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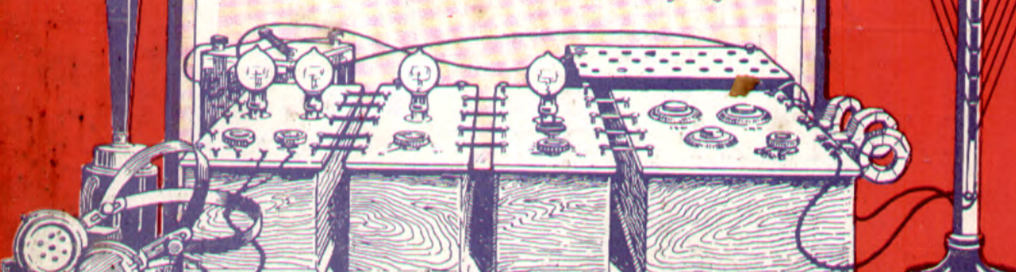

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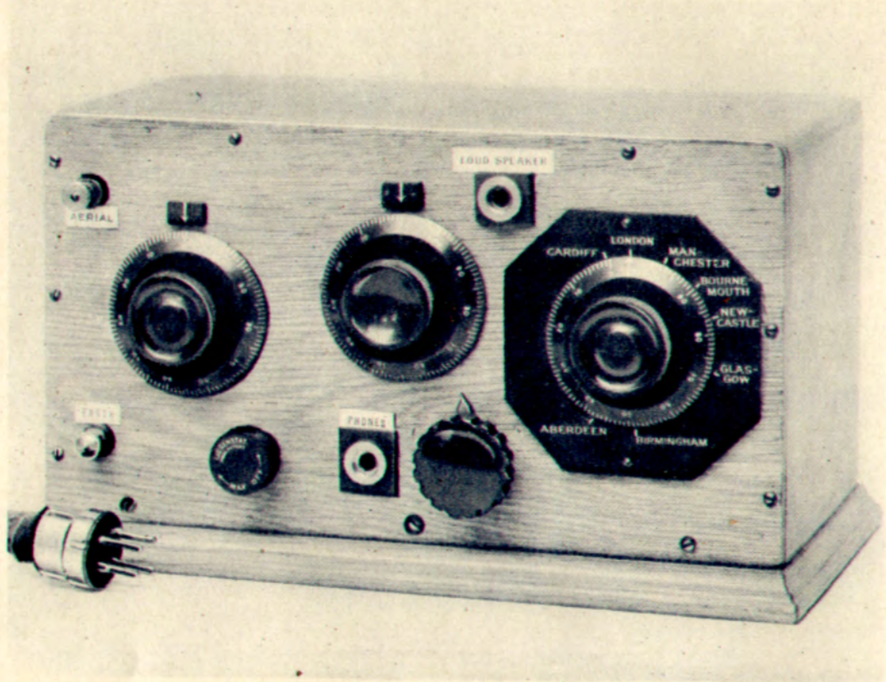


Fig. 19. Complete set, using Baty components. Tuning is constant, so that when the secondary condenser has been set the anode condenser may be marked with the names of the broadcasting stations

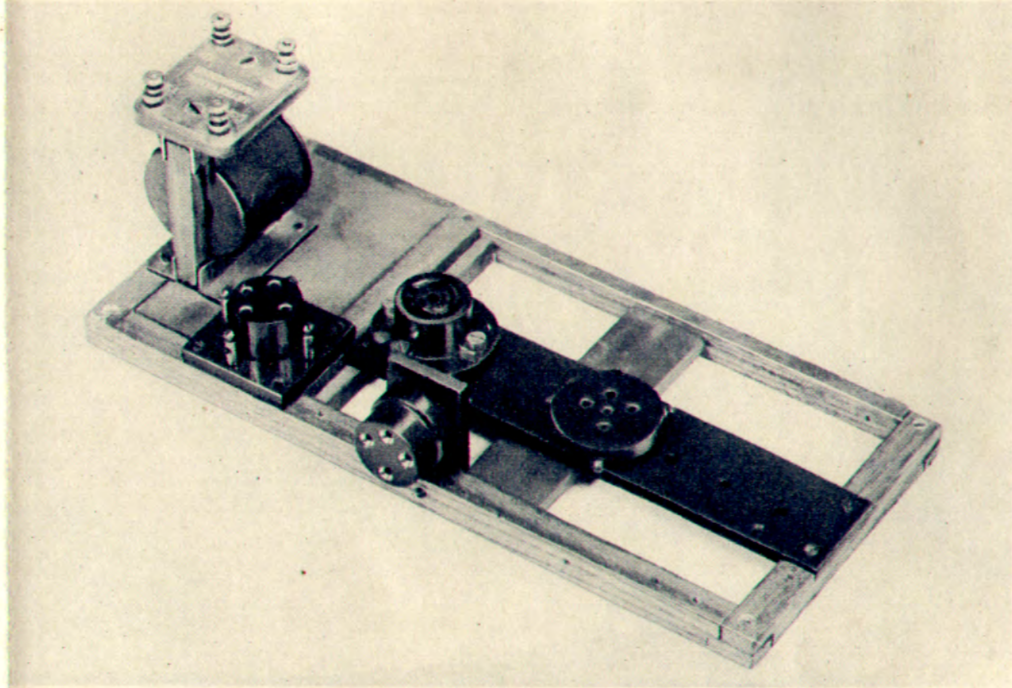


Fig. 20. Framework base with the surface mounting. The surface fixing valve-holders and L.F. transformer are in position. Note the position of the valve-holder at the back of the frame for all the battery leads

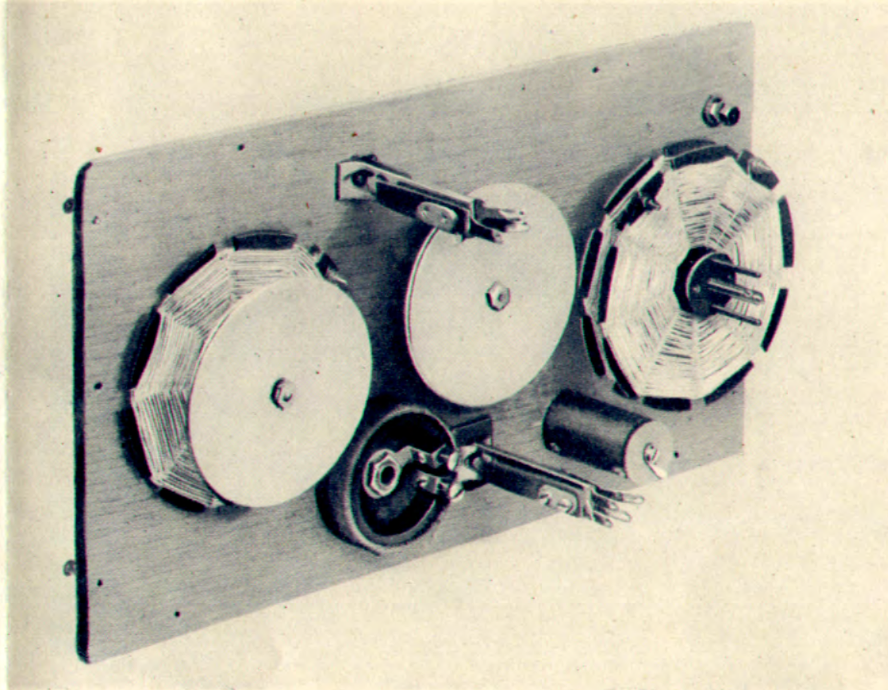


Fig. 21. Back of wooden panel with the components mounted ready for bolting to the base-frame. The lower jack is for the telephones. When its plug is withdrawn the third valve lights up

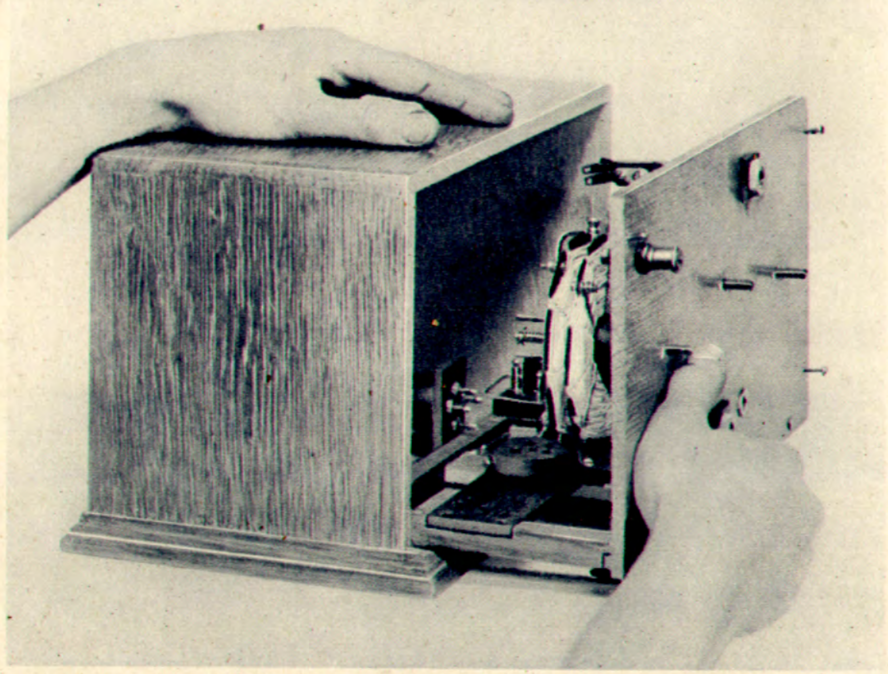


Fig. 22. How the base-frame and panel slides into the cabinet. The panel fits flush with the sides of the cabinet and is screwed into position, the base-frame resting on the bottom of the cabinet

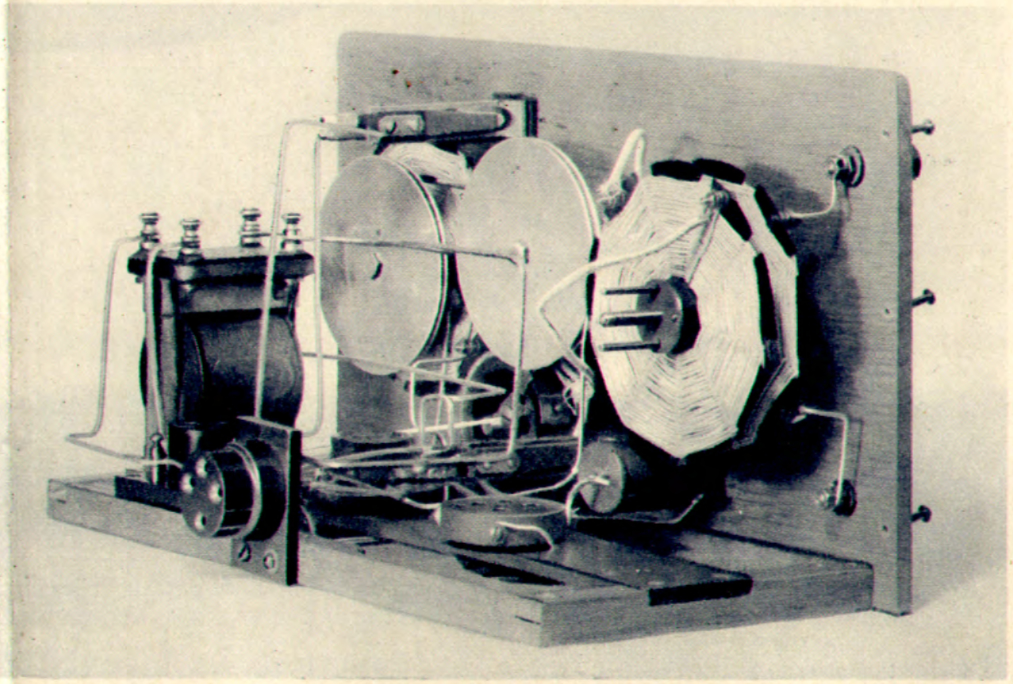


Fig. 23. View of the wiring from the left. Notice the flexible connexions from the moving coil of the aerial coupler to the secondary condenser, and the use of square section tinned copper wire

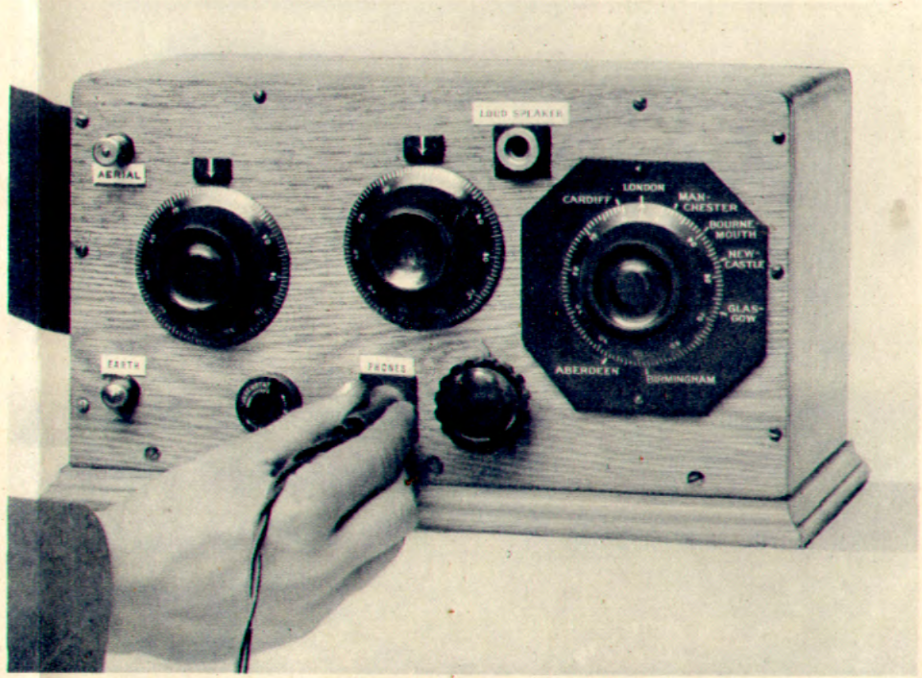
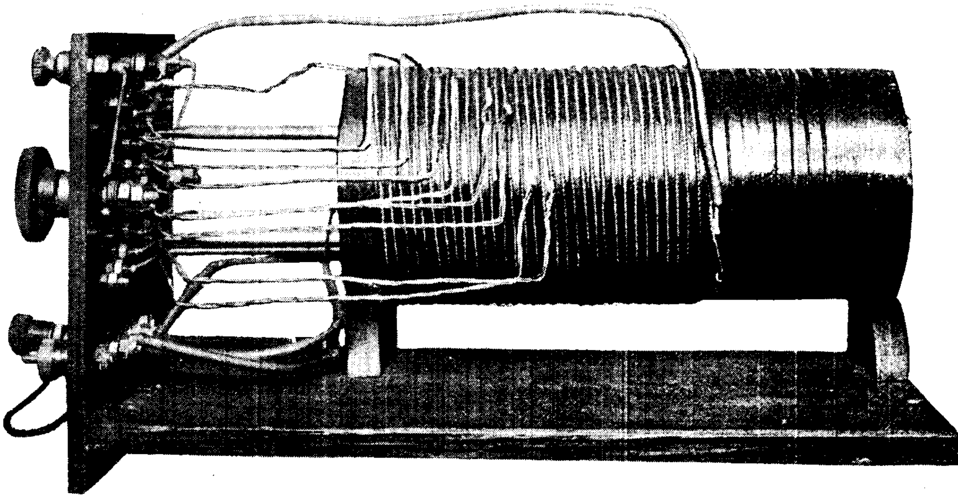


Fig. 24. Before reception the battery plug is inserted at the rear and the telephone plug in the jack. The anode condenser dial is set and the knob of the aerial coupler on the left turned till the station is heard

TUNED ANODE SET: A SIMPLY OPERATED RECEIVER OF PROVED EFFICIENCY AND HANDSOME APPEARANCE WHICH CAN BE MARKED IN WAVE-LENGTHS OR STATIONS

To face page 2106

From photographs of a set specially designed and constructed for HARMSWORTH'S WIRELESS ENCYCLOPEDIA



INDUCTANCE COIL OF THE AMATEUR'S TRANSMITTER

Fig. 21. Here the aerial tuning inductance coil of 6 RJ amateur transmission station is seen from the side. The winding, it will be observed, is held in position by a helical groove cut in the ebonite former. Notice how the tappings are taken

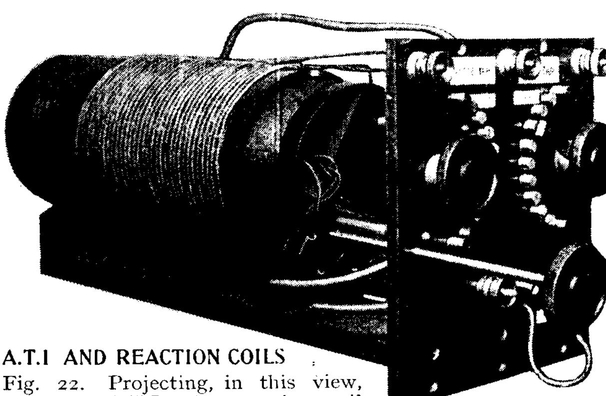
between the studs are effected on the actual instrument. From this it will be seen that all the tappings are taken to one of the switches, while connexions from the latter are taken right across to the other switch. The first turn of the coil is taken to the centre terminal shown at the top of the panel in Fig. 18, while the centre points of each switch are connected to the corresponding terminals in the corners of the panel.

The reaction coil, which is shown projecting from the A.T.I. in Fig. 22, is supported on two runners, consisting of round brass rods. The latter are carried at one end on the inclined piece of ebonite at the rear of the A.T.I. former, shown in Fig. 20, and at the other end by the ebonite panel.

The former upon which the reaction coil is wound is another piece of ebonite tube, but is 4 in. long and $3\frac{3}{8}$ in. in diameter. It is wound with 45 turns of 10/40 silk-braided copper wire, and three tappings are taken off at points equidistant through its length. The tap of the reaction coil is connected to the anode of the modulator valve, but between the terminating points of this lead a 15 volt battery, with its negative side to the anode, is interposed. From the anode oscillator the lead continues to the grids of the valves, as shown in Fig. 15.

The reaction coil is adjusted, with respect to the A.T.I., by moving the knob fitted to the end of the push-rod. This detail is clearly shown in Fig. 22, from which it will be seen that the push-rod is attached to the cross-piece fitted to the end of the reaction former.

The outer terminals on the upper edge of the tuner panel are connected to aerial and the anodes of the oscillator valves respectively. The Weston milliammeter is connected in series in the latter lead, and it is shunted by a ·002 mfd. fixed condenser, which acts as a high-frequency by-



A.T.I AND REACTION COILS

Fig. 22. Projecting, in this view, from the A.T.I., the reaction coil runs on two round brass runners. Observe the neatly arranged tapping studs, terminals and switches on the panel

pass. Connexion from the centre terminal is taken to the hot-wire ammeter, shown at A in Fig. 15. This instrument is fitted with an auxiliary resistance which alters the meter's range from 0 to ·5, to from 0 to 1 amperes. Another lead is taken at this connexion to the positive side of the high-tension supply. From the diagram, Fig. 15, it will also be gathered that the opposite side of the hot-wire ammeter is connected via a ·001 mfd. variable condenser to earth.

In connexion with this condenser it is important to note that the vanes are separated to a larger air space than those used for receiving on account of the high voltage used.

The wave-length range covered by the tuner, when the variable condenser is wired in series as shown, is from 150 to 220 metres when connected to the normal aerial. The latter has a fundamental wave-length of approximately 85 metres.

Proceeding now with the wiring of the set, reference must again be made to Fig. 15. The negative side of the rectified high-tension supply is connected to the negative pole of the filaments of all three valves.

The modulator valve is a Marconi-Osram L.S. 5 type, which is a low-temperature emitter, primarily designed for power amplification. It has an elliptical grid and anode, and on this account possesses a very low internal impedance. For this reason it is eminently suitable as a modulator for low powers.

The battery, to the negative pole of which the anode of the modulator valve is connected, is a large capacity Gecophone unit, and it is fixed to the left-hand side of the bureau, with its tappings facing the operator. This feature is shown in Fig. 7 on the plate, where it may be seen immediately beneath the telephones.

How the Modulator is Connected

The positive filament lead of the modulator valve is connected to the fixed end of the reaction coil via a variable condenser of ·0075 mfd. capacity. This is similar in construction to the aerial tuning condenser, it having large air spacing between the vanes. An iron-cored choke is shunted across this condenser, as shown in Fig. 15. The inductance value of this choke is not at all critical, and the instrument used in this set is the secondary winding of an old ½ in. spark coil.

The grid of the modulator valve is connected to the secondary winding of the modulation transformer, the other end of which is taken to the positive filament lead. Connexions from the primary winding of the modulation transformer are taken to the negative filament lead and one side of the microphone, while the other side of the latter is connected to the filament positive.

An ex-Royal Air Force modulation transformer is used, which has a secondary winding with a resistance of 2,600 ohms. The primary has a resistance of only 1·5 to 2 ohms.

Transformer and Microphone Details

Before this transformer was purchased excellent results were obtained by the use of an old Ford ignition coil, from which the hammer break and blocking condenser had been removed. The input winding of this instrument was used as the primary and the output, or high-tension, winding as the secondary.

A plug switch is connected in place of terminals for the microphone, so that different types may be readily used without disturbing any other arrangements. The microphone which is in use on the set is of the G.P.O. solid-back type, and excellent speech is obtained by its aid. It will be seen from Fig. 15 that the microphone is shunted across the 6 volt filament accumulator. A Weston type milliammeter is inserted in one lead, and is shunted by a ·002 mfd. condenser as a by-pass. This instrument reads from zero to one thousand milliamperes. When operating, a normal microphone current of 250 milliamperes is recorded.

A high-tension voltmeter, reading from 0 to 1,000 volts D.C., is shunted across the high-tension mains. This instrument is also of the Weston moving-coil pattern.

Transmitter Operation. The operation of the transmitter, once the wave-length has been set, is a matter of great simplicity, and all the controls are arranged so that they are readily operated from a convenient position in front of the apparatus. Fig. 11 on the plate facing page 2076 shows the operator at work at his set, and clearly indicates the convenience of the arrangements. It will be seen that the microphone is placed opposite to the speaker's mouth, and that the controls are within convenient reach of his hands.

The first step in switching on the transmitter is to light the filaments of the oscillator and modulator valves, and then switch on the high tension. The latter is accomplished by turning the rotary switch on the power input panel situated on the left-hand side of the bureau (see Fig. 7). A close-up view of this panel is given in Fig. 23, from which it will be seen that the rotary switch is the third from the top.

It is found beneficial to switch the low tension on first, because by this means surges on the high tension, which might occur if the latter were first connected, are prevented. Should this happen, it is possible that the smoothing condensers would be severely damaged.

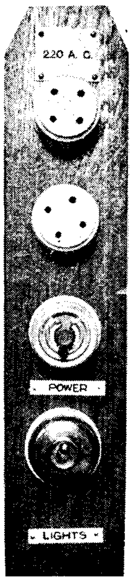


Fig. 23. Close view of the power input panel

The anode current of the oscillator valves should be kept as low as possible, consistent with efficiency, by means of the variable potential on the oscillator grids. In practice, with 600 volts D.C. on the anodes of these valves, the flow of current is from 16 to 18 milliamperes. This is roughly an input value of 10 watts.

On the completion of the above adjustment the next step is the setting of the "aerial tap" of the aerial tuning inductance and the aerial tuning condenser. By this means, and with the aid of the wave-meter, the wave-length required is obtained.

It is now necessary to regard the reading of the hot-wire ammeter (shown at the extreme right of the bureau in Fig. 17). This reading is brought to its maximum value by altering the adjustment of the reaction coil with respect to the A.T.I. and at the same time altering the reaction tapping. On this particular set it is found that the best results are obtained with the reaction coil very closely coupled, but with all the winding in use.

The modulator circuit is next adjusted or tuned, by altering the ·00075 mfd. variable condenser which is shunted across the iron-cored choke. This condenser is the instrument immediately beneath the red pilot lamp shown in the centre of the apparatus in Fig. 7. At this stage it may perhaps be necessary to readjust the aerial tuning slightly.

Speech in the microphone is now tried, and the deflections of the radiation ammeter, the anode current milliammeter and the microphone current milliammeter will give a measure of the modulation being achieved.

While the transmitter is in operation the transmitted speech may be heard in the telephones on a "side-tone" circuit. This consists of a separate receiving circuit tuned to the wave-length of the transmitter and very closely coupled to it. Or, again, it is possible to use the main receiver itself, not connected to the aerial.

Under good conditions the aerial current of 6 RJ is approximately ·6 ampere for telephony and ·7 on continuous wave. The latter figure obtains on a wave-length of 200 metres and with a 10 watt input. While these figures do not show any remarkable radiation efficiency, the speech quality is reported as being very good. Alterations in the aerial and earth systems would result in a large increase in radiation efficiency.

The Receiver. The receiver may be seen more clearly in Fig. 9, while a complete circuit diagram is given in Fig. 24. The whole instrument was built at different times, and the unit system was considered the most useful to adopt on this account. With the exception of the two transformer-coupled high-frequency amplifiers, which are on one panel, every valve is quite independently arranged on its own separate panel. Unlike the majority of receivers, this instrument is arranged from right to left instead of in the reverse order. This is because the aerial enters on the right-hand side of the cabin, and on this account the arrangement is more convenient. Referring to Fig. 9 on the plate, and starting from the right-hand side, the first panel contains the two transformer-coupled high-frequency amplifiers. Adjacent to this is a panel on which is mounted another high-frequency amplifier, but which is of the tuned-anode type. The latter is followed by the rectifier, the valve of which is mounted behind the panel, and which may be seen through the window.

Following the rectifier are two low-frequency amplifiers, while the last panel is a power amplifier. Every panel is connected to its neighbour by plugs and jacks arranged in the anode circuits, and by this means it is a simple matter to

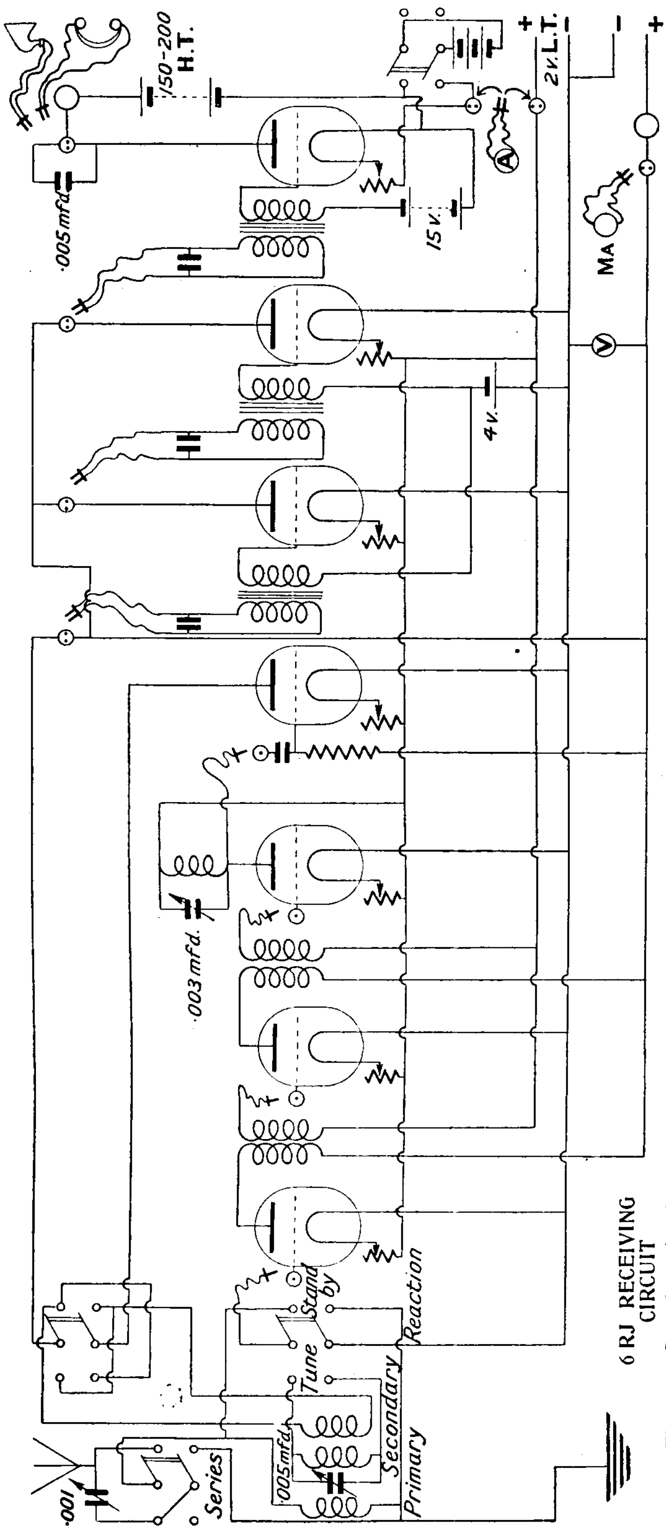


Fig. 24. Complete circuit diagram of the receiving arrangements of 6 RJ. The set has been built up at different times on the unit system

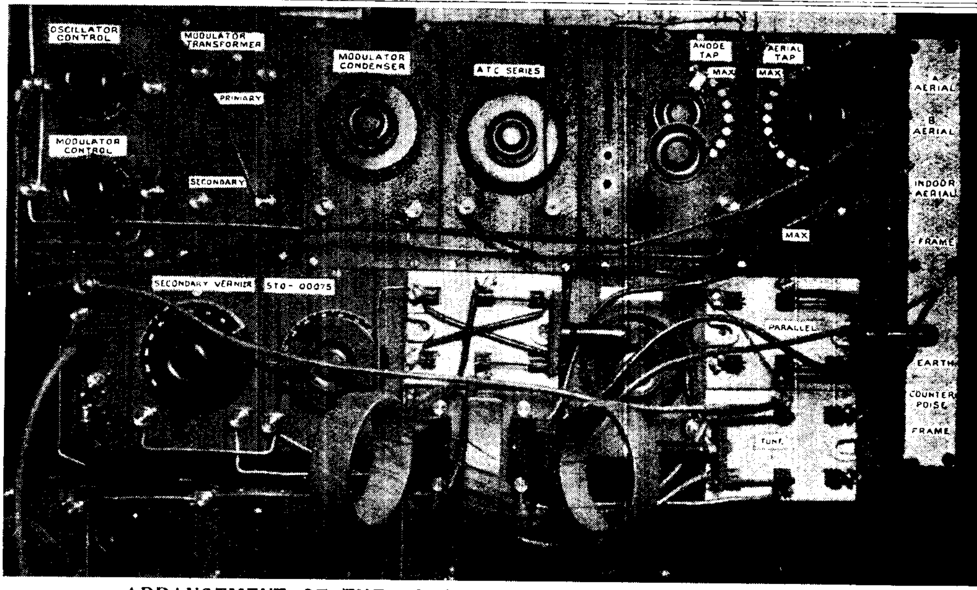
change over instantly to any arrangement desired. The tuned anode panel is the only one having the valve at the front, and this design was specially adopted for experimental purposes.

Above the valve panels is situated the tuner. This is a two-circuit arrangement, having an open and a closed circuit and is fitted with a three-coil holder to suit the Burndept coils. The latter detail is clearly shown in Figs. 9 and 25, where it may be seen in the centre of the lower row of instruments. Body capacity effects are not very noticeable in this set, and it has been found unnecessary to use long tuning handles.

If reference is made to Fig. 24, it will be seen that there is a tune-stand-by switch fitted in the tuner circuit. This switch is shown also in the photograph, Fig. 25, where it is the lower of the two D.P., D.T. switches on the right-hand side. The upper switch of the same type is a series-parallel switch for a ·001 mfd. tuning condenser. The latter instrument is to the left of the switches.

Another switch is fitted above the three-coil holder. This is for effecting a reversal of reaction when desired, and it is a very useful appliance, especially if a coil of non-standard connexions is used at any time.

A closed circuit condenser of ·0005 mfd. fitted with a vernier attachment is arranged towards the left of the coil holder. These instruments comprise the



ARRANGEMENT OF THE DIFFERENT UNITS IN THE TUNER PANEL

Fig. 25. This illustration clearly shows the various positions of the different tuning components, with the three-coil holder in the lower row; Burndept coils are used for tuning. A switch enables the reaction effect to be reversed if this is desired

fine tuning apparatus of the receiver, and despite its simplicity, it is very selective, for 2 LO can be eliminated and the other stations brought in without undue manipulation.

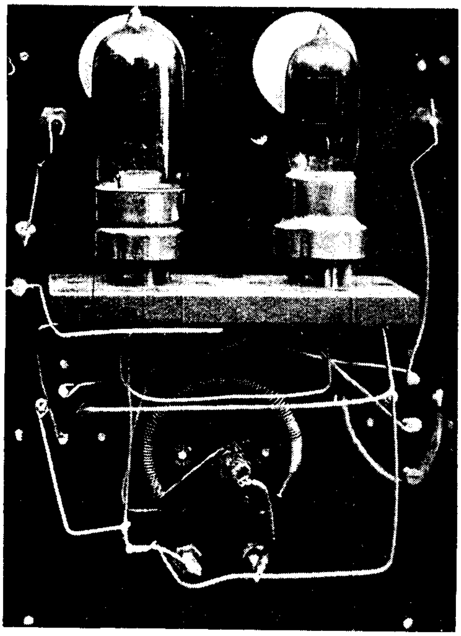
At the extreme left of the tuner is a small panel on which is mounted a crystal detector. A plug and cord are fitted to this panel, which by a suitable circuit arrangement allows the crystal to be substituted for the rectifying valve. The crystal detector is of a very simple type, employing swivel action, and is fitted with a Hertzite crystal and the usual cat's-whisker.

An indication of the sensitivity of the set may be gathered from the fact that it is possible to listen to 2 LO quite comfortably on an Amplion loud speaker with the crystal detector only in circuit. The station is located approximately seven miles from 2 LO as the crow flies.

The valve panels will now be described in detail. Figs. 26 and 27 are photographs of the front and rear of the transformer-coupled high-frequency amplifiers respectively. Referring to Fig. 27, it will be seen that the transformers are adapted for plug-in mounting, and are fitted on either side of the panel. They are of Marconi manufacture, and are, for all practical purposes, aperiodic.

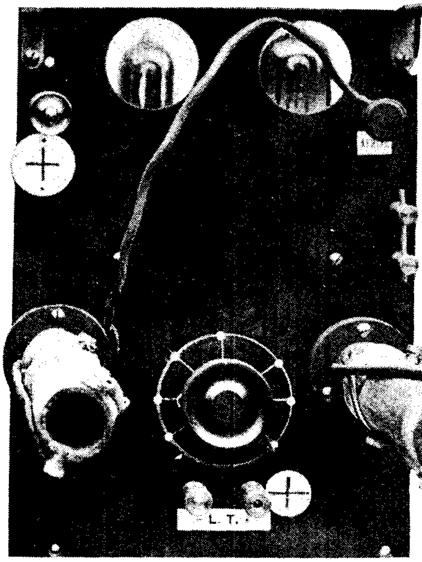
However, for very short wave-lengths transformers of a similar type, but with windings of a different value, are substituted for those shown. Between the transformers is the filament resistance, which controls both valves. The plug which connects this panel to the aerial may be seen on the top right-hand corner, while the low-tension terminals are at the bottom. The back of the panel (Fig. 26) has a shelf fitted, upon which the valve-holders are mounted. Both valves are of the D.E.R. type, but are of different dates of manufacture, which accounts for their different shape. It will be seen that all connexions are carried out in bare wire in order to reduce capacity effects. The latter is a most important point when dealing with very short wave-lengths.

The next panel is shown in detail in Fig. 28, which is a front view. This panel is a development of different units, which accounts for its somewhat "built up" appearance. At the top, in the centre, is the valve holder and valve. The latter is a special type which is being developed for high-frequency working. Immediately below this is a variable condenser of a capacity of ·0003 mfd. It is an ex-Government instrument of a very high-class type, and is ideal for the purpose. At the bottom of the panel is situated a coil holder, which takes the standard Burndept coils. This panel has a plug-in arrangement similar to that in the first. A rear



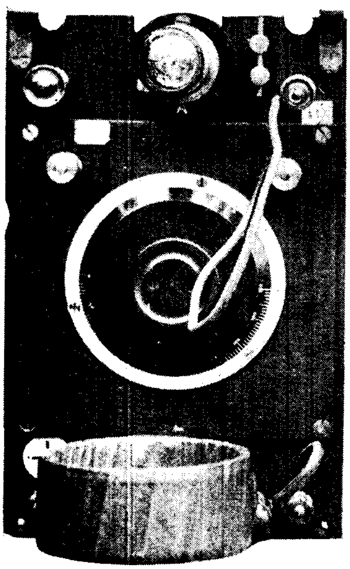
H.F. AMPLIFIER (REAR)

Fig. 26. Rear view of the transformer-coupled H.F. amplifier. Note the shelf on which the valve holders are mounted



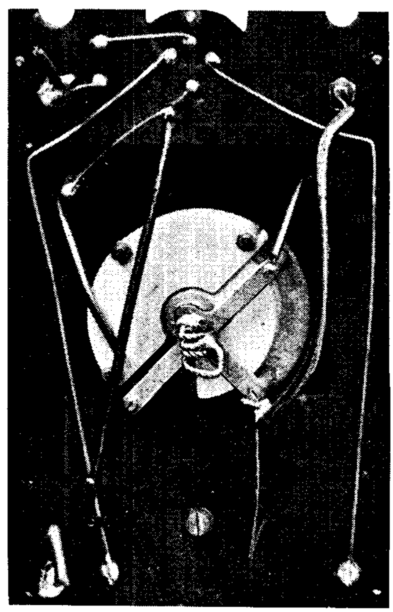
H.F. AMPLIFIER (FRONT)

Fig. 27. This view shows the two-valve transformer-coupled high-frequency amplifier from the front. The Marconi transformers, adapted for plugging in, are situated on either side of the filament resistance



SECOND H.F. PANEL

Fig. 28. Front view of the second high-frequency panel, showing the valve, condenser and plug-in Burndept coil

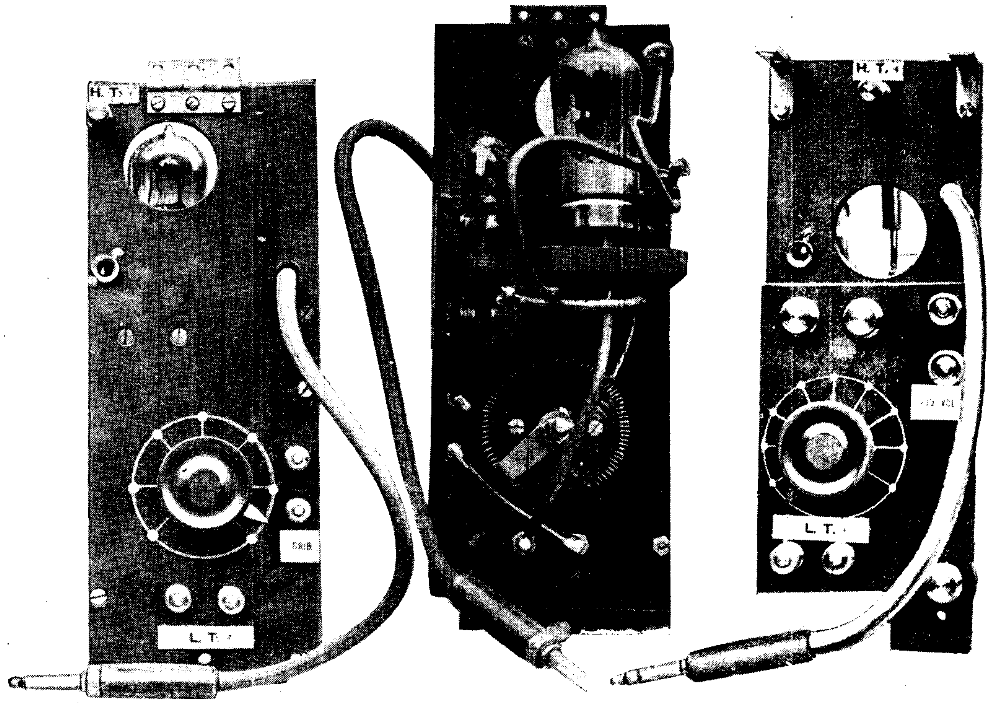


SEEN FROM BEHIND

Fig. 29. Rear view of the second high-frequency panel. The neatness and spacing of the wiring should be particularly noted

view of this panel is given in Fig. 29, from which it will be seen that here, again, all connexions are thoroughly well spaced.

There are no special features in the rectifying panel, but it is clearly shown in the general view, Fig. 9. This panel also uses a D.E.R. valve, and the grid leak is, of course, connected from condenser to earth, instead of across the former. A fine-movement filament resistance is fitted, which allows of very gradual regulation of the filament voltage. The reaction is applied to the rectifying valve, and is taken to the third coil in the three-coil holder. Two stages of low-frequency amplification follow the rectifier, one panel being illustrated in Fig. 30. This panel is identical with the next.



L.F. AMPLIFICATION PANELS OF THE RECEIVER AT 6 RJ AMATEUR STATION

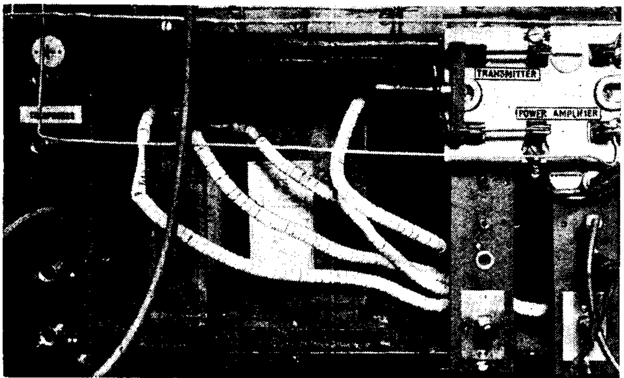
Fig. 30 (left). L.F. amplifier panel, which follows the rectifying panel. The filament resistance is the only control. Fig. 31 (centre). Rear view, showing valve platform and transformer. Fig. 32 (right). Front view of the power amplifier; an L.S. 5 valve is used here

The only control on the front of the panel is the filament resistance. This is of the correct resistance for the D.E.R. type of valve which it controls. It will be seen that the plug and flexible lead project from a hole near the panel top, and that at the opposite side of the panel is the jack for the plug on the next panel. The "engraving" round the filament resistance is accomplished by scribing the lines deeply with a steel scriber and then filling in with white enamel. At the junction of each line is a circular dot, which was made by the point of a small twist drill. At the right of the filament resistance are two terminals for connecting the grid-biasing batteries, if required.

