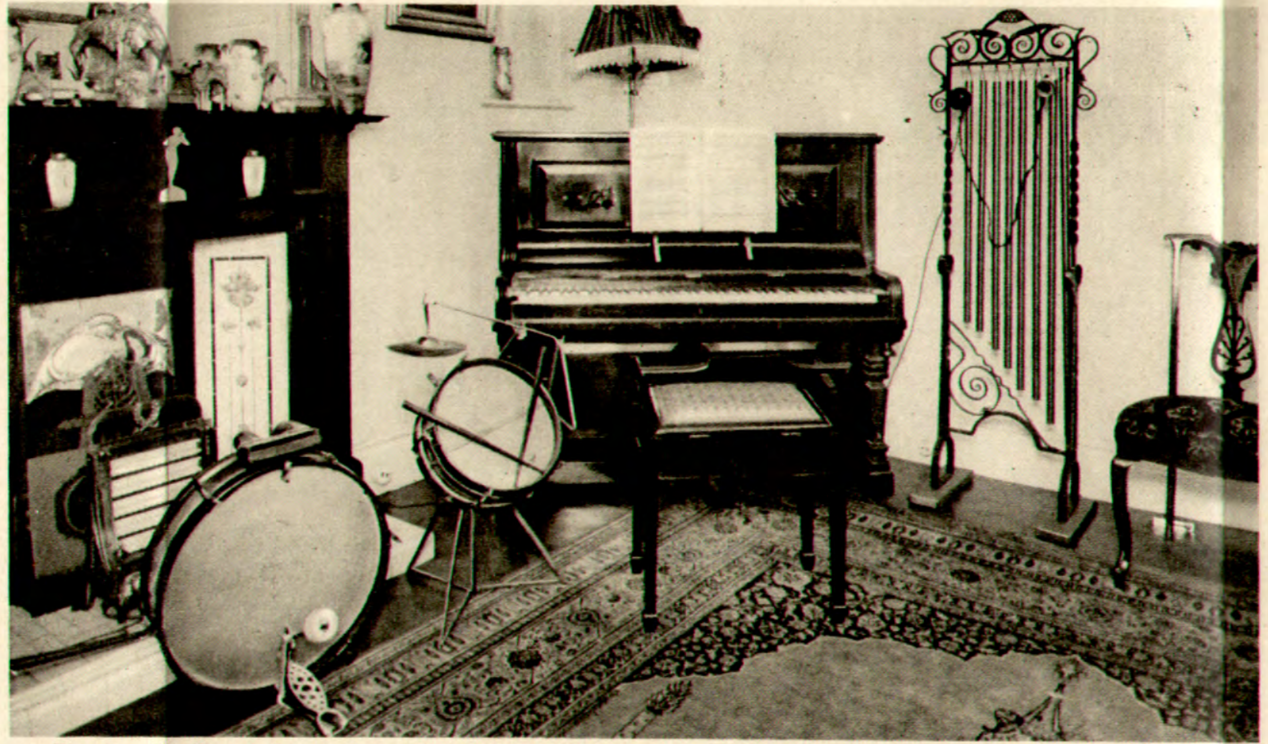


Fig. 8. Studio of the station. This is situated in a room adjoining the transmitting apparatus. The microphones are seen on the frame carrying tubular bells. A land line connects studio and transmitter

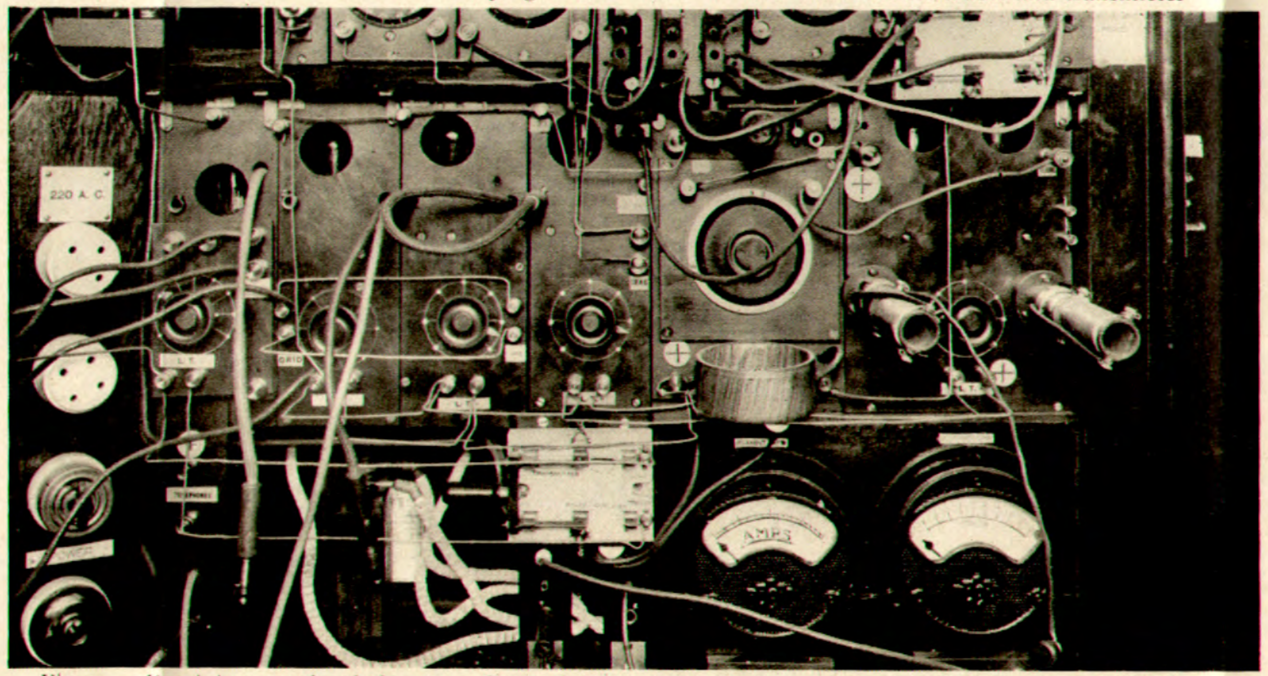


Fig. 9. Receiving panels of the set. From left to right these panels are transformer-coupled H.F. amplifier, rectifier, two L.F. amplifiers, and a power amplifier. The unit system has been used in construction

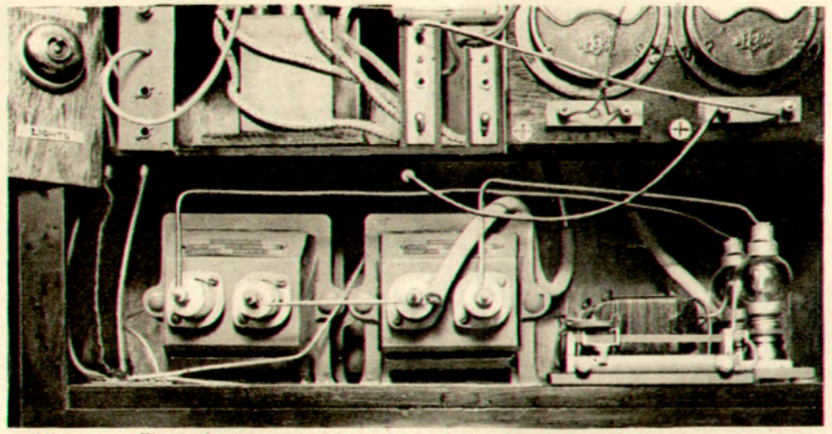


Fig. 10. Transformers employed at 6RJ. Each is of ½ k.w. capacity and designed, in this case, for 220 volts input and 1,500 volts output

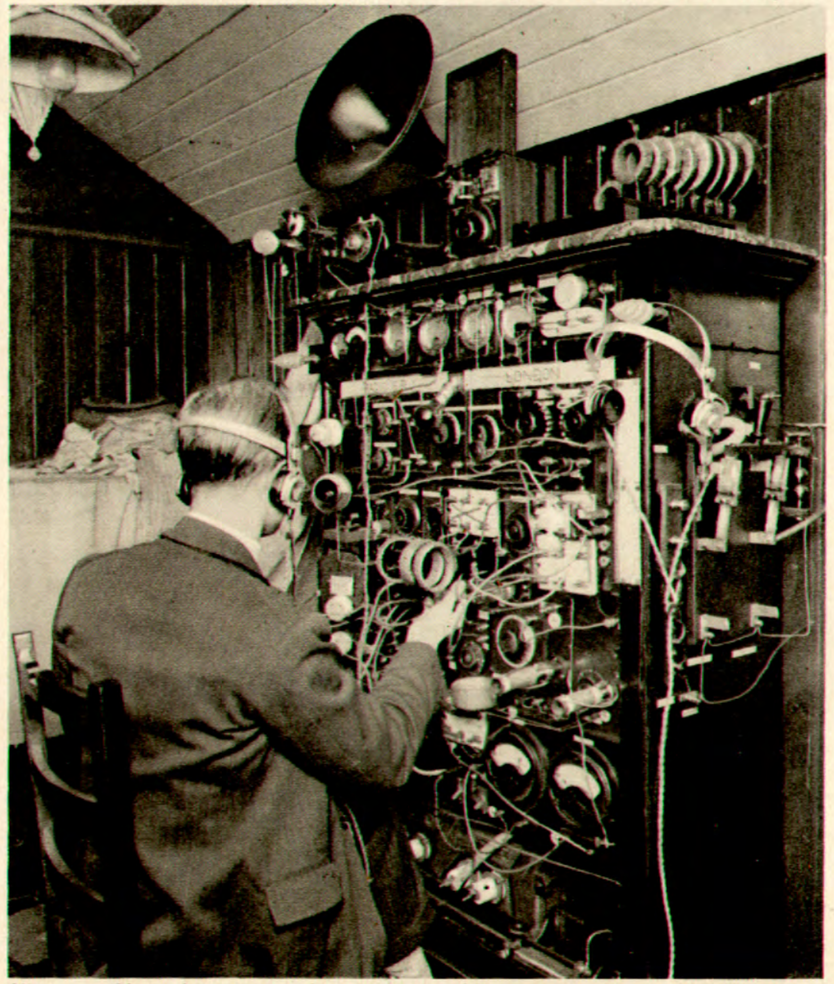


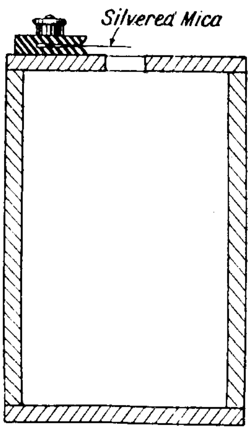
Fig. 11. Here the operator is seen engaged in transmitting. The microphone is level with the mouth, and all controls are within easy reach

TRANSMISSION FOR AMATEURS: A SERIES OF INTERESTING VIEWS TAKEN AT 6RJ, THE WELL-KNOWN AMATEUR TRANSMISSION STATION IN LONDON

To face page 2076

The only method which seems to offer reasonable hope of synchronous television is that of A. A. Campbell Swinton, who, in 1908, proposed the use of a beam of cathode rays (*q.v.*) for the purpose of reproducing the picture at the receiving station. Such a cathode beam had been used in 1906 by Braun for the study of oscillating currents. It was worked by the magnetic deflection of cathode rays, originally discovered by Crookes, the magnet being energized by the current under investigation.

Campbell Swinton proposes to throw the cathode beam upon a screen consisting of small blocks of rubidium, which are known to discharge negative electricity readily under the action of light. On the other side of the screen (J, Fig. 1) is a receptacle, K, filled with sodium vapour and containing another screen of wire gauze, L, through which the image to be transmitted is thrown by the lens, M, on to the rubidium screen, J.



TELEVISION RESONATOR

Fig. 2. One of the composite resonators employed in the Fournier d'Albe system

A narrow beam of light falling upon one of the rubidium blocks will then discharge electrons from the rubidium on to the wire gauze as soon as the electrons are supplied by the cathode beam. The electrons will charge up the gauze, and the charge is conveyed to the wireless transmitting apparatus shown.

The receiving apparatus thereupon sends a cathode beam (or stream of electrons) from its filament through the magnetic field on a definite patch of fluorescent screen, H, producing a luminous patch which reproduces the original ray of the transmitting station.

It then merely remains to make a cathode beam search out every part of the screen J at the transmitting end. This is done by two electro-magnets, D and E, at right angles to each other, actuated by two coupled alternators, G_1 and F_1, having frequencies of 10 and 1000 per second respectively. The cathode beam thus sweeps out the screen J in a rapid zigzag in one-tenth of a second. Simultaneously two similar alternators, G_2 and F_2, at the receiving station deflect any cathode beam from the filament on to the proper position on the screen H.

The two sets of alternators are kept in synchronism by a special wireless control. The general effect is that the original image is drawn on the receiving screen ten times a second, so that any change or movement should be evident to the eye.

The feasibility of the scheme hinges on the question whether a beam of light, falling upon a negatively charged rubidium surface for $\frac{1}{100,000}$ of a second, can liberate sufficient energy to give a perceptible impulse to a wireless transmitting set. This question has not yet been experimentally tested.

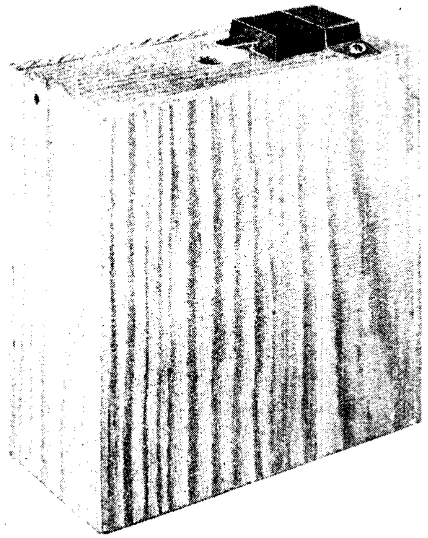
Among other receiving devices proposed are the string galvanometer, the string electrometer, the "Faraday effect" of an electro-magnet on a beam of light in certain media (Jenkins), and a minute mirror oscillating in synchronism with another at the transmitting station (Mihaly).

The formidable difficulties inherent in the maintenance of synchronism between motors at the two stations led the writer to devise a system which does not require synchronism. It depends upon the use of different musical frequencies for the different patches of the image or view to be transmitted.

The experimental facts relied upon in this method are the following:

1. Intermittent light falling upon selenium with any frequency from 20 to 20,000 per second produces fluctuations in the conductivity of selenium capable of instantaneously producing audible musical notes in a telephone receiver in circuit with the selenium.
2. Such audible musical notes may be used to actuate resonators attuned to them in such a manner that each resonator produces a patch of light when (and only when) its own note is sounded, with or without the other notes.
3. By a suitable construction of the resonators, selectivity can be made very narrow, so that about 30 different resonators can be brought into the compass of a single octave.

Since the scale of musical notes contains some 10 octaves, it is possible to employ some 300 different resonators.



RESONATOR FOR UNSYNCHRONIZED TELEVISION

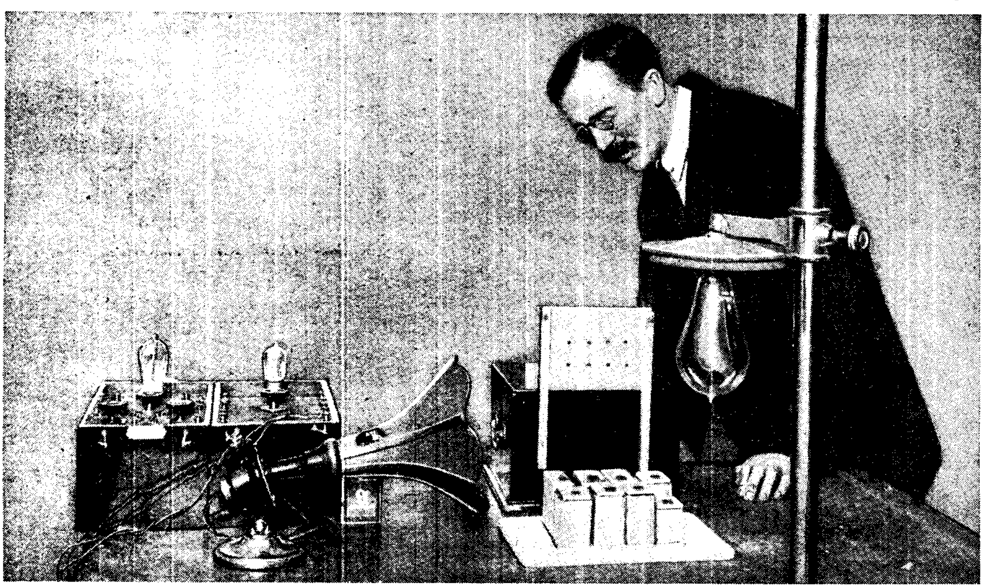
Fig. 3. This box resounds to the same note as the mica reed mounted on it. The mica is silvered to make its vibration visible by means of a light beam reflected from it

The breaking up of the original image into patches of different musical frequencies is accomplished by two endless bands of perforated paper or other material passing across the focal plane of the picture at right angles and in close proximity to each other. One of the bands has rows of perforations of 50, 52, 54, etc., holes, up to 100, or multiples of those numbers, while the other band has rows of perforations in the proportions 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024. The combined effect of the two bands geared together and moving with suitable speed is to break up the image into several hundred different frequencies.

The whole of the intermittent light is concentrated on to one selenium cell, which may either produce the sounds in a loud speaker or actuate a wireless transmitter directly.

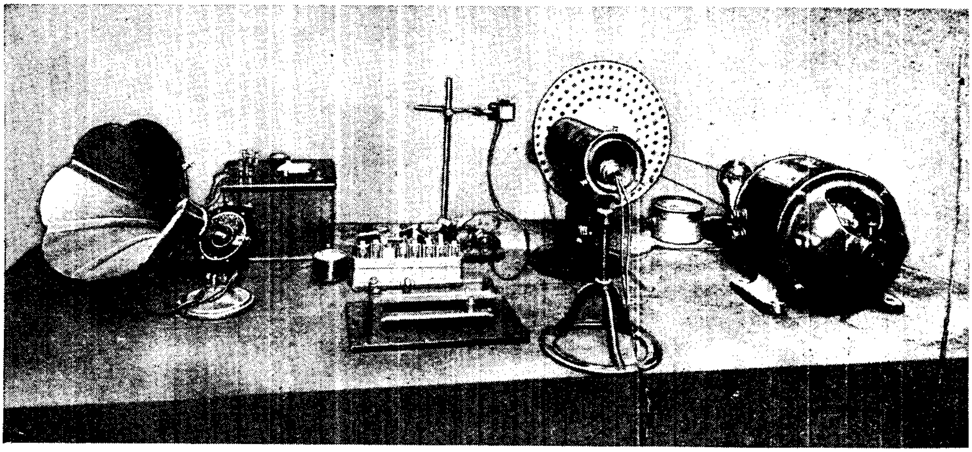
At the receiving station the sound is reproduced by a loud speaker and analysed by the resonators, each of which produces a luminous patch on a screen in the proper position as determined by its note.

The resonators used are of a composite type (Fig. 2). Each consists of a box having an aperture at one end, near which a "reed" of silvered mica is fixed. The volume of the box and the size of the hole are chosen so as to resound to a definite note. The length and thickness of the reed are so adjusted that the reed resounds to the same note as the box. When the note sounds, the reed vibrates, and a pencil of light reflected from its silvered surface is drawn out sideways.



DR. FOURNIER D'ALBE AND HIS TELEVISION RECEIVER

Fig. 4. The amplified sound transmitted acts on a group of acoustic resonators, each of which produces a patch of reflected light on a ground-glass screen when its note is produced by the transmitter. The original image is thus built up



EXPERIMENTAL TRANSMITTING APPARATUS

Fig. 5. Here the revolving screen disk is seen between a lamp and a selenium cell (in clamp). The sound due to the intermittent illumination of the selenium is amplified in the loud speaker; and an object passing between the disk and the cell cuts off one or more notes, thus modifying the sound transmitted by telephony

This displacement is utilized to produce a luminous patch in the proper place on the screen.

The resulting picture will consist of only 300 patches, and will therefore be very coarse-grained. But as it employs only one radio wave-length in transmission, more sets of 300 patches each may be transmitted on other wave-lengths to make up the number finally required.

The method has the advantage of being immediately applicable to ordinary wireless transmitting and receiving sets.

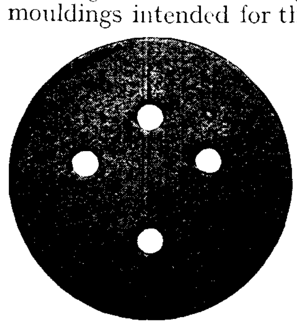
TELLURIUM. One of the metallic elements. Its chemical symbol is Te, and atomic weight 127·5. Tellurium is chiefly found in combination with other metals in the minerals sylvanite, black tellurium and tetradymite. The pure metal is brittle and silvery white. Sylvanite, a combination of gold and silver, is used as a crystal rectifier. Black or leaf tellurium, or nagyagite, a combination of tellurium, antimony, sulphur, gold and lead, is also used as a crystal rectifier. Tellurium-zincite makes a very good crystal rectifier combination. It requires a dry battery and potentiometer for its working. The applied voltage must exceed a third of a volt or no current will flow at all through the combination.

TEMPLATE. Device for automatically locating the shape or dimensions of a piece of work, or for facilitating the accuracy of an operation in the construction of a piece of apparatus.

As applied to wireless work, a template of the type illustrated in Fig. 1 is perhaps the most generally useful. This is intended to aid in the accurate drilling of the four holes for the valve sockets when constructing a wireless set.

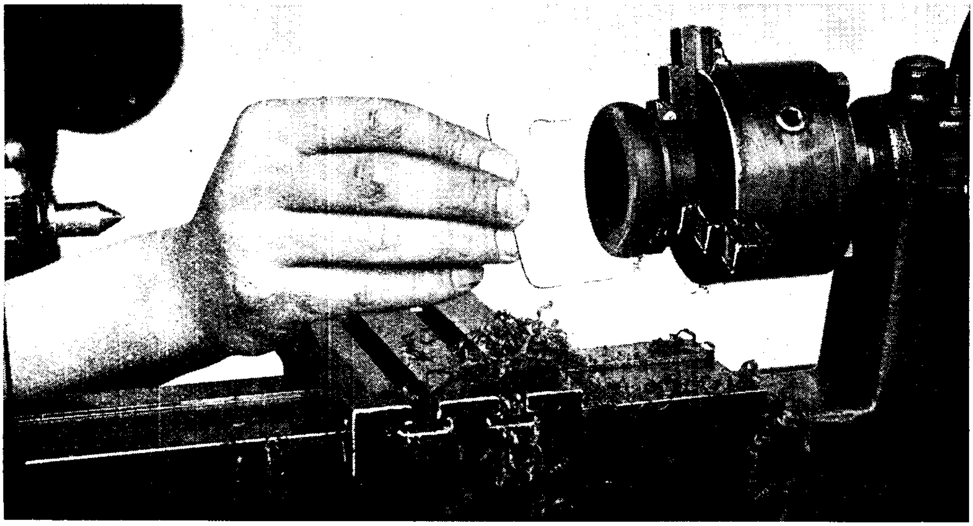
The template consists of a piece of steel, circular in form, and having four holes accurately drilled in it. Their size and spacing correspond with the locations for the standard valve sockets, and to use the template all that has to be done is to place it on the panel at the desired spot, hold it firmly, and drill through the holes.

Another tool known as a template is shown in Fig. 3, and is used in the marking of mitred work. It is useful when marking out and cutting the corners of mouldings intended for the embellishment of a wireless cabinet. The tool is rested with the wood in the angle of the appliance, and the angles marked on the work with a sharp pencil or scriber. After the wood has been sawn to shape and planed up the template is



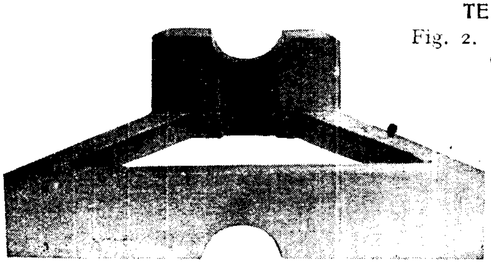
DRILLING TEMPLATE

Fig. 1. Accuracy in the drilling of holes for valve sockets is ensured by the use of this appliance



TEMPLATE EMPLOYED IN LATHE TURNING

Fig. 2. In circular work such as in turning an earpiece cap, a template of this pattern is employed

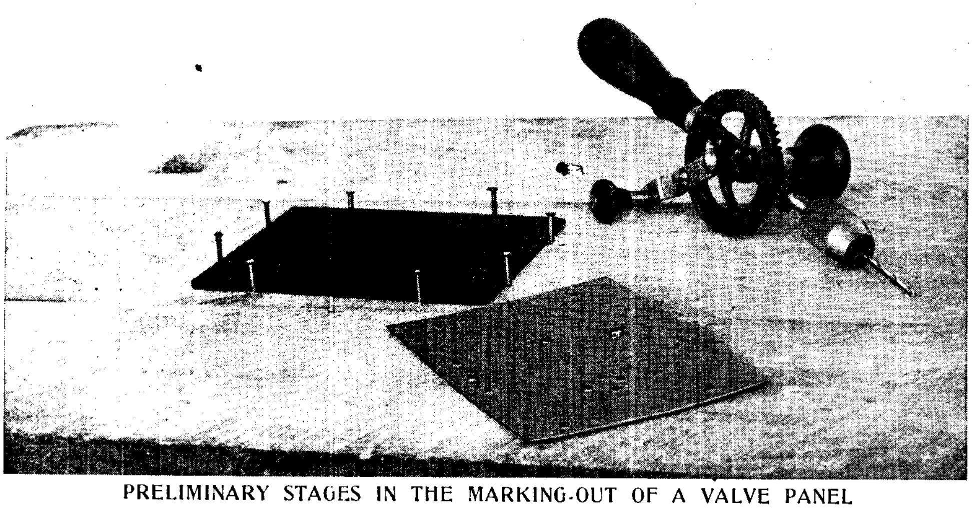


MITRE TEMPLATE

Fig. 3. This appliance is used to mark out and test the angles of mouldings of cabinets and such similar mitred work

used as a test to see that the angles are true, and, if necessary, any alterations are then made until the wood and the angles on the template are in agreement.

Templates can be quickly made by the amateur, and, for such purposes as the turning of an earcap or other piece of circular work, are a great saving of time and add to the correctness of the finished article. One such application is illustrated



PRELIMINARY STAGES IN THE MARKING-OUT OF A VALVE PANEL

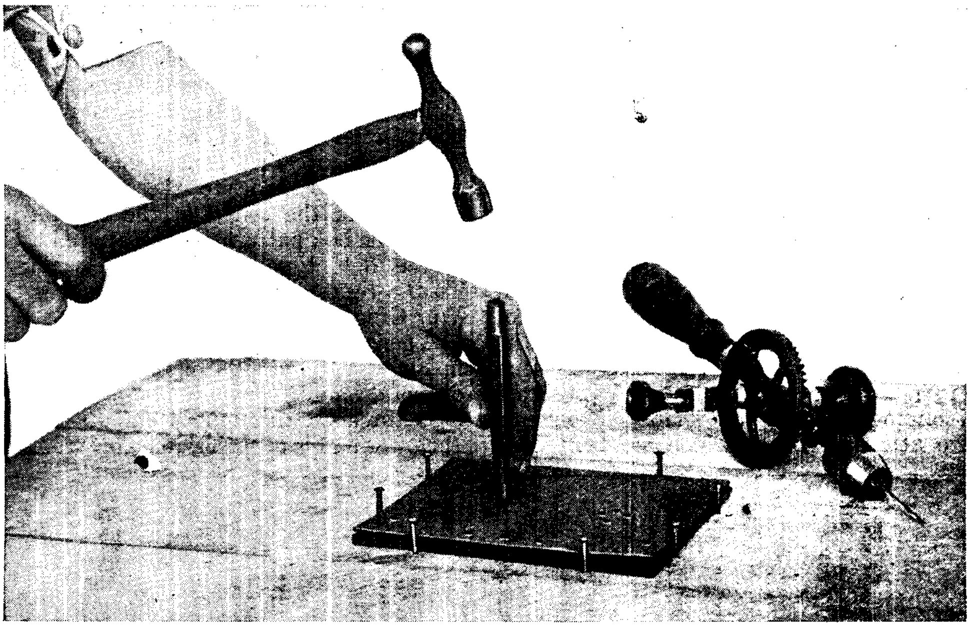
Fig. 4. In marking out the panel for a single-valve set the ebonite sheet is first held securely in position by means of surrounding nails as above. Holes are then drilled according to their disposition on the template seen in the foreground

in Fig. 2, where the template is made of sheet zinc cut to the reverse of the desired shape to be produced on the work.

One way in which a template can save the novice a great deal of time and trouble is in the shaping and drilling of a panel for a receiving set. In such a case it is desirable to cut a cardboard or three-ply wood template of the full size of the panel, and punch holes in it at the exact spots where holes are required on the actual panel. If desired the actual components could be assembled on the card or three-ply wood to make sure that all is correct. Whether this be done or not, the template is then used as a guide in drilling of the panel.

A way to set up the panel for this operation is shown in Fig. 4, where the panel is seen laid flat on the work bench and held in place by a few short nails driven into the bench near the sides of the panel. The cardboard template is seen at the front and the hand drill in readiness at the side.

The cardboard template is then placed on the top of the panel and is held in place there by the nails. The whereabouts of the holes are then transferred to the panel by means of a fine centre-punch, as shown in Fig. 5, taking care to keep the punch in the centre of the holes in the template. The drilling is then carried out, and if there be any tendency for the drill to cut to one side of the hole in the template the operation should be stopped and the reason ascertained, and corrections made as required by repunching the hole or, in a bad case, plugging it and commencing again. As a rule, however, the template will be found to give most satisfactory results in every way, and is well worth the time spent in preparing it.



HOW THE TEMPLATE IS USED FOR MARKING THE PANEL

Fig. 5. With the aid of the template which lies on the surface of the panel, the correct positions for all the holes is ascertained. Before drilling, these are indented or centre-popped by hammering with a punch

TERMINAL. Name given to a metallic conductor to which, or from which, electrical connexion may be made. Owing to the extremely varied applications of the terminal and the different classes of work to which it is put, terminals vary alike in size, shape and purpose. As a general rule, terminals are made from brass owing to its relatively slow oxidation and freedom from corrosion. These are both extremely good qualities for sound electrical connexion. In accumulators terminals are coated with vaseline to prevent corrosion by the acid, and for the same reason are frequently lead-plated. Terminals are often nickel-plated or lacquered to preserve their appearance and prevent corrosion.

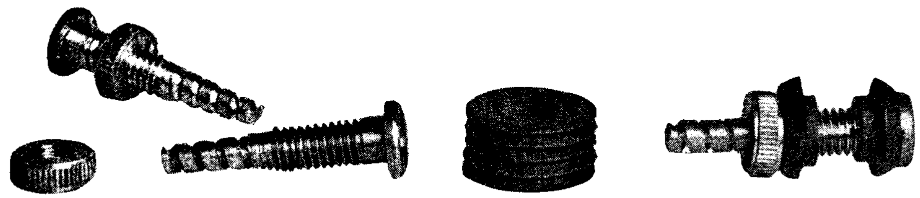


Fig. 1. Shown complete on the right and in parts on the left, this very useful appliance functions either as a plug or socket

USEFUL TERMINAL THAT SERVES A DUAL PURPOSE

A group of terminals largely used in wireless is illustrated in Fig. 2. In the top row a collection of six terminals is seen. The first on the left side is a spade terminal, and is connected to the end of a flexible lead for attachment to different parts of apparatus or for making a better connexion than that obtainable with the ends of stranded wire.

The next terminal is a valve socket, which is sometimes used in connexion with a split pin or plug, an example of which is seen to the extreme right in the top row. Two spade terminals are seen in the centre and consist of light brass stampings forming a U-shape. The stems are fitted with lugs which are bent over to embrace the connecting wire. The next terminal in the top row is a contact stud, which is largely used in switch construction.

The terminals in the bottom row are commercial types of terminals used in general electrical instrument making. The two terminals, one to the extreme left and one in the centre of the lower row, are of the box pattern, while between them is the hole type of telephone terminal. To the right of the centre terminal is the War Office terminal.

A general purposes terminal is illustrated in Fig. 1. It consists of a tapered piece of metal having a flange at one end and it is threaded throughout half its length. Its lower half is of spring-like construction.

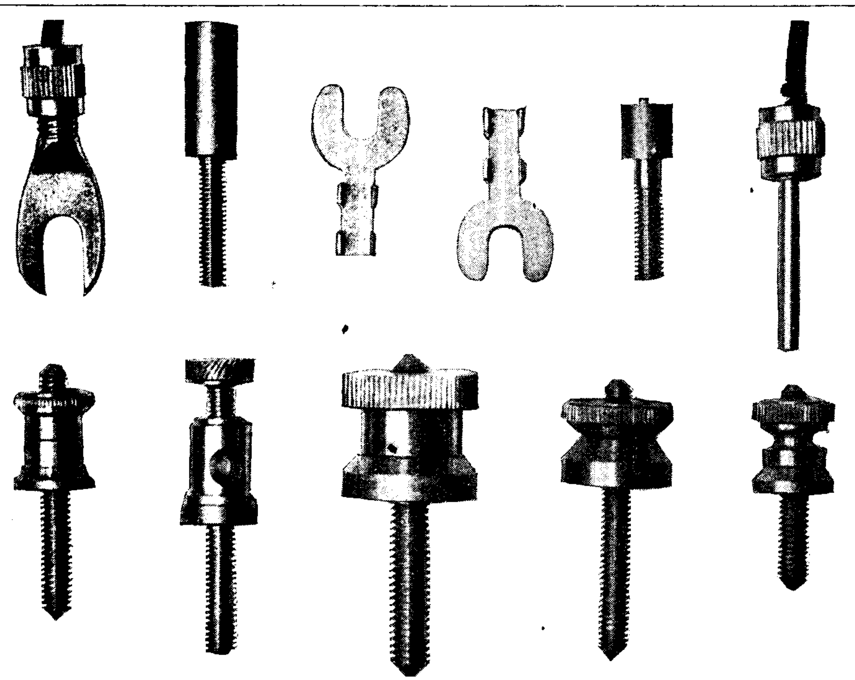
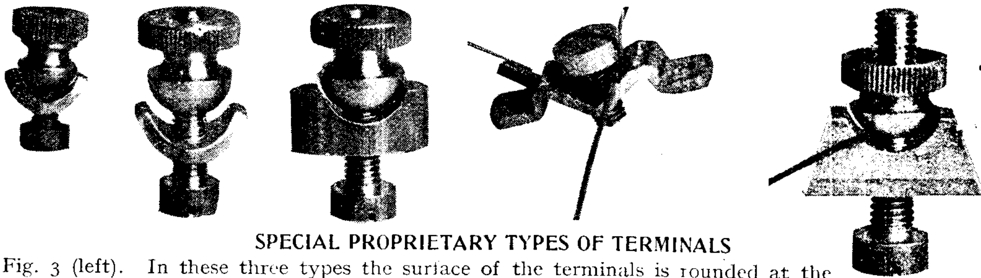


Fig. 2. A variety of different terminals used in wireless construction is shown here; included are spade, valve socket, split pin and general purpose types

Courtesy Wates Brothers, Ltd.

GROUP OF TERMINALS FREQUENTLY USED IN WIRELESS



SPECIAL PROPRIETARY TYPES OF TERMINALS

Fig. 3 (left). In these three types the surface of the terminals is rounded at the point of connexion with the wire. Fig. 4 (right). Two further examples of special terminals, V-shaped and rounded. The one on the left has a soldering tag attached to it

Courtesy Gent & Co., Ltd.

The centre of the terminal is hollow, so that the end of one terminal may be firmly inserted into the hole of the other. In this way the terminal forms a combined plug and socket.

The terminal seen to the right is fitted with two ebonite bushes by which the terminal can be used in a material of a non-insulating nature if required. This terminal also shows a slot cut parallel to its length by which a wire may be attached when the terminal is used as a wander plug. A round milled nut is provided on the terminal, which may be used for tightening the terminal to the panel or for attachment of a wire. The ebonite bush seen in the centre of the illustration forms an ebonite knob when the terminal is used as a wander plug.

Fig. 3 illustrates a patented type of terminal which is designed to enable connexions to be made with the least waste of time.

Instead of the usual flat washer type of gripping surfaces, in this instance they are spherical, the upper or moving portion being convex and the lower concave. The latter may be either a stamping out of sheet material, or it may be milled out of specially shaped extruded material as indicated in the right-hand terminal.

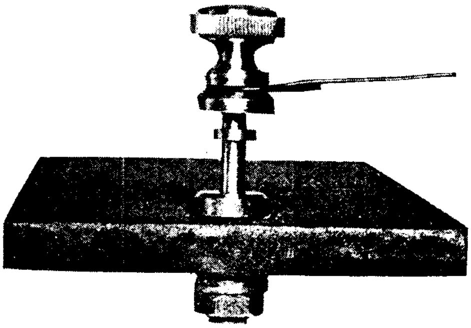
Reference to Fig. 4 will show the method of holding the wire between the two surfaces, from which it is clear that wherever the wire is placed between them, the screwing action of the nut will tend always to force the wire downwards, where the grip is most secure.

A special adaptation of this principle is illustrated in the left-hand side of Fig. 4, which is a cheap form of stamped terminal having a soldering tag attached to one of its feet.

A form of terminal incorporating a plug and socket is illustrated in Fig. 5. The socket has a flanged edge and is attached to a panel by means of a nut screwed to a threaded shank. The plug head is fitted with a terminal nut for facility in connecting a wire.

The method of attaching telephone type terminals to an ebonite panel is shown in Fig. 6, and consists of first drilling a hole through the panel. This hole is preferably tapped and the screwed shank of the terminal screwed through it, and then the whole made secure by placing a washer over the shank and screwing a lock nut tightly against it. Instead of using pliers for this work it is better to employ some such instrument as the nut grips shown in Fig. 6, as these avoid damage to the flats on the nut, and also are strong enough to enable the nut to be properly tightened.

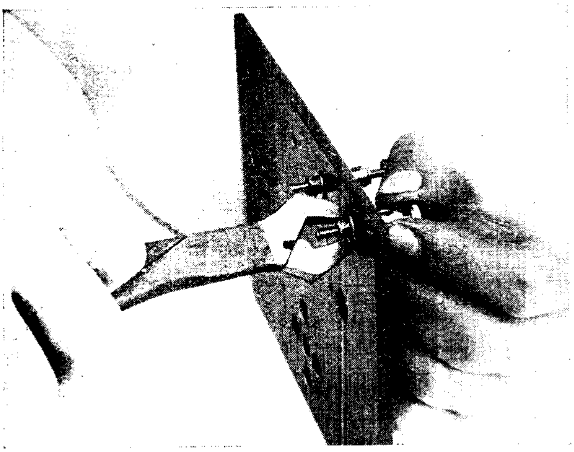
As telephone terminals have a set-screw for securing the connecting wires, it is most important that they be well fixed to the panel, as if they move it will be necessary to take the panel from the case and refix the terminal. Connexions are made to the shank by another nut and washer or by soldering. When nuts are used the



USEFUL PLUG-IN TERMINAL

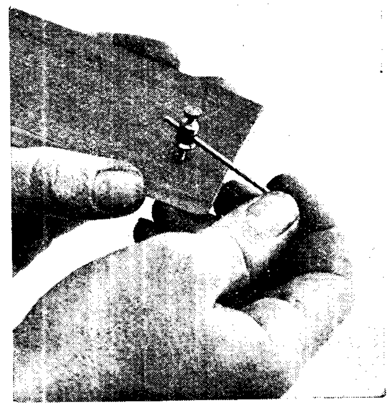
Fig. 5. For attachment of a connecting wire a milled nut is used in this very convenient form of plug-in terminal,

Courtesy Wates Brothers



FIXING TERMINAL TO PANEL

Fig. 6. A lock nut and a securing washer are used in fixing a telephone type of terminal to the panel. Note how the terminal is held in position by using the fingers of the left hand. Special pliers are employed



FOR USE IN A WOODEN BASE

Fig. 7. In this example an ordinary wood screw is fitted in the shank to enable the terminal to be fitted on a wooden base

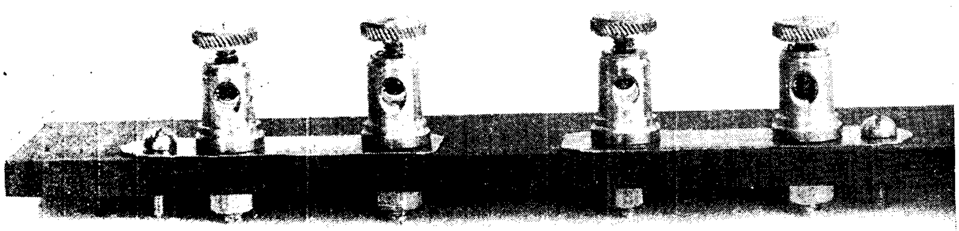
wire is best fitted with a spade terminal or a tag (*q.v.*).

Another pattern of telephone terminal is made with a wood screw shank as shown in Fig. 7, and to fix this the plan illustrated in Fig. 7 is as good as any. First a small hole is made in the wood with a gimlet or the point of a drill and the terminal started in it by turning it by hand. After the terminal has been started it is tightened, as shown in Fig. 7, by a tommy bar of brass wire, which is used as a lever to turn the terminal.

It is necessary to screw in these patterns tightly to prevent their accidentally slackening. They can be removed in the same way, but often leave the screwed part of the shank in the hole. This can usually be removed by gripping with a pair of nippers or a pair of pliers, and the screw removed by turning it in an anticlockwise direction.

Telephone terminals can be employed as a means of making connexion between two pieces of apparatus which have to be put into the same circuit. One way of doing this is shown in Fig. 8, where two telephone terminals are mounted on a strip of copper. This acts as a connector between them. Thus the two terminals are on the same circuit and two telephones can be connected to them. A similar pair is provided next to them to take the other ends of the telephone leads.

There are right and wrong ways of attaching a connecting wire to a screw terminal. The correct way is shown in Fig. 10, where it will be seen that the wire is bent to an eye shape with the end of the eye turned in the same way as the nut will be turned. The tendency then will be for the nut to draw the end of the eye into the space between the nut and the terminal base, and thus make a sound joint.

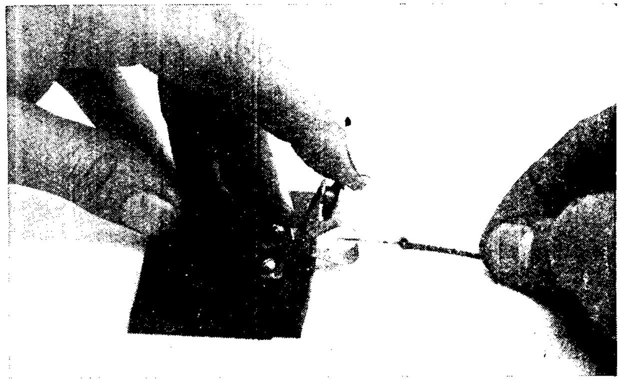


USING TELEPHONE TERMINALS FOR APPARATUS CONNEXIONS

Fig. 8. Here is shown an ebonite panel with four terminals mounted thereon to make easy connexions between two pieces of apparatus. The terminals are connected as shown by means of copper strips between the pillar and the ebonite panel

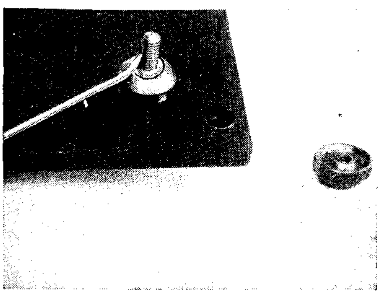
The rule is to have the end of the wire pointing in the direction of rotation of the hands of a clock.

Sometimes a sufficiency of terminals is not available, and then a substitute must be found. One effective plan is to use ordinary cheese-headed screws, as shown in Fig. 11, by screwing them into the tapped holes of the panel. A washer is placed on the face of the panel, and a second beneath the head of the screw. The wire is connected between the washers and the screw tightened.



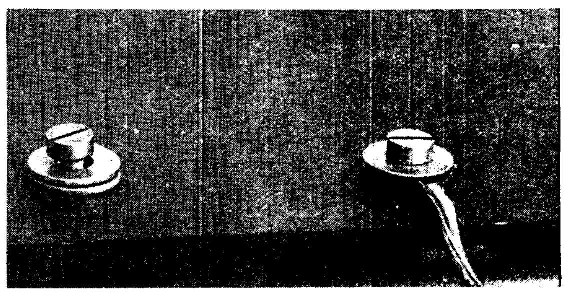
SIMPLE QUICK GRIP TERMINAL

Fig. 9. Quick and easy connexions are effected by clamping a trouser clip to a baseboard by means of small screws



CONNEXION TO TERMINAL

Fig. 10. Wire connexions should be made as shown here. The eye of the wire is turned in the same direction as the rotation of the milled nut



TERMINAL SUBSTITUTES

Fig. 11. Telephone terminal substitutes are easily made by means of an ordinary cheese-headed screw with two washers, in the manner illustrated here. Holes for the screws are tapped in the ebonite

One advantage of this plan is that the holes are in the desired places, and the screws are readily replaced with terminals whenever desired, and without spoiling the appearance of the panel. Another plan to make a quick grip terminal is shown in Fig. 9, where a trouser clip is attached to the baseboard by a small screw. The wire is gripped as shown in Fig. 9.

Connexions are made to the set through an insulated wire attached to the screw holding the clip to the base. *See* Wiring.

TESLA, NIKOLA. American electrical expert. Nikola Tesla was born at Smiljan, in Yugo-Slavia, 1857, and was educated at Graz and Prague Universities, studying electricity. He entered the Austrian telegraphs department, and in 1884 he went to America, where he became naturalized and an assistant to Edison. He made a special study of alternating currents of high frequency and high potential, and invented a large number of

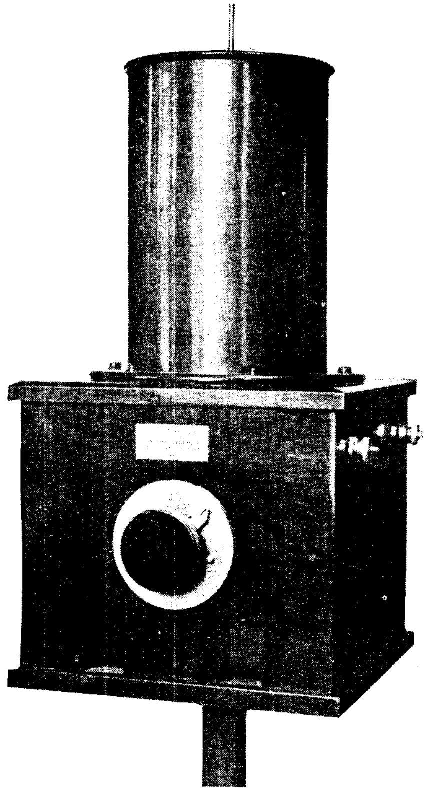
NIKOLA TESLA

Educated in Europe, Tesla proceeded to America, where he became assistant to Edison, the famous inventor. Many electrical inventions were evolved by him, and his name is well known in scientific circles all over the world electrical appliances and made many improvements on existing ones. The Tesla transformer is well known, and is separately described below.

TESLA TRANSFORMER. An oscillation transformer due to Nikola Tesla.

The Tesla transformer consists essentially of a primary with a few turns of thick copper wire, and a secondary with a large number of turns of fine wire. The primary and secondary are separated by an air space, a glass dielectric, or an ebonite dielectric. The thickness of the dielectric is great enough to ensure that no direct discharge between the primary and secondary windings is possible. For that reason the transformer is often enclosed in a glass case filled with pure paraffin oil to increase the insulation. Only one layer is used for both the primary and the secondary windings.

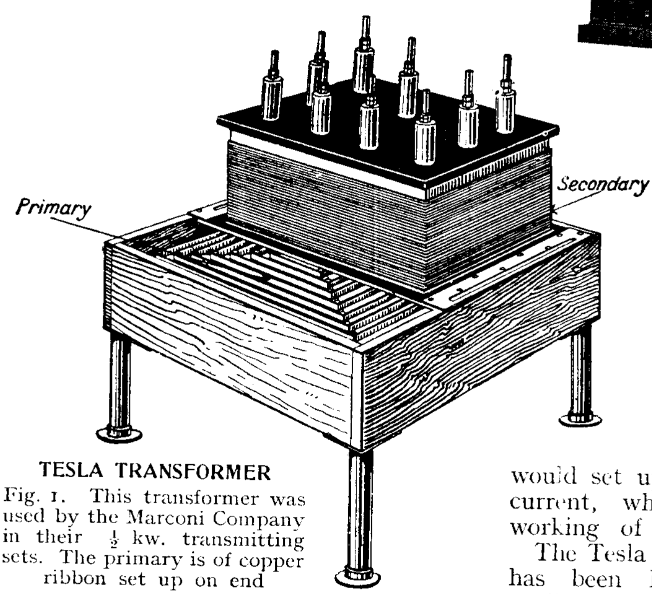
The primary winding of a Tesla transformer forms part of an ordinary oscillating discharge circuit. The H.F. oscillating currents which flow in the primary set up through it an oscillating magnetic field, which induces a high-frequency E.M.F. in the secondary winding in the usual way. Since there is a large number of turns in the secondary winding as compared with that in the primary, the induced E.M.F. in the secondary has a very high voltage, and may in some forms of the Tesla transformer be as high as a million volts. A very powerful brush discharge can be obtained as a result. If there had been more than one layer for the secondary winding, the inductive effects upon the inner windings would set up a high impedance to the current, which is detrimental to the working of the transformer.