Fig. 31 is a rear view of the same panel. The valve is supported on a shelf, into which are fitted four standard valve sockets. To the left of the shelf is a transformer, which in this instance is an ex-Government instrument.

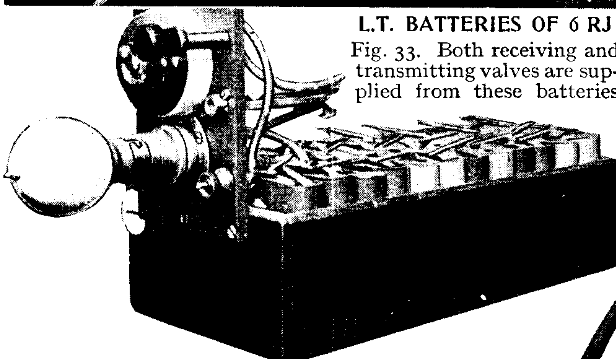
A detailed photograph of the front view of the power amplifier appears in Fig. 32. This part of the receiver has been designed for use with an L.S. 5 type of valve, which is a special power-amplifying valve of the dull emitter type. The transformer used in connexion with this valve is a large one, and has a winding of a specially low impedance to suit the valve. Further, it has been designed to withstand an anode voltage of some 200 volts. The transformer is clearly shown in the view of the rear of the panel in Fig. 35. From this illustration it is clear that the transformer is of the open-core type, and has the windings arranged longitudinally over the core. On the rear end plate is attached a ·002 mfd. Dubilier condenser. This is fitted across the primary winding. The valve is carried on a shelf designed for this purpose, and the height of the shelf is such that the filament may be viewed conveniently from the front of the panel, through the peep-hole.

Receiver Battery Arrangements. Fig. 33 is an illustration of the low-tension batteries at 6 RJ. There are two of these, and they supply current for both transmitter and receiver valves. The larger one is a 6 volt 40 ampere-hour (actual) accumulator. This is connected to the



L.T. BATTERIES OF 6 RJ

Fig. 33. Both receiving and transmitting valves are supplied from these batteries



HIGH-TENSION BATTERY

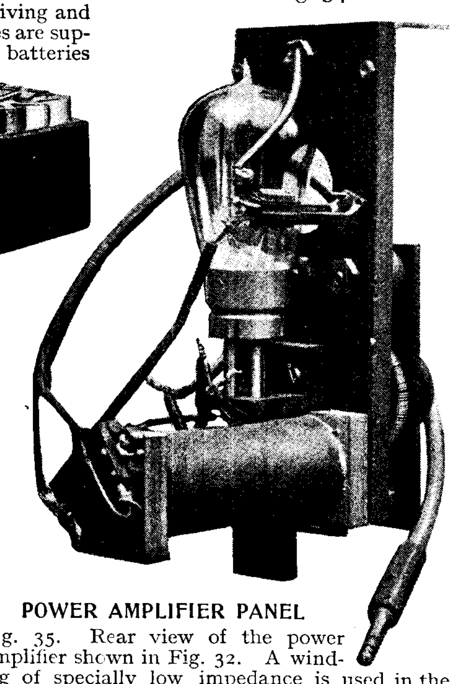
Fig. 34. To make up this battery a large number of pocket-lamp batteries are soldered together in series with connexions to the panel

change-over switch mounted on the porcelain base shown. With the switch in position indicated in the photograph, the low tension is connected to the transmitting valves and the receiver is out of circuit. When the switch is moved to the opposite position the transmitting valves are disconnected and the current is fed to the L.S. 5 valve in the power amplifier. The leads from the batteries are covered with a form of interlocking bead insulation which prevents short circuit, and which is impervious to the effects of acid.

To the left of the large accumulator is a smaller one of 2 volts, 10 ampere-hour capacity. This supplies the filaments of all the remaining valves in the receiver with current. While this may perhaps appear to be rather small for the purpose, it must be remembered that all the valves are of the D.E.R. type, and take a current of ·38 ampere only. It is seldom that all the valves are in use at the same time. One of the key switches shown is connected in the circuit of the smaller battery, and serves as a main switch.

It is always an advantage to know the rate of discharge and the P.D. across an accumulator, and with this in view the ammeter and voltmeter, shown to the right in Fig. 9 on the plate, are connected in circuit. The ammeter is always in circuit, while the voltmeter has a key switch connected with it, so that a reading may be taken when desired.

The main high-tension battery of the receiver is illustrated in Fig. 34. This is



POWER AMPLIFIER PANEL

Fig. 35. Rear view of the power amplifier shown in Fig. 32. A winding of specially low impedance is used in the transformer, which is of the open-core type

composed of a large number of pocket-lamp batteries arranged within a wooden box. The batteries are all soldered together in series, and the final connexions are taken to the ebonite panel shown in front of the box.

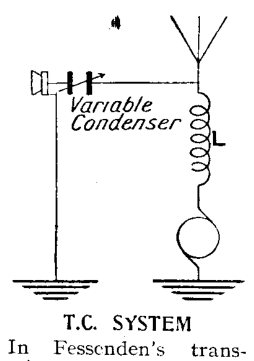
By an ingenious application of an electric lamp a short circuit of the batteries is rendered impossible. It will be realized that even when the power amplifier is in use a current of only a few milliamperes is drawn from the cells. Therefore if a lamp of, say, 100 volts 15 watts is connected in series in one lead of the batteries it will not normally be caused to light. Should, however, an accidental short circuit occur, then the lamp will immediately light, and at once limit the current to that value which the lamp itself consumes. As the latter is quite small, and as a short circuit is immediately indicated, it follows that the batteries are saved from any injury. This system might with advantage be fitted in all experimental receivers, where there is always a danger of short circuit from loose, bare connexions.

From the foregoing it will be seen that the receiver is a straightforward job from beginning to end. It employs no unorthodox circuits, and probably on that account is thoroughly reliable and stable. Further, it is sufficiently sensitive to bring in American broadcasting under good conditions, and a great number of French and Dutch amateurs may be heard on the loud speaker.

No claims to remarkable efficiency are made for either the transmitter or receiver, but it fulfils all the functions for which it was designed, and in that respect its continued existence in the form described is fully justified.—*R. B. Hurton, A. H. Howe.*

TRANSMITTER CONDENSER SYSTEM. This is a form of transmitter due to Fessenden in which a condenser is used directly in place of the usual carbon microphone.

In the Fessenden system a condenser with one or more movable plates and one or more fixed plates is so arranged that the movement of the movable plates is controlled by sound vibrations. This causes changes in the capacity of the condenser, changes which follow closely the variations in sound. The figure shows diagrammatically the connexions for such condenser-controlled circuit.



T.C. SYSTEM
In Fessenden's transmitter a microphone controls the capacity of a variable condenser

The condenser is connected to aerial and earth as shown. L is an inductance coil connected to the source of alternating current supply at high frequency, which is in turn earthed as shown.

When the capacity of the condenser is varied by the sound waves it will detune the aerial, and the detuning effect will be large if the aerial capacity is small, the aerial damping small and the condenser transmitter variations large. *See* Broadcasting; Microphone; Transmission.

TRANSMITTING CONDENSER. Variety of condenser used in transmitting. The most common types of condensers employed in wireless transmitting circuits use mica or glass as the dielectric, with tinfoil or copper as the conducting coatings. The disadvantage of compressed air and oil condensers is that they are bulky for their capacity. Where very high voltages are required the condenser plates are immersed in oil to prevent brush discharge, while with moderate voltages a coating of paraffin over glass jars, especially at the edges of the metal foil, will generally reduce the discharge.

In small installations, where the power does not exceed 5 kw., Leyden jars make good transmitting condensers. They are best made by electrolytically depositing copper on the inside and outside of the jar for about two-thirds of the way up. The standard jar has a capacity of about ·002 mfd., and a number of these jars are held in specially designed racks. The bottom of the rack is of metal, and the outside coatings of the jars all rest upon this rack, the inside coatings being connected by stranded uninsulated cable soldered to them and to brass rods passing through the covers of the jars. The brass rods are connected to bus bars forming the charging connexions of the whole Leyden jar unit.

Metal plate condensers immersed in an oil tank are more compact than Leyden jars, and are more used on board ship. A fuller description of transmitting condensers as used in small sets is given in this Encyclopedia under the heading Main Condenser. For the Marconi $1\frac{1}{2}$ kw. quenched gap transmitter, as used on board ship, the transmitting condenser is a mica condenser immersed in oil. It is contained in a metal box with a sealed ebonite top, has a capacity of ·01 mfd. and is tested to stand normal voltages of 8,000.

The capacity of a condenser in the closed transmitting circuit may be found from the formula

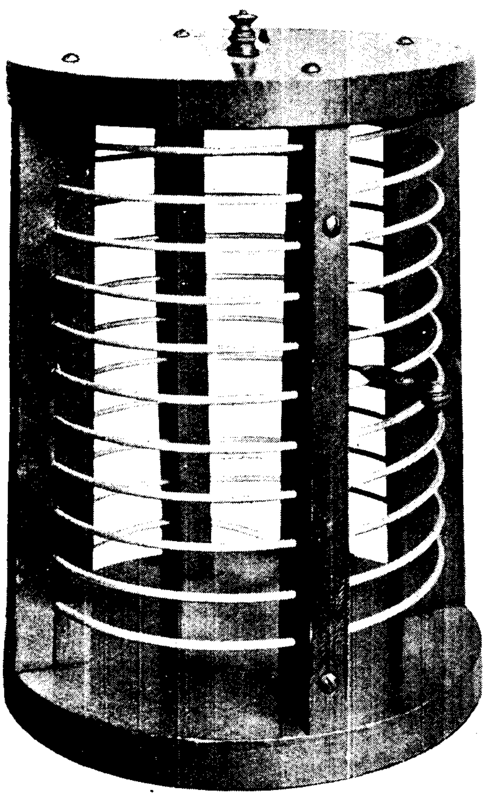
$$C = \frac{2 \times 10^6 P}{NE^2}$$

where C is the capacity in microfarads, P the power in watts, N the number of condenser charges per second, and E the maximum E.M.F. in volts.

If a low maximum voltage is used the capacity of the condenser for a given power is large, but rapidly becomes less as the voltage is raised, since for a given power the capacity varies as the square of the voltage. As high a voltage as possible, without brush discharge taking place, should be used, to keep the size of the condenser as small as possible. Thus for $\frac{1}{2}$ kw. at 10,000 volts at 1,000 sparks per second

$$C = \frac{2 \times 10^6 \times 500}{1000 \times 144 \times 10^6} = \cdot 007 \text{ mfd.}$$

The size and number of sheets of dielectric required may be obtained from the formulae given in this Encyclopedia under the headings Capacity and Electrostatic Capacity. *See* Condenser; Main Condenser; Transmission.



TRANSMITTING INDUCTANCE

This apparatus is made from thick-sectioned copper strip or rod. It is mounted so that each turn is well spaced from the next

Courtesy Economic Electric Co., Ltd.

TRANSMITTING INDUCTANCE. Transmitting inductances are invariably made of heavy-sectioned copper strip or rod, uncovered, and mounted so that each individual turn is well spaced from its neighbour. A photograph of such an inductance is shown. It is an instrument suitable for amateur transmitting work for an A.T.I. Hardwood is used throughout in its construction, the framework consisting of four vertical members attached to top and bottom disks. The wire, which is in this case round copper rod, is supported on the upright pillars and takes the form of a helix.

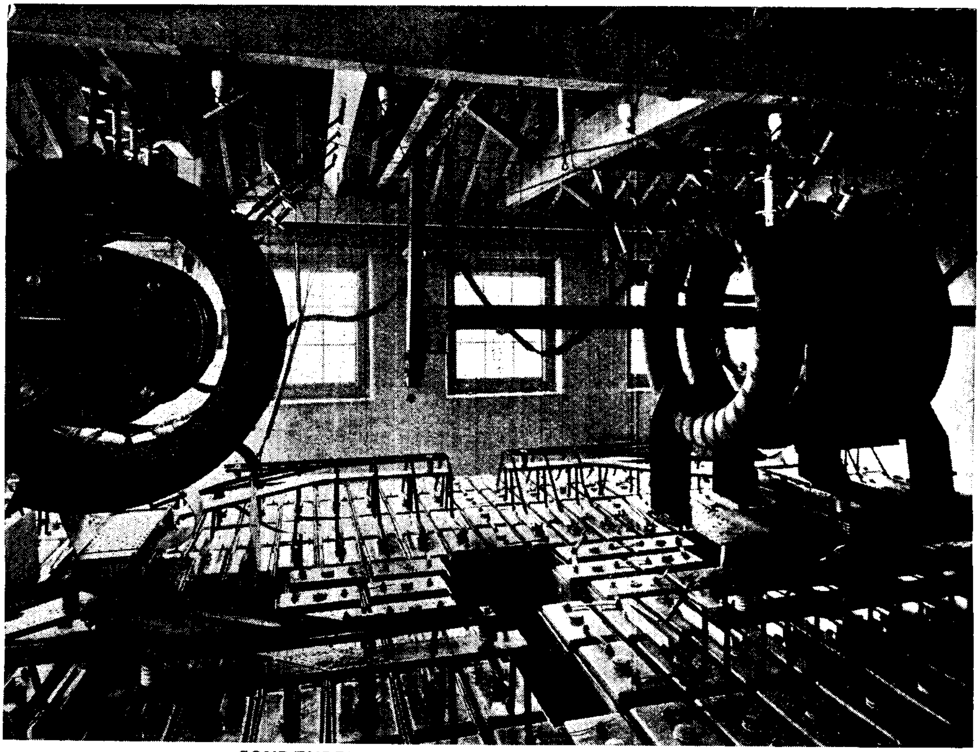
It is from this design that the instrument derives its name—a transmitting helix. One end of the coil is brought to the terminal at the top, while the other connexion is variable, and made by a spring clip at any point. A flexible lead must be fixed to the clip to convey the current to other parts of the apparatus. *See* Helix; Inductance.

TRANSMITTING JIGGER. An oscillation transformer having a variable primary or secondary, and permitting of varying degrees of coupling, by adjustments, between the two circuits. An example of a transmitting jigger in service at a very high-powered station is illustrated, which shows the jigger which was used in connexion with the spark transmitter at the Carnarvon station of the Marconi Company. The jigger itself is shown to the right, and consists of four large hoop-shaped coils enclosed within fabric insulation. Further bands of insulating material are wrapped transversely round the coils, and serve to preserve their true shape.

Each coil is suspended separately from the roof of the building upon insulated steel rods, while their lower extremities are attached to flat brackets of sheet material. Further coils mounted on bobbins are concentrically arranged within the outer ones.

On the floor below the jiggers shown in the illustration is a large bank of fixed condensers, all totally enclosed in hermetically sealed containers filled with oil. *See* Oscillation Transformer.

TREMBLER. An interrupter for induction coils, resembling the hammer break, but on a small scale. A typical form of trembler as fitted to induction coils is shown. The instrument is mounted on an ebonite panel, and is usually attached to the end of the coil cover.



CONDENSER BANK AND TRANSMITTING JIGGERS

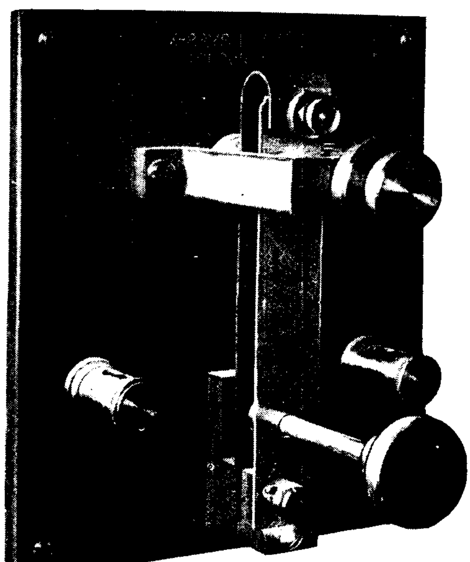
This photograph, which was taken at the Carnarvon station of the Marconi Company before the advent of valve transmitters, shows a bank of condensers with the fabric-covered circular oscillating jiggers above

Courtesy Marconi's Wireless Telegraph Co., Ltd.

From the illustration it will be seen that the trembler consists of two flat strips of spongy brass or phosphor-bronze, which are fixed at their lower end upon a brass block. At the upper end they are free to vibrate, and move between the inside faces of a brass casting, milled to shape.

The strip nearest to the coil carries an iron armature in the form of a flat solid disk. This is arranged to come opposite to, and be in, the magnetic field of the laminated core of the coil. It is therefore attracted to the core when current is passed through and the core energized. Platinum contacts are fitted to the upper ends of the strips, which make contact when the coil core is not energized, but which break circuit when the armature is attracted away from its normal position. Thus the core and the strips to which it is attached are continually moving backwards and forwards, making and breaking contact at every cycle of operations.

The knurled screws shown in the illustration are for adjusting the strength of



TREMBLER FOR WIRELESS USE

The trembler is an instrument for the rapid making and breaking of the circuit of an induction coil. It can be adjusted to function at different speeds. The springs are adjusted by screws

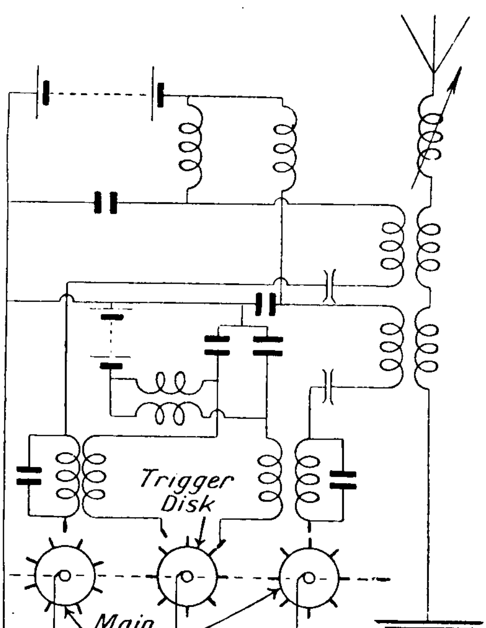
Courtesy X Rays, Ltd.

the flat springs, thus altering the frequency with which the trembler operates. *See* Hammer Break; Induction Coil.

TRIGGER BATTERY. Name given to a small battery which is inserted in the grid circuit to give the grid its initial charge when a valve is used for transmission. *See* Grid Battery.

TRIGGER DISK. In a multi-disk discharger a rotary spark gap for tuning the main dischargers.

In the Marconi multi-disk discharger a number of rotary spark gaps with equal numbers of studs on their circumferences are arranged so that sparking takes place in regular succession at each of the disks. Between two successive sparks of the first disk, for example, there will be a number given by the other disks of the system, so that a much greater number of sparks per second occurs for each revolution of the driving shaft than if only one disk were used. Each disk is connected to an oscillation circuit, and by arranging the correct speed for the disks the impulses from each spark assist the next, and a continuous oscillation is set up in the aerial circuit. The trigger disk in a multi-disk discharger is an arrangement to ensure



SPARK GAP CIRCUIT WITH TRIGGER DISK
Circuit diagram showing the trigger disk and the main disks of a spark gap circuit

the regularity of the discharges from the main discharge gaps and to do away with any irregular sparking which may occur.

In series with each disk is inserted a quenched gap so that the normal supply voltage will not cause a spark to pass. The trigger disk is fixed on the same shaft as the main disks and has the same number of electrodes. For the trigger disk the fixed electrodes are arranged so that when discharge takes place a discharge also takes place on the main disk. The oscillation circuits of the trigger disk electrodes have a considerably higher frequency than that of the main oscillattion and aerial circuits, to which, however, they are coupled by coils in series with the two latter circuits.

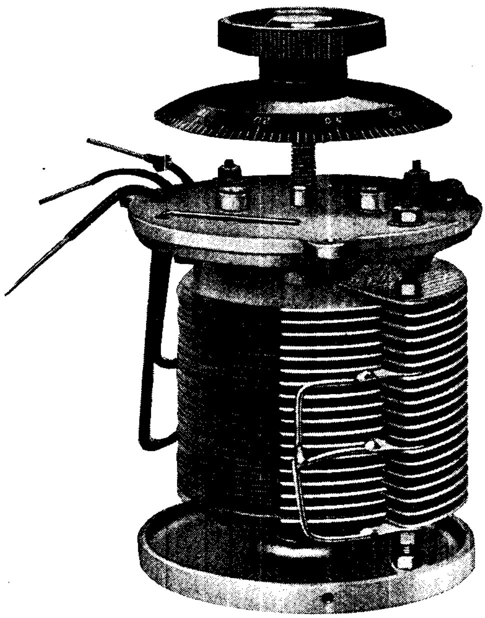
When a spark takes place across the electrodes of the trigger disk a high voltage is simultaneously induced into one of the main oscillation circuits, and this induces the discharge to take place in that circuit.

The figure shows two main oscillation circuits and disks with a trigger disk and circuits in between them. The discharge of the trigger disk is coinciding with the right-hand main disk. The next discharge of the trigger disk will coincide with that of the left-hand main disk. It is clear that the principle may be applied to any number of main rotary discharges, the voltage impulses from the trigger disk boosting up the voltage in the main oscillation circuits at the correct times and ensuring regular discharges. *See* Broadcasting; Rotary Spark Gap; Spark Gap; Transmission.

TRIODE. This is another name for a three-electrode valve. *See* Anode; Filament; Grid; Three-electrode Valve; Valves.

TRIPLE CONDENSER. A triple condenser is a variable condenser having three identical sets of fixed and moving vanes, the latter being all on the one spindle. The photograph is an illustration of the "Polar" triple condenser. From this it is clear that mica insulation is used between the plates, thus ensuring at all degrees of rotation that the dielectric remains constant and perfect. The connexions from the three tiers of fixed vanes are clearly shown in the illustration. They are attached to the vanes by thin metal tags which are inserted beneath the spacer washers. To the left-hand side of the condenser are shown the leads proceeding from the moving vanes.

It is claimed by the makers that each third of the condenser is absolutely identical in physical and electrical properties. This construction renders the instrument of considerable utility to experimenters who desire to tune three high-frequency circuits simultaneously. Both top and bottom end-plates are of cast aluminium, which while ensuring rigidity of construction also performs the function of screening the instrument against the effects of body capacity. A further screen is introduced between each section, thus ensuring the absence of any reactive effects between the different portions.



TRIPLE CONDENSER

In this Polar triple condenser there are three sets of fixed and moving vanes. It is used to tune three high-frequency circuits simultaneously

The following details of the capacities of the instruments are indicative of the uses to which the condenser may be put:

	Mfd.
Minimum capacity of one section	·00007
Maximum capacity of one section	·00026
Minimum capacity of the whole condenser	·000215
Maximum capacity of the whole condenser	·00078

The following capacity limits may be obtained by joining the separate sections in series or parallel:

Minimum.	Maximum.	Method of Connexions.
·00007	·00026	One section
·000035	·00013	Two sections in series
·000014	·00052	Two in parallel
·000215	·00078	Three in parallel

From the above it is evident that the limits of capacity of the instrument as a whole are from ·000014 mfd. to ·00078 mfd. *See* Condenser; Parallel; Series.

TRUE POWER. Apparent power multiplied by the power factor of the particular alternating current circuit in question. The term kilovolt-ampere is used to express the apparent power in a circuit, that is the product of the effective values of the current and the voltage in a reactive circuit. The term kilowatt is used for expressing the true power, and is the reading obtained by a wattmeter applied to the circuit. The ratio of the watts to the volt-amperes is called the power factor.

Suppose, for example, an alternating current generator is supplying a load of 600 kilowatts, and the power factor is 80 per cent. The true power is 600 kilowatts, while the apparent power is $600/{\cdot}8 = 750$ kilovolt-amperes. *See* Power Factor.

T.S.F. These are the initial letters of the French term télégraphie sans fil, or telegraphy without wires. It occurs as an abbreviation very commonly in the names of French wireless companies and French books on wireless. The letters may also represent the words telegraphia sem fios, the Portuguese expression for wireless telegraphy.

T.S.H. These letters form the initials of the words telegrafia sin hilos, the Spanish term for wireless telegraphy.

TUBE. This is an American term used largely for valves of all kinds. *See* Valves.

TUBULAR AERIAL. Name applied to a proprietary form of aerial wire manufactured by Sparklets, Ltd., London, N. It is characterized by the

TUBULAR AERIAL

This aerial is made of interwoven strips of thin copper, and presents a very large surface for the high-frequency currents

Courtesy Sparklets, Ltd.

use of a number of thin, narrow strips of copper which are plaited or braided together to form a tubular cord. The structure is particularly light and has the merit of offering a large surface area to the incoming signals.

It may be employed usefully under all ordinary conditions of amateur use. For portable sets and indoor purposes it is very effective, owing to its flexibility and lightness, apart from its efficiency as a receiver or collector of energy. This aerial material is an attempt to take advantage of a well-known propensity of high-frequency oscillatory electric currents to flow over the surface of a conductor and not through it, in the manner of the steady currents such as those given out by high- and low-tension batteries.

For this reason the tubular form which results from the inter-weaving of the strips of copper shows a distinct advantage by providing a large surface area with a minimum of weight.

TUBULAR CONDENSER: FOR FINE OR VERNIER TUNING

How the Experimenter may Construct a Novel Type of Variable Condenser

When a variable condenser of very low value is required the ordinary plate type is not suitable. Here the making of a tubular condenser, a most useful type, is fully described. Reference should be made also to the main heading Condenser. See also Air Condenser; Billi Condenser, and under the names of particular types

A tubular condenser is a type of condenser characterized by the use of tubular moving and fixed plates. Such a condenser has many advantages for amateur construction when a condenser of low value is required, such as those for use across the primary of a high-frequency transformer or as a vernier condenser in parallel with a larger condenser of the ordinary moving plate type. One tube may slide in and out of another, or the tubes may be made to move concentrically with one another.

An amateur-made instrument of this latter pattern is illustrated in Fig. 1; from which it will be seen that the fixed plate is made from a tube with the major portion of its length cut away to half its diameter, leaving a trough-like piece of metal. Each end is enclosed by a disk of ebonite. At the front a square plate of ebonite is fitted to the outside of the fixed tube as a means of attaching the latter to a panel or small case.

The moving element, which is illustrated in Fig. 2, is simply of half-diameter tube with an upright piece of brass soldered to each end, one of these having a blind hole through it, the other being provided with a nut which is soldered to the inner face of the upright, a hole being drilled through the upright and tapped with the same thread as the nut.

The fixed plate is illustrated in Fig. 3, and is simply a length of brass tube which may conveniently be 1 in. in diameter and 3 in. in length. The moving tube may be cut from a piece of brass tube $\frac{7}{8}$ in. in diameter and should be $2\frac{1}{2}$ in. in length, this size being appropriate for a small vernier condenser.

The same methods of construction can be adopted for tubular condensers of larger capacity. In the shaping of the fixed tube the best plan is first to cut it to length and clean up the ends square and true, preferably by mounting it in a lathe and turning the ends. The next step is to place a piece of round wood through the tube, making it a close fit, and then to cut it with a hack-saw at a distance of $\frac{1}{4}$ in. from each end square through the tube for half its diameter, after which the unwanted piece of metal can be removed by cutting it out with a cold chisel and hammer, if the tube be supported on a bar of iron or steel. Another method is to drill a series of small holes along the tube and file away the wall of metal between the holes, finishing the work by careful filing with a smooth file, cleaning off any suggestion of burr or roughness.

The next step is to turn up two disks of ebonite to fit closely into this tube. These disks should have a centre hole through them and should fit closely into the ends of the tubular member. They may be gently hammered into position with a hide-faced mallet. The ebonite plate should be prepared 2 in. square and a hole bored through it to be a close fit on the outside of the fixed tube. Four holes are also drilled in the corners for fixing purposes. The progress of the work at this stage is illustrated in Fig. 4.

To fix this plate to the tube it is best to remove the disk from the tube and

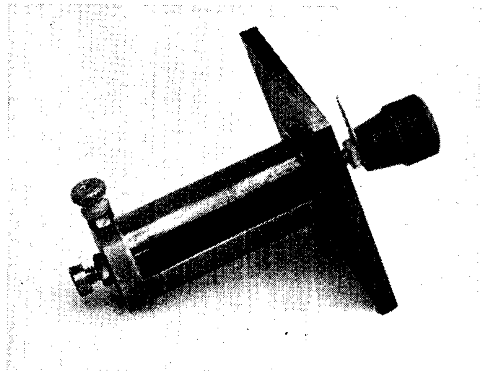


Fig. 1. Completed home-made tubular condenser. This instrument is of small capacity, and is useful as a vernier condenser

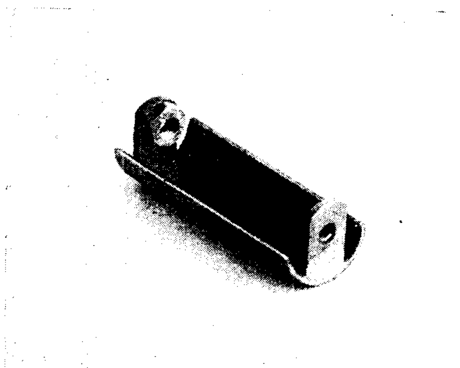


Fig. 2. Curved metal is used to form the movable plate. To this the supporting arms, seen at either end, are securely soldered

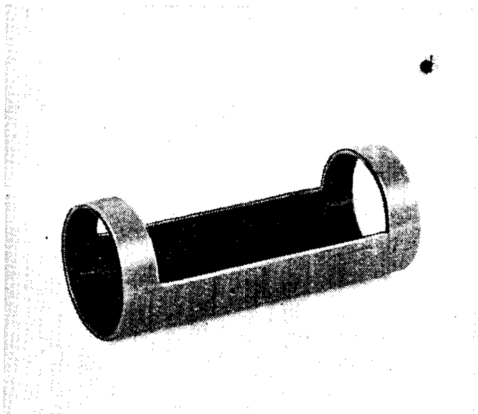


Fig. 3. Brass tubing of the specified length is cut to shape as shown, this forming the fixed plate of the condenser

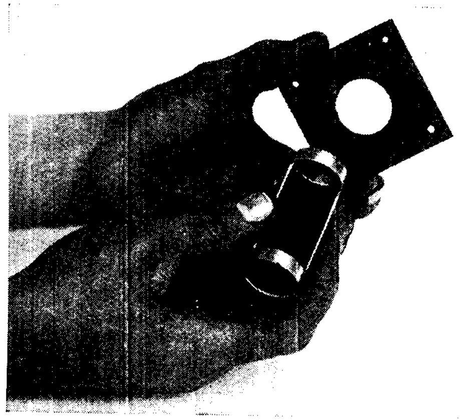


Fig. 4. Attaching the fixed plate to the panel plate. The latter is of ebonite, and makes a close fit with the end of the tube

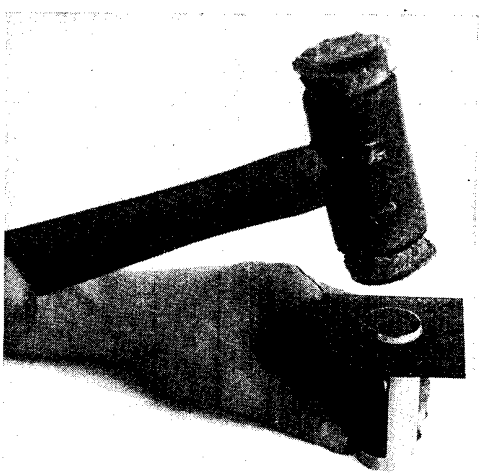


Fig. 5. How the fixed tube is connected to the front plate. A hide-faced mallet is employed for this purpose

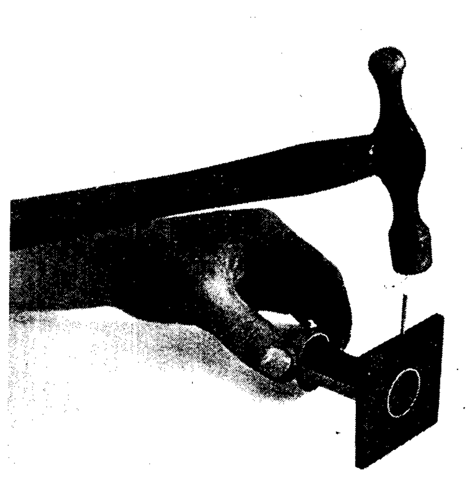
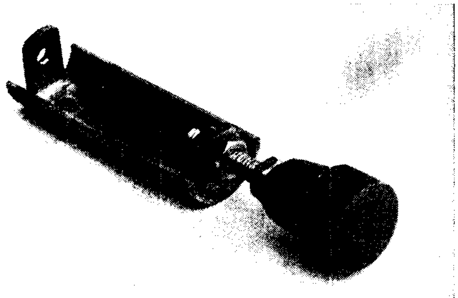


Fig. 6. A long, fine pin is used to secure the tube to the fixed ebonite plate. Light taps are given with a hammer

HOW THE AMATEUR MAY CONSTRUCT A TUBULAR CONDENSER AT HOME

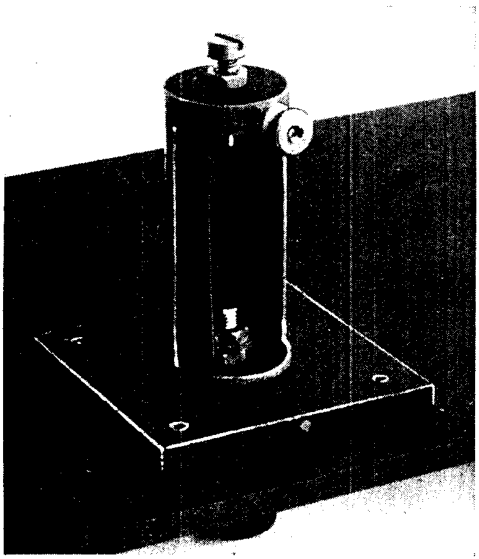
ATTACHING THE TERMINAL

Fig. 7. Screwing the terminal to the fixed plate. Note the lock nut, which should be tightened



INCORPORATION OF SPINDLE

Fig. 8. Lock nuts are used to secure the moving plate to the spindle of the condenser



REAR OF COMPLETED CONDENSER

Fig. 9. Here the finished instrument is seen attached to the panel. The purpose of the square of ebonite is now clearly seen

press the tube into the square plate, taking care to keep the cut-away portion towards the top, and then to insert the small disk into the end of the tube, driving it home with a hide-faced mallet, as illustrated in Fig. 5. If the disk be very slightly tapered it will be found that when it is driven home the tube will slightly expand and will be gripped firmly in its place; but to render it quite secure a small hole is drilled at right angles and a small brass pin about $\frac{1}{16}$ in. in diameter driven through the ebonite plate, through the brass tube, and into the ebonite disk, this operation being illustrated in Fig. 6, which will make the whereabouts of the pin apparent.

A terminal should next be provided on the end of the disk by drilling a hole through the narrow part of the fixed tube and screwing a piece of stemming or small brass screwed rod into a hole tapped in the ebonite disk. A lock nut is provided as shown in Fig. 7, and should be tightened up. If a screw is used, the head should be cut off and a milled edge terminal nut fitted to the screwed shank.

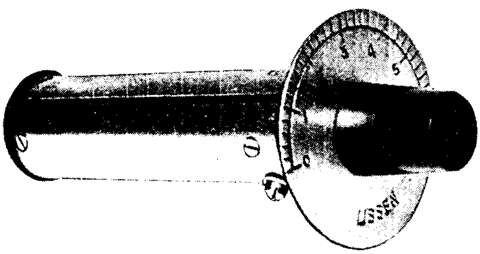
A small ebonite knob should next be made or obtained and fitted to a short piece of screwed rod or stemming. This knob is screwed to the stemming and secured with a lock nut. The stemming should then be screwed into the end of the moving member and be secured thereto with another lock nut as shown in Fig. 8, this having previously been screwed on to the stemming.

It only now remains to make a pivot pin for the outer end of the moving plate. This is simply an ordinary cheese-headed brass screw, the point end of which is turned or filed to a smaller diameter so that it is free of the screw thread. It should be of such a diameter that the moving plates can turn easily, but without shaking, upon it.

A hole is then tapped through the centre of the end disk, a screw fitted to it and secured with a lock nut. To assemble the moving plate, the spindle and screw are both removed, the moving plate dropped into its place, and both the spindle and screw inserted and a lock nut tightened up with the aid of a thin spanner. The screw should be so adjusted that the moving plate can turn freely.

The condenser can be fitted to the back of the panel, as shown in Fig. 9, by screwing a square plate to the back of the panel with four small countersunk brass screws. In this case the spindle should have a pointer attached to it, and a scale should be marked upon, or secured to, the panel and divided into a convenient number of divisions, preferably from 0 to 180 degrees. Connexions are made to the condenser by attaching one wire to the end centre screw and the other to the terminal on the outer or fixed plate.

When fitting this terminal, care should be taken to see that the screw shank does



LISSEN TUBULAR CONDENSER

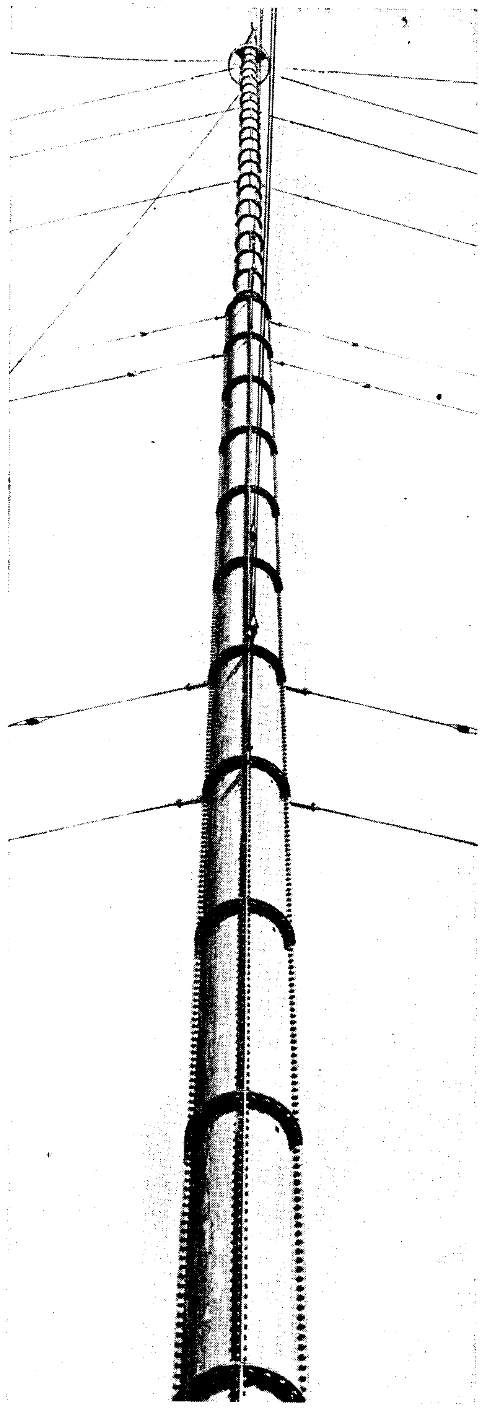
Fig. 10. For fine tuning purposes the Lissen vernier tubular condenser will be found very useful and accurate

not penetrate the centre hole in the disk, as otherwise it would cause a short circuit. If preferred, the condenser may be mounted on a small wood case and used as a separate unit. In this event two terminals should be brought out on to the front of the ebonite panel and a pointer and scale arranged to move over the opposite half. The terminals connexions should be made from the condenser terminals to those on the top of the case.

An example of a commercial tubular condenser is illustrated in Fig. 10, showing the Lissen tubular condenser. This is made for panel mounting and is of the rotary pattern. It is about 1 in. diameter and $3\frac{1}{2}$ in. long, is intended for fine tuning, and for use as a vernier condenser.

TUBULAR MAST. Form of mast made from steel tube. The tubular form of wireless mast is sometimes fitted to very large high-powered stations, and in these instances the tube is constructed of sheets of steel of circular arc formation having flanges on all edges in order that they may be riveted together in erection. Such a mast is illustrated in Fig. 1, and shows one of the masts at the Carnarvon station of the Marconi Co., the photograph being taken with the lens projected upwards from the ground.

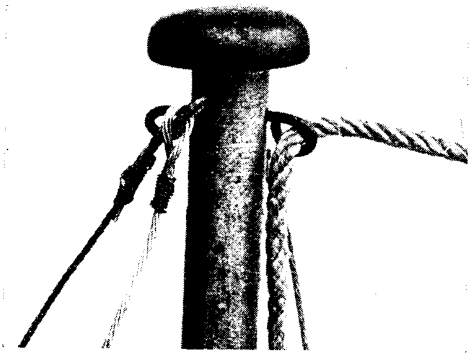
From this illustration it is evident that the mast is composed of a number of



LARGE TUBULAR MAST

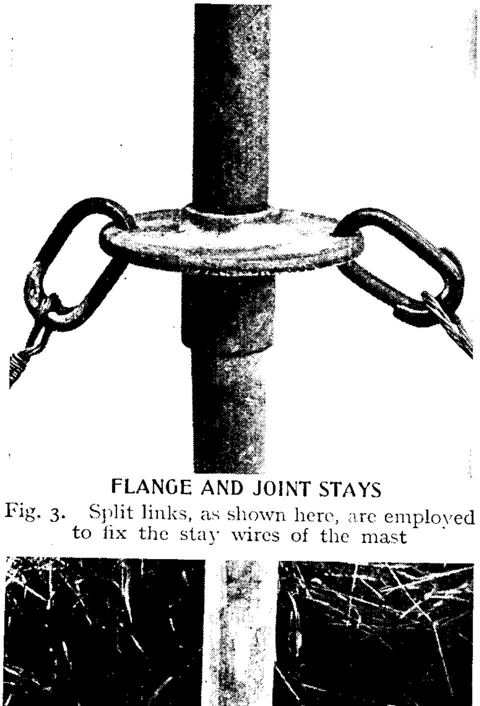
Fig. 1. Quarter-circular flanged sections are riveted together and guyed at intervals in such masts as these, used in high-power stations

Courtesy Marconi's Wireless Telegraph Co., Ltd.