TESLA OSCILLATION TRANSFORMER

Fig. 2. Very powerful brush discharges are obtained by using this instrument, the voltage rising as high as a million in some types

Courtesy Watson & Sons, Ltd.



TESLA TRANSFORMER

Fig. 1. This transformer was used by the Marconi Company in their ½ kw. transmitting sets. The primary is of copper ribbon set up on end

The Tesla type of coupling transformer has been largely developed by Marconi's Wireless Telegraph Company and by the Telefunken Co. The Marconi Tesla type of coupling transformer is generally known as a jigger. The transformer used for the half-kilowatt transmitting set has a primary of copper ribbon wound on edge as a square-shaped spiral. It is mounted on an ebonite support. The secondary is wound outside the primary, and between them is a sheet of ebonite. The secondary consists of insulated copper stranded cable wound round a square wooden box, which has an ebonite panel in which are tappings to the secondary. Fig. 1 shows this type of transformer.

One end of the secondary is connected to the aerial by plugging into one of the brass sockets on the ebonite panel. A tapping is taken from any other socket, according to the number of turns in the secondary which may be required to the earth. Spring clips are used to connect up the primary winding, and the position of these clips being variable the inductance effect may be varied.

The degree of coupling is altered in a simple way. The box round which the secondary turns are made slides on the frame of the primary windings.

Fig. 2 shows a Tesla transformer of the enclosed type mounted on a pillar, part of which can be seen. A control knob is fitted to the front of the lower cabinet. This knob has a pointer attached to it which moves over an ivorine scale. Input terminals are shown fitted to the right-hand side of the wooden cabinet, while at the top of the upper metal cylinder is a discharge rod. *See* Jigger; Transformer.

TEST BUZZER. A buzzer used in a circuit for the purpose of finding faults in a piece of wireless apparatus. The application of the test buzzer is useful where it is required to test out a condenser or other component when it is suspected of insulation leakage or lack of continuity.

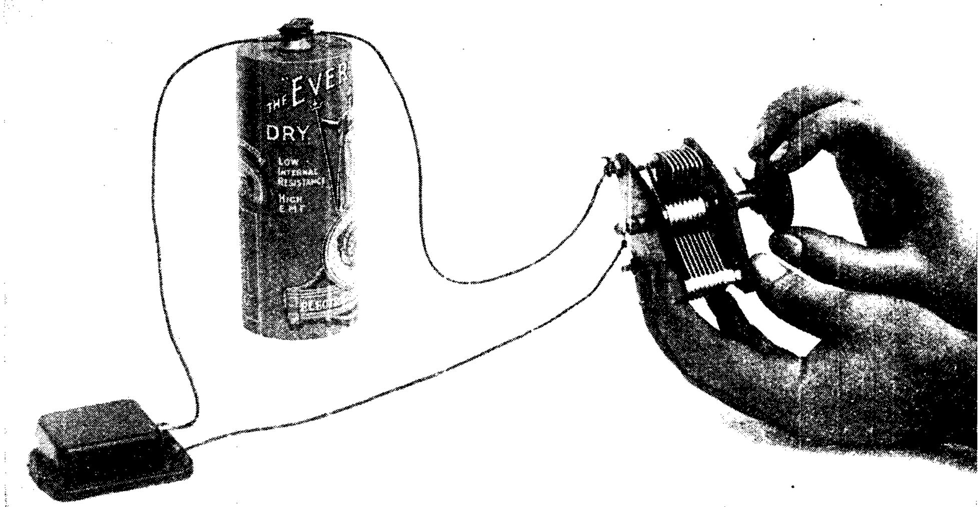
A circuit incorporating a test buzzer may be made by joining one terminal of the buzzer to a suitable battery, while the remaining terminals on both buzzer and battery have flexible leads attached to them. If the ends of these leads are connected together, the circuit is completed, and the buzzer responds to the current. If the ends of the leads are connected to a variable condenser, as shown in Fig. 1, no sound should be heard from the buzzer if the insulation of the condenser is in order. If the condenser is faulty and the plates touch, the test buzzer will operate.

The test buzzer may similarly be applied for testing the continuity of a tapped or sliding inductance. In such cases the buzzer will be expected to operate until its circuit includes a part of the inductance containing the broken connexion.

Test buzzers used for purposes such as mentioned above should respond to a small current, and to this end a small type is suitable.

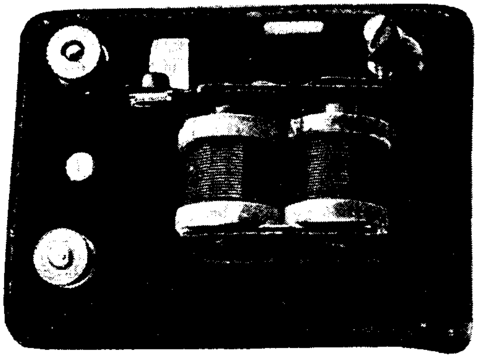
A convenient test buzzer is illustrated in Fig. 2. The buzzer is constructed from light stampings or pressings of sheet metal, and has an extremely light armature.

It must be remembered that the test buzzer is not suitable for testing circuits having a high resistance, as owing to their



TEST BUZZER IN USE WITH A VARIABLE AIR CONDENSER

Fig. 1. Notice the circuit arrangement of this test. No sound should be heard if the insulation between the two sets of plates is sound and no contact occurs due to a bent plate



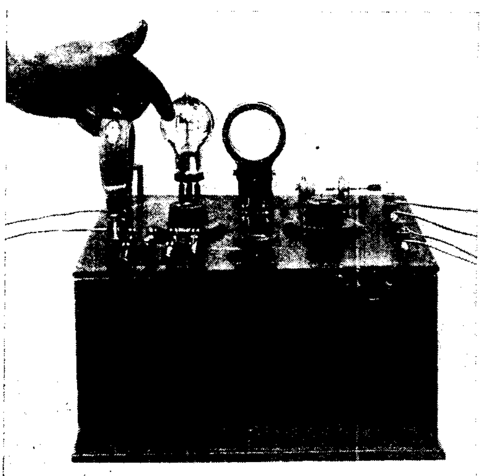
TEST BUZZER FOR LOW RESISTANCE

Fig. 2. For testing low-resistance wireless components this form of test buzzer will be found very useful

Courtesy Peto-Scott Co., Ltd.

high resistance sufficient current is not passed to operate the buzzer. *See* Buzzer: Fault Finding; Testing.

TESTING. The testing of wireless circuits is dealt with extensively under the heading Fault Finding, for the subjects of fault finding and testing are necessarily closely connected. In wireless receivers there is one test which may be universally applied and which will tell immediately whether the apparatus is functioning. When everything is ready, a sharp, light tap with the back of the finger should be given to the valves, as in Fig. 1. This should result in a ringing noise in the telephones similar in quality to the note given by a tuning fork. It is known technically as

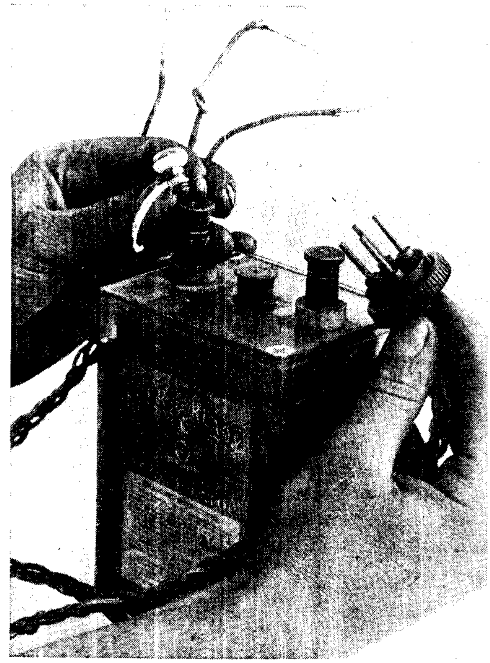


TESTING FOR VALVE EFFICIENCY

Fig. 1. Valves may be tested to ascertain whether they are functioning correctly by tapping sharply. A ringing microphonic sound should be heard in the telephones

a microphonic noise. If this is entirely absent the operator may be certain that something is wrong with his set, and should apply the methods of testing outlined in the article on Faults.

It is occasionally necessary to test a piece of twisted flexible wire to ascertain whether the ends are of the correct polarity, particularly when such wire is used for battery connexions, as, for instance, in conjunction with a four-pin plug. This test may be effected very simply in

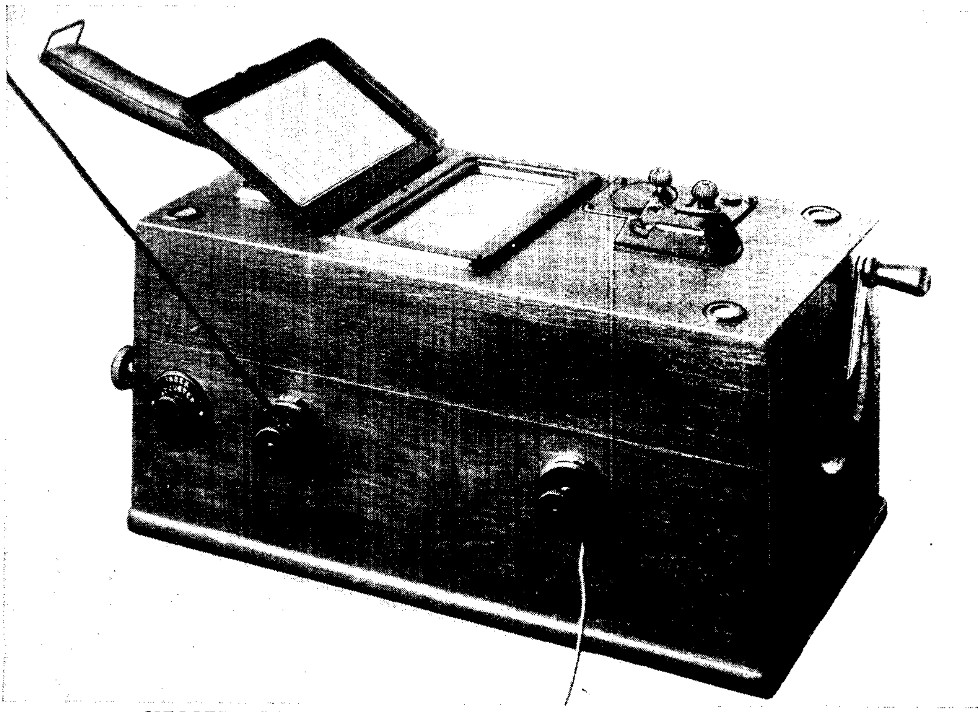


HOW WIRE POLARITY IS TESTED

Fig. 2. An illustration of the manner employed in testing twisted flex to find whether the ends are of the correct polarity

the manner indicated in Fig. 2. From this it will be noticed that the end of one wire is connected to a battery, while one of the other ends is connected to one pole of a lamp. If the lamp lights when its free pole is touched by the free battery terminal, the wire used is continuous, and if both ends are knotted a permanent record will result. Should the lamp not light, it shows that the wrong piece of wire is used, and the test must be repeated until the correct wire is found.

The megger (*q.v.*) will be found a useful instrument to carry out tests on the efficiency of insulation in aerial systems. An aerial theoretically should possess an infinite resistance to earth, but the

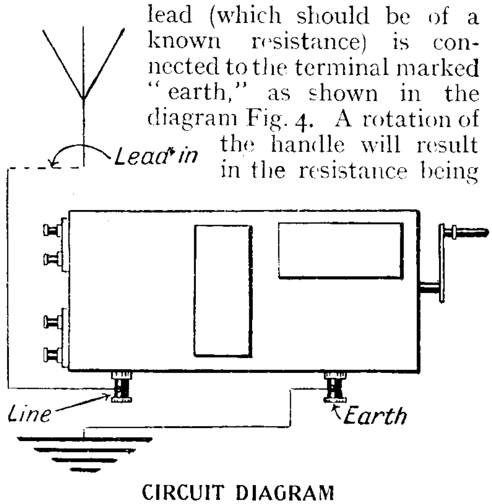


MEGGER USED FOR TESTING RESISTANCE OF AERIAL TO EARTH

Fig. 3. How a megger is used to test the efficiency of the insulation of an aerial. The left-hand wire is joined to the aerial and the one on the right leads to the earth

Courtesy Evershed & Vignoles

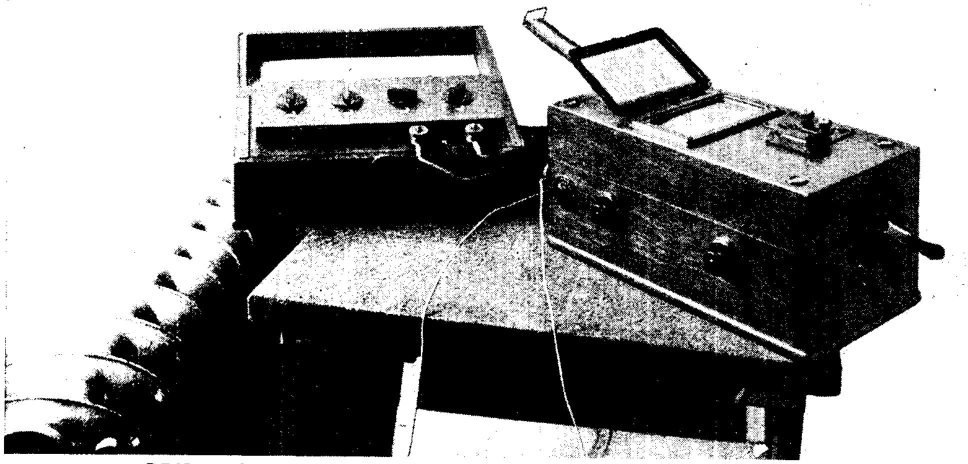
majority fall far short of this, particularly in wet weather. Fig. 3 clearly shows how the megger is applied to this form of test. The aerial lead-in wire is connected to the terminal marked "line," while the earth lead (which should be of a known resistance) is connected to the terminal marked "earth," as shown in the diagram Fig. 4. A rotation of the handle will result in the resistance being indicated by the pointer moving over the dial. It should be the aim of the operator to keep this resistance at the very highest possible value, particularly in the case of transmitters.



CIRCUIT DIAGRAM

Fig. 4. Diagrammatic representation of the connexions to the megger for testing aerial insulation as shown in Fig. 3

Another interesting test may be carried out with the bridge forms of meggers, used for measuring low resistances. This test is for ascertaining the resistance to earth of the earth connexion of the set. In this instance it is, of course, necessary to reduce this resistance to a value of a very low order. This test could be carried out with beneficial results at regular periods throughout the year for the purpose of collecting data on the effect of moisture on the earth connexion. By using different earth connexions and testing each on the same days and under the same atmospheric conditions, it would be possible finally to ascertain the best form of earth obtainable under individual circumstances. Fig. 5 shows the ohmmeter connected with a suitable resistance box. In the test illustrated two earths were used, one of known resistance, and the unknown one (in this case a hot-water



BRIDGE MEGGER FOR FINDING RESISTANCE OF EARTH LEADS

Fig. 5. The resistance of leads to the earth should always be as low as is possible, and to test for this, this special low-resistance test is applied

Courtesy Evershed & Vignoles

radiator) was compared with the one of known value. Connexions for this test are given in the diagram Fig. 6.

Resistances of the order of 1 megohm and upwards may be tested with great accuracy by means of a galvanometer deflection. The galvanometer used must be a very sensitive mirror instrument, preferably having a resistance of 5,000 to 10,000 ohms. The method of connecting it with the unknown resistance is illustrated in Fig. 7, from which it is clear that the whole circuit is a series arrangement consisting of the galvanometer, a battery of from 100 to 200 volts, a key and the unknown resistance. It is essential that the complete circuit be well insulated from earth.

On the depression of the key a deflection of the galvanometer will result, and from this deflection the resistance of R may be calculated. The formula which is necessary

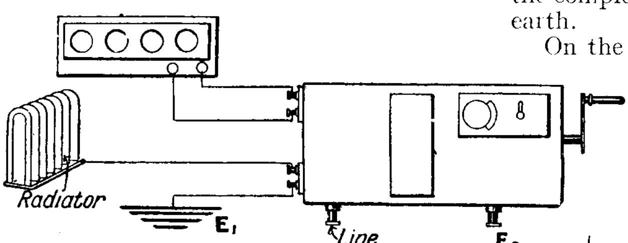


Fig. 6. How an unknown earth resistance (here, the radiator) is tested against a known resistance as at E_1

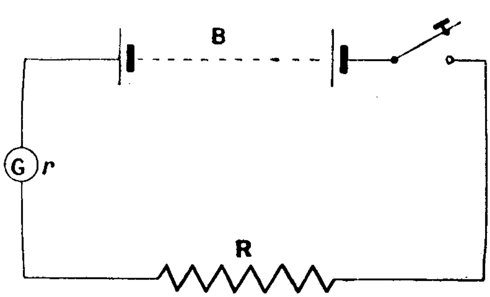


Fig. 7. How resistances may be tested by means of an ordinary galvanometer

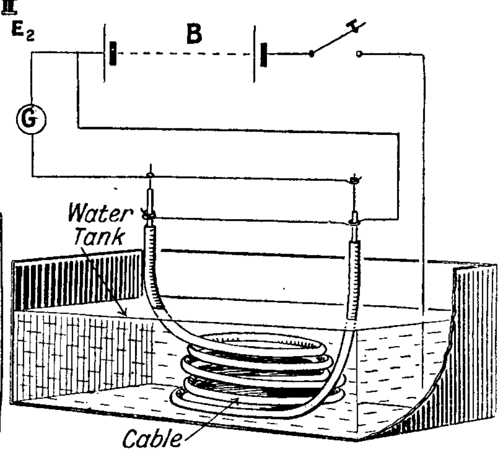


Fig. 8. Diagrammatic lay-out and circuit, showing how the insulation of a cable may be tested

for this calculation is given as

$$C \text{ (amperes)} = G \times D = \frac{E}{R + r}$$

$$R \text{ (ohms)} = \frac{E}{G \times D} - r$$

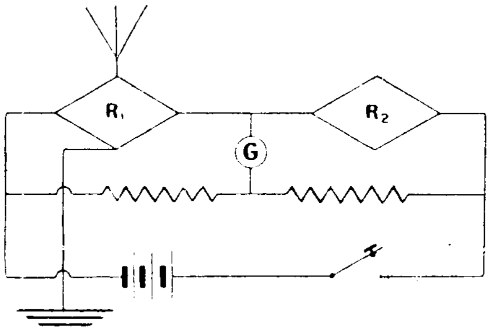
where the constant G is the factor by which the deflection is multiplied to give amperes; D is the scale deflection; E is the E.M.F. of the battery, which must be accurately determined; r is the resistance of the galvanometer. By a similar method the insulation of a cable may be tested. Reference to the diagram in Fig. 8 will show that the cable is immersed in a tank containing water, but that the ends are above the level of the liquid. The external circuit is the same as in the last test, but the two bare ends of the cable are short-circuited, as shown, and the connexion taken to the galvanometer. This is for the protection of the instrument. The formula in this instance is the same as for the previous test.

Th. This is the chemical symbol for the rare metal thorium, which in its compounds is largely used for coating the filaments of dull emitter valves. *See* Dull Emitter Valves; Thorium.

THERMAL DETECTOR. Detector of high-frequency electric currents by means of the heating of fine high-resistance conductors.

Thermal wave detectors are not nearly as sensitive as coherers or magnetic detectors, but such detectors are of interest to the wireless experimenter, for they were among the earliest means used to detect electro-magnetic waves. The bolometer is the instrument commonly used to measure the heat due to the change in the resistance of a conductor, and thermal methods of detecting electro-magnetic waves are often known as bolometric methods.

Many experimenters, including Duddell, Tissot, Boys and Fleming, have carried out experiments by the bolometric method, and in 1889 Gregory described such a method of detecting electro-magnetic waves. The figure shows a method due to Rubens and Ritter, and explained by them in 1890. R_1 R_2 are two rectangles of very fine iron wire, arranged in the Wheatstone bridge system of conductors. R_1 is connected to an aerial and to earth as shown. The resistances of the bridge are balanced in the ordinary way. When electro-magnetic waves fall on the aerial the resistance R_1 is heated, and the balance of the bridge consequently upset, causing the galvanometer to deflect and so enabling the waves to be measured.



RUBENS AND RITTER DETECTOR

By means of the change of resistance of a conductor, due to heating, electro-magnetic waves are detected

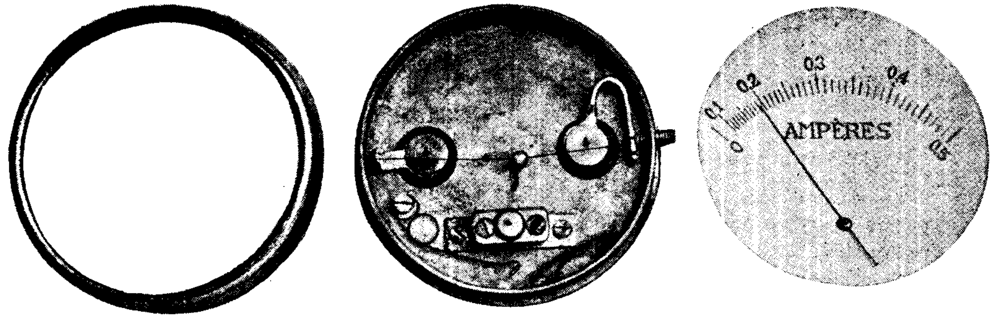
Tissot used a similar bridge arrangement with a platinum wire between ·01 and ·02 millimetre in diameter, and with such an arrangement he detected waves at a distance of 40 miles. *See* Barretter; Bolometer.

THERMIONIC AMPLIFIER. Term sometimes used in wireless for a three-electrode valve used as an amplifying valve. *See* Amplifier; High-frequency Amplifier; Low-frequency Amplifier; Valves.

THERMIONIC DETECTOR. General name given to any form of detecting valve used in wireless, and so called because an essential part of the detection is the heating of a filament to give off electrons. *See* Valves.

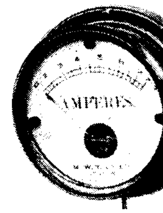
THERMIONIC VALVE or Valve. An ionic valve in which the source of free electrons is an electrode maintained at a suitable temperature by external means. A valve having two electrodes is sometimes called a diode; one with three electrodes a triode; and one having four electrodes a tetrode. *See* Anode; Filament; Grid; Valves.

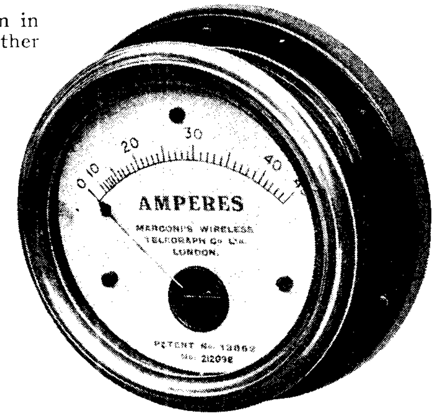
THERMO-ELECTRIC AMMETER. Hot-wire ammeter, measuring current by the expansion of a wire which is heated by the current passing through it. Fig. 1 shows the internal construction of a thermo-electric or hot-wire ammeter suitable for the requirements of the amateur



DISASSEMBLED THERMO-ELECTRIC AMMETER

Fig. 1. A thermo-electric, or hot-wire, ammeter shown in parts. The dial is on the right, and the wire and other details of the mechanism are shown in the centre





MARCONI THERMO-ELECTRIC AMMETERS

Fig. 2. These instruments are very accurate, the points between which the wire is stretched being fixed on a composite metal base to avoid relative changes in position caused by variations of external temperatures

Courtesy Marconi's Wireless Telegraph Co., Ltd.

transmitter. The hot wire can be seen stretched between the ebonite-bushed supports on either side of the case. Another wire is attached to the centre of the hot wire, and at right-angles to it, which is given a turn round the metre staff or spindle. Thus when the hot wire becomes in a sagging condition due to the heat of the current, it is pulled downwards by the other wire, which terminates on the end of a flat spring. In this action it causes the staff to rotate and the pointer to move over the scale. The zero reading of the instrument is capable of adjustment to suit varying atmospheric temperatures by moving the little knob shown on the right-hand side of the case.

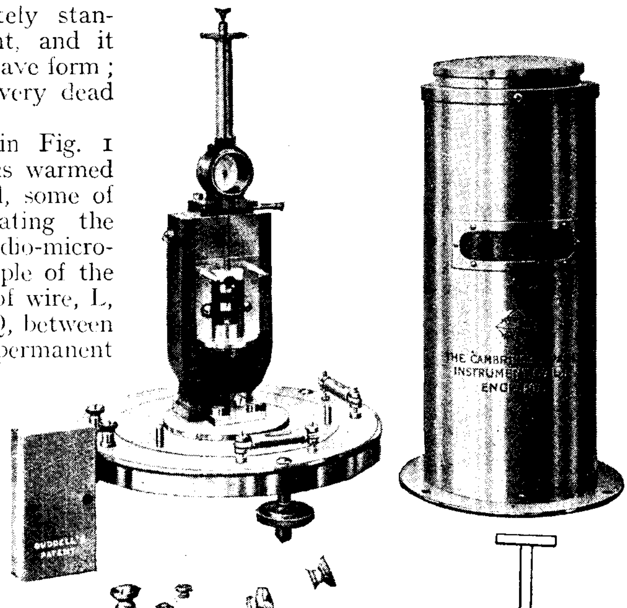
Two instruments suitable for commercial stations are illustrated in Fig. 2. These are much more accurate, and are fitted with a base made of composite metals to ensure that the fixed points upon which the hot wire is stretched do not change their relative positions despite changes of temperature.

When choosing a hot-wire ammeter, see that the reading desired comes well to the centre of the scale, for both ends are cramped, particularly the start. *See* Ammeter; Hot-wire Instruments.

THERMO-ELECTRICITY. Study of electric currents caused by heat. The electric currents due to heat were noticed by Seebeck in 1822. He found that when an electric circuit was formed of two or more different conductors and the junctions of the conductors were at different temperatures, an electric current was produced which varied with the variation in temperature. The current may be made to pass either way by varying the temperatures of the elements of the junction. *See* Thermopile.

THERMO-GALVANOMETER. Type of sensitive galvanometer which makes use of a thermo-couple to measure small alternating currents. The best known type of thermo-galvanometer is that devised by Duddell. The alternating current passes through a heater, near to which is placed one or more fine thermo-junctions, and the rise in temperature due to the current is indicated on a moving coil galvanometer having a high volt sensitivity. The deflections of the galvanometer are virtually proportional to the square of the current through the heater. The instrument has practically no self-inductance or capacity, and can therefore be used on a circuit of any frequency, while currents as low as twenty microamperes may be readily measured. It can be accurately standardized by continuous current, and it can be used on circuits of any wave form; it has a short period, and is very dead beat.

The instrument illustrated in Fig. 1 consists of a resistance which is warmed by the current to be measured, some of the heat thus generated heating the thermo-junction of a Boys radio-micrometer. Fig. 2 shows the principle of the galvanometer. A single loop of wire, L, is suspended by a quartz fibre, Q, between the pole pieces, N, S, of a permanent magnet. The loop is surmounted by a glass stem, G, carrying a mirror, M, whilst its lower ends are connected to a bismuth-antimony thermocouple. The heater resistance is fixed immediately below the thermo-couple, and as it is a straight filament only 3 or 4 mm. long, with two straight wires leading to the terminals, the inductance and capacity are very small.



DUDDELL THERMO-GALVANOMETER

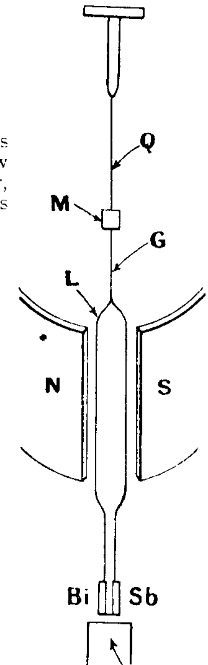
Fig. 1. This sensitive instrument makes use of a thermo-coupler to measure low A C. It is shown in parts with the cover, which minimises external heating effects

Courtesy Cambridge & Paul Instrument Co., Ltd.

The suspension, heater, etc., are protected from sudden changes in temperature by being enclosed in a heavy metal block with a removable front, shown on the left of Fig. 1. The heaters are set up in protecting cases with contact rings, so that they can be interchanged quickly when it is desired to alter the sensitivity of the instrument appreciably. The sensitivity may also be varied by altering the distance between the couple and the heater by turning an ebonite milled head. The clip which holds the heater has a spherical seating, so that it can be adjusted centrally under the thermo-couple by set-screws. The suspension can be securely clamped. A large double cover, seen on the right, thoroughly protects the instrument from outside temperature effects.

The galvanometer is usually fitted with a plane mirror and convex lens of 1 metre focal length (for 1 metre scale distance). The period is normally between 3 and 4 seconds. The instrument is adjusted to be just aperiodic. It is of very quick action; the spot swings up to its position and almost immediately comes to rest.

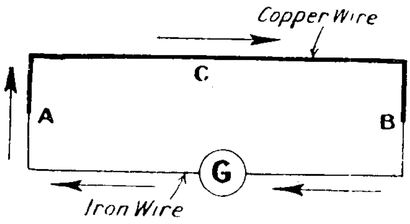
The resistance can be easily varied by substituting different heaters. Two heaters of resistance about 4 and 100 ohms respectively are usually supplied with each instrument, but heaters having resistances of about 10, 40, 400 or 1,000 ohms can be provided, if desired; other resistances can be made to order. The heaters from 40 ohms downwards are metal wires, and are adjusted to within about ± 10 per cent. Those above 40 ohms consist of a deposit of platinum on quartz, and are adjusted to within about ± 5 per cent of the above values. The deflections are practically proportional to the square of the R.M.S. values of the current when the heater is central under the junction. *See* Galvanometer.



THEORETICAL DIAGRAM

Fig. 2. An illustration of the principle of the Duddell thermo-galvanometer shown in Fig. 1

THERMOPILE. An instrument which consists of one or more junctions of dissimilar metals which has the peculiarity



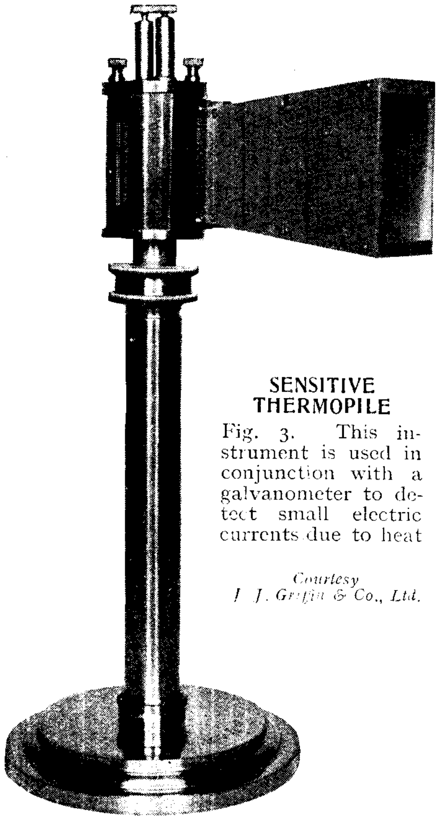
PRINCIPLE OF THE THERMOPILE

Fig. 1. An electric current is caused by the heating of the junction of the two dissimilar metals

that if one set of members of the junctions is heated an electric current is produced.

Fig. 1 shows a circuit which consists of a copper wire and an iron wire, joined together. In the circuit is inserted a sensitive galvanometer, G. Suppose both junctions are initially at the same temperature. Then, if the end of the copper wire at B is heated, an electric current will flow in the circuit in the direction shown by the arrows, *i.e.* from the copper to the iron through the heated junction, and from the iron to the copper through the cold junction. The current will go on increasing in strength as the temperature is raised, up to a limit. This limit for a copper-iron junction is about 270° C., depending upon the purity of the copper and iron, and at this limit there is a maximum current. Increasing the temperature only causes a fall in the current.

A curious fact to be noted is that if the junction is heated past another certain temperature, about 540° C., when the current has dropped from its maximum to zero again, the current begins to increase once more, but in the reverse direction. Such currents are known as thermo-electric currents, and were discovered by Seebeck in 1822. The thermopile is an instrument which makes use of these currents, a number of junctions of two dissimilar metals being arranged to multiply the effect. Various metals are used for the junctions, as bismuth and antimony, iron and antimony-zinc alloy, etc. Fig. 2 shows how the junctions are arranged to multiply the effect. One set of junctions is shielded from the source of heat, and the other is not. The deflection of the galvanometer may be used to measure the heat which falls on the junctions.

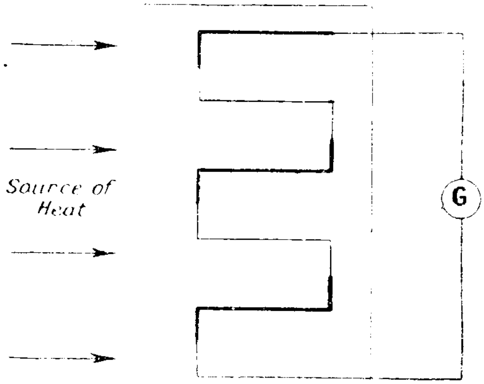


SENSITIVE THERMOPILE

Fig. 3. This instrument is used in conjunction with a galvanometer to detect small electric currents due to heat

Courtesy J. J. Griffin & Co., Ltd.

A sensitive thermopile may act as a receiver to detect the heat energy of a light beam, a low-resistance telephone being connected in place of the galvanometer. The thermopile must have a very small heat capacity if the heat energy of a beam of light which falls upon it is being measured, the latter being vibrated by means of sound. But such a receiver has only a scientific interest, being considerably less sensitive than the selenium cell.

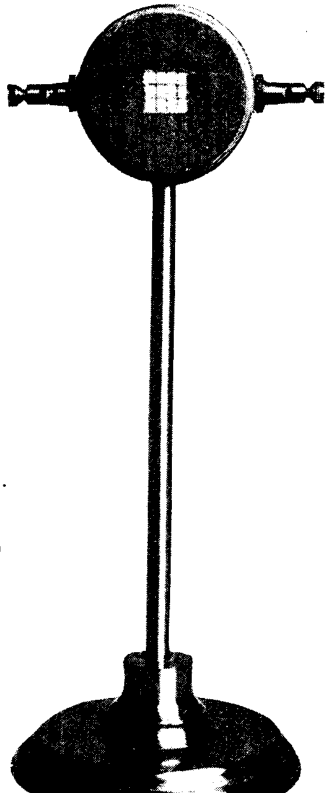


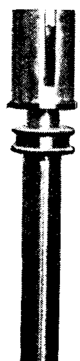
THERMOPILE JUNCTIONS

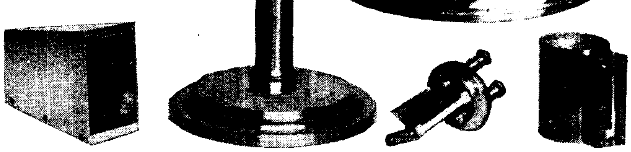
Fig. 2. How the junctions of a thermopile are arranged in such a manner as to multiply the effect of one junction

Fig. 3 is a photograph of a delicate form of thermopile suitable for laboratory work in connexion with any sufficiently sensitive galvanometer. The instrument is fitted at the top of a brass pillar, standing upon a heavy metal base. Details of the actual thermopile are shown in Fig. 4. The heat or composite element is attached to the fitting shown immediately to the right of the standard, while on the extreme right is the surrounding cover. Referring again to Fig. 3, it will be seen that in front of the case containing the composite elements is a rectangular-sectioned tapered funnel. This may be removed when desired by pushing it upwards in its slide.

A somewhat simpler form of thermopile appears in Fig. 5. This is not intended to possess any directional effect, as is the other instrument illustrated. The elements are exposed to the atmosphere by being placed within the square hole in the outer surrounding casing. A terminal is attached to either side of the cover for connexion to the galvanometer.







THERMOPILES COMPLETE AND IN PARTS

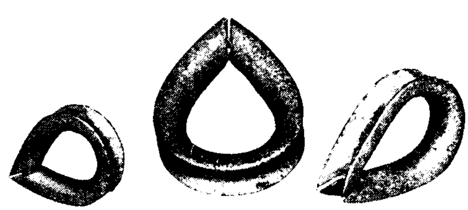
Fig. 4 (below). Components of the instrument shown in Fig. 3. Fig. 5 (above). A simpler form of thermopile. Connexions to a galvanometer are made by the two terminals shown

Courtesy J. J. Griffin & Co., Ltd.

THIMBLE. Name given to a small metal fitting used to prevent the chafing of a rope when the latter is attached to a piece of apparatus such as an aerial spreader. A useful and extensively adopted pattern of thimble is illustrated. These are made of galvanized iron in various sizes, and are so shaped that they fit readily to the shape of the eye which is necessarily formed in the rope to receive them.

In use the rope is bent around the hollow portion on the exterior of the thimble and the end is spliced or whipped to the standing part of the cord. The thimble is thereby firmly attached to the bight or eye on the end of the rope, and by distributing the pressure upon it relieves it of detrimental strain. Thimbles should always be used for the point of attachment between a halyard and bridle or spreader of an aerial system, and also for attachment to stays, guy-ropes and the like. *See* Bridle ; Eye.

THOERNBLAD, THOR. Swedish wireless authority. Born at Upsala, Sweden, in 1885, he early began to make a special study of wireless, and became one of the leading authorities in Sweden on the subject. He was educated at the High School at Stockholm, at the Royal Technological Academy of Stockholm, and Stockholm University. He was sent by the Swedish Government to foreign countries to study other systems of wireless transmission. He has written the standard Swedish work on wireless telegraphy and a large number of articles for the technical press, and is a member of many Swedish societies.



GALVANIZED IRON THIMBLES

This metal fitting is used to prevent the chafing of a rope, as may happen, for example, in the ropes of a spreader, or in the guy-ropes supporting an aerial mast

THOMPSON, SILVANUS PHILLIPS (1851–1916). British physicist. He was born at York, June 19th, 1851, and educated at the schools of the Society of Friends, to which sect he belonged, at the London University and the Royal School of Mines. In 1878 he was appointed professor

SILVANUS P. THOMPSON

Former professor of experimental physics at University College, Bristol, Thompson did much to advance the popularity of electrical science. He was the author of many standard scientific books and papers

of experimental physics at University College, Bristol, and his lectures there on electricity attracted world-wide attention. In 1881 he published his famous textbook, "Elementary Lessons in Electricity and Magnetism," which remained a standard textbook for over thirty years.

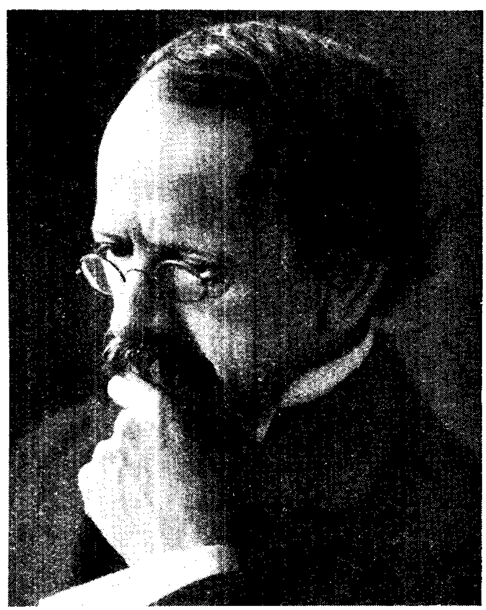
In 1885 Thompson was appointed professor of physics at the City and Guilds of London Technical College, Finsbury, of which he afterwards became principal, and in 1889 he was elected F.R.S.

Silvanus Thompson did much to popularize electricity and mathematics generally. He published anonymously "Calculus Made Easy," a radical departure from the ordinary style of textbook. He also wrote "Dynamo-electric Machinery," 1882; "The Electro-magnet and Electro-magnetic Mechanism," 1891, and biographies of Faraday and Kelvin. He died June 12th, 1916.

THOMSON, SIR JOSEPH JOHN. British physicist. Born near Manchester, December 18th, 1856, he was educated at Owens College, Manchester, and Trinity College, Cambridge, where he took his degree as second wrangler. He was second Smith's Prizeman, and in 1880 was elected a fellow of Trinity, became a lecturer there in 1883, and in 1884 Cavendish professor of experimental physics.

During his control of the Cavendish Laboratory Sir Joseph Thomson not only carried out a series of researches which have revolutionized completely the whole ideas on electricity and matter, but he attracted round him a brilliant band of workers who have made the laboratory the most famous in the world. During this period Sir Joseph Thomson made the remarkable and epoch-making discovery of the electron. As long ago as 1881, the year after he took his degree, Sir Joseph Thomson promulgated the theory of the nature of electric inertia, from which an estimation of the size of the electron was afterwards made.

If the electron had been the only discovery of Sir Joseph Thomson's, that



SIR J. J. THOMSON

This famous scientist was born near Manchester, and after being educated at Cambridge became a lecturer and professor there. To him is due the epoch-making discovery of the electron discovery would have made his name famous for all time. But he showed a similar brilliancy in many other directions in physics, and he has left his name imperishably on many other electrical subjects.

In 1884 Thomson was elected a fellow of the Royal Society, in 1894 president of the Cambridge Philosophical Society, and president of the Royal Society in 1915. In 1905 he became professor of physics at the Royal Institution, London, while still holding the Cavendish professorship.

Sir Joseph Thomson, who was knighted in 1908, has received many honours for his remarkable work in physics, and has been honoured by innumerable foreign societies and universities. In 1894 he was awarded the Royal Medal, and in 1902 the Hughes Medal of the Royal Society. The same year he received the Hodgkins Medal of the Smithsonian Institute, and the Nobel Prize for physics in 1906. In 1912 he was awarded the Order of Merit.

Sir Joseph was appointed master of Trinity College in 1918, and in 1919 he was elected to a recently founded professorship of physics at the Cavendish Laboratory. He has written many books, the most important of which are as follows: "A Treatise on the Motion of Vortex Rings," 1884; "The Application of Dynamics to Physics and Chemistry," 1886; "Recent Researches in Electricity and Magnetism," 1892; "Elements of the Mathematical Theory of Electricity and Magnetism," 1895, which has run through many editions; and "The Conduction of Electricity Through Gases," 1903. Sir Joseph has also written many articles for scientific journals and a number of textbooks on physics. *See* Electrons.

THORIUM. One of the metallic chemical elements. Its chemical symbol is Th, and its atomic weight 232·5. It belongs to the cerium group of minerals, and is found in Norway, Brazil, N. America, etc. It is a grey metallic-looking powder. Thorium is one of the radio-active elements, though its emanations are not the same as those given out by radium itself.

Thorium is important on account of its compound thoria, the oxide, ThO_2. Thoria is not only largely used in the manufacture of gas mantles, but also in the making of filaments for valves. Langmuir showed that when the ordinary filament was coated with thoria, or thorium nitrate preferably, a species of alloy with the tungsten of the filament is formed, known as thoriated tungsten. The electron emission for a given temperature is several thousand times as great as with ordinary pure tungsten, and consequently to get the same results as with ordinary tungsten filaments a much lower temperature is needed. This is the principle of the dull emitter valve, a principle discovered by Wehnelt in 1903, and one which has meant a great advance in wireless reception valves, as well as great economy in running costs, a single dry cell of good make being sufficient to heat the filaments of two or three dull emitter valves.

Thorium is also used to control the vacuum in transmitting valves. With high-voltage valves it is essential that the vacuum shall be maintained at as high a value as possible. One of the methods used to control the vacuum in X-ray bulbs and similar high-vacuum bulbs is to take advantage of the property possessed by certain substances of absorbing or occluding large quantities of gas. Thorium has the property of occluding large quantities of oxygen, nitrogen, etc., and a small quantity of the metal is often included in the bulb for that reason. *See* Dull Emitter Valves.

THREE-ELECTRODE VALVE. This is the popular name for the most commonly used valve in wireless. The three electrodes are named the filament, the grid and the anode or plate. The three-electrode valve is dealt with in this Encyclopedia under the names of the particular valves, as Mullard, etc. *See* also Audion; Dull Emitter Valves; Valves for Reception and Transmission.

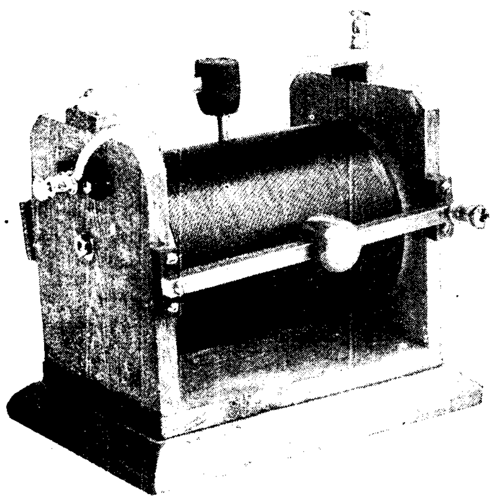
THREE-PHASE ALTERNATOR. Alternating current generator having three separate windings arranged in its armature (usually the stator in A.C. machines), and which produces three separate phases of current arranged so that their maximum values are spaced at 120 degrees.

The method of connexion to the mains differs according to the individual needs of the external circuit, and two methods are in general use. One system is known as "star" connexions. Here the end of each phase or winding is connected to one central point, while the free ends are connected to the lines. In the mesh system the windings are connected in series and the mains are taken from each point of connexion.

Where the load of a three-phase alternator is taken by motors, it is usual to have three-phase motors, but if lighting constitutes the whole or any portion of the load it is general practice to balance the current taken from each phase by arranging the lamps so that an approximately equal circuit is carried in each phase. *See* Delta Connexions; Mesh Grouping; Polyphase Alternator.

THREE-SLIDE TUNER. A type of variable inductance employing three sliding contacts which make contact with a cylindrical inductance. The advantage of the three-slide tuner is found in greater selectivity of signals. In many cases this type of tuner may be adapted from the single or double type of sliding inductance by the addition of extra slider rods and contacts.

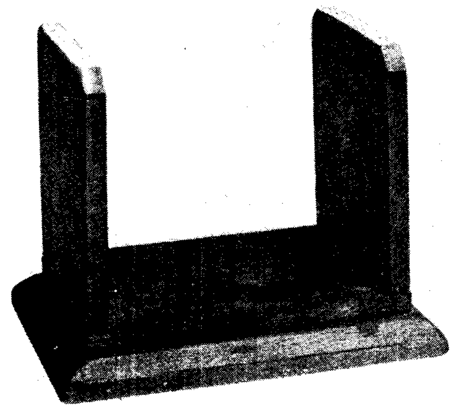
An easily constructed three-slide tuner is illustrated in Fig. 1, from which the general appearance of the instrument may be gathered.



COMPLETE THREE-SLIDE TUNER

Fig. 1. Suitable for operation with a crystal or simple valve detector, this efficient three-slide inductance is easily made by the experimenter

The base is cut from a piece of straight-grained hardwood, and measures $6\frac{1}{2}$ in. by $4\frac{3}{4}$ in. The edges are moulded or bevelled to individual requirements in order to give the tuner a finished appearance. Two wooden uprights are required for mounting the coil and the slider rods, and may be cut from $\frac{3}{8}$ in. hardwood, each to measure $4\frac{1}{4}$ in. by $3\frac{3}{4}$ in. The top corners of each piece are cut off to an extent of $\frac{1}{2}$ in. along the top and sides. After suitably sandpapering and staining the base and supports the

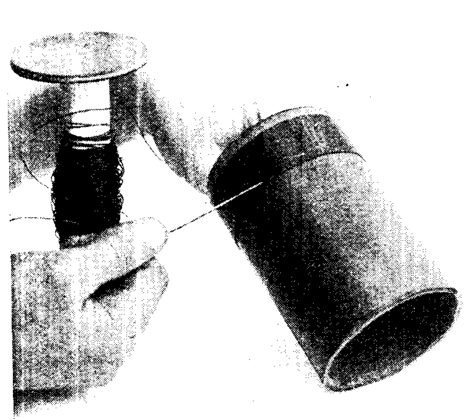


SUPPORT FOR THE TUNER

Fig. 2. How the moulded wooden base and side supports for the inductance and slider rods are pieced together

latter are screwed to the former in the manner shown in Fig. 2. The distance between the insides of the supports is 5 in., and this distance should be allowed irrespective of the thickness of the supports. This completes the woodwork of the instrument, which may be put aside until a later stage.

The inductance coil is wound on a $3\frac{1}{4}$ in. diameter cardboard former, 5 in. in length. It should be ascertained at this stage that the coil former makes a tight fit inside the uprights on the base. The inductance former is now thoroughly



WINDING THE INDUCTANCE

Fig. 3. In winding the inductance, the former is supported and rotated with the left hand, while the right maintains the wire at the correct tension

impregnated with paraffin wax or well shellacked to prevent the admission of damp. The former is ready for wiring at this stage, No. 24 enamelled wire being used.