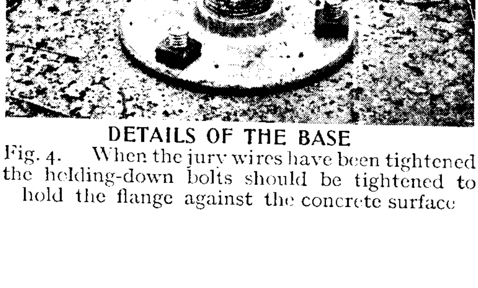
CAP AND EYEBOLTS

Fig. 2. The hardwood cap is necessary to prevent the hollow tube from filling with water



FLANGE AND JOINT STAYS

Fig. 3. Split links, as shown here, are employed to fix the stay wires of the mast



DETAILS OF THE BASE

Fig. 4. When the jury wires have been tightened the holding-down bolts should be tightened to hold the flange against the concrete surface

flanged tubular sections riveted together, and with every sixth section guyed with steel guy-ropes. Each individual section is itself composed of four quarter-circle arcs of sheet steel riveted down both flanged sides. This construction renders it possible for the whole mast to be made completely and transported to the site of erection in small sections. When erection is in progress each section is riveted to its neighbour, the mast being surrounded by a staging, which is built up with the mast and taken away on completion.

The guys are attached to steel strips passed under the rivet heads and held by them. Each guy is insulated from the mast by cylindrical insulators designed to be always under compression and attached to the guys at a point a few feet only from the mast.

The amateur can make a tolerably good tubular mast by the use of ordinary galvanized iron gas barrel. This can be obtained in various sizes ranging from 1 in. to 2 in. in diameter, and in lengths up to 15 or 16 ft. For most purposes two lengths will be quite sufficient; indeed, it would be unwise for the amateur to use more, or to construct a tubular mast of this kind of a greater height than about 30 ft., the particular difficulty being that of erecting it without buckling the tube.

This, however, is overcome by the use of the lever method and the careful control of the stay wires as described in the article on aerial (*q.v.*) The next points for consideration are the method of treatment of the top and the middle joint of the mast, and of securing the mast at the foot. One efficient way of doing this is to excavate the earth to the depth of a foot or so and for an area of about 2 sq. ft. Then mix up a concrete composed of Portland cement and sand and broken brick, moisten it with water, mix it well, and then pour it into the hole in the earth, ramming it down tightly and consolidating it.

A short length of tube, screwed at the upper end and provided with a standard socket, is driven into the centre of the concrete while the mass is wet, the threads in the upper part of the socket being filed or turned out. Another little detail to notice is that the lower end of the tube used for the lower part of the mast will fit easily into the socket.

Directly the socket has been fixed the other piece is screwed into it and a standard flange screwed on to the tube. This flange should have three ½ in. holes drilled through it for the reception of the holding-down bolts, the positions for these being determined by the holes in the flange, and if short rods be driven through these holes into the moist cement the flange can then be carefully removed and the holding-down bolts driven into these holes and secured with a little cement mortar.

The flange is then immediately placed in position to hold the base in position until the concrete has set hard. This will take three or four days at the least, and so should be prepared in advance accordingly. The joint between the upper and lower mast can be effected with a standard socket and flange plate, the latter being drilled to receive split links or means of attachment for the stay wires. The flange is simply screwed tightly on to the threaded part of the upper tube, the socket screwed up against the flange, and the lower tube screwed into the socket.

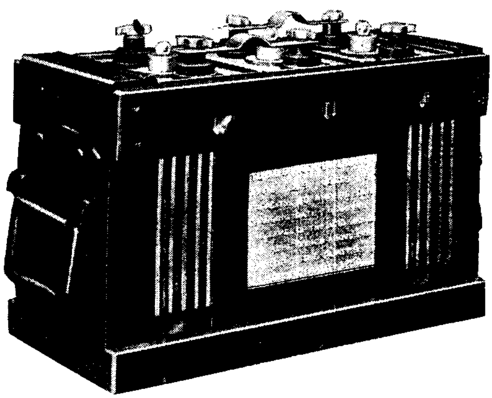
The split links and stay wires are then attached, and are shown in position in Fig. 3. The top of the mast is shown in detail in Fig. 2, and should be provided with a hardwood cap to prevent the ingress of rain-water. Two stout iron or steel bars are then forged with an eye on one end, passed through holes drilled in the upper part of the tube, and the opposite end of the rod formed into an eye. This serves for the attachment of the upper stay wires. The halyard may be passed through the eye.

Alternatively, the stay wires can be worked in pairs and looped around the top of the mast and bear upon cross pins similar to those already described. In any case it is essential to see that this part of the work is sound and strong enough to stand up to the strains likely to be imposed upon it.

When the concrete has set the mast may be erected in the manner described under the heading Aerial (*q.v.*). The flange is screwed tightly on to the end of the tube, and as soon as the latter is approximately vertical it should be coaxed over the ends of the holding-down bolts. After the guy-wires have been tightened up properly the nuts may be screwed on to the bolts to draw the flange firmly against the surface of the concrete, as shown in Fig. 4.

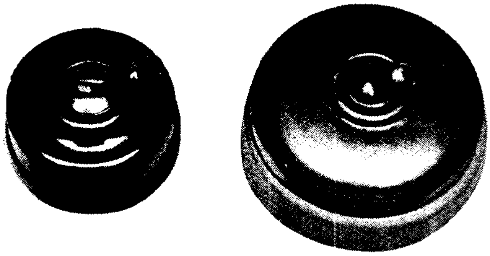
TUDOR ACCUMULATOR. This name is applied to batteries made by the Tudor Accumulator Co., Ltd. In wireless work accumulators are items of primary importance, as they are needed to supply the filament-heating current for the valves and also for other purposes in amateur sets. In large transmitting sets accumulators are necessarily of considerable size. The Tudor accumulators for wireless purposes have been specially developed, and are put up in the best quality celluloid boxes with sealed covers provided with rubber filling plugs having the usual glass air vent.

The plates are of the positive type. The positive plates consist of lead plates cast in one piece with a large surface and thin vertical ribs. These are intersected at intervals by horizontal ribs, thus giving the plates greater mechanical strength. A thoroughly adherent homogeneous coating of peroxide of lead is formed on this surface by a Planté process. The negative plate consists of grids, the outer surface being composed of smooth, finely perforated lead sheets. The space between them is divided by vertical and horizontal ribs into a number of small cells, this design ensuring perfect contact between the active materials of the grid and also full porosity and absence of shrinkage.



TUDOR ACCUMULATOR
This accumulator, specially made for wireless purposes, has a capacity of 40 ampere-hours. It is provided with a wooden carrying case

In the example illustrated, which shows a Tudor accumulator for wireless purposes which is known as the C.L.H.9, the accumulator has an actual capacity of 40 ampere-hours. It measures a little under 12 in. in length, 5 in. in width, and slightly over 7 in. in height, exclusive of the carrying case. This is in the form of a well-finished crate, and is thoroughly coated with anti-sulphuric paint and



TUMBLER SWITCHES

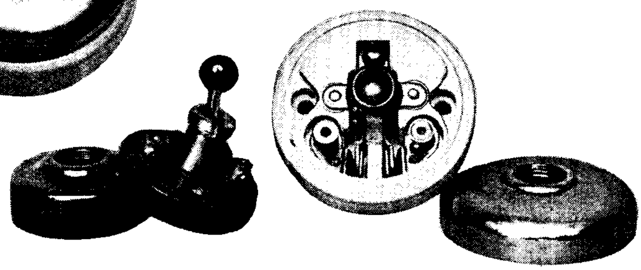
Fig. 1. Two varieties which are very useful for many wireless purposes

Courtesy Economic Electric Co., Ltd.

fitted with iron drop handles. It is thus conveniently portable, and owing to its large capacity gives long life to the average receiving set. *See* Accumulator ; Battery.

TUMBLER SWITCH. A pattern of switch commonly used in electric light installations. Two examples are illustrated in Fig. 1, that on the left side being a miniature type suitable in wireless apparatus for such purposes as the control of a local component, as, for instance, an anode loading coil. It comprises an ebonite or china base, removable metal cover and a central member. To the upper part of this is attached a lever, and the lower end of the lever bears against a rocker arm which when depressed completes the circuit through two copper contacts, these being connected by means of bushings and pinching screws to the conductors forming part of the circuit.

The internal construction is seen from Fig. 2, where the covers have been removed. The larger pattern on the right of Figs. 1 and 2 is a standard form of tumbler switch capable of dealing with current up to a value of 5 amperes. It has a china base and removable metal cover. The contact arm and contacts are of substantial



SEEN DISASSEMBLED

Fig. 2. This view gives a very clear idea of the internal details of the normal types of tumbler switch shown complete in Fig. 1

Courtesy Economic Electric Co., Ltd.

construction, and the contact lever is spring-controlled. The purpose of the spring is to raise the lever rapidly when contact is broken and minimise sparking troubles.

Tumbler switches are noted for their durability, and when of reputable make seldom give trouble or need attention. They may be used for controlling all manner of electrical circuits where the amperage does not exceed that for which the switch has been designed. This, in the case of the miniature switch, may be taken as two amperes. For the standard switch five amperes will probably have to be dealt with, while for heavier currents more substantial switches may be employed.

TUNED ANODE: ITS USES AND ADVANTAGES

Full Details for the Construction of a Set of Unusual Interest

Here is described an admirable method of high-frequency amplification, with its application to a receiving set employing the ingenious and very compact Baty components. The description is accompanied with a photogravure plate. See related headings, such as Anode Circuit; High-frequency Amplification; Reaction; Reflex Set

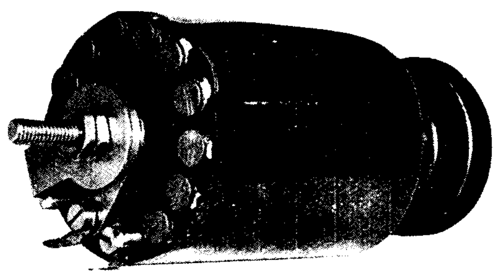
Tuned anode is an expression applied to a method of amplification characterized by the use of an inductance coil in the anode circuit of the valve. This inductance is customarily tuned by means of a variable condenser shunted across it. It provides an admirable and easily controlled method of high-frequency amplification, and may be employed in ordinary simple circuits or in the more complicated reflex or dual amplification systems.

There are many ways in which the tuned anode circuit can be arranged, and several of them are dealt with under the heading Anode Circuit (*q.v.*). In a tuned anode system, when it is desired to receive signals over a wide range of wave-lengths, it is necessary to change the value of the inductance in the anode circuit. This is accomplished in some systems by interchangeable plug-in coils. A very convenient plan, especially for panel-mounted sets, is to employ an anode reactance unit such as that illustrated in Fig. 1.

There are several of these general types of combination, and most of them comprise a tapped inductance, usually composed of fine gauge wire, tappings being taken off at appropriate positions according to the desired range of wave-lengths to which the set is to be tuned.

In the example illustrated the central spindle, with an external ebonite knob and centre-hole fixing bushing, has a contact arm at the inner end of this rod. This arm makes contact with a series of contact studs which are connected to the tappings; so that, when the aerial inductance value is altered, the anode reaction value can be correspondingly changed by simple rotation of the knob. It is possible to obtain a high degree of amplification by means of the tuned anode method.

A commonly adopted plan in tuned anode systems is to arrange for a reaction coil to react on to the anode coil, or for the anode coil to react on to the aerial coil, or in some cases a combination of both these methods giving, in addition to the amplification associated with the tuned anode system, that due to regeneration by virtue of the reaction coil.

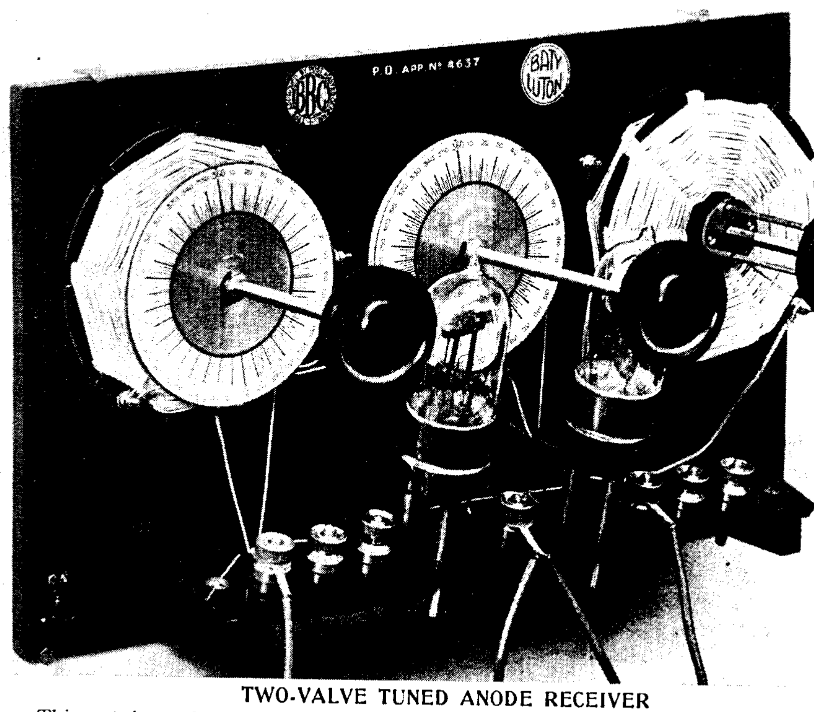


ANODE REACTANCE UNIT

Fig. 1. This is a vital component of tuned anode sets. The tappings enable the desired range of wave-lengths to be tuned in

Courtesy Lissen, Ltd.

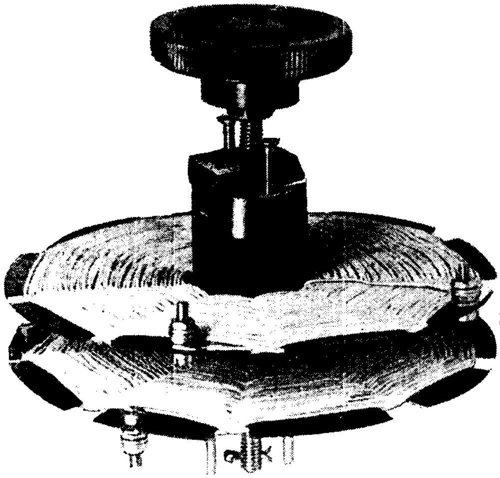
How to Make a Tuned Anode Set. The two-valve receiver designed by Ernest J. Baty is an ingenious and compact instrument which gives extremely good results employing the ordinary tuned anode circuit with one or two modifications. The complete set as sold is seen in the photograph Fig. 2, its circuit diagram being given as Fig. 7. The receiver can be purchased complete, and the special components are also supplied separately. It is economical in cost and



TWO-VALVE TUNED ANODE RECEIVER

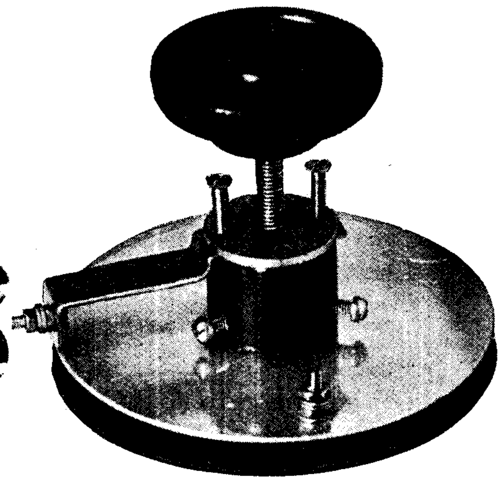
Fig. 2. This set is made up with Baty variable condensers and spider coils. It is remarkably selective and, on a good aerial, will bring in all B.B.C. stations at good strength

Courtesy Ernest J. Baty, B.Sc.



BATY VARIO-COUPLER

Fig. 3. In this aperiodic coupler two spider coils are wound over thin sheets of ebonite. Wave-length range is increased by loosening the coupling of the coils

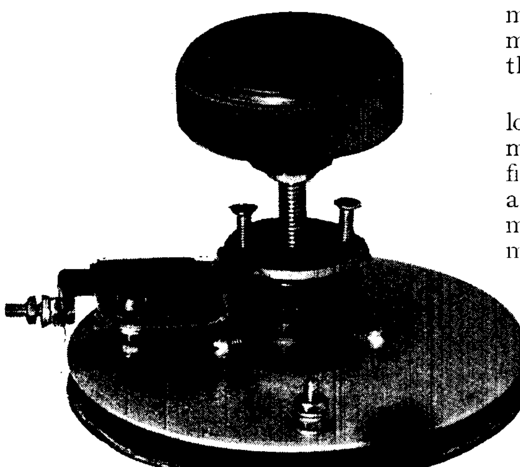


BATY VARIABLE CONDENSER

Fig. 4. Aluminium disks, one of which is mica-coated, make up this condenser. Adjustment with this instrument is very fine, the minimum capacity being extremely low

space taken up; the latter feature is well shown in Fig. 2.

The set as sold is made up on a piece of ebonized mahogany 12 in. wide by 7 in. deep. At the bottom is an ebonite shelf carrying valve holders and all terminals, and the total depth of the instrument (ignoring control knobs) is only 2½ in. Aerial tuning is by two variably coupled spider coils consisting of 100 turns of number 32 D.C.C. wire wound on thin ebonite formers. The complete vario-coupler is shown in Fig. 3. The secondary coil of this vario-coupler is tuned by one of the special Baty condensers, seen in the centre of Fig. 2, marked in degrees from 0 to 360.



ANODE TUNING CONDENSER

Fig. 5. On the connecting arm of this condenser a special form of fixed grid condenser is mounted. This is more clearly seen in Fig. 8

Courtesy Ernest J. Baty, B.Sc.

Details of the Baty condenser can be seen in Figs. 4, 5 and 8. It consists of two circular aluminium plates 3 in. in diameter, the fixed plate being mounted on an ebonite hub. The moving plate is mounted on a threaded spindle which passes through the hub, and by means of the knob screwed on to the spindle it is rotated, and thus moved to or from the fixed plate. The moving plate is coated with mica 1 mil thick, fixed with shellac.

These two plates are seen clearly in the lower part of Fig. 8. Its construction makes this condenser essentially one of fine adjustment, and, in fact, it acts as a vernier condenser with a fairly high maximum capacity and an extremely low minimum capacity.

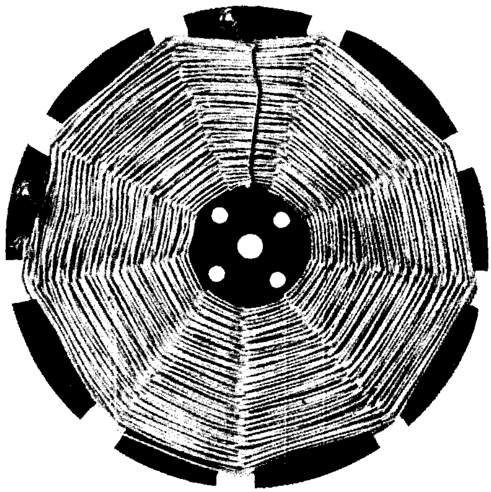
When the two plates are screwed up tight the capacity is ·0004 mfd., and when fairly widely separated ·000002 mfd. This is a minimum value which is never achieved by the ordinary type of vane condenser. Connexions are made by means of a nut on the fixed plate and a copper strip arm on the hub, connected by means of the threaded spindle to the moving plate.

The anode condenser (Fig. 5) is similar, but carries a small grid condenser in addition mounted on the connecting strip.

This is constructed of a piece of copper $\frac{5}{8}$ in. square, bolted over and separated from the connecting strip by a piece of mica. This and other details are seen in Fig. 8, which also shows, by comparison with Fig. 4, how the condenser is fixed to the panel. The two countersunk screws seen standing out of the ebonite hub are passed through the panel. The circular brass plate drilled with five holes seen in Fig. 8 can be used as a template for drilling the panel. The anode coil (Fig. 6) is wound in exactly the same way as the aerial coils, and is mounted directly under the anode condenser.

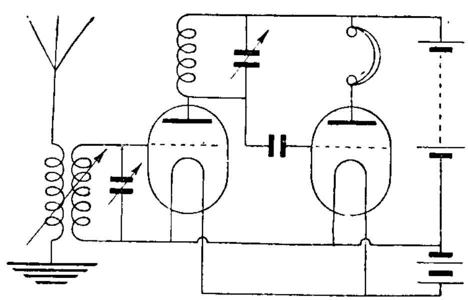
When the set is built up from components, both the circuit diagram (Fig. 7) and the general lay-out (Fig. 9) should be studied. From these diagrams it will be seen that no grid leak is provided, nor are filament resistances. The latter can be included if desired, but, unless they can be fixed in one position and a constant current supply assured, tuning difficulties are increased, as there are five variable factors instead of three. Excellent results can be obtained with dull emitter valves.

The aerial circuit is aperiodic, wavelength variation being obtained by varying the amount of coupling. The setting of the second condenser is somewhat critical. When once adjusted to the particular aerial,



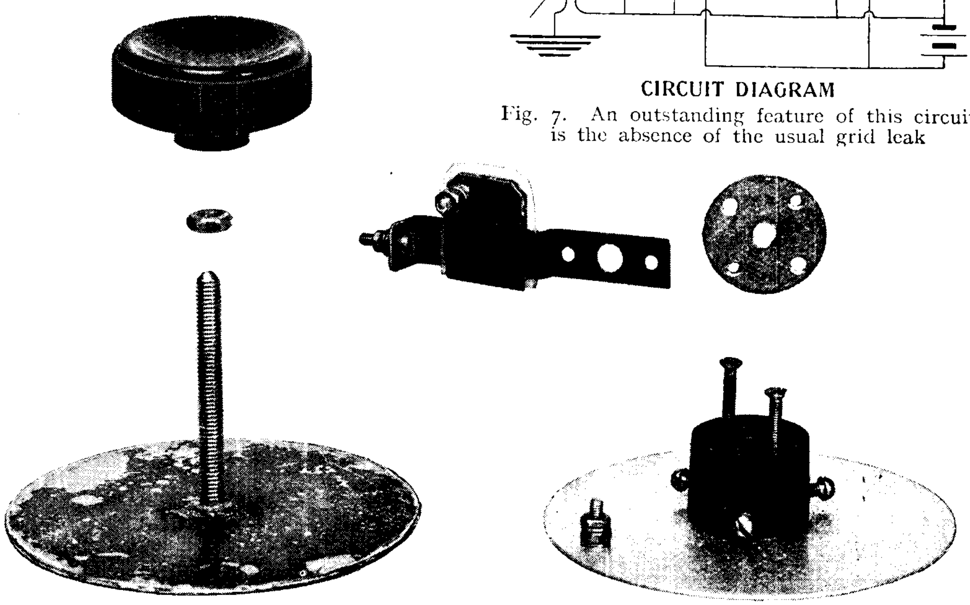
SPIDER COIL FOR ANODE TUNING

Fig. 6. This coil is wound with 100 turns, and is exactly similar to the two coils of the vario-coupler. It is mounted behind the anode condenser



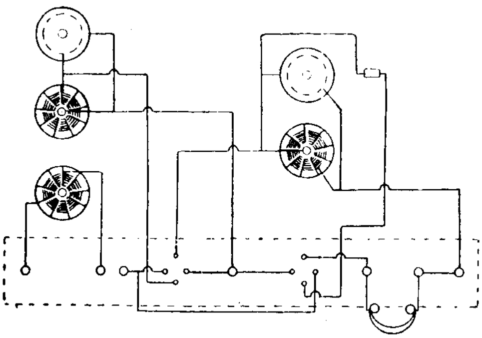
CIRCUIT DIAGRAM

Fig. 7. An outstanding feature of this circuit is the absence of the usual grid leak



HOW THE BATY CONDENSER IS MADE UP

Fig. 8. On the left is seen the moving plate, covered with mica, and on the right is the fixed plate, with its ebonite hub and securing screws. Above is a fixing plate for the contact arm, which is seen in the centre, with its small grid condenser



TUNED ANODE LAY-OUT

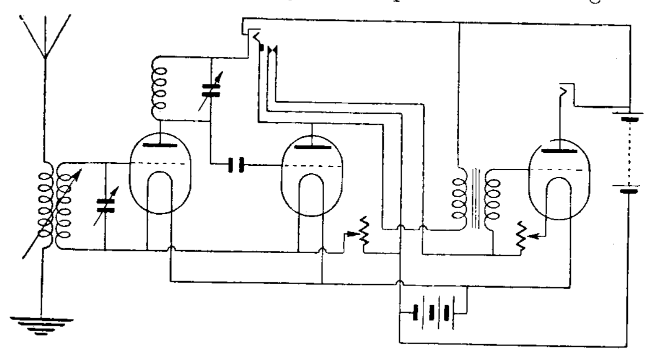
Fig. 9. This diagram shows the circuit of the set and gives an idea of the relative disposition of the components

earth, valves and low- and high-tension currents, it remains fixed and does not vary with the wave-length. Note also from the circuit diagram that low- and high-tension negatives are joined together, and that therefore if a low-frequency amplifier is added to the set similar connexion must be made.

Tuning is not difficult if a proper system is observed, and, when once the setting of the aerial secondary condenser is established, is even simpler. The set will be found to be so stable that, provided it is used with the same aerial, valves and telephones, the anode condenser can easily be calibrated in broadcast stations.

The wave-length of the set is from about 280 metres to nearly 1,100 metres, the highest limit being reached with the aerial coils about 1 in. apart and the anode condenser screwed up tight. The wave-length is reduced progressively by tightening the aerial coupling and loosening the anode condenser.

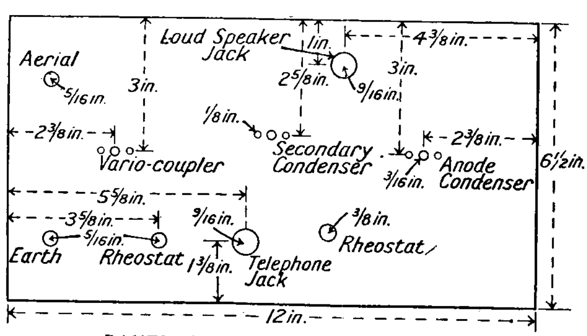
When tuning the set for the first time the best method is to have the aerial coils fairly tight, about ¼ in. apart, and the anode condenser turned about one revolution from the tight-up position, and then to loosen the aerial secondary condenser gradually until a signal is heard, whether Morse or broadcasting. When a signal is obtained, adjust the vario-coupler and anode condenser until it is at maximum loudness. Then leave them alone and make the final adjustment on the secondary condenser. This will give the permanent setting for this condenser, and it need not be touched again. All further tuning is done on the coupler and anode condenser. As a rough guide it will be found that one-third of a turn of the anode condenser from the screw-up-tight position reduces the wave-length to about 600 metres, two-thirds to about 400, and one complete turn gives about 360 metres. At the latter wave-length the coupler coils will be about ¼ in. apart. The secondary circuit oscillates whenever the coupling is sufficiently loose, but re-radiation is practically impossible.



THREE-VALVE TUNED ANODE CIRCUIT DIAGRAM

Fig. 10. In this diagram are clearly indicated the various connexions necessary in the wiring of the three-valve set

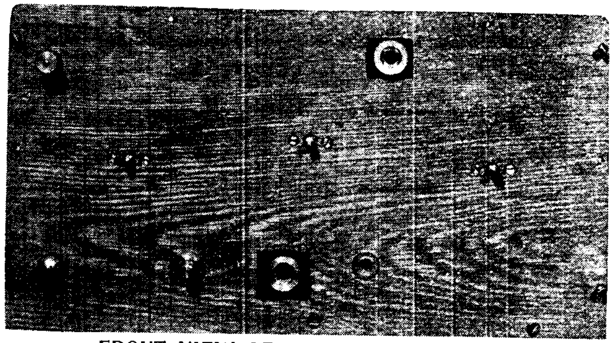
The quality of reception obtained when the set is properly tuned is extremely good, and on a good aerial all the B.B.C. stations come in at good telephone strength. At 25 miles from a broadcasting station under good conditions a small loud speaker can be used without low-frequency amplification.



PANEL OF THE THREE-VALVE SET

Fig. 11. Diagrammatic lay-out of the panel of the three-valve set. The panel, in this case, is made of wood, instead of the conventional ebonite

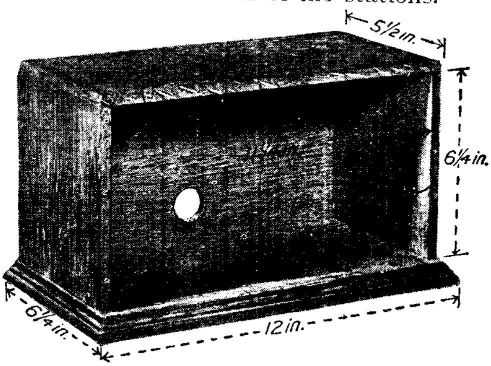
A three-valve receiver made up with Baty components, with the addition of a low-frequency amplifier valve and transformer, is shown complete in Fig. 19 on the plate facing page 2106. The components are housed in an oak cabinet and protected from dust. Instead of rear controls, as in Fig. 2, the control spindles are brought through the panel, also of oak. Aerial and earth terminals are ebonite-bushed, and telephone and loud-speaker connexions are made by means of jacks. Further, it will be seen that, as tuning is straightforward and the set is thoroughly stable, it is actually possible to mark the anode condenser with the names of the stations.



FRONT VIEW OF THREE-VALVE PANEL

Fig. 12. Baty components are used in the set. In the centre are the three spindles of the vario-coupler and two condensers. The jacks are ebonite-insulated

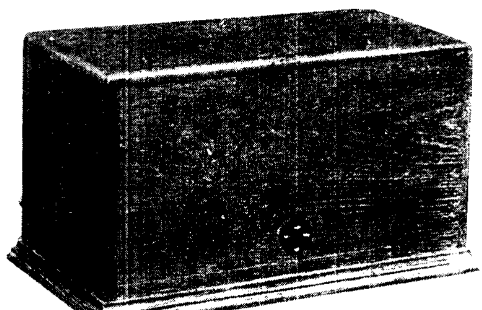
The circuit diagram is given in Fig. 10, and the lay-out and dimensions for the panel in Fig. 11. This shows the smallest panel that can be used with Baty components, owing to the size of the coils and



INTERIOR VIEW OF THE CABINET

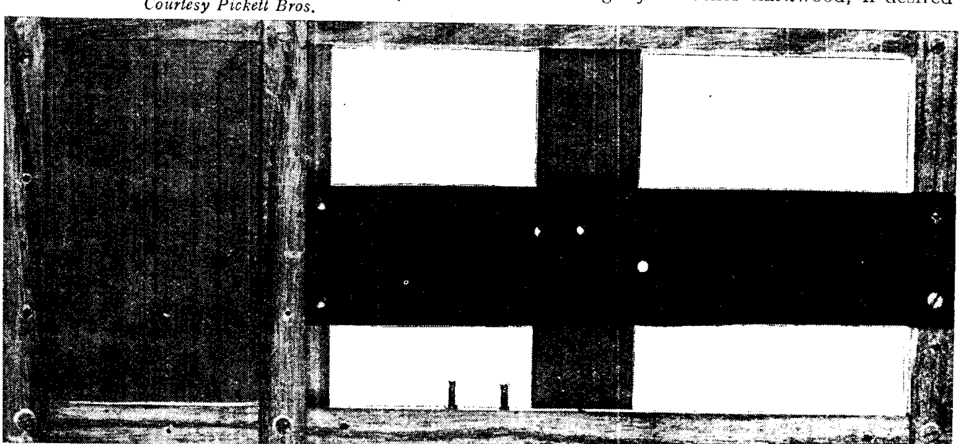
Fig. 13. Dimensions of the wax-polished oak case. At the back is a hole to accommodate the valve holder, into which the batteries plug is inserted

Courtesy Pickett Bros.



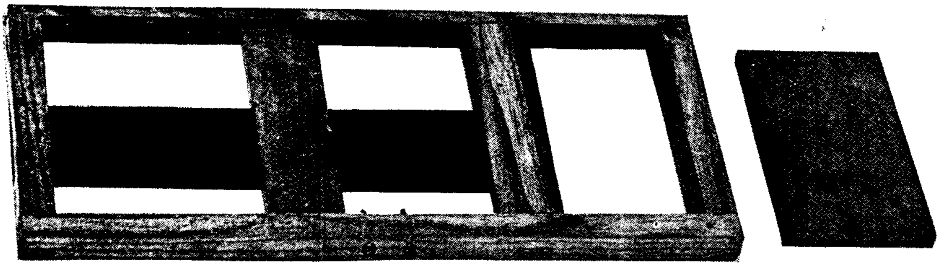
REAR VIEW OF THE OAK CASE

Fig. 14. Note the position of the valve holder for the batteries plug. This case may be made in mahogany or other hardwood, if desired



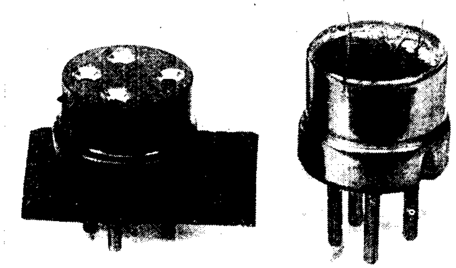
BOX FRAME WITH EBONITE SHELF FOR VALVE HOLDERS

Fig. 15. The frame, with valve shelf and transformer platform, indicated here is bolted to the base of the panel, and rests on the bottom of the cabinet



UNDERSIDE OF THE OAK FRAMEWORK BASE

Fig. 16. Here is shown the support for the valve-holder shelf and the transformer panel



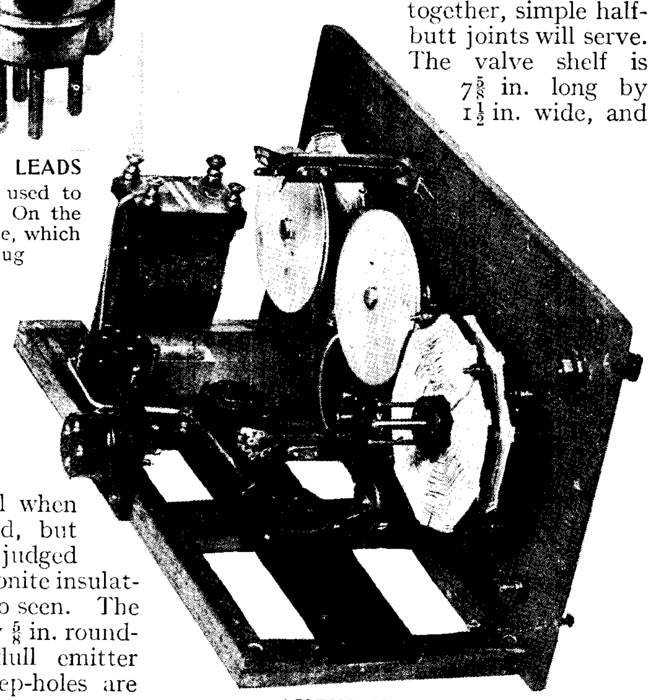
VALVE HOLDER FOR BATTERY LEADS

Fig. 17. An ebonite support is used to screw on the back of the frame. On the right is the bottom of an old valve, which serves as a batteries leads plug

condensers; nevertheless, it is reasonably compact for a three-valve set. Holes for spindles and the small screws that support the hubs of condensers and coils can be bored by using the brass disk seen in Fig. 8 as a template. The appearance of the panel when all components are mounted, but without control knobs, can be judged from Fig. 12, where the thin ebonite insulating plates for the jacks are also seen. The panel is fixed to the cabinet by $\frac{5}{8}$ in. round-headed brass screws. As dull emitter valves are used, no valve peep-holes are provided.

The cabinet itself is an open box (Figs. 13 and 14) made in wax-polished oak by Pickett Bros. Internal dimensions are $11\frac{1}{4}$ in. wide by $6\frac{1}{4}$ in. high, $5\frac{1}{2}$ in. deep, and the panel fits flush on the front edges. It is made in $\frac{3}{8}$ in. oak with a 12 in. base finished with moulding strips. The hole in the back wall (Fig. 13) is cut with a 1 in. centre bit to allow the valve holder, into which all battery leads are plugged, to fit neatly, as seen in the back view of the cabinet (Fig. 14).

Bolted to the bottom of the panel is a framework, made of $\frac{1}{2}$ in. oak or other hardwood, which accommodates the valve shelf and other components. Its form is seen in Fig. 15, a view from underneath being given in Fig. 16. If the frame is screwed together, simple half-butt joints will serve. The valve shelf is $7\frac{5}{8}$ in. long by $1\frac{1}{2}$ in. wide, and is let into the oak frame on the outer side and supported on a fillet on the cross-piece on the right. A piece of $\frac{1}{4}$ in. wood, about 1 in. or less wide, is arranged to support the ebonite shelf in the centre to take the pressure when the valves are thrust into their sockets.



ASSEMBLY COMPLETED

Fig. 18. Here the panel and base frame are bolted together, showing the relative positions of the components, which are all in place. The set is now quite ready for wiring

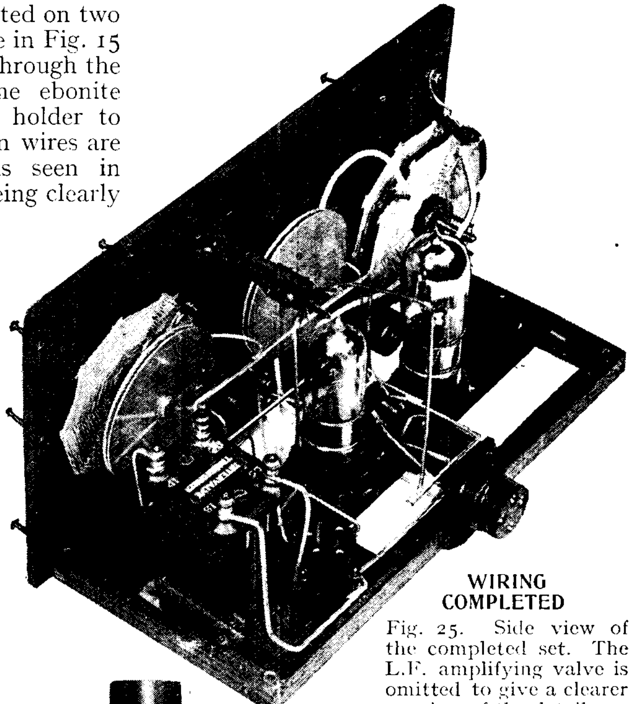
The valve holders can be of any surface-mounting type. As the framework rests directly on the bottom of the cabinet (as seen in Fig. 22), no wiring under the frame is possible, and therefore the ordinary type of valve holder is ruled out.

The space on the right of the framework is filled in with a platform of three-ply or other wood to support the transformer. This platform is seen separately in the underside view, Fig. 16. It is supported on two fillets. At the rear of the frame in Fig. 15 two screws are seen projecting through the framework ; these support the ebonite bracket which carries a valve holder to which the high- and low-tension wires are carried. This valve holder is seen in position in Fig. 18, its details being clearly shown in Fig. 17. It is mounted on ebonite $1\frac{1}{4}$ in. wide by 2 in. long.

On the right is seen the base of an old burnt-out valve, to which the battery leads are connected. This battery plug is arranged at the back of the set. By so doing wiring of the set is simplified by shortening the leads, and leads from the batteries pass up behind the table on which the set is placed, keeping them out of the way. The set is designed so that once the filament resistances are set they need not be altered.

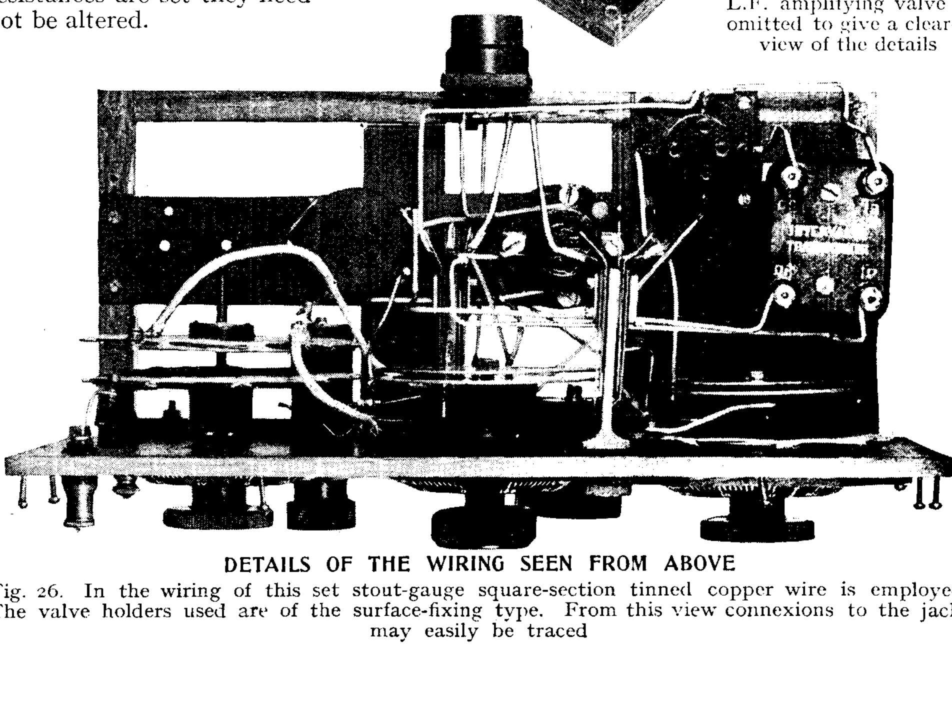
Thus all that is necessary when reception is desired is to push the plug home at the back of the cabinet, so that the most inexperienced person can switch the set on at any time without risk of error.

The Baty components, two rheostats and the two jacks (which are best of the anti-capacity type), are seen mounted on



WIRING COMPLETED

Fig. 25. Side view of the completed set. The L.F. amplifying valve is omitted to give a clearer view of the details



DETAILS OF THE WIRING SEEN FROM ABOVE

Fig. 26. In the wiring of this set stout-gauge square-section tinned copper wire is employed. The valve holders used are of the surface-fixing type. From this view connexions to the jacks may easily be traced

the back of the panel in Fig. 21. Panel and frame are assembled together in Fig. 23, and the method of inserting the whole into the cabinet is shown in Fig. 22.

Details of the wiring may be gathered from Figs. 23, 25 and 26. In use a plug connected to the telephones is inserted in the lower jack in Fig. 24 before the battery plug at the rear of the case is pushed home. Two valves only are then in use. When this plug is withdrawn the third valve lights up automatically, as will be realized by studying the circuit diagram, Fig. 10. A plug connected with a loud speaker can then be inserted in the upper jack. Tuning is carried out on the principles previously described.

The advantage of this set is that once the aerial secondary condenser has been adjusted for the particular aerial, earth and valves in use, the settings for the anode condenser will remain unchanged for each station. Accordingly its dial can be marked off in stations or wave-lengths. Any inexpert person can therefore tune in by setting first the anode condenser and then turning the knob of the aerial coupler until the desired station is heard.—*S. G. Stubbs.*

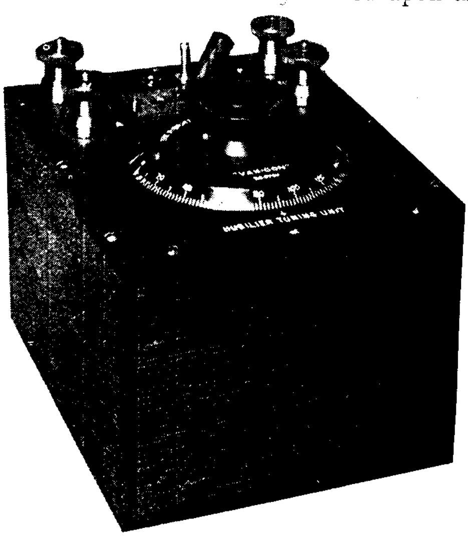
TUNERS: HOW TO MAKE AND USE THEM

Varieties and Uses of this Important Unit Fully Described and Illustrated

By the use of the tuning unit, a separate part of many receiving and transmitting sets, the wave-length may be widely varied. Its function is fully dealt with here. Reference should be made to such headings as Amplifier; Coils; Crystal Receiver; Inductance; Transmission, and also to the titles of the various valve sets described

The expression tuner is applied in wireless to an apparatus comprising an inductance, capacity, or both, and adapted for regulating a wireless receiving or transmitting set so that messages can be sent out or received at any desired wave-length or frequency. The tuner, in practice, can be either an independent unit, and connected by suitable wires to the receiver or transmitter, or it may be incorporated in a self-contained set.

In the ordinary average run of amateur work the tuner is usually looked upon as a separate unit, and the experimenter will usually find that such a piece of apparatus, if it covers the band of wave-lengths used by the stations it is most desired to hear, will be very useful, as to bring it into operation only requires connecting on one side to aerial and earth and on the other to the detector. The latter may be a crystal, valve or any of the other recognized combinations.



DUBILIER TUNING UNIT

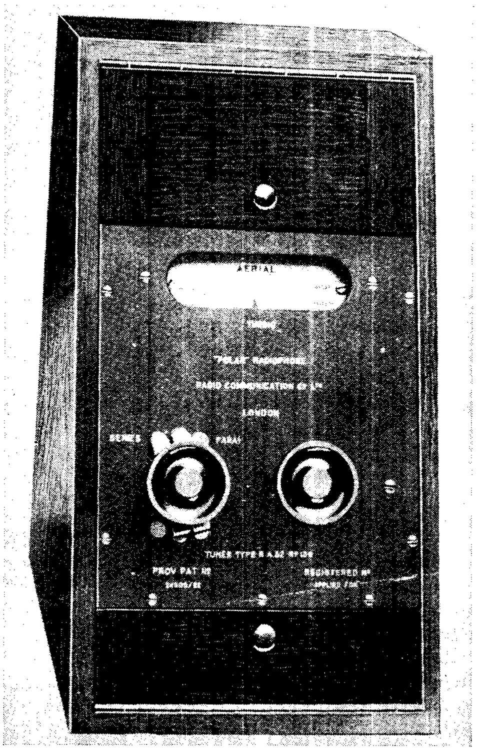
Fig. 1. This is a self-contained unit with a condenser and coils suitable for direct attachment to any form of detector for tuning to any desired wave-length

There are many forms of tuners. The simplest consists of a coil of wire with a sliding contact movable over a bared path on the wire, this putting into circuit any number of turns. This type of tuner is often known as a sliding inductance, and is dealt with under that heading in this Encyclopedia.

In another pattern a plug-in coil of the honeycomb or other type can be employed, the coil in use at any given moment having a value appropriate to the wave-length on which it is desired to operate. As a rule, most ordinary tuners comprise an inductance in the form either of a tapped coil, as one of the plug-in variety, or a series of basket coils with a condenser shunted across them, the whole usually being mounted in a wooden case with an ebonite top, somewhat similar to the Dubilier unit illustrated in Fig. 1.

In some cases, as in that illustrated, a series-parallel switch is provided so that the condenser can either be in series with the inductance or shunted across it, at will. Terminals are provided on the ebonite panel for the attachment of the connecting wires.

Another method, illustrated in Figs. 3 and 4, is that adopted by the Lissen Co. and others. In the example illustrated the tuner comprises a cylindrical former, both ends of which are closed by disks of insulating material. The outside of the former is bank-wound and suitably tapped. The tappings are taken to contact studs arranged concentrically on the underside of the lower disk, as is visible in Fig. 4. A laminated contact arm is attached to a



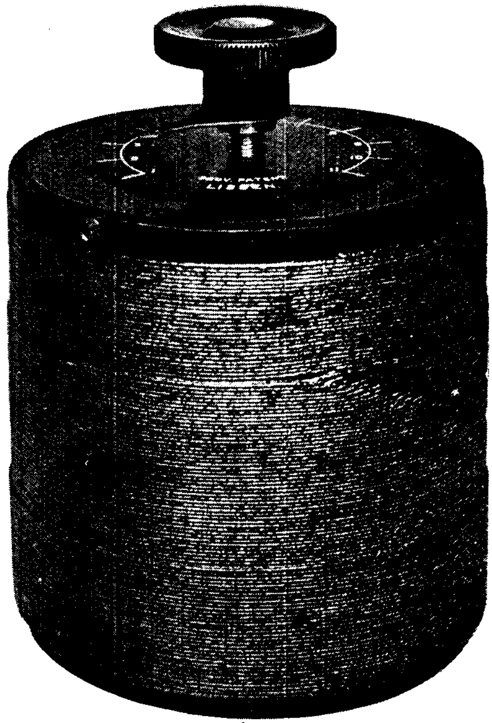
POLAR TUNING UNIT

Fig. 2. In this instrument the cabinet is hinged so that the interior can be examined. The pointer shows the wave-length

spindle passed through the centre of the tuner and terminated in an ebonite handle or knob provided with a pointer.

These tuners are wound for a wave-length range of 150 metres to 4,000 metres, the desired value of inductance being obtained by the rotation of the knob so that the contact arm makes contact with the proper tapping point. In many cases a short-circuiting device is provided, so that the end coils can be earthed to minimise dead-end effects.

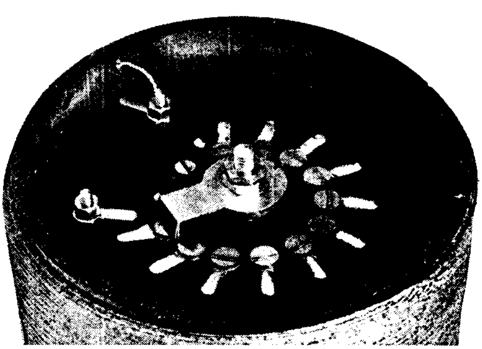
In another type of tuner, supplied by the Radio Communication Co., Ltd., and



LISSEN TUNER UNIT

Fig. 3. This consists of a former closed at both ends by disks and bank-wound. Tappings are taken to contacts as shown in Fig. 4

illustrated in Fig. 2, the inductance, variable condenser and series-parallel switch are arranged within a sloping cabinet having an ebonite panel in the centre part thereof. Hinged portions at the top and bottom permit of access to the interior. A special feature of this tuner is the use of an indicating pointer which travels in a horizontal direction in various

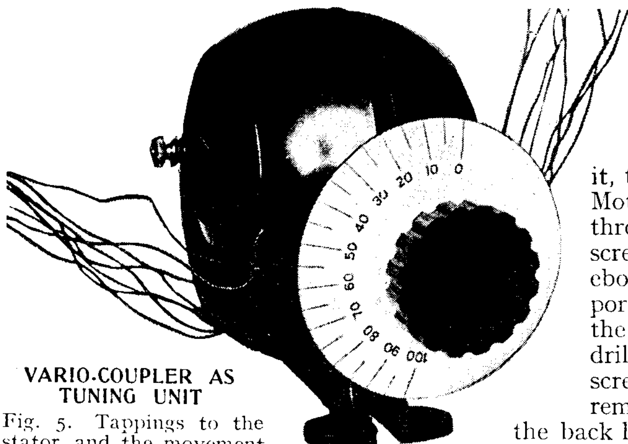


UNDERSIDE OF THE LISSEN TUNER

Fig. 4. Here are given details of the tappings on the insulated disk, enabling the wave-length range to be adjusted as required

positions, the wave-length to which the tuner is then adjusted being indicated on the scale. It is consequently possible to set this tuner to the wave-length of any station it may be desired to hear.

A somewhat different tuner is covered by a group of appliances variously known as variometers, vario-couplers and the like. One such example is illustrated in Fig. 5, which shows a simple type of vario-coupler. This may be used in various ways. In one example of tuning with such a device, tappings are taken from the stator winding to contact studs controlled by a contact switch. Connexions are then made to the rotor, which is then brought into the aerial inductance circuit, and fine tuning is effected by the partial rotation of the rotor, the coarse tuning being dealt with through the tuning switch operating across the tapping points.



VARIO-COUPLER AS TUNING UNIT

Fig. 5. Tappings to the stator and the movement of the rotor enable coarse and fine tunings to be made as required

In the former case the tuning is effected by varying the value of the inductance and capacity. In the case of the variometer, tuning is effected by the changes in the electro-magnetic and electrostatic fields set up around the rotor and stator, which by the variation of their interaction provide the tuning effect.

Another method of tuning which is extensively adopted is that generally known as spade tuning. Tuners of this character are made in various forms, and one simple device is shown in Fig. 6, which consists merely of a coil holder supporting an inductance coil of appropriate value. Attached to an insulated pin on the coil holder is a pear-shaped plate of brass with an ebonite knob at its outer end. This plate is capable of movement across the face of the coil and acts as a damping plate.

Its purpose is to vary the value of the electro-magnetic field set up around the inductance coil and thereby effect a change in the frequency, or, in other words, tune the coil. Such a simple arrangement has the disadvantage that it does not provide a very fine adjustment of the damping plate or spade. A method of doing this more accurately is illustrated in Fig. 7, and shows a device easily made by the home craftsman. The spade is similarly mounted to the foregoing example, but carries at its upper end a small lever arm to which a lead weight is attached.

The lower end of the spade has an angle plate riveted to it, this plate being suitably curved. Motion is imparted to the spade through the agency of a long screwed rod terminating in an ebonite knob. This rod is supported in a U-shaped brass bracket, the upper ends of which are first drilled and tapped to suit the screwed rod. The latter is then removed and the upper part of the back leg of the bracket is filed out to the full diameter of the screwed rod. The lower part of the front leg of the bracket is filed away in a similar manner. Consequently if the screwed rod be raised, it will disengage from the two halves of the screwed portion of the bracket and can be pushed bodily forwards and backwards. By releasing the screwed rod, it drops into the two halves of the screwed portion and can then be rotated, thereby giving a micrometric adjustment and constituting a simple but efficient tuner.

The action of raising the screwed rod to release it is clearly shown in Fig. 8, which should make this simple but practicable and quick adjustment device clear.

Another extensive use of spade tuning is its application to high-frequency transformers. One method of making a simple tuner of this character is illustrated in Fig. 10, which shows a high-frequency transformer plugged into a standard valve holder in the usual way. An ebonite pillar is attached to the panel at a small distance from the largest diameter

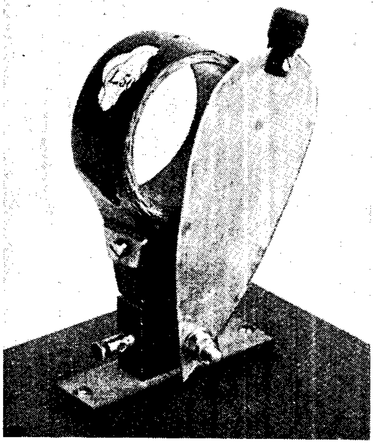


Fig. 6. Simple spade tuner. The brass shield which moves over the coil has a damping effect

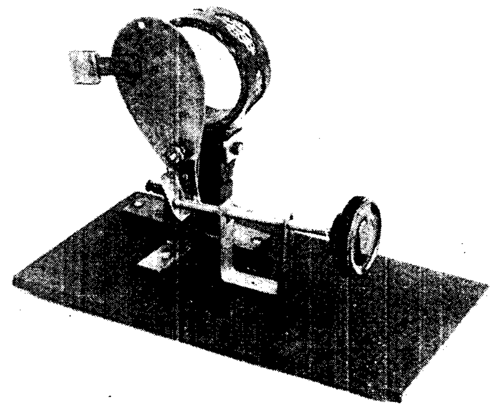


Fig. 7. This fine adjustment device for the spade tuner is easily made at home by the amateur

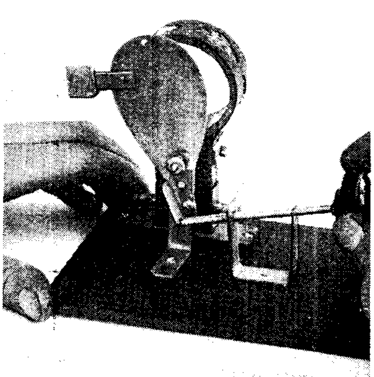


Fig. 8. By raising the screwed rod a large movement is given to the shield; fine adjustment is given by turning

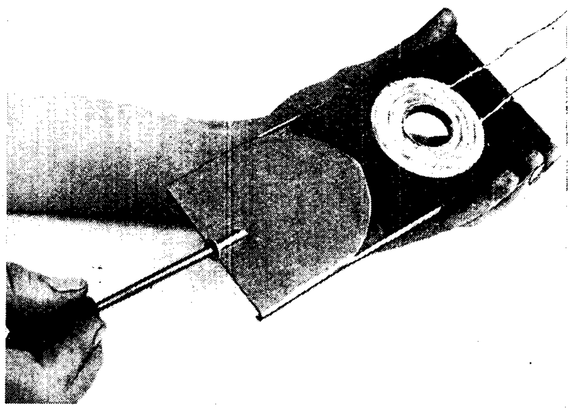


Fig. 9. Tuned H.F. transformer with the spade clear of the coil, in which position it has no damping effect

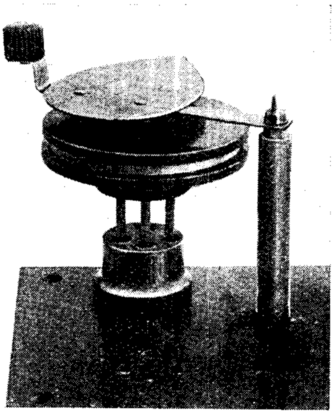


Fig. 10. Another application of the spade tuner. This tuner, like that in Fig. 9, is for a plug-in H.F. transformer

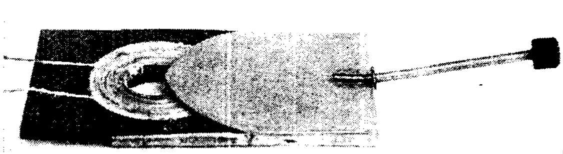
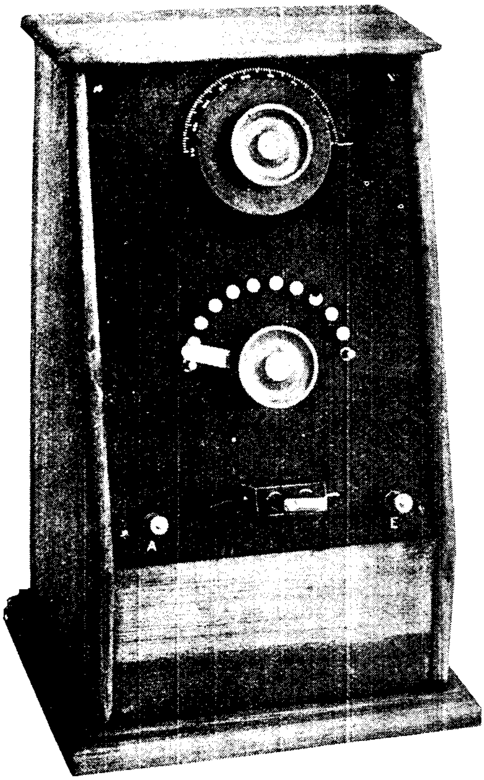


Fig. 11. This model, shown also in Fig. 9, is suitable for building into a cabinet, and is operated by a push and pull movement of the spade

DEVICES FOR IMPROVED TUNING EASILY CONSTRUCTED BY THE AMATEUR



USEFUL HOME-MADE TUNER

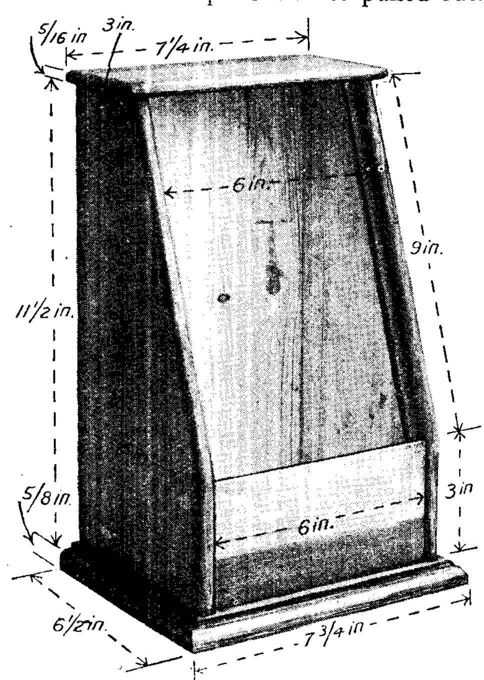
Fig. 12. Any wave-length between 200 and 600 metres may be tuned on this easily constructed instrument, which is very suitable for broadcast reception from B.B.C. stations

of the plug-in transformer. The upper end of this pillar is provided with a short length of screwed rod and a spring washer and nuts, between which is attached one end of a lever.

The outer end of the lever is provided with a small ebonite knob. The spade is attached to the lever in such a position that it can be moved across the upper surface of the plug-in transformer, which it does in a similar manner to the foregoing examples. The purpose of shaping the spades or plates to the approximate pear formation is to facilitate the coarse or fine tuning, as by completely rotating the spade until the small end brushes the coil, the tuning will be particularly fine, the reverse being the case when the opposite end is first moved towards the transformer.

Another type of spade tuner suitable for building into a cabinet is illustrated in Figs. 9 and 11. In this example a slab or other type coil is wound and waxed or provided with a coating of celluloid varnish in the usual way to make it compact. It is then sunk into a hole bored through the ebonite plate of suitable proportions, two grooves being cut across the face of the ebonite for the connecting wires to the coil, the latter being fixed ultimately with wax or compound; the coil is firmly fixed in the hole in the ebonite plate, either with wax or insulating compound.

The spade, or tuning plate, can be cut from sheet brass or copper to the shape shown in Fig. 9, and is provided with two grooved side-pieces, so shaped that the whole device can move bodily across the ebonite plate. To facilitate this, a rod, terminating with an ebonite knob, is attached to the back part of the plate. The use of the tuner is illustrated in Fig. 9, which shows how, by moving the plate forwards and backwards, the coil is tuned. Such a tuner is very useful on portable sets or those where space is limited and it is desirable to make the cabinet one of minimum size. The only disadvantage is the fact that the rod and controlling knob have to be pushed in or pulled out.



CABINET OF THE AMATEUR'S TUNING UNIT

Fig. 13. When constructing the case for the home-constructed tuner the experimenter should adhere as closely as possible to these dimensions

The rod is usually provided with a pointer or scale of some sort so that the proper setting for any desired wave-length within the range of the coil can be attained without waste of time.

The construction of a self-contained tuner, suitable for broadcast reception and having a wave-length range of about 200 to 600 metres when used in conjunction with the average amateur aerial, is not a difficult matter. One pattern suitable for amateur construction is illustrated in Fig. 12, which shows the completed unit. It comprises a sloping-fronted case with an ebonite panel, to the back of which is attached a tapped basket coil, the tappings being taken out to contact studs on the front of the panel.

Above them is located the dial and knob controlling the movement of the variable condenser, which has a value of about ·0005 mfd. At the lower part of the panel is located an ordinary coil holder, normally short-circuited by a connecting strip plugged into it. This holder is used for the loading coil, to increase the range of the wave-length reception to any desired value.

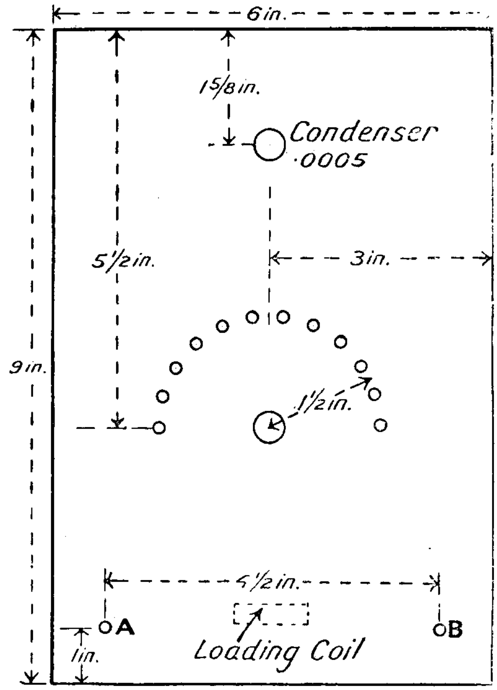
The case, with the dimensions, is illustrated in Fig. 13, and can be constructed from deal or other timber in the way described in the article on cabinets (*q.v.*). The panel lay-out is given in Fig. 14, from which the location of the various parts can be determined. After the panel has been prepared three basket coils should be wound, each of them having 25 turns of No. 22 D.C.C. wire. Ordinary paraffin-waxed bell wire answers admirably.

These should be wound on a former having 15 spokes, twisting the wire in and out between them in the manner described in the article on basket coils (*q.v.*). Tappings, however, have to be made in these patterns in the following order:

1. At the start of the first coil, and also at the fourth, eleventh and sixteenth turns, and at the finishing end. Tappings can be taken by leaving a short loop of wire in the winding and attaching the connecting wire to it, as is visible in Fig. 18.

2. The second coil has tappings taken at the start, at the ninth and eighteenth turns, and at the finishing end, this coil being illustrated in Fig. 18, which shows the whereabouts and mode of tapping.

3. The third coil has tappings taken at the first, tenth and finishing turns.



PANEL LAY-OUT

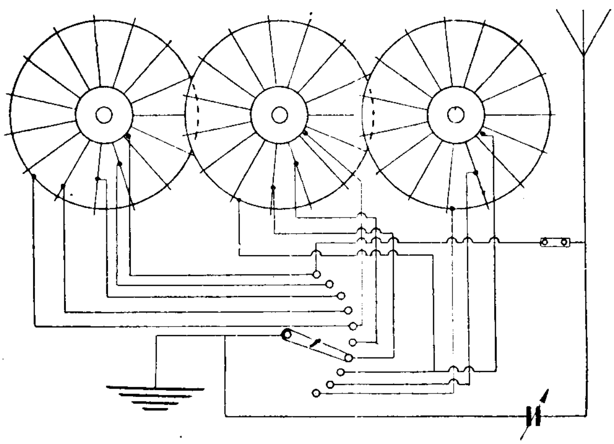
Fig. 14. The panel lay-out and dimensions are given here for the tuner unit illustrated in Fig. 12. From this the positions of the various parts can be determined

It is important that each of these coils is wound in the same direction, and that the tappings are taken to the contact studs in their proper order—that is, the start of the first coil to the first or left-hand side contact stud when the panel is viewed from the front, connexions to the loading coil and the aerial terminal being also made to this stud. The next three tappings are taken from the first coil to the next three studs respectively, the end of the first coil winding and the start of the second coil winding being connected together to the fifth stud. The end of the second and the start of the third are also connected together and to the eighth contact stud. The spindle of the contact arm is connected to earth.

Before the tappings are connected to the contact studs, however, it is necessary to provide a support for the three basket coils. The method of doing this is clearly shown in Fig. 17, and comprises an ebonite post attached to a square ebonite base. The post should measure about 1¼ in. in length and ½ in. in diameter. The plate may be about 2½ in. square. It is attached to the back of the panel by tapped holes and screws.

The upper end of the post is provided with a cheese-headed screw, and the coils are then slipped over the post with an insulating washer between each coil, the lowest coil being held down by an external washer, which is tightened by means of a screw. The whereabouts of these parts and the simple method of effecting connexions between tappings and the contact studs are clearly shown in Fig. 19.

In assembling the coils it is important to arrange them with their turns all in the same diameter and in their proper order, the first coil being put nearest the panel. The condenser is then attached to the back of the panel and provided with its dial and knob in the usual way. It is connected to the aerial and earth terminals by insulated wires, the earth terminal connected to the moving plates and the aerial to the fixed plates, as shown in Fig. 19.



CIRCUIT DIAGRAM OF TUNER

Fig. 15. In this illustration are given details of the different connexions involved in the construction of the tuning unit shown in the preceding illustrations

The theoretical circuit diagram of this tuner is given in Fig. 15, which should make the mode of connexions clear. When completed, all the circuit should be tested for continuity and correctness of connexion, after which the panel is attached to the apparatus at the side of the cabinet by means of round-headed screws. This tuner will be found simple to make and efficient and reliable in use.

In Figs. 20, 21 are illustrated unit-form tuning inductances by Tingey Wireless, Ltd., for use with the unit receiving set of that make. They consist of multi-layer coils wound on a spider held between two ebonite cheeks. The windings are protected by the covering of a flexible black tape of high dielectric strength. Four tappings are taken off the windings, and the connexions are taken to the stud switches shown. The latter are attached to the front coil cheeks by ebonite spacing pillars and screws.

Below the ebonite panel upon which the switch is mounted is a small ebonite pillar, the dimensions of which are such that the whole instrument stands vertically upon the table. Flexible connexions are taken from the terminals shown to the set, and this wire must be long enough to allow the coils to be placed at a reasonable distance from each other should this be required.

Tuning is accomplished by sliding the coils about the table and placing them at any desired relationship with one another, their tightness or looseness of coupling being obtained by placing them near or far apart and by altering their relative angular position. In the majority of cases two inductances would be used, one for the A.T.I. and the other for reaction.

These inductances are made to cover various ranges, and are usually obtained in pairs for the purpose above described.

A standard Marconi tuner, as supplied with the 1½ kilowatt transmitting and receiving stations of that make, covers all the wave-lengths at present in use for commercial telegraphic and telephonic transmission. Coarse wave-length adjustment may be made by depressing key switches. The circuit in which these are arranged provides that only that portion of the inductance which is actually required shall be in circuit, thus all dead-end losses are eliminated, with increased efficiency.

Two variable condensers are fitted, one in each circuit, these being precision instruments designed to remain constant in value despite all the changes in atmospheric conditions to which ship's apparatus is subject. On the panel of the tuner are fitted two switches by which the connexions of the condensers may be changed over from series to parallel. A stud-switch fitted between the two rows of

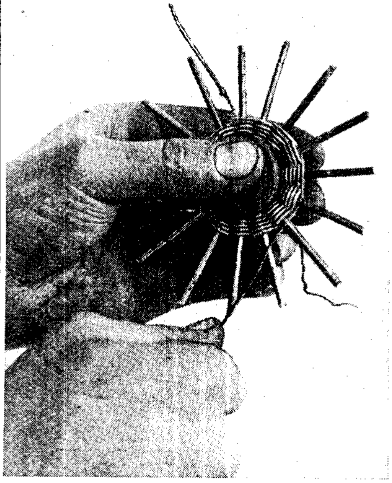


Fig. 16. The coils are wound on a fifteen-shape former. Note how tappings are taken

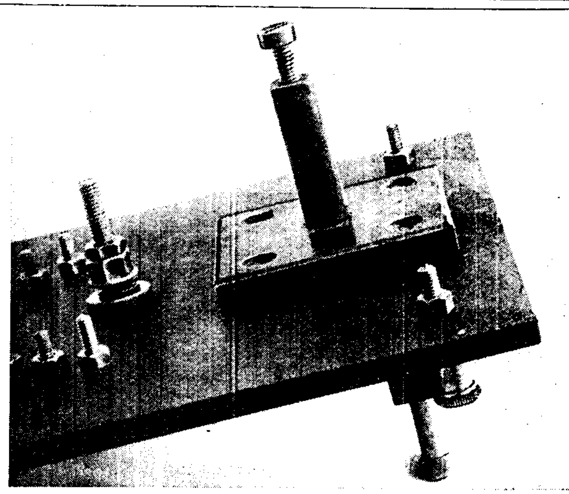


Fig. 17. Post and base for mounting the coils. These parts are constructed in ebonite. Notice the positions of the terminals and contact studs

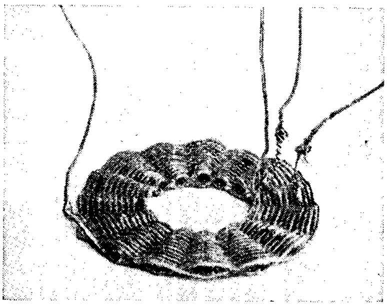


Fig. 18. Tappings taken from the basket coil inductance. Four of these are made

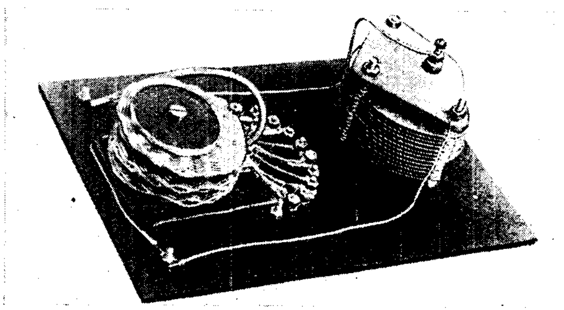


Fig. 19. Underside of complete panel and tuning device, showing condenser and tapped coils with necessary connexions

BASKET COILS FOR THE HOME-MADE TUNING UNIT

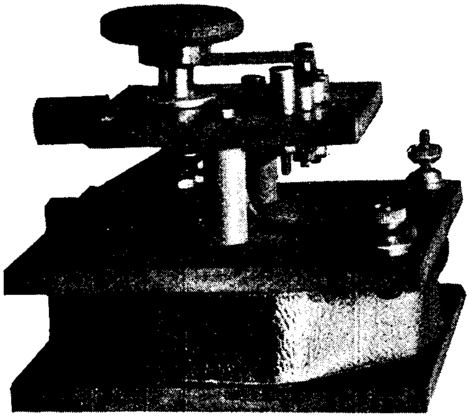
key-switches is connected in the circuit of a further inductance, known as the "coupling coil."

TUNGAR RECTIFIER. Device for rectifying alternating current for the purpose of charging accumulators. The alternating current is rectified by means of a rectifying valve, which is a gas-filled valve with a heavy tungsten wire filament. The diameter of the wire used for the filament depends upon the capacity of the rectifier. The anode is made of carbon. There are a number of sizes of these Tungar rectifiers. The home charging type, the type suitable for recharging accumulators as used in wireless, is made in two sizes. The small size of rectifier will charge three battery cells at two amperes or six cells at one ampere, while the larger size will charge three cells at five amperes or six cells at three amperes.

In case the alternating current supply fails the battery cannot discharge through the rectifier, and the latter resumes its action automatically as soon as the current comes on again.

In Fig. 2 is shown the interior of a Tungar battery charger taken from its outer case. The special lamp rectifier may be clearly seen in front of the transformer. On the top of the latter is a terminal board containing three terminals for the different supply voltages. In this instance the instrument is for connexion to any alternating current main where the voltage is from 200 to 250 and the frequency 40 to 50 cycles.

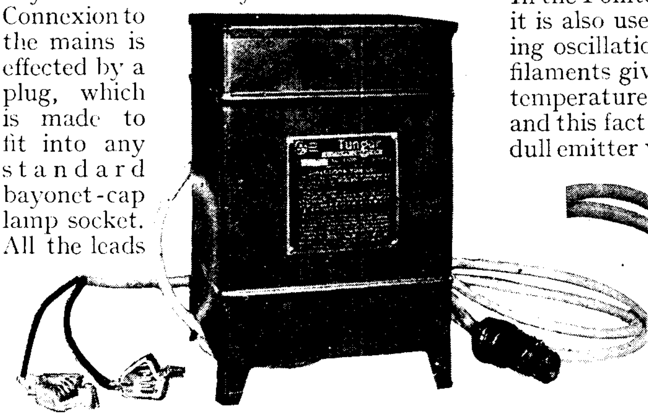
The appearance of the charger when in use may be gathered from Fig. 1. Here the instrument is shown complete with the connecting leads attached. The leads to the battery are fitted with special clip



TINGEY TUNING UNIT

Fig. 20. This unit contains multi-layer coils wound on a former between two ebonite cheeks. It is a very efficient instrument

terminals enabling them to be attached to any form of battery terminal or lead. Connexion to the mains is effected by a plug, which is made to fit into any standard bayonet-cap lamp socket. All the leads



TUNGAR RECTIFIER

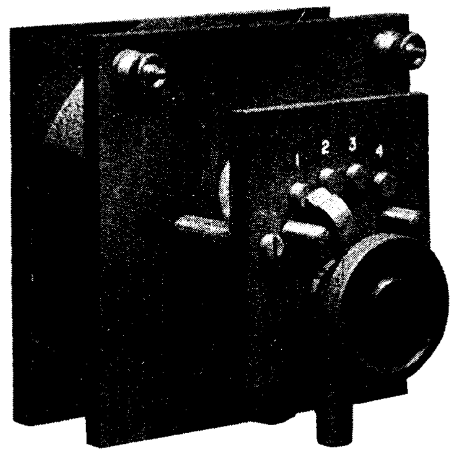
Fig. 1. How this charger looks when in use. The battery leads are fitted with special clip terminals for connexion to any type of battery terminal

Courtesy British Thomson-Houston Co., Ltd.

are heavily insulated with thick rubber, while they are also well protected from mechanical injury. *See* Accumulator; Electrolytic Rectifier; Rectifier.

TUNGSTEN. One of the metallic elements. Its chemical symbol is W, and atomic weight 184. It is a hard, grey, brittle metal with the high melting point of 3,300° C.

Tungsten is largely used as an alloy to increase the hardness of steels, and drawn into a fine wire is used in the manufacture of incandescent lamp filaments. It forms the filament of the Tungar rectifier (*q.v.*) and the electrodes of the tungsten arc.

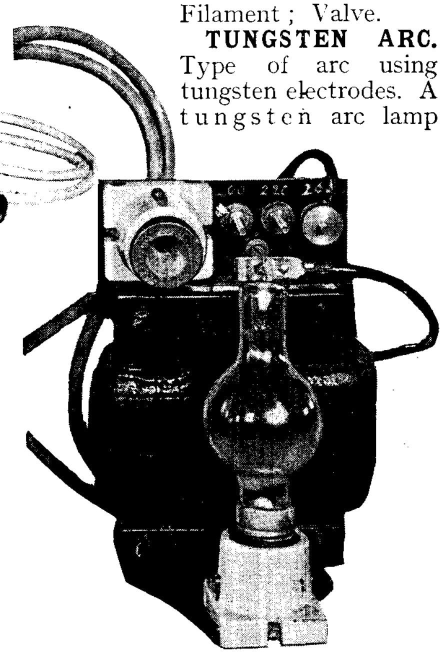


TAPPINGS OF THE TINGEY TUNER

Fig. 21. In the Tingey tuner the coils are tapped as shown, and the coils are moved about on a table to provide the necessary coupling effect

In the Pointolite lamp tungsten is used, and it is also used as the filament in the Fleming oscillation valve. Thoriated tungsten filaments give off electrons at a much lower temperature than ordinary metal filaments, and this fact forms the basic principle of the dull emitter valve. *See* Dull Emitter Valve; Filament; Valve.

TUNGSTEN ARC. Type of arc using tungsten electrodes. A tungsten arc lamp



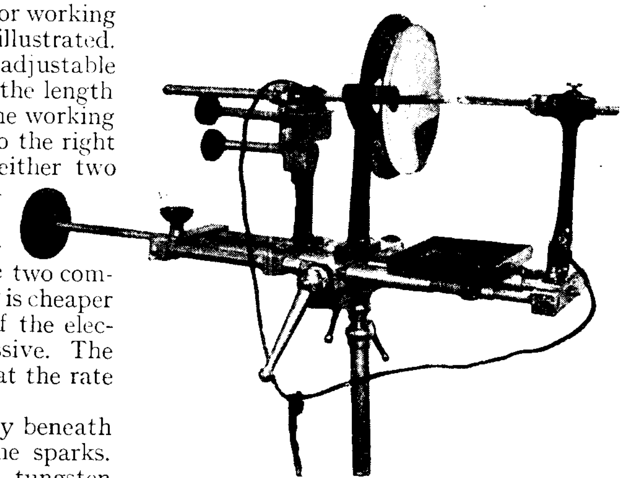
INTERIOR OF RECTIFIER

Fig. 2. Different supply voltages may be used with the three terminals shown above the transformers, which are mounted behind the lamp rectifier

Courtesy British Thomson-Houston Co., Ltd.

suitable for laboratory use and for working off the direct current mains is illustrated. The lamp is supported on an adjustable metal framework which enables the length of the arc to be altered to suit the working conditions. The arc is shown to the right of the mirror, and consists of either two rods of tungsten or one of tungsten and the other of carbon. There is stated to be little difference in efficiency between these two combinations, but although the latter is cheaper in first cost, the consumption of the electrodes during use is rather excessive. The rods are stated to be consumed at the rate of $1\frac{1}{2}$ in. per pair per hour.

The lamp illustrated has a tray beneath the point of arcing to catch the sparks. A necessary attachment to all tungsten lamps, which is not apparent in the illustration, is a shield to protect the operator from the effects of the ultra-violet rays produced. *See* Arc.



TUNGSTEN ELECTRODES IN USE

Tungsten electrodes are used in this arc. The arc is on the right of the mirror. A rod of carbon may be used instead of one of the tungsten rods

Courtesy Watson & Sons, Ltd.

TUNING RECEIVERS FOR THE BEST RESULTS

The Right Methods for Tuning Simple and Complicated Valve and Crystal Sets

In this article the art of tuning step by step is explained from a purely practical point of view, from the simple receiving set up to the complicated three- and four-circuit sets. The reader should also consult the headings dealing with special sets, as Neutrodyne Receiver, and also such articles as Reaction

Tuning is the act or art of adjusting wireless instruments for the purpose of transmission or reception of any particular wave-length. It is the adjustment in practice of the values of inductance or capacity, or both, to enable a wireless set to receive or transmit on some known wave-length.

The mere manipulation of the controls on a wireless set is a very simple matter, consisting only of the moving of a few knobs, dials or handles. It is in the proper manner of handling them and the care with which it is done that the art of tuning is displayed.

This art can be acquired in many ways. Perhaps the best is to study the theory of wireless reception and make a set throughout, and at each stage in the construction ascertain the purpose and function of each component and its bearing on the set as a whole.

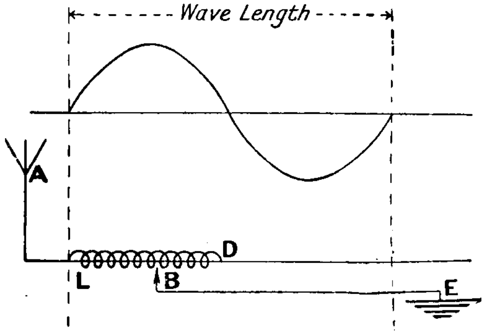
This would be analogous to a great pianist taking a course of pianoforte construction, and is not in either case essential, as it is possible to learn tuning by merely practising with a wireless set.

To do this most efficiently, however, it is desirable to have in mind what happens when the various knobs and controls are moved.

The fundamentals of tuning are based on the phenomenon known as sympathetic vibration, both acoustic and electrical. Suppose that a speech is being delivered at a transmitting station, then vibrations of the air caused by the voice of the speaker will strike the diaphragm of the transmitting microphone in the form of sound waves.

This causes the microphone to regulate the pulsations or vibrations of an alternating electric current, which ultimately is radiated through the ether, in the form of wireless waves. These waves are intercepted by the aerial used in conjunction with the receiving set, and set up in it a series of electrical pulsations or vibrations, which are handed on to the apparatus, and when the set is properly tuned or adjusted ultimately actuate the diaphragm of the telephones and are heard as sound waves by the human ears.

Now, each station transmits messages on some known wave-length, or, in other words, at a known number of vibrations per second, and the purpose of tuning a set is to make it respond more readily to one particular set of vibrations than any others. This is true of all wireless transmission and reception, whether by spark or in code or in the form of telephony, but as the greater number of amateurs are most interested in the reception of telephony, the following notes are chiefly given from that point of view, although the same principles apply to all sets, with a few exceptions. The properties that must be present in any wireless set for it to be able to receive signals are known as inductance and capacity. These terms, their meaning and their application, are described under their respective headings in this Encyclopedia, to which reference should be made for information on the technical aspects.



TUNING IN THEORY

Fig. 1. Diagram to illustrate the supremely important part played by a variable inductance in simple wireless tuning

The physical means for providing capacity are by the aerial and the earth itself, and the variable and fixed condensers used in the set itself. Inductance is provided by a coil or coils of insulated wire wound around a tubular former, or in one of its many variations, such as the basket coil. The combination of the aerial, aerial lead in, the inductance coil and the earth lead constitutes a system in which electrical pulsations or vibrations are set up when the wireless waves strike the aerial. These vibrations will be at a maximum at some particular frequency or wave-length dependent on the values of inductance and capacity in these components.

To make the set respond to a particular wave-length, therefore, it is necessary to be able to vary the values of inductance and capacity at will. This is accomplished in various ways in practice, and the first point to grasp in tuning is that, no matter what form the inductance may take, the more inductance the higher will be the wave-length, other things being equal, and similarly with the capacity or condenser.

The diagram Fig. 1 should make this first point clear, and is really the basis of all tuning. The upper part of the diagram shows a curve representing the wireless wave it is desired to hear, and the length represents the wave-length, which for the broadcasting stations varies from just over 300 metres to about 500 metres. Now, suppose for a moment that the aerial wire and the lead-in wire were joined to the wire taken from the inductance coil, and this were joined to the earth lead, and the whole stretched tightly between two posts, it would vibrate and emit a note if it were swept by a violin bow. Moreover, it would always emit the same note under the same conditions, but to make it sound a lower note it would have to be lengthened, and for a higher-pitched note would have to be shortened. Similarly with the wireless set, to reach a higher wave-length the inductance must be increased, and for lower wave-lengths must be reduced in value. This is shown in the diagram at the lower part, where the aerial is illustrated by the conventional sign as at A, and at L the coil of wire forming the inductance.

Electrical currents always take the path of least resistance, and this fact is employed in elementary forms of tuning, such as that shown in Fig. 1 at B E, which represents a path of low resistance in the form of a wire with one end earthed at E and the other end, at B, movably connected to any of the turns of the inductance. The only effective inductance of the coil is that between the point where it is attached to the aerial wire and the point where the earth tapping, B, is taken. The surplus from B to the end D is known as the end coils or dead end, and may have a detrimental effect on reception.