Two small holes are drilled at one end of the inductance former, through which holes the beginning end of the wire is passed two or three times to form loops, by which the wire is securely anchored. The winding is best performed in a lathe, if available, but quite a neat job may be made with hand winding if care is taken in the process. The best way of holding the former is illustrated in Fig. 3, where the left hand is inserted inside the tube and the right hand used for guiding the wire in position. After about eight turns have been put on, the turns may be brought up closer by pressing them up with the end of a rule or similar piece of flat-ended wood.

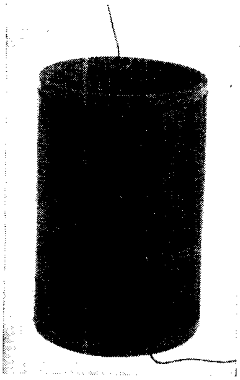
When the former is wound, leaving at least $\frac{3}{8}$ in. of the wire free at either end, the end may be fastened off in a similar way to the beginning. The completed inductance, which shows the method of fixing the beginning and end of the wire is illustrated in Fig. 5. One end of the wire may be cut off, as connexion is only required at one end.

The coil is mounted securely to the supports by a length of 2 B.A. stemming, which passes right through the inside of the coil and presses the supports to the ends of the inductance by means of nuts attached to both ends of the rod. A $\frac{3}{16}$ in. hole is drilled through the centre of each support, through which the rod is passed.

The slider rods are cut from $\frac{1}{4}$ in. square brass rod. Three are required of a length to allow their ends to come flush with the outside of the supports. In order to preserve the high insulation obtainable with the use of ebonite, the slider rods are mounted on small blocks of this material. A clearance hole is drilled at the end of each slider rod by which it is secured to the ebonite blocks. Three holes are required in each block, the two outside holes being for screws to hold the block to the support, and the centre one being a tapped hole into which a metal screw fixes the slider rod. At one end of each slider rod the stem of a telephone type terminal performs the function, as shown in Fig. 4. This illustration shows

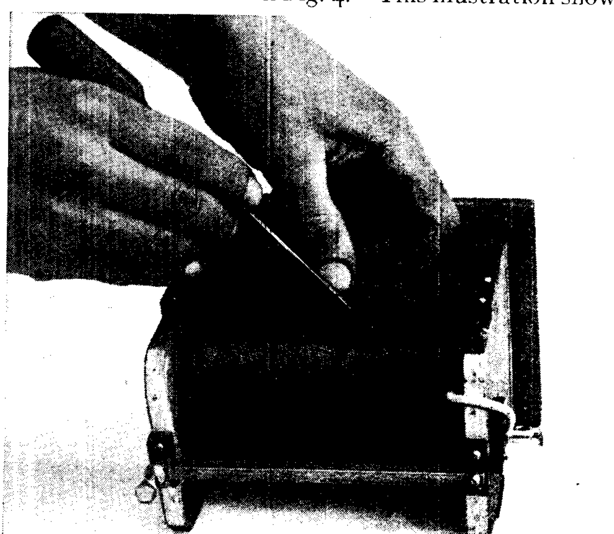
SLIDER ROD FOR THE COIL

Fig. 4. The slider rod is fixed to an ebonite block by the screwed shank of the terminal, as shown here



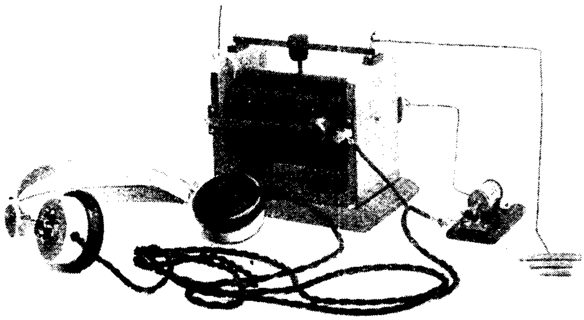
WIRING OF THE COIL COMPLETED

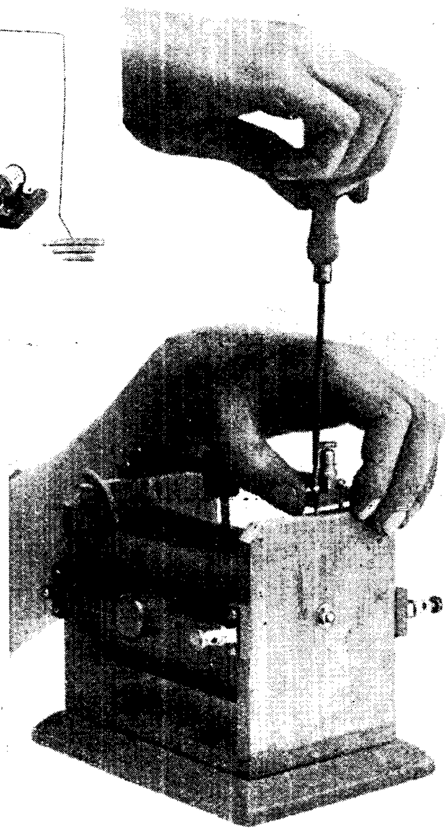
Fig. 5. Completed inductance coil for the three-slide tuner. Inspection of this photograph will show how the ends of the wires are fixed



COIL COMPLETE AND IN POSITION

Fig. 6. A straight edge is employed for steadying the narrow-ended screwdriver which is used to remove the insulation where the slider is to move along the coil. The coil is now practically ready for use



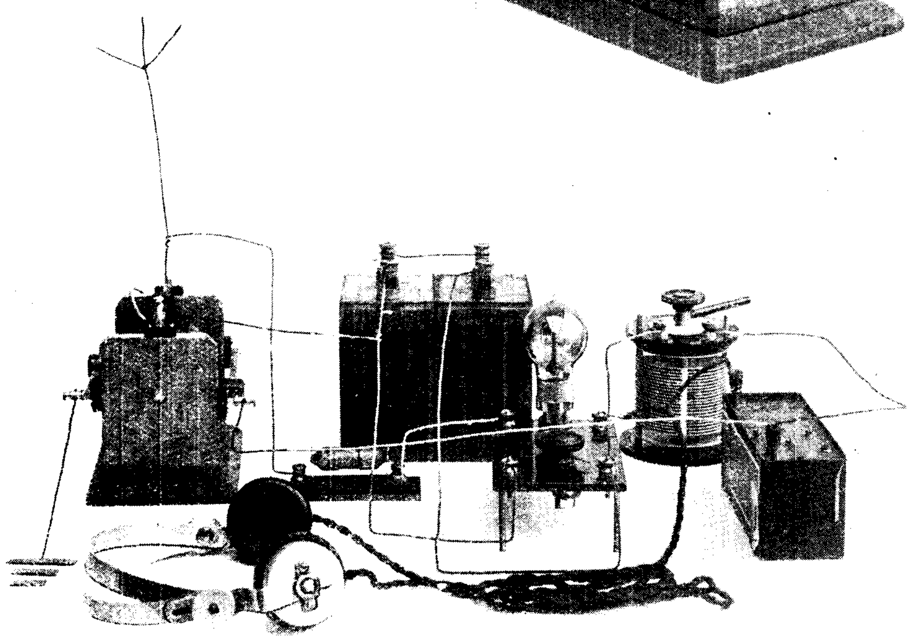


COMPLETING THE INSTRUMENT

Fig. 7 (above). The tuner used with a crystal detector. Fig. 8 (right). The slider rod and ebonite block being screwed to one support

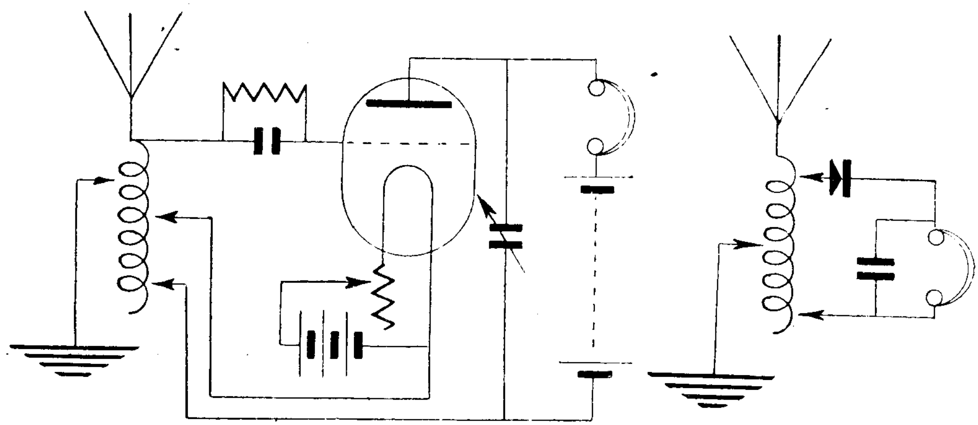
a slider bar with ebonite block with the terminal screwed in position.

The slider contacts, which are shown in later illustrations, may be constructed of ebonite rod if desired, but the experimenter is recommended to purchase these components, as they are extremely cheap, and their construction is not at all easy. The slider rods with contacts fitted should now be assembled to locate the position of the latter on the inductance. This is



THREE-SLIDER COIL IN VALVE CIRCUIT

Fig. 9. Here is shown a lay-out in which the three-slide inductance is employed with a regenerative one-valve detector circuit. The three-slide inductance is valuable in such a circuit, being very selective in its effects



CIRCUIT DIAGRAMS OF THE TWO LAY-OUTS

Fig. 10 (left). Theoretical circuit of a single-valve regenerative set embodying a three-slide inductance coil. Fig. 11 (right). How the three-slide tuner may be embodied in a crystal circuit

done by rapidly moving the slider along the bar until a mark is made on the inductance. The slider rod is temporarily removed while the insulation on the wire is scraped off. This operation is performed by fitting a straight edge to the mark on the inductance which acts as a guide, while a narrow-bladed screwdriver is rubbed along the surface of the wire. The operation of removing the insulation is shown in Fig. 6.

This illustration also shows a terminal mounted on the outside of one of the supports by means of an ebonite block. This terminal connects to the beginning of the coil winding.

After the insulation has been cleared from the path of each slider contact, the slider rods may be screwed permanently down in the manner illustrated in Fig. 8.

It is advisable before putting the completed instrument into operation to test out the contacts for continuity of insulation, instructions for which will be found in the article on Faults.

A circuit diagram in which the three-slide tuner is used with a crystal detector and telephones is illustrated in Fig. 11, while a pictorial lay-out of the complete receiver is given in Fig. 7.

The tuner working with a single-valve regenerative detector is illustrated in Fig. 9, the wiring of which may be followed from the circuit diagram given in Fig. 10, showing the connexions. *See* Coils; Crystal Sets; Inductance Coil.

THREE-VALVE SET: A SIMPLE LONG RANGE RECEIVER

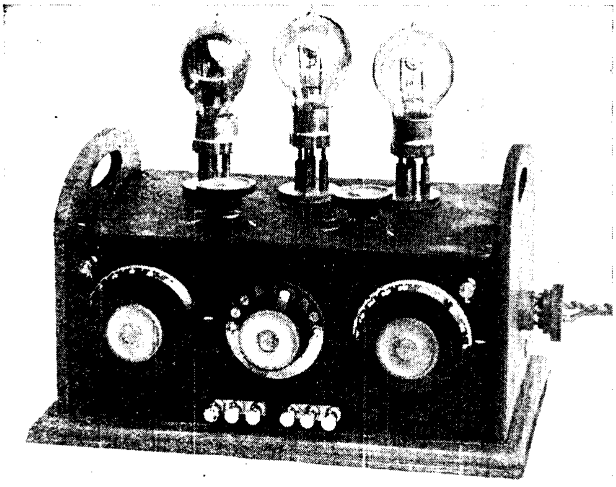
How to Construct an Efficient Three-Valve Receiver with a Normal Range of 225 Miles

The experimenter who is interested in this most efficient receiver will find that it is one of those referred to on the Broadcasting map which faces page 282. For the reception of B.B.C. transmissions few more suitable sets exist, and the range covers practically all the stations. The reader is referred also to Crystal Receiver; High Frequency; Four-valve Set, and similar general headings

A three-valve set designed in conjunction with the Broadcast map facing page 282, in which it figures as No. 6, is shown completed in Fig. 1. The set employs a valve detector preceded by a single stage of high-frequency transformer-coupled amplification. Volume is given to the signal strength by a stage of low-frequency amplification. Tuning is effected by means of a tapped inductance used in conjunction with a variable condenser. Greater selectivity is obtained by shunting the primary of the high-frequency transformer with a variable condenser of ·00025 mfd. capacity.

Distant stations are best heard in the headphones, although the set will operate a loud speaker if within 10 to 15 miles of a broadcasting station. The high-frequency valve renders the set suitable for operation on a comparatively inefficient aerial.

The components are mounted on two ebonite panels, which form the top and the front side of the instrument. The tuning components are assembled to the

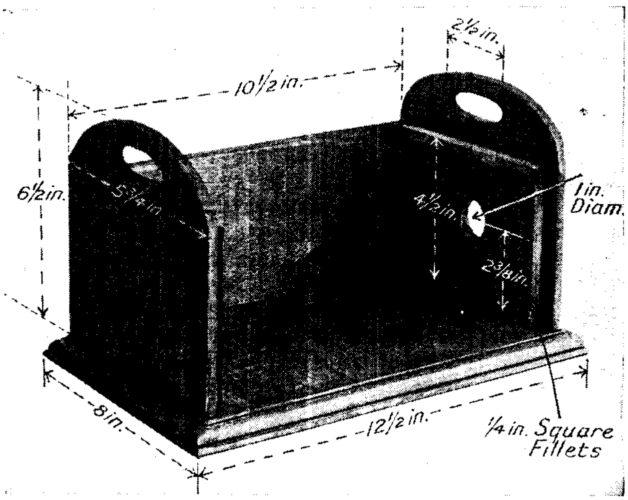


COMPLETE RECEIVER

Fig. 1. The finished three-valve set. Note the prolongation of the two sides to form the carrying handles of the set

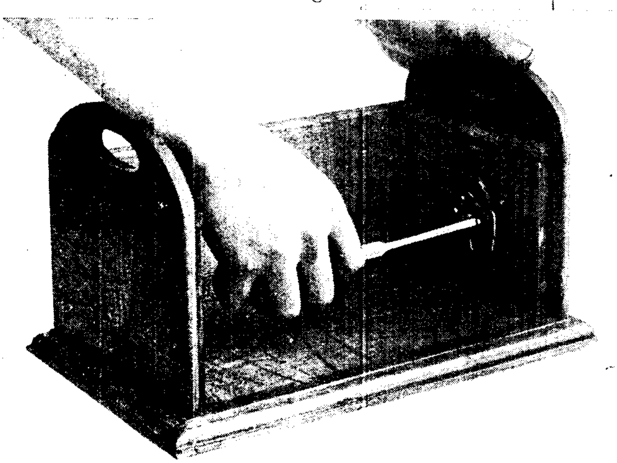
front panel, while to the top panel are fitted two filament resistances and the valve holders.

A rather unusual appearance is given to the set by extending the sides of the case upwards to form carrying handles. This feature is shown in Fig. 2, which gives the dimensioned sizes for the construction of the case. Any well-seasoned hardwood is suitable, among which oak or mahogany are to be recommended. A hole of 1 in. diameter is required in the centre of the right-hand side. The top of a flanged valve holder projects through the hole and forms a means of attachment for the battery connexions. This method employs plaited leads from the high- and low-tension batteries, which terminate in a four-prong plug fitting into the sockets of the valve holder. All battery connexions may thus be instantly detached from the set without the necessity of altering the settings of the two filament resistances. Owing also to the offset position of one of the valve-holder legs, that normally occupied by the anode of the valve, it is impossible to connect the battery leads incorrectly.



CASE DIMENSIONS

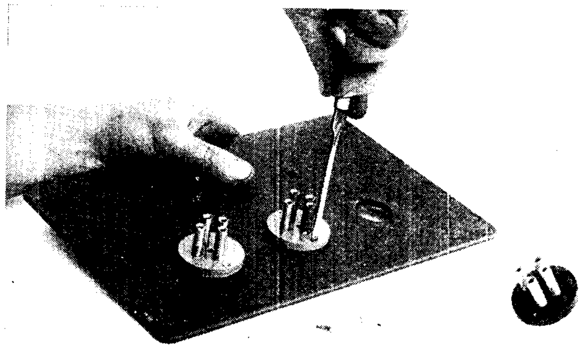
Fig. 2. These figures will help the constructor in assembling his cabinet. Notice the fillets inset on either side of the cabinet



INSERTION OF THE BATTERY CONNEXIONS

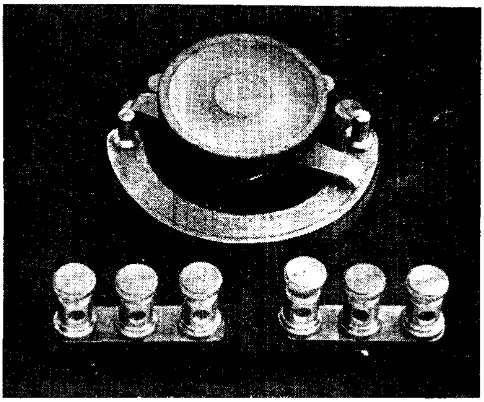
Fig. 3. Battery connexions are led to a valve holder screwed by its flanges to the inside of the case, as shown here

A flanged-type valve holder is the most suitable, as it may be directly attached to the side of the case by means of wood screws, in the manner shown in Fig. 3. The three valve holders used for their legitimate purpose may be of any convenient pattern, but a neat form of valve holder made up from valve legs is shown in use with this set. These may easily be constructed from small disks of ebonite turned up to a diameter of 1½ in. Holes of suitable diameter to permit the attachment of the valve sockets are drilled in the centre of each disk, and also two holes to the outside of the disk by which the component may be screwed to the panel. This operation is shown in Fig. 4, where one of the valve holders is seen



FIRST STEP IN COMPONENTS ASSEMBLY

Fig. 4. How the valve holders are fixed upon the ebonite panel. One of these special valve holders is shown more clearly in the foreground of the illustration



PANEL DETAIL

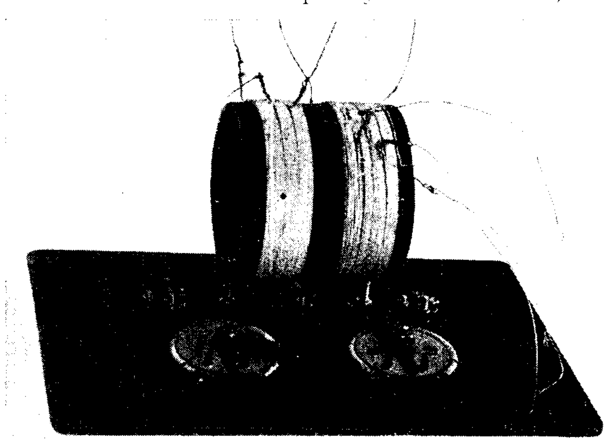
Fig. 5. An illustration from close range showing the arrangement of the terminal board and the seven-stud switch used on the set

in the foreground. The centre one is fixed in the centre of the panel at a distance of 2¼ in. from the back. The other valve holders are placed at a distance of 2¾ in. from the centre one on either side of it, so that they fall in line.

Of the two filament resistances, the one to the left operates the high-frequency valve, while that to the right varies the brilliance of both the detector and the low-frequency valve. They are both placed 2¼ in. from the front of the panel and 1¼ in. from either side of the centre line.

The top panel measures 10½ in. by 7 in., and is rounded over at its front and back edges where it overlaps the front and back sides. Before fitting the components, the positions of which have just been described, the panel should be well matted on both sides to the instructions to be found under the heading Ebonite. At this stage the tapped inductance is made and mounted. This is wound on an ebonite tube of 3½ in. diameter, having a length also of 3½ in. Two $\frac{3}{16}$ in. holes are drilled in line at either end of the inductance former, by which it is mounted to the top panel.

Seventy turns of No. 24 gauge D.C.C. wire are used, and are tapped at every tenth turn, making a total of 7 taps. It will be found that this amount of wire does not completely fill the former, and



BEHIND THE PANEL

Fig. 6. The completed coil is mounted so that the inductance comes over the central valve holder; it is held in place by means of screwed rod

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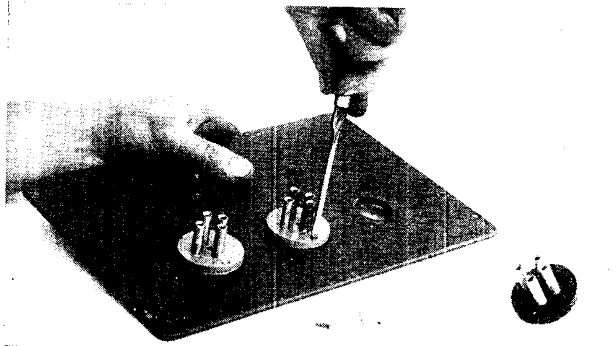

FIRST STEP IN COMPONENTS ASSEMBLY

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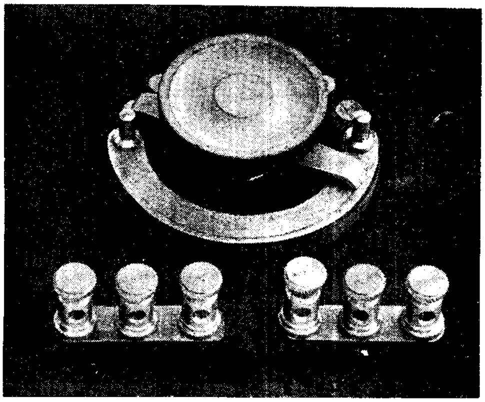

PANEL DETAIL

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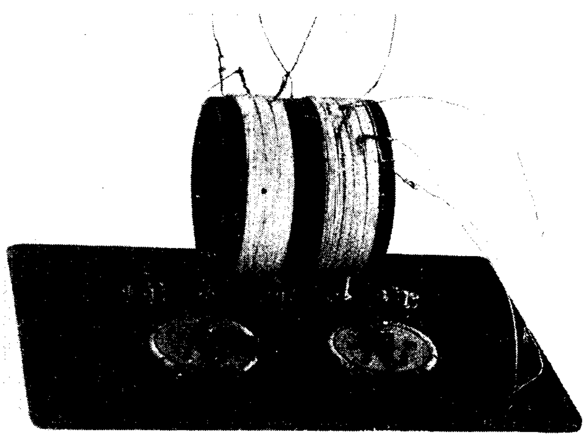
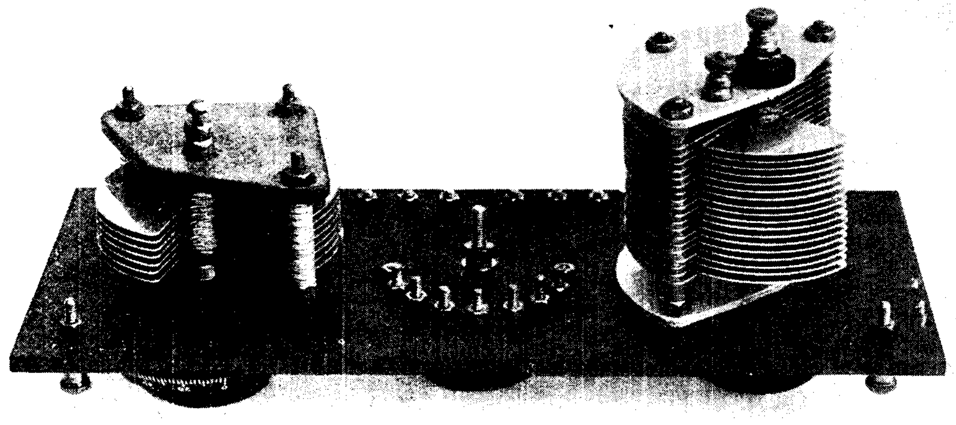


BEHIND THE PANEL

Fig. 6. The completed coil is mounted so that the inductance comes over the central valve holder; it is held in place by means of screwed rod



REAR OF THE VERTICAL PANEL OF THE THREE-VALVE SET

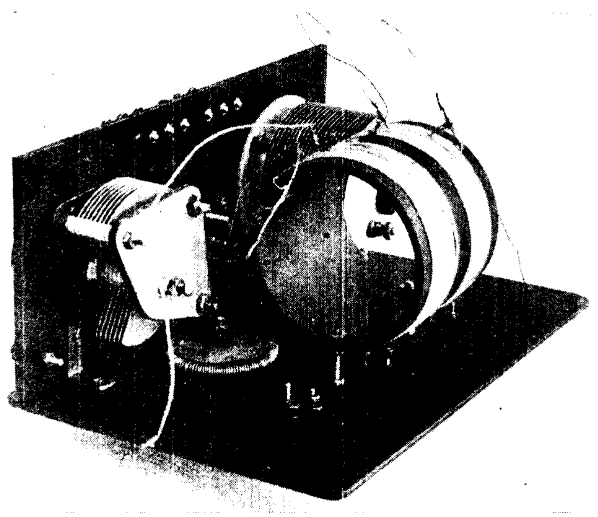
Fig. 7. As it appears at this stage the front panel is ready for mounting in position on the horizontal panel. This view indicates clearly the positions of the condensers and the contact studs of the switch shown in Fig. 5

for this reason a small space may be arranged between each point of tapping. The completed coil is mounted to the panel by means of two short lengths of 2 B.A. screwed rod attached to the panel so that the inductance comes over the centre valve holder, as shown in Fig. 6. A nut is threaded on to each screwed rod, after which the inductance is fitted. It is then held rigidly by the addition of two more nuts tightened down on the inside of the inductance.

A high- and a low-frequency transformer are mounted on either side of the inductance, but these components may be left to a later stage in order to facilitate the construction.

The front panel measures $10\frac{1}{2}$ in. by $4\frac{1}{2}$ in., and is matted to match the top panel. Aerial and earth terminals are fixed in the top left and right corners of the front panel respectively, while the telephones are mounted on a block of ebonite to the bottom centre. The block is of ornamental shape, and holds two sets of three terminals, each set being electrically connected by a brass strip underneath the base of the terminals. This arrangement forms a terminal board, to which three pairs of telephones may be fitted. A close-up of the terminal board is given in Fig. 5.

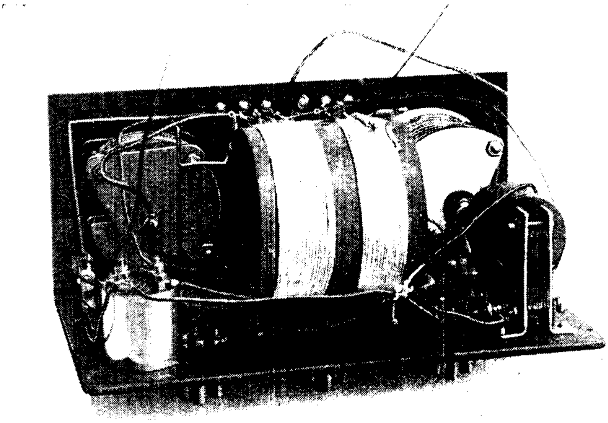
This illustration also shows the seven-stud switch, which is the next point to be dealt with in the construction of the set. An ebonite ring is required, having an external diameter of $2\frac{1}{2}$ in. and an internal diameter of $1\frac{3}{4}$ in. This may be turned from sheet ebonite of $\frac{1}{4}$ in. thickness. Seven equally spaced holes of the same diameter as the contact studs are drilled on one side of the ring, their object being to enable the switch contact



PANELS FITTED TOGETHER

Fig. 8. Two brass angle brackets are employed to unite the vertical panel with the horizontal one ; one of these is seen on the left here below the variable condenser

studs to come flush with the surface of the ring. On the other half of the ring a brass back-plate is fitted, and held in position by two stop pegs, the back-plate serving to take the pressure of the contact arm. The contact arm is of the laminated variety, and tapers to a $\frac{1}{4}$ in. at the end, where it makes full contact with the studs. The remainder of the switch construction follows standard practice, and does not need further comment.



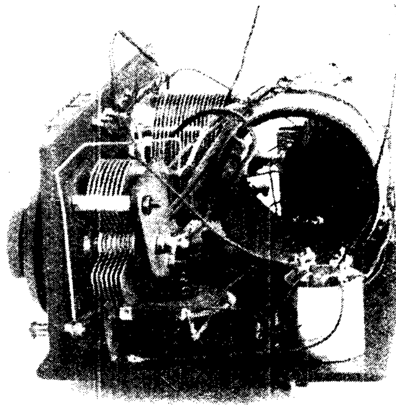
COMPLETED WIRING OF THE SET

Fig. 9. Here is presented a rear view of the two panels, showing the finished wiring and the positions of the transformers

A variable condenser of ·0005 mfd. capacity, used for tuning the aerial circuit, is attached to the right-hand side of the front panel, while a smaller one of ·00025 mfd. capacity occupies a similar position to the left side of the switch. This latter condenser is shunted across the primary of the high-frequency transformer.

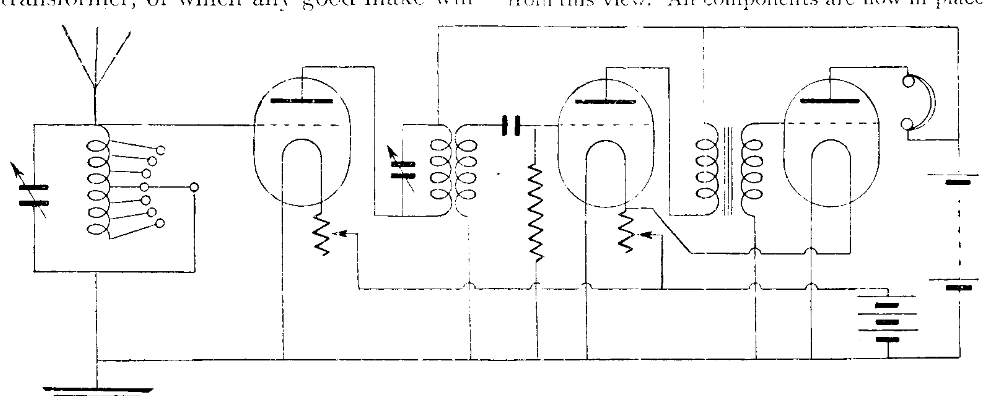
The appearance of the front panel is indicated in Fig. 7. At this stage the front panel may be attached to the top panel. For this purpose two right-angle brackets are required, and are attached one at each end of the panels. One of the brackets is shown in Fig. 8, which illustrates the two panels with the components mounted at this point.

The high-frequency transformer used is a G.R.C. broadcast wave-length transformer, and is attached to the left side of the inductance coil viewed from the back of the panel. The low-frequency transformer, of which any good make will



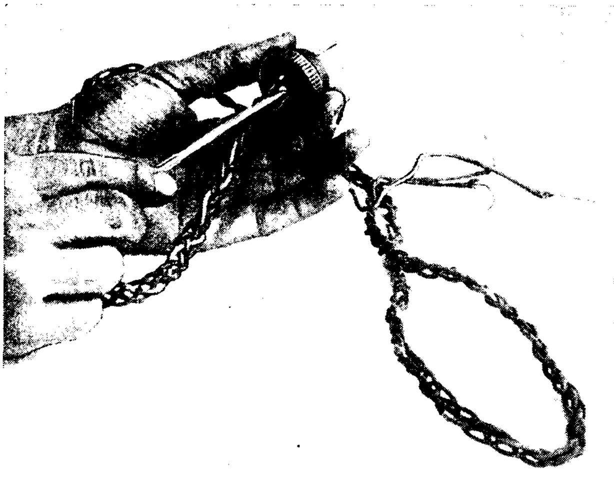
SEEN FROM THE SIDE

Fig 10. Further details of the somewhat involved wiring necessary in this set may be obtained from this view. All components are now in place



WIRING DIAGRAM OF THE THREE-VALVE RECEIVER

Fig. 11. Before embarking on the task of connecting up the several components, the constructor should devote a little time to the study of this circuit diagram



DETAIL OF BATTERY CONNEXIONS

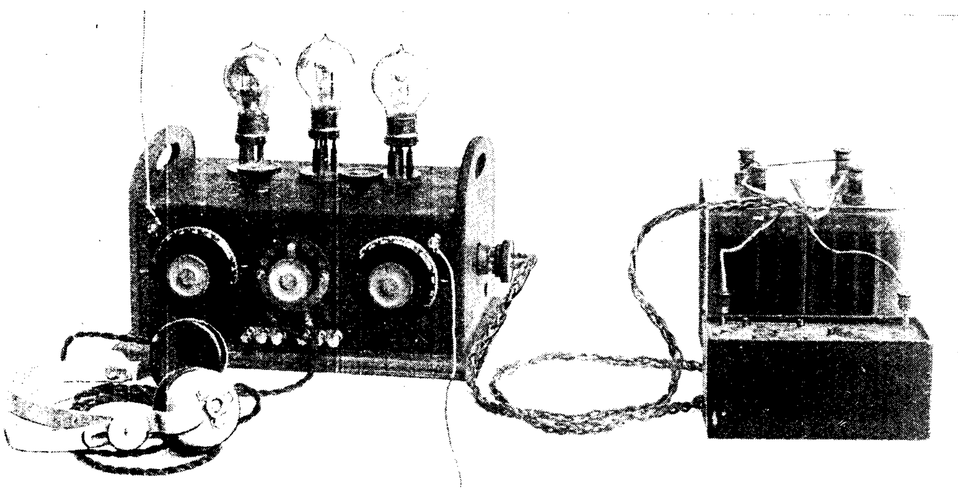
Fig. 12. This illustration shows the cap being attached by a central screw to the four-prong plug containing the battery leads. This plugs into the side of the case

be suitable, is mounted on the opposite side of the inductance. The position of these components is illustrated in Fig. 9. Wiring up the components may now be commenced to the circuit diagram given in Fig. 11. A back view of the wiring is shown in Fig. 9, while a side view showing the positions of the grid leak and condenser is illustrated in Fig. 10.

After the interior of the set has been freed from any trace of soldering material or short pieces of connecting wire, it may be fitted to the case. In order to make connexion to the valve holder acting as a battery plug, short leads are soldered to appropriate points on the wiring and joined up to the valve holder legs when the set is assembled. The case should be marked with the correct battery connexions to avoid the possibility of mistake.

A four-prong plug is made by screwing plugs into a disk of ebonite and soldering flexible leads to their ends. In order to take off the strain of a pull from the soldered connexions, an ebonite cap is turned up and fits over the disk in which the plugs are screwed. The cap is attached to the disk by a central screw, the operation of tightening which is illustrated in Fig. 12. It is a good plan to use different-coloured flex wires for the plug connexions, but if they are not available the ends of the wires must be sorted out by an electrical test and then marked. Fig. 13 shows the completed set connected up to aerial and earth and batteries.

The set will be found to tune quite easily, the broadcasting stations coming in usually about the middle stud. The variable condenser across the primary of the transformer gives quite critical tuning, which makes for good selectivity.



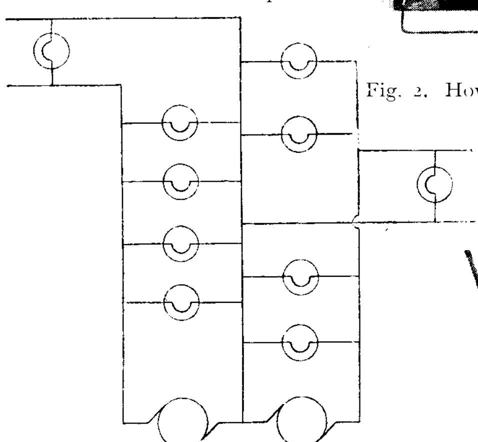
THREE-VALVE RECEIVER COMPLETE AND READY FOR USE

Fig. 13. Aerial, earth and battery connexions are complete, and the set is now ready for reception. It will be observed that the receiver is a compact and very neat piece of apparatus

THREE-WIRE SYSTEM. A method of electric wiring primarily used for power and lighting circuits, in which two generators of equal output are employed. The generators are arranged in series, so that the positive of one and the negative of the other form the outside wires of the three-wire system. The remaining generator poles are connected together and to the centre wire of the system. An outline showing the principle of the three-wire system is illustrated in Fig. 1.

The load in each circuit is arranged as far as possible to balance, in which circumstance the middle or balancing wire carries practically no current. The current carried by the centre wire is equal to the difference between the currents in the two outside wires of the system. It will be seen, therefore, that considerably less current is carried in the centre wire, and it may be, consequently, of smaller cross-section than the outside wires.

The invention of the three-wire system is due to Hopkinson and Edison, the latter using generators of 110 volts in each circuit. Where power at greater potential is required it may be taken from the outside wires of the system, whereby the balance is preserved and double the voltage is obtainable. For lighting purposes, where 110 volts forms a useful pressure, lamps are connected to the centre and either of the outside wires. In order to preserve a state of balance between the two circuits a balancer, consisting of two shunt- or compound-wound generators, is introduced in actual practice.

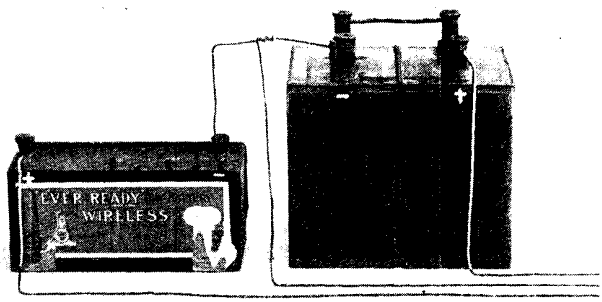


THREE-WIRE SYSTEM

Fig. 1. Diagram showing the method of wiring in the three-wire system

Fig. 3 shows a portion of a wiring conduit where the three wires in one conduit branch out into two directions of the two-wire system for connexion to the lamp circuit. The outside wires turn respectively to the left and right bend of the conduit, while the centre wire taps a wire common to each of the two wire circuits inside the inspection box.

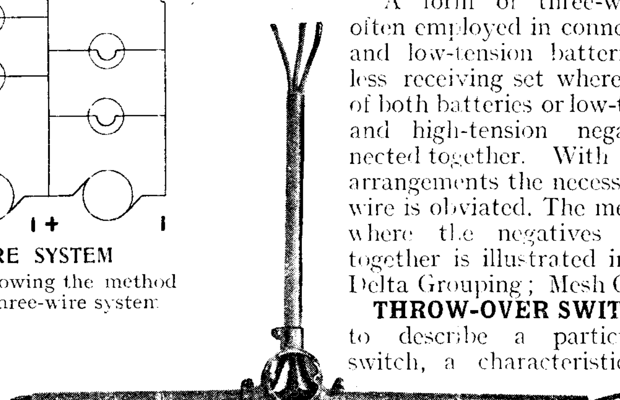
A somewhat similar system of wiring is the system known as Delta Grouping or Mesh Connexions, separately described in this Encyclopedia under these two headings.



NEGATIVES CONNECTED TOGETHER

Fig. 2. How the three-wire system is applied to the high- and low-tension batteries of a receiving set

A form of three-wire system is often employed in connecting the high- and low-tension batteries to a wireless receiving set where the negatives of both batteries or low-tension positive and high-tension negative are connected together. With either of these arrangements the necessity of a fourth wire is obviated. The method of wiring where the negatives are connected together is illustrated in Fig. 2. *See* Delta Grouping; Mesh Connexions.



PROTECTED THREE-WIRE CONNEXIONS

Fig. 3. Three wires are connected into two, as shown here. The cover of the inspection box is shown removed

THROW-OVER SWITCH. Term used to describe a particular kind of switch, a characteristic of which is that contact is effected by means of a movable arm, which, when

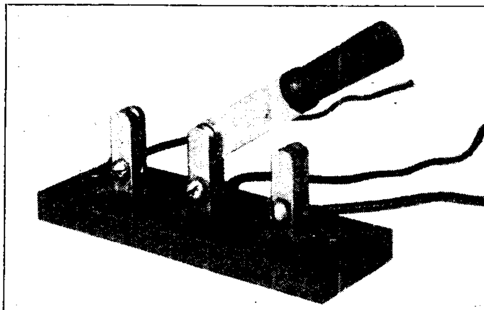


Fig. 1. Simple type of throw-over switch much used in wireless for panel mounting
Courtesy Economic Electric Co., Ltd.

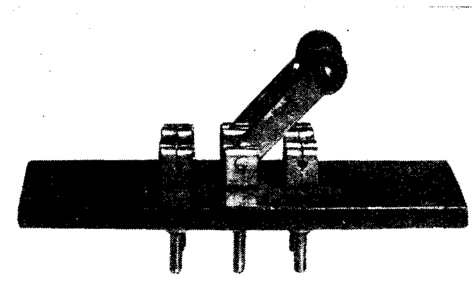


Fig. 2. This pattern of double-pole switch is useful for many purposes, and is easily mounted on the panel of a wireless set

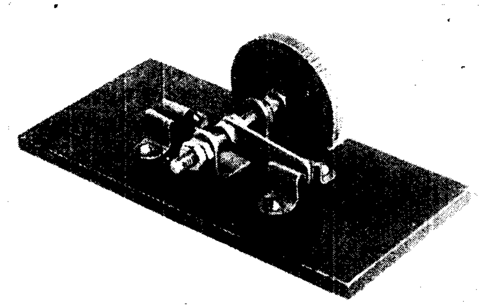


Fig. 3. Back view of a home-made type operated by pressure of finger or thumb

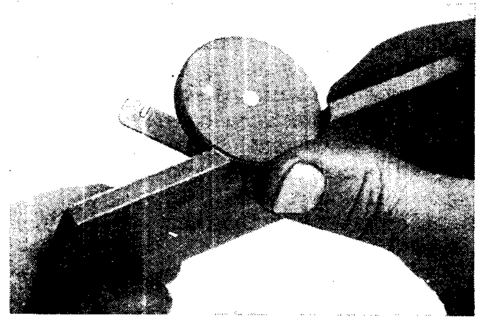


Fig. 4. How, by easy pressure, the home-constructed switch is made to function

GOOD TYPES OF THROW-OVER SWITCHES

thrown over or moved through approximately 180°, makes contact with one or other of two separate contact points. Throw-over switches of small size are frequently used on amateur wireless apparatus and can be worked into a circuit in many different ways, examples of which are to be found in many of the circuits illustrated and described in this Encyclopedia.

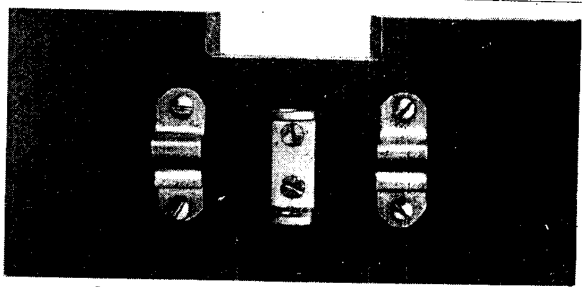
A standard pattern is illustrated in Fig. 1; this consists of an ebonite base with three square upright brass pieces mounted upon it, with studs equidistant from a central one. This acts as a pivot for a brass strip or contact blade, the end of which is provided with an ebonite handle. The two outer brass posts are slotted so that the contact blade can be inserted into either of them, thus completing the circuit from the central point to either of the outer contacts. Such an arrangement is known as a single-pole throw-over switch.

A somewhat similar arrangement, employing two sets of contacts, is illustrated in Fig. 2, and is known as a double-pole throw-over switch. This type can either be mounted on an independent base or the components can be directly mounted upon the panel, as the whole of the contacts and pivots are provided with screwed shanks, lock nuts and washers for that purpose.

The construction of a small throw-over switch suitable for mounting behind a panel of an amateur set is illustrated in Fig. 3, which shows the device from the back of the panel. It can either be built up on a small sub-base, as shown in Fig. 3, or the components can be directly mounted on the back of the panel. In either case it is operated in the manner shown in Fig. 4, by pressing the thumb on the rim of a large diameter ebonite disk, thereby rotating it.

This disk is attached to a spindle which carries a contact arm, which is free to rotate in a small U-shaped bracket bearing. Consequently, when the disk, which has a knurled end, is rotated, the contact blade is swung from one side to the other. Such an arrangement has the advantage that the unsightly appearance of this type of switch is avoided. Moreover, there is less dust in the interior of the set, and consequently there is a minimum of risk of parasitic noises and poor connexions due to the presence of the dust.

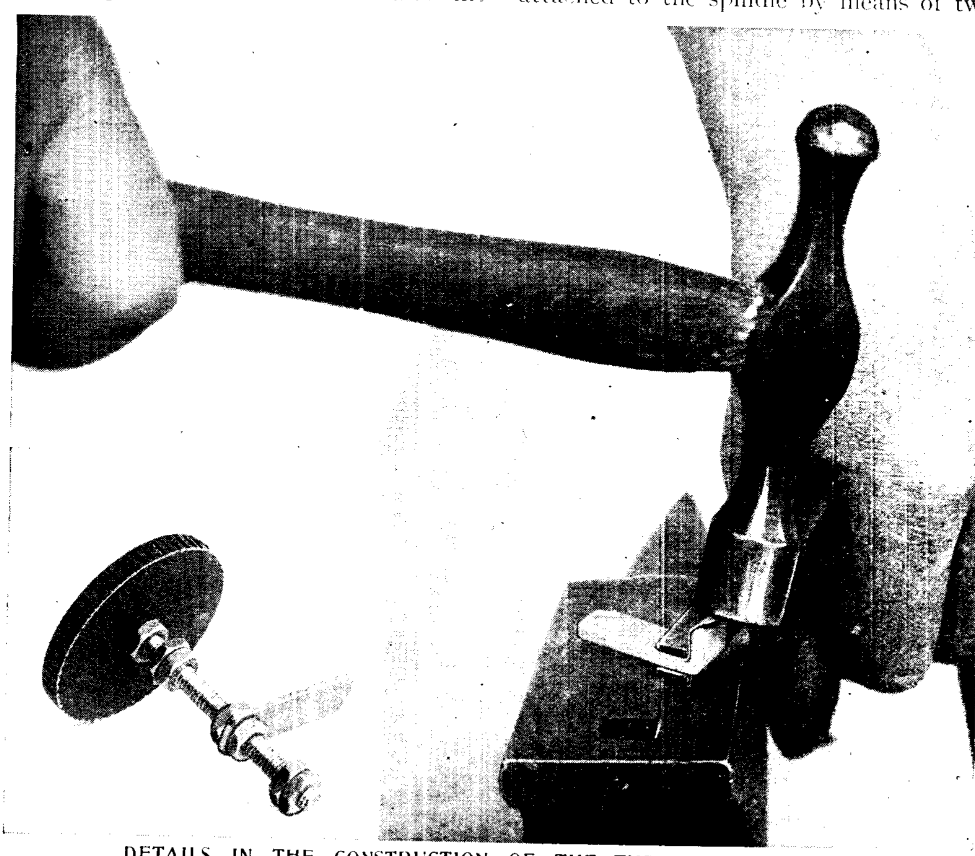
The dimensions for this type of switch may be varied through very wide limits, according to the space available. A convenient size is to make the ebonite disk $1\frac{1}{2}$ in. in diameter, the contact blade 1 in. in length, and the breadth of the bearing bracket between the two ends, in which the spindle rests, about $\frac{3}{4}$ in. apart. Details of the spindle and knob are clearly shown in Fig. 6, which shows that a piece of screwed rod about No. 4 B.A. can be used. The ebonite disk should have a hole drilled and tapped in the centre, and the edge of the disk should be knurled to provide a grip for the thumb.



BASE OF THE HOME-MADE SWITCH

Fig. 5. The central bearing piece in which the spindle turns is mounted between the two contact pieces. Note the inset in the base for the ebonite knob

The spindle is then screwed into the central hole and secured by means of a lock nut. Two nuts are screwed on to the spindle and run up nearly to the knob, their positions being quite clear from Fig. 6. The contact arm may be made from strip brass about $\frac{5}{16}$ in. in width, has a hole drilled near one end, and is attached to the spindle by means of two



DETAILS IN THE CONSTRUCTION OF THE THROW-OVER SWITCH

Fig. 6 (left). Knurled ebonite forms the actuating knob fixed on the spindle on which the contact arm is mounted. Fig 7 (above). Shaping the contacts by bending over a steel block and hammering. An anvil provides a useful resistance in this operation lock nuts. Two more lock nuts are required for the lower part of the spindle to keep it in position in the bearing bracket, as seen in Fig. 3.

The next step is to make the central bearing bracket, which is shown in Fig. 5. This is simply a U-shaped post, bent from a strip of brass about $\frac{5}{16}$ in. wide and $\frac{1}{16}$ in. in thickness. The two up-turned ends are drilled to allow the spindle to turn freely in it. Two holes are drilled and countersunk in the foot portion for attachment to the ebonite panel. The contacts can be made from hard, springy brass, copper or phosphor-bronze.

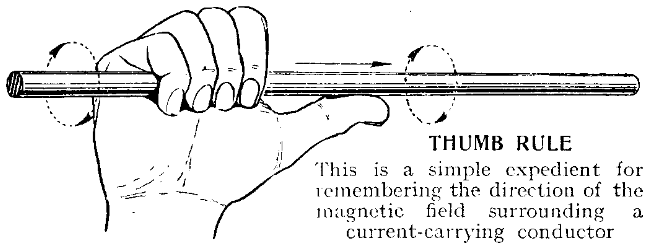
The simplest way to shape them is shown in Fig. 7, and consists of taking a piece of strip steel about $\frac{1}{4}$ in. in width and shaping it by bending it at right angles and slightly hammering the end. The strip to be shaped is then bent at right angles and held firmly in position in the angle of the piece of steel with the aid of a pair of flat-nose pliers, the upstanding portion of the contact blade being hammered over in the manner illustrated in Fig. 7. If done in this way all the contacts will be of uniform size and shape, and will require the minimum of cleaning up and finishing.