A practical arrangement of these principles occurs in a common type of crystal receiving set, where the tapping point takes the form of an insulated slider movable on a conducting bar, and making contact with a bared path on the coil of wire. Tuning is effected by sliding the knob until signals are heard in the telephones and brought to full intensity by very slightly moving the knob back and forth until the loudest signals are heard.

Such a device has several disadvantages and is very broad in tuning—that is, it permits signals from other stations to affect the set, and is really only suitable for crystal sets worked near to a broadcasting station, or as a means for coarse tuning when the set can be sharply tuned by a condenser or other means.

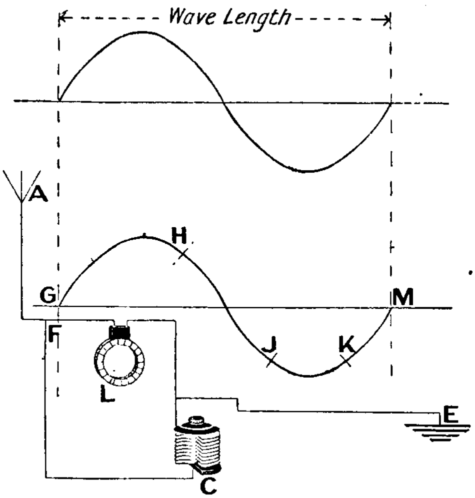
The next point to grasp in tuning is the function of the condenser, which, as is well known, consists of a pair or more plates of metal separated by air or some dielectric or insulating medium. This actually operates on a principle altogether different from the inductance, and, in fact, offers an actual break in the metallic circuit in which it is inserted. It nevertheless has a very similar effect as an inductance on tuning, so far as the actual handling of a wireless set is concerned, and it is possible to tune a wireless set with only an aerial wire, a condenser, and an earth lead, and the same basic rule applies that the greater the value of the condenser the higher the wave-length that can be received, and vice versa, other things being equal.

In practice, however, it is customary to combine an inductance and a capacity and to place them in series or parallel, and in very many cases the inductance is in the form of a plug-in coil with the condenser shunted across it—that is, in parallel with the inductance.

Such an arrangement is illustrated pictorially in Fig. 2, where the wave-length curve is shown at the top, and the aerial at A, the plug-in coil at L, the condenser at C, and the earth at E, and the wire F connecting the aerial with one side of the condenser.

With such an arrangement at any given moment, when the set is properly tuned to the desired wave-length, the set will be in resonance, and a curve of the sum of the values could be shown diagrammatically as that at G, H, J, K, M. The aerial wire to the coil holder, together with that of the internal connexions to one side of the condenser as at F, might be assumed to provide the portion G to H, the virtual inductance of the coil the portion H to J, the condenser that part from J to K, while the remainder is made up of the earth lead and internal connexions from the condenser, neglecting these in the set to the detector or elsewhere. In practice the portions of the curve as shown by G to H and K to M are constant for any individual set when connected to a given aerial and earth lead, but are variables for other aerials or earth connexions. All variations of tuning have to be accomplished in practice over the portions H, J, K, representing the values contributed by the inductance and capacity.

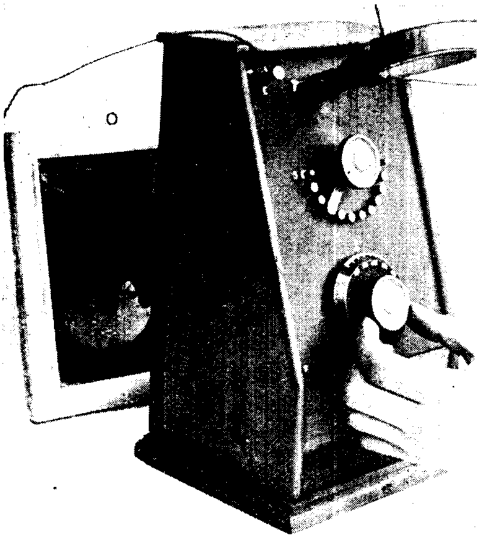
It should be noted that the values of the aerial and earth and the connexions thereto vary with each individual case, and this is one of the reasons why it is only possible to give general instructions for tuning, as the setting of a particular receiver to give quite excellent results on one aerial will probably have to be altered if the same set is used on some other aerial. The remarks that follow are confined to the tuning of the set itself, it being assumed throughout that the aerial and earth constants remain the same through the whole series. Tuning of receiving sets is most conveniently grouped under several heads according to the circuit in use, and is not so greatly affected by the number of valves as it is by the complication of the circuit.



TUNING VARIABLES

Fig. 2. In wireless practice it is usual to employ an inductance in the form of a loading coil, and a capacity in the form of a variable air condenser for tuning. Here the effects are shown

Most crystal sets have a simple single circuit, and the same can be said of many valve sets. A single circuit set is one having only a single tunable circuit, generally known as the aerial or primary. A two-circuit set has either an aerial circuit and a tuned secondary circuit loosely coupled to the aerial circuit, or may be



SINGLE CIRCUIT TUNER

Fig. 3. This has a fixed inductance with a series of tappings, a loading coil for high wave-lengths, and a variable condenser. The mirror indicates the movement of the condenser vanes

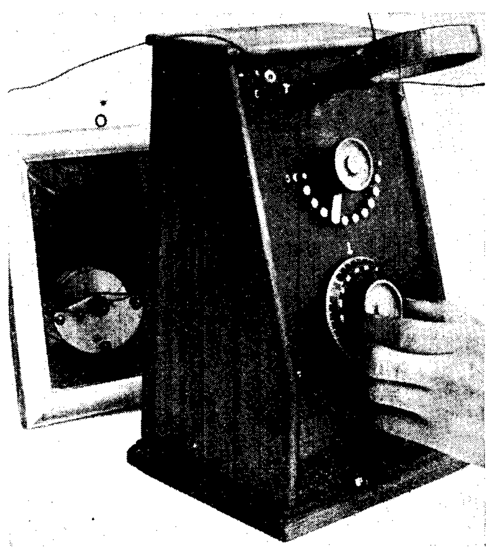
such a circuit as a tuned anode. Three-circuit sets, as a rule, have an aerial, a secondary and a tuned high-frequency circuit. Four-circuit sets are more rare, and are more difficult to tune properly.

The best plan is to commence by tuning a single-circuit set. Fig. 3 shows such a tuner unit applicable to a crystal or simple valve set. The tuner is characteristic of many, and comprises a fixed inductance with a series of tappings controlled by a movable switch arm. A loading coil holder is provided for the higher wave-lengths, and is wired so that the coil when plugged in is in series with the fixed inductance and therefore virtually increases its length. When the loading coil is not in use the holder should be short-circuited by a metallic plug-in contact piece.

Fine tuning is provided by a variable condenser, usually with a value ranging from zero to ·0005 to ·001 mfd., the position of which behind the panel is revealed in the various illustrations by the mirror set at the back of the tuner. The dial of the condenser should be so marked that when set at zero the whole of the moving plates are fully separated from the fixed plates, and at 180 degrees the plates are fully engaged. On some condensers the figures range differently, but the highest figure should correspond with the position of full engagement of the moving plates.

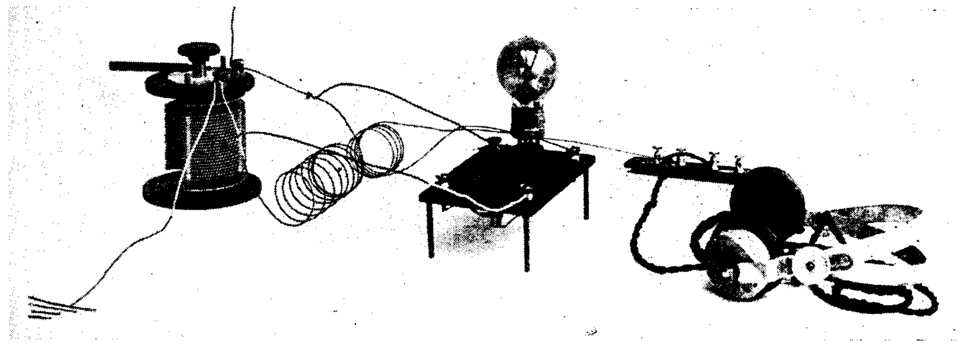
The first step in practical tuning is to find the best value of inductance and capacity, and as a start the local station will be tuned in, as it is the easiest to pick up. This is done by moving the contact switch to any one of the middle studs on the tapped inductance and then revolving the condenser dial slowly through its full range from zero to a maximum, listening all the while for the least trace of a signal. Should this be heard, move the dial very slightly and slowly until it increases or diminishes in strength, then turn the dial back again until the signal strength increases, then beyond that point until it loses strength, and so on back and forth until the best point is found. Suppose that at this point the dial reading shows 160, as in Fig. 3. The greater part of the condenser is in circuit, and an improvement is obtained by adding inductance and reducing the capacity.

This is done by moving the tapping switch one stud to the right, which in most sets adds to the inductance value, and, knowing that the wave-length depends upon the product of the values of inductance and capacity, it follows that the station should again be picked up if the condenser be turned to the left, as on most sets the capacity is increased by right-handed turning of the controls.



INCREASING THE INDUCTANCE

Fig. 4. With increased inductance the capacity may be decreased. The condenser vanes will be seen to be much farther out of engagement than in Fig. 3, in the mirror



TUNING IN A WIRELESS RECEIVER WITH REACTION

Fig. 5. This is a pictorial lay-out of a set specially constructed to show the principle of reaction, and the effect of two coils on one another from the point of view of tuning

In the case illustrated the same station was tuned in again as shown in Fig. 4, when the condenser dial showed a reading of 30 degrees, but with an increase in signal strength, this usually being the case with single-circuit sets. The loudest signals are, as a rule, found with maximum inductance and minimum capacity. The relative positions can be judged by comparison of the illustrations Figs. 3 and 4, as the condenser movements are clearly shown in the mirror.

Suppose it is now desired to tune in a station of higher wave-length. It is obvious that the condenser should first be turned to the right to increase its capacity to the utmost, and the station, if then reached, should be tuned to full strength, but if this is not the case the tapping switch arm is moved to the right by one contact point, and the procedure repeated until the station is heard.

It has been supposed so far that the detector is operative, but when a crystal set is used for the first time it is necessary to be sure that the cat's-whisker is on a sensitive spot, otherwise signals cannot be heard at all. Under such circumstances the condenser dial should be turned with the right hand while the cat's-whisker is manipulated with the left, as shown in Fig. 7, taking care all the while to have the end of the cat's-whisker resting lightly on the crystal, as shown through the magnifying glass in Fig. 6.

Directly a station is heard, stop all movements of the dials at that spot, and adjust the crystal until the signals are at a maximum, then readjust the dials, as it is then known that the crystal is operative.

Another effective plan is to use a test buzzer wired up as shown in Fig. 8. one wire from the buzzer being coiled around the aerial lead-in. The sounds of the buzzer can be distinctly heard in the telephones when the crystal is on a sensitive spot, and this test is very useful when a strange crystal set is to be tuned. Actually the buzzer can be more remote from the set, so as not to be heard except through the telephones.

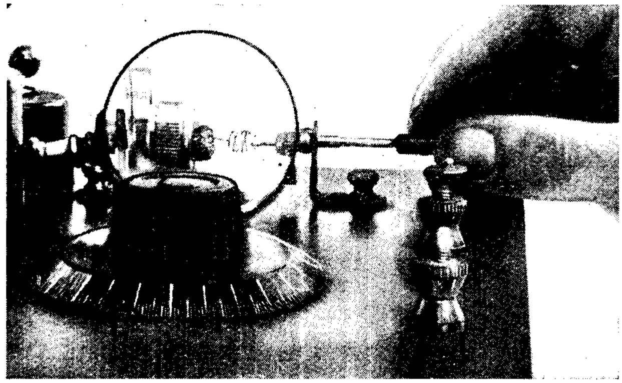
A wave-meter can be used in the same way, and has the advantage that if set to the desired wave-length it indicates the sensitive spots on the crystal, and also the proper tuning position, the sounds being at a maximum when the set is tuned to the wave-length to which the wave-meter is set, which should be that of the station it is desired to hear.

Having mastered the elements of tuning in this way (and it should be noted that these methods apply to all sets having inductance and capacity) it will be desirable to tackle the greatest source of annoyance to other listeners when improperly used—that is, reaction.

Reaction when properly used will not cause annoyance to anyone, but wrongly handled will absolutely spoil the reception of others for miles around. To understand reaction, reference should be made to the articles in this Encyclopedia under that heading and also to Fig. 5, showing a pictorial lay-out of a single-valve set with reaction. No matter how the components may be disguised, all reaction devices reduce themselves to the simple state shown in Fig. 5, and consist of a coil of wire in the anode circuit of the valve, which coil is brought near to the aerial or other inductance.

What happens when this is done and the pulsating high-tension current is flowing through the coils is shown photographically in Fig. 10, where the iron filings have been displaced by the energy radiated from the coils. This energy is invisible on a wireless set, but if the picture be borne in mind it will serve to remind the user that the two fields of electro-magnetic energy are too close to one another, and that is the cause of the shrieks and noises heard in the telephones, and by those in the near vicinity.

In practice the reaction coil is so disposed that it can be brought near to or remote from the aerial or anode coil. A pictorial arrangement is shown in Fig. 14, where the aerial inductance is wound on a tubular former and the reaction coil on a movable ring which slides on the tube. The reaction effect is obtained by bringing the reaction coil near to the other. Although such devices are differently

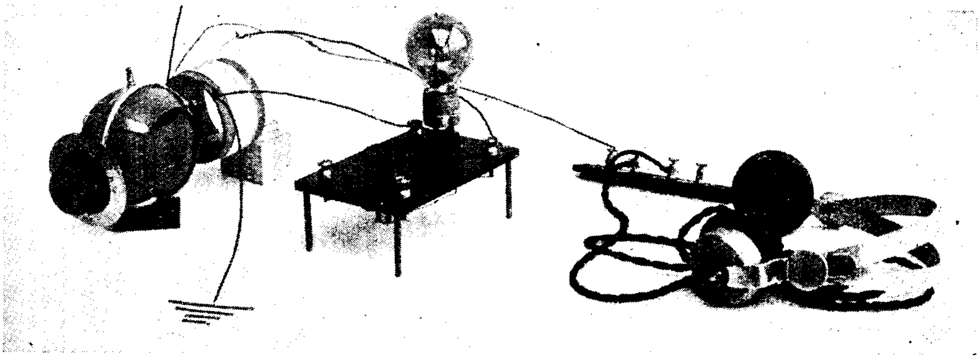


TUNING WITH A CRYSTAL DETECTOR

Fig. 6. Part of the art of tuning with a crystal is to ensure a light, firm cat's-whisker contact. Fig. 7 (below). The cat's-whisker is manipulated simultaneously with the condenser to make sure of crystal contact

EMPLOYING A TESTING BUZZER FOR TUNING PURPOSES

Fig. 8. How a testing buzzer is used for tuning in a crystal detector and for making sure that the most sensitive spot in the latter has been found



LAY-OUT OF A WIRELESS SET WITH A VARIOMETER

Fig. 9. Variometer tuning is one of the commonest and simplest forms employed. In this lay-out the variometer is shown with a reaction coil

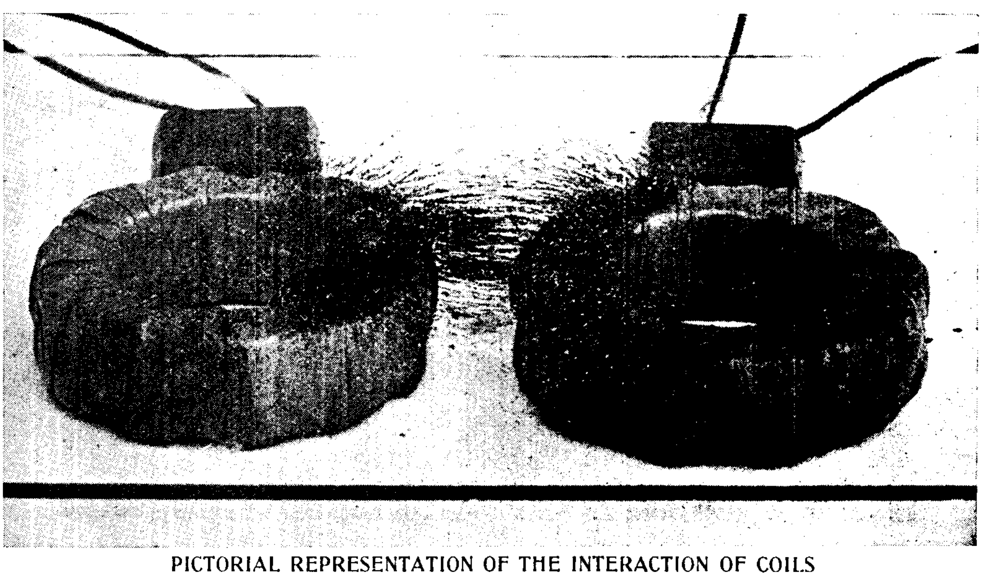
arranged in many sets, the principle is the same, and when tuning with a reaction set this fundamental point should be remembered.

When commencing to tune-in a station, the reaction coil ought to be arranged so that it is some distance from the aerial or other coil, and left there until the station is picked up, when it should be brought gently nearer to the primary coil. This will increase the signal strength up to a point when the set will begin to shriek and howl, which indicates that it is in a state of self-oscillation, and this condition must be instantly corrected.

The first thing to do is to loosen the coupling—that is, to move the reaction coil away from the other until the set stops howling. If the sounds in the telephones be listened to carefully, it will be noted that at a certain point the reaction effect commences, and this point is distinguished by a slight sound only describable as a plop. At this point the reaction coil begins to feed energy to the aerial coil.

This increase may be continued until the set is on the verge of oscillating, and after a little practice it is quite possible to tune to this point without actually letting the set oscillate at all.

It will be found that the farther the station to be tuned is located from the receiving set, the tighter can be the coupling without the set oscillating.



PICTORIAL REPRESENTATION OF THE INTERACTION OF COILS

Fig. 10. This photograph clearly shows why two coils have such an effect upon one another when a current is passing through them. It is due to this effect that reaction may cause so much trouble. The coils here are under glass and the filings above

Some small adjustments to the aerial tuning condenser will have to be made when the reaction coil is brought near the aerial coil, as the feed-back of energy appears to add to the resistance and reduce the wave-length, requiring added capacity or inductance to correct it.

It will be found in practice that, if a single-valve set with reaction be tuned to the oscillation point and the reaction carefully adjusted, it is possible to tune-in stations at a great distance, and this is sometimes possible by a critical adjustment of the filament resistance.

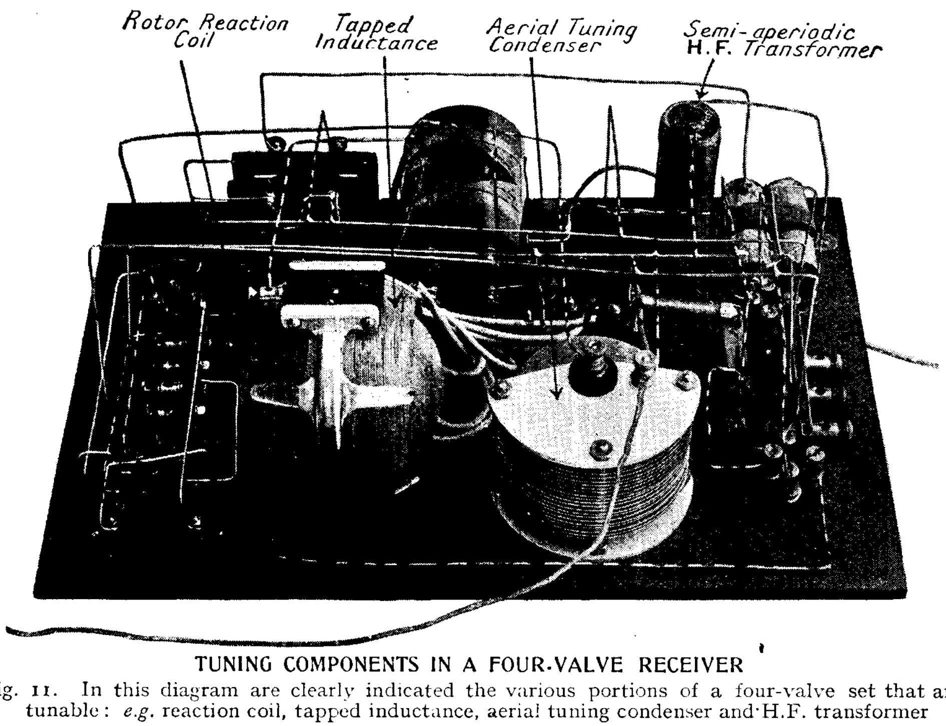
Movement of the contact arm by so small an amount as one turn of the resistance wire, as shown in Fig. 12, will often prevent the set oscillating without having to loosen the coupling, and will thus add to the range of the set. In this connexion tuning by means of a potentiometer will often add wonderfully to the range of reception. This is because, as shown in Fig. 13, the potentiometer makes it possible to vary the potential of the filament voltage, because one end of the potentiometer is positive and the other negative, and the sliding contact can be varied from a maximum position at either end to zero in the centre.

In the illustration the slider is so placed that a strong negative potential is being applied to the grid of the valve. This device, carefully adjusted after the station has been tuned in, will, as a rule, allow of greater stability and strength of signals. Its principal use in tuning is to check oscillation of high-frequency valves and thereby allow the signal strength to be built up without the set breaking into detrimental oscillation.

Apart from the range of reception achieved by careful tuning, the quality of reception ought to be considered, and the presence of a variable grid leak and grid condenser, such as that in Fig. 15, helps greatly. It should normally be adjusted to a medium value and then critically tuned after the station has been picked up.

Another tuning device is the damping plate shown in Fig. 16; it is used in the same way as a condenser, as by bringing the plate nearer to the coil it reduces the wave-length. It is often used in conjunction with high-frequency transformers.

Tuning by variometer is simple, and merely consists in rotating the knob until signals are heard. When used in conjunction with a reaction coil, as that in Fig. 9, some slight further adjustment is



TUNING COMPONENTS IN A FOUR-VALVE RECEIVER

Fig. 11. In this diagram are clearly indicated the various portions of a four-valve set that are tunable: *e.g.* reaction coil, tapped inductance, aerial tuning condenser and H.F. transformer

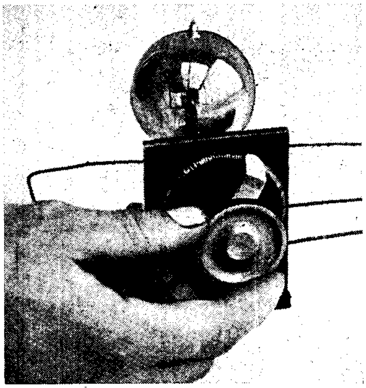


Fig. 12. The slightest movement of the rheostat—even over one turn—will prevent oscillation

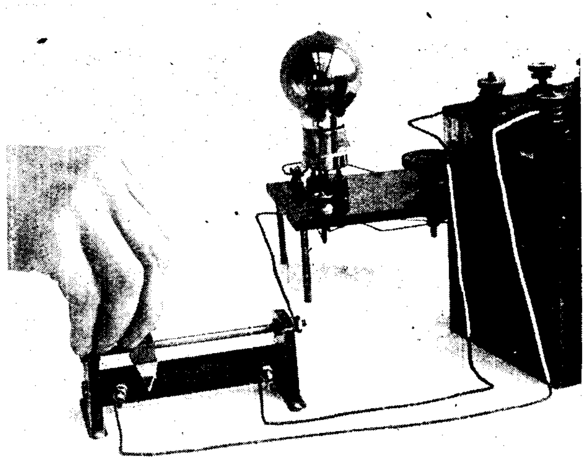


Fig. 13. Potentiometers are valuable in tuning. By their use the potential of the filament may be varied easily and finely

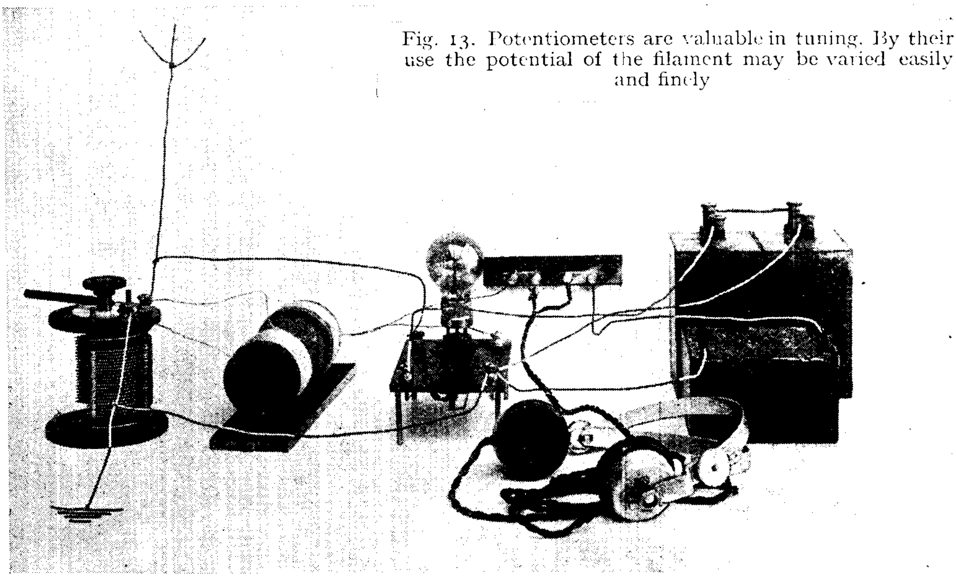


Fig. 14. Here the aerial inductance is wound on a tubular former, and the reaction coil, with which it is tuned, on a movable ring that slides on the tube

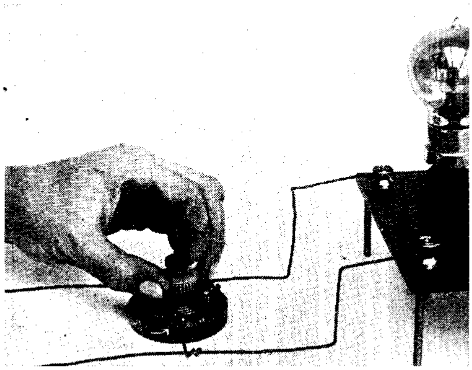


Fig. 15. Reception quality is improved by using a variable grid leak and condenser

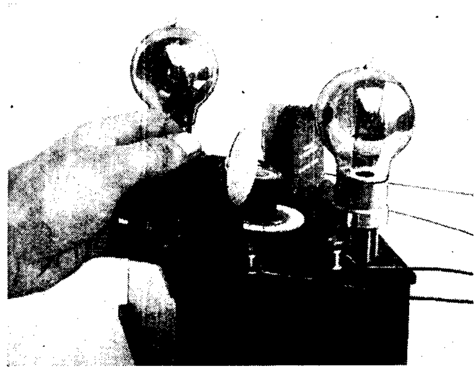


Fig. 16. Damping plates used with H.F. transformers vary the wave-length that is received

VARIOUS METHODS USED TO OBTAIN REFINEMENTS OF TUNING needed after the reaction coil has been set to its proper place. Otherwise a variometer can be considered as a constantly variable inductance coil and employed accordingly. The method of tuning is shown in Fig. 17, where the variometer principle is illustrated in conjunction with a multi-valve set.

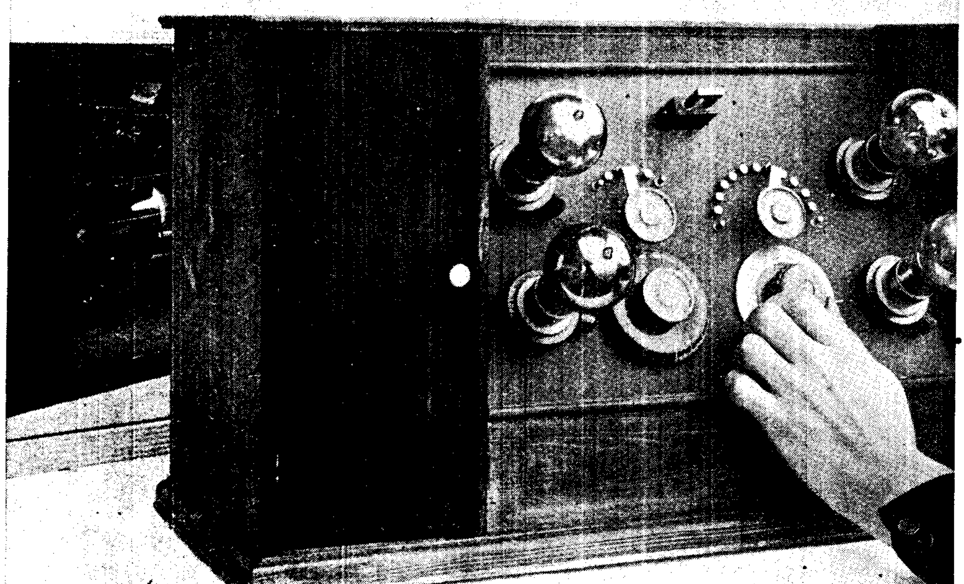
When tuning a multi-valve set, or one with two or more circuits, it is necessary to remember that all the circuits have to be tuned to become in resonance, and some idea of the importance of this is obtained from a consideration of Fig. 11, showing the tunable portions of a normal type of four-valve receiving set.

Another example of the use of two circuits that have to be tuned to resonance is the ordinary tuned anode two-valve set. The principle of tuning a two-circuit set is shown diagrammatically in Fig. 18. The upper part shows the wave-length; below it is the aerial circuit corresponding to the earlier example, and below this is the secondary circuit.

This is known, in this example, as the tuned anode, and it is necessary to adjust the values of the aerial inductance, L_1, and capacity, C_1, as before described. The secondary circuit has then to be similarly tuned by adjustment of the anode inductance, L_2, and capacity C_2, to exactly the corresponding wave-length to that of the aerial circuit, so that the amplified impulses in the secondary circuit will have the same wave-length and characteristics. As is shown at the bottom of Fig. 18, the height or amplitude of the curve, representing the amplification achieved, is increased from G to H on the diagram. To do this sometimes necessitates the use of an anode loading coil, as shown in Fig. 19, to give sufficient inductance to this part of the circuit; it is employed in a similar manner to an aerial loading coil.

The stages in tuning a four-valve set with two circuits are illustrated in Figs. 20 to 22. The first process is the switching on of the filament lighting current to a medium value. This is followed by adjustment of the coarse and fine tappings of the inductance, as shown in Fig. 20, completing the aerial tuning by adjustment of the A.T. condenser, as in Fig. 21. The signals are then brought up to full strength by adjustment of the reaction coil, as in Fig. 22, and then the tuning is completed by critical adjustment of all the controls.

The idea of a three-circuit tuning system is shown diagrammatically in Fig. 26, which

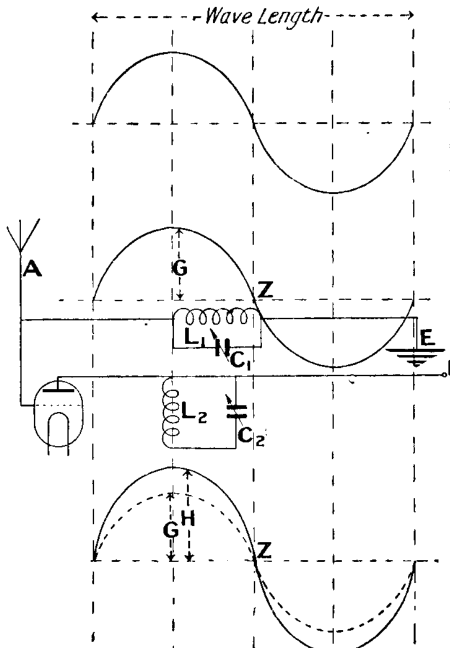


VARIOMETER AS CONSTANTLY VARIABLE INDUCTANCE

Fig. 17. Here the multi-valve set is being tuned in by means of a variometer, the movement of which can be seen in the mirror placed at the back of the set. The stud switches and condensers also play important parts in the tuning of the set

corresponds to the former diagrams with the addition of the third circuit, which also has to be brought into resonance with the others. This, when properly done, has the apparent effect, shown diagrammatically in Fig. 26, of building up the weak signals in the aerial circuit, as shown, from the height *a* through successive stages, as at *b*, to a maximum at *d*, accomplished by tuning the three inductances and capacities simultaneously. This is difficult.

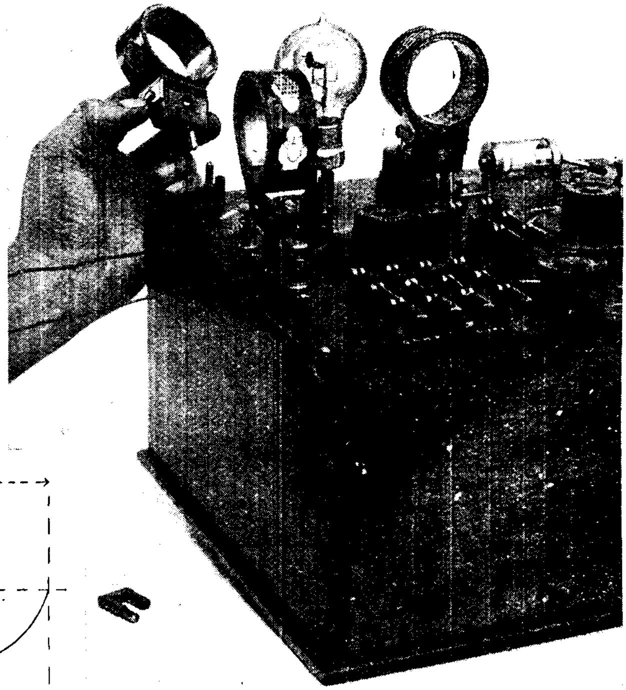
The characteristic sequence of operations is shown in



TUNING-IN TWO CIRCUITS

Fig. 18. Diagrammatic representation to show how tuning is carried out in a two-circuit set

Figs. 23 to 29. The first shows a trial with only the aerial coil and condenser and with parallel connexions. This not being suitable, a larger coil is substituted, as in Fig. 24, after which the series connexion should be tried by throwing over the switch, so covering a new set of wave-length ranges. When the best position is found, as indicated by the sounds in the telephones, the value of the coil required



ANODE LOADING COIL IN USE

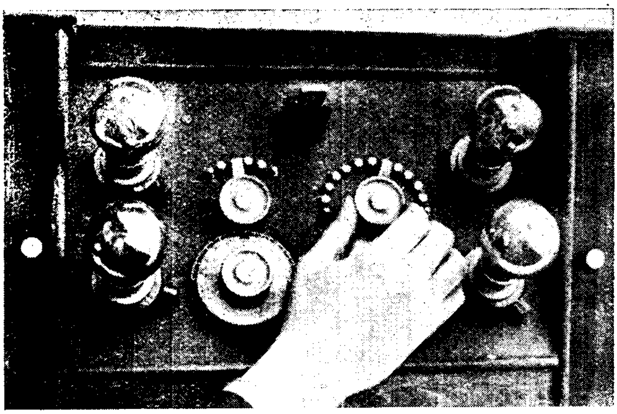
Fig. 19. Here the anode loading coil is being added to the inductance of part of the circuit and so increase its wave-length range

may be judged, and the switch can be brought back to parallel position and the condenser setting adjusted as described for the simple tuner.

But even at this setting the capacity is high, and still better results will follow the use of a slightly higher value of inductance, such as the use of the coil shown in Fig. 25, which should reduce the capacity reading to about 35 on the dial.

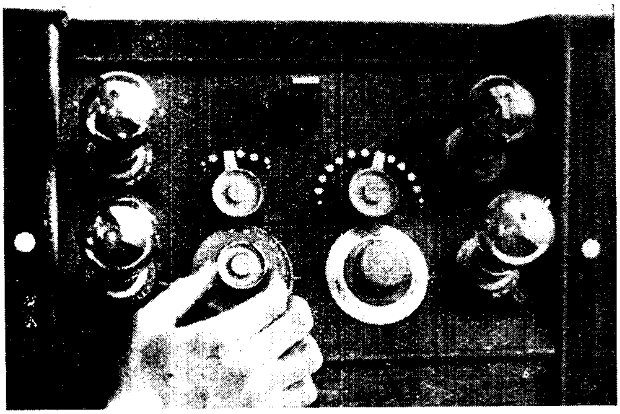
The secondary circuit coil is then plugged into the holder and the primary condenser again adjusted, as in Fig. 27, as the coil has a slight damping effect on the primary. The tune and stand-by switch is then thrown to the tune position, and the secondary condenser adjusted, as in Fig. 28, until signals are again heard. The aerial condenser should not be touched during this process, as it is known that that circuit is properly tuned. The degree of coupling should be varied a little to get the best results, and then the third circuit carefully tuned, as in Fig. 29, when the signals should come in very strongly.

Should they not do this it may be because the connexions are the wrong way



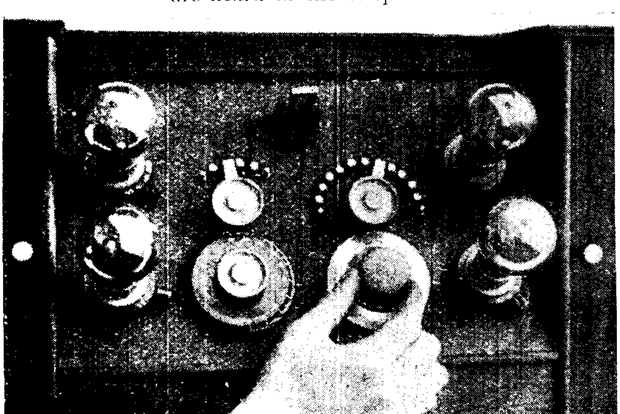
INDUCTANCE ADJUSTMENT

Fig. 20. How the adjustment of the inductance in a four-valve set is carried out. This is done after a preliminary adjustment of the filament rheostat



TUNING BY AERIAL TUNING CONDENSER

Fig. 21. After the preliminary adjustment of the inductance, the aerial tuning condenser is then adjusted until signals are heard in the telephones



ADJUSTMENT OF THE REACTION COIL

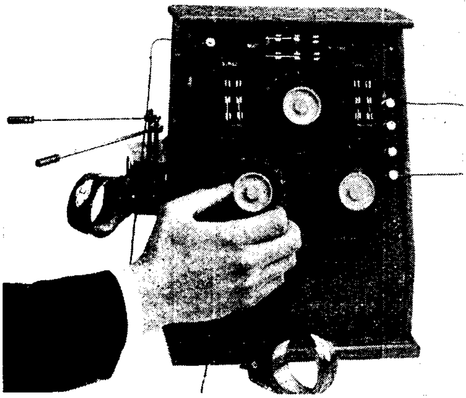
Fig. 22. By adjusting the reaction coil after the inductance and condenser have been set, signals may be brought up to their full strength

round on the coil reacting on the aerial, and the reversing switch, if fitted, should be thrown. Otherwise the connexions will have to be reversed. Other steps in tuning include the adjustment of the filament resistances and the potentiometer, as already described, as well as varying the value of high-tension voltage, until the best results are obtained either in the form of loud signals or as regards quality of reception.

The latter should always be aimed at, especially for loud-speaker work, and is generally achieved by carefully tuning the various circuits, and then reducing the filament voltage as much as possible. In tuning for loud-speaker work, remember that an excess of high-frequency amplification will tend to high-pitched tones, and that increases of low-frequency amplification usually smooth out the tones and improve the lower notes, although the tonal qualities of a particular receiver are also dependent to a much greater extent on the fixed values of the set as a whole.

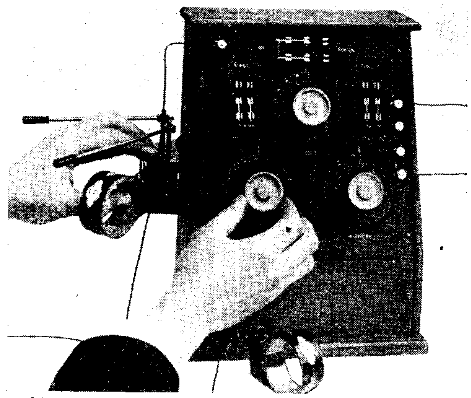
Sets where one filament resistance controls two or more valves require more critical adjustment, as does the high-tension voltage. This should be tried at various points in the battery, as shown in Fig. 30. Tuning of the two high-frequency stages is facilitated by the use of a dual condenser, tuning both as one and making the set virtually a two-circuit receiver.

Tuning a dual set is best accomplished by first treating it as a crystal and high-frequency set, as shown in Fig. 31, then turning over to the dual connexions and critically adjusting all controls. Tuning a four-circuit set, such as the Cockaday, shown in Fig. 32, is effected by selecting a medium value on the tapped inductance with simultaneous



TUNING-IN A THREE-CIRCUIT SET

Fig. 23. The coil is inserted and tuned. Full capacity is shown, indicating that the coil has too little inductance



VARYING CAPACITY AND INDUCTANCE

Fig. 24. A coil with a larger inductance value being inserted the capacity required is less and the tuning is improved accordingly

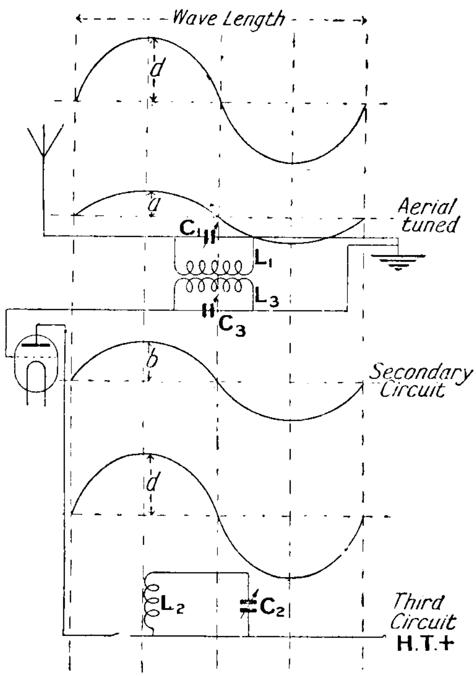
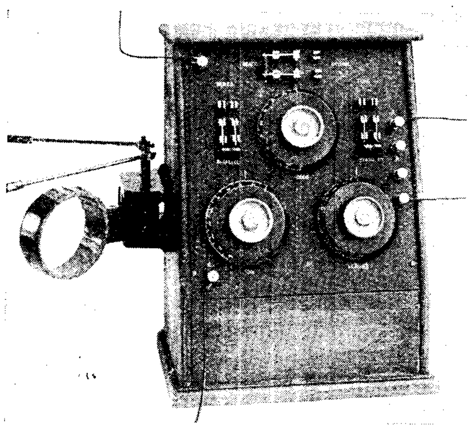


DIAGRAM OF THREE-CIRCUIT TUNING

Fig. 26. Study of this diagram with the appropriate text will assist the understanding of three-circuit tuning

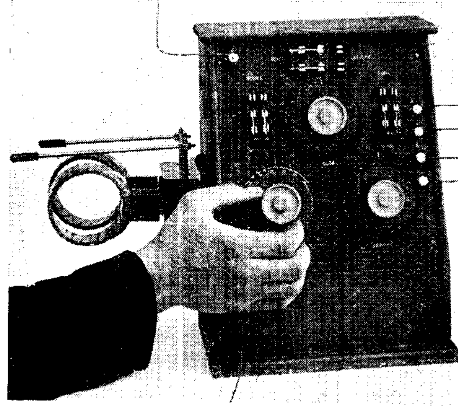
adjustment of the two condensers, with the first valve filament current at a high value. As the station is heard, the set will commence to oscillate, and this is then checked by reducing the filament current and by vernier control of the two condensers.