Holes are then drilled through the bottom part in order to attach the contacts to the panel or base. If round-headed screws be used, connexion can be made with them.

This switch can be used in several different ways, either by taking one wire directly to the spindle and other wires to the contacts; or pairs of wires can be taken to the contacts only and the blade used simply to complete the connexion between either pair of contacts. The latter is the better plan when it can be followed, as it obviates any chance of losses in transmission through the current having to pass through the spindle and the spindle bearings.

When completed, the spindle is inserted in its place, and the lock nuts adjusted so that it turns freely in its bearings. The exact position for the contact arm is then found by adjusting the nuts which secure it to the spindle. Its position having been ascertained, the nuts should be tightened up very securely, and preferably soldered to the spindle, as this will obviate any chance of their ever loosening and rendering the switch inoperative. *See* Switch.

THUMB RULE. Simple rule to indicate the direction of the magnetic field surrounding a current-carrying conductor. The figure shows a wire carrying an electric current in the direction shown by the



THUMB RULE

This is a simple expedient for remembering the direction of the magnetic field surrounding a current-carrying conductor

arrow. If the wire is grasped by the right hand so that the thumb points in the direction of the current, the fingers will point in the direction of the magnetic field. *See* Fleming's Rule; Maxwell's Corkscrew Rule.

TICKER or TIKKER. A rapid make and break device used as a receiver of continuous waves.

A ticker in a receiving set corresponds in function to a chopper in a transmitting set. As explained under the heading Chopper, on page 417, the waves in the case of a continuous wave transmitter occur at radio-frequency, and would be inaudible in a receiver designed for the reception of quenched spark signals. To make the signals audible the radio wave-train frequency is broken up into groups or isolated wave trains of audible frequency by means of the rapid make and break device called the chopper.

This breaking up of the continuous wave trains can equally well take place at the receiving end as at the transmitting end. Such a device is used for the reception of signals sent out by the Poulsen arc transmitter, for example. In the early Poulsen receivers a make and break circuit was made to function in a very similar way to the interrupter of an induction coil. This ticker was placed in series with the telephones which had shunted across them a condenser of large capacity.

The Austin ticker makes use of a rotary metal disk on the edge of which is cut a small groove in which rests a fine steel wire. The wire rests quite lightly in the groove, and when the wheel vibrates the wire chatters or oscillates up and down rapidly and so makes and breaks the circuit. The wire is partly curved to give a spring effect and the direction of rotation of the wheel is against the spring in order to make the chatter as pronounced as possible, so giving clearer signals. *See* Chopper; Tone Wheel.

TICKLER COIL. American term for the reaction coil or coupling device used to control the amount of current fed back from the anode circuit to the grid circuit in a regenerative set. *See* Armstrong Circuits; Coil; Reaction; Regeneration; Tuning.

TIGHT COUPLING. Degree of coupling between two inductances or circuits. The term coupling is used in this sense to indicate the placing of inductances, etc., in regard to one another so that electro-magnetic induction takes place between them. Examples of apparatus for coupling are spark coils, loose couplers, reaction coils, etc. If the coupling effect is approaching a maximum it is said to be tight coupling. *See* Coupling; Loose Coupling.

TIMED SPARK TRANSMITTER. A transmitter so devised that sparks take place with great rapidity, separated from one another by a time interval which is an exact multiple of the period of the radiating aerial system, thus producing an oscillation therein, which persists without complete disappearance, although there may be some variation of amplitude of the oscillation between consecutive sparks. *See* Rotary Spark Gap; Spark Gap.

TIME SIGNALS. Regular time signals are now sent out from a large number of stations all over the world, as well as being broadcast. The first signals were sent out twice a day from the Eiffel Station, and were intended chiefly to help navigation.

In 1912, as a result of an international conference, it was agreed to use an international code of time signals, and this code was put into operation on July 1st, 1913, from the Eiffel Tower, and is used for time signals by most other stations throughout the world. The Eiffel Tower Station also gives time signals on its original system, the latter signals at 10.44 and 22.45 Greenwich mean time, and the former or international signals at 09.23 G.M.T.

The Eiffel Tower (call sign F L) wavelength is 2,600 metres, and with most receiving sets a special loading coil must be used in order to make signals audible. The Eiffel Tower signals are complicated to the wireless listener-in who has not heard them before, but they are intended primarily for navigation. The signals are so arranged that the greatest accuracy is obtained, enabling captains of ships to check their chronometers. When signals are sent out automatically and received automatically a degree of accuracy approximating to over one hundredth of a second is attainable. When it is not possible to receive automatically or to send by automatic control, the degree of accuracy is only within one second or so and cannot be relied upon for less.

With the automatic method of sending out time signals an automatic transmission is made by suitable connexion to the pendulum of some standard clock. The time signals sent out each evening by the British Broadcasting Company from 2 LO are sent out in this way, the signals being automatically controlled by the seconds pendulum of the clock at Greenwich. In this case five successive seconds are broadcast, giving six beats of the pendulum, which are heard in the telephones or the loud speaker as curious sharp clicks. The sixth and last click indicates the exact time being broadcast. The B.B.C. also broadcasts each day the chimes of Big Ben at Westminster. The exact time given by Big Ben is the first stroke of the hour. Thus, if Big Ben is striking seven o'clock the first stroke of the seven indicating the hour gives the hour, and not the last stroke as is commonly supposed.

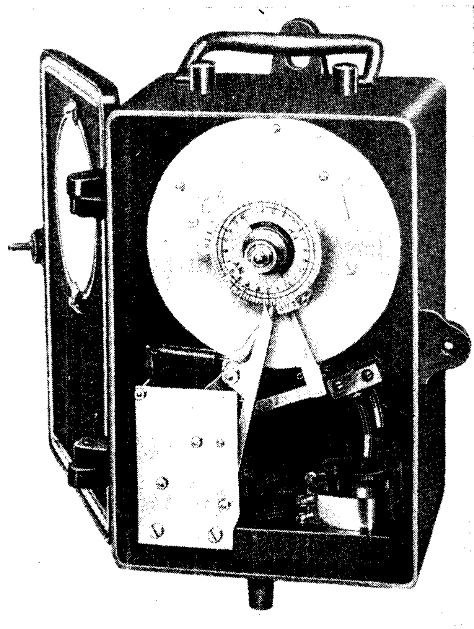
In the case of the Paris time signal, the one most familiar to British readers, a series of 300 dots, each formed by a single spark, is sent out. The 60th-61st, 120th-121st, 180th-181st and 240th-241st dots are replaced by a dash so that the listener-in may check his counting of the dots. The dots are sent out automatically by a pendulum control which beats 50 times every 49 seconds. These signals are compared at the time with the ticking of the standard clock at the Paris Observatory. This takes place at exactly one second intervals, so that the Paris time signals are vernier signals, and readings are made for the purposes on those beats which are coincident. There are, of course, six of these usually.

Before the time signals are sent out each day a series of dots are sent out for one minute and then a series of alternate dots and dashes for fifty seconds to serve as a stand-by warning. After ten seconds the time signal dots are sent out. These signals are read also by the Paris Observatory, which calculates the exact time for the first and last dot, and later each day (just before the 10.44 and 22.44 G.M.T. signals) the corrected times are sent out by Eiffel Tower. The time signals are sidereal time and may be converted to mean time from the usual standard time conversion tables.

Time signals are sent out in Europe from the Eiffel Tower (F L), 2,600 metres; on 15,500 metres at Bordeaux (L Y); on 23,450 metres at Lyons (Y N), in France; from Nauen, Germany (P O Z), on 13,000 metres, C.W., and 3,100 metres, spark; from Petrograd (R A C) and Moscow (R A T), 5,000 metres, in Russia; all daily. The times are as follow, but are subject to alteration.

Paris (Eiffel Tower)	00.23	International signals.
	09.58/10.00	Time signals (beats) in sidereal time.
	10.05	International Synoptic code (begins ON M)
	10.44	Old system time signals.
	21.58/22.00	Time signals (beats) in sidereal time.
	22.44	Old system time signals.
Lyons	08.00	Time signals (beats) in sidereal time.
Bordeaux	20.00	—
Nauen	11.57	International time signals.
	23.57	—
Petrograd	Irregular—Russian system	
Moscow	,,	Russian system

TIME SWITCH. A form of automatic switch which embodies a clock by which the circuit can be opened or closed at any predetermined time. The photograph shows a typical example of time switch. The clockwork mechanism is at the top within the large circular case. In the centre is the time selector, which is set by hand to the hour at which the switch is to operate. It will be seen that this is actuated by a trigger mechanism consisting of a rotating stop worked by the clock, which pushes the trigger at the appointed time. This motion releases a spring which causes the dippers to drop or come out of the mercury cups, shown at the bottom right-hand corner, according to whether the switch is to make or break contact.



TIME SWITCH

Clockwork mechanism, by which an electric circuit is opened or closed, is used to operate this automatic time switch

Courtesy General Electric Co., Ltd.

In some switches of this nature, day-indicating clocks are fitted which enable the switch to work only on certain days. Alternatively, they may be obtained to remain inoperative on any required day. The particular switch illustrated is a portable model, and is enclosed within a cast-iron casing having a glazed and hinged door. A handle is fitted at the top, while a lug is also provided, enabling it to be fixed to a wall if desired.

Such switches have many uses in general electrical engineering work, and are used extensively in charging circuits working off the mains, where they may be set to cut out of circuit when the charge is timed to be complete.

TIN. One of the metallic elements, chemical symbol Sn. Tin is a soft metal, white in colour, with a very low tenacity. The specific gravity varies, according to the treatment, from 7·14 to 7·30. The melting point of tin is approximately 232° C. The thermal conductivity is about 15 as compared with silver at 100. Its electrical conductivity is about 13 as compared with silver at 100. The most important use of tin in wireless work is in the form of tinfoil (*q.v.*), and also in the various alloys which it forms with copper antimony and lead.

TINFOIL. A thin sheet of metal consisting chiefly of tin. The term can be applied to thin sheets of pure tin or to a form which it frequently takes, of a very thin sheet of lead entirely coated with tin. The material is sometimes known as condenser foil and is available in various-sized sheets. One size which is commonly used is 14 in. in length and 11 in. in width. About 25 of these sheets weigh 1 lb. The thickness of the tinfoil is only about two or three thousandths of an inch or less.

Tinfoil is extensively used in wireless work in the construction of various forms of fixed condenser. In such an application the base of the condenser may be a plate of ebonite upon which a small piece of tinfoil is laid. This is followed by a dielectric, which may be waxed paper or mica. Alternate sheets of tinfoil and dielectric are then placed upon each other until the required capacity is obtained. Fig. 2 shows a characteristic use of tinfoil for such work.

For experimental purposes tinfoil can often be used for coating the exterior or other portion of a glass jar, somewhat in the manner shown in Fig. 3, such jars being needed for experiments in static electricity. The tinfoil for this purpose should be cut to the desired width and of sufficient length to encircle the glass, if possible, in one continuous piece. It should be carefully smoothed by resting it on a perfectly smooth flat surface, such as a clean piece of glass and gently wiping it over with a round ruler, piece of polished metal, or other article of a like character. This will speedily flatten the tinfoil, but it is necessary to manipulate the instrument at right angles to the length of the tinfoil, otherwise the material will be unequally stretched, and will not lie flat on the glass.

Tinfoil in such an application can be cemented to the glass by cleaning the glass thoroughly, warming it and then brushing it over with shellac dissolved in methylated spirit or with a thin shellac varnish. This must be applied evenly and as thinly as possible, and as soon as it is tacky the tinfoil can be pressed upon it. Another plan is to warm the glass and also to warm

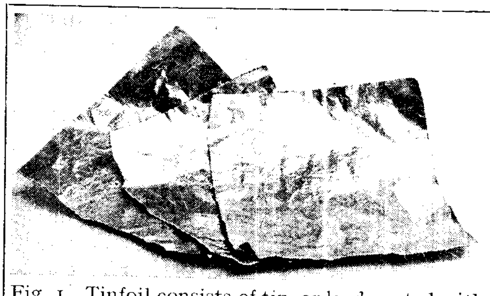


Fig. 1. Tinfoil consists of tin, or lead coated with tin ; it is largely used for condensers

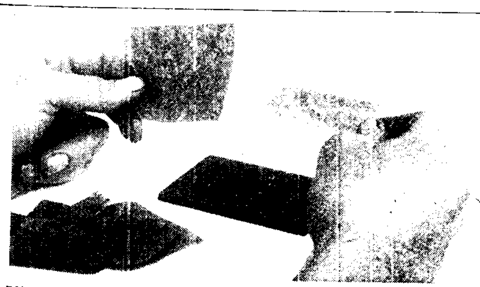


Fig. 2. Waxed paper or mica forms the dielectric between the tinfoil sheets of the fixed condenser

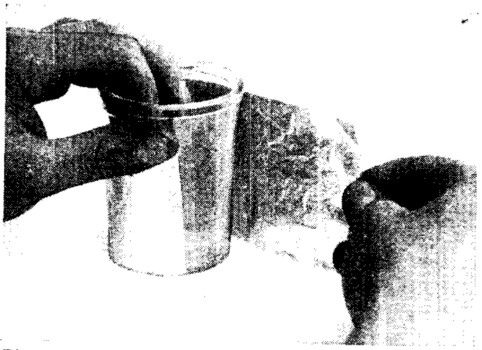


Fig. 3. Using tinfoil in the making of a Leyden jar ; a thin shellac varnish holds the foil in place

Fig. 4. Shellac varnish is used to hold the tinfoil plates of a Wimshurst machine

APPLICATIONS OF TINFOIL TO WIRELESS PRACTICE the tinfoil, work it tightly around the glass, and only cement the ends of the tinfoil, or the overlap, the joint being effected with shellac varnish.

Another use for tinfoil is in the construction of the plates of a Wimshurst machine, this application being illustrated in Fig. 4. In this case the pieces of tinfoil are cut to the required shape and are attached to the ebonite disk either with shellac varnish or a very thin solution of rubber or celluloid. They must be pressed very firmly in contact with the surface of the ebonite, allowed to harden, and are then slightly smoothed and rounded on the edges by lightly rubbing with a bone handle such as that of a toothbrush.

The expression tinfoil is often applied to other materials than pure tin, such as the silver paper of commerce. For experimental purposes this material can often be used as a substitute for pure tinfoil. If there is any choice between several pieces of this homely material, it is best to select that which, when lightly shaken, emits a metallic sound. The softer varieties often contain a large proportion of lead. In any case, only use those parts of a sheet which are perfectly free from pinholes and other imperfections.

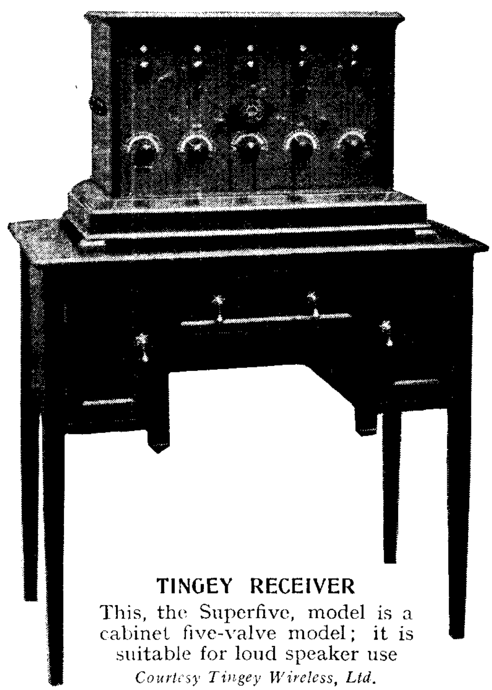
TINGEY RECEIVING SETS. Receiving sets bearing this name are the production of the Tingey Wireless, Ltd., well-known manufacturers of wireless apparatus and scientific instruments. The example illustrated shows the Tingey Superfive set complete in its cabinet and standing upon a table adapted for wireless work, drawers and cupboards providing storage space for telephones, batteries and other small impedimenta such as spare valves. It is claimed for this set that loud speaker reception up to 500 miles can be obtained under normal conditions, and that under reasonably favourable conditions reception up to 3,000 miles has been obtained.

A variety of different types of wireless apparatus are supplied by this firm that are characterized by efficiency and neatness. One special feature of the set illustrated and also of others bearing the same name is the use of special taps, connecting by means of a wander plug to a short length of flexible wire whereby various combinations are possible, such, for example, as the use of one or more stages of amplification, the plugs being introduced into whichever socket it is desired to employ for the particular combination required.

TONE FILTER. An arrangement of fixed condensers and choke coils, or both, in a receiving circuit whereby the steady anode current and the audio-frequency currents are directed along certain conductive paths to produce the best tone and reproduction in the telephones or loud speaker.

The loud speaker is operated by the audio-frequency currents flowing in the plate circuit of the last valve. This circuit also carries the positive current giving a potential to the anode of the last valve. This current is of a steady, unidirectional character, and has not a beneficial effect on the tone of reproduction from the loud speaker. The tone filter prevents this current from affecting the loud speaker by the presence of a fixed condenser arranged in series with it. In some types of tone filter a fixed condenser is inserted in each lead of the instrument. It is well known that a condenser completely stops the path of a unidirectional current, but offers a path of low resistance to an oscillatory and audio-frequency pulsating current.

As it stands, however, with the fixed condensers only, the arrangement is not practicable, as the steady plate current is



TINGEY RECEIVER
This, the Superfive, model is a cabinet five-valve model; it is suitable for loud speaker use
Courtesy Tingey Wireless, Ltd.

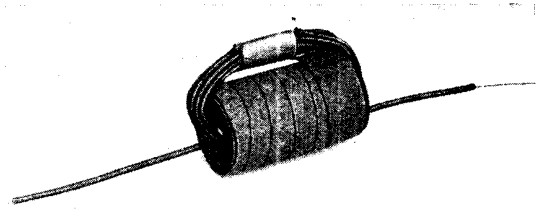


Fig. 1. Complete choke coil, showing the metal tube fitting over the ends of the wires forming the core

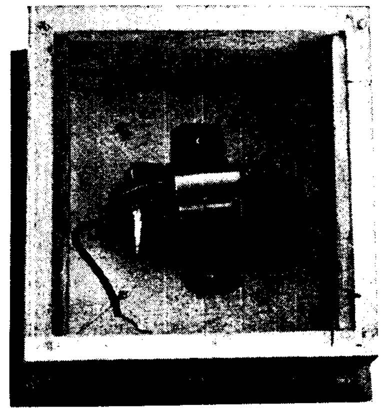


Fig. 2. How the choke coil is fitted in position at the bottom of the cabinet

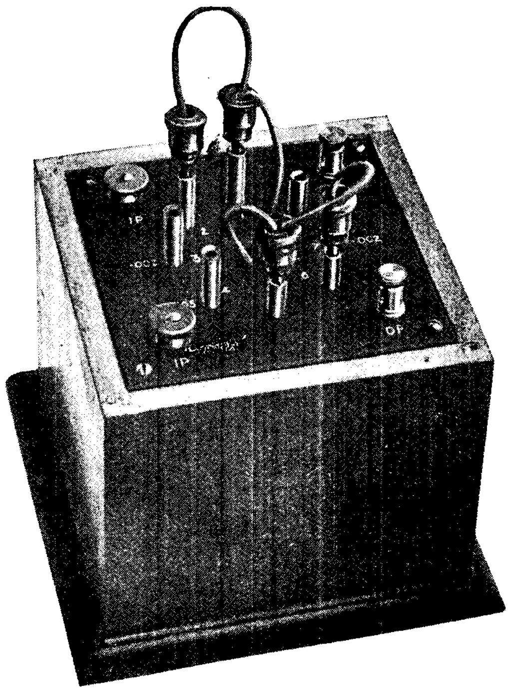


Fig. 3. Completed tone filter, suitable for use with a loud speaker to obtain pure reception

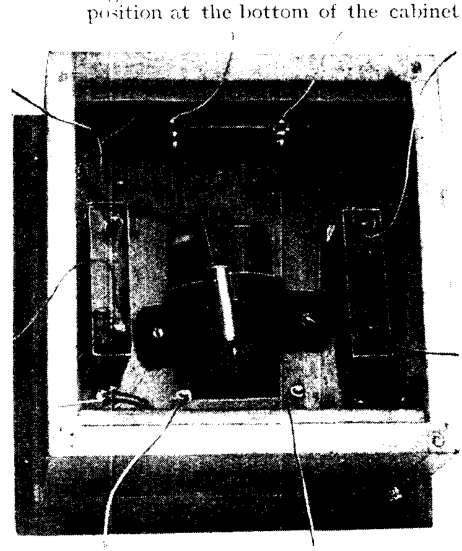


Fig. 4. Positions of the four condensers and connecting wires soldered to them

STEPS IN THE CONSTRUCTION OF A RELIABLE TONE FILTER

entirely blocked and the last valve therefore rendered inoperative.

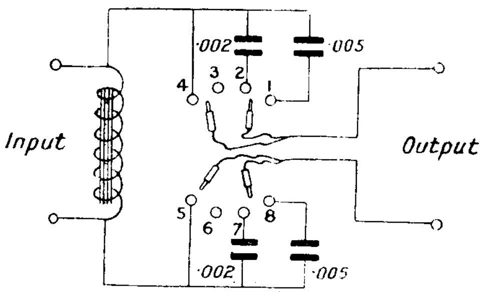
The trouble is overcome by the introduction of a choke coil, which is wired across the loud speaker and condensers. The choke coil consists of a high-value inductance, and although offering a comparatively low resistance to the steady plate current, gives a higher impedance to oscillatory or pulsating currents.

With this double arrangement of fixed condensers and choke coil the two currents are separated, and are directed along the paths where the most beneficial effects to good reception are felt.

It is of advantage to arrange the fixed condensers so that they may be interchanged with others of different value, or alternatively the values varied by plugging in additional condensers.

This arrangement is employed in the tone filter illustrated in Fig. 3. This instrument will be found to have extremely beneficial results on the purity of speech and music by means of loud-speaker reception, and by the plug-in arrangement of the fixed condensers the most suitable values can easily be found.

A square box is required measuring 4 in. on the side and having a depth of 3½ in. This may be fitted with an ornamental or moulded base to suit individual



WIRING DIAGRAM

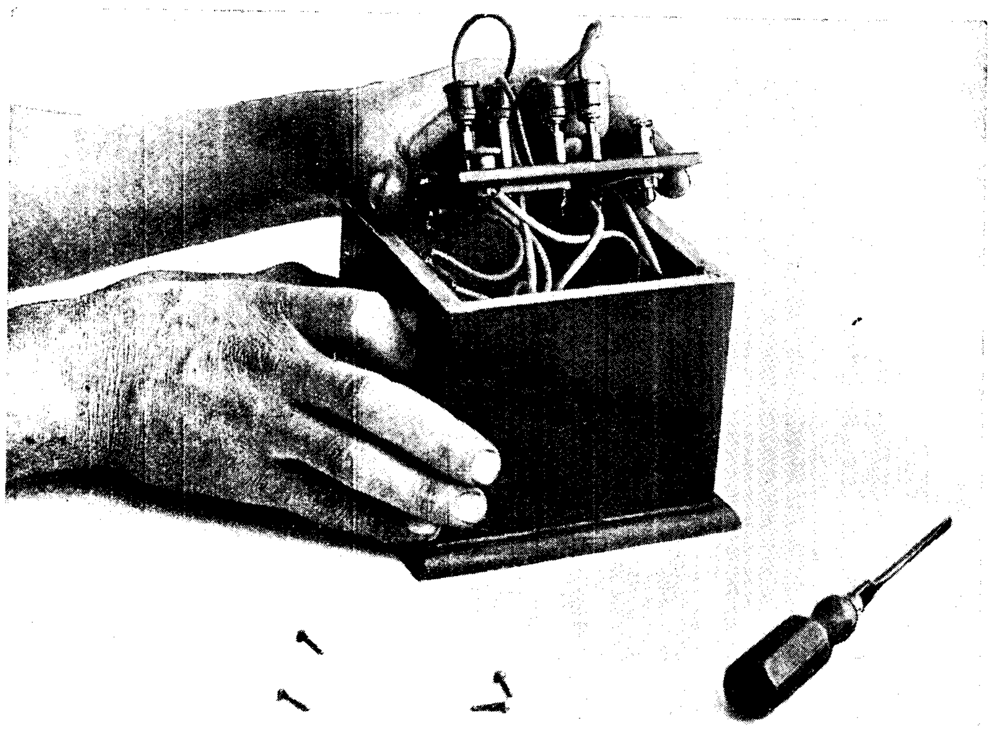
Fig. 5. Here is given the wiring of the tone filter, with details of the various values of the fixed condensers

requirements. On either of the two opposite sides of the box two ¼ in. square fillets are attached to the inside of the box so that an ebonite panel may rest on them, with the top side coming flush with the top of the box.

The panel, which is to be cut from good quality ebonite, should be a good fit to the inside of the box, holes being provided at each corner by which it is permanently screwed to it. In the centre of the panel a ⅜ in. hole is drilled, around which eight valve sockets are secured, forming two sets of fours. These may be spaced on a ring having a radius of 1 in. around the centre hole. At a distance of ⅝ in. from each adjacent side and at each corner, four terminals are secured for the input and output respectively. The input terminals are of the square, box-like variety, while the others are hole-type telephone terminals.

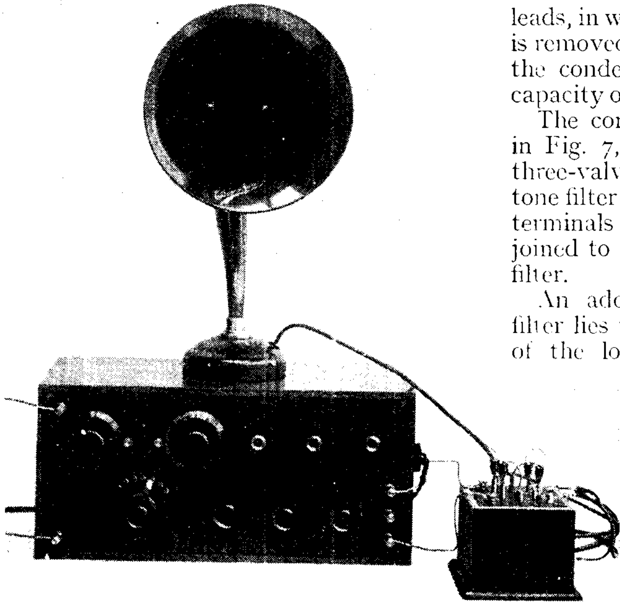
The choke coil used in the tone filter is as described under the heading Choke Coils. The core is composed of a number of soft iron wires pushed through the central hole of the bobbin and bent round to meet, where they are secured by a strip of bent-over metal to form a tube. This feature is illustrated in Fig. 1, which shows the completed choke coil. It is fastened to the bottom of the box in the position indicated in Fig. 2 by means of a strap of thin sheet ebonite, which is bent to shape by gentle warming.

Four fixed condensers are required, two having a value of ·002 mfd., and the other two of ·005 mfd. capacity. The two



LAST STAGES IN THE CONSTRUCTION OF THE TONE FILTER

Fig. 6. After the wiring of the tone filter has been completed the panel lid is securely closed down, care being taken lest the connecting wires should touch at any point



TONE FILTER IN USE

Fig. 7. How the instrument is connected in place between the telephone output terminals of the set and the terminals of the loud speaker

condensers of larger value may be of the Mansbridge type, and are attached to the base on either side of the choke coil, as shown in Fig. 4. The smaller condensers are screwed to the other two sides of the case. Higher value condensers, up to ·1 mfd., may be found necessary with certain types of loud speaker.

The wiring diagram is given in Fig. 5, which gives the values and positions of the condensers. Flexible leads are attached to the output terminals, their ends being taken through the central hole in the panel. Two wander plugs are fitted to the end of each flexible lead so that they may be inserted in adjacent sockets.

After all the connexions have been made, the panel may be fastened down to the box, taking care that the wires are not allowed to touch. The operation of closing the panel to the box is illustrated in Fig. 6.

In order that the sockets may be correctly located they should be lettered or numbered and marked with the condenser value appropriate to each socket. From the numbering shown in the circuit diagram it will be seen that when a plug on each flexible lead is attached to sockets marked 4 and 5, the condensers are cut out from the circuit. If desired, a condenser can be inserted in only one of the telephone leads, in which case the plug in either 4 or 5 is removed and inserted to introduce either the condenser of ·002 mfd. or ·005 mfd. capacity or both.

The completed tone filter is illustrated in Fig. 7, where it is connected up to a three-valve set, the input terminals of the tone filter being connected to the telephone terminals of the set, and the loud speaker joined to the output terminals of the tone filter.

An additional advantage of the tone filter lies in its protection to the windings of the loud speaker, which it preserves from the high potential from the high-tension battery. With the use of the tone filter there is no possibility of burning out the insulation of the loud speaker or of insulation breakdown caused by the high voltages required by the plate of the last valve. *See* Choke Coil; Interference Eliminator; Tuning.

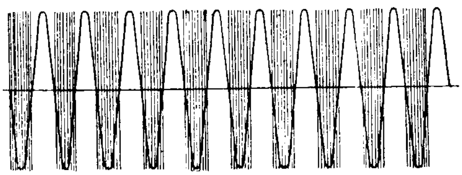
TONE TUNING. Tuning the parts of a set of receiving instruments to the note frequency for the transmitter, or to the beat frequency when the beat method of reception is in use. It is also known as note tuning. *See* Beat Reception; Heterodyne; Tuning.

TONE WHEEL. A commutator or interrupter, forming part of a receiving circuit, so arranged as to perform either of the following operations: (*a*) to produce rectification by running synchronously with the received oscillation; (*b*) to convert the high-frequency current into an alternating current of low frequency by running asynchronously with the received oscillation.

The tone wheel is a special form of ticker apparatus invented by R. Goldschmidt, and has been employed successfully to communicate between Germany and the United States. Essentially the Goldschmidt tone wheel consists of a toothed wheel which is caused to rotate at a constant speed. The pitch of the teeth is about 1 mm., and in between them is insulating material.

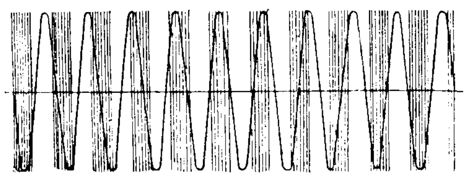
On the edge of this toothed disk presses a copper gauze brush covered with an insulating material which wears away with the copper. This copper brush is connected to one side of the receiving circuit and the tone wheel to the other. As the wheel revolves it alternately makes and breaks contact.

Stanley, in his textbook of wireless telegraphy, explains the action of the tone wheel as follows. Suppose an undamped wave reception is taking place on a wave-length of 6,000 metres, so that the oscillations in the receiving circuit have a frequency of 50,000. If the widths of the



H.F. OSCILLATING CURRENT

Fig. 1. A pictorial representation of high-frequency current when the oscillations are not heard in the telephones



TONE WHEEL EFFECTS

Fig. 2. Here is given a diagrammatic representation of how a tone wheel so modifies high-frequency currents that they become audio-frequency currents

teeth and the insulation between them are equal then there will be equal times, when the wheel is rotating, when the circuit will be made and broken. Suppose the wheel is rotated at such a rate that 50,000 makes and breaks are made each second.

When the wheel is rotating at this speed one half of each oscillation is wiped out and the other halves, at a frequency of 50,000, are available in the circuit. The current oscillations are as shown in Fig. 1, but it is clear they will not cause any sound in the telephones. Now suppose the wheel is rotated just a little faster or slower, so that there would be, say, 51,000 or 49,000 makes and breaks per second. The rectification in this case is not quite complete, and there will be a number of pulses in one direction followed by an equal number in the opposite. The diagram, Fig. 2, shows these pulses, which send pulses of current through the telephones at beat frequency. The note heard in the telephones will depend on the speed of the wheel.

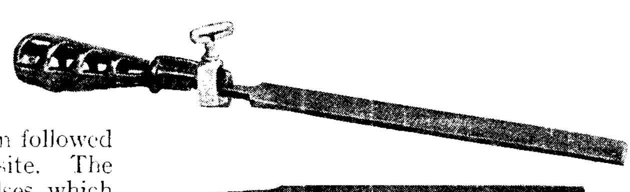
The Goldschmidt tone wheel is used for long-wave work. These waves have a low frequency, and the wheel, if used for short waves, would have to have such a large number of teeth and be driven at such a high speed that it would become a mechanical impossibility to keep the wheel running true for any length of time. *See* Beat Reception; Heterodyne; Ticker.

TONIC TRAIN. This is an alternative name for Interrupted Continuous Waves, fully dealt with under that heading in this Encyclopedia.

TOOL HANDLE. Name applied generally to a device adapted to be grasped by the hand and for the movement and control of a hand tool. Commonly used tool handles are made in several different shapes according to their particular purpose, in different materials, chiefly wood, and in various styles of finish. The common tool handles, such as those used for files, are generally made of beech or similar hardwood, circular in cross section and rather larger in diameter at the outer end than in the centre part of the handle.

The tool is usually fixed by means of a pointed part worked on the end of the tool called a tang which is often heated and forced into the centre of the handle. To prevent the wood splitting when the tool is driven in, a ferrule of iron or brass is fitted around the handle end. Chisel handles are made in various shapes. One known as the carver's handle is generally made of boxwood, polished and varnished, and is larger in diameter in the centre part of the handle than at the ends.

The ordinary chisel handle has a neck or small diameter portion near to the ferrule. It is shaped in this way because the carver's chisels and gouges are often manipulated solely by one hand. The carpenter's chisels are often worked by both hands, and the large portion at the end of the handle is more suitable for



ADAPTABLE TOOL HANDLE

This piece of apparatus can be rapidly adapted for use with a variety of tools. A clamp and thumb screw are used to hold the tool driving with a mallet. A hammer should not be used, as this tends to split the handle of the chisel. If only a hammer is available a small block of wood should be used between the top of the handle and the hammer head.

Screwdriver handles are often made T-shaped to give a larger purchase. A useful type of tool-holder or handle is illustrated. It is made of malleable iron, enamelled black. The handle portion is hollowed and pierced, and provides a sure and practicable gripping device. The outer end of the handle is provided with a clamp and thumb-screw. The tang of the tool to be used with this handle is inserted in the slot in the end of the universal handle, and is also passed through the clamp. The thumb-screw is then tightened up, thus holding the tool securely.

This type of tool handle is very useful for files, chisels and other tools which are only used occasionally, as it can instantly be removed from one tool and applied to another. To guard against accident all tool handles must be firmly and securely attached to the shank or tang of the tool. Tools with a tang should never be used unless provided with a suitable handle.

In general, the amateur will find it best to use the regulation ash chisel handles with a varnish finish for chisels and gouges, and boxwood carver's handles for files and carving tools, and the universal handles for use with tools that are only required occasionally. *See* under the names of the various tools, as Chisel ; File, etc.

TORIKATA, WICHI. Japanese wireless expert. Born 1883, he was educated as an electrical engineer at the Tokyo Imperial University. He began at once the study of wireless and telephony as assistant to Dr. Osuke Asano. Torikata is one of the inventors of the T.Y.K. arc and of wave telephony superposed on electric power transmission lines. He has been awarded many decorations for his services in wireless, and the medals of many scientific societies. He is director of the Electrotechnical Laboratory, Japanese Department of Communications.

TORQUE. Tendency to turn any body about an axis. The torque which is exerted by a force of one pound at a radius of one foot is called the turning moment unit. In popular language torque is the twisting effect of a force or number of forces acting upon a body. There is a torque exerted, for example, between the field magnet poles and the armature of an electric motor due to the electrical forces set up by the relative motion of the two. Torque is usually measured in foot-pounds.

TOSI, ALESSANDRO. Italian wireless expert. Born in 1867, he is famous for his invention, with Dr. E. Bellini, of the Bellini-Tosi direction-finder, on which he carried out a series of researches. In 1907 with Bellini, he invented the radiogoniometer and was awarded, with his co-inventor, a gold medal by the Italian and Belgian governments. The two have been awarded many prizes for their important invention, which is described in this Encyclopedia under the heading Bellini-Tosi Aerial.

TRAIN. Term used in wireless for a series or train of ether waves. *See* Waves.

TRANSFERS. Term applied to an article of commerce comprising a sheet of paper or other material the surface of which is coated in such a way that by suitable treatment any tracing or device on the surface of the paper can be transferred from it to the surface of some other material. In their application to wireless, transfers are usually in the form of printed characters or words of suitable size, and are used for application to the panel as a means of designating the function of the various parts of the apparatus.

Specific instructions are usually given for the application of the transfer, but generally the method is to damp the surface of the panel at the spot where the transfer is to be applied and the particular word or characters cut from the sheet of transfers, with one edge parallel with the bottom line of the panel. The transfer is then applied to the face of the panel, and pressed firmly into contact, with or without the application of heat, the back of the paper being damped with a cloth and the whole allowed to set. The paper can then be stripped off, leaving the transfer in position.

It will be appreciated that the tracing on the transfer appears in the reverse to that of the finished lettering. The use of transfers in this way overcomes one of the chief of the minor difficulties of the amateur wireless constructor, that of obtaining a neatly lettered panel. The transfers are fairly durable, and to increase their durability they may be finished with shellac or other insulating varnish.

TRANSFORMATION RATIO. In a transformer the ratio between the number of turns in the primary to that in the secondary. If the transformer is properly designed, practically all the flux due to the current flowing through the primary will cut every turn of the secondary winding. The E.M.F. induced in each turn of the secondary is equal to that induced in each turn of the primary, so that the ratio of the total primary to the total secondary E.M.F is the ratio of the number of primary turns to the number of secondary turns, the transformation ratio.

The transformation ratio is usually denoted by the letter T, so that a transformer with 100 primary turns and 1,000 secondary has a transformation ratio T of 1 to 10. *See* Transformer.

TRANSFORMERS: TYPES, USES AND CONSTRUCTION

The Best High- and Low-Frequency Transformers and How to Make Them, Fully Illustrated

This section begins with the general theory of the transformer, follows with descriptions of various types, and concludes with instructions for making a "push-pull" and a high-frequency transformer. See also Audio-frequency Transformer; Inter-valve Transformer; Quadrature Transformer; Shielded Transformer, etc.

In alternating current work a transformer is an appliance for producing in a secondary circuit an alternating voltage differing from that in a primary circuit.

The word transformer is to a large extent limited in application to static apparatus, or those without moving parts, but in the fullest extent of the term all appliances that transform one form of current or pressure into another can be classed under the heading transformer.

The essential purpose of any transformer is, as the name suggests, to transform or alter the pressure, and necessarily the amount of volume, in an inverse ratio. In this sense a motor generator is a converter or transformer of electrical energy, but is usually spoken of as a converter. In wireless work transformers are very extensively used, both of the static and rotary types, and of the latter several are dealt with in this Encyclopedia under their respective headings.

How the Transformer Works

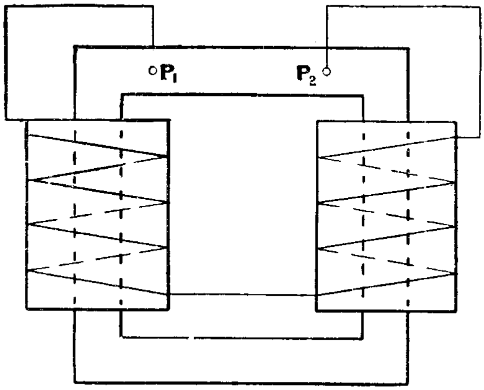
Static transformers are made in many different patterns, sizes and shapes, each adapted particularly to some specific purpose, but in its most elementary form a transformer consists of two coils of insulated wire, placed in proximity to one another and well insulated from each other. The first coil, or that in which the initial electric current flows, is known as the primary; the other coil as the secondary. Now it is well known that when a current of electricity flows through a coil of insulated wire, a magnetic field is set up in the vicinity, as is explained under the headings Electricity and Magnetism. Furthermore, when a coil of insulated wire is placed within a magnetic field of varying intensity, a current flow takes place through the coil, provided it forms part of a circuit. Consequently the transfer of energy from the primary to the secondary coil is effected by the magnetic field. Neglecting for the moment all questions of energy loss, and assuming a given magnetic field, the voltage and amperage of the secondary coil will be in a definite relationship to the E.M.F. of the primary coil.

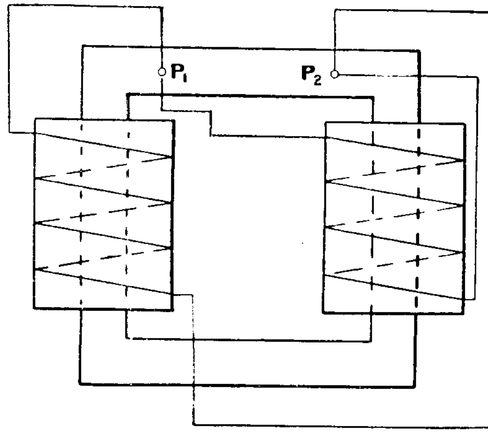
Step-up and Step-down Transformers

This relationship is determined by the number of turns of wire in the primary coil as compared with those in the secondary coil. When the turns in the primary are less than those in the secondary, the transformer is said to be a step-up transformer, as the secondary voltage will be higher than the primary. Conversely, a step-down transformer is one in which the secondary voltage is lower than the primary, the secondary winding having fewer turns than the primary.

In considering the action of a transformer it has to be realized that it does not change one form of power into another, but only changes one factor of power or energy. The fact that a transformer alters or increases the pressure does not imply that the transformer is a creator of power or energy, but every increase of pressure is accompanied by a corresponding decrease of current.

Whatever the design of transformer the product of volts and amperes flowing for a given time in the primary must be theoretically equal to that induced in the secondary. For example, if the primary of a transformer has 100 turns and the secondary 1,000 turns, the ratio will be as 1 : 10, consequently the voltage of the secondary will be 10 times that in the primary, but the amperage in the secondary will be one-tenth that of the primary.





TRANSFORMER WINDING

Fig. 1 (*a*; left). Theoretical series winding, and (*b*; right) theoretical parallel winding

Stated in figures, the same transformer, if it had 10 volts electro-motive force and a current of 5 amperes applied to the primary, would induce a secondary electro-motive force of 100 volts and a current of ·5, or one half an ampere, the product of the two being the same in both cases, viz. 50 watts. In all voltage-operated appliances a transformer is therefore of considerable value and application, as it is possible to apply to a circuit, or some part of a compound circuit, such as those in a wireless receiving set, a very strong voltage, or conversely to reduce a strong voltage to a weak one, but with a considerable amount of current.

Transformers are used in wireless sets for inter-valve couplings and for amplification purposes. The transformer does not amplify signals, but merely steps up or increases the plate voltage of the preceding valve, and such a transformer is known as a low-frequency amplifying transformer. Transformers for stepping up the incoming signals in an aerial circuit are generally of the open- or air-core type, and consist of two coils of wire without an iron core.

In this sense a vario-coupler or a loose coupler is a transformer, and acts in much the same way. Other applications are between the anode circuit of the last valve and the telephones. This type of transformer is known as a step-down or telephone transformer, and permits the use of low-resistance telephones or loud speakers.

In spark transmitting stations large iron-core transformers are used to produce high voltages such as are needed to jump the spark gap and charge the condensers. Electrical transmissions are also changed or boosted by the use of transformers, and other uses are to reduce the house supply current when alternating current is available, before it goes to a rectifier for conversion to direct current for filament-lighting or battery-charging purposes.

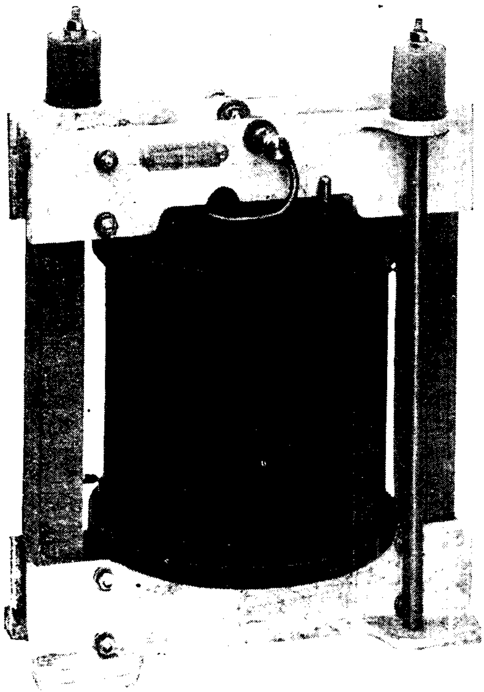
It has been stated earlier that the ratio between the primary and secondary voltages is directly proportional to the number of turns of wire of which they are composed, but this is only partially true, as no appliance is 100 per cent efficient. The most general losses in transformers are due to various causes, such as magnetic losses, core losses, eddy current losses, copper losses and hysteresis.

The latter is dealt with under that heading in this Encyclopedia. Magnetic leakage is due to the fact that the whole of the flux in the iron-core transformer does not pass through the windings.

In practice there is a slight leakage known as the leakage flux, because the current flowing in each winding will cause a small amount of flux to flow through its own coils, and this does not flow through the coils of the other winding, but flows round in the air spaces between them. This leakage flux is produced by the current in the particular winding, and sets up similar effects as self-induction in each winding. For this reason the windings should be as compact as possible. This also has the effect of ensuring that as far as is practicable all the flux due to the current flowing throughout the primary will cut every turn of the secondary winding.

Another loss that has to be considered is that due to the resistance of the windings. In most cases this is reduced by the use of the largest diameter of wire consistent with the purpose of the transformer. On the other hand, resistance wire is used in some high-frequency transformers, but in this case the resistance loss is of less importance than other effects which it is desired to obtain.

Eddy current and hysteresis losses are minimised by the use of laminations of special grades of iron.



TRANSMITTING TRANSFORMER

Fig. 2. This closed-core type has superimposed primary and secondary transformers. The coils are enclosed in ebonite and supported on a light metal framework

Courtesy Marconi's Wireless Telegraph Co., Ltd.

The efficiency of commercial transformers varies somewhat. In transformers of large size the efficiency of the instrument may rise as high as 97 per cent, but in the small and cheap transformers the loss of efficiency may be much greater, and be over 20 per cent.

Simple transformers are wound with the primary as one coil and the secondary as another, but in some cases the windings are arranged as two coils on the two legs of the core. The step-up ratio will then vary according to the manner in which the coils are connected. If, for example, the secondary has 100 turns for every turn of the primary, then if the primary and the secondary windings be in series, the ratio will be 1 : 100, but if the secondary be in parallel and the primary in series the ratio will be only 1 : 50. Parallel windings and series windings are shown in Fig. 1.

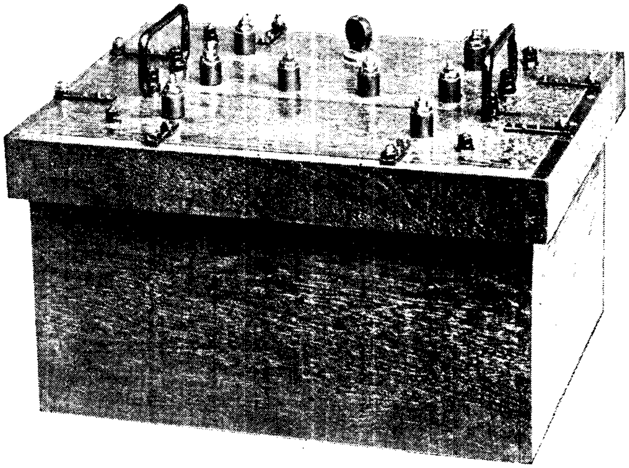
How Transformers are Wound

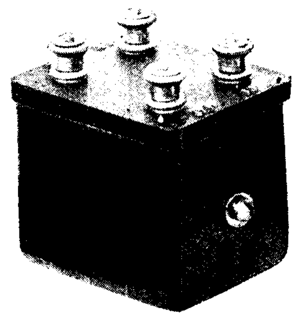
When the primaries are in parallel and the secondaries in series the ratio is 1 : 200, but only 1 : 100 when the secondaries are in parallel and associated with primaries in parallel. An application of this fact is dealt with in the push-pull type of transformer, dealt with later. Large transformers call for special attention, particularly with regard to the insulation of the windings and to the cooling of the instrument. To protect the windings to some extent a common custom is to connect the centre of the secondary windings permanently to earth, as this virtually halves the maximum voltage likely to be impressed on the insulation should a leak to earth occur.

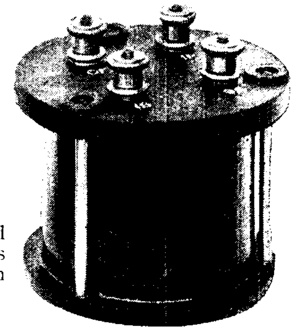
Transformers of large size are cooled by immersion in transformer oil, or in smaller types by enclosing the windings in a well-ventilated case and trusting to convection to dissipate the heat.

Transformers for dealing with H.F. currents or for transferring energy from one oscillatory circuit to another are generally of the air-core type. They consist of equal turns of wire wound very closely together. The primaries are preferably adjustable, as by tapping, or may be tuned by a condenser of low value shunted across the primary. Transformers of this type have a certain natural L.F. value, due to their inductance and self-capacity, and only amplify at a maximum waves that are received at this particular frequency. Consequently this type of transformer is generally designed to cover a comparatively short band of wave-lengths.

When the transformer windings and proportions are such that they cause a particularly marked transference of energy from the primary to the secondary at one particular frequency or wave-length it is said to be periodic. H.F. transformers which are reasonably efficient over a comparatively wide range of frequencies or wave-lengths are said to be aperiodic. In one pattern of H.F. transformer, as made by the Marconi Co., the windings are carried out with a special resistance wire







VARIOUS TYPES OF TRANSFORMERS

Fig. 3 (above). This Marconi type is enclosed within a lined box filled with oil. Figs. 4(*a*) and 4(*b*) (right) are by the Fuller's United Electric Works; windings and cores are enclosed in cast iron to minimise interference

which has the effect of partially damping the magnetic field.

When such a transformer is located in a circuit between the anode of a first valve and the grid of a second, the amplified changes of high-frequency current pass through the primary winding and induce amplified oscillatory currents in the secondary windings, which are passed on to the grid of the second valve.

In other examples of high-frequency transformers tuning is effected with damping plates.

An example of a ½ kilowatt transformer by Marconi's Wireless Telegraph Co., Ltd., is illustrated in Fig. 2, and consists of the closed-core type with superimposed primary and secondary windings, and neither of these windings is adjustable. The coils are enclosed in an ebonite casing supported on a light metal framework.

Such a transformer would be used in the circuit of a ½ kilowatt ship's set, such as those used for the smaller passenger boats employing a spark transmitter.

The transformer illustrated in Fig. 3 is a component of the Marconi Co., and is supplied for use with their 1½ kilowatt marine transmitters. It is enclosed within a stout wooden box which is specially lined internally, and which is kept full of oil of a high flashpoint. The windings, which are tapped and whose ends are brought to the terminals shown at the top of the box, are heavily insulated, apart from the insulation derived from the oil.

Four primary and four secondary terminals are fitted. The former are arranged in the outer positions, while the latter are all in one straight line down the centre of the cover. At the rear of the cover is a plug for filling and draining the oil, while handles are also fitted to allow of easy transporting about the cabin.

The ledge naturally formed by the shape of the box beneath the cover is lined with a resilient packing to prevent oil leakage, while straps are fitted from the cover to the edges of the box to ensure absolute oil-tightness being maintained under seagoing conditions.

Fig. 4(*a*) and Fig. 4(*b*) show two good types of inter-valve transformer as made by the Fuller's United Electric Works, Ltd. In these examples the transformer winding and core are enclosed in a cast-iron casing, the top of which is closed with an ebonite plate to which are attached the terminals for connexion to the primary and secondary windings. The feature of enclosing the transformer windings is to avoid interference from stray magnetic fields or other causes, which might set up noises in the telephones.

Another type of inter-valve transformer suitable for low-frequency use is the Gecophone, illustrated in Fig. 5. In this case the core entirely surrounds the primary and secondary windings, the terminations of which are brought out by clip terminals attached to an ebonite bar mounted on side supports attached to the laminated core.

The Sterling low-frequency transformer is illustrated in Fig. 7, and is similar in essential principles to the previous example; but in this case the windings are set in a vertical plane, and the very substantial laminated core is disposed horizontally. Mounted in this way, the transformer occupies the minimum of height, which is often a convenience when planning a cabinet receiving set. Soldering tags are provided for attachment of the connecting wires to the primary and secondary windings.

The Maxvol low-frequency transformer is illustrated in Fig. 6, and is of the upright variety intended for inter-valve coupling for low-frequency amplification purposes. In its general characteristics it follows accepted practice, in that the coil windings are disposed horizontally and arranged within a closed laminated

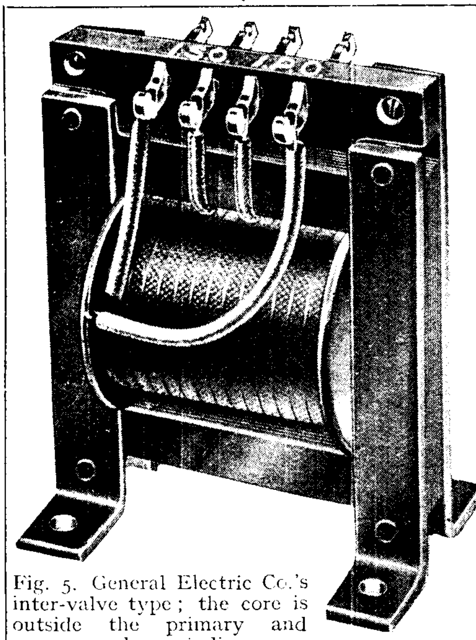


Fig. 5. General Electric Co.'s inter-valve type; the core is outside the primary and secondary windings

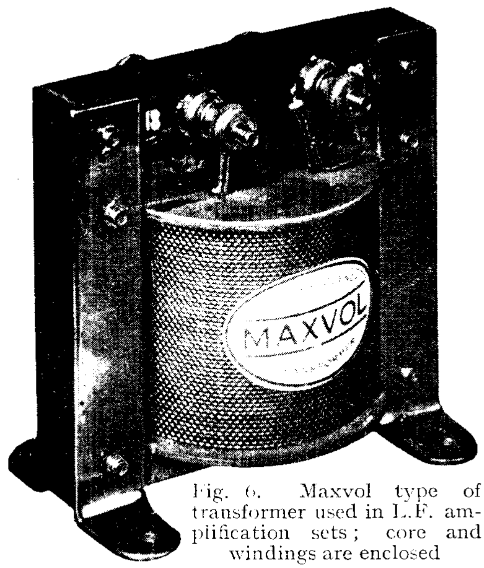


Fig. 6. Maxvol type of transformer used in L.F. amplification sets; core and windings are enclosed

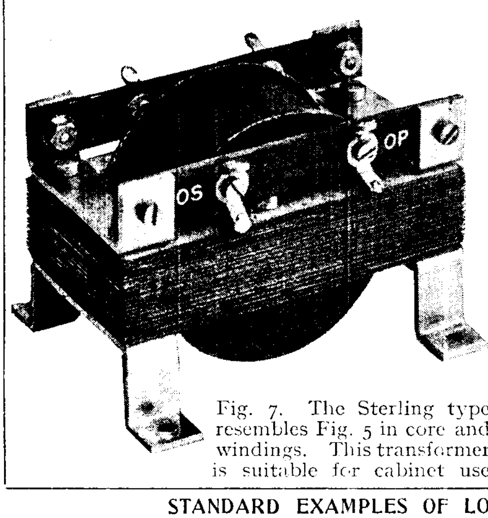


Fig. 7. The Sterling type resembles Fig. 5 in core and windings. This transformer is suitable for cabinet use

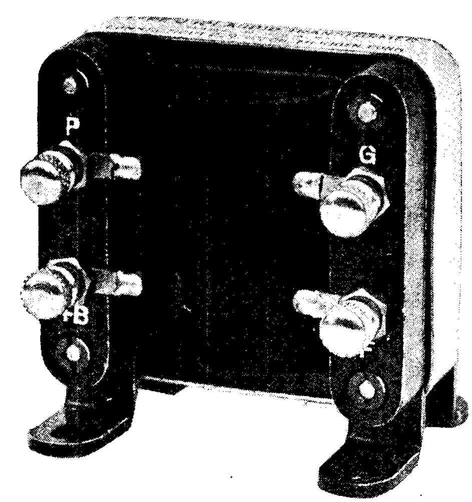


Fig. 8. This, the Connecticut, L.F. transformer, is enclosed by pressed metal shields

STANDARD EXAMPLES OF LOW-FREQUENCY TRANSFORMERS

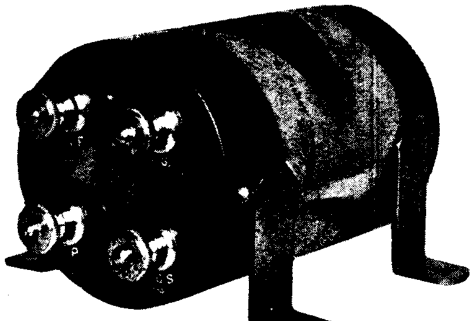


Fig. 9. The Eureka is a somewhat unusual type in which the whole is encased in a sealed cylinder of metal
Courtesy Electric Appliances Co., Ltd.

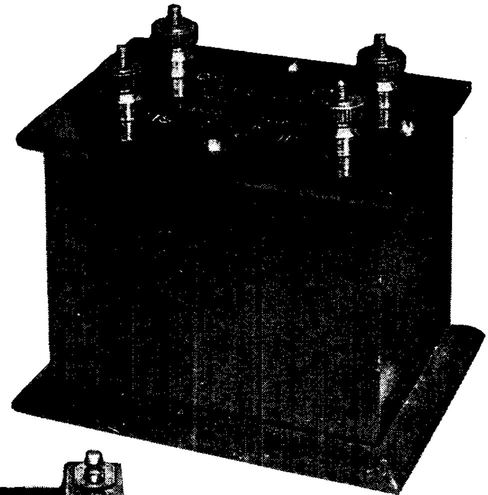


Fig. 10. Enclosed in a wooden case, this example has a transformation ratio of 3 : 1. It is a L.F. type

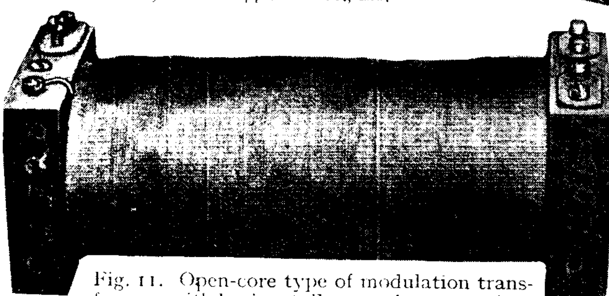


Fig. 11. Open-core type of modulation transformer, with horizontally superimposed windings, for use in small transmitting sets

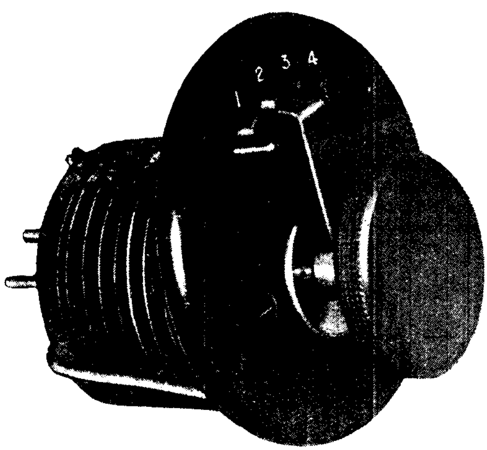


Fig. 12. Variable H.F. plug-in transformer for a wide range of wave-lengths
Courtesy Economic Electric Co., Ltd.

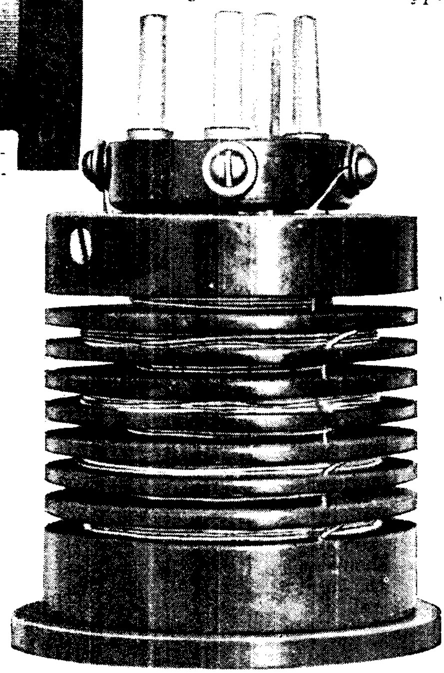


Fig. 13. This H.F. example, fitted with standard valve plugs, forms a very convenient accessory to efficient reception
Courtesy L. McMichael, Ltd.

HIGH- AND LOW-FREQUENCY TRANSFORMERS FOR SPECIAL PURPOSES

iron core, to the top of which is attached an ebonite insulating bar providing support for the terminals.

A very good type of shrouded transformer for audio-frequency amplification is the Connecticut, illustrated in Fig. 8. In this example the transformer is entirely enclosed by pressed metal shields, enabling it to be placed in a receiving set with little interaction effect.

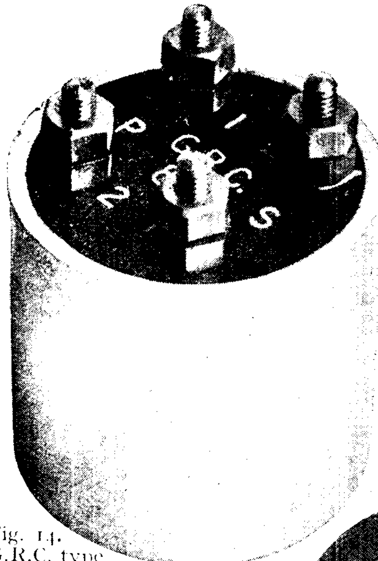


Fig. 14. G.R.C. type H.F. transformer, with an aluminium casing surrounding the windings

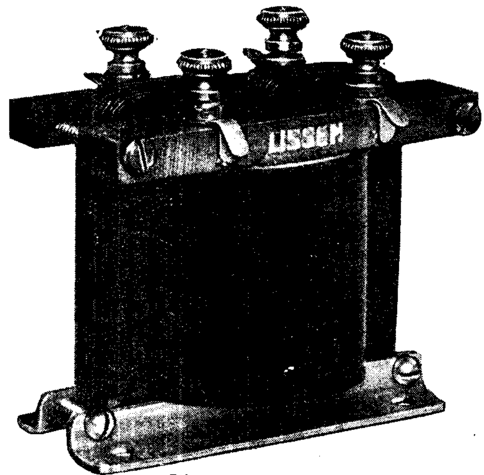


Fig. 15. Lissen type T.3 transformer, with a laminated iron core in two sections

Fig. 16. Marconi Scientific Instruments Co.'s transformer. The windings are made round an ebonite rod; the instrument is aperiodic

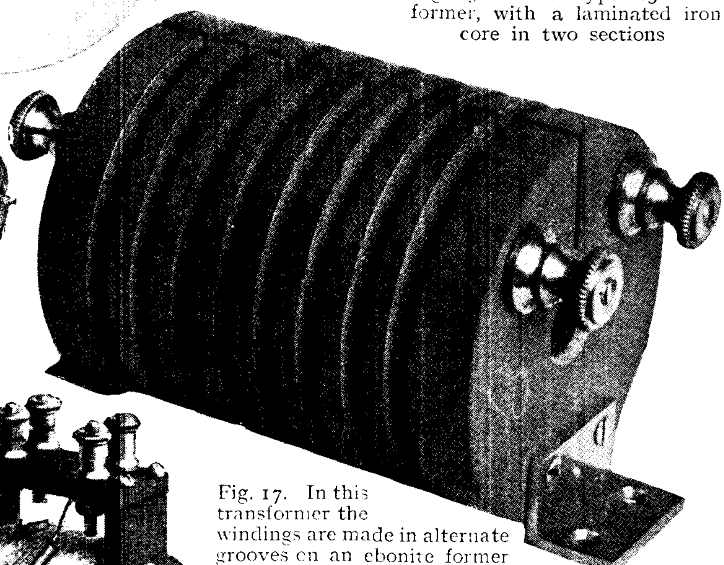


Fig. 17. In this transformer the windings are made in alternate grooves on an ebonite former
Courtesy Economic Electric Co., Ltd.

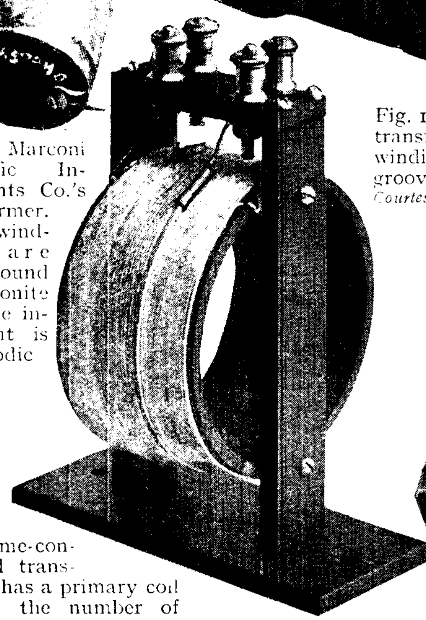


Fig. 18. This home-constructed transformer has a primary coil of half the number of turns of the secondary coil

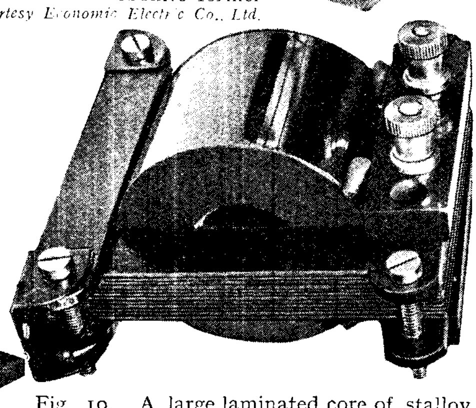


Fig. 19. A large laminated core of stalloy is embodied in this T.2 transformer by the Lissen Co.; it is tested up to 1,000 volts

FURTHER TRANSFORMERS OF PROVED EFFICIENCY FOR WIRELESS USE

An admirable transformer of the shrouded type is the Eureka, made by the Electrical Appliances Co., Ltd., and illustrated in Fig. 9. This is a departure from the usual design of transformers in that the windings are separately prepared and the whole is enclosed within a cylindrical metal case closed with a metallic end cap. Four feet are attached to the case so that the instrument can be fixed to the back of the panel, or in any desired position. The windings terminate on one end plate in terminals mounted firmly on insulated bushes. The whole transformer is sealed and damp-proof, and gives very pure amplification entirely free from distortion.

Transformers Enclosed in Cabinets

For experimental purposes the transformer illustrated in Fig. 10 has much to commend it, as the instrument is enclosed in a polished wood case with an ebonite top. The terminals of the primary and secondary windings are carried through the top, and are instantly available for connecting into the circuit. When used for low-frequency inter-valve coupling these transformers have a ratio of 3 : 1.

The modulation transformer shown in Fig. 11 is of the open-core type, with superimposed windings arranged horizontally. The windings are supported by a bobbin which surrounds the core and is attached to ebonite end plates, to the upper parts of which are fixed the terminal tags for attachment of the conductors. Transformers of this pattern may be used in small transmitting sets to modulate the transmitted signals.

As has previously been explained, the high-frequency transformers are not as a rule provided with iron cores. Moreover, they are usually small in size, at least, so far as they apply to the average wireless receiving set used by the amateur. In one pattern, illustrated in Fig. 13, as made by L. McMichael, Ltd., the primary and secondary windings are wound in grooves in the outer edge of a block of ebonite. Several of these grooves are turned, and the windings are disposed alternately between those of large and small diameter.

In this way they are subjected to the full intensity of the lines of magnetic force. The ends of the windings are brought out at the lower end of the transformer and connected in the standard manner for valve sockets. Arranged in this way, a transformer of any given value can be plugged in a standard valve socket and wired up to any part of the circuit.

Transformers of this type have to be proportioned as regards their windings to suit the wave-length it is desired to receive. To overcome this difficulty to some extent, the type of high-frequency transformer illustrated in Fig. 12, as supplied by the Economic Electric Co., has a series of tappings taken from the windings so that their values can be altered within limits, and thus increase the range of wave-lengths for which the transformer is suited.

Another pattern, illustrated in Fig. 14, as supplied by the General Radio Co., comprises a shrouded construction consisting of an aluminium body which contains the windings. These terminate in the customary terminals on the upper part of the transformer. This transformer is specially intended to be used in conjunction with a variable condenser of low value, which should be shunted across the primary winding.

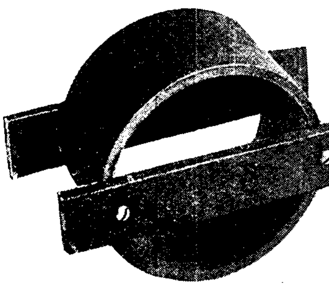
In a further pattern of high-frequency transformer intended for panel mounting, and illustrated in Fig. 17, a series of grooves is turned on a block of ebonite and the primary and secondary windings wound in alternate grooves.

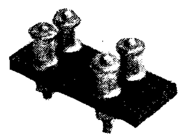
Various Well-known Commercial Types

The transformer illustrated in Fig. 16 is made by the Marconi Scientific Instruments Co., and consists of two windings on an ebonite bar. In this case the transformer is aperiodic and tunes over a fairly wide band of wave-lengths, usually sufficient for all ordinary B.B.C. transmissions. A feature of this transformer is the use of resistance-wire winding.

The Lissen type T.3 low-frequency transformer is illustrated in Fig. 15, and is sold under a guarantee. It is a more or less standard arrangement, comprising a laminated iron core, which, however, is made in two separate sections with the coil winding around the two portions of the core, which run through the centre of the windings.

In the T.2 type of low-frequency transformer, illustrated in Fig. 19, a ratio of 4 to 1 is employed; it has a large-sectioned core built up from laminae of stalloy. Transformers of this type are tested between winding and winding and between the frame to a voltage of 1,000, and also tested for other leakages. The plates and feet for fastening the transformer





SIMPLE CONSTRUCTION OF H.F. TRANSFORMER

Fig. 20. Ebonite former and side supports for the transformer shown in Fig. 18. At the right is the top plate with the four terminals

to the cabinet are disposed in the form of clamps with clamping screws outside the core. This small detail tends to eliminate stray eddy currents in the core, and leads to purity of reproduction.

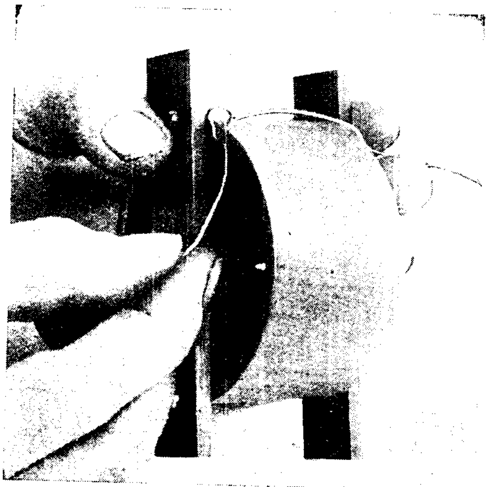
The construction of a type of high-frequency transformer is not a difficult matter. The important item is in the proportioning of the windings. For high-frequency work this is generally unity—that is, there are an equal number of turns in the primary and secondary. Fine gauge wire is used. But in some circuits the transformer is of the step-up character. This principle is adopted in the example illustrated in Fig. 18. The primary consists of half the number of turns of the secondary.

In the construction adopted the base is a piece of ebonite $\frac{3}{16}$ in. thick, 3 in. long and $1\frac{1}{2}$ in. wide, on which are fixed two uprights united at the top by a cross-bar of the same material, with supports for the terminals. The ebonite tube former, 3 in. in diameter, is located between these uprights, and upon this are wound the primary and secondary windings.

The first step in construction is to cut the former tube to the requisite length, in this case $1\frac{1}{4}$ in. The side pieces are prepared next, and measure $\frac{1}{2}$ in. in width, $\frac{3}{16}$ in. in thickness and $4\frac{1}{4}$ in. in length. Notches or recesses are filed across the diameter of the ebonite former, the side pieces fitted into the notches and secured with round-headed brass screws tapped into the former. The top plate is cut to fit the top of the side supports, screwed to each with two screws and provided with four terminals, which are clearly visible in Fig. 20.

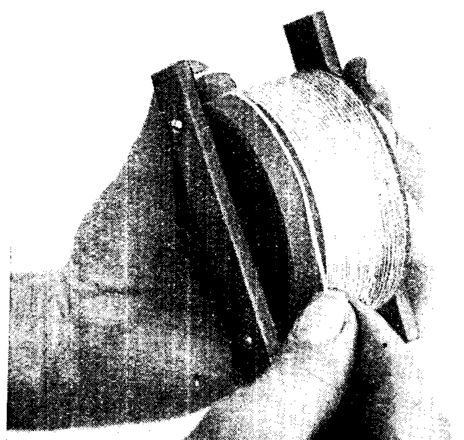
The base is then prepared and the two uprights secured to it with four screws in a similar manner to the top bar, after which it is removed, and the top bar, for the winding operation.

The secondary is wound first, and is commenced by twisting the wire through two small holes drilled near the edge of the former, as shown in Fig. 21. The wire is then wound on by hand, keeping each turn as tight and close as possible, the operation being illustrated in Fig. 22. A sufficient surplus of wire should be left at the commencement and finish for connexions,



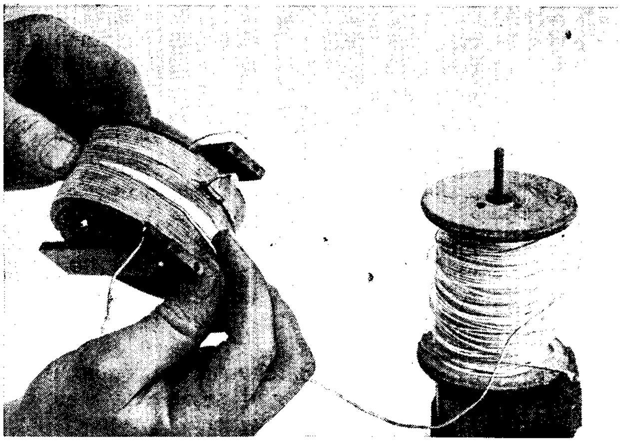
BEGINNING THE WINDING

Fig. 21. The wire of the secondary is first twisted through two small holes as shown



WIRING IN PROGRESS

Fig. 22. How the winding is carried out; each turn should be kept as tight as possible



LATER STAGE IN THE WINDING

Fig. 23. Here the primary is being wound over the central portion of the secondary; it should be carried out over a single turn of oiled silk

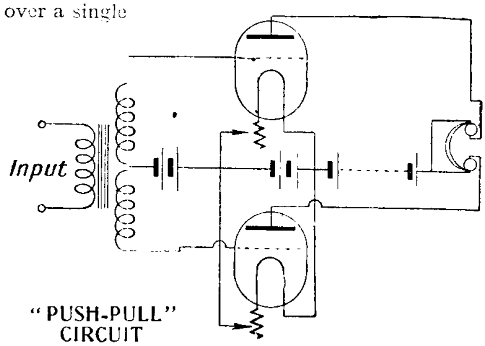
the finish of the wire being carried out in the same way as the commencement, by threading through two small holes.

The primary winding occupies the centre portion of the secondary winding and is applied in a similar manner, except that it should be wound upon a single turn of oiled silk to improve the insulation qualities. The method of winding is clearly shown in Fig. 23.

When the windings are completed the whole may be given a coat of shellac varnish, celluloid varnish or other insulating compound. This will help to keep the winding in its place. The ends of the windings are then connected to their terminals and the top plate screwed to the side pieces, as shown in Fig. 25, after which the base is screwed into position and the transformer thereby completed. It should be tested for electrical continuity in the usual way.

A push-pull transformer is a type of iron-core low-frequency transformer in which the primary and secondary coils are tapped at their centres to form separate circuits. A simple form of low-frequency amplifier circuit using a push-pull transformer is illustrated in Fig. 24. The primary of the transformer is connected to the output of the receiving set, while the secondary has a central tap connected through a suitable grid-biasing battery to low-tension negative and the valve filaments.

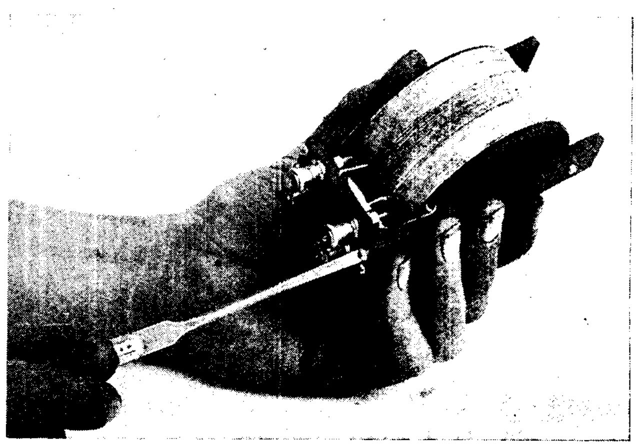
The other ends of the secondaries are connected to the grids of the valves. In operation the action of the two secondary coils will be at 180° out of phase with each other. The result of this is that when a positive impulse is affecting the grid of one valve the other will be negatively affected. In the next half-cycle of operation the reverse will take place. Great



"PUSH-PULL" CIRCUIT

Fig. 24. This diagram illustrates how a push-pull transformer is used in a simple two-valve L.F. amplifier circuit

amplification is claimed with this method of connecting audio-frequency amplifiers, as

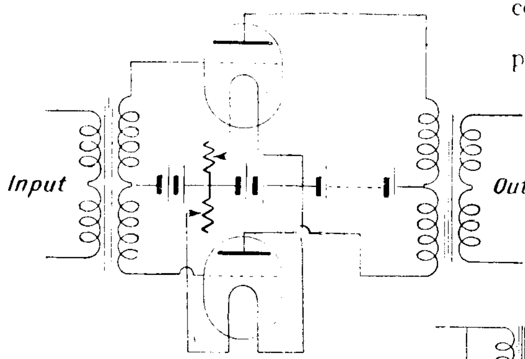


ASSEMBLING THE TRANSFORMER

Fig. 25. After the connexions have been made the top plate is assembled. A coat of shellac varnish should be applied to the windings to hold them in position and for insulation

owing to the damping action on each valve by the other a considerable amount of feed back is possible, if regeneration at audio-frequency is desired.

From the illustrations of circuits employing push-pull transformers it will be seen that the arrangement of the tapped transformer allows the valves to be virtually wired in parallel.



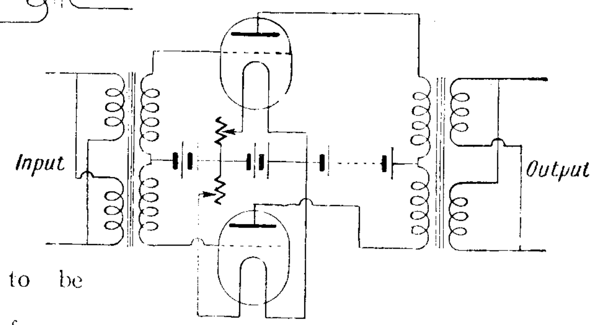
TWO TRANSFORMERS IN USE

Fig. 26. How two push-pull transformers are employed, the two halves of one primary and one secondary being connected in series

In Fig. 24 a second push-pull transformer is dispensed with by connecting the anodes of the valves to separate earpieces of a telephone head set, the remaining connexions of the telephones being connected to high-tension positive.

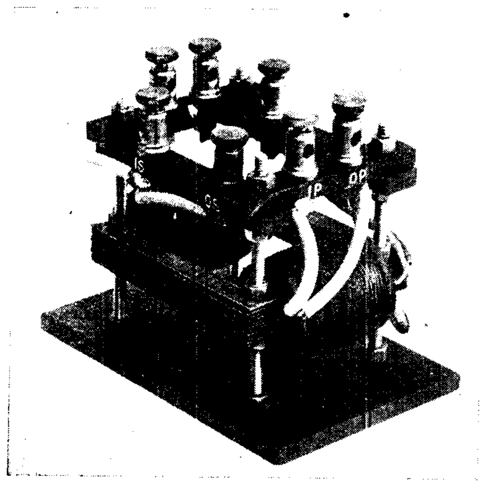
The circuit shown in Fig. 26 employs two push-pull transformers in which the two halves of the tapped primary of the input transformer are connected in series, which arrangement is also adopted in the secondary of the output transformer. A similar circuit in which these coils are connected in parallel is shown in Fig. 27.

Considerable amount of experiment with push-pull transformers can be made along the lines suggested by the diagrams in Figs. 26 and 27. An easily constructed transformer of this type is illustrated in Fig. 28, and consists of two separate coils, each containing a primary and secondary winding, the ends of which are connected to



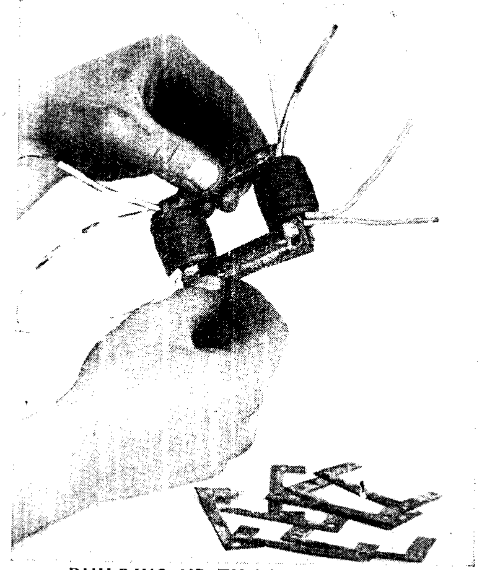
TRANSFORMERS IN PARALLEL

Fig. 27. Two push-pull transformers are used here, the two halves of one primary and one secondary being connected in parallel



PUSH-PULL - TRANSFORMER

Fig. 28. This transformer is easily made by the amateur; it is of the push-pull type, with the terminals arranged on the top for convenience in experimental work



BUILDING UP THE TRANSFORMER

Fig. 29. Above is illustrated the method of assembly of the laminations to the coils in the home-constructed push-pull transformer

CONSTRUCTIONAL DETAILS

Fig. 30. The transformer laminations are kept in position by four brass rods, which form feet to support the transformer

ebonite strips arranged at the top of the instrument. This arrangement enables a number of different methods of connexion to be tested without alteration to the transformer.

The constructor should buy the transformer bobbins already wound, as this part of the construction is tedious. The coils should have a ratio of about 4 to 1 between secondary and primary and should be about $1\frac{1}{2}$ in. in diameter and $1\frac{1}{4}$ in. deep.

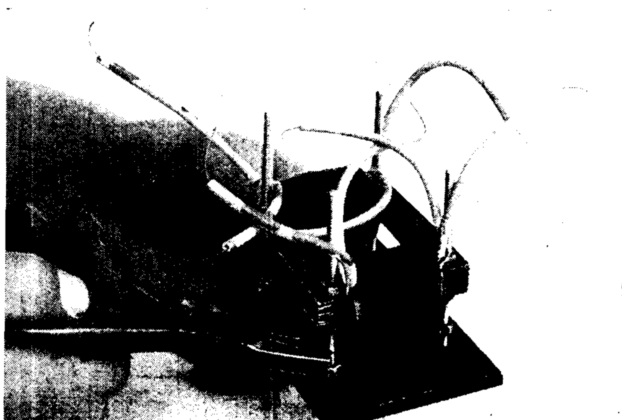
The transformer is of the closed-core type, the core consisting of a number of soft iron laminations. These may be cut to shape from thin gauge sheet iron or may be purchased ready for use. About 50 laminations are required, and should measure $2\frac{3}{4}$ in. on their long side. For the short sides two different lengths are required, one lamination being $1\frac{1}{4}$ in. long and the other $\frac{3}{4}$ in. The object of the different-sized laminations is to obtain a neat join between each lamination, which permits of a greater number of laminations to be used, as the overlap is obviated. In assembling, the short- and long-sided laminations are arranged alternately. The side of each type of lamination is $\frac{3}{8}$ in. in width. At the corners of the long sides holes of $\frac{3}{16}$ in. are drilled so that the laminations may be supported on vertical brass pillars. The method of fitting the laminations with the coils in position is illustrated in Fig. 29. Four rods of 2 B.A. stemming are cut to lengths of $2\frac{1}{2}$ in., and are bolted up to the laminations by means of locking nuts, as shown in Fig. 30.

An ebonite base made from $\frac{1}{4}$ in. ebonite is cut to size, 4 in. long by $2\frac{1}{2}$ in. wide. Four 2 B.A. tapping holes are drilled, to which the legs of the transformer are screwed. They are rigidly fixed by means of locking nuts, as shown in Fig. 31.

The connecting wires from the coils are attached to terminals mounted to strips on the top of the instrument. These strips are clearly shown in Fig. 33, which also illustrates the method of fixing the terminal strips. When in position the connecting wires are joined to the underside of the terminals, so that each pair of terminals is connected to either a primary or secondary winding.

As the connecting wires are fitted, the terminals corresponding should be appropriately lettered, which is seen in the illustration of the completed instrument in Fig. 28.

Amateurs who delight to make as much of the receiving set as possible, and wish to make a low-frequency or a telephone transformer, cannot do better than attempt the construction of a shell type such as that shown in Fig. 32. In this case the windings are superimposed and wound on an ebonite bobbin, through the centre of which are passed a number of soft iron

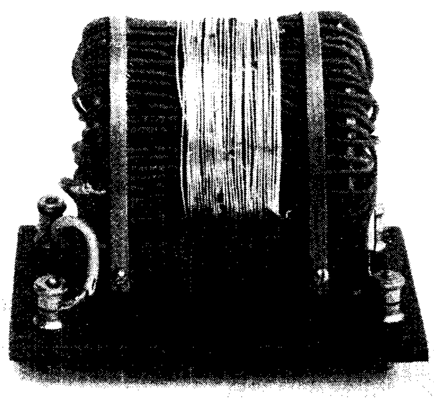


MOUNTING THE TRANSFORMER

Fig. 31. Lock nuts tightened down to the base are employed to hold the brass supports on which the laminations of the transformer are bolted in position

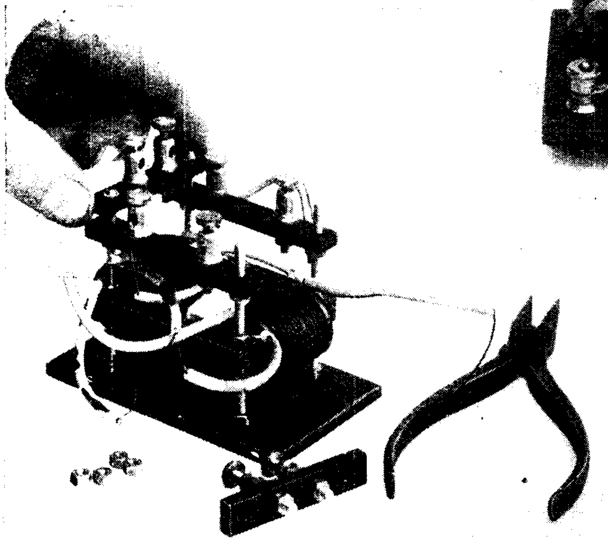
wires. The ends of these wires are ultimately turned over the outside of the windings and thus enclose them. The whole is mounted on an ebonite base and makes a neat and workmanlike job. If good grade material be used and the insulation be perfect throughout, the result will be quite satisfactory.

The first step is the preparation of the bobbin, which can be made from an ebonite tube about 1 in. diameter and 2½ in. long.



SHELL TYPE TRANSFORMER

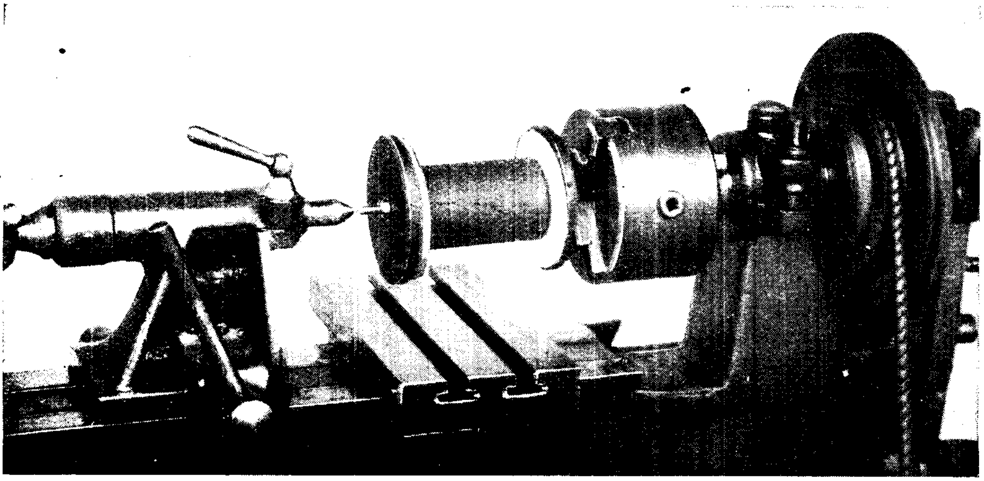
Fig. 32. This, the shell type of transformer, gives very efficient results. It is easily enough constructed, and will give no trouble to the amateur who makes it



FINISHING THE PUSH-PULL TRANSFORMER

Fig. 33. Here are given details of the four terminal strips, which are assembled on the top of the push-pull transformer by means of the brass supports

Two ebonite disks are attached to the ends and should be some 2 in. diameter. The bobbin is then mounted in a lathe and is ready for the winding, as shown in Fig. 34. The bobbin is best mounted on a mandrel and secured with a nut and washer to prevent it slipping. The spool containing the wire has next to be mounted in some simple way



FORMER CONSTRUCTION OF THE SHELL TYPE TRANSFORMER

Fig. 34. When it is ready to receive the winding, the bobbin of the shell transformer is mounted in a lathe. The bobbin is made of ebonite, with disks of the same material attached at either end

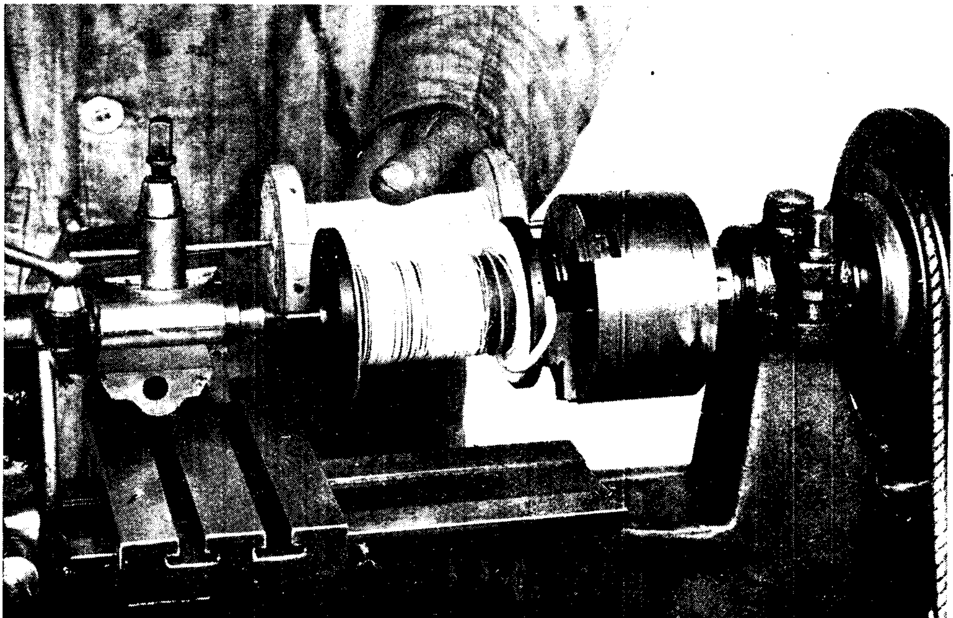


Fig. 35. One excellent method of winding the bobbin for the transformer is to mount the spool of wire on a round rod attached to the tool post of the lathe in such a way that the spool is free to revolve easily. The use of the lathe simplifies considerably the otherwise tedious task of winding

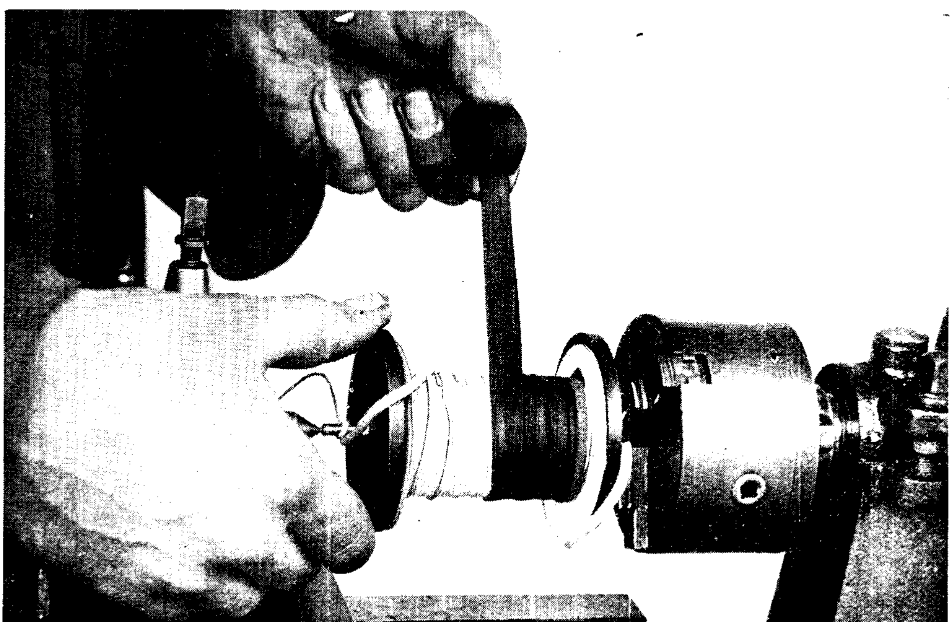
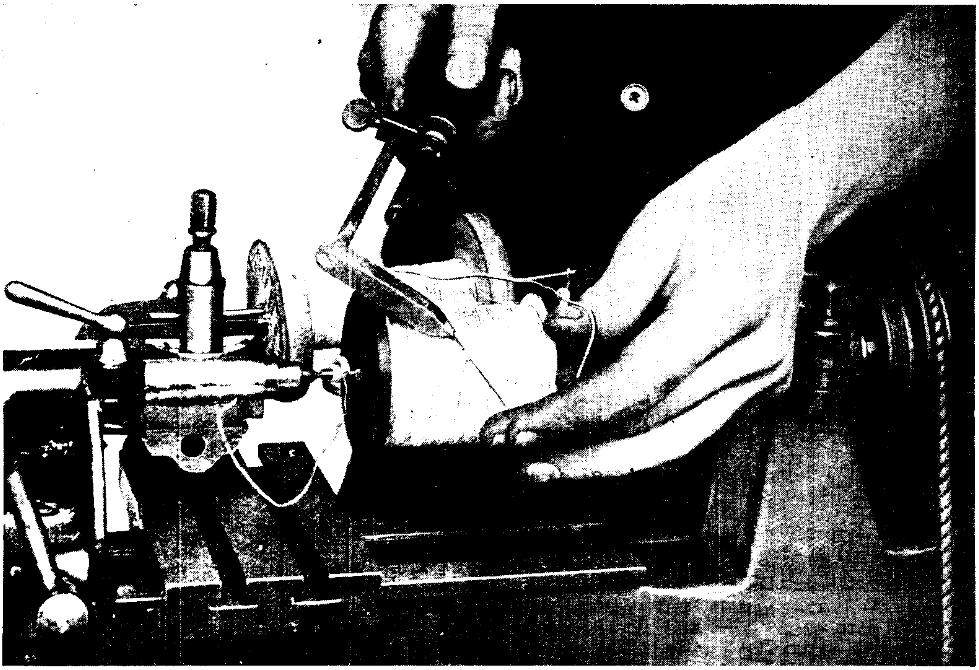


Fig. 36. When the primary winding is complete it is covered with a double layer of waxed silk tape before the winding of the secondary is fixed above it

STAGES IN THE COIL-WINDING OF THE SHELL L.F. TRANSFORMER



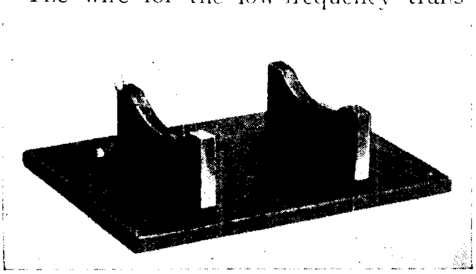
HOW THE WINDINGS OF THE PRIMARY AND SECONDARY ARE FINISHED

Fig. 37. When the windings are completed their ends are soldered to thicker wires, which are covered with an insulating sleeving; the whole is then covered with a double layer of waxed silk

so that it will allow the wire to unroll easily.

One method is that shown in Fig. 35, where the spool is supported by a round rod attached to the tool post of the lathe. The spool is free to revolve and also to slide to and fro, being guided by the left hand. The winding is a tedious process, and it will save trouble to note how many times the mandrel rotates for one movement of the treadle, as if this is known the number of treadle strokes only need be counted and the result multiplied by the ratio of turns to find the total number of turns of wire wound on to the bobbin.

The wire for the low-frequency transformer should be about No. 38 B.W.G. D.S.C. copper wire. It must be perfectly insulated throughout, and wound without any breaks or kinks. At the start a short piece of thicker wire is soldered to the thin wire, and is covered with sleeving and turned over the edge of the bobbin disk to keep it away from the windings. About 2,500 turns will be wound on to the bobbin, and the end of the wire finished, as at the start, with a stouter piece.