In the Flewelling and other super sets the valve has to be made to oscillate,



REDUCING CAPACITY VALUES

Fig. 25. By the use of an inductance coil, as here, a good value is obtained for the condenser setting



ADJUSTMENT OF PRIMARY CONDENSER

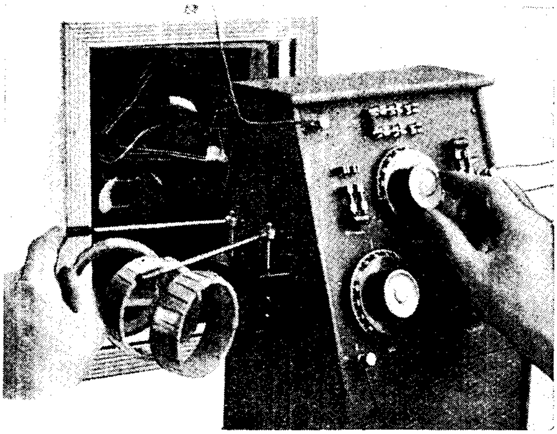
Fig. 27. The secondary coil is placed in position and the primary condenser adjusted again

and in the Flewelling the super effect is built up almost entirely by critical adjustment of the variable grid leak and a vernier condenser in the aerial circuit.

Super-regenerative sets are first tightly coupled to make the valve oscillate and then the condensers which are employed to tune the coils are simultaneously adjusted. As this sets up very great noises and would cause considerable annoyance to others, it is best to use a frame aerial or to learn the tuning on wave-lengths other than those for broadcasting.

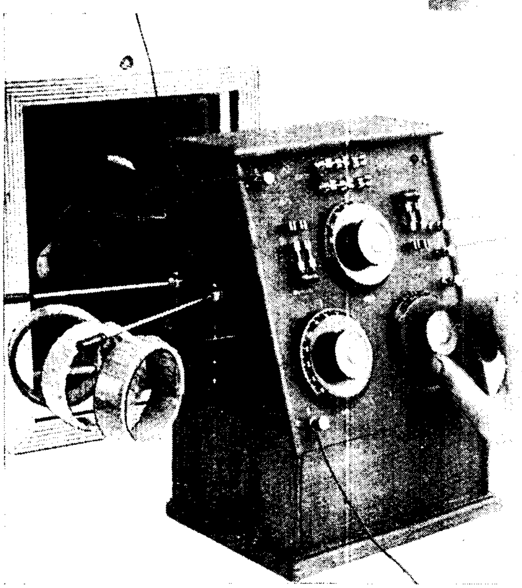
Specific instructions for tuning the various peculiar sets, such as the Armstrong, Flewelling, Neutrodyne Reflex and others, are dealt with under their respective headings in this Encyclopedia.

When regeneration or re-action are used, it is vital to tune on a systematic basis, which can only be done if these are understood. *See* Regeneration.



ADDITION OF THIRD COIL

Fig. 28. Here a third tuning coil has been added, the tune and stand-by switch thrown into the tune position and the secondary condenser adjusted

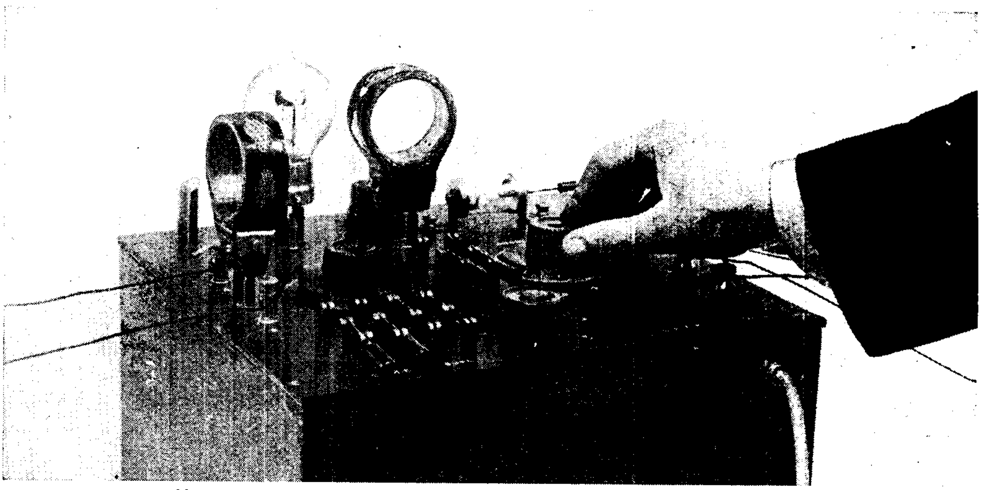


TUNING WITH THIRD CONDENSER

Fig. 29. Here the third tuning condenser is seen being manipulated to tune in the third circuit of the set

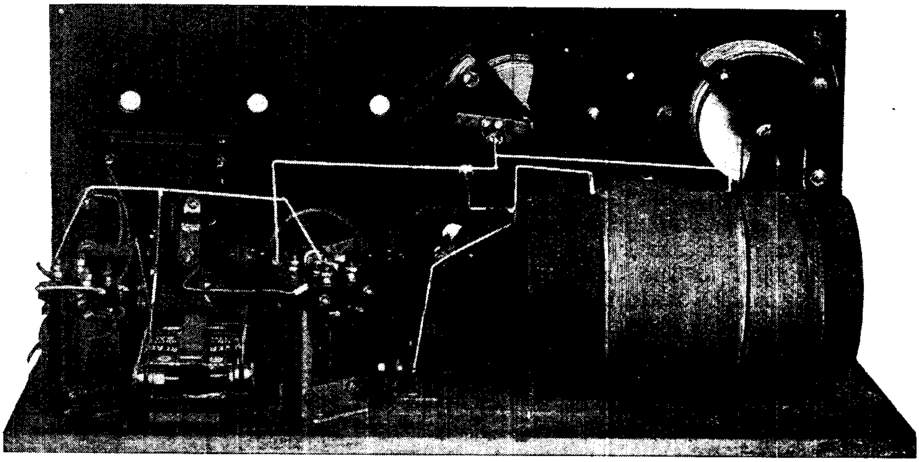
VARYING THE HIGH-TENSION VOLTAGE

Fig. 30. Various battery voltages should be tried, as it is important that the anodes of the valves should have the correct voltage, this having a marked effect on the tuning



TUNING THE HIGH-FREQUENCY CIRCUIT OF A DUAL SET

Fig. 31. In tuning this set the best practice is first to tune as though the receiver consisted only of crystal and high-frequency circuits

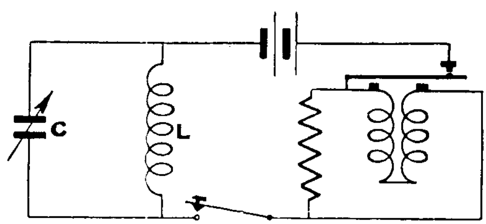


COCKADAY FOUR-CIRCUIT RECEIVER

Fig. 32. This very efficient four-circuit set is tuned by selecting a medium value for the tapped inductance and carrying out simultaneous adjustment in the condensers

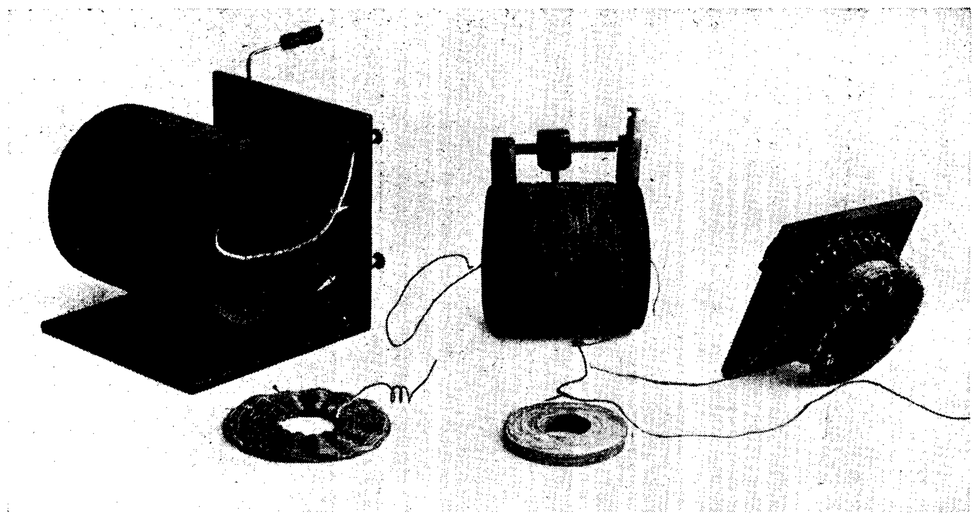
TUNING BUZZER. This is the name given to any type of buzzer the frequency of the oscillations from which can be adjusted. Such a buzzer must have two circuits, the oscillatory circuit and the generating circuit for exciting the oscillatory circuit. The figure shows the complete diagram of the circuits.

The condenser is variable, so that the oscillatory circuit, L C, can be made to emit waves of any desired length for testing purposes. Alternatively, it may be used to excite any other oscillatory circuit so that the wave-length of that circuit may be measured by means of a wave-meter. The resistance shunted across the buzzer is to prevent arcing at the buzzer contact. *See* Buzzer; Shunted Buzzer; Twin-note Buzzers.



TUNING BUZZER CIRCUIT

In this circuit the tuning buzzer excites the variable oscillatory circuit L C so that the desired wave-length may be emitted

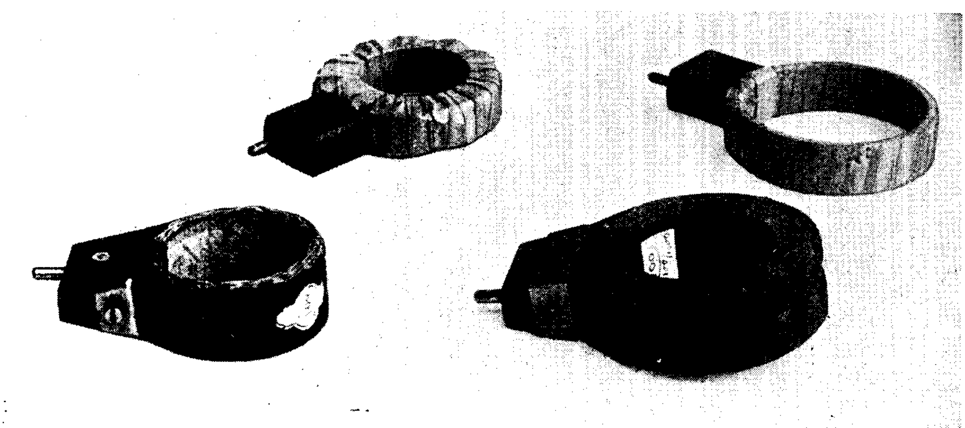


VARIOUS TYPES OF TUNING COILS

Fig. 1. In this illustration presenting a variety of tuning coils are shown a basket coil, a single-slider coil, a tapped coil and an ordinary slab coil

TUNING COIL. The expression tuning coil is applied to an inductance specially adapted for the purpose of tuning a circuit to some particular frequency. Tuning coils are made in many varieties and devices, some of which are illustrated in Fig. 1. The simplest consists of a coil of insulated wire wrapped around the exterior of a circular tubular former. A path is bared by removal of the insulation to provide an adjustable contact surface for a sliding contact. In Fig. 1 two forms of this type of tuning coil are illustrated. In one, two columns support a brass bar, on which moves the contact member, and in the other case a swinging contact blade, located between the inductance coil and the panel, is employed.

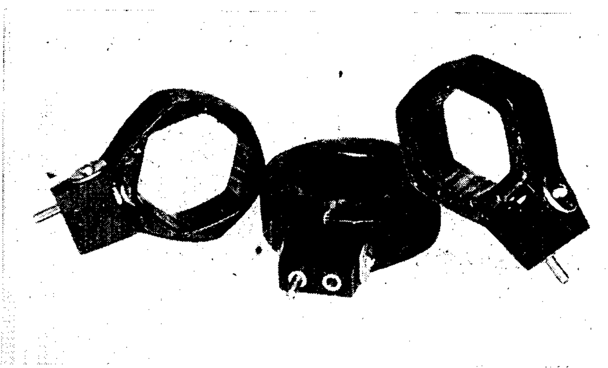
Another form of tuning coil comprises a tapped inductance, such as that illustrated on the right of Fig. 1, the contacts in this case being effected by means of tappings attached to contact studs, the circuit being completed through a movable contact arm. Coils of this character are self-tunable, in the sense that they can be tuned without the aid of external or additional apparatus. They are, however, broad in tuning, and generally only employed in simple apparatus or in conjunction with some other device to ensure sufficiently sharp tuning.



TUNING COILS: FURTHER TYPES THAT PLUG IN

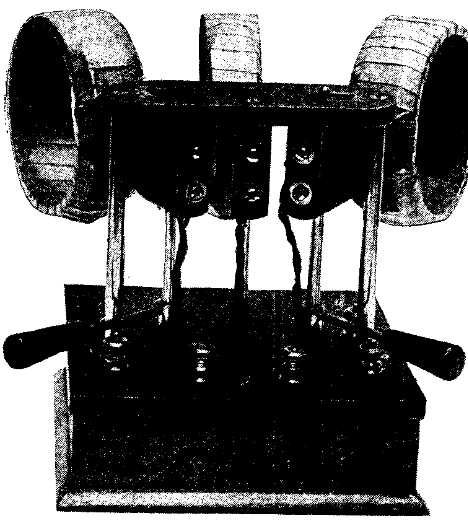
Fig. 2. These examples of plug-in tuning coils can be easily obtained in a large variety of sizes, enabling a wide range of wave-lengths to be covered

Tuning coils which are used in conjunction with other apparatus are of many types, including the basket variety and the slab coil, both of which are illustrated in Fig. 1. All of these coils are extensively dealt with in this Encyclopedia under their respective headings. A very convenient form of tuning coil is that known as a plug-in variety, of which four examples are illustrated in Fig. 2. In all of them a coil of wire is suitably mounted on an ebonite block, fitted with contact socket and contact plug, these being connected respectively to the two ends of the windings. Commercial coils of this type are made with stated values,



SPECIAL LISSEN TUNING COILS

Fig. 3. In these tuning coils the windings are so arranged that the self-capacity of the coil is reduced to a minimum



HOW THE COILS ARE MOUNTED

Fig. 4. A special stand is used for mounting the tuning coils. The two outer ones are movable and the centre one is fixed

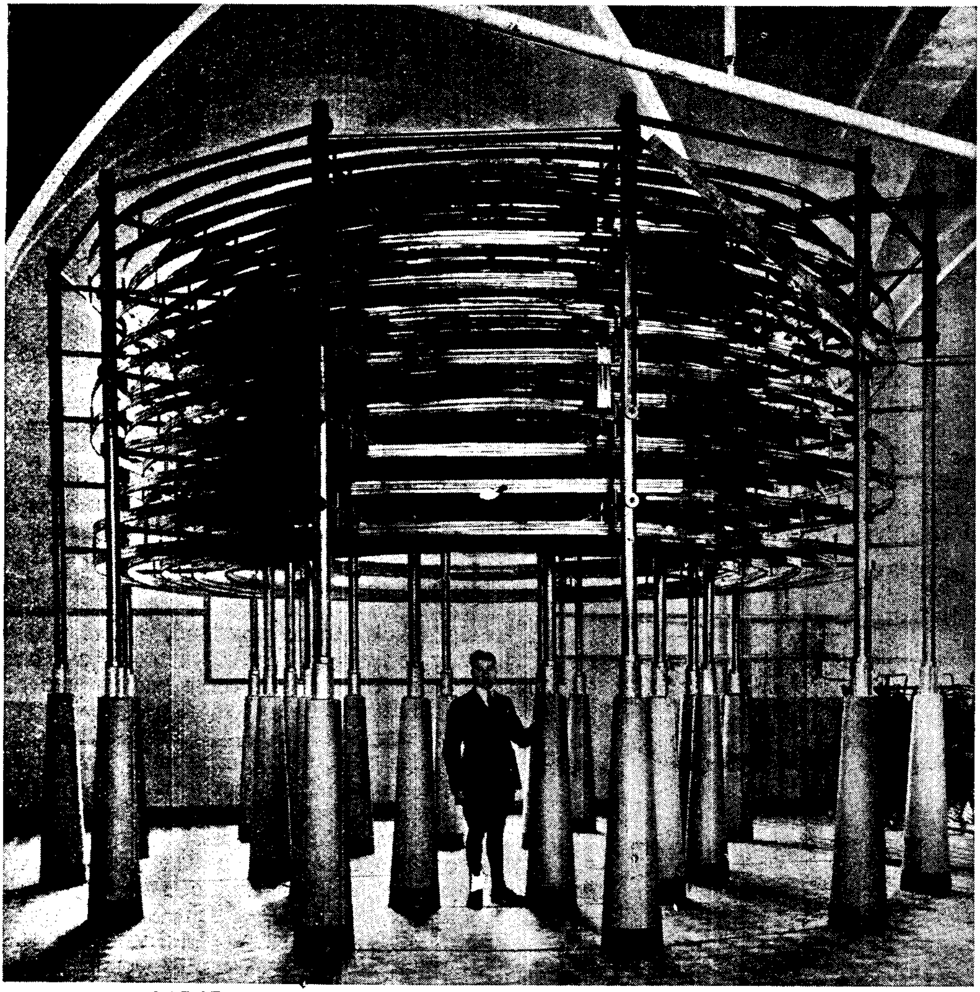
and are suitable for a certain range of wave-lengths, particulars of them being supplied by the manufacturers, and some further reference is made to them under the titles of Plug-in Coils and Coils (*q.v.*).

A variation of plug-in tuning coils are those made by the Lissen Co. and illustrated in Fig. 3. A feature in this case is the method of arranging the windings, the object being to reduce the self-capacity to a minimum. By the method used the windings finish up in a horizontal form instead of the more usual circular arrangement. Most of these coils are mounted to the set in a socket, or may be arranged on an independent stand, such as that illustrated in Fig. 4. With apparatus of this type, the most useful is that in which three holders are provided, one of which may be fixed and the other two adjustable, so that the coils in these holders can be adjusted relatively to each other.

In the Igranic Gimbolder, illustrated in page 464, the tuning coils have two movements. First, each may be moved about the axis passing through the diameter of the coil, and, secondly, the coils are movably mounted to the stand, thus providing a wide range of adjustment for fine tuning purposes. Such coil holders are highly desirable additions to the tuning coils themselves, especially when used for the primary or aerial circuits.

In transmission work, tuning coils are often composed of uninsulated copper or other metal strip wound in a helical formation mounted upon suitable insulated supports. An example of a large inductance or tuning coil of this character, as used in the Sainte-Assise transcontinental station, near Paris, is illustrated in Fig. 5. Some idea of the magnitude of this coil can be gathered from the person standing beneath it.

How to make a Tuning Coil Stand. The tuning stand illustrated in Fig 6 may be constructed in a few hours by the amateur mechanic, and will be found an extremely useful accessory, particularly adaptable as a tuning unit in connexion with separate valve panels for experimental work, and may be fastened, minus baseboard, to the side of a cabinet set



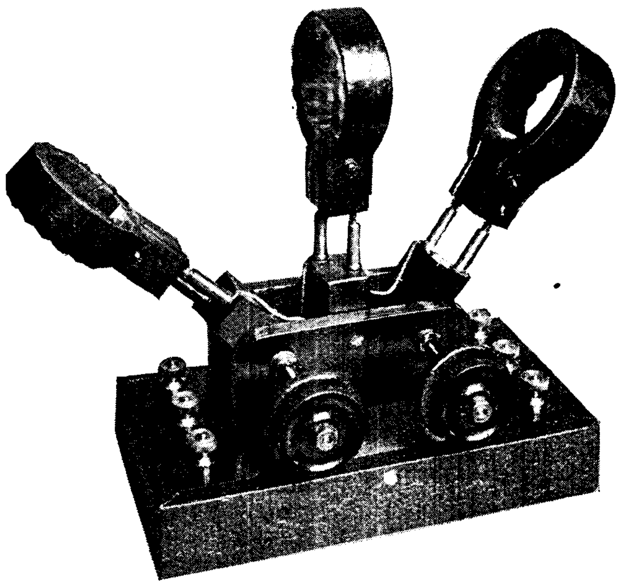
LARGE INDUCTANCE COIL OF THE SAINTE ASSISE STATION

Fig. 5. At the Sainte Assise transcontinental station, near Paris, a large tuning coil of uninsulated copper band wound in helical shape is used. Insulated pillars are used to support the structure, whose enormous size is well estimated by comparison with the figure of the operator seen standing beside one of the pillars

The base is 7 in. in length and 3½ in. in width, and should not be less than ¼ in. in thickness. It may be of wood, provided the terminals are fitted with ebonite bushes and washers, which are now easily obtainable. Three terminals are fitted at each end of the baseboard, care being taken to arrange them not less than ½ in. from the edge in each case, which will give a separation of 1⅛ in.

The pair of vertical supporting pieces for the blocks are 4¼ in. long by 1⅝ in. high, and are screwed centrally upon the baseboard with a space of 1¼ in. between them, the holes for the turning rods, however, being first drilled to clear 2 B.A. rod, the separation of the moving centres being 2¾ in. wide and ⅝ in. from the top. The blocks are all of similar dimensions, and may be cut from scrap ebonite, which may be purchased quite cheaply; or they may be purchased ready prepared with standard plug fittings.

The blocks used in the tuning stand illustrated measure 1⅝ in. by ¾ in. by 1⅛ in., and are arranged with valve sockets to take coils fitted with two valve pins, the method of fitting being to drill and tap the hole of sufficient depth to allow of the valve sockets being screwed right home, the



COMPLETE TUNING STAND

Fig. 6. The experimenter may easily construct this three-coil stand, which is quickly made and is an extremely useful unit for any valve set

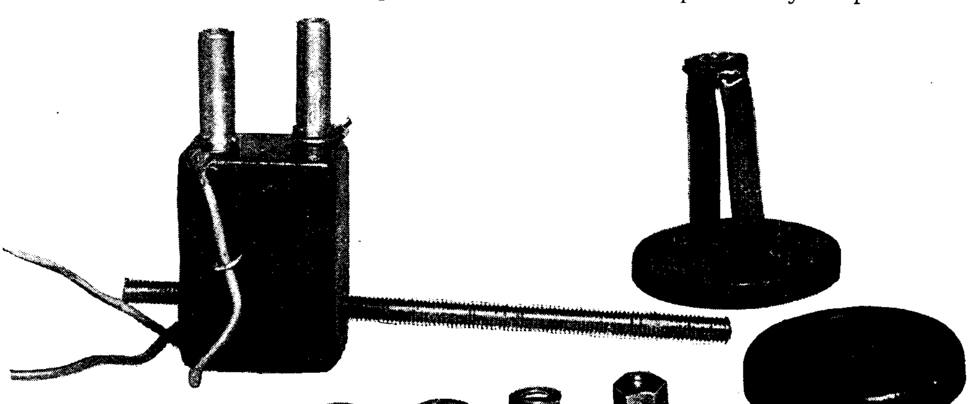
and prevent turning, after the manner of a cotter pin connexion to the bottom bracket spindle of a bicycle.

In order to hold heavy coils in any position, a clamping arrangement is provided which is fully illustrated in detail in Fig. 7. Two circles of hardwood $1\frac{3}{4}$ in. in diameter and about $\frac{3}{16}$ in. thick are cut out and are drilled in a centre with a 2 B.A. clearing hole. Good substitutes for these are the two ends of a cotton reel with the centre cut away. Four pieces of thin brass, $1\frac{3}{4}$ in. long and $\frac{3}{8}$ in. wide, are now prepared. Take two of them, and bind one end of each with fine copper wire to a 2 B.A. brass nut, bending the brass slightly to the shape if necessary.

Now solder them in position to the nut with wire complete, taking care to avoid the thread The opposite ends may now be bent at right angles and fastened with a brass rivet or small screw to the hardwood disks. The operation of these clamps will be easily understood upon reference to the illustrations Figs. 7 and 8, and the details of assembly which follow.

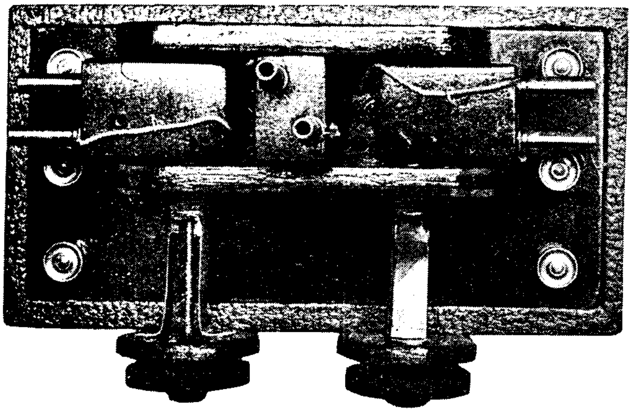
connecting wire being held firmly between the block and a washer. Two of the blocks are now drilled right through the $1\frac{1}{8}$ in. way and $\frac{1}{2}$ in. from the bottom with a hole which may be tapped 2 B.A. A piece of 2 B.A. rod 5 in. long is threaded through till it projects $\frac{1}{2}$ in. at the back. A small hole is drilled through the centre of the block, and in such a position at right angles to the rod that it just cuts into the rod without unduly weakening it, in order that a nail driven through may firmly hold the 2 B.A.rod in position

The inside measurements of the small box enclosing the wiring are 7 in. by $3\frac{1}{2}$ in. by 1 in. deep, and it should be fitted at either end, inside, with small fillets in order that the panel may drop in flush.



MOVING BLOCK OF THE TUNING COIL STAND SEEN IN DETAIL

Fig. 7. In this photograph a clear view is given of the clamping arrangements and the necessary washers, spring washers, ebonite knob and screwed rod for the home-made tuning coil stand



PLAN VIEW OF THE STAND

Fig. 8. From this aspect it is clearly seen that the two outside coil holders are built to be turned at right angles to the centre one, which is fixed

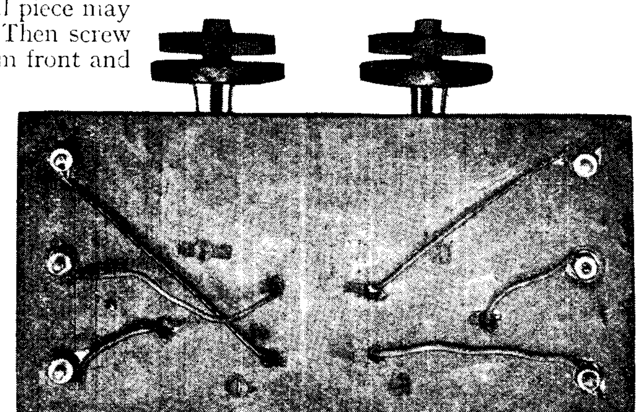
This box may be of polished wood, or finished in any way the constructor may fancy. The assembly is quite simple. The terminals being in position upon the baseboard, the valve sockets should be wired with sufficient leads, which will, of course, be flexible covered wire in the case of the moving blocks. The rear vertical supporting piece is now removed from its temporarily fitted position upon the base, and six holes are drilled through the panel in convenient positions for the leads to pass through.

The rods of the moving pair of blocks are now pushed through the holes already prepared for them, first threading a 2 B.A. washer upon the spindle, and their respective leads pushed through the holes in the panel. The back vertical piece may next be fastened in position. Then screw the central and fixed block from front and back. From the front side of the stand provide the two rods with a washer or spring washer, then screw on the clamping pieces, and finally a lock nut and ebonite knob, fastened in the usual manner with a thin spanner.

The terminals may now be wired upon the underside, as shown in Fig. 9; the first moving block to the first two left side terminals, the fixed block to the two front terminals, and the second moving block to the two terminals remaining. It will be noticed in the photographs that the flexible leads are fastened with small staples below the coil sockets. This will be found necessary in order to prevent the leads breaking at the point where they leave the sockets. Care should be taken to allow free movement of the lead within the staples. *See* Burndept Coil; Coil; Igranic Coil; Inductance Coil, etc.

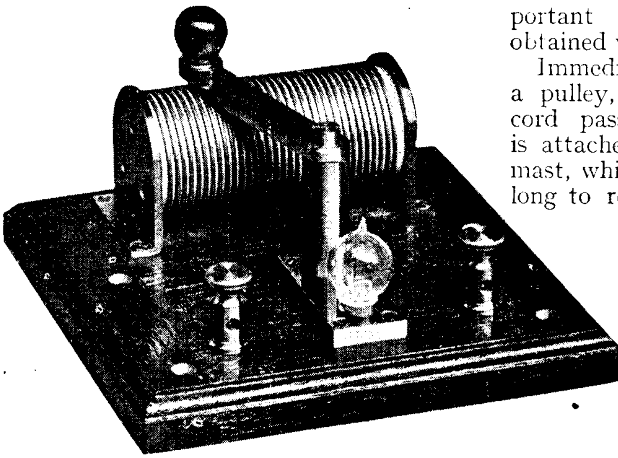
TUNING LAMP. In early forms of ship transmitting and receiving sets, a 4 volt lamp in series with an inductance coil shunted across the aerial. It was used to indicate when the maximum energy was being put into the aerial circuit—that is, when the aerial and closed circuits were in resonance, or when the most efficient degree of coupling was obtained.

The standard form of tuning lamp which was used in conjunction with marine transmitters is illustrated. The lamp itself is a 4 volt lamp with the ordinary S.B.C. fitting. It is connected in series with a small inductance coil, consisting of 8 ft. of No. 16 S.W.G. bare copper wire wound on a boxwood former. A sliding contact is fitted, enabling any number of turns to be used as desired, one end of the winding being taken to one of the terminals on the base, while the other end is left free. Connexion from the tapping arm of the slider is taken to the second terminal.



UNDERSIDE OF THE PANEL

Fig. 9. Here the wiring is shown. The flexible leads are fastened down to the panel by staples to prevent the wearing and breaking of the insulation



FOUR-VOLT TUNING LAMP

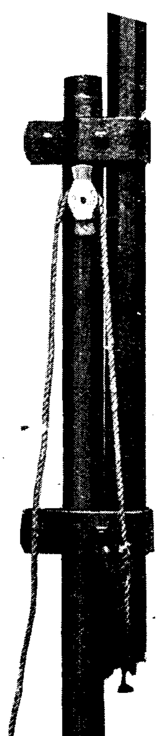
In early forms of ships' transmitters and receivers this type of 4 volt lamp was used to indicate when the maximum energy was being put into the aerial circuit

Courtesy Marconi's Wireless Telegraph Co., Ltd.

The whole instrument is mounted upon a substantial teak base, having countersunk holes for receiving the screws which attach it to the operator's bench.

TUNING SWITCH. The term tuning switch is applied to all forms of selector switch facilitating tuning operations in a wireless receiving or transmitting set. In this connexion the series-parallel switches, reversing switches and inductance switches may be considered in the same category. Such switches are separately dealt with under their various headings in this Encyclopedia.

TURRET MAST. Form of single-pole mast made in two sections which may be erected from the ground. A close-up view of the mechanism of the turret form of aerial mast is shown. Fitted to the lower portion of the mast are two hoops of strap-iron, which allow the upper section to slide within them. It is important that this sliding motion be obtained without any lateral play.



TURRET MAST

This type is made in two sections, the upper of which is movable

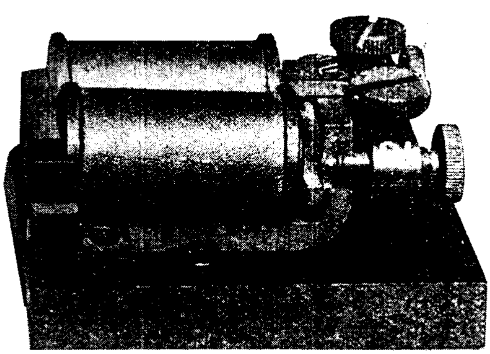
Courtesy Simpson & Blyth

Immediately below the upper hoop is a pulley, through which the operating cord passes. One end of the latter is attached to the bottom of the upper mast, while the free end is sufficiently long to reach the ground.

Located in the lower hoop is the fulcrum of another hoop of iron rod which is capable of swivelling about its upper end. This embraces the upper mast, and when erection is in progress allows the latter to slide without hindrance when the rope is pulled. As soon as the lower end of the moving portion of the mast passes the hoop, gravity causes it to swing and catch on the head of the nail shown. Thus the upper mast is prevented from sliding down. *See* Pole Mast.

TWIN-NOTE BUZZER. Buzzer having two armatures, each separately attracted by separate magnets, and each tuned so as to be capable of giving a different note or frequency. A photograph of such an instrument is given. Here it is clear that the instrument is self-contained and mounted on the one base. The magnets, of which there are two, are side by side, their frame being continued further than the pole pieces in order to form a support for the contact-adjusting screws. The latter are platinum-tipped and make contact with further contacts attached to the armature face. *See* Buzzer.

TWIN-WIRE AERIAL. Type of aerial employing two wires running parallel to and insulated from each other except at



TWIN-NOTE BUZZER

Two armatures are used here, each giving a different note or frequency. Each may be separately adjusted for this purpose

TWIN-WIRE AERIAL

Fig. 1. How the aerial is suspended by a pole lashed to a tree. This pole should be fixed as high up the tree as possible

their point of contact with the lead-in wire. The most common forms of twin-wire aerials are the inverted L and the T types. With the restriction of the length of the aerial by the Postmaster-General to 100 ft., the inverted L aerial is the most suitable for broadcast reception. The reason for this is that this type of aerial has a fundamental wave-length naturally higher than the T type.

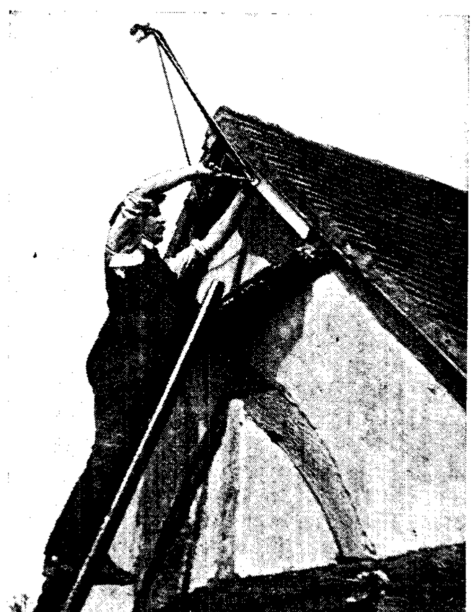
The twin-wire aerial has a higher capacity than the single wire, and this factor is not of advantage in many receiving installations. This usually means that a certain amount of damping effect is present which is not favourable for good reception.

Where a twin-wire aerial is used it is important to make sure that each wire is of exactly the same length to the point where they meet the single common lead-in wire. If this is neglected a double wave-length is obtained which makes it extremely difficult to tune to the critical point for the best reception. The capacity of the twin wires should also be the same, which is often a difficult matter to obtain, especially when the aerial runs parallel to a building or other object.

The wires of a twin-wire aerial should be spaced well apart in order to reduce the capacity as far as possible. Under normal conditions six feet should be allowed.

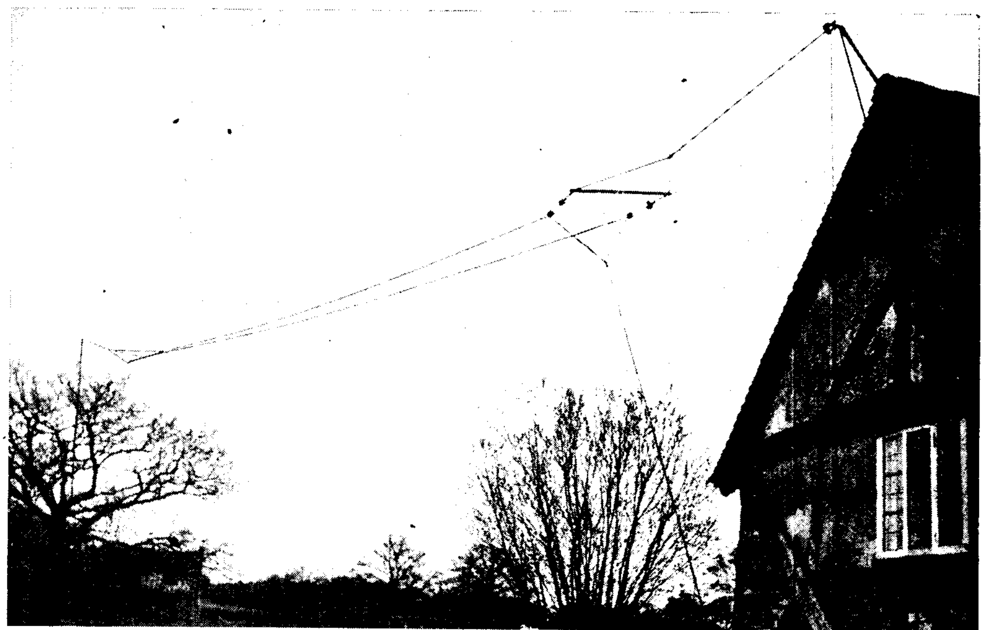
In the erection of a twin-wire aerial the first point lies in the selection of the best site. The various factors governing this should be studied. The approximate distance of suitable trees or buildings for the support of the farthermost end of the aerial should be measured. Directional effect should also be studied, as it will be found that an aerial pointing towards a broadcasting station, having a lead-in at the end farthest from the station, will have better reception from that station than if placed in any other position.

Screening is also a very important point in determining the position of the aerial. Not only the immediate proximity of buildings or trees should be



HOUSE CONNEXION FOR THE AERIAL

Fig. 2. Securing the special bracket to the side of the house. Two plates of wood are first fixed to give added strength



CONNEXIONS OF THE TWIN-WIRE AERIAL COMPLETED

Fig. 3. Here the bracket, seen in course of erection in Fig. 2, is shown in position with the aerial wire and the halyard also fixed and ready for use

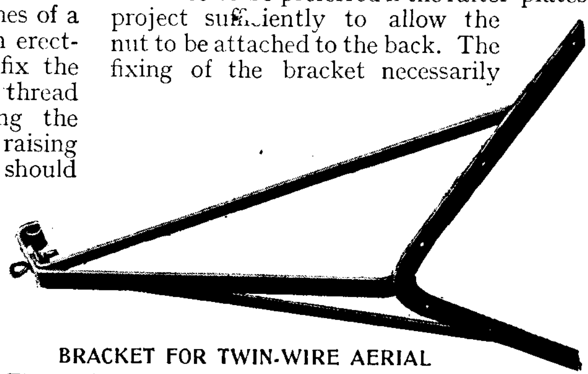
regarded, but the effects of neighbouring hills or tall houses should also be noted.

If available a neighbouring tree may be utilized for the support of one end of the aerial, and this method has the advantage of saving the cost of a pole and its erection. If the tree is sufficiently high the aerial may be attached to the upper branches or trunk direct, but a small pole may be lashed or otherwise secured so that the aerial may come right above the top. Where this method is adopted the growth of the tree should be borne in mind, especially if the erection takes place during the winter.

This form of aerial support is utilized in the aerial illustrated in Fig. 1, where a pole is lashed to the upper branches of a tree. The method of procedure in erecting this type of support is to fix the pulley to the top of the pole and thread the cord for raising or lowering the aerial through the pulley prior to raising the pole into position. A knot should be tied at each end of the cord to prevent the possibility of one end being pulled through. An end is then thrown clear of the branches for attachment of the aerial, while the other end is made fast in a convenient position.

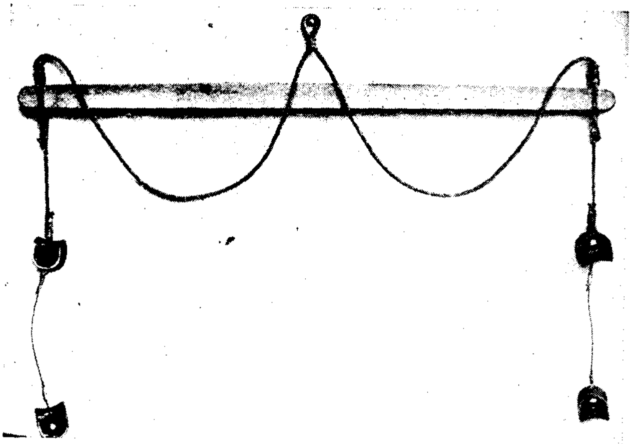
At the lead-in end of the aerial the house or building is often used for the support of the aerial. Additional height may be obtained, with increased freedom from screening, by the construction of an iron bracket, of which one pattern is illustrated in Fig. 4. Such a bracket has considerable weight, and care must be taken to see that the wood to which it is bolted or screwed is perfectly sound and free from decay and that it is securely attached to the building. In addition to the weight of the bracket the strain of the aerial itself must be taken into account.

It should be sufficiently well anchored to take the weight of a person hanging to it. Coach bolts may be used, or nuts and bolts are to be preferred if the rafter plates project sufficiently to allow the nut to be attached to the back. The fixing of the bracket necessarily



BRACKET FOR TWIN-WIRE AERIAL

Fig. 4. This special bracket is designed for supporting the twin-wire aerial at the house end



SPREADER FOR TWIN-WIRE AERIAL

Fig. 5. Completed spreader with bridle and insulators fixed. Notice how the ends of the aerial are fixed on to the spreader

depends on the construction of the building. The erection of an iron bracket for the support of the house end of an aerial is illustrated in Fig. 2. The eye fixed at the end of the bracket is for attachment of the pulley and is shown in Fig. 3, where the aerial is raised in position.