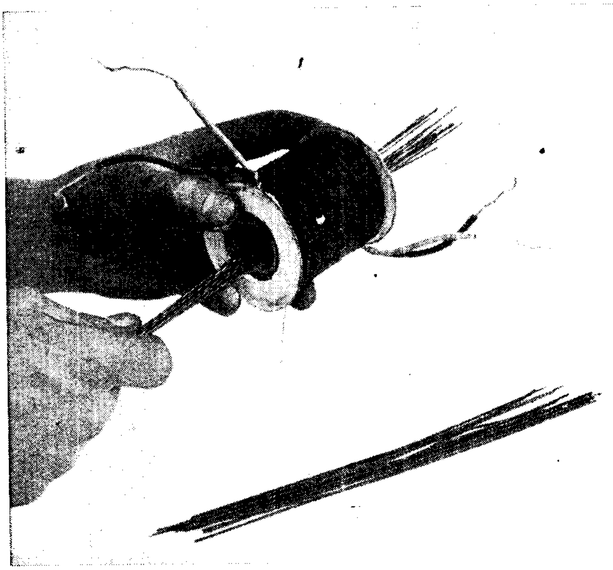
BASE FOR THE TRANSFORMER

Fig. 38. Two saddles are fitted to the base, as shown, to support the windings. The whole is made from sheet ebonite

The next step is shown in Fig. 36, and consists of covering the primary winding with a double layer of waxed silk tape, after which the bobbin is wound full of No. 42 D.S.C. wire in the same way as the primary.

There should be about 10,000 turns of this wire, but the amount is not very critical. The ends of the secondary windings are soldered to thicker wires, as shown in Fig. 37, and covered with sleeving. The whole is then covered with a double layer of waxed silk as before, and is then ready for the core.

The next step is to prepare the base from ebonite, as shown in Fig. 38, making the base about 4 in. long, $2\frac{1}{2}$ in. wide, and at least $\frac{3}{16}$ in. thick. Two saddles (*q.v.*) should be fitted, as shown in the same picture, for the bobbin to rest upon. The

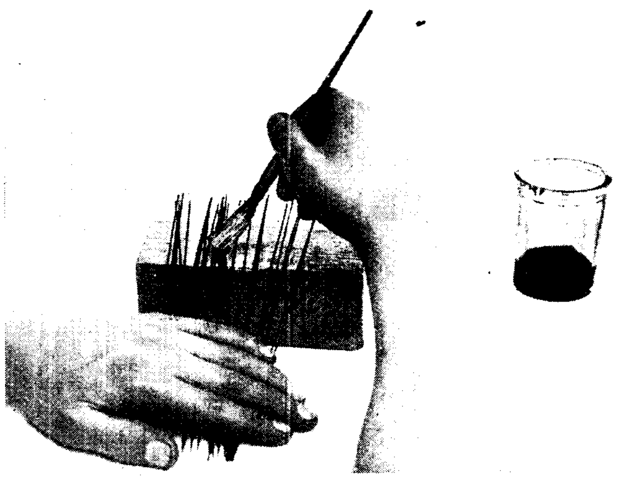


WIRE FOR THE CORE

Fig. 39. The insulated core wires, made from Swedish iron, are placed through the central hole in the bobbin

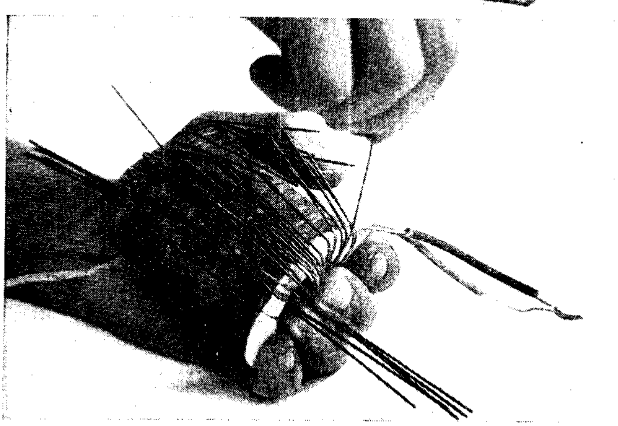
core is made from soft Swedish iron wires about No. 40 gauge or rather thicker, and about 8 in. long.

These wires should be thoroughly well insulated with shellac varnish, as shown in Fig. 40, or may be dipped in molten paraffin wax and set aside until dry. They are then placed through the centre of the bobbin, as shown in Fig. 39, and bent over the outside of the windings, as shown in Fig. 41, so that the ends overlap, when they are secured with a binding of fine wire or silk, as shown in Fig. 42. After this the whole is placed on the saddle on the base and secured with a couple of brass strip clips, as shown in Fig. 43. The transformer is completed by connecting the primary and secondary leads to terminals on the base. The electrical continuity of the windings is tested with a dry battery and telephones in the usual way, and, if desired, the insulation can be tested by applying a high voltage between windings and windings and between windings and core. For a telephone transformer the windings are altered in ratio as already explained.



INSULATING THE CORE WIRES

Fig. 40. For purposes of insulation the core wires may either be shellac-varnished, as here, or dipped in molten paraffin wax



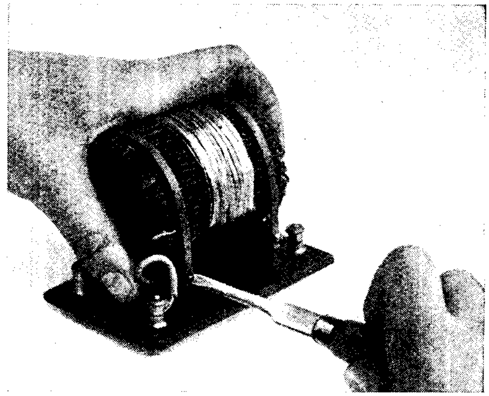
CONSTRUCTION OF THE TRANSFORMER CORE

Fig. 41. As illustrated here, the insulated iron wires forming the core are bent over the outside of the bobbin on which the windings are made. They are afterwards secured in position with silk thread or wire

It frequently happens that a commercial transformer is difficult to fit into a restricted space, and to overcome this the method shown in Fig. 44 is sometimes effective. Two

FINISHING THE TRANSFORMER

Fig. 42. When the core windings have been bent over they are bound round with silk or fine wire to hold them in position

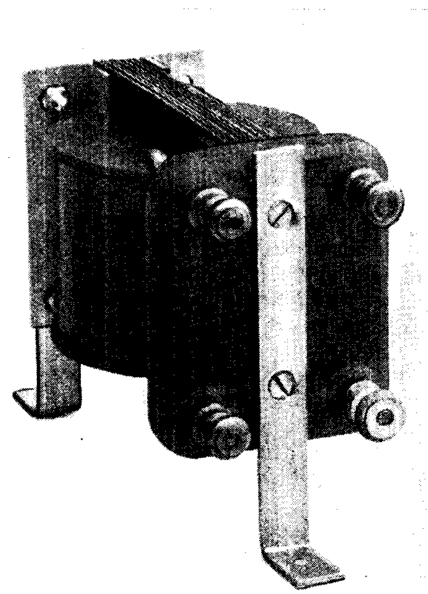


HOW THE TRANSFORMER IS MOUNTED

Fig. 43. Brass strips bent over the ends of the transformer and fixed to ebonite saddles hold the instrument firmly on its base

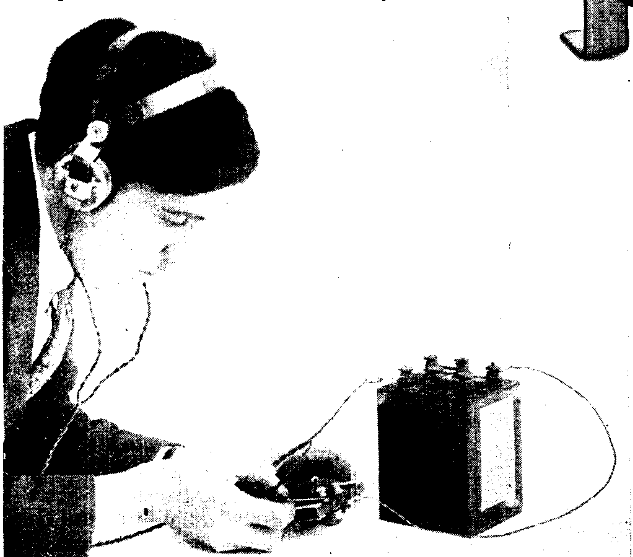
strips of brass are bent to form supports or feet, and are attached to the base and to the top of the transformer so that it can be placed in a horizontal position.

When a transformer fails to act, the best plan is to test the continuity of the windings by connecting one pole of a battery or accumulator, to one end of the primary winding and connecting the other battery pole to one of the telephone leads. On completing the circuit by connecting the other telephone lead to the second primary terminal a loud click should be heard.



BRACKETS FOR FITTING

Fig. 44. When mounting has to be effected in a restricted space, it may be accomplished by using such brass strips as these



COMMON TRANSFORMER TEST

Fig. 45. When the experimenter believes there is leakage between the primary and secondary of his transformer he may employ this test

The secondary is tested in the same way, and finally the secondary to the primary, as shown in Fig. 45. In this last case, if a click is heard, it indicates that the insulation has broken down.

As a rough guide to the winding of high-frequency transformers, the following will be useful to the amateur. The wire used should be about No. 38 gauge. The sizes given refer to the inner and outer diameters of the ebonite former on which the wire is wound. The primary is wound on first, then the secondary, with equal turns in each.

Table of windings for high-frequency transformers of the plug-in type:

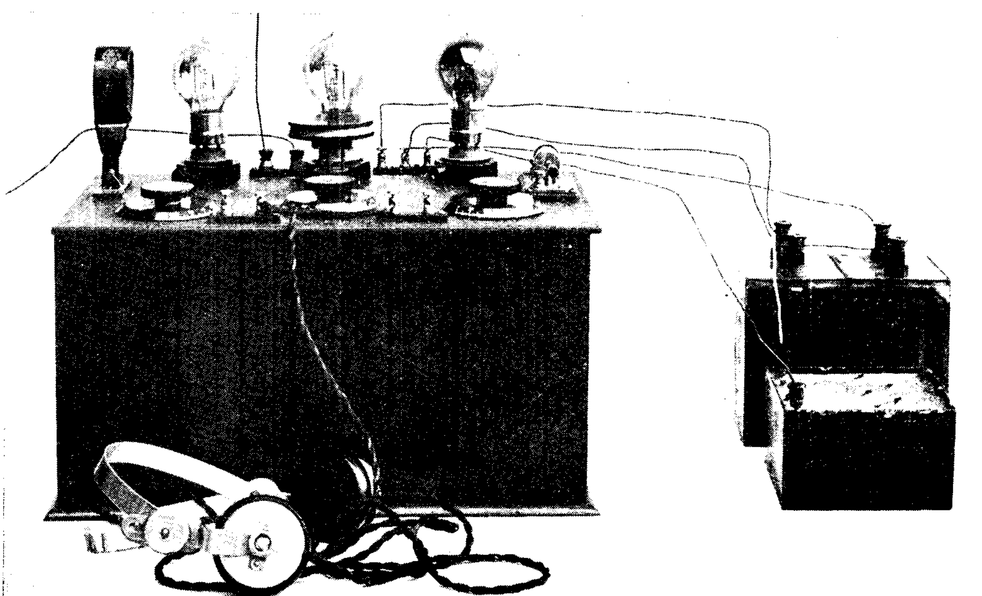
Turns.	Metres wave-length.	Inner diam.	Outer diam.
		in.	in.
30	190–240	1¾	2
45	240–300	1¾	2¼
80	300–400	1¾	2¾
240	550–750	1¾	3
340	950–1,200	1¾	3¼
900	2,500–3,500	1¾	3½

A variable condenser with a value of ·0002 mfd. should be shunted across the primary winding.

TRANSFORMER-COUPLED SET. This set, which is shown complete and in use in Fig. 1, is similar in its circuit arrangements to No. 7 on the Broadcasting Map facing page 282 of this Encyclopedia, the only deviation from the circuit there given being the use of a plug-in aerial coil and a tuning condenser instead of the plain sliding inductance, which, however, can be used if preferred.

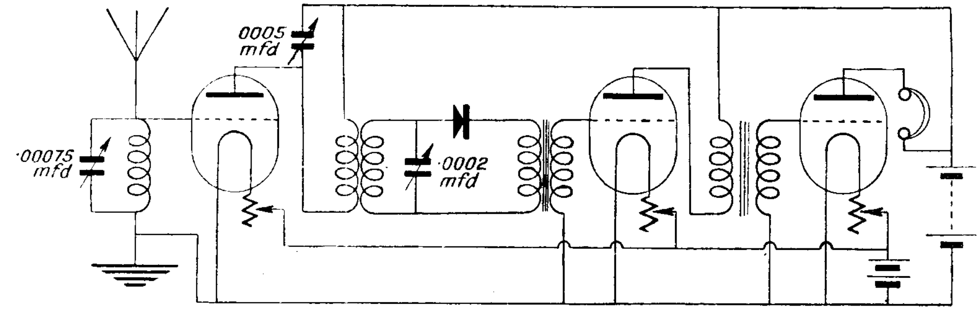
The set comprises three valves and a crystal detector. The first of these valves acts as a high-frequency amplifier, and is coupled by a high-frequency transformer to the crystal, where the signals are rectified and handed on to the second valve, which acts as a low-frequency amplifier, the third valve also acting in a similar capacity. With this arrangement remarkably clear and pure signals are obtained over very considerable distances, and with sufficient strength for loud-speaker work at reasonable distances, and with good headphone strength from the more distant stations. The valves used in the set illustrated are the ordinary Marconi-Osram R type, but others will be found to give satisfactory results.

The theoretical circuit diagram for this set is given in Fig. 2, which also includes the appropriate values of the components. The first step in the construction is to prepare the case, or to obtain one of suitable dimensions. The sizes for this are given in Fig. 3, which also shows that, in this case, economy has been studied



COMPLETED TRANSFORMER-COUPLED SET READY FOR USE

Fig. 1. Three valves and a crystal detector are employed in this receiver. This is the set whose circuit appears as number seven on the Broadcasting Map facing page 282



CIRCUIT DIAGRAM OF THE TRANSFORMER-COUPLED SET

Fig. 2. Valves used in this set are the Marconi-Osram R type, though others will give equally good results. Appropriate values of condensers are given above

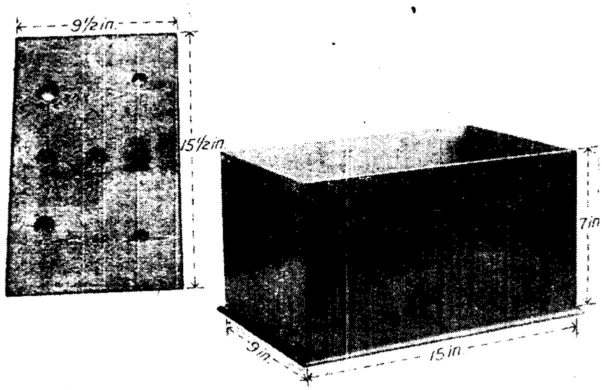
by using a hardwood panel instead of the more usual ebonite. This is rendered practically possible by the extensive use of local ebonite bushings. When these are properly fitted to a sound, dry wooden panel, the results are quite satisfactory. It should be noted, however, that nowhere must the ordinary insulated wire pass through or come in contact with the panel unless it passes through an ebonite bushing.

After the panel has been prepared, the whereabouts of the various fittings should be accurately marked upon it, and holes about 1 in. in diameter drilled for the ebonite bushes. These may simply consist of disks of ebonite equal in thickness to that of the panel, and fit closely into the holes in the wood. They are kept in position by means of washers placed between the various fittings, the underside of the panel, and in between the fixing nut or screw and the top of the panel, in this way thoroughly insulating the components.

In the case of the valve holders, rectangular pieces of ebonite are used on the underside. To reduce the bushings to a minimum, Holderstat combined valve holders and filament resistances are used, these being mounted, as already described, on ebonite bushings with rectangular plates of ebonite on the underside. The coil holder and crystal detector, having ebonite bases, may be mounted directly to the top of the panel.

Small ebonite plates are provided for each group of terminals, the shanks of which pass through clearance holes drilled through the wood panel, connexions being subsequently made to the ends of the shanks by soldering, as by this means the wires are kept free from the surface of the panel. The whereabouts of the fittings on the top of the panel is clearly shown in Fig. 5, which also gives the dimensions, although these may have to be amended slightly if other components are used.

The method of fitting the condensers is clearly shown in Fig. 4, which shows the ebonite bush in position in the hole, and the condenser, with its ebonite end plates, in the act of being inserted into position. It is secured in the usual way with a centre-fitting nut, with an ebonite washer between it and the panel. There are three condensers required, all of which may be fitted in the same way. If condensers having metal end plates are used, these should be insulated with a sheet of thin ebonite, fibre or rubber.



PANEL AND CASE FOR THE SET

Fig. 3. Dimensions of these parts should be studied before commencing construction. A hardwood panel has been used instead of the conventional ebonite

The components necessary for this set are as follows:

3 Holderstat valve holders and filament resistances combined.

1 ordinary valve holder.

3 variable condensers, with values of ·0005, ·00075 and ·0002 mfd. respectively.

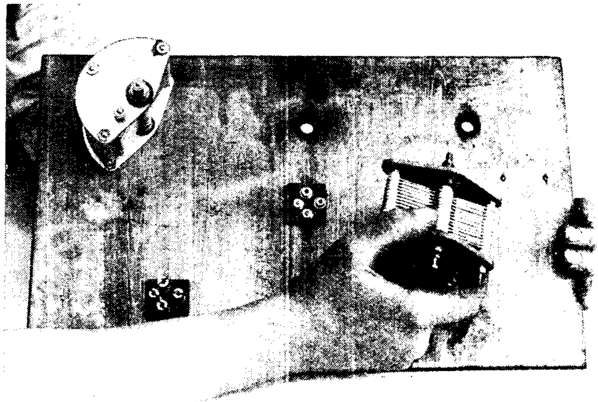
1 crystal detector complete.

1 ordinary plug-in coil holder.

1 low-frequency transformer, such as the Eureka Concert Grand.

1 low-frequency power amplifier transformer for the second stage.

A quantity of assorted terminals, connecting wire and sleeving.

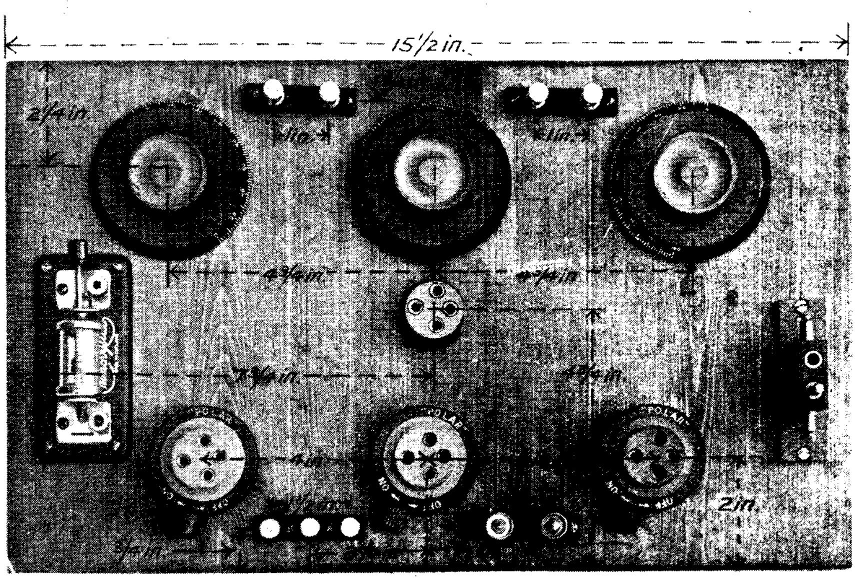


HOW THE CONDENSERS SHOULD BE FITTED

Fig. 4. When fitting components to the hardwood panel, a bushing of ebonite is necessary for the condenser, as shown

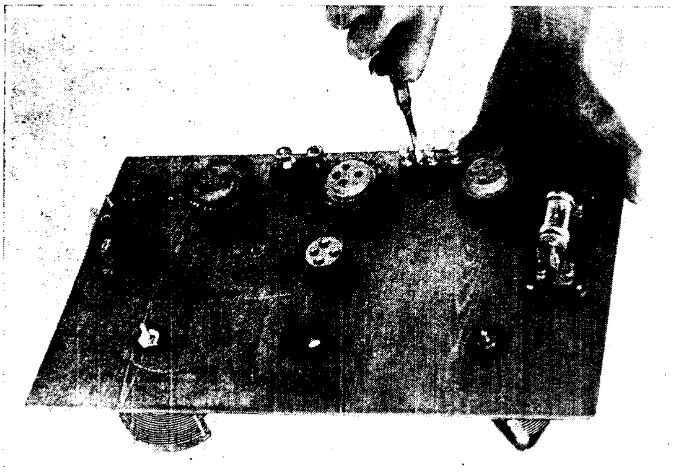
Dials and knobs are required for the three condensers and the plug-in coils and transformer. For average use a No. 2½ Burndept or a No. 35 or 50 Igranic plug-in coil should answer for most of the B.B.C. stations, and a No. 1 Oojah plug-in high-frequency transformer.

After the condensers and filament resistances have been fitted, the terminal strips should be built up by drilling and tapping holes for the reception of the terminals, mounting the latter on the ebonite strip and finally screwing it to the top of the panel, as shown in Fig. 6, this being followed by the placing and fixing of the two low-frequency transformers, the whole of these parts being seen in their positions in Fig. 7, which should make their arrangement perfectly clear.



POSITIONS OF THE COMPONENTS ON THE PANEL

Fig. 5. The main spacing dimensions of the panel of transformer-coupled receiver, giving the relative positions of the rheostats, condensers, crystal detector and other components, are shown in this illustration



ATTACHING THE TERMINALS TO THE PANEL

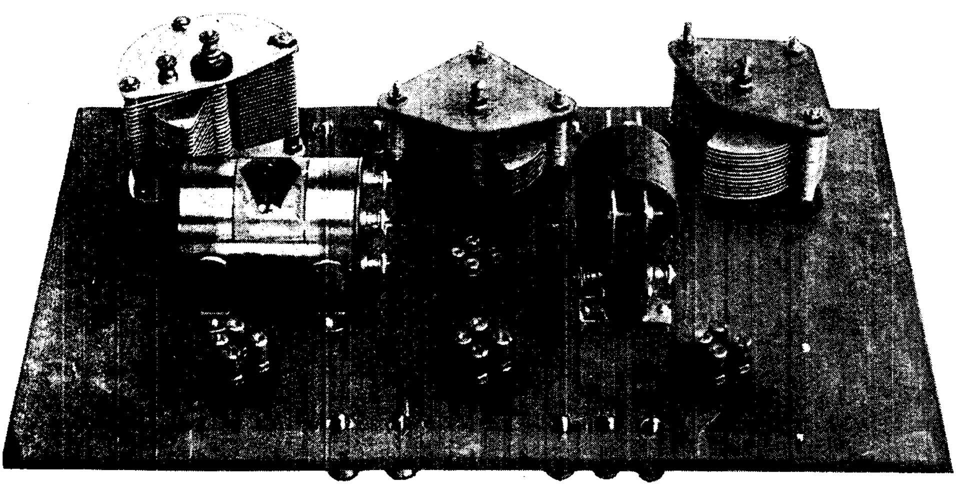
Fig. 6. As in the case of the other components, an insulating plate of ebonite is used as a mounting for the terminals in this set

is a minimum of risk of short-circuiting through any of the wires accidentally touching each other, and also any losses of the steady plate or low-frequency current are avoided should the wires accidentally touch the wooden panel.

When all the components have been wired the circuit should be tested for continuity with the aid of a dry battery and telephones in the usual way, and the condenser dials adjusted to give a correct reading—that is to say that if the dial is divided from 0 to 180, when the 0 is opposite the indicating mark on the panel the condenser moving plates should be fully exposed, and at 180 they should be entirely between the fixed plates.

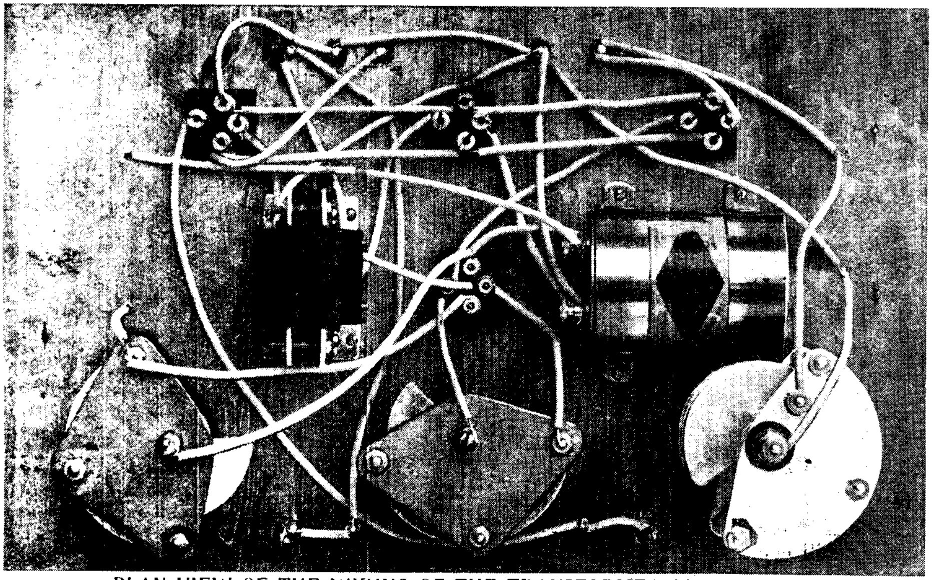
The next item is the wiring of the set. This is preferably carried out in an orderly manner, commencing with the aerial circuit, then running the wires to the filament circuits, and finally wiring up the two transformers. A plan view of the wiring is given in Fig. 8, and this, in conjunction with Fig. 10, which shows a different view of the wiring, should make the whereabouts of every wire perfectly clear. In this example the wiring is carried out with No. 18 gauge tinned copper wire, covered with soft rubber sleeving. Carried out in this way, there

Everything being in order, the panel is placed on the top of the cabinet, as shown in Fig. 9, and secured with a few small brass screws. The appearance of the set thus finished is shown in Fig. 11. The aerial coil is then inserted in the coil holder, the valves placed in their valve holders, and the transformer into the centre holder on the panel, as shown in



PANEL WITH ALL THE COMPONENTS IN POSITION

Fig. 7. A little time spent on the study of this photograph will reward the constructor, as the exact locations of the components is of some importance. Note the positions of the two low-frequency transformers relatively to each other

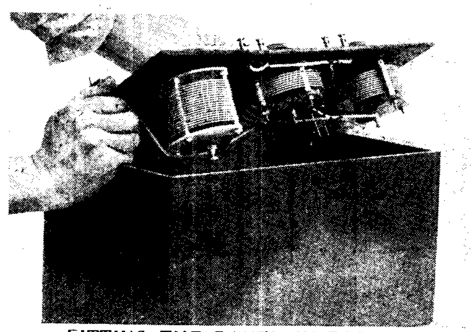


PLAN VIEW OF THE WIRING OF THE TRANSFORMER-COUPLED SET

Fig. 8. How connexions in the set are carried out. Notice that insulated sleeving is used throughout, because the panel is made of wood instead of ebonite. This wiring should be studied along with Fig. 10 below

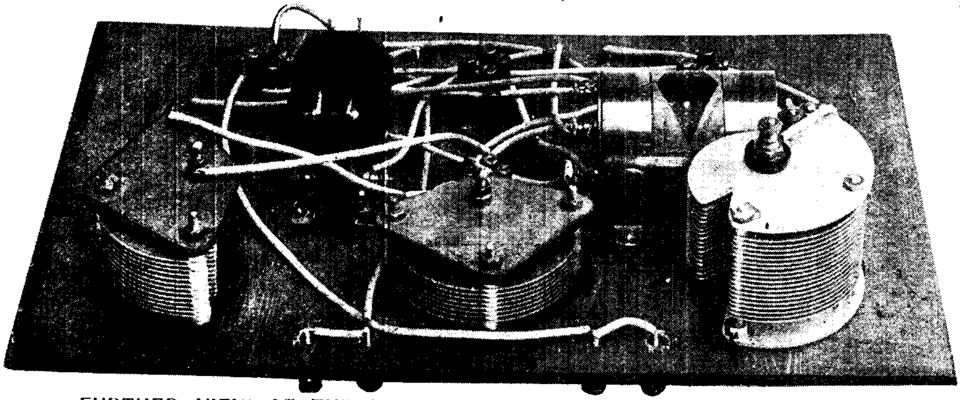
Fig. 12. The set is then connected to the high- and low-tension batteries, the aerial and earth leads, and the telephones connected: and, supposing that broadcasting is in progress, the valves should be turned up so that the filaments burn at their proper brightness.

The aerial tuning condenser should be set at about 25 on the scale. The two condensers across the high-frequency transformer should be set at about 10 on the scale. The crystal is then carefully adjusted, and if a buzzer test can be arranged it will facilitate the finding of a sensitive spot, and, when once this is found



FITTING THE PANEL IN POSITION

Fig. 9. Care must be taken in this process. The panel is secured with small brass screws



FURTHER VIEW OF THE WIRING OF THE TRANSFORMER-COUPLED SET

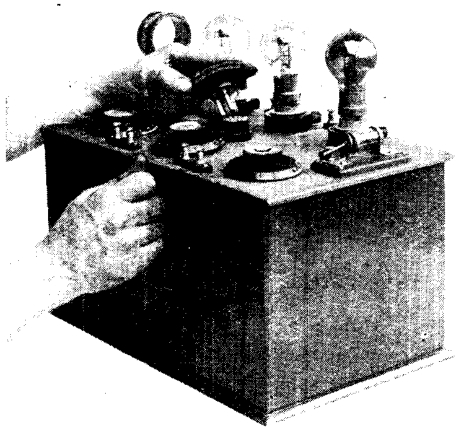
Fig. 10. Since some difficulty may be encountered in the making of the connexions, a second view of the wiring has been included. It should be studied along with Fig. 8

the cat's-whisker should not be readjusted until the set has been tuned in and signals are heard. The tuning of the transformer-coupled set does not present any great difficulties.

If the aerial tuning condenser be gently rotated backwards and forwards, the signals should be picked up pretty quickly. Directly a signal is heard the crystal should be adjusted to its maximum sensitivity, and, without touching the aerial tuning condenser, the other two condensers should be gently moved back and forth until the signals increase in strength, after which the primary tuning condenser only should be critically adjusted, followed by the equally critical adjustment of the secondary condenser. The final delicate adjustment of all three condensers will generally result in the loudest possible signals.

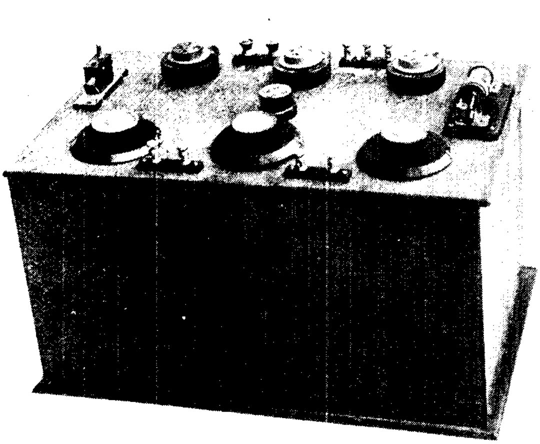
The filament resistance controlling the first valve will probably be found to affect the result considerably, and should not be turned up too much at the start. If the set has any tendency to howl, which is unlikely, it can be checked by reducing the filament brightness of the first valve; the others should be turned up to their maximum. Once the tuning positions for the particular station have been ascertained, they should be noted, as by setting the three dials to the same positions, and suitably adjusting the crystal the same station can be picked up at any time.

This set has the merit of giving very pure and clear speech and music, and is practically immune from howling and re-radiation, once, of course, it has been adjusted for the reception of any particular station.



FITTING THE MOVABLE COMPONENTS

Fig. 12. The H.F. transformer is of the plug-in type, and can be varied to suit different wavelengths



COMPLETED RECEIVER

Fig. 11. It will be observed that the completed set, when fitted with its components, presents an elegant appearance. Here the set is ready for valves, coils and plug-in transformer

TRANSFORMER OIL. High-flash insulating oil, in which are immersed the component windings of the transformer for the purpose of dissipating the heat generated during transmission and for improving the insulation.

A transformer oil is a mineral oil obtained from crude oil by distillation at a certain temperature, upon which depend the quality and suitability of the oil. For good oil a breakdown voltage of 25,000 between $\frac{1}{2}$ in. spheres with a $\frac{1}{8}$ in. gap is required. The oil must be free from moisture, since the presence of even small quantities of moisture lowers the breakdown voltage considerably, one-fortieth of one per cent of moisture causing a drop of seventy per cent in voltage breakdown strength, for example.

The oil should have a flash point considerably higher than the maximum temperature it may reach in use. A flash point of about 180° C. is usually taken as safe. The oil must, of course, be free from acid, and should also be mobile at freezing temperatures commonly met with.

TRANSMISSION AND TRANSMITTERS—I

Standard Systems of Transmission in Public Use Fully Described

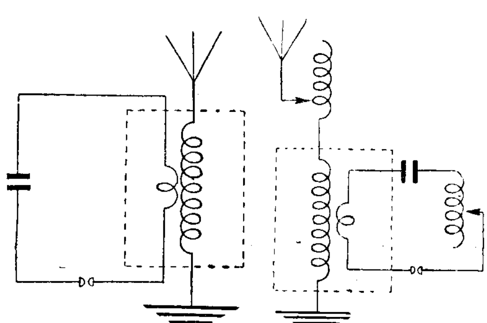
This section contains a general review of transmission and photographs and descriptions of various forms of transmitters used. It is followed by a chapter on Amateur Transmission by Wm. Le Queux and a final section giving constructional details of actual amateur transmitting stations. The reader should also consult such articles as Arc Transmitter; Broadcasting, and under names of broadcasting stations

Transmission is applied in a general sense to the setting up of electro-magnetic waves in the ether for the purpose of radiating wireless telephony or telegraphy. A brief outline will be given under this heading of the various systems of radiating electro-magnetic waves, and the type of work for which the different systems are most suited.

Spark Systems. The "spark" system of transmission was for a very long period the only one in use, and is still found to a large extent on ship's installations, particularly on the smaller vessels. The spark system is considered first, therefore.

In its simplest form the spark transmitter consists of some form of generator of high-tension current, a spark gap across which a fixed condenser is connected, and an aerial and earth connexion. Upon the condenser being charged up, the pressure from the generator still rises until the air dielectric between the electrodes of the spark gap is broken down by a spark jumping across the gap. This spark is, of course, a conductor, and has the action of discharging the condenser.

The result of this is that the plate of the condenser which had been of negative polarity now becomes positive, but not to the same extent to which it had previously been negative on account of losses of energy due to pressure waves and resistance. This process continues, gradually decreasing in strength until the whole of the energy in the condenser becomes absorbed. The result is that an oscillatory current of gradually diminishing strength is produced.



COUPLED CIRCUIT TRANSMITTER

Fig. 1 (left). In this simple circuit the coils shown inside the dotted rectangle are known as the "jigger." Fig. 2 (right). Tuning inductances are shown added to the jigger

As the aerial is connected to one side of this condenser and the earth to the other, electro-magnetic waves are produced, the frequency of which will be constant, but the amplitude of which will diminish in accordance with the diminishing value of the current. These are known as "damped" waves. Their wave-length depends on the amount of capacity and inductance in the circuit—which includes the aerial and earth wire—and their amplitude upon the energy used.

It is necessary to consider the different properties of closed and open oscillatory circuits. Briefly, the former is a bad radiator on account of the small amplitude of the waves which may be produced by its means, while the latter is a good one on account of the large amplitude of waves which may be produced within it. The closed circuit, however, has the advantage of possessing good energy-storing properties, and it is obvious, therefore, that if we can combine the two circuits so as to obtain the good properties of both the efficiency of the apparatus will be increased to a very large extent.

This arrangement is illustrated diagrammatically in Fig. 1, which is known as the "coupled circuit" transmitter, now in general use for spark work. The coils shown in the dotted rectangle are inductively coupled, and the general term applied to the apparatus embodying them is "jigger." From this illustration it is obvious that the left hand is the closed circuit, and the right hand is the open circuit, while the actual coils compose the "jigger primary" and "jigger secondary" respectively.

Fig. 2 is an elaboration of this arrangement which has the addition of tuning inductances in both closed and open circuits, by means of which the tuning of the whole apparatus to different wave-lengths may be accomplished.

So far the systems which have been described have made use of the ordinary fixed discharger, and now it is necessary to point out the improvement occasioned by substituting for this device some form of "disk" or "rotary" discharger. An important point when dealing with electrical discharges for the radiation of electro-magnetic waves is that provision should be available to alter the phasal relationship of current and point of discharge or interruption. The methods for accomplishing this action, and the reasons for its desirability, are fully described under the heading Disk Discharger.

Adjusting the Disk Discharger

In the majority of cases the disk discharger has some form of scale attached to it by which it is possible to set the relationship of disk to phase within very fine limits. The first step in the adjustment of the transmitter as a whole is to give the alternator a speed which is estimated to be of the correct frequency. After this the adjustment on the discharger is varied until the apparatus emits a pure musical note. When this condition obtains the ratio of input to output is such that the station is working at its greatest efficiency.

Spark transmission, while possessing many advantages from the point of view of simplicity and ease of operation, is not all that can be desired so far as adhering closely to its true wave-length is concerned, and where a number of stations—for instance, ships—are all transmitting simultaneously on a close band of wave-lengths it is frequently impossible for a receiving operator to be able to select any one station because of jamming. Before the introduction of the valve as a transmitting instrument the transmission of continuous waves, which possess more sharply defined tuning than damped waves, was effected by the use of high-frequency alternators.

Notable amongst alternators of this type are the Goldschmidt and Alexanderson, which are designed, according to circumstances, to generate at frequencies ranging from 10,000 to 1,000,000 cycles per second.

Another system for the production of continuous waves is by utilizing some source of high-tension D.C. in conjunction with suitable disk dischargers. This is known as the "timed-spark" system, and consists of energizing the aerial in periods of very rapid succession, allowing the very smallest time-interval between one wave-train and the next. To accomplish this a number of disk dischargers may be run together, each one individually timed to discharge at regular intervals, so that the normal time intervals between successive sparks which obtain in ordinary spark working are filled up with other discharges of identical character.

Certain forms of arc apparatus, notably the Poulsen, may be used to generate continuous waves. This apparatus was a commercial development following Duddell's experiments, and in the main consists of an arc enclosed in a chamber filled with a gas composed of hydrocarbons, with the addition of apparatus for the production of a strong magnetic field at right angles to the gap, the object of which is to steady the discharge. Poulsen arcs frequently have their positive electrodes of copper, hollow in formation and water-cooled, while their negatives are the usual carbon.

Valve Systems. The great majority of modern transmitters use the thermionic valve for the production of continuous oscillations. Valves are obtainable for use with any desired power, from the small 10 watt types, suitable for amateur working, to the largest transmitters employing many valves of two or three kilowatts and more. Where valves are used, the source of current supply is generally D.C. or rectified A.C. In either case, where it is actually generated, *i.e.* taken from a source other than batteries, smoothing circuits should be inserted. This is essential if a pure whistling C.W. is desired, or if the transmission of telephony is subsequently to be added. If this is not done a continuous humming noise will be present in the transmission. The actual voltage to be applied to the anode of the valves depends entirely on the type of valve used, and the maker's figures must be consulted on this matter.

Action of the Valve in Transmitting

It is necessary at this stage to explain briefly the manner in which the valve, as a transmitting instrument, functions. In the first place, when the filament is heated and a high potential is applied to the anode, current passes between these two electrodes. The value of this current may be altered at will by applying positive or negative potentials to the grid. This explains the reason for the valve being so called, for it is a device which is capable of passing current in any strength desired up to a maximum, by applying varying potentials to the grid.

The changes which occur in the current strength between filament and anode are proportionately greater than those applied to the grid, or, in other words, a small grid variation of potential produces a correspondingly larger change from filament to anode. Oscillatory currents from the anode are taken to the aerial and there form trains of oscillations. Further, the currents are again applied to the grid, and, operating on that electrode in the manner previously described, allow still larger currents to flow from filament to anode. This, again, is transferred to the aerial and boosts the currents in it. The result of this action is to cause electromagnetic waves to be radiated out from the aerial into the ether.

Briefly, for telegraphic work that is all that is required, except that a key is inserted in the grid circuit by which the operator is able to vary at will the time period over which the oscillations are to continue, making a short period for a dot and a larger one for a dash.

Transmitting by Continuous Waves

Certain forms of continuous waves, such as the interrupted variety, may be received with an ordinary crystal receiver, or a valve receiver without a heterodyne. This is accomplished by inserting a buzzer in the circuit, which interrupts the constant wave-train into a series of small trains of low frequency. Their actual frequency depends entirely on the rapidity with which the buzzer vibrates.

The wave-lengths on which telegraphic signals are transmitted depend on the purpose for which they are required, certain definite wave-lengths being allotted to different spheres of utility. For instance, marine work generally is confined to two wave-lengths, namely, 300 and 600 metres. Powerful transatlantic transmitting stations usually work on wave-lengths of the order of 15,000 to 20,000 metres, as it has been found that it is commercially more economical and reliable to use these long waves. Standard telegraphic time signals from the Eiffel Tower, Paris, are sent out on a wave-length of 2,600 metres.

For the purpose of transmitting telephony it is essential that continuous waves be used, and, while those radiated from an arc transmitter are fully capable of being used for telephony, the valve is invariably chosen on account of its greater reliability and efficiency.

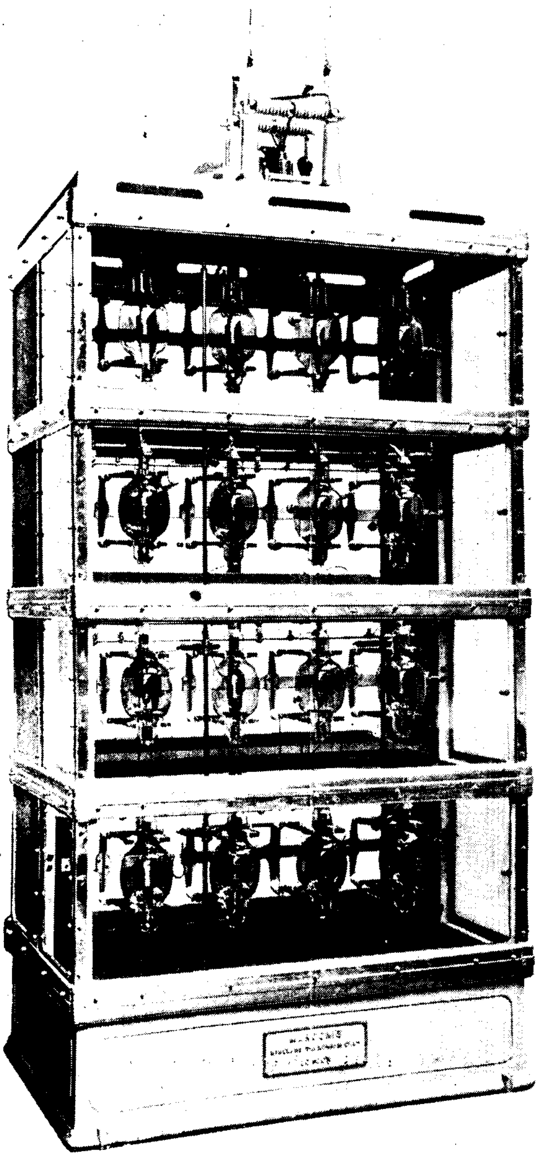
In telephonic transmission the place of the telegraphic key is taken by the microphone, by means of which the voice and music frequencies are impressed on the C.W. frequency. Thus there are two individual wave-trains, the carrier wave and the modulated wave. In large transmitters it is essential that the current from the microphone be amplified before being applied to the transmitter. The extent of this amplification depends on the type of microphone in use and the power and type of transmitting circuit. Resistance-coupled amplifiers are preferred, for they do not distort the initial voice frequencies from the microphone, and therefore purer transmission results.

The Choke Control System

A system known as choke control is now universally adopted for telephonic transmission. In this system a further valve, known as the control valve, is connected with one end of the choke, the other end being connected with the H.T. supply to the oscillating valve. Thus a variable current is present in the choke, which results in the voltage applied to the oscillation generator being varied in sympathy with the potentials on the grid of the control valve. By this arrangement the currents in the aerial are varied in strict proportion to the applied modulated currents, resulting in the transmission of speech and music of very good quality.

It is general practice in all telephonic transmitters to have a system of "side tone," by means of which an operator on the premises is able to tell the quality of the transmission in a pair of ordinary telephones or a loud speaker.

In Fig. 3 is shown a valve transmitter without any tuning apparatus arranged on the unit system. Four units are shown, each of 4 kilowatts, giving 16 kilowatts in all. The general design follows the lay-out of an expanding bookcase, wherein each successive unit fits into a recess in the top of the one below. In the application of this system to wireless transmitters the fitting of one layer into the next automatically makes contact and completes the circuits.



UNIT SYSTEM VALVE TRANSMITTER

Fig. 3. Four units make up this transmitter, each of 4 kw. The general lay-out is like an expanding bookcase, and the fitting of one layer into another automatically makes contact and completes the circuit

Courtesy Marconi's Wireless Telegraph Co., Ltd.

The valves are held vertically in holders designed specially to allow of easy and quick replacement in the event of failure. Connexions from the valves are all arranged on the bus-bar system in stiff copper strips, each strip being bolted to the next where connexion is necessary.

A low-powered transmitter suitable for amateur working is shown in Fig. 4. This instrument is made by Tingey Wireless, Ltd., and consists of two units, in which the front one is a tuner and the rear one a transmitter. The latter is a four-valve instrument arranged for telephony or continuous wave telegraphy.

On the rear unit are mounted a stud switch, condenser and hot-wire ammeter for the aerial current. This unit is connected to the valve panel by strip connexions.

The valve unit is fitted with switches by which the operator is able to change over from transmit to receive and from C.W. to telephony. The terminals on the left-hand side are for aerial and earth, while a further terminal for connexion to the receiver is fitted. On the right-hand side are terminals for the batteries, or generator, those on the front edge of the panel being for the microphone and tapping key.

Marine Transmission Sets. A typical marine transmitter employing a rotary form of discharger is illustrated in Figs. 5, 6 and 7. In Fig. 5 is shown an outside view of the instrument. In the main it consists of a box-like cabinet having metal shields at both sides and at the back, while the front is made of a panel of polished and enamelled slate. Below this is a cupboard having a door opening from the front and allowing its contents to be immediately accessible.

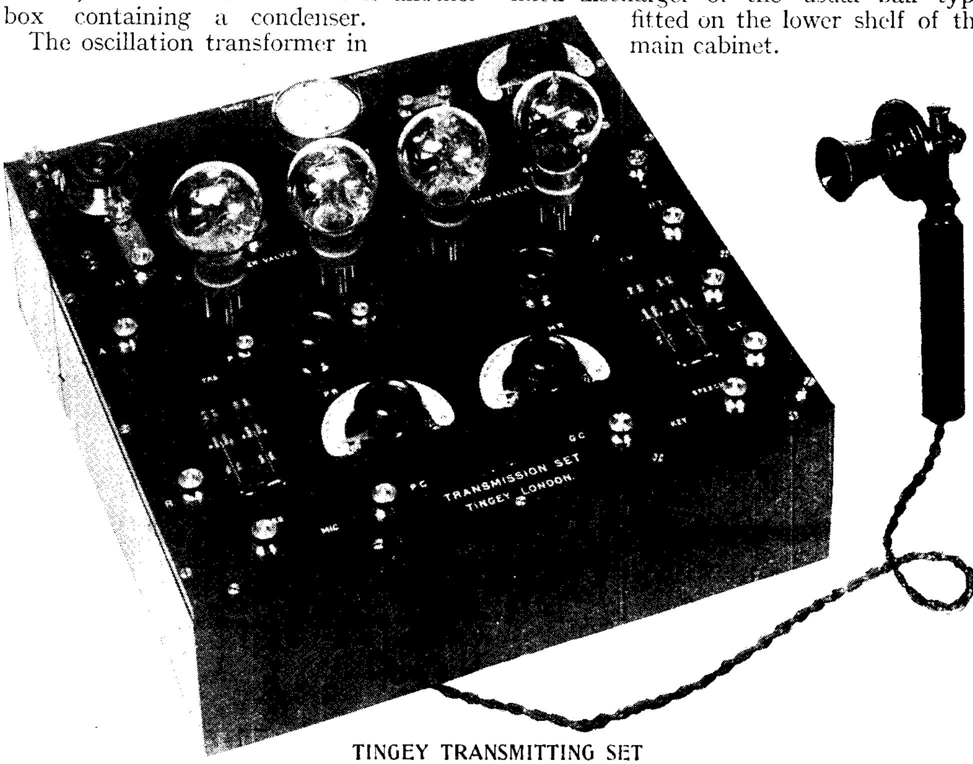
Mounted on the panel are the controls, which are of the utmost simplicity. The two hand wheels control respectively the wave-length and power input. There are four positions on the wave-length switch, those on the standard arrangement being for 300, 450, 600 and 800 metres, while on the power switch, which is on the right, are fitted positions corresponding to "off," quarter, half and three-quarter power. The latter is fitted to enable the operator to comply with the international regulation that the minimum power necessary for the particular transmission shall be used. This regulation was made to reduce the possibility of jamming.

Below the handle is a glass-covered case containing an automatic starting device. This is to enable the operator to start his set by merely pressing one small push-button on his table. At the top of the panel is an aerial ammeter of the hot-wire type having a scale reading from zero to 15 amperes.