The spreaders for a twin-wire aerial should be about 6 ft. long, and may be constructed from a length of 2 in. door stopping.

Stout cord is used for the bridle, the ends of which are fitted into notches cut at the ends of the spreader. The ends are connected in the manner illustrated in Fig. 5, where each end is bent round the notches of the spreader and bound tightly with stout string.

The length of the bridle cord should be about two and a half times the length of the spreader. To secure the eye of the bridle equidistant from either end of the bridle the spreader should be balanced on the finger by the bridle until the former is horizontal. The bridle is then looped and the eye inserted in the loop and bound tightly with string. Before fixing the bridle a length of 2 ft. of cord is looped through each loop of the bridle and forms a means of attachment for the insulators.

This is illustrated in Fig. 5, which shows the completed spreader and bridle. A second insulator is attached to the end of the first, as shown in the illustration. For connecting the aerial wires themselves each end is looped through its appropriate insulator and fastened by twisting the end several times round the length of aerial wire. It is important to have each wire exactly the same length, and the

AN IMPORTANT OPERATION IN THE CONSTRUCTION OF THE AERIAL

Fig. 6. It is of paramount importance in the construction of a twin-wire aerial that the two wires should be of exactly the same length. This photograph illustrates how that result is achieved

method shown in Fig. 6 will assist in the operation. The farthermost end, which is completed, is fastened in a convenient position while an assistant stretches the other end taut.

The loose ends from the aerial wires are soldered together at a distance of about 6 ft. from the aerial wire and one end utilized as a lead-in. *See* Aerial.

TWIST DRILL. Term used to describe a particular type of drill. It is characterized by the presence of two long helical grooves formed on the surface of the steel of which the drill is made. Twist drills are available in two classes. For amateur work those commonly employed are made of ordinary cast steel, and are often spoken of as carbon steel twist drills. Others are made from a particularly hard grade of steel and are known as the high-speed steel, or simply high-speed twist drills. The latter are chiefly used for manufacturing processes, as they can be run at very high speeds.

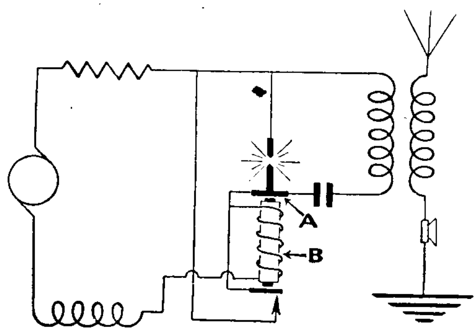
The method of use is dealt with under the heading Drills and Drilling (*q.v.*).

TWO-ELECTRODE VALVE. Valve which has only two electrodes, a filament and an anode. The two-electrode valve was invented by J. A. Fleming, and was the first really great step forward in wireless telephony. *See* Fleming Valve.

T.Y.K. ARC. Abbreviation for the method of wireless telephony invented by W. Torikata, E. Yokoyama and M. Kitamura, of Japan, the initials of whose surnames give the title to the system.

The T.Y.K. arc has magnetite and brass electrodes instead of the more usual copper-carbon electrodes. Other electrodes are also used in the system, as aluminium, silicon, ferro-silicon, carborundum or boron with graphite, iron or copper pyrites, bornite, molybdenite. The figure shows the circuit diagram of the T.Y.K. system, and it presents several unusual features. The materials used for the electrodes are such that a high resistance film forms on their surfaces. This necessitates a temporary high voltage to start the discharge. The way this is carried out is as follows:

To one of the electrodes is attached an armature, A. The two electrodes are in contact, and a steady current is caused to flow in the circuit through the spark induction coil, B. This attracts the armature A, drawing the electrodes apart. The break of the spark coil current at its interrupter



CIRCUIT DIAGRAM OF THE T.Y.K. ARC

Several unusual features appear in this circuit. A temporary high voltage is necessary to start the discharge over the high-resistance film-coated electrodes

induces a high electro-motive force which, acting through the coil and the spark gap in series, breaks down the film on the gap electrodes.

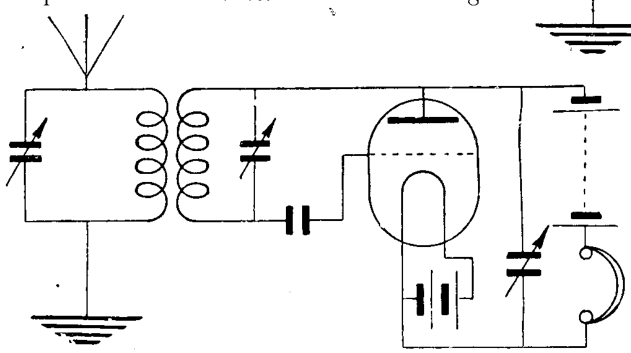
The power supplied to the gap is 500 volts and ·2 ampere. A condenser of approximately ·05 mfd. is used in the primary oscillating circuit. The T.Y.K. sets have only been used in small units, a range of 30–40 miles being about the maximum for the commercial sets which have been used on board ships. Ordinary crystal detector reception is employed, but with the introduction of the three-electrode valve the range of these sets has been considerably increased.

A remarkable point to note in connexion with the T.Y.K. arc is that the materials used for the electrodes are nearly all rectifiers of alternating currents at low voltages when they are, of course, in contact. Most of the substances, in proper pairs, have indeed been used for crystal rectification. Eccles has pointed out that many of these pairs of substances will set up weak continuous electric oscillations in a suitably shunted oscillation circuit. *See* Crystal.

U

ULTRA-AUDION CIRCUIT. Name given to a circuit due to Dr. Lee de Forest and C. V. Logwood. The circuit is normally used for receiving, though it may also be used for transmission. The circuit diagram of the ultra-audion is shown at Fig. 1. The telephones and high-tension battery are shunted by a bridging condenser. Connected between the anode and the grid is the oscillating circuit. One side of this oscillating circuit is connected directly to the anode and the other to the grid through a small value fixed condenser. A grid leak may be used in connexion with this condenser in the usual way, to prevent the accumulation of an excessive negative charge on the grid and consequent limitation of the anode current.

Dr. Lee de Forest explains the action as follows. There is only one oscillating circuit. This circuit is such that a sudden change of potential impressed on the anode produces in turn a change in the potential impressed on the grid of such a character as to produce, in its turn, an opposite change of value of potential on the anode. Thus the to-and-fro action is reciprocal and self-sustainin~. Armstrong



LEE DE FOREST'S ULTRA-AUDION CIRCUIT

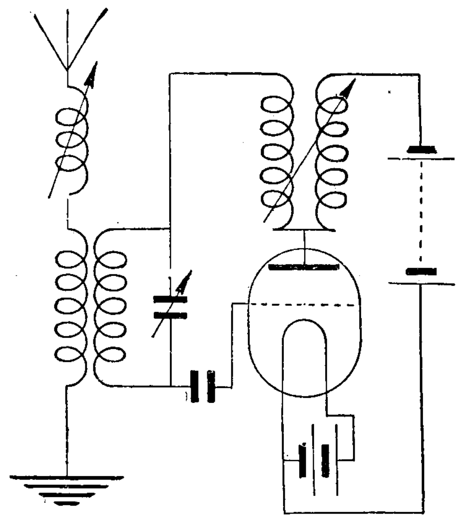
Fig. 1. In this circuit the telephones and H.T. battery are shunted by a bridging condenser. Between anode and grid is the oscillating circuit

claims that the circuit is regenerative in the sense that there is inductive capacity coupling between the anode and grid circuits. The oscillating circuit is connected across the grid and the anode instead of across the grid and the filament, and this, De Forest claims, makes it essentially different from the usual regenerative circuit.

Fig. 2 shows another arrangement of the De Forest ultra-audion circuit. This circuit differs from the usual ultra-audion in that there is a coupling added between the grid and anode circuits. This coupling reinforces the production of oscillations and gives greater outputs in consequence.

ULTRA-VIOLET RAYS. Those electromagnetic rays which come between the violet rays of light and X-rays. They have wave-lengths from 3934 to 600 Ångström units (*q.v.*) and a frequency of 3×10^{15} cycles.

Ultra-violet rays are interesting to the



FURTHER ULTRA-AUDION CIRCUIT

Fig. 2. This circuit differs from the first in that there is coupling, which is added between the anode and grid circuits

wireless experimenter, for in 1887 Hertz found that the passage of an electric spark took place more readily when a second spark occurred so that the light from this second spark fell upon the first spark gap. This effect was found to be due to the ultra-violet rays given out by the second spark. The remarkable discovery was later made that a negatively charged body rapidly loses its charge when exposed to the rays, while an uncharged body, if insulated, becomes positively charged.

The discovery of Hertz has been made use of in an attempt by Sella to transmit speech. The phenomenon is still more marked if discharge takes place through rarefied gases.

Since ordinary glass is opaque to ultra-violet rays, the bulb used is made of some substance transparent to ultra-violet rays, as quartz. Fig. 1 shows one such type of exhausted bulb, with a platinum plate and metal ball for electrodes. A photophonic arrangement was used for transmitting, and the variations of violet light on the platinum plate caused a variation in current reproduced in the telephones as sound waves. Dussaud varied the method by placing a fluorescent body near

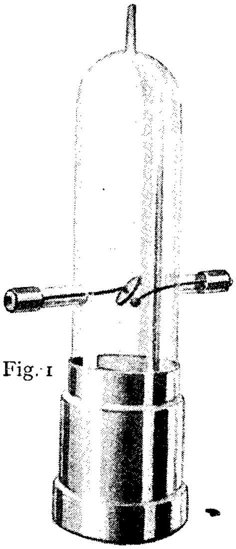


Fig. 1

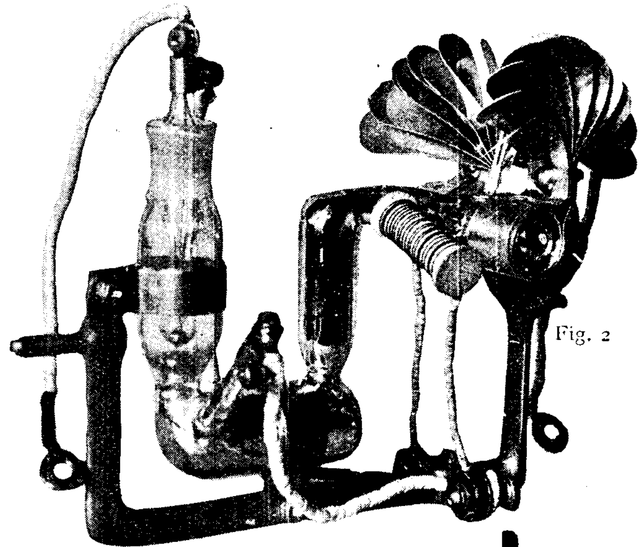


Fig. 2

APPARATUS FOR ULTRA-VIOLET RAYS

Fig. 1. Exhausted tube made of quartz with plate and ball electrodes. Fig. 2. Burner part of mercury vapour lamp for generating rays. Fig. 3. Lamp used with the ultra-violet tube shown in Fig. 2. Fig. 4. Another variety of lamp. Fig. 5. Tubular diaphragms used with the lamps to direct the rays

Figs. 2, 3, 4 and 5, Courtesy Watson & Sons, Ltd.

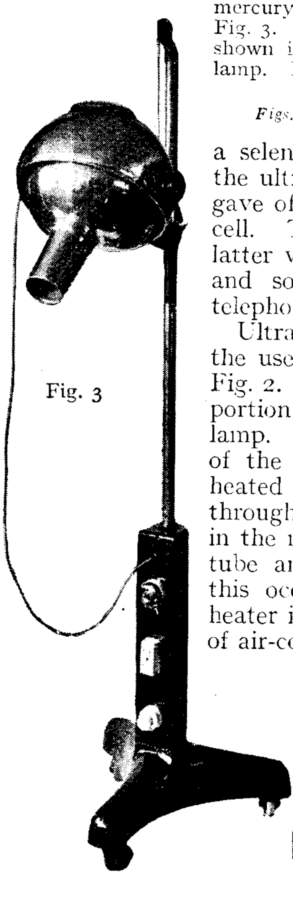


Fig. 3

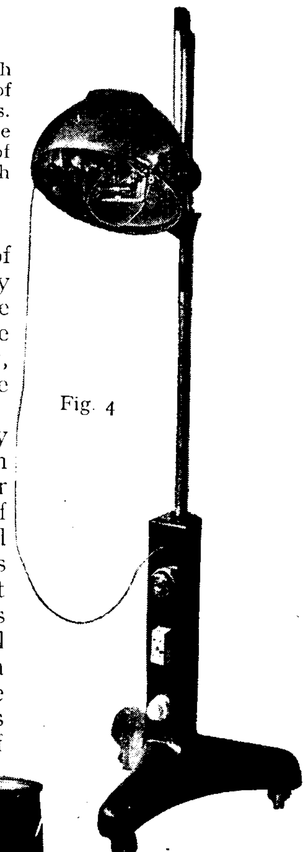


Fig. 4

a selenium cell. Under the influence of the ultra-violet rays the fluorescent body gave off rays of light which acted on the cell. The current passing through the latter varied with the light falling on it, and so produced sound waves in the telephones in the usual way.

Ultra-violet rays may be generated by the use of a tube of the type shown in Fig. 2. This illustration shows the burner portion of the mercury vapour type of lamp. The upper part of the right hand of the tube contains mercury, which is heated by the passage of the main current through the wire helix. This action results in the mercury passing down the vertical tube and an arc being formed. Upon this occurring, the current through the heater is automatically cut off. Two sets of air-cooling fins, arranged in the form of

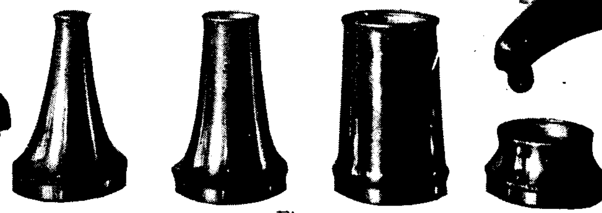


Fig. 5

semicircles, are attached to the heated limb of the tube. A lamp of this type is rich in ultra-violet rays of wave-lengths from 1,900 to 2,500 A.U.

In Figs. 3 and 4 respectively are shown the complete lamps employing the type of tube just described. The stand to which the lamp is attached has a heavy three-legged base, to which are fitted a switch, fuse and plug attachment for the flexible lead. The lamp itself is adjustable both vertically and horizontally.

It is necessary that the lamp should be provided with different types of tubular diaphragms to enable the rays to be directed in different manners for different purposes. A set of these is illustrated in Fig. 5. These screw on to the front of the aluminium casing of the lamp, as shown in Fig. 3. *See* X-rays.

UMBRELLA AERIAL. An aerial whose component wires radiate from a centre pole or mast like the ribs of an umbrella. The advantage of such a multi-wire aerial is that it has a larger capacity, and therefore yields a longer wave-length for transmitting, than a single wire of the same length. The effective inductance is also reduced, so helping to increase the aerial current.

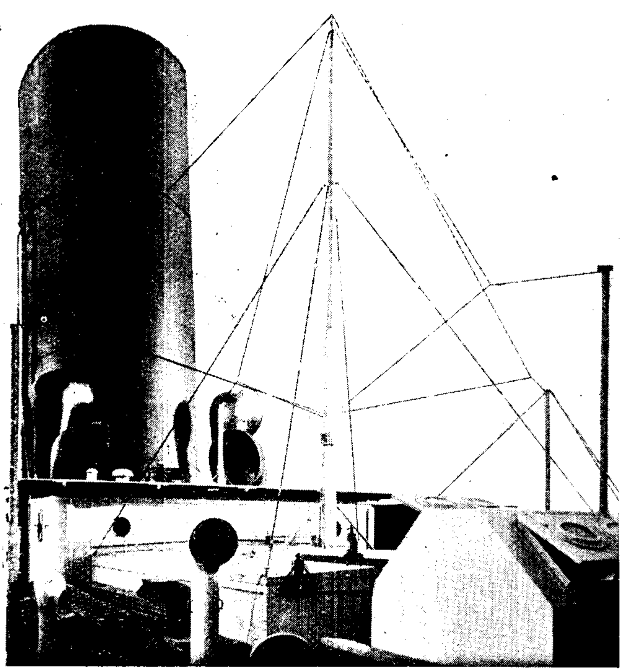
The umbrella aerial has the advantage over the L and T types of aerials in that it requires only one supporting mast. The wires are arranged symmetrically, and connected in parallel to a conducting ring, which is situated at the top of the mast and well insulated. From this ring the down lead is taken to the instruments. The effective wave-length of an umbrella aerial is the distance measured from the centre of one rib to the top, plus the length of the down lead.

The umbrella type of aerial is used very largely by the Telefunken Co., and that erected at the powerful German station at Nauen had a central mast of 900 ft. high, since replaced by two similar masts. At Funabashi, in Japan, a similar aerial has been erected. Such aerials have the advantage of radiating equally in all directions, and have a very long range. It has been stated that with a mast only about 150 ft. high, reception on crystal receivers over a hundred miles away is regularly carried out.

This type of aerial has a great and obvious advantage for military purposes in that it is easily portable. But it requires a large ground area to radiate the wires at their proper angles, and this is sometimes a difficulty. The aerial, too, must be of considerable height for long-distance transmission.

For reception purposes it is not advisable to bring the aerial wires close to the ground. The ends of the ribs, as it were, should be raised, and the angle between the ribs and the central mast should be as great as possible. In the station at Funabashi the central mast, which is 650 ft. in height, has a ring of 250 ft. masts round it, to which are fastened the ribs of the umbrella aerial.

Fig. 1 shows the type of umbrella aerial as used on board ship in connexion with direction-finding equipment by Marconi's Wireless Telegraph Company.



SHIP'S UMBRELLA AERIAL

Fig. 1. This type of umbrella aerial is used on board ships which are fitted with direction-finding apparatus

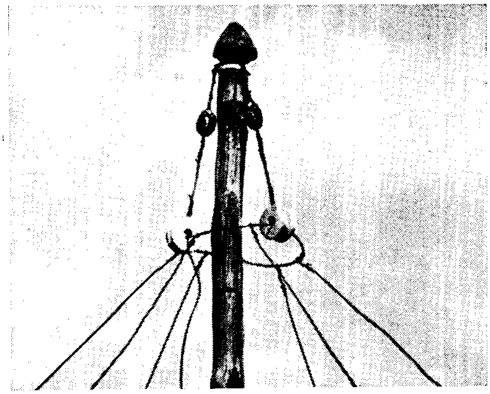
Courtesy Marconi's Wireless Telegraph Co., Ltd.

The umbrella aerial has the advantage that it is particularly easy for the amateur to erect. All that is really essential is a lofty pole, which can be set up in the ordinary way in a suitable open space, the aerial proper being composed of a series of six or more stranded copper wires connected together at the top by a ring of brass wire about $\frac{1}{4}$ in. or so in thickness, this ring being supported by the top of the post through suitable insulators.

These are clearly shown in Fig. 2. In arranging this part of the work, which should be prepared before the pole is erected, the brass wire ring should first be made and should measure about 9 in. in diameter. Three reel insulators are slipped on to the ring before the ends are joined. The joint may be effected by means of a ferrule of brass slipped over the two ends and securely pinned and soldered. The three egg insulators are attached by thongs to a necked cap at the upper part of the mast, this being composed of a reel insulator, to the outside of which the thongs are attached and covered with an acorn-shaped hardwood cap. The whole structure is secured to the pole by a central coach screw.

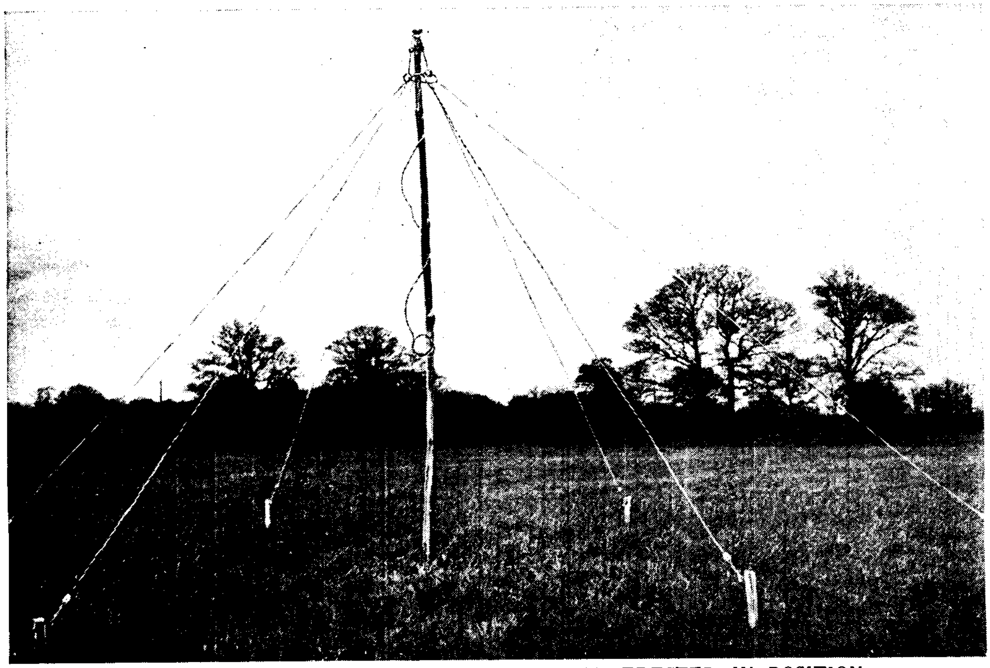
The upper end of the pole is reinforced with metal bands to prevent it from splitting, and three short cords are then connected between the egg insulators and the reel insulators, thus supporting the ring. Two separate stranded wire aerials are securely attached to each division of the ring between the insulators. A separate lead-in wire should be similarly connected to the ring.

When this part of the work is completed the pole should be erected in the



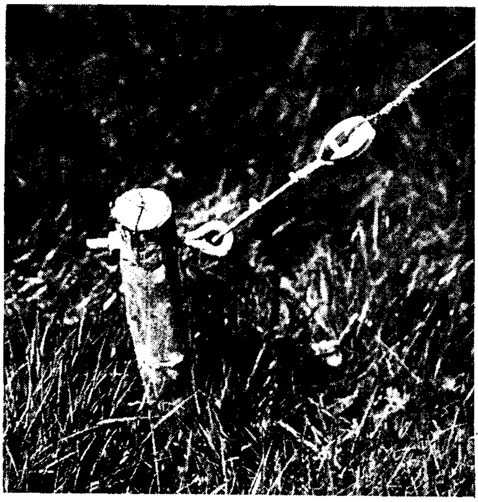
INSULATORS FOR UMBRELLA AERIAL

Fig. 2. Top of amateur-made umbrella aerial, showing the aerial wires and the insulating ring at the top of the mast



COMPLETED AMATEUR'S UMBRELLA AERIAL ERECTED IN POSITION

Fig. 3. In this type the aerial wires themselves also act as the guy-wires for the pole. They are all carefully insulated and the lead-in taken from the central ring at the top



WIRE-END DETAIL

Fig. 4. How the aerial wires are fastened to, and completely insulated from, the wooden stakes, which are firmly driven into the ground

usual way, and the aerial wires brought out to stakes securely driven into the ground, as shown in Fig. 3. The method of insulating the ends of the aerial wires by means of egg insulators connected by cords and eyebolts through the stakes is clearly shown in Fig. 4.

It will be found in practice that if the lengths of the aerial be made uniform, and the stakes be about 2 ft. in length, the act of driving the stakes into the ground will sufficiently tighten the aerial wires to make the whole self-supporting. *See* Aerial; Direction Finder.

UNIDIRECTIONAL. Flowing in one direction only, in the form of a direct current, as distinct from an alternating current. *See* Alternating Current; Current; Direct Current.

UNIDIRECTIONAL RECEIVER. A receiver so arranged that the resulting sensitivity is nearly zero in one direction and is maximum in substantially the opposite direction. *See* Bellini-Tosi Aerial; Direction Finder; Frame Aerial.

UNIDIRECTIONAL TRANSMITTER. A transmitter so arranged that the resulting transmission is nearly zero in one direction and reaches its maximum in substantially the opposite direction. *See* Bellini-Tosi Aerial; Direction Finder; Frame Aerial; Short Wave.

THE UNIDYNE SYSTEM OF RECEPTION

How to Build a Two-valve Set Eliminating the High-tension Battery

Here is described a circuit invented by G. V. Dowding and K. D. Rogers which represents an important advance in the design of receiving apparatus. By the use of a two-grid valve this circuit entirely obviates the use of the troublesome high-tension battery. See Four-electrode Valve

The Unidyne method of valve reception was introduced by Messrs. G. V. Dowding and Keith D. Rogers to eliminate the necessity of using the high-tension battery.

It depends for its success upon the use of a four-electrode valve having two grids, the inner grid being made positive by connexion to the low-tension battery positive pole.

This, when used as a detector, has the effect of overcoming to a certain extent the space charge of the valve, and thus shooting the electrons past the main or control grid to the plate.

Further, the main grid is given a positive bias, its potential being controlled by a variable resistance connected from the grid to the positive pole of the battery. This bias further serves to reduce the space charge of the valve and assists the electrons on their way. It thus has the effect of speeding up the electrons, which naturally means that more electrons will reach the plate in a given interval of time, and thus the amplification, which is controlled by the grid of the valve, is increased.

The plate plays little part in the speeding up of the electrons, as it only has a comparatively low positive potential, being connected via the telephones (in the case of the one-valve circuit) to the positive pole of the battery.

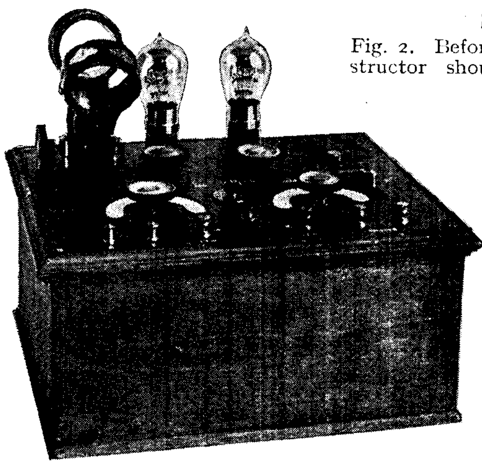
As Sir Oliver Lodge says concerning this system:

"The conducting power of the valve must depend upon the state of ionization of its contents—that is, on the number of free electrons in it. If there are few, it will act as a poor conductor, requiring a high E.M.F. to produce a required current, and soon reaching saturation. If they are many, a low E.M.F. will produce the same current.

"It may be possible, also, to coax the electrons near the grid, where they are easily tractable by its fluctuating potential, and in that way to secure easier conduction than if the negative charges have to be drawn up from the filament.

"It would seem that this end can be secured by giving the grid a positive bias, so that electrons accumulate in its immediate neighbourhood and are available for transmission to the plate, in accordance with the received alternations, provided the alternations are strong enough to overcome the bias.

"The necessary strength of alternations can be secured by reaction, and under those conditions a low-tension battery is able to transmit the required current, through the low-resistance valve, a high-tension battery ceasing to be necessary."

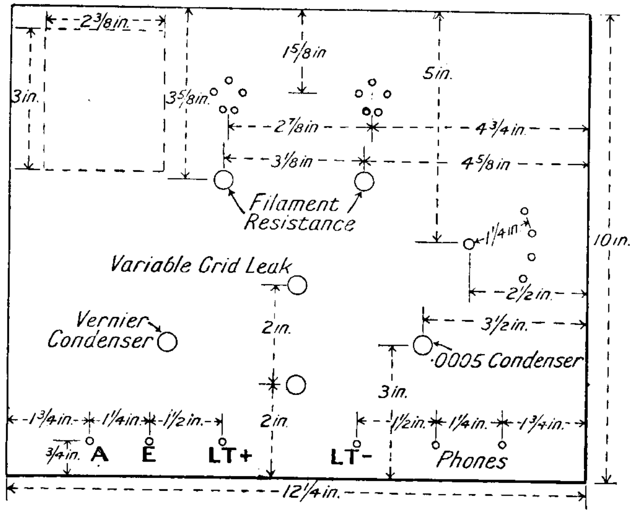


COMPLETED UNIDYNE RECEIVER

Fig. 1. The cabinet for the Unidyne set is an ordinary oblong box with ornamental moulding. A five-electrode Thorpe valve is used

In the case of the low-frequency amplifier the inner or control grid is made positive by connexion as before to the positive pole of the low-tension battery, while the main grid potential is again controlled by a variable resistance. The resistance is placed in series with the secondary of the low-frequency transformer and the low-tension battery, and in shunt with a small fixed condenser.

This break and leak in the circuit are necessary to control the potential of the grid, as the amplification is governed by the values of the leak and condenser.

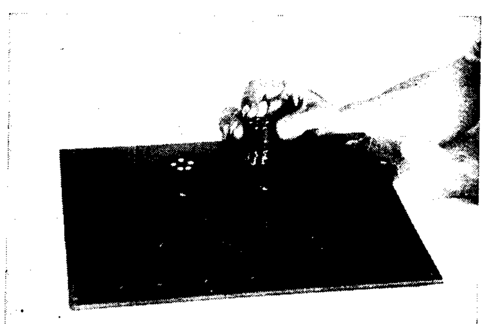


MEASUREMENTS FOR THE PANEL

Fig. 2. Before proceeding to the drilling of the panel the constructor should make a template from the measurements given on this lay-out

If the grid is allowed to become too negative loss of signal strength occurs owing to the fact that electrons are slowed down in their passage from filament to the plate. On the other hand, if the grid is allowed to become too positive, it would tend to "flatten" the characteristics of incoming signal impulses, and thereby cause considerable distortion.

The completed set is illustrated in Fig. 1, and consists of a box-like case with a horizontal panel. The panel, which is of $\frac{1}{4}$ in. thickness, fits flush to the sides of the case and, as shown in the illustration, is covered at the joint with an ornamental



MOUNTING THE VALVE HOLDERS

Fig. 3. Correct placing of the valve holders is essential to the effective working of the set. This illustration indicates how the right spacing of the prong-holes is assured

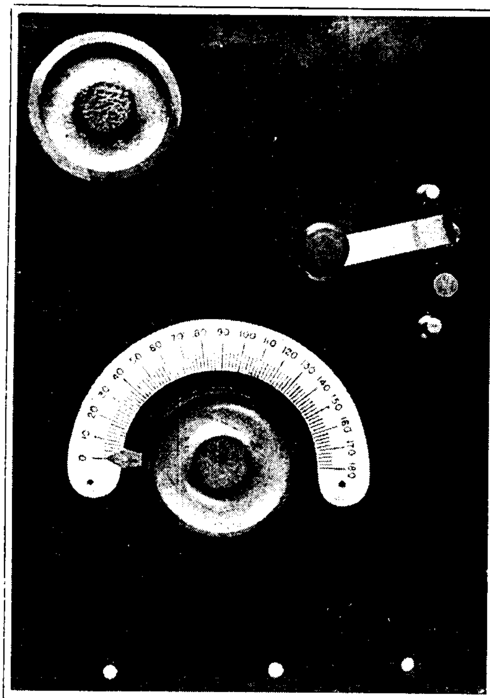


Fig. 4. Close-up view of the special panel switch, showing the stop pegs used

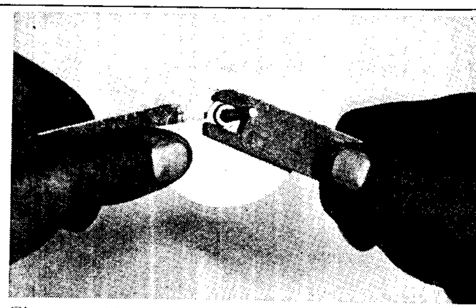


Fig. 5. Here the single moving plate of the vernier condenser is being tightened to its spindle

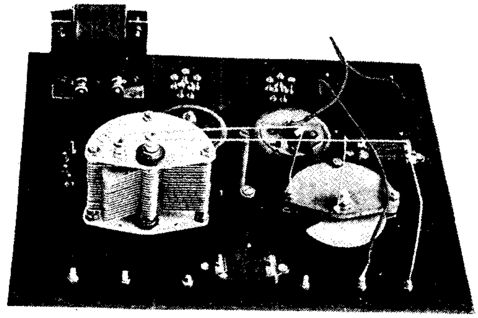
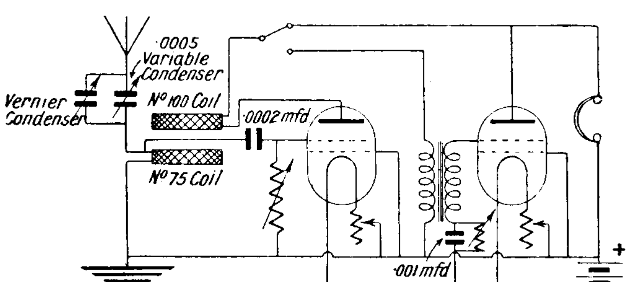


Fig. 6. In wiring the first stage shows the aerial tuning circuit. Here this is completed

DETAILS IN THE CONSTRUCTION OF THE UNIDYNE RECEIVER

moulding. The case is constructed from $\frac{3}{8}$ in. prepared deal, or other wood as desired, and measures $12\frac{1}{4}$ in. by 10 in., with a depth of 6 in. The figures given represent outside sizes.

The best method of assuring that the panel is a good fit to the case is to cut it roughly to size, allowing a slight overlap on all four sides. Countersunk holes are now drilled around the edges of the panel, so that the latter may be screwed into the position it will permanently occupy. With a fairly smooth file or sharp scraper the overlap is worked down flush to the edges of the case. The moulding, which can be procured quite cheaply, is now tacked and glued round the edges so that the top edge comes flush with the top of the panel. A little scratch at any particular corner covering both panel and moulding will enable the panel to be subsequently fitted the same way round. The panel is now removed from the case, and the latter sandpapered and stained to the instructions given under the appropriate headings in this Encyclopedia.



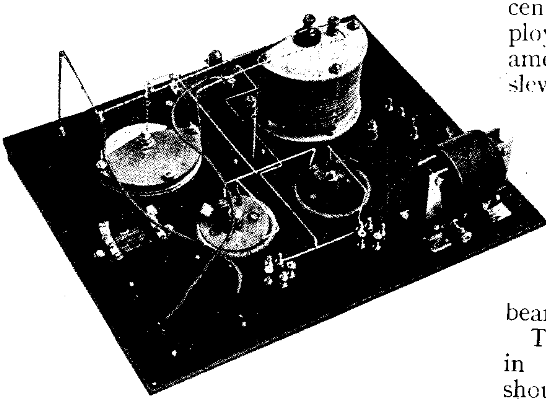
WIRING OF THE RECEIVER

Fig. 7. Before the wiring is commenced this circuit diagram should be carefully studied

The panel is matted on both sides in order to eliminate losses from surface leakages, which are frequently caused by the presence of foreign material in the surface skin of the ebonite. In every way losses should be avoided, in order that the principles of the Unidyne circuit may be tested under the most favourable conditions.

A lay-out for drilling the panel is given in Fig. 2, and shows the position for the major components. The two valves are placed centrally at the back of the panel, and in front of them the two filament resistances are fitted. At the back of the panel, to the left, a two-coil holder is attached, with which a variable coupling between the aerial tuning coil and the reaction coil is possible. Similarly situated to the right of the panel and on the underside, a low-frequency transformer is fitted.

Immediately in front of this last component is a two-stud rotary switch, enabling either one or two valves to be employed. The main tuning condenser is placed in front of the switch, while the vernier condenser, which is shunted across it, occupies a similar position to the left of the set. Between the condensers two



FURTHER STEP IN THE WIRING

Fig. 8. In wiring the set the second stage is the connexion of the valve filaments, which is shown completed here

variable grid leaks are attached. Aerial and earth terminals are fitted to the front of the panel at the left side. Centrally situated, to the front, are the low-tension terminals, while telephone terminals are fitted in line with the other terminals to the right of the set.

The valves employed are Thorpe four-electrode valves. In this valve five prongs are provided, instead of the customary four, and special valve holders are therefore required. These may be purchased, but if difficulty is found in obtaining them, ordinary valve sockets secured to the panel will answer quite well. Five small holes are drilled in the panel where each valve holder is fitted, the holes corresponding to the positions of the valve prongs on the valve. A good method of marking their correct positions is to apply a little white paint to the extreme ends of the valve prongs, and then to put the valve holder carefully in place. When it is taken up the paint adhering to the panel will indicate the correct positions. The same method may be adopted if valve sockets are used in place of the valve holders. The operation is shown in Fig. 3, where the valve holder is being slowly approached to the panel.

The method of fitting the coil holder will depend upon the type employed, but as a general rule holes are provided at the corners by which it may be secured in position. The moving coil should have a stiff action, in order to prevent it from falling down when a loose coupling is employed.

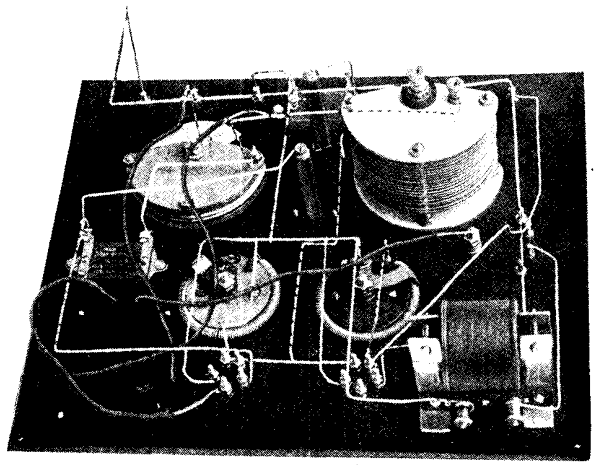
As far as possible, components of the central hole fixing type should be employed, as this type saves a considerable amount of time in fixing and can be slewed round if desired to a better position. As a general rule the bearing spindle projects beyond the instrument and is threaded on its outside. A hexagonal nut is provided, fitting on the spindle, by which it may be secured in position. No tapping is necessary and no drilling beyond the single hole through which the spindle bearing projects is required.

The variable condenser, which is wired in series with the aerial tuning coil, should be of good make and free from any uneven movement in turning. Stiffness of movement is also to be avoided, as well as too much slackness. This latter is especially bad where the condenser is used in an horizontal position, as, owing to the unbalanced spindle, trouble occurs by the moving plates falling to the bottom of their own accord.

A close-up view of the two-stud switch is given in Fig. 4, which enables the experimenter to gather details of its construction. On either side of the contact studs stop pegs are provided to prevent the switch arm from coming off the studs.

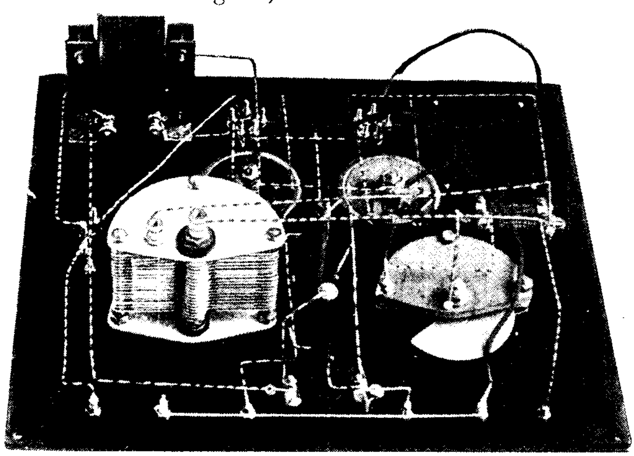
The vernier condenser may be purchased or constructed, as desired. If the latter is preferred the necessary components, if not to hand, may easily be purchased. A close-up view of a home-constructed vernier condenser is given in Fig. 5. Two ebonite plates are required, between which two fixed condenser plates are bolted. The plates are spaced apart with spacer washers, through which short lengths of screwed rod are fitted. The collection of plates is held by nuts fitting to the outside of the back plate. The screwed rod is usually screwed into the front ebonite plate of the condenser, and therefore, on this side, nuts are not required. The front plate is bushed with brass, in which bush the condenser spindle rotates. The single moving plate is attached to the spindle, the plate being tightened and adjusted by means of locking nuts and brass washers.

Having mounted all the components to the panel, the apparatus is ready for wiring. The wiring diagram is given in Fig. 7. Wiring is carried out with stiff tinned wire, as shown in the illustration in Fig. 6, where the first stage, the completion of the aerial tuning circuit, is given. By taking the wiring as far as possible in natural stages, the work may be made easier to follow. The next step, shown in Fig. 8, represents the low-tension circuit to the valves. After this step has been completed a battery test may be made to ensure correctness of wiring, which is indicated by the valves lighting to the control of the filament resistances.



APPROACHING COMPLETION

Fig. 9. This view, taken in semi-plan, will be helpful to the experimenter. The wiring is now almost entirely carried out



UNDERSIDE OF THE UNIDYNE PANEL

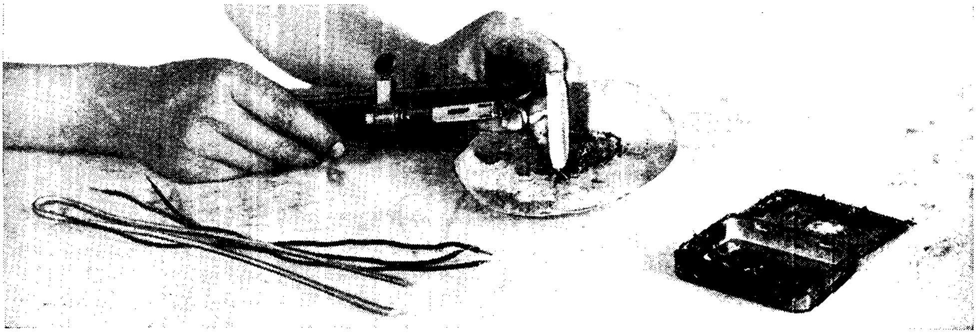
Fig. 10. Since the wiring of the Unidyne set calls for care, several views are included. This photograph is taken from the front edge of the panel

In the Thorpe valve the prong marked on the cap with a dot is the anode. Exactly opposite to this prong on the other side of the base of the valve are two prongs set close together. These are the prongs connecting to the filament. When the valve is held base upwards with the anode prong away from the observer and the filament prongs in line with and towards the observer the prong to the extreme right is the inner or auxilary grid. This grid connects directly in both valves to low-tension positive. The last remaining prong to the left is the outer grid, which is connected in the circuit in the normal manner.

The grid connexions may now be made as shown in Fig. 9. Connexions to the switch are shown completed in Fig. 10.