The interior arrangements in this set may be seen by reference to Figs. 6 and 7. At the bottom of the cabinet is housed the generator. This is a form of converter, which, being fed with D.C. at a pressure of 110 volts, delivers A.C. of 500 cycles at a pressure of 200 volts. The end of the spindle of the machine carries a synchronous discharger having an air-cooling device on its surrounding cover. In the box at the back of the shelf, immediately above the generator, is situated the main transformer, while in front of this is another box containing a condenser.

The oscillation transformer in the set consists of spirally wound coils of heavy copper rod placed side by side. They are clearly shown in Fig. 7 behind the transformer and condenser. Attached to the top members of the framework is the A.T.I., which is made in the form of a helix, also in copper rod. Tappings from both oscillation transformer and A.T.I. are taken to the switch, which is controlled by the wave-length hand-wheel. This switch is illustrated in Fig. 7, from which it will be seen that the hand-wheel is geared to a rack upon which sliding contacts are attached.

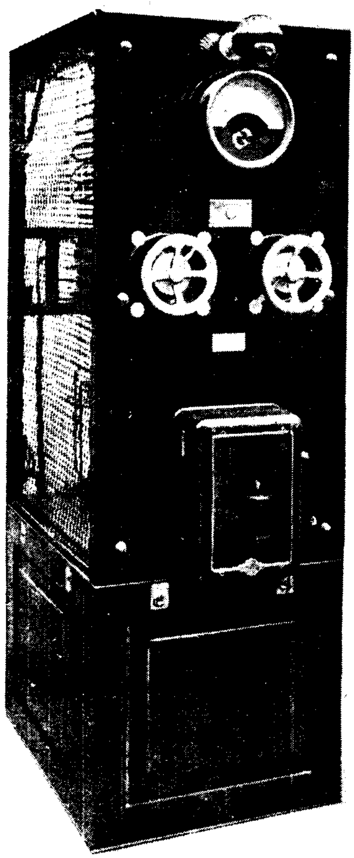
This set is fitted with a complete emergency installation of $\frac{1}{4}$ kw. capacity. It is situated half-way up the back of the cabinet, and fed from the ordinary D.C. ship's supply. It consists of a special form of induction coil or transformer having three windings. The coil is completely enclosed within a hardwood cabinet, on top of which is mounted a commutator form of interrupter driven independently by a small motor. The output of this coil is connected to a fixed discharger of the usual ball type fitted on the lower shelf of the main cabinet.



TINGEY TRANSMITTING SET

Fig. 4. This low-powered transmitter is suitable for amateur working. It is a four-valve set arranged for telephony or continuous wave telegraphy. The set is neat and compact, and gives good results

Courtesy Tingey Wireless, Ltd.



SHIP'S TRANSMITTER

Fig. 5. General view of a ship's transmission set using a rotary discharger. This set is entirely enclosed, as shown; the two wheels control wave-length and power input

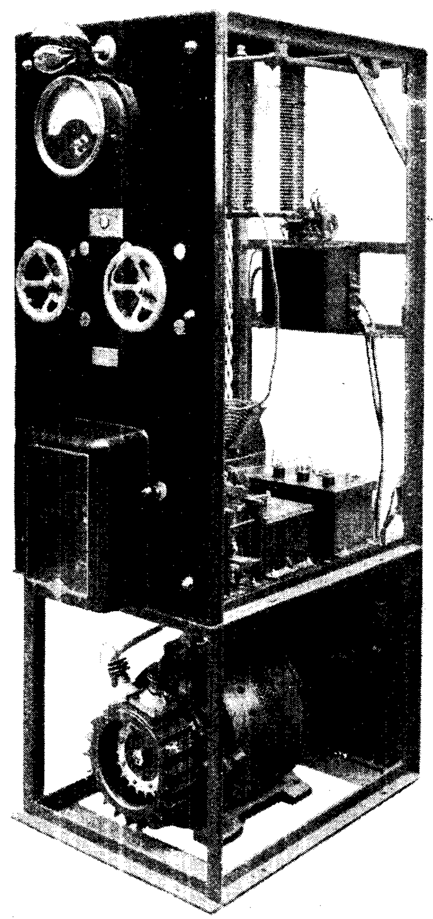
Courtesy Radio Communication Co., Ltd

The emergency gear is brought into operation by pressing a button on the front panel to the right of the motor-starter; thus, should any breakdown occur, an emergency set is instantly available.

A close-up view of the coil and interrupter gear on this emergency set is illustrated in Fig. 8. Here the rotary interrupter is clearly shown on the top of the coil cabinet. The motor is enclosed in the square iron casting on the left, the motor spindle being continued to take the special form of interrupting commutator. The latter is a cylinder of insulating material having conducting strips inlaid in it. The brushes, of which there are four, are arranged in pairs, and situated so that their points of contact are at 90° to one another. Adjustment for both pressure and wear of brushes is provided on the rockers.

A small type of marine transmitter and receiver of $\frac{1}{4}$ kw. capacity is illustrated in Fig. 9, and grouped as in the operator's cabin on board ship.

On the wall, to the left, is the main power switchboard, consisting of a polished slate panel on which are mounted voltmeter and ammeter, switches for charging, etc., and cartridge fuses. To the right of this board and at the top is a resistance board, while beneath it is a smaller switchboard purely for charging purposes.



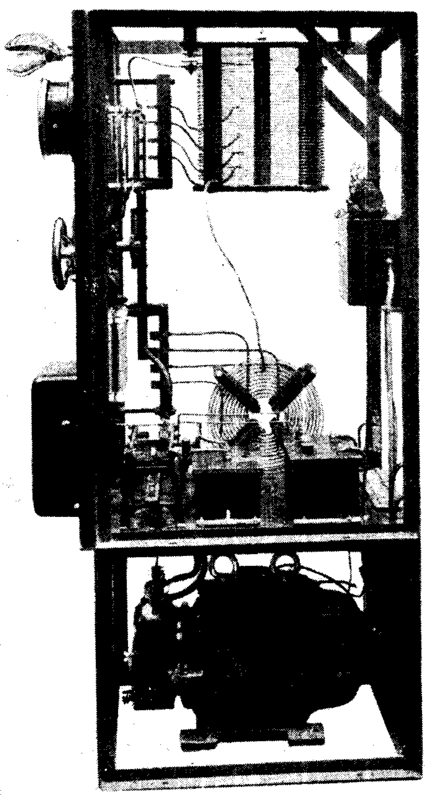
SIDE VIEW OF THE SET

Fig. 6. At the bottom are seen the generator and rotary spark gap. The main transformer and condenser are on the shelf immediately above the generator unit

Courtesy Radio Communication Co., Ltd.

On the table below is mounted the whole of the transmitting and receiving apparatus. The transmitter is housed in the wooden framework to the right, and consists of tuning inductances and variable condenser, aerial ammeter of the hot-wire type, a discharger, fixed condenser, etc. Immediately in front of the transmitter itself is the tapping key. On the front right leg of the table is located the starter for the generator, which is housed on the floor below.

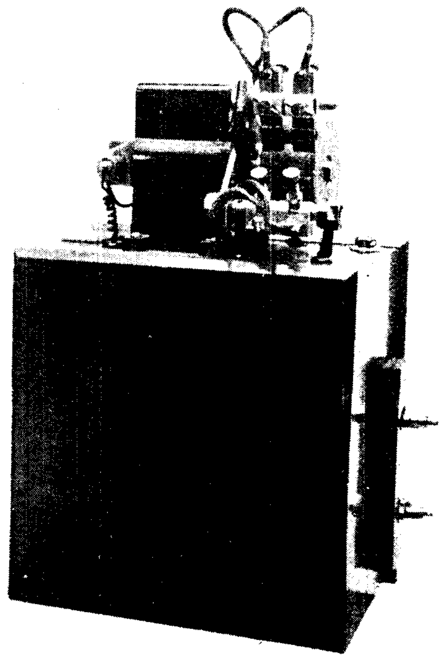
The receiver is on the left-hand side of the table, and consists of a high-frequency amplifier tuner using a V.24 valve and a rectifying panel mounted on the sloping cabinet. Coarse tuning may be accomplished on the sliding inductance shown at the extreme left. Final equipment consists of a blotting pad and writing materials for the convenience of the operator.



INTERNAL DETAILS OF THE SET

Fig. 7. In this view are shown details of the oscillation transformer and the aerial tuning inductance of the transmitting set

Courtesy Radio Communication Co., Ltd



EMERGENCY INTERRUPTER GEAR

Fig. 8. Close view of the coil and interrupter gear in the emergency set incorporated in the set shown in Figs. 5, 6 and 7

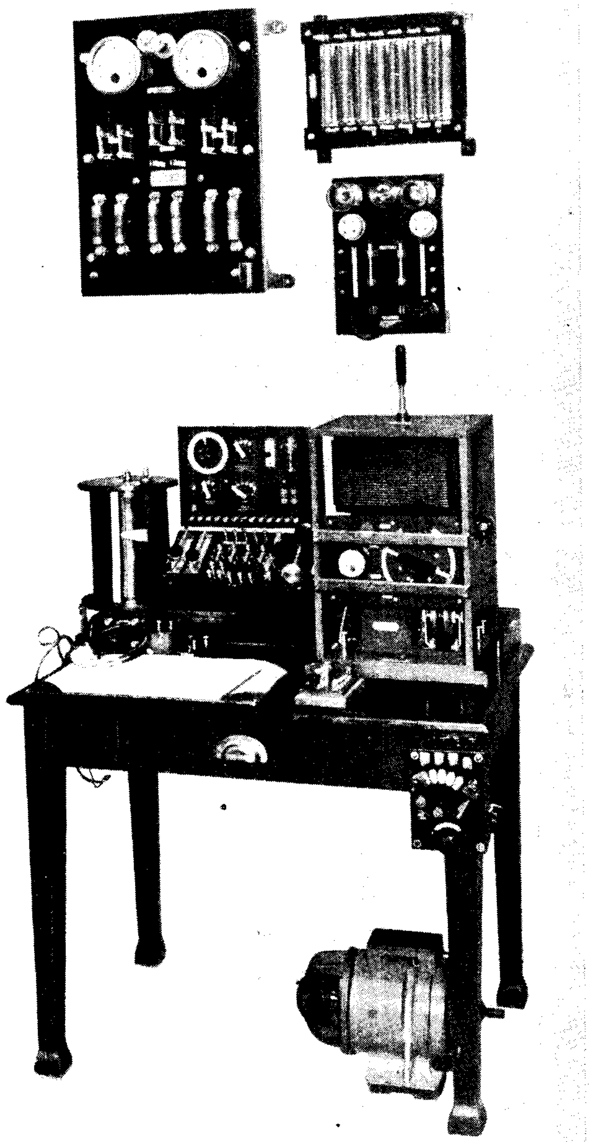
In Fig. 10 is illustrated the complete wireless installation on board the Cunard liner "Berengaria." The main portions of the valve transmitter are shown on the extreme left-hand side of the operator's bench. It is a three-valve set, arranged for C.W. working, having a maximum power of $1\frac{1}{2}$ kw. Controls are fitted, enabling any desired power up to the maximum to be used.

At the back of the bench, in front of the operator's chair, is the valve receiver, heterodyne unit and wave-meter. The actual receiver is a three-valve instrument consisting of one rectifier (with optional crystal) and a two-stage low-frequency amplifier. Immediately above the receiver is a large D.P.D.T. switch for the transmitter.

The right-hand end of the bench supports the transmitter tuning arrangements and an emergency spark set. The latter is sufficiently powerful to enable the operator to get into touch with any near-by ship when the main transmitter is out of order or the ship's main current supply fails. The transmitting variometer is located on the wall at the back of the bench, and consists of spiral inductances mounted on hinged brackets which enable their relative positions to be altered at will. Under the bench, and situated within convenient reach of the operator's right hand, is the starter for the main generator.

Sometimes, for convenience of working and to save space, ship transmitters are arranged within a cabinet. Of this type of apparatus, those illustrated in Figs. 11 and 12 are conventional examples. Fig. 11 shows a $\frac{1}{4}$ kw. station by Siemens Bros. & Co., Ltd. This is a spark station in which the generator, which is supplied with current from the ship's mains, is housed within the lower compartments of the cabinet. The tuning variometer is shown to the left, and consists of three spiral inductances of copper strip arranged so that they may be moved through a vertical plane. To the right of this is a box containing condensers and fittings for any one of a series of interchangeable loading coils for obtaining different wave-lengths.

On the switchboard at the rear of the cabinet are mounted meters for the main input, and switches, circuit-breakers, resistances, etc. for charging purposes. Immediately in front of this board are mounted the main and auxiliary gaps and a plug-board for different circuit arrangements. A Morse tapping key is situated conveniently within the operator's reach on the hinged table. Beneath the latter is the main hand-wheel for controlling the generator.



$\frac{1}{4}$ KW. SHIP'S TRANSMITTER

Fig. 9. On the wall to the left is the main power switchboard; to the top right is the resistance board, and below, the charging switchboard. On the table is the transmitting and receiving apparatus

Courtesy Marconi's Wireless Telegraph Co., Ltd

Fig. 12 shows a larger and more powerful set, employing a valve transmitter, by Marconi's Wireless Telegraph Co., Ltd. This is typical of the most modern practice, and provision is made for either C.W. or telephony working. The valves, which are three in number, are arranged in a special compartment, which is normally shielded to prevent accident from shock. On the lower left-hand corner of this is a main switch, while on the upper corner, the same side, is a push-button, which must be pressed to discharge the condensers before the valve connexions are safe to touch.

Above this button is a Weston moving-coil ammeter.

The tuning part of the transmitter is arranged on top of the cabinet in a separate case-work. Reaction controls are on the left, followed by a plug-board for wave-length variation by using different tappings on the inductances.

The knob to the right of this plug-board is a control for a variometer, and on the right of this is the aerial hot-wire ammeter.

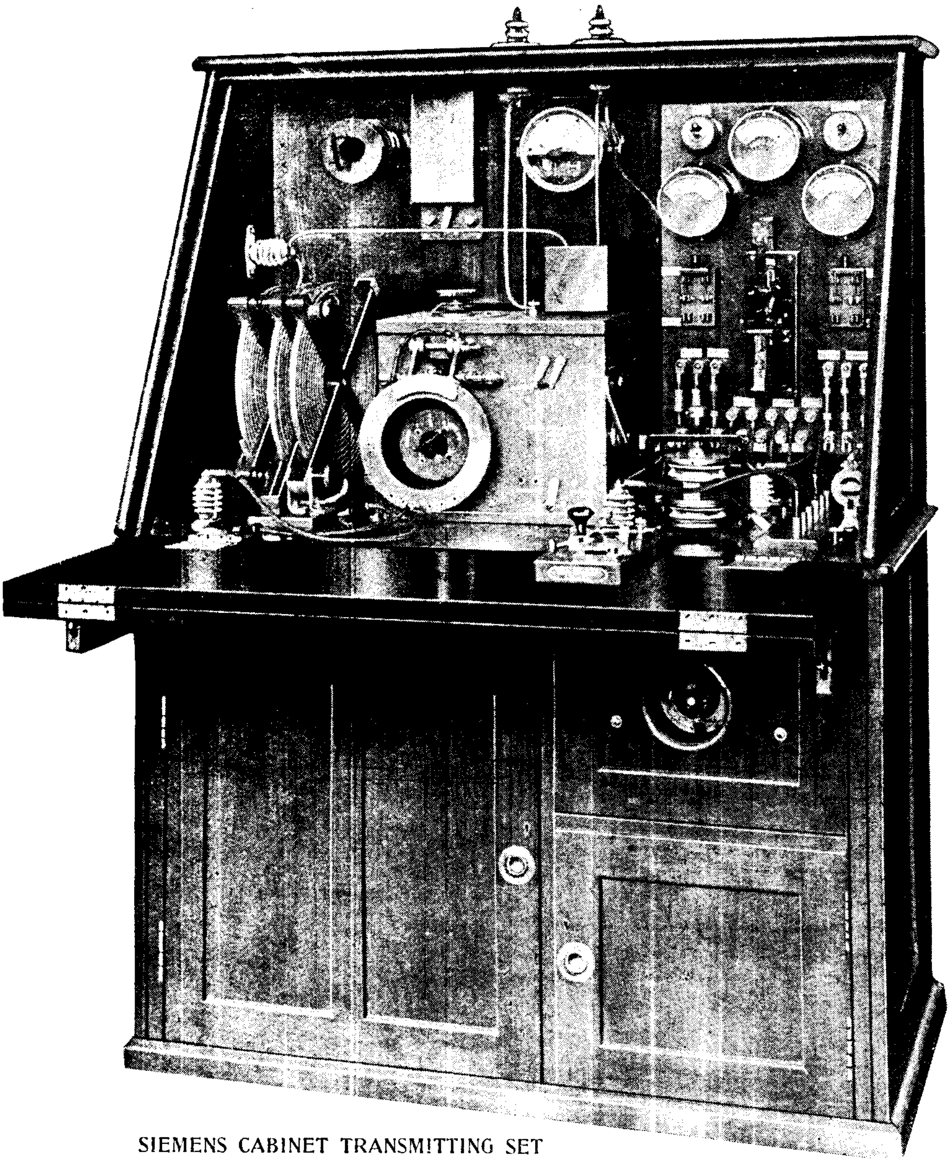
Transmitting key and microphone are arranged on the right-hand side of the cabinet, and may be clearly seen, the former on the table, and the latter hanging on a hook on the right-hand wall.

The receiver is a seven-valve instrument, employing V.24 valves for amplification

WIRELESS APPARATUS ON BOARD THE "BERENGARIA"

Fig. 10. Above is given a view of the complete wireless installation on board the Cunard liner "Berengaria." It is a three-valve set, arranged for C.W., and has a maximum power of 1½ kw. The main part of the valve transmitter is shown on the extreme left

Courtesy Siemens Bros. & Co., Ltd.



SIEMENS CABINET TRANSMITTING SET

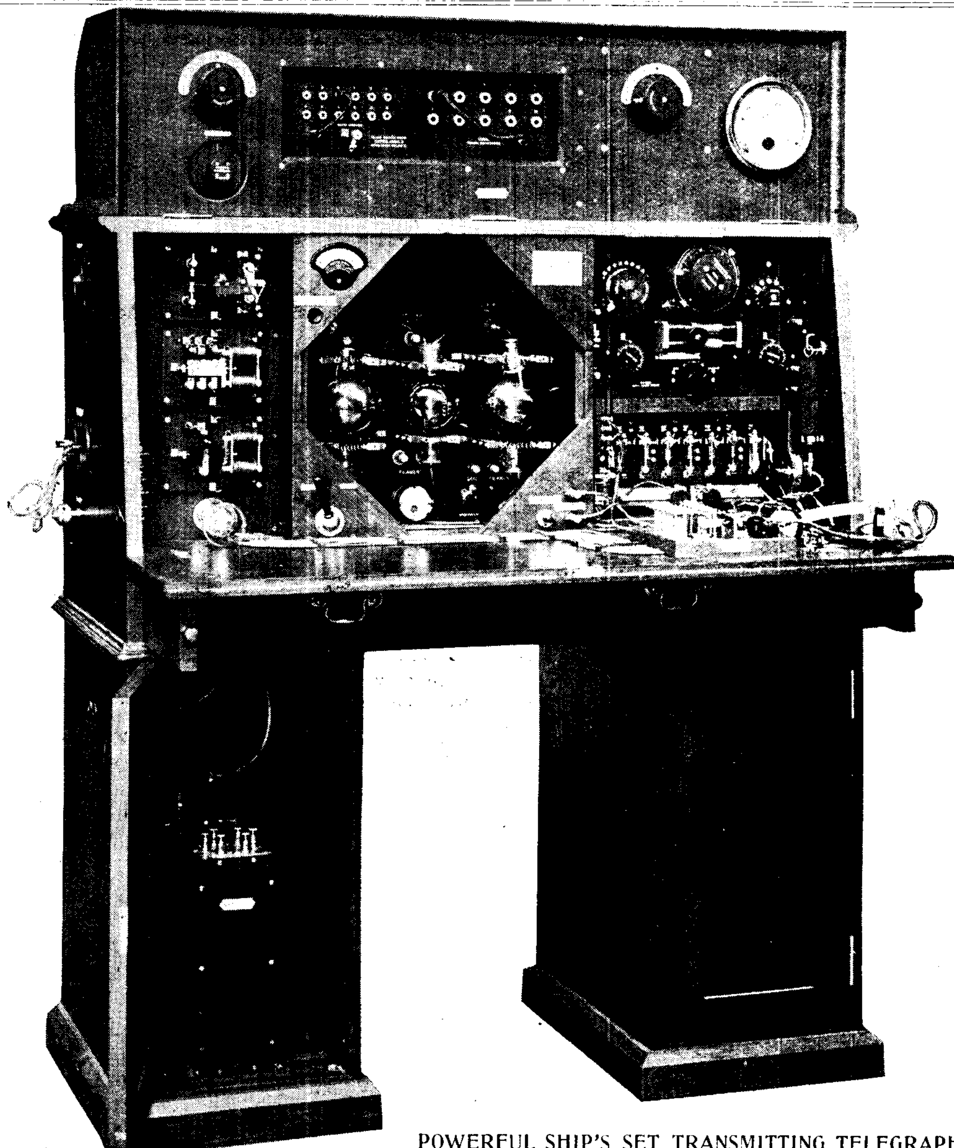
Fig. 11. Current from the ship's mains is used in this compact transmitter. The generator is housed in the lower part of the cabinet and supplies current for spark transmissions

Courtesy Siemens Bros. & Co., Ltd.

and a Q valve for rectification. Potentiometer control is fitted, but for convenience in handling there is only one filament resistance.

Above the valve panel is located the receiver tuner. Here the stud switches at the top are for A.T.I. and jigger respectively, while between them is the main aerial tuning condenser. Below this is a sliding double tubular condenser, with a horizontal ivorine scale attached. On either side of this are knobs controlling the coil couplings, giving the required amount of selectivity.

Fig. 13 is another Siemens marine installation fitted in a cabin. It follows the same general design as the cabinet set illustrated in Fig. 11, except that the individual components are much larger and are spread out on the table and cabin



POWERFUL SHIP'S SET TRANSMITTING TELEGRAPHY AND TELEPHONY

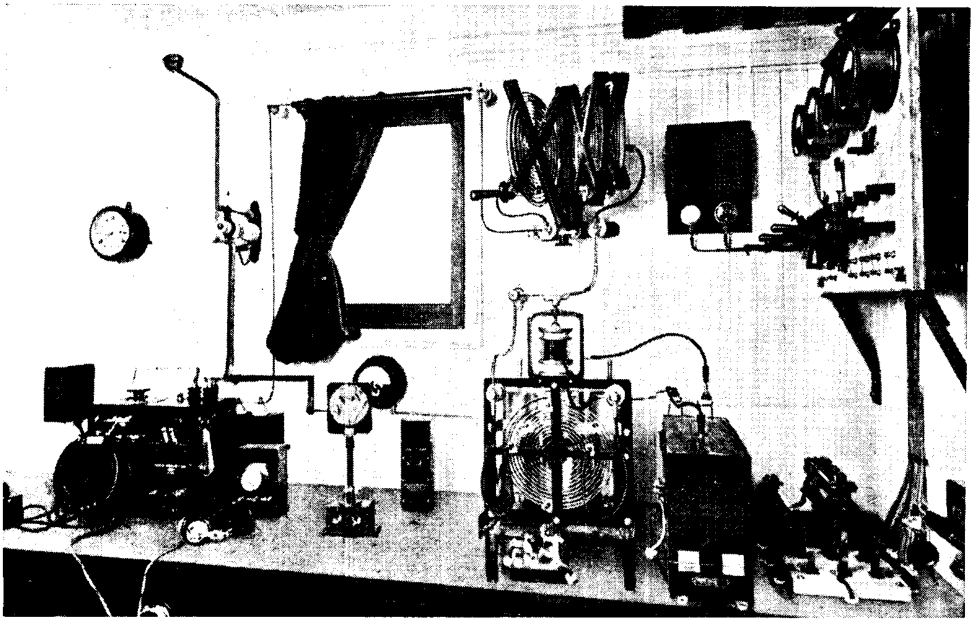
Fig. 12. Transmission on this apparatus is effected by three valves, and can be carried out either in C.W. or telephony. The receiver is a seven-valve instrument, in which potentiometer control is employed, and is of the latest design

Courtesy Marconi's Wireless Telegraph Co., Ltd.

walls. This set is rated to give an output of ½ kw.

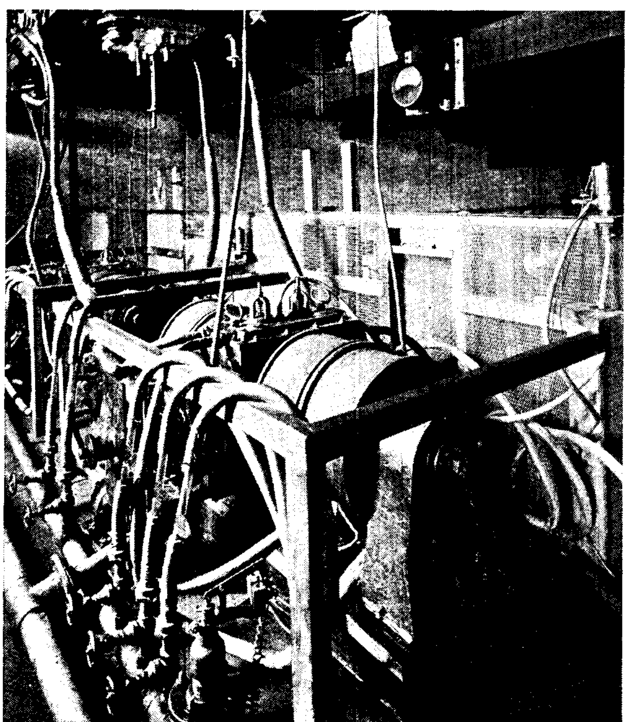
In this set the transmitting apparatus is grouped on the right side of the cabin, the tuning variometer being attached to the wall, and the main transformers, spark gap and key being located on the bench. Power switchboards are fitted on the right-hand wall, provision being made in this gear to allow for any desired accumulator charging or discharging arrangement.

On the left of the bench will be seen the receiver, mounted within the square cabinet. Hanging on the front is the interchangeable loading coil, while the telephones are shown on the bench. The aerial leads for both instruments are of heavy-sectioned copper, bare, and supported from the walls on china insulators.



SIEMENS RECEIVING AND TRANSMITTING SET

Fig. 13. On the right-hand wall above are fitted the power switchboards for transmission. The receiving set is on the bench to the left. The transmitter output is ½ kw.



CARNARVON ARC TRANSMITTER

Fig. 14. At Carnarvon the installation is of 200 kw. The discharger is seen in the foreground, and the arc is enclosed in the water-cooled chamber in the centre

The lead-in insulator is specially designed for seagoing conditions, having glands for the prevention of the entry of water.

An arc transmitter of very high power is illustrated in Fig. 14. This is a 200 kw. installation, which has been in use at the Carnarvon station of the Marconi Company. The discharger is seen in the foreground, and is a totally enclosed piece of apparatus, wherein the arc itself is propagated in the central box-like compartment. The latter is hermetically sealed as far as the atmosphere is concerned, and is filled with gas, as previously described. Water-cooling is provided to the chamber in which the arc is generated in order to neutralize the effects of the enormous heat. The pipes for conveying the water to the installation are clearly shown.

On either side of the arc chamber are arranged the blowing magnets. The cores are supported on massive cast-iron brackets. All the leads to and from the arc apparatus are heavily insulated and protected against mechanical injury, while at the back, behind the expanded metal shielding, is the switch-gear.

A second installation is fitted behind the one shown to the front. This is of identical design and construction, and may be used in case of emergency.

Aircraft Transmitters. Modern commercial aircraft working requires high-powered transmitters designed specially to suit the conditions peculiar to this form of communication. All large aerodromes are fitted with telephony and C.W. transmitters and receivers, and a typical example is shown in Fig. 15, which is a $1\frac{1}{2}$ kw. aerodrome set by the Marconi Company.

The principal features of this installation are that it is designed to ensure maximum reliability and accessibility of parts in the rare event of breakdown. On the table to the left is the tuner, which has a normal wave-length of about 900 metres. The inductances are wound in stranded wire, and a rotating coil is fitted within the outer inductances. Tappings with a wander plug are fitted on both sets of inductances, enabling different wave-lengths to be worked when desired.

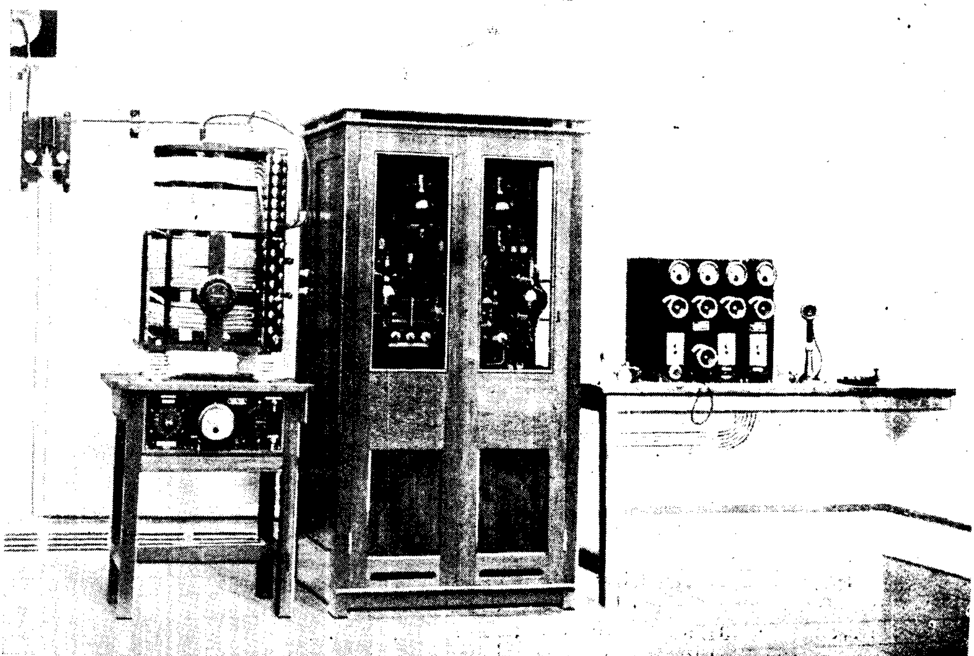
Within the central cupboard are the transmitting, "drive" and modulator valves, together with all the usual auxiliary apparatus, consisting of condensers, transformers, etc.

The receiver is mounted upon the bench to the right, and is a totally enclosed instrument, having controls mounted upon the front panel. Here are also placed the microphone, very similar in appearance to the ordinary Post Office telephone instrument, and the Morse tapping key for the C.W. transmissions. The telephones are also arranged conveniently near this apparatus.

The transmitter, once set to the correct wave-length for the particular work in hand, requires no further adjustment, so that no useful purpose is served by having its controls near the receiver.

The receiving sets for use with apparatus of this kind, but for attachment to the aeroplane itself, are fully described under the heading Remote Control in this Encyclopedia.

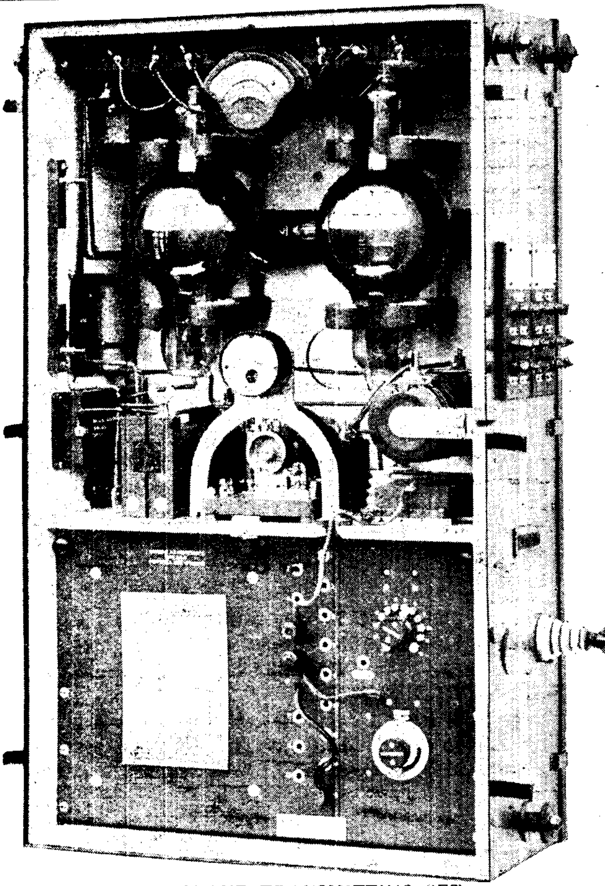
Fig. 16 shows the latest practice in high-powered aircraft transmitters by the



FOR AIRCRAFT COMMUNICATION: $1\frac{1}{2}$ KW. TRANSMITTER

Fig. 15. This set is suitable for installation in aerodromes to communicate with aeroplanes. On the left is shown the tuner; in the cabinet are the transmitting and modulator valves, and on the right is the receiver. Access to all parts is very easy

Courtesy Marconi's Wireless Telegraph Co., Ltd.



AEROPLANE TRANSMITTING SET

Fig. 16. In this set the valves are held in specially designed brackets lined with soft packing to eliminate breakages liable to occur through landing shocks

Courtesy Marconi's Wireless Telegraph Co., Ltd.

Marconi Co. This is a continuous wave or telephony set rated at 500 watts, the whole apparatus being contained within a cabinet for convenience of handling and transport. In the lower compartment is the tuner, the wave-length adjustment of which is varied by means of flexible leads with wander plugs which plug into different tappings on the inductances. Reaction is variable by means of a stud switch, and a variometer is also fitted for tuning purposes.

The two 250 watt valves are clearly shown in the upper compartment. They are held in specially designed brackets, lined with soft packing to eliminate breakage due to shocks in landing, etc. Below the valves are the condensers, chokes and other apparatus, while mounted on a special bracket and facing the front is the aerial hot-wire ammeter. At the top is an ebonite strip in which the terminals for the valve leads are located, and in front of this, in the centre, is a Weston moving-coil milliammeter. The terminals for the various leads to the batteries, etc., are shown on the right-hand side of the case.—*R. B. Hurton.*

TRANSMISSION—II. THE AMATEUR AND HIS PROBLEMS

By William Le Queux, M.Inst.R.E.

Here one of the earliest experimenters in the field of British amateur transmitters describes the principles and practice of amateur transmission and discusses high tension, microphone, and earth and aerial problems. **See also the following section**

The amateur wireless experimenter has never been quite happy with his hobby unless he has been able to " answer back."

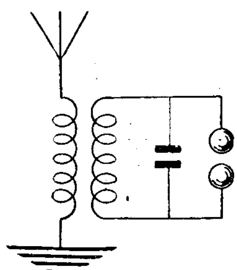
Marconi's earliest difficulties were not those of causing disturbances in the ether, but in detecting those which had been set up, and it is still the case that the amateur of to-day has his hands full in increasing the sensitiveness of his set for receiving.

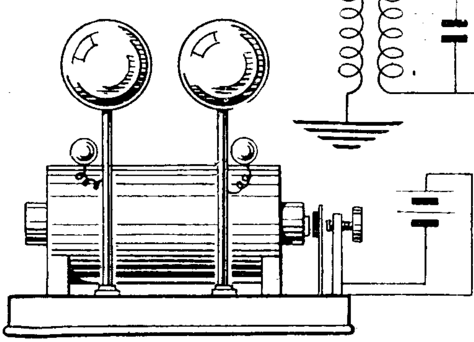
The earliest type of transmitter, ascribed to Rigi, was that of two metallic balls, which, oppositely charged to a high potential, equalized the stresses by rupturing the ether between the balls, and in this manner set the ether in sympathetic vibration (Fig. 1).

The surfaces of the balls were very highly polished, and sometimes even platinized in the effort to make the spark take place more suddenly. The spark was also sometimes arranged to take place in oil to increase the disruptive force produced.

It was found, however, that a more efficient and far-reaching disturbance was effected if metallic plates were added, as in Fig. 4, thus increasing the electrical capacity and the amount of the consequent discharge. This oscillator was very shortly improved into the form of an aerial wire running vertically upwards, and the circuit completed by being connected on the other side to the earth, a capacity-shunted inductance being connected between (Fig. 2).

Here it should be understood that the reason why the vertical aerial was so much more efficient was because the field, both electrostatic and electro-magnetic, was spread out in space. The compact oscillating circuits of Figs. 1 and 4 did not distribute their field over such a large area, and thus they had a better chance of changing





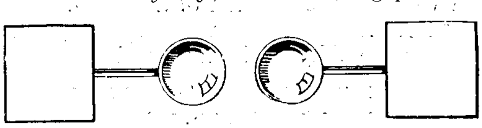
TRANSMISSION IN DEVELOPMENT

Fig. 1 (left). Early type of transmitter ascribed to Rigi. Fig. 2 (top). Spark circuit coupled to aerial. Fig. 3 (right). One spark ball earthed and the other connected to aerial, inductance and condenser

more or less completely from one to the other in the time at their disposal.

With an elongated aerial the electrostatic charge, we will say, rushing up the aerial wire could not in the time absorb all the energy of the preceding electro-magnetic field; and the electro-magnetic field which followed could not, in the time, convert all the energy which was building it up into an electro-magnetic field.

So at each cycle or change some of the energy was left out of count, or pushed off out of the way, by the succeeding phases



INCREASED OUTPUT EFFICIENCY

Fig. 4. This illustration shows the development of the apparatus in Fig. 1. Here the radiation is made more effective by the addition of capacity plates

of the energy, which was being continually and freshly supplied. These homeless fractions of the energy of each phase constitute, then, the energy which is radiated, and with which the transmitting amateur has to deal.

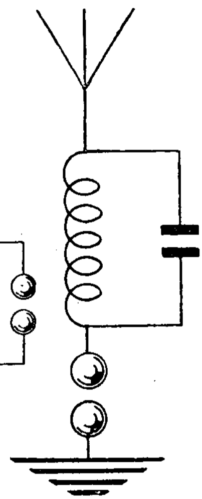


Fig. 2, then, was the earliest practical form of what we now call the untuned aerial, and, signalling with its use, a distance of several miles was achieved, even when employing the very inefficient coherer of metal filings as a detector. The chief cause of the inefficiency of this transmitter was the fact that it made an "ethereal noise," that is, the frequency and wave-length of its oscillations were not regular, and tended towards self-interference. Expedients were soon set afoot to devise a means whereby the frequency should not be modified by the means of establishing it.

This was ultimately effected by inductively coupling the circuit in which the spark was discharged to that which was in metallic contact with the aerial wire (Fig. 3).

In this form of transmitter the functions of the circuits, primary and secondary, closely approximated to those of a Tesla transformer, and it is this form which survives in the arrangements of spark transmitting stations to-day. The most outstanding feature of this type is the H.F. component of its secondary currents, and the possibility of approaching more nearly to the enormous frequencies of oscillation of the free electric circuit of low capacity and self-induction.

It was quite a "stunt" in the early amateur transmitting days to allow fearsome-looking sparks to jump to the operator's body from the aerial circuit without any obvious discomfort.

The drawback to this method of transmission is still its ethereal noisiness, and the difficulty in confining its effects within anything like narrow limits. This may be considered something of an advantage when signals of distress at sea are being transmitted, for a spark "S.O.S." will punch through and attract attention when the same signal sent by a "C.W." station, and being more narrowly tuned, might miss some of the marks at which it was aimed.

So it will be seen that spark transmission with limited powers should be a system to be used very sparingly by the experimenting amateur for the risk of spoiling his neighbour's enjoyment of the use of the ether, and would need a great deal of contemplated scientific advantage to himself to justify it in the mind of the sportsmanlike amateur.

With the advent of the thermionic valve, however, the case for the amateur transmitter at once underwent a change for the better. It was so easy, as even the broadcast listener knows to his sorrow, to get a valve to set its connected aerial into oscillation.

Simple C.W. Transmitter

Nobody with a reactance set will, of course, knowingly allow it to re-radiate, but if you have a Morse tapping key in your H.T. battery circuit it will be the easiest thing in the world to send C.W. signals for miles with a simple circuit as ordinarily arranged for receiving only. Such a C.W. sending set will be very useful for communicating over distances of several miles with such low and selective power as not to interfere with any neighbouring receiver unless the latter was tuned very closely to the wave-length used on the transmitter.

Such arrangements will need the use of the Morse code, which is now rapidly becoming an anachronism as far as the amateur experimenter is concerned, as speech is so easily possible now, and is much more convenient.

C.W. Transmission. Few writers in the pages of our technical journals pay a great deal of attention to the matter of the oscillating valve. They denounce the reactive receiver who "canaries" across their ether while their ears are extended out across the Atlantic. But they do not say what makes his valve oscillate.

Perhaps we may be allowed to digress to introduce an illustration. If we put a seashell to our ear we shall hear a roar, "the sound of the waves on the beach," we were told by our nurse: but really the amplified resonance of the sound waves which unamplified we did not notice. If this noise could be coupled up in some reactively resonant manner, we should get a simile to the oscillating valve. We can slightly vary the expedient and still get our simile, however.

If the telephone receiver on our domestic Post Office telephone installation is placed squarely in front of and close up to the transmitter of the instrument it will howl.

The sensitive diaphragm of the transmitter has been set quivering slightly by the displacement of the air caused by bringing up the receiver, and so generates feeble variations in resistance in the transmitter and battery circuit. These throw the circuit containing the secondary of the transformer and the receiver into electrical oscillations, which set the receiver into stronger vibrations, communicated in turn to the diaphragm of the transmitter.

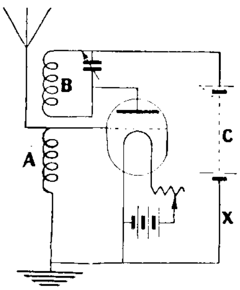
This, in its turn, varies the current flowing in the circuit common to the two, and these currents, minute at first, soon build up by reaction and make a piercing howl, depending for its pitch and volume on the natural frequency of vibration of the diaphragm and the electrical constants of the circuit.

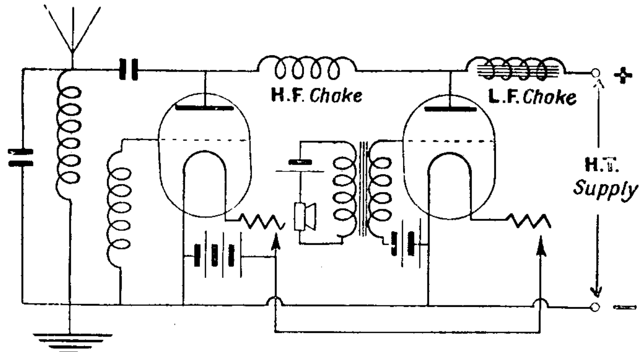
A former Premier, the late Marquis of Salisbury, used to say that the ether was the infinitive of the verb to oscillate, and, of its nature, it is difficult to conceive it as ever being really quiescent. Anything there being at all sympathetic with it will vibrate with it.

How Oscillations are Generated

Consider in this connexion the diagram Fig. 5. The coil A connected with the aerial shares, with the aerial, some of the tiny oscillations it has picked up from a quivering ether. As the oscillating currents are finding their way to earth, the connexion to the grid of the valve causes the grid to vary in potential. The valve itself amplifies this variation, and passes on the amplified variation to the coil B, which in turn is inductively coupled to the coil A, and passes back into it again some more of the energy, which again goes the round of the circuit, A grid B, increasing each time till the valve is in full blast, or "saturated," as we call it, and all this is done in a very minute fraction of a second.

You now have the whole system, aerial and all, wildly oscillating and disturbing the ether rhythmically by the energy it is abstracting from the high-tension battery C. If we break the circuit at X, we cut off the supplies and stop the oscillations. If we place a key at X, we can stop it or allow it to start at will, and we have the ready means of sending Morse signals. If we do





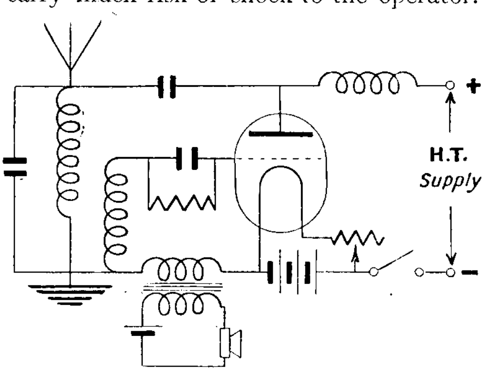
TRANSMITTING CIRCUITS

Fig. 5 (left). One-valve circuit with Morse key at X. Fig. 6 (right). Two-valve set with high-frequency and low-frequency choke coils

not vary the circuit otherwise, the stream of energy emitted when the key is closed will be continuous, and of a uniform frequency and wave-length, and hence is called continuous wave telegraphy.

There are still many war trained amateurs who would soon be able to recall their Morse dexterity, and they are reminded that C.W. signals travel farther, and are more secret and less disturbing to others, than a circuit using the same power for the purpose of radio-telephony.

A design of a workable C.W. circuit is given in Fig. 7, and on this diagram is also indicated how such a unit could readily be converted for speech, by providing a microphone, microphone battery and microphone transformer, the secondary of this transformer being put across the position where the C.W. key would normally come. It will be noticed that this key is put near the "earth" lead, and will therefore not carry much risk of shock to the operator.



C.W. TRANSMISSION CIRCUIT

Fig. 7. Above is a useful C.W. transmitting circuit which can also be used for purposes of telephony transmission

In this circuit also is put a fixed condenser of about ·002 mfd., and an "air choke" consisting of about 350 turns of No. 30 S.S.C. copper wire on a 3 in. diameter former. This is to keep back the oscillations which might otherwise traverse the high-tension battery and get away to earth without doing their share of the work. This diagram is of a class known as "grid control," as it directly varies the potential of the grid at speech frequency and so controls the flow of electrons across the valve from the filament to the plate.

Reverting for a moment to Fig. 5, it should not be forgotten that the electrodes of the valve itself have a capacity between themselves quite sufficient in amount to complete a high-frequency circuit, in the one case through coil A, via the filament and the grid, and in the case of coil B between the filament and the plate, and as the effective charges on these will be varied as the voltage on the grid varies, a variation in the emitted wave-length may easily occur in working.

Moreover, a grid-control circuit is undoubtedly difficult to adjust, and it is not an easy matter with it to avoid distortion of the emitted speech or music, for all its apparent simplicity. It is not one which we would recommend the amateur to adopt, though we have reviewed it here so as to lead up to the development of a better system.

A circuit not open to this objection, and requiring the addition only of another valve and a high-resistance choke coil, is called the "choke control," and, properly constructed and adjusted, it is by far the best circuit for the amateur transmitter who has been allowed to use a restricted amount of power. A type of this circuit was a deserved favourite with British air forces during the Great War for communicating between planes and the ground.

It is not in the province of this article to give dimensions of the components of a choke-control wireless telephone transmitter. Taking Fig. 7 as being an efficient oscillator circuit, we will take away the telephone transformer from the earth lead to the negative low-tension battery, and straight away put it into the circuit of another valve, which, for convenience of leaving the first diagram otherwise unaltered, we will place to the right of it.

Extending our positive H.T. lead so as to join on to the plate of the new valve, we will carry it still further and put a choke coil in it before we connect it again to the positive of the H.T. battery. (Fig. 6).

Choice of the Transmitting Choke Coil

This choke coil may well be the secondary of a Ford ignition coil, or, if specially constructed, the coil may be about 20,000 turns of No. 40 S.S.C. copper wire wound upon a core of No. 24 soft iron wire about ⅝ in. in diameter and 4 in. long. If a Ford ignition coil or a Disposals Board 1 in. spark coil is used, special care must be exercised to see that the primary circuit is open, as well as being well insulated, for any wire in such a coil which makes a complete metallic loop will vitiate the whole purpose of the coil, and it will not choke.

A coil of this type also may be used for the modulator transformer, but in this case it should be dismantled. The primary wire is pulled out from the end of the bundle, thus leaving a cylinder of secondary windings which may be slipped on to a new core and primary winding, as the spark coil primary winding has not enough wire on it to function properly. 250 to 300 turns of No. 22 or slightly smaller D.S.C. copper wire should be wound upon the removed iron core for the new primary. You may have to take out a few inside layers of the secondary to accommodate it after winding, but if carefully done it should put you in possession of a very good microphone transformer.

A leak of about ·2 megohm or 200,000 ohms should be tried across the secondary and a biasing battery connected as indicated on one side, to make sure that the grid of the modulating valve is sufficiently negative.

The microphone battery must accommodate itself to the microphone; that is, if you have a low-resistance transmitter you will not want much voltage, probably one dry cell will do. A "solid back," such as is used on the standard G.P.O. telephones, is quite a good transmitter, and should be fairly easily procured.

The two valves which you now have connected up are in parallel, and they are drawing their positive plate potential from the H.T. battery via the choke coil. This, while it allows enough steady current to flow, will resist a rapidly fluctuating change, so that when, by means of the microphone, you have altered the plate current by varying the grid potential of the modulating valve on the right, and increased or diminished the demand of its plate for satisfaction, it can only draw its instantaneous supplies from the circuit containing the plate of the oscillating valve, and so starve the latter, or, reversely, overload it with the power to radiate.

As you are doing this in consonance with the sound waves impinging on the diaphragm of the microphone, the C.W. emission is modulated, and radiates as it is so controlled.

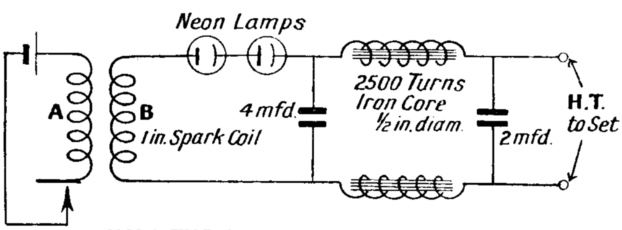
High-tension Supply. The provision of the high-tension supply for the amateur's transmitting set may offer some difficulty at the commencement of his experiments, but any good high-tension battery that will stand up to 100 volts on a light load will be quite serviceable. It will be reasonable for the amateur at the commencement of his experiments in transmission to take no more than 5 milliamperes or ·005 ampere from this source of power and for not too long at a time. With such occasional use the ordinary receiving H.T. battery should be quite suitable.

Additional H.T. for Oscillation

It may be difficult to start the valve oscillating by design with less than 100 volts, and so a small amount of additional H.T. may be useful to have on hand. Generators to be turned by hand can be obtained for providing the H.T. current, but one will generally find that they are hard put to it to spare a hand to turn it while the other adjustments are clamouring for attention. Neat little motor-driven sets are also available, either worked off an accumulator or a small motor, taking its power from the house electric light mains.

The house mains themselves may be made to provide the H.T. power. If the house service is direct current it is a simple matter to arrange, as it will rarely be as low as 100 volts, the usual being in the neighbourhood of 200 volts. The amateur is advised to have a supply board fitted by a competent electrician with 5 ampere fuses in each lead, and even then to protect the leads down to his set with 1 ampere fuses. The electric supply company's inspectors do not like a hurried call to replace the main house fuse when the failure is due to an amateur's faulty experiment.

It will also be quite advisable to put an ordinary house lamp—carbon filament for preference—into each lead with the



HOW THE H.T. CURRENT IS SUPPLIED

Fig. 8. Here the spark coil is driven off a 2 volt accumulator. A is the primary and B the secondary winding

1 ampere fuse, as these lamps will take all the load in the case of an accidental short circuit. The fire insurance companies also might have something unpleasant to say in the matter if the house was set alight by a short circuit brought about by unskilled experimenting. Failing any of the foregoing, it will be quite an easy matter to use a 1 in. spark coil to get what is wanted. In the diagram Fig. 8 the spark coil is driven off a 2 volt accumulator, A being the primary and B the secondary winding.

On one side two Osglim or neon lamps are connected in series as shown, and two choke coils inserted in the H.T. leads to the set, as indicated. A 4 mfd. and a 2 mfd. condenser should be inserted across the leads as indicated, and the result should be quite smooth working. With an alternating current supply it is possible also, by means of specially wound transformers and rectifying valves, to arrange for the H.T. as well as filament current by merely turning on a switch; but the design and construction of such a set is a matter rather beyond the scope of the ordinary transmitting amateur, and even if successfully achieved one might have to go over everything again from the start if an accident necessitated the installation of a new valve.

The Amateur's Microphone. As in photography everything ranks in secondary importance to the lens used, so in wireless transmission the microphone is the centre round which is grouped everything as being more or less accessory to it.

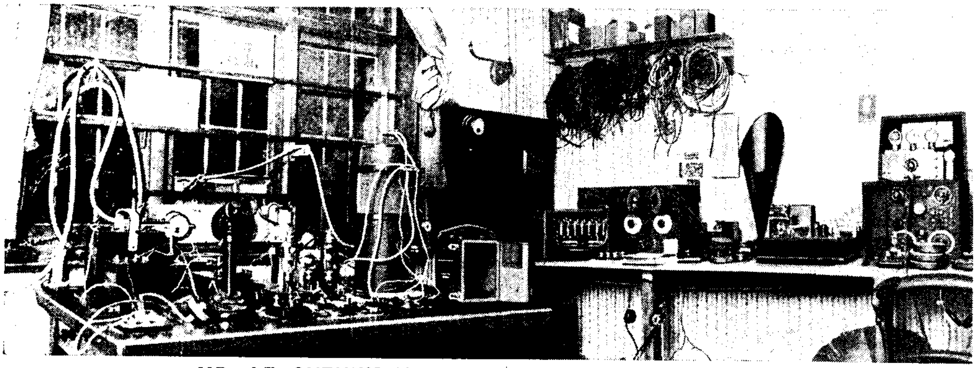
The air waves set in motion by speech and music are very complex, and also of a very low order of mechanical power, and no microphone has yet been devised which will at once be sufficiently sensitive and versatile. Conductors will allow currents to pass through them in proportion to the conductivity of their material, but the conductivity of a chain of particles of conducting matter will depend upon the closeness of the contact which they are making with each other and with other parts of the electrical circuit which they are in.

Carbon is a substance which is particularly suitable for the application of the principle of varying the conductivity of a circuit with the pressure between adjacent particles, and one of the simplest and most efficient microphones consists of two conducting plates forming the lid and bottom of a small box which is filled loosely with polished carbon granules.

All that is necessary, then, is to vary the pressure between the lid and the bottom of the box in order to vary its conductivity for the electric current. Generally the bottom, we will say, is held fast, whilst the lid has attached to it an elastic diaphragm so arranged that the air waves will impinge upon it and make it vibrate in syntony with themselves.

Any student of the science of sound remembering the "Chladni's Plate" experiment knows how an elastic plate will endeavour to accommodate itself to a complex vibration, but in the nature of things the vibration of the diaphragm of a microphone can be but a compromise, both in the response and also in the passing on to the carbon granules of the fluctuating pressure which it is vainly trying to pick up.

The wonder, then, is, not that the carbon



MR. LE QUEUX'S TRANSMISSION SET AT GUILDFORD

Fig. 25. Among the pioneers of amateur wireless in this country, Mr. William Le Queux, the well-known author, was one of the first British experimenters to build his own transmission station. Our photograph gives a view of the early telephony and Morse printing arrangements of 2 AZ

microphone is not perfect, but that it is as good as it is.

Attempts to modify the arrangements of the diaphragm have been made where a flow of conducting liquid between two electrodes has been varied, and efforts to do away with the diaphragm altogether by using a sensitive flame between two electrodes kept at a fairly high potential have been more or less successful, but the British Broadcasting Company use a light pancake coil freely suspended in a strong magnetic field, so that when the coil moves at all the wires generate a current in them by cutting the lines of force.

The "solid back" type of transmitter used on the Post Office type of telephones can work on a circuit containing a battery of from 2 to 24 volts, but a "capsule" or "inset" type will probably not stand a great deal more than 2 volts without causing "hissing" and "frying" noises, due to the current striking small arcs across minute gaps between the carbon particles.

It is a great and common mistake to overload the transmitter with voltage and consequent current. The best way of increasing the effect of the speech current variations on the transmitted continuous wave is by means of the step-up microphone transformer.

Earth Connexions and Aerials. Following the advice given in countless manuals and by well-meaning friends, the beginning amateur probably just makes the best possible connexion that he can to the water supply pipe of the house.

If this lead pipe continues for some distance unbroken by screwed union joints, in moist clay or earth, particularly if it runs beneath the aerial and is soldered to the stout copper earth lead, it is good. It must be remembered that a wire cannot be soldered to a water pipe properly while the pipe contains any water. If the lead water pipe soon joins to an iron one with screwed joints secured with white and red lead putty, considerable resistance may be introduced at that joint, and as an earth it is not nearly so desirable.

Even with an irreproachable lead pipe the wire connecting it to the set should be short, stout and insulated, and run as straight as possible.

"Two earths in parallel are better than one" is only strictly true in a limited number of cases, for if the two so paralleled have not the same resistance, or, even more important, the same inductance, the use of the two simultaneously may seriously interfere with the efficiency of the set, by bringing in two different natural frequencies which will seek antagonistically to satisfy themselves.

Provided that it is buried deep enough in damp soil, few earths can surpass in efficiency an old galvanized bucket filled with broken coke, with a thick wire soldered on to the metal of the bucket body, and the joint protected by pitch or tar against contact with the wet earth. Again, a copper mat of fine mesh is a good earth when spread under the aerial in damp ground.

The bellhanger's gimlet as a tool is not known and appreciated as it should be amongst wireless people.

Eighteen to twenty-four inches long, and costing about 1s. 6d., one can start inside a room at an outside wall and make a small hole just above the skirting board to run a good 7/22 or larger-sized copper lead directly to the buried earth. The consequent damage to the property is infinitesimal and can be repaired at any time with a spoonful of cement.

For the purpose of receiving wireless signals there are few forms of aerial better than a 7/22 stranded enamelled copper wire. For transmitting, however, where ease of dissipating even a small amount of energy is a consideration, the wires would be better if spaced out farther apart.

Twin wires on spreaders are good but often clumsy-looking, and are apt to flog about in a high wind. A cage aerial is much better for transmitting, as is obviously also the opinion of the Admiralty and the B.B.C.

Children's wooden hoops or the like, having a diameter round about twelve inches or more, may have equidistant holes drilled round them through their faces and the wire threaded through these holes. When the wires are in position, they may be jammed tight in the holes by pointed wooden match sticks, otherwise the hoops may, when hoisted in the air, incline about from side to side in a manner that is the reverse of smart-looking. Painting them with black water-resisting material will also prevent their warping and looking, if anything, rather worse.

The cage aerial so constructed should be set out upon the ground level between two posts to keep it taut while being assembled, the ends of the wires being carefully grouped and soldered where looped into the insulators at the ends.

If the lead-in is attached at one end, a good solid soldered joint may be made with a stranded lead-in wire, but if it is decided to make it a T aerial, the lead-in wire should make soldered connexion with each of the several wires of the cage.

For the amateur, a cage type of down lead-in wire is not at all essential, but there is no objection to it, and it certainly looks more finished.

The insulation of the transmitting aerial is very important, as is also the avoidance of capacity effects in the leading-in wires by parallel walls or metal pipes, for otherwise it may easily happen that a considerable part of the transmitting energy provided will leak away to earth rather than charge up the aerial.

It should not be forgotten that insulation which is quite efficient for receiving is quite inadequate for transmitting, as the voltage is generally much higher, and the aerial current certainly much greater.

TRANSMISSION—III. CONSTRUCTING AMATEUR STATIONS

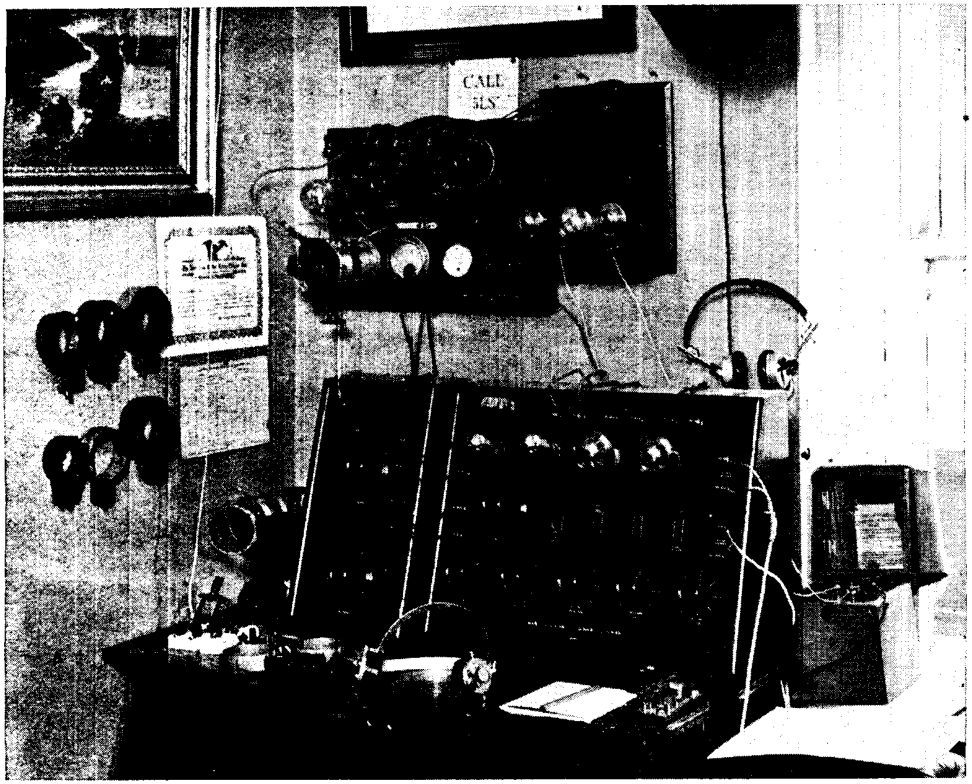
How Two Excellent Transmitting Sets were Built and Their Working Described

This section contains a detailed description of the construction of the well-known amateur stations, 5 LS and 6 RJ, and also the circuit designs. The reader should also consult Part II of this series of articles, by William Le Queux, and the many constructional articles in this Encyclopedia dealing with the components of transmitters and receivers

Of amateur-made and operated transmitters and receivers, the station 5 LS, illustrated in Figs. 1 and 2, is an excellent example. Referring now to Fig. 2, which shows the transmitter only, it will be seen that the whole set is mounted upon a wooden baseboard, attached to the wall. The station is designed primarily for C.W. Morse, working on low wave-lengths and power, the standard wave-length being 200 metres, and the power input 10 watts.

A circuit diagram of the transmitter is given in Fig. 3, the Hartley circuit being employed. Starting with the A.T.I., which is clearly shown in the top left-hand corner in Fig. 3, this consists of 28 turns of 16 S.W.G. tinned copper wire on a 3½ in. diameter ebonite tube. This tube is grooved spirally to take the wire, and has been slotted down in four places in order to reduce the amount of material in contact with the conductor. Within the A.T.I. is the grid coil, which is rotatable, and is mounted upon a piece of 3 in. diameter ebonite tubing. Across this latter coil is a ·0005 mfd. variable condenser made with specially widely spaced vanes. This condenser is the Burndept instrument contained within the walnut cabinet shown at the right of the baseboard.

The H.T. supply for this set was a source of some difficulty, because no electric supply is available in the house. Excellent results have been obtained, however, by the use of an ex-army T.V.T. unit of 30 watts rating. A 6 volt accumulator is applied to the primary of this instrument, which gives a secondary output of 600 volts A.C. When tonic-train working is employed this A.C. is fed directly to the anode of the transmitting valve via the anode milliammeter. For



GENERAL VIEW OF 5 LS, A WELL-KNOWN AMATEUR STATION

Fig. 1. The apparatus in use at 5 LS is designed primarily for C.W. Morse on low ranges of power and wave-length. The standard wave-length is 200 metres, and the power input is 10 watts. Fig. 3 shows the circuit diagram

C.W. working or telephony, a smoothing circuit is of course necessary, and the output of the T.V.T. unit is connected to the rectifying and smoothing unit shown in Fig. 1 to the right of the transmitter.

This consists of two neon tubes, each of 5 watts capacity, in series, having the addition of two large iron-cored chokes, followed by a bank of condensers totalling approximately 8 mfd. This smoothing unit gives very satisfactory service, no A.C. hum being apparent in the transmission.

All the terminals on the transmitter are arranged on strips of ebonite mounted upon the baseboard, most of the connexions being carried out in bare wires. The position of the tapping key in the circuit may be gathered from the diagram, Fig. 3, where is also shown the arrangements made for the addition of a microphone for telephony working. When working on telephony the tapping key and grid leak are shorted, while for Morse transmitting the modulation transformer secondary is disconnected from the grid.

The two meters fitted are respectively the anode milliammeter and aerial ammeter. The former usually indicates 20 milliamperes. At 200 metres, using a two-wire aerial, with the conductors 9 ft. apart and with a natural earth on to a water pipe, the apparent aerial ammeter reading is ·45 ampere. As this meter may be shorted by means of a switch and a small lamp indicator brought into circuit, the actual radiation probably increases to ·5 ampere with the resistance of the meter thus removed.

In ordinary course of working regular messages may be exchanged with other amateur stations at Manchester and in France.

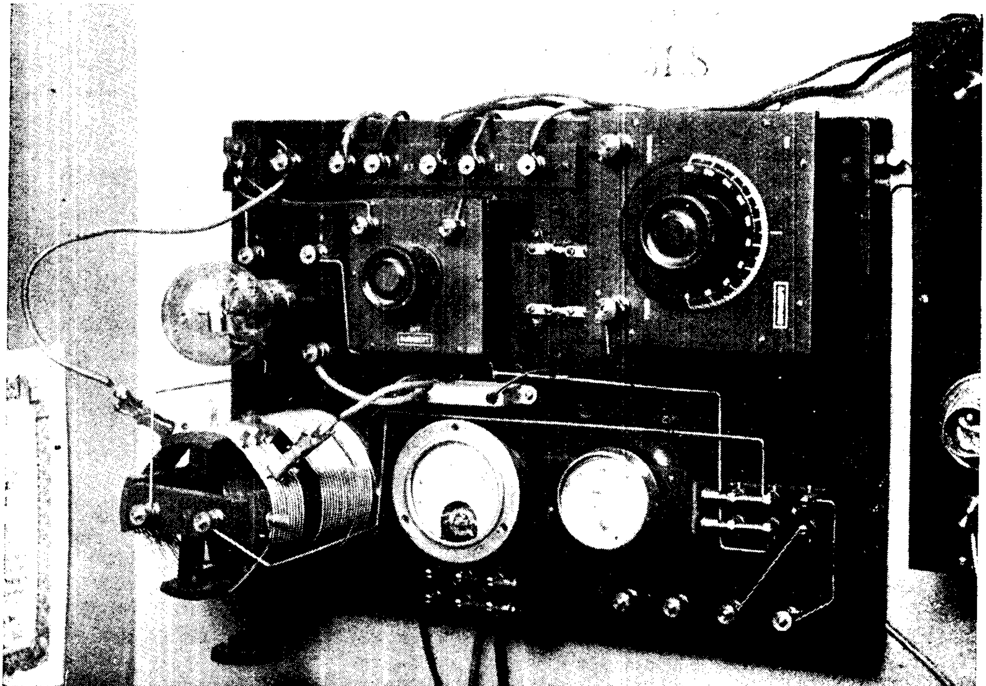
The receiving instrument used at this station is a four-valve instrument, and is a modification of the Burndept Ultra IV set, altered to suit the individual needs of the owner. Practically the only deviation from standard is the substitution of the ordinary high-frequency circuit for a tuned anode. Any or all valves may be used at will by the use of the anti-capacity switches fitted. The first valve on the left is the tuned anode amplifier, a coil holder being situated above it, and a condenser with vernier below.

This valve is followed by the rectifier, which in turn is followed by an ordinary low-frequency amplifier. The last valve is a power amplifier specially designed to give a minimum of distortion on telephony.

Figs. 4 and 5 show what is probably the most powerful amateur wireless station in the world. Its call sign is 2 BGM, and it is owned and operated by W. P. Inman, of New York, United States of America. The station has as much power as many of the large broadcasting stations, the input being 1,000 watts. It is built on the lines of a commercial broadcasting station, and four 250 watt valves are used, the aerial radiation being 6 amperes. The station has a transmitting range of several thousand miles, and comprises a receiving apparatus as well as a transmitting one. Fig. 4 shows the direction-finding apparatus used in reception, and Fig. 5 a view of the transmitting valves and inductances and transformers. In the receiving apparatus photograph the panel on the left at the bottom is the radio compass. The large dials are, on the left, the aerial tuning condenser, and, on the right, the secondary condenser. The tapped aerial tuning inductance is just above the aerial tuning condenser, and the secondary inductance to its right. The reaction coil calibrated dial is shown on the top right-hand side of the panel.

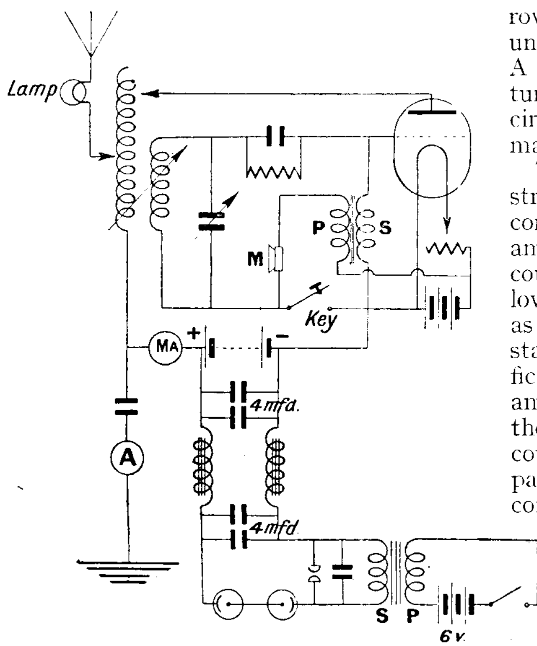
The radio compass panel is connected to a two-stage amplifier and detector, one or more stages of amplification being used, as required, by a plug-in arrangement. The receiver covers a range of 150–25,000 metres.

6 RJ Transmitter and Receiver. The amateur transmitting and receiving station illustrated in Figs. 6 to 35 is owned and worked by Mr. A. H. Howe, of London, S.E., the call-sign being 6 RJ. The general lay-out of the station is unique in that while it is all self-contained in one cabinet—an old French bureau—and while all the panels, etc., containing the various



VIEW OF PART OF THE TRANSMISSION APPARATUS AT 5 LS

Fig. 2. Above is shown the station's apparatus which controls the transmission; in the bottom left-hand corner appears the aerial tuning inductance coil. The set has an effective range of several hundred miles and transmits and receives messages in England and abroad



TRANSMITTER CIRCUIT OF 5 LS

Fig. 3. When employed for telephony the key is shorted and also the grid leak. When on telegraphy the modulation transformer secondary is disconnected from the grid

components are fixtures in that cabinet, the station is still of a purely experimental nature in that any circuit may be changed with ease, and any individual part altered almost at a moment's notice, in order that a new arrangement may be tried and tested.

A view of the complete station is given in Fig. 7 on the plate. On the top of the bureau, which is a marble slab, are shown the high-tension battery for the receiver, the loud speaker, wave-meter and rack containing a complete set of Burndept coils. Beneath the marble slab is situated the instrument board for the transmitter. All these instruments are of the Weston moving-coil type, with the exception of the one on the extreme right, which is the radiation meter, and is therefore of the hot-wire type.

The tuning arrangements are fitted underneath the instrument board. These take up two rows of panels, the upper one being the transmitter tuner, which includes filament resistances for the transmitting and modulating valves, and the lower row of panels comprising the receiver tuner. The main transmitting valve may be seen at the extreme left of the upper row of tuning panels, and immediately underneath it is the speech microphone. A plug-board is fitted on the right of the tuner which is connected in the aerial circuits and allows quick changes to be made.

The receiver, which is a seven-valve instrument, is situated under the tuners. It consists of three stages of radio-frequency amplification—two stages transformer-coupled and one stage tuned anode—followed by either a valve or crystal rectifier, as desired. Following the rectifier are two stages of ordinary audio-frequency amplification, and after this is a one-stage power amplifier. With the single exception of the panel containing the two transformer-coupled radio-frequency amplifiers, every panel is an entirely separate unit and is connected to its neighbour by a plug and jack. Thus any combination of valves may be obtained merely by changing over the plugs and jacks. The receiver is worked entirely by D.E.R. valves, of the Marconi-Osram type, with the exception of the power valve, which is also a dull emitter.

The remaining portion of the bureau, under the receiver, is devoted to power supply for both instruments. Two shelves are taken up by these arrangements. The upper one contains the low-frequency accumulators, change-over switch, and voltmeter and ammeter. Two accumulators are used, a small 2 volt cell for the D.E.R. valves, and a large 6 volt battery which is alternatively used for the power amplifier and the transmitting valves. The change-over switch on the porcelain base, shown in the centre of this portion of the apparatus, is used to effect this change.

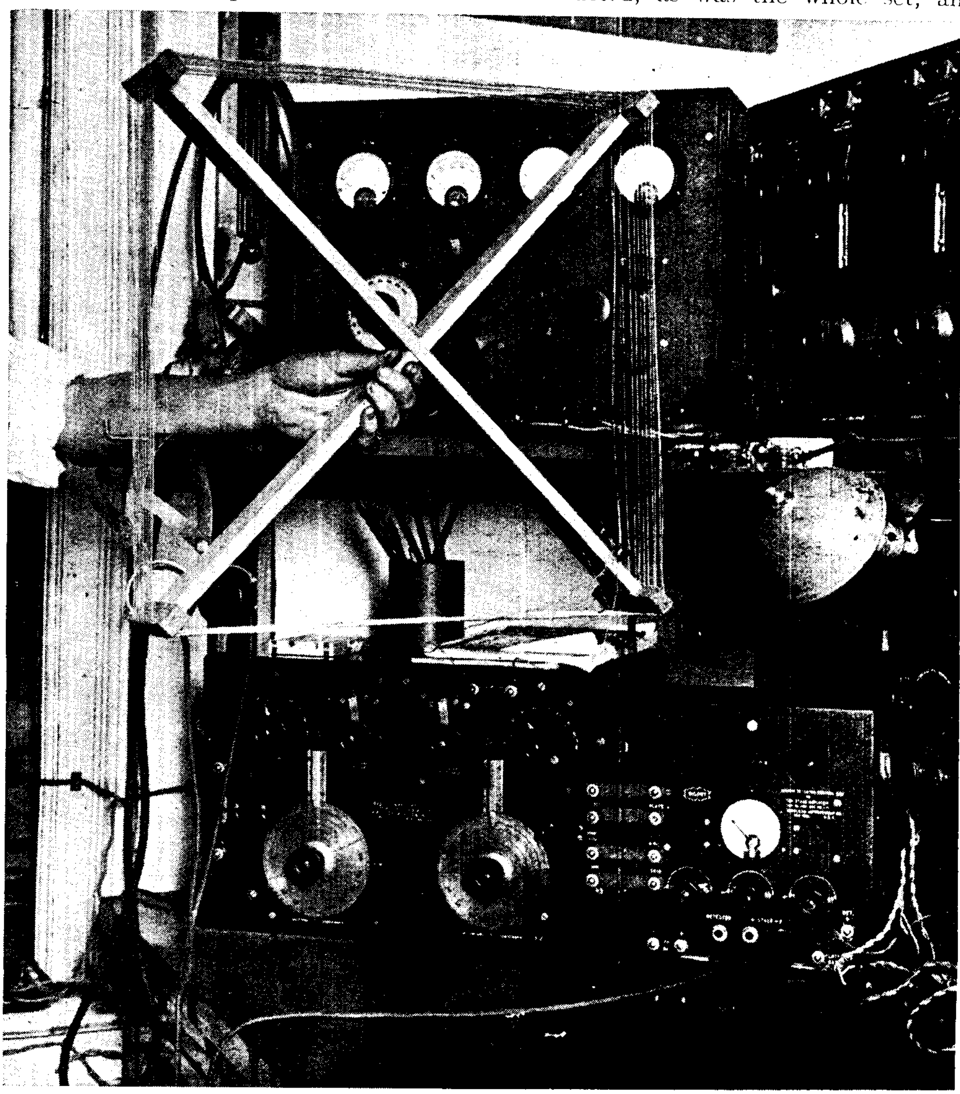
Alternating current from the mains, which is 50-cycle, is used for working the transmitter, and the lowest shelf of the bureau supports the power transformers, two-electrode valve rectifiers, and smoothing circuits.

On the right-hand wall of the bureau are fitted the aerial and earth switching arrangements (see Fig. 12), while on the left wall are the valve grid batteries. The latter are fitted with $1\frac{1}{2}$ volt tappings.

The problems attending the transmission of vocal, instrumental and gramophone music have not been overlooked in the design of this station, and a portion of one of the rooms in the house adjoining the station cabin has been fitted up as a studio. An illustration of this feature appears in Fig. 8 on the plate. A land-line which is kept clear from all walls connects the studio to the transmitter. Two microphones are in circuit with the land-lines, these being shown attached to the frame carrying the tubular bells. The studio "property" consists of the bells previously mentioned, a piano and trap drums.

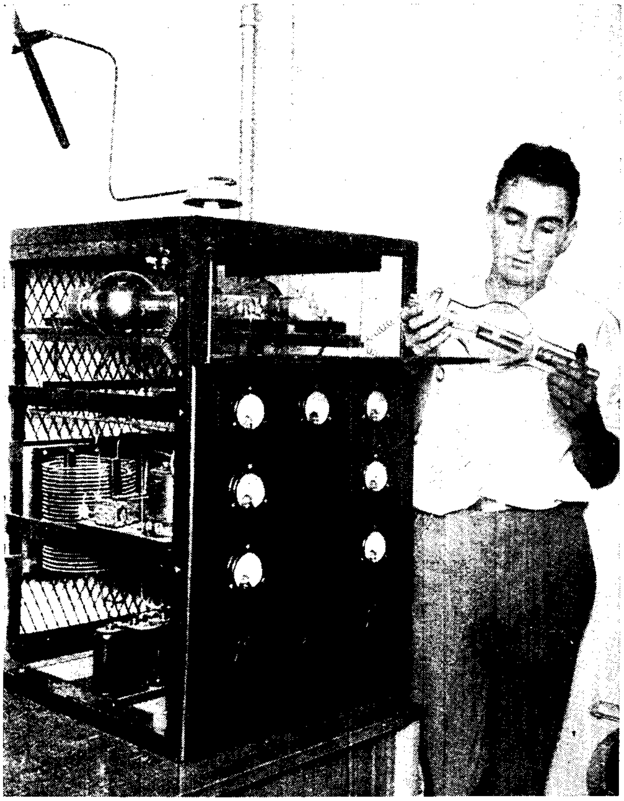
Fig. 6, in page 2076, shows the aerial arrangements at 6 RJ. The aerial is supported on two portable steel masts actually of the same height, although this is not apparent from the photograph. Each mast is supported by wire guys, broken with shell insulators at a point some two-thirds of their height from the ground. The aerial is of the two-wire inverted L type, with the lead-in coming down vertically to the cabin shown to the left of the picture.

There are one or two points in the construction of the cabin which are of interest. In the first place it was entirely home-constructed, as was the whole set, and



2 BGM, ONE OF THE MOST POWERFUL AMATEUR STATIONS IN THE WORLD

Fig. 4. Owned by Mr. W. P. Inman, of New York, 2 BGM is probably the most powerful amateur transmitting station in the world, its input being 1,000 watts; four 250 watt valves are used. and the aerial radiation is 6 amperes. This picture shows part of the station



TRANSMITTING PANEL OF 2 BGM

Fig. 5. Shown examining one of the 250 watt valves of his 1,000 watt transmitting set, is Mr. W. P. Inman, the owner of the station, which is heard as far away as Honolulu

great care has been exercised in its building. Damp has been rigorously excluded in a novel manner. Each wall and the roof is made in three thicknesses of match-boarding, and each thickness or skin is separated from the next by an air space of about three inches. The floor is in two thicknesses, these being separated by longitudinal joists. That this construction is fully justified is proved by the fact that at no time has any ill effect from cold or damp made itself felt, and no heating apparatus is ever required when the station is not working.

A workshop is also incorporated in the cabin, and it is here that the entire construction of the set has been carried out. The only machine tool used has been a small drill. The transmitting set has been designed to work off the ordinary house supply current, which in this instance is A.C. at 220 volts, 50 cycles. Reference to Fig. 15, which is a complete circuit diagram of the transmitter,

AERIAL USED FOR WIRELESS TRANSMISSION FROM 6 RJ

Fig. 6. Twin wires are employed in the transmitting aerial. It is supported upon portable steel masts of equal height and very sturdy construction

will indicate how this is accomplished, while separate circuits of the power supply only are given in Figs. 13 and 14.

In the first place an anode current supply at a pressure of about 700 volts was considered necessary. To this end the two large transformers shown pictorially in Fig. 10, and diagrammatically at A in Fig. 14 were obtained. They are each of ·25 kw. capacity, and being designed for 220 volts input, the primary windings have been put in series across the 220 volt mains.

The secondary windings, each giving 1,500 volts when the primary is fed with 220, in this instance give only 750 volts, since the primaries are in series.

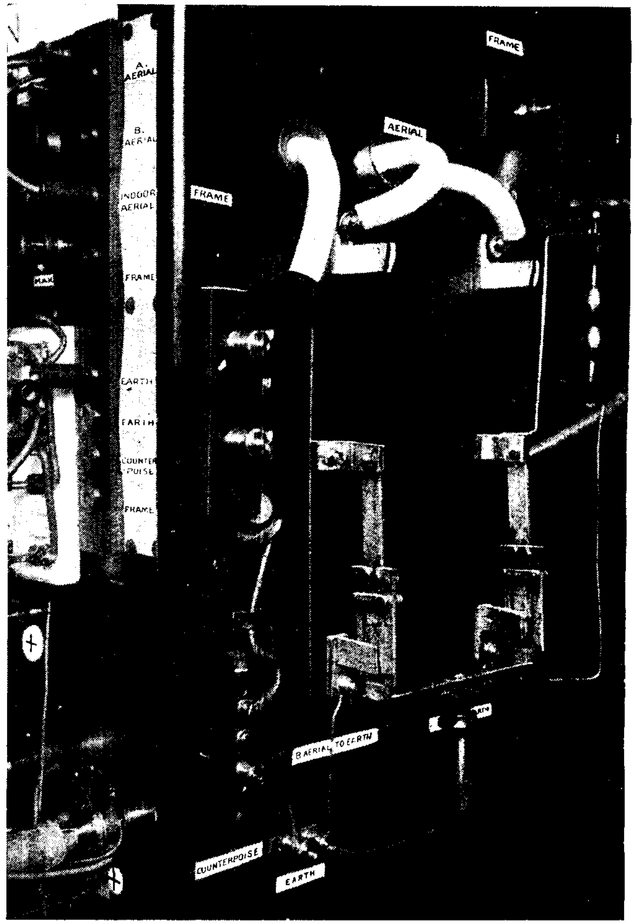
From the wiring diagram, Fig. 14, it will be seen that the outer connexions of the two secondaries are taken to the anodes of the two-electrode rectifying valves. The latter are of the Marconi-Osram U3 type, and are clearly shown in Figs. 10 (on the plate) and 16.

These two valves have their filaments supplied from two small transformers, in which the primary and secondary windings are again respectively joined in series. The filament transformers are shown to advantage in Fig. 16, while the circuit diagram, Fig. 14, will indicate their disposition in the circuit. These are step-down transformers, and their secondary windings deliver about 20 volts. The latter is applied to the filaments through a filament resistance of maximum value of 10 ohms.

Reference again to Fig. 14 will show that the centre point of the rectifier filament connexion forms the positive line of the rectified high-tension supply, while the negative is the centre point of the secondary windings of the main transformers.

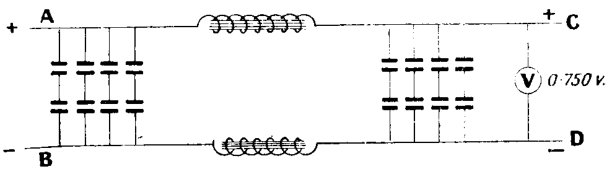
The action of the rectifier is due to the well-known property of the two-electrode valve in possessing unilateral conductivity. By using a circuit such as that shown in Fig. 14, it is possible to rectify both halves of the alternating current wave, one valve being employed on one half of the wave, and the other valve on the next half.

While the alternating current is now rectified completely and with little loss, it is by no means suitable for use in connexion with wireless telegraphy or telephony. This is because the current is still "wavy" in character, in a similar manner to the "waviness" of ordinary generated current from a dynamo. Means must now be taken to smooth the ripple out of the current, otherwise the resultant transmission would be a continuous hum.



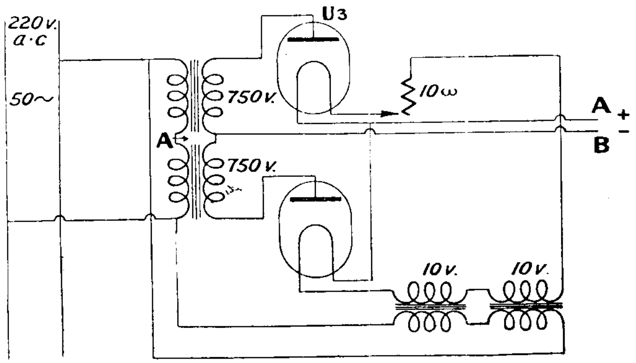
SWITCHING ARRANGEMENTS AT 6 RJ

Fig. 12. Above is presented a view of the aerial and earth switching arrangements fitted to the right-hand side of the main bureau of the amateur transmitting station, 6 RJ. On the opposite wall are the valve grid batteries



6 RJ FILTER CIRCUIT DIAGRAM

Fig. 13. Diagram of the smoothing or filter circuit

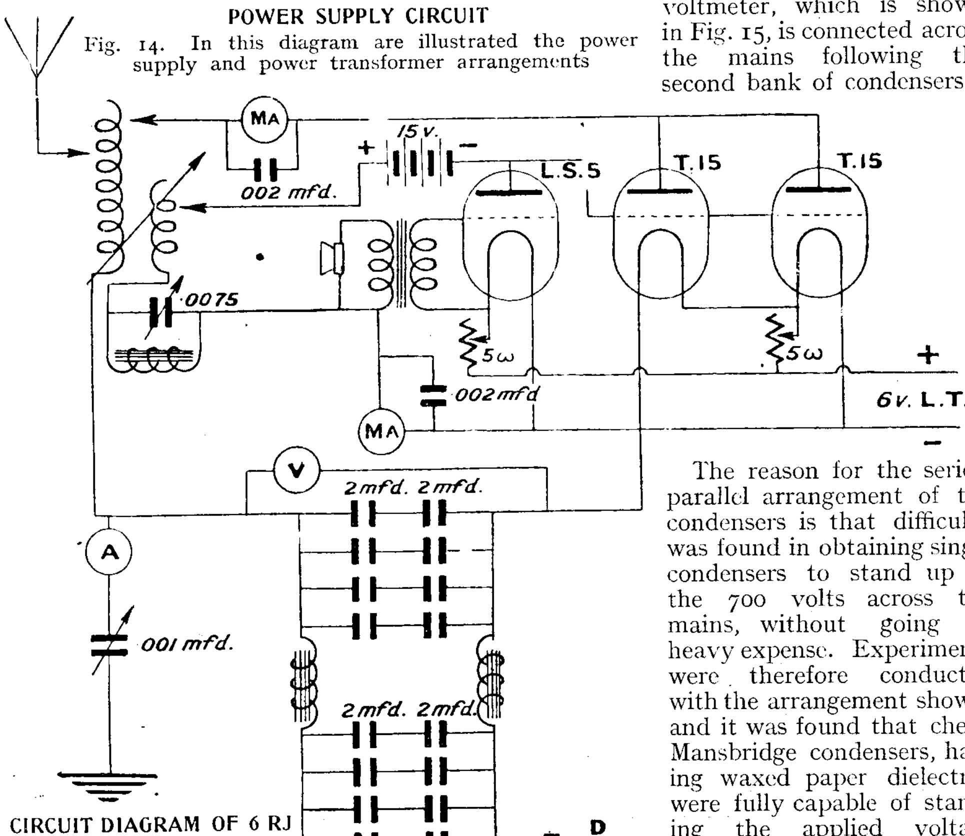


POWER SUPPLY CIRCUIT

Fig. 14. In this diagram are illustrated the power supply and power transformer arrangements

To achieve this end a smoothing circuit consisting of a bank of fixed condensers and a number of iron-cored chokes has to be adopted. This circuit is shown in detail in Fig. 13, where the points shown as A and B are continuations of the leads designated A and B in Fig. 14. From Fig. 13 it will be seen that a bank of condensers consisting of eight of 2 mfd. capacity are connected, in a series-parallel arrangement, across the mains.

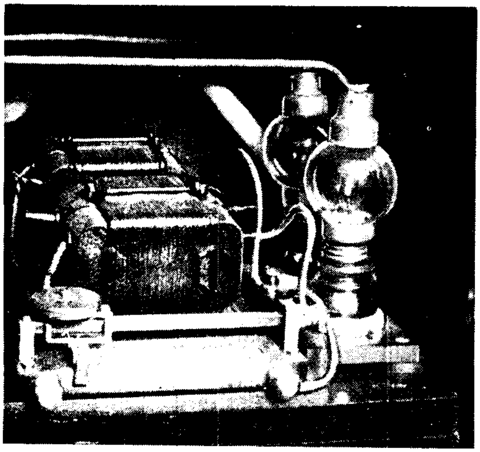
These are followed by two iron-cored chokes, each of 10 henries value, one in each lead. Following these is another bank of condensers, similar to the first set. A Weston moving-coil type of voltmeter, which is shown in Fig. 15, is connected across the mains following the second bank of condensers.



CIRCUIT DIAGRAM OF 6 RJ

Fig. 15. This diagram gives the complete circuit arrangements of the station 6 RJ, except the power circuits

The reason for the series-parallel arrangement of the condensers is that difficulty was found in obtaining single condensers to stand up to the 700 volts across the mains, without going to heavy expense. Experiments were therefore conducted with the arrangement shown, and it was found that cheap Mansbridge condensers, having waxed paper dielectric, were fully capable of standing the applied voltage without failure. From reports received on the transmissions, it is evident that



INPUT RECTIFIER FOR TRANSMITTER

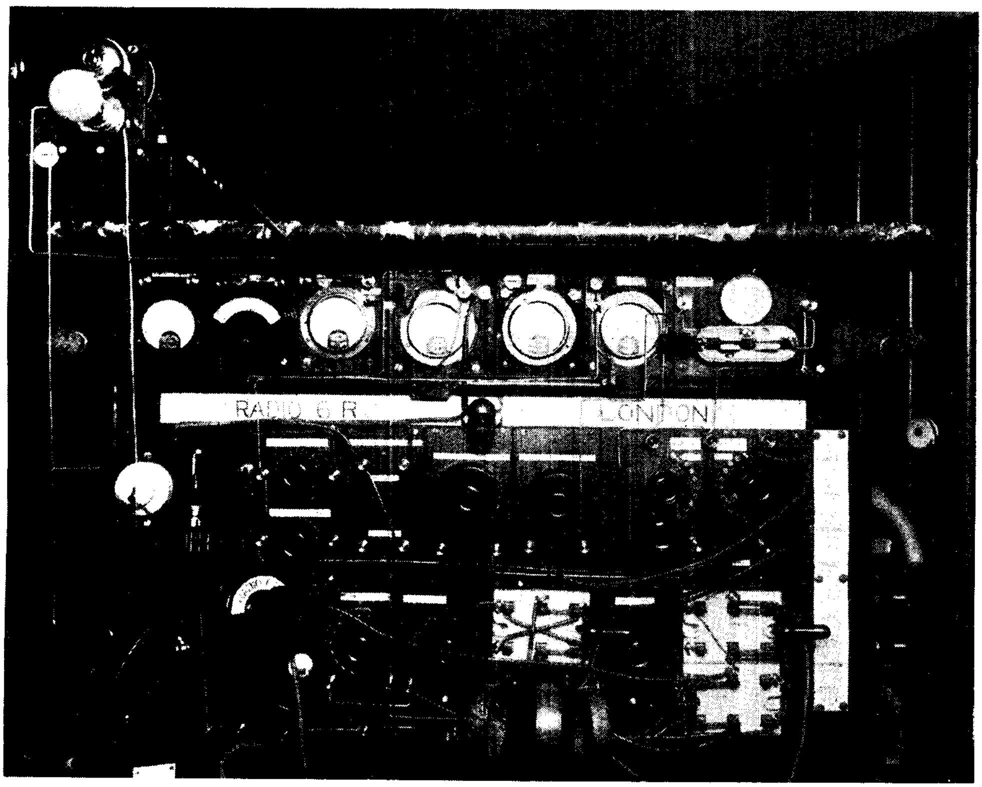
Fig. 16. On the right are the Marconi-Osram U3 valves, and in the centre the filament transformers; they are of the step-down type

the smoothing of the rectified A.C. is a complete success.

The system used in the transmitter proper is known as the "absorption control," and this was chosen instead of choke control because it offered greater opportunities for the experiments in modulation which the owner desired to make.

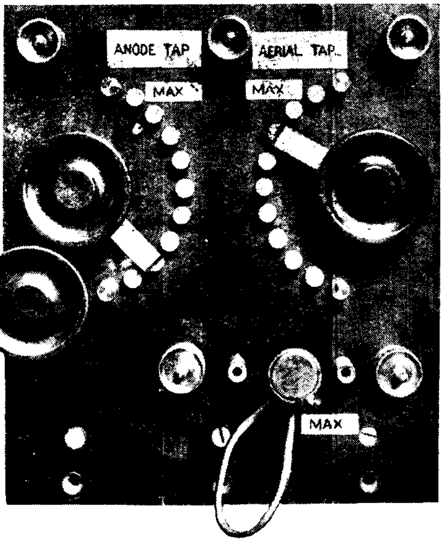
The circuit is shown in its entirety in Fig. 15, and this may be subdivided into two distinct parts, namely, the oscillator, which includes the aerial tuning system, and the modulator.

The oscillator consists of two Marconi-Osram T15 type valves, running in parallel. These are indicated in the diagram, Fig. 13, under their correct heading. Two valves running in parallel were chosen, not with a view to increased power output, but to decrease the internal impedance or anode resistance-factor of the oscillator. From the diagram, Fig. 15, it will be seen that the anodes of both valves are connected together and pass via the milliammeter straight to the aerial tuning inductance. The grids also are interconnected, and are joined to the anode of the third or modulator valve.



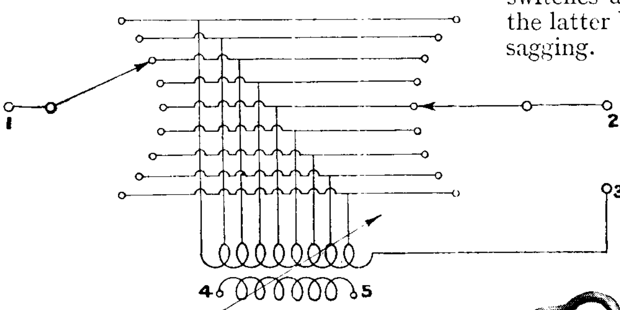
GENERAL VIEW OF 6 RJ TRANSMITTING STATION

Fig. 17. This view includes the transmitting apparatus and the receiving tuner. The various indicators, such as ammeters, voltmeters, etc., are arranged in a row above. On the top of the marble slab is the H.T. battery for the receiver



TUNER PANEL OF 6 RJ

Fig. 18. The tuning arrangements of 6 RJ consist of an aerial tuning inductance and a reaction coil. Three main contacts are fitted



A.T.I. TAPPINGS

Fig. 19. This diagram shows the arrangement of the tappings of the aerial tuning inductance coil

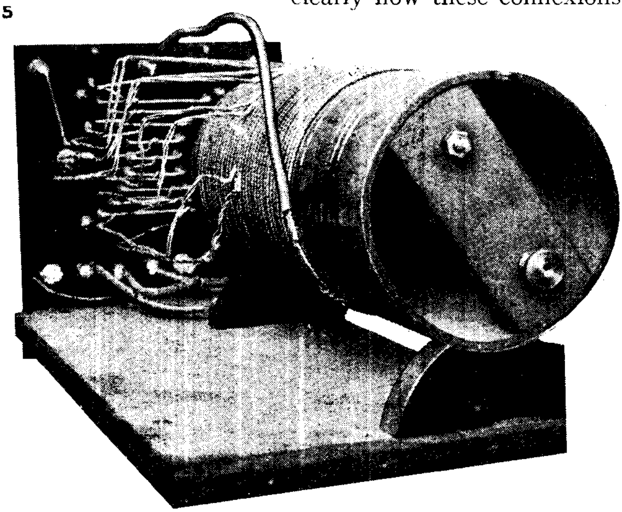
The filaments of the oscillator valves are fed from a 6 volt, 40 (actual) ampere-hour accumulator, control being effected through a 5 ohm resistance. The same accumulator feeds the modulator valve and also the power amplifier valve on the receiver—the latter by a change-over switch which is shown in Fig. 17.

Passing now to the tuner: this is illustrated in Fig. 18, which is a front view of the panel, while a separate wiring diagram is given in Fig. 19. The tuner consists essentially of a coil forming the aerial tuning inductance, and a second coil sliding within the latter, which is for reaction.

Three main controls are fitted, two being stud switches for variation of wave-length, and a movable arm controlling the amount of reaction. The A.T.I. is shown to advantage in the photographs, Figs. 20 and 21. It is wound on a former composed of a piece of ebonite tube 4 in. diameter by 10 in. long, and with stranded copper wire of 16/33 gauge, the turns being spaced approximately $\frac{1}{32}$ in. apart. The tube has a light thread cut throughout the whole of its outside surface, and in this thread the wire is tightly wound. This construction renders winding an easy matter, and ensures the coil keeping to its original electrical characteristics.

Nine tappings are taken off this coil, the first at the fifteenth turn from the back end, and the others at every alternate turn. The connexions from the tappings on the coil to the two stud switches are also made of the same wire, the latter being sufficiently stiff to prevent sagging. Soldered connexions are used throughout.

Reference to the diagram, Fig. 19, will show that the tappings are taken to both of the stud switches, the opposite studs on the latter being wired in parallel. The photograph, Fig. 20, shows clearly how these connexions



AERIAL TUNING INDUCTANCE OF 6 RJ

Fig. 20. In the aerial tuning inductance the wire is of 16/33 gauge, and is wound on an ebonite former. Tappings and contacts are shown