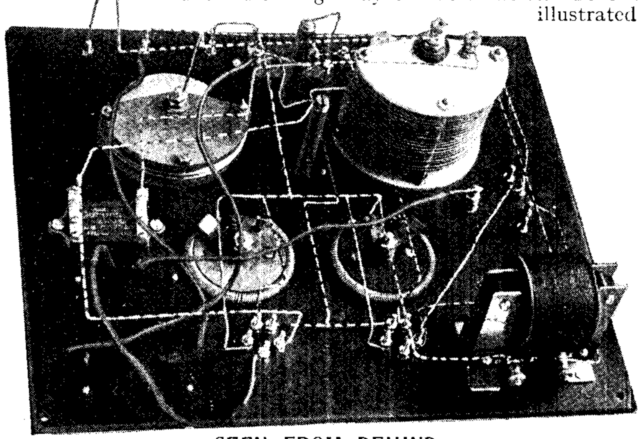
Connexion to the movable coil holder is made with flexible insulated wire. Unless this connexion is well made, trouble may be experienced by one or more strands of wire coming away from the point of connexion and shooting across the coil. The fault is obviated by tinning the bared ends of the wire where they pass under the clamping screw. The operation of soldering the ends of the leads is illustrated in Fig. 11.

A semi-plan view taken from the front edge of the panel is given in Fig. 10, and illustrates the completed wiring. A similar view showing the back view of the wiring is given in Fig. 12.



SOLDERING THE ENDS OF FLEXIBLE WIRES FOR THE COIL HOLDER

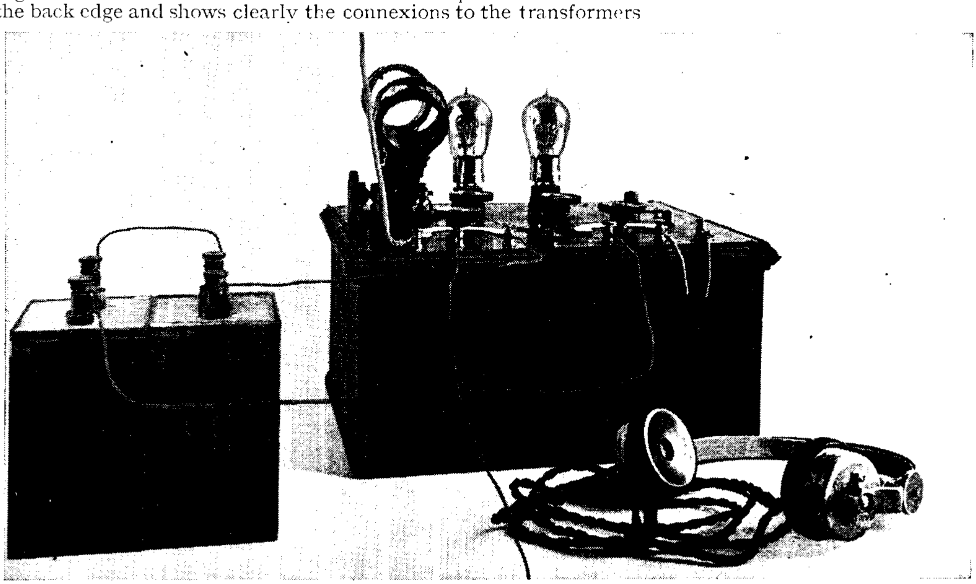
Fig. 11. Connexions in this receiver should be carefully made, as trouble may be encountered through frayed ends of wires. To obviate this the latter are soldered, as illustrated



SEEN FROM BEHIND

Fig. 12. This further view of the underside of the panel is taken from the back edge and shows clearly the connexions to the transformers

Having checked over the wiring with the diagram, all traces of solder and flux must be removed from the panel, when it may be finally fitted to the case. The completed instrument connected to low-tension battery, aerial and earth and telephones is illustrated in Fig. 13. A 4 volt battery is suitable for lighting the Thorpe valve. This valve has a fairly low current consumption, a discharge rate of 1 ampere



COMPLETE UNIDYNE RECEIVER READY FOR USE

Fig. 13. Here is shown the completed instrument. It is seen connected to the low-tension battery, and aerial and earth leads are in place. A 4 volt battery is suitable for lighting the Thorpe valve

being amply sufficient for both valves used in the set described.

Preconceived ideas on tuning, especially those on reaction, should be forgotten when tuning the Unidyne set. Although it will be found to oscillate readily on either one or two valves, the oscillation has not the same characteristics as the circuit incorporating the high-tension battery. It will be noticed on tuning to the carrier wave of a transmitting station that the normal whistle appears fiercer. On first tuning the set the experimenter will notice the particular quietness of the receiver, which gives the impression that it is not in working order. This should be ignored, and rotation of the series condenser and reaction coil effected until the fierce rush of a carrier wave is heard. The reaction coil is now slowly moved to obtain a looser coupling. It is best to tune the set as a one-valve receiver first of all, and to switch in the low-frequency amplifier afterwards. When this is done a slight readjustment of the reaction coil and the variable condenser will be necessary to bring the station being received up to full strength.

The detector valve grid leak plays an important part in the tuning of the set, and it will be found to have considerable control over the reaction. This is of advantage when tuning in a distant station, as a finer control is provided by this method than by the movement of the reaction coil to or from the aerial tuning coil.

The variable grid leak wired in series with the transformer secondary is important in obtaining maximum low-frequency amplification. The effect of the second grid leak is not critical, however, and the leak will probably not require adjusting until the signal is being well received.

UNILATERAL CONDUCTIVITY. Conducting in one direction only. This property of unilateral conductivity possessed by certain crystals and certain forms of electrical apparatus is of great importance in wireless. Dunwoody, in 1906, discovered the unilateral conductivity of carborundum, and afterwards a large number of substances were found to possess this property. It must be clearly understood that though unilateral conductivity means conducting in one direction only, in actual fact such crystals or crystal combinations conduct in both directions, but they are far more conductive in one direction than in the reverse, and for small currents they are actually unilateral conductors, so enabling them to be used as rectifying detectors in wireless.

The electrolytic detector is another unilateral conductor, due to Fessenden. There are several forms of such detectors which are fully described under Electrolytic Detector.

The Fleming two-electrode valve and the modern three- or four-electrode valves are also unilateral conductors. The mercury valve rectifier is still another device used for the rectification of alternating or high-frequency currents.

See Crystal; Fleming Valve; Mercury Rectifier; Neon Tube; Noden Valve; Rectifier; Valve; Zehnder Trigger Tube.

UNITED STATES BROADCASTING PRACTICE

Descriptive Notes on the Great American Transmitters

Amateurs of wireless in Great Britain are well advised to equip themselves with some knowledge of the great stations of the United States, for many are now listening regularly to the transmissions from the New World and all know of the B.B.C. experiments in relaying from KDKA, at Pittsburg. Wireless is on a high level of development in the United States. See also Relaying; Transmission, etc.

The first transmission of music and news by wireless in the United States was in 1907, and in 1908–9 opera was transmitted from the Metropolitan Opera House, New York. It was not until 1916 that regular news and music were broadcasted from the De Forest laboratory in Highbridge, New York, and the same year the United States election returns were broadcasted. From then progress was rapid.

Broadcasting in the United States is carried out under considerably different regulations from those in force in Great Britain. All broadcasting stations are divided into three main classes, class A, class B and class C.

Class A stations are limited to a transmitting power of 500 watts, and it is the class to which the great majority of amateur and experimental and small broadcasting stations belong. Class B stations use 500–1,000 watts, and class C is a class which transmits on 360 metres, the standard broadcasting wave-length before the new regulations. In class A the wave-length band allotted is 222–300 metres and the stations are grouped into districts so that two stations transmitting on 300 metres, say, are situated far enough apart from one another to avoid any interference with each other's transmissions. Alternatively, to avoid jamming on the same wave-length, different times of transmission are allotted to such stations.

Class B stations transmit on 300–545 metres, and the arrangement of times of transmission or wave-lengths used by any station is the same as for class A stations. There are close on a thousand stations now which regularly broadcast concerts, speeches, etc., and before the new regulations came into force in 1922 the problem of interference was one which was giving serious concern to the authorities. But under these regulations interference of one broadcasting station with another is very small. Nearly 20,000 amateur transmitting stations are licensed.

KDKA's Transmissions to England

The Westinghouse station at Pittsburg, call sign KDKA, is one of the best known American stations in Great Britain, for it was from this station that American broadcasting was picked up by 2 LO via Biggin Hill and re-broadcast in the early part of 1924.

The KDKA Atlantic transmissions are made on a wave-length of 102 metres. The success of the station is due to the Westinghouse Electric and Manufacturing Co., and much of the experimental work of transmitting across the Atlantic was carried out at the end of 1923 in conjunction with the Metropolitan-Vickers Electrical Co. at Manchester.

KDKA was opened in 1920, and originally transmitted on 360 metres. The normal wave-length for transmission is now 326 metres.

Power is supplied to the transmitters from a direct-power plant through a step-down transformer for the valve filaments, and through a special motor generator set which converts 220 volts D.C. to 2,000 volts D.C. for the anodes of the valves.

Fig. 1 shows the circuit diagram of the system. The A.C. supply to the filaments is a low-voltage supply at 25 cycles only. To prevent any of this 25 cycle voltage being impressed on the grid and anode circuits the return of the grid circuits and of the anode circuits is connected to the centre point of the resistance shunted across the filaments.

Transmitting Equipment of KDKA

There are five modulation valves and four 250 watt power valves which, with the condensers and oscillation transformer, change the 2,000 volt D.C. into A.C. A remote-controlled double-throw switch brings the aerial into operation either for sending or receiving. The five modulation valves are rated at 250 watts each, and their function is to vary the voltage on the anodes of the power valves according to the audio-frequency impressed upon their grids by the speech amplifiers.

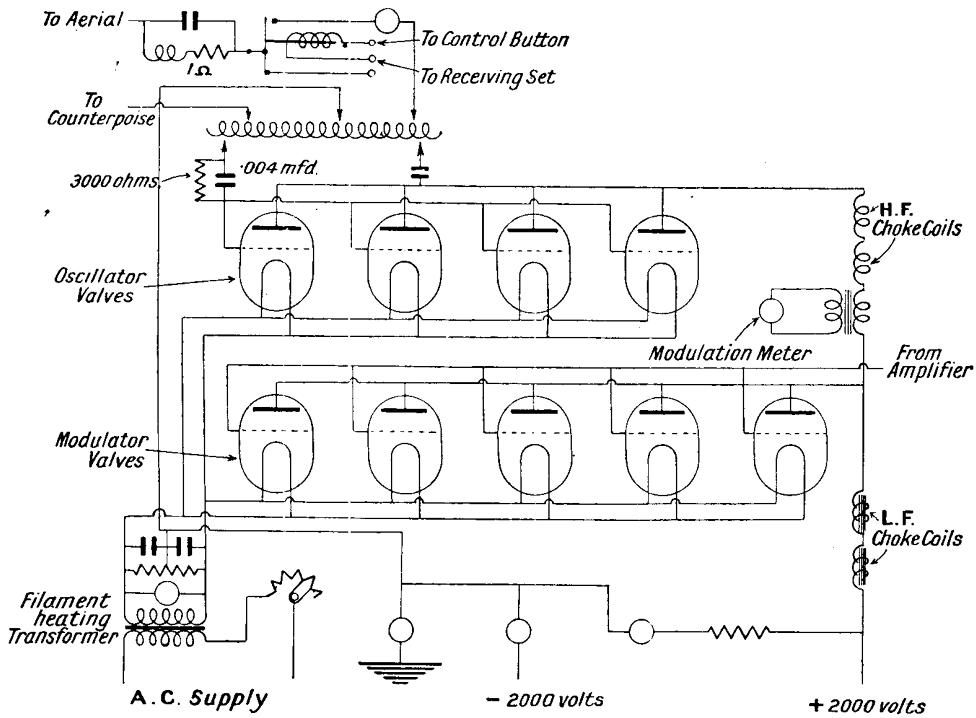
A constant current choke coil is connected in series with the positive lead of the modulation and power valve anodes. The grids of the modulation valves are kept at a negative potential of 60 volts with respect to the filaments by means of a battery.

When at any instant the grids of the modulator valves have impressed upon them by the amplifier a small negative or zero potential with respect to their filaments the impedances from anode to filament are low, and a large anode current flows from the 2,000 volt D.C. circuit to the modulation valve anodes.

The audio-frequency choke coils have an inductance of 50 henries. They are in series with the anode supply, and owing to their large inductance the total generator current changes very little in a short interval. Hence the voltage impressed on the power valve anodes is lowered.

At the next instant, however, when the modulation valve grids have a high negative potential with respect to their filaments the anode impedance is high, and little or no current flows through the modulation valves. The choke coils tend to keep the total generator current constant and create a voltage which adds to the generator voltage, and this forces most of the current into the power valves. The audio-frequency chokes cause the speech voltage impressed on the grids of the modulation valves by the speech amplifier.

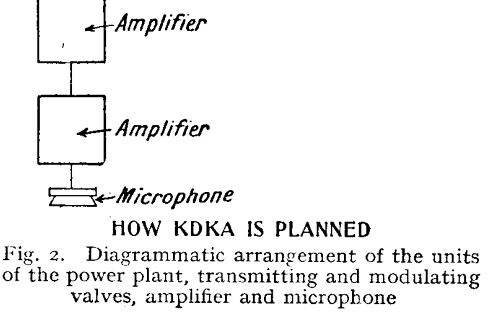
Fig. 2 shows diagrammatically the arrangement of the units of the power plant, transmitting and modulation valves, amplifier and microphone. The latter are not shown in the circuit diagram.



CIRCUIT DIAGRAM OF THE TRANSMITTING AND RECEIVING APPARATUS OF KDKA

Fig. 1. KDKA is the call sign of the Westinghouse station at Pittsburg, U.S.A. The A.C. supply to the filaments is a low voltage supply at 25 cycles. Each half of the resistances shunted across the filaments is shunted by a fixed condenser

The aerial consists of six wires, 190 ft. in length, on spreaders measuring 50 ft., and 210 ft. above the ground. A counterpoise, 100 ft. above the ground, is identical in construction with the aerial. The studio is situated about half a mile away. KDKA makes a special feature of land-line transmissions, and the station is permanently connected to every church, theatre and public hall of any size in Pittsburg and the neighbourhood.



HOW KDKA IS PLANNED

Fig. 2. Diagrammatic arrangement of the units of the power plant, transmitting and modulating valves, amplifier and microphone

The 102 metre set used for Atlantic transmission delivers 7 kilowatts to the aerial, corresponding to an input of nearly 30 kilowatts. Specially designed valves fitted with a water-cooling system have to be used to deal with such large powers. The aerial used is made of copper tubing.

Fig. 3 shows the control instrument and panels of KDKA.

WGY Schenectady, the station of the General Electric Co., Schenectady, New York, has constantly been picked up in Europe. It was opened early in 1922, and was the first station to use the pallo-photophone in the transmission of speeches by well-known people.

With the 1,000 watt transmitter control panel, either C.W. or I.C.W. or telephony may be used at will by the operator. Four 250 watt valves are used, two as oscillators and two for modulation, and two 50 watt valves for speech amplification. Current

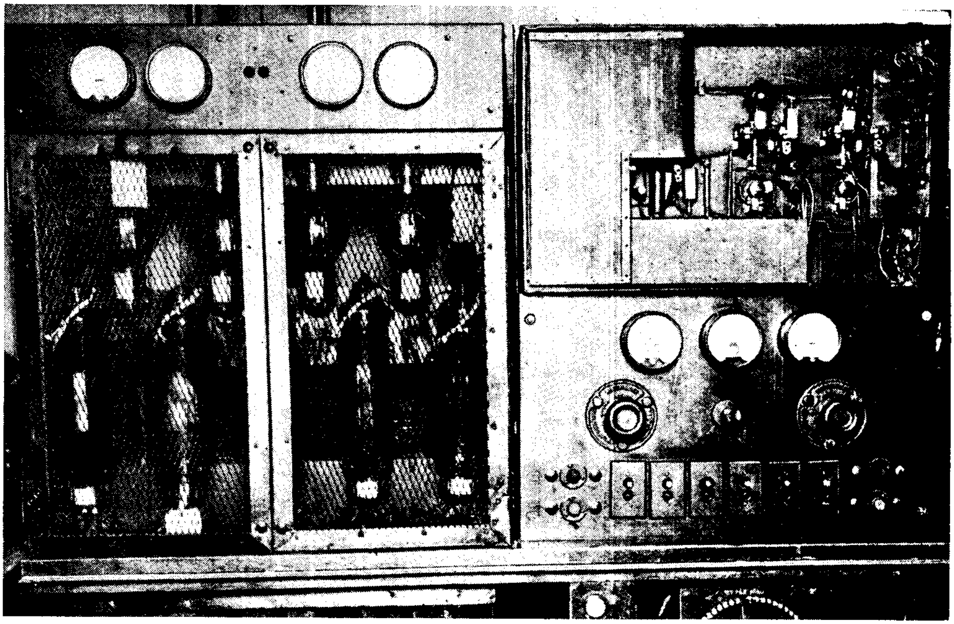


Fig. 3. An interesting feature of the Westinghouse station at Pittsburg is that it is connected to every church, theatre and public hall of any size in the city. Its fittings are all of the latest and most efficient types

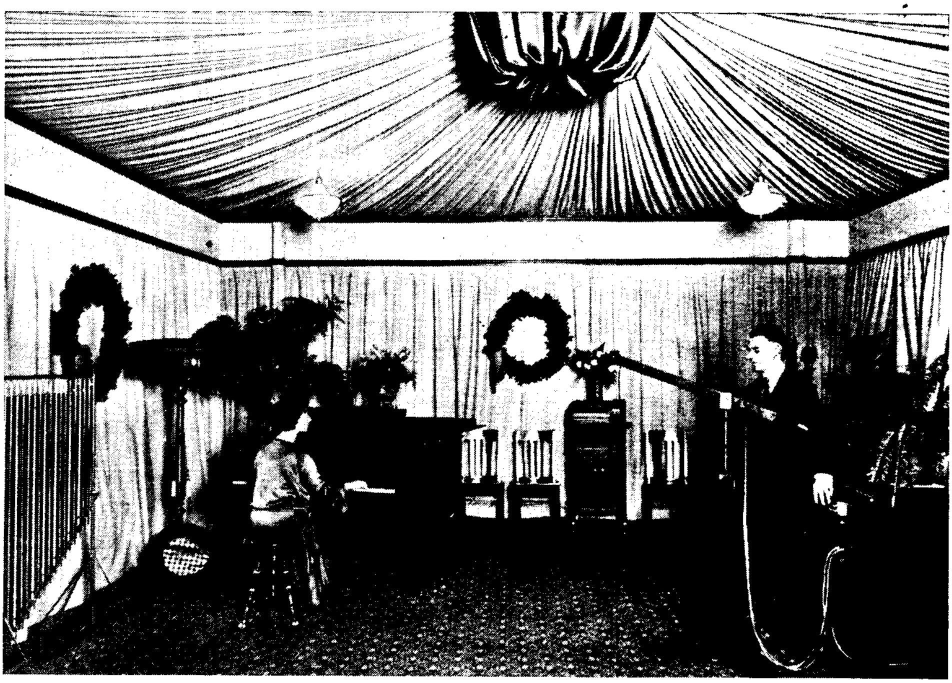
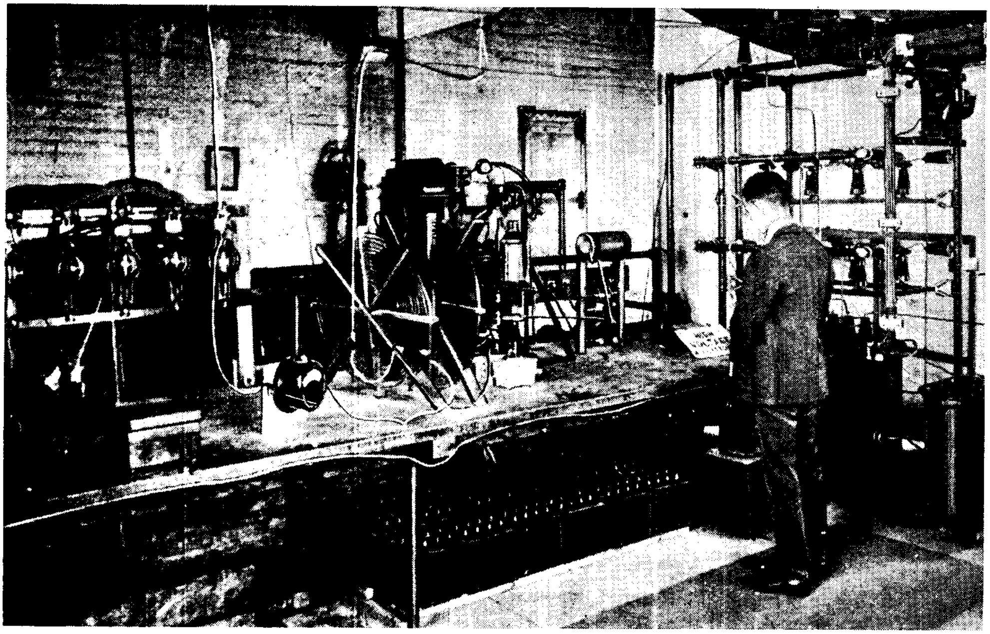


Fig. 4. Like most studios, the Pittsburg one is made as sound-proof as possible by having its walls and ceiling entirely covered by hangings of cloth. The first experiments in Trans-atlantic transmission were made from this station

INTERIOR VIEWS OF KDKA STATION AT PITTSBURG



TRANSMITTING APPARATUS OF WGY, SCHENECTADY

Fig. 5. Seen on the left above is the bank of transmitting valves. In the centre are the stands with the inductance coils, and underneath is seen the series of accumulators used

is supplied from a three-unit motor generator, consisting of a double current self-excited generator and a high voltage direct current generator, driven by a single-phase direct current motor, supplied from a 110 volt line.

The station specializes in broadcasting services from churches and public halls and institutions, and a special portable control panel is used for the purpose. The modulation and other controls are carried out in the church or hall itself, making a finer adjustment possible, so that the station end is only concerned with seeing that the amplifiers and broadcasting transmitter are working properly. When WGY is operating at full power 12,000 volts are applied to the plates of the valves. Six kenotron rectifiers are used for the purpose.

The aerial is 350 ft. in length and is supported on steel towers 180 ft. high.

Fig. 5 shows the transmitting apparatus of the station. On the left are the transmitting valves and in the centre the inductance coils. Underneath the latter may be seen the bank of accumulators.

Another well-known American station, due to the Westinghouse Electric and Manufacturing Co. at Newark, New Jersey, is WJZ. This station is remarkable for the great distances over which its concerts have been heard. It has already been partly dealt with under the heading Newark Station in this Encyclopedia. Supplementary to the information given on page 1470, it may be added that the usual wave-length used is 360 metres, though transmission also takes place on 455 metres. The whole of the transmitting may be controlled from the studio itself, and special separate microphones are installed for transmission of speech, pianoforte and other music. The Newark station is also equipped for reception on wave-lengths ranging from 150 to 2,300 metres. The transmitting panels, Fig. 6, each of a kilowatt, are duplicated.

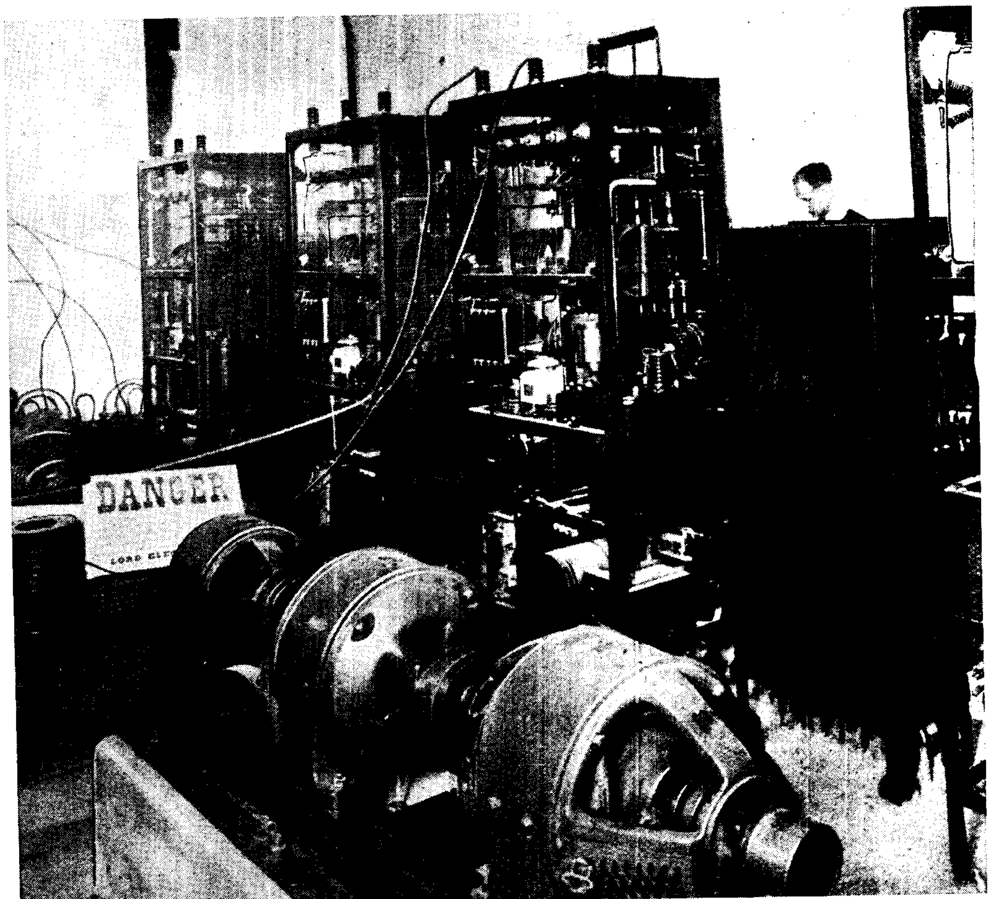
Another American station which is frequently heard in Great Britain is WHAZ, the wireless station at Rensselaer Polytechnic Institute, Troy, New York. This station was originally only intended for lecture purposes and laboratory experiments, and was built up of separate units until ultimately it became powerful enough to be suitable for broadcasting, and is now one of the best known of the American stations.

The broadcasting apparatus consists of a Western Electric 500 watt transmitter, a regulation spark transmitter and a continuous wave Colpitts oscillator circuit transmitter. The station has a range of over 2,000 miles under normal conditions, and of course very much farther under favourable conditions.

Radio Central, situated 70 miles out of New York, at Rocky Point, L.I., is the most powerful of the American transmitting stations. It was opened on November 5th, 1921, and is powerful enough to communicate directly with Europe, Japan, Australia and, in fact, the whole world.

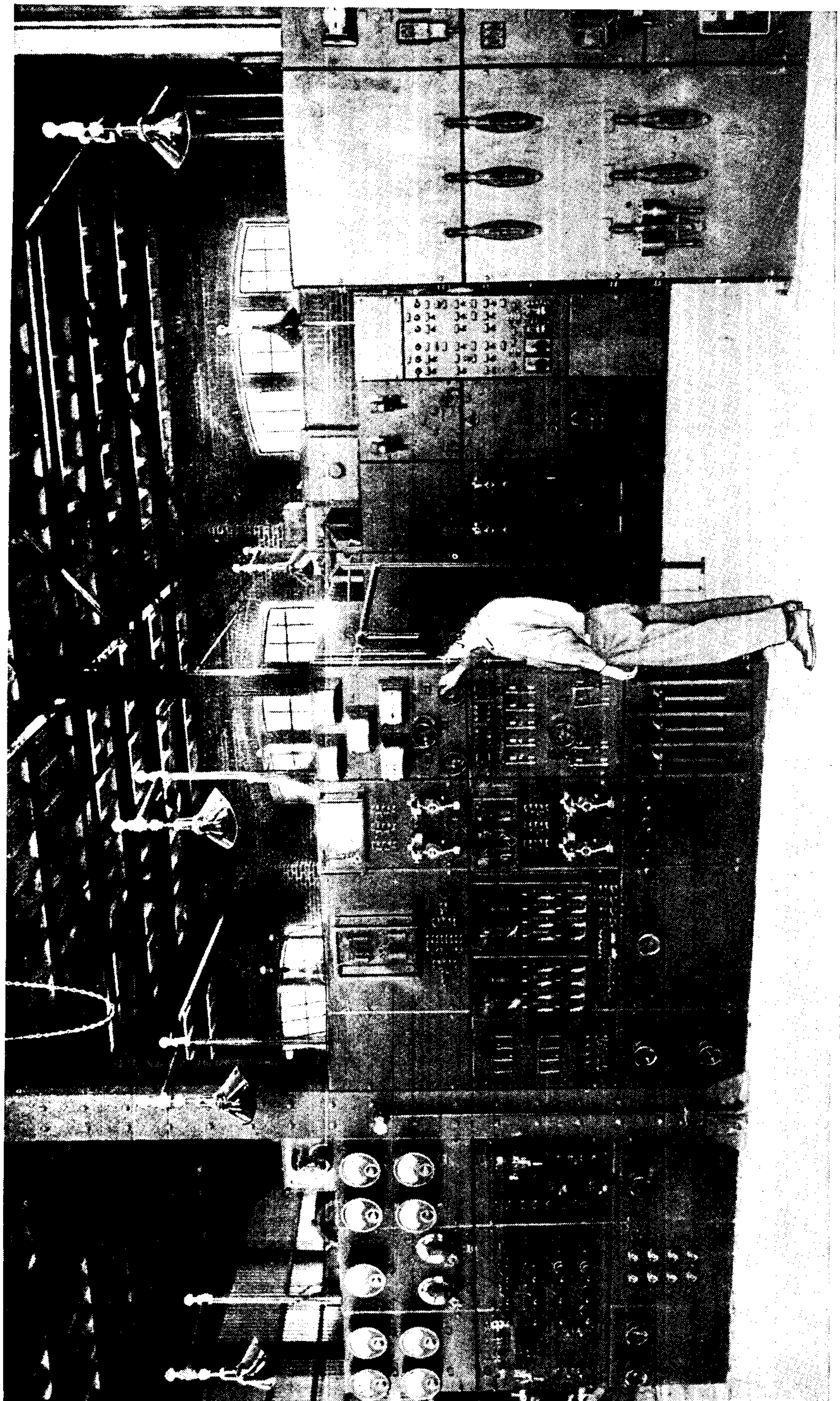
This powerful wireless station is divided into three closely connected units. They are, first, a high-power multiplex transmitting station located at Rocky Point on Long Island, 70 miles from New York, and having a number of separate aerials, each designed to communicate with a given country. Second, a multiplex receiving station located at Riverhead, Long Island, 16 miles distant from the transmitter, and so planned and arranged as to receive simultaneously all wireless messages which may be transmitted to the United States. Third, a central traffic office in New York, where all actual wireless operating takes place. Here wireless messages are directly wirelessed to foreign points through Radio Central, the direct transmission being carried out by means of a special remote control system, similar to that described under Remote Control in this Encyclopedia.

Some idea of the size of Radio Central may be gathered from the fact that it covers ten square miles. There are twelve aerial towers, each 410 ft. in height, and each having a spreader for the aerial wires



INTERIOR OF TRANSMITTING ROOM AT WJZ, NEW YORK

Fig. 6. WJZ is the Westinghouse station at Newark, New Jersey. The transmitting panels are all duplicated in case of one breaking down. All the transmitting may be controlled from the studio

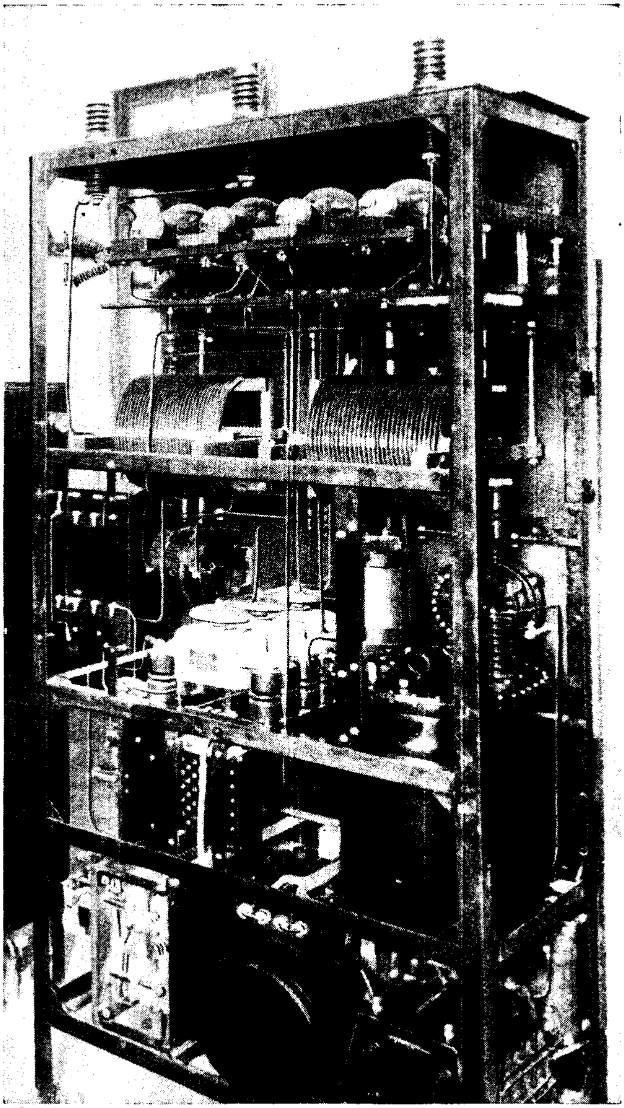


CONTROL BOARDS AT THE RADIO CENTRAL STATION, ROCKY POINT

Fig. 7. Radio Central is probably the largest wireless station in the world, as its area covers no less than ten square miles. Here are shown the control boards, with the voltage regulators, amplifier controls and power supply panels of this excellently equipped transmitting station

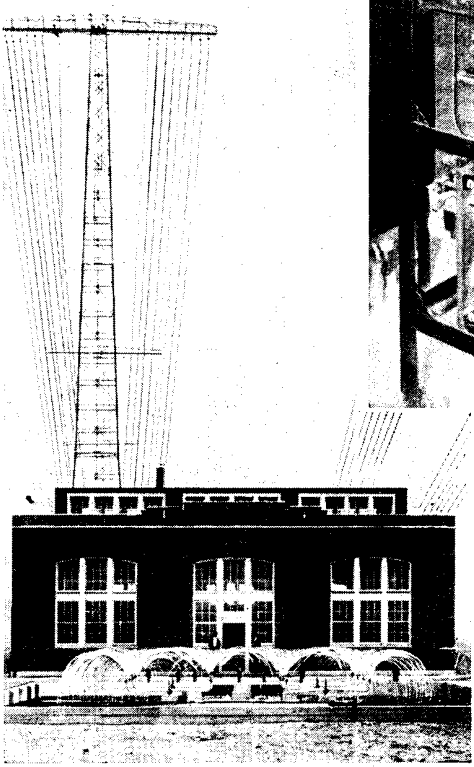
150 ft. in length. The distance between adjacent aerial towers is 1,250 ft. Each aerial is composed of sixteen silicon-bronze cables $\frac{3}{8}$ in. in diameter. The final form of the station involves 72 such towers being erected, and 12 aerials radiating from a centre like the spokes of a wheel. Ten high-frequency alternators are employed with a total output of 2,000 kilowatts. With each of the twelve transmitting units a speed of over 100 words a minute is possible, so that with all 12 working over 1,200 words a minute can be transmitted to any part of the world.

Fig 9 shows one of the giant masts used and the system of aerial wires. The building shown is one of the



TRANSMITTING PANEL OF WJZ

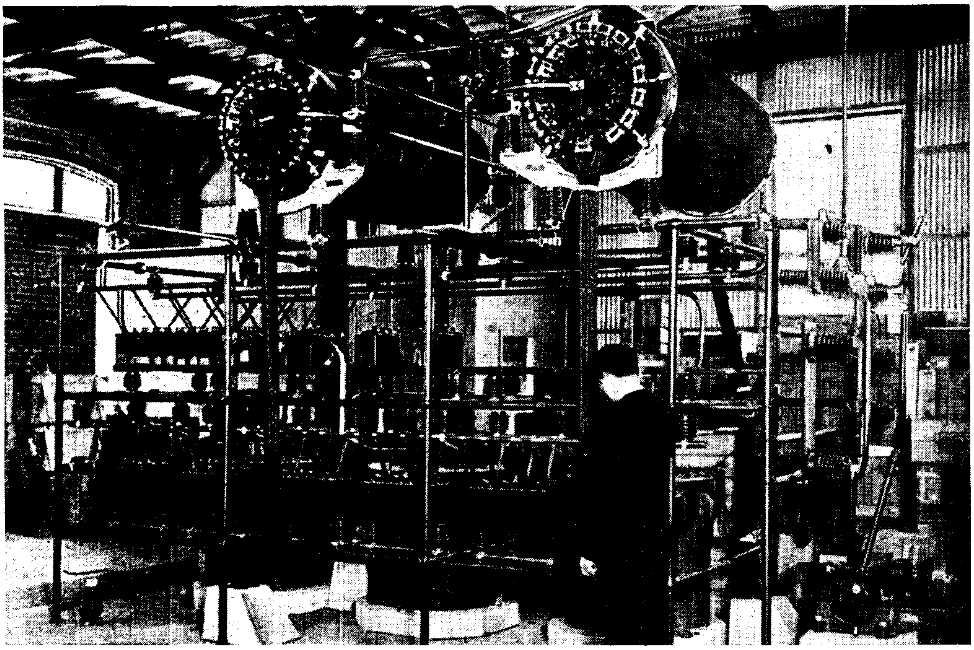
Fig. 8. Four such panels as these are employed at the Newark station, two being duplicates for use in emergency



AERIAL MAST AT RADIO CENTRAL

Fig. 9. The building shown here is one of the nine receiving stations at Rocky Point.

receiving stations. Fig. 7 shows a view of the interior of one of the stations, showing the magnetic amplifier and transformer rack. Some of the large generators employed are shown in Fig. 7, which is a view of the interior of the power house, while Fig. 10 shows two of the high-frequency alternators, each of 200 kilowatts. In front of Fig. 9 will be noticed the cooling pond which is a part of the circulating cooling system for the Alexanderson alternators. In Fig. 7 are



HIGH-FREQUENCY ALTERNATORS USED AT ROCKY POINT

Fig. 10. Here are shown two of the H.F. alternators, each of 200 kilowatts, employed at the Radio Central station on Long Island. Reference to Fig. 9 will show the cooling pond used in connexion with this apparatus

shown the control boards at Radio Central, comprising the voltage regulators, magnetic amplifier control, telegraph control and main power supply panels.

The Arlington time signal is as well known to wireless experimenters as the Eiffel tower time signals. The call sign of Arlington, which is situated at Washington, is NAA. It is one of the United States' many stations, and began transmitting in 1913 with a 100 kilowatt Fessenden spark set. The station has to its credit the first successful wireless telephony experiment, when in October, 1915, conversation was carried on between Arlington and the Eiffel Tower in Paris.

There are five aerial masts at Arlington, each 800 ft. above sea level. Three form a isosceles triangle with a base which runs magnetic north and south, and are 200 ft. in height. The other two are 400 ft. in height. The time signals are sent out at noon and 10 p.m., while weather signals, and movements of ships, storm warnings and the like, are sent out all day long to assist navigation.

UNITS: THEIR DETERMINATION AND PRACTICAL IMPORTANCE

By Sir Oliver Lodge, F.R.S., D.Sc.

Here our distinguished Consultative Editor gives an extraordinarily fascinating account of a subject which, to the unthinking reader, might appear to possess little interest. He shows the immense labour required to determine the simpler electric units, discusses certain fundamental units whose value is unknown, and shows the inter-relation of all electrical units. See Ampere ; Capacity, etc.

To apply counting or numerical specification to a continuous quantity, it must be cut up artificially into units. "Counting" only naturally applies to such things as apples or nuts or atoms. It does not naturally apply to length, or time, or temperature, or electric current, or potential. But length may be expressed numerically by means of the artificial units of feet or miles, which, of course, require definition ; time, in days or weeks or seconds ; temperature, in degrees. The real unit of temperature commonly employed is the interval between freezing and boiling water, which may be subdivided into any convenient similar units, 100 on the centigrade scale, 180 on the Fahrenheit scale.

The fundamental unit of time now employed is the period of rotation of the earth, with which hardly anything interferes, so that it keeps very constant, though not perfectly so. It can be cut up into hours, etc., at pleasure. Another unit that might be employed is the period of revolution round the sun. But the year is not so uniform as the day, and the two are incommensurable: there is no numerical relation between them, except an approximate one, and that is what involves the trouble of Leap Year.

Determining Standards of Measurement

There is no very convenient unit of length. For though the metric system tried to use the distance from Pole to Equator on the earth, it was not known with sufficient accuracy to be of much use. Consequently the unit of length is defined as the length of a certain piece of metal, carefully preserved in the Houses of Parliament or the Mint, as a standard.

This is rather analogous to the unit of resistance. It might be defined as the resistance of a certain wire, carefully preserved at the National Physical Laboratory. But the originators of electrical units were more ambitious than that. They aimed at expressing everything in terms of length, mass and time; that is in terms of centimetres, grammes and seconds, the so-called C.G.S. system, which had served so well for ordinary mechanics and for everything concerned with matter alone.

But the attempt to force electric and magnetic quantities into a mechanical system of units—though it has turned out so valuable—was very enterprising and ambitious; for electricity and magnetism are not concerned with matter alone, but with the ether also, and we have no dynamics of the ether. Most of its fundamental properties are unknown. What we clearly know about it is the rate at which it transmits waves. Consequently some extra convention had to be introduced; and there were two alternatives, one a convention suited to electrostatic measurements, the other a convention suited to magnetic measurements. No selection was made between them; both were employed. One convention is the basis of the electric system, the other of the magnetic system of units. But inasmuch as engineering has not made much use of electrostatics and has made a great deal of use of electromagnetism, the magnetic system has overpowered the other, and practical units based upon it are known to every workman. These things are the volts, amperes and ohms of commerce.

In the determination of these units, however, a great deal of scientific knowledge, skill and ingenuity were involved. Those who are old remember the time when these units did not exist. Very many have contributed to them, but they owe more to Lord Kelvin than to any other single man. Ohm's law was known long before the ohm was defined, and still longer before the names *volt*, *ampere* and *farad* appeared. The units were all named after eminent men of different nationalities. This system of nomenclature has been continued to other units in less common use, such as watt, joule, henry, gauss, maxwell, kelvin, etc.

How the Ohm was Defined and Measured

The first to be accurately defined and measured was the ohm, partly because it was a thing that could be fixed by a piece of metal and stored in a cupboard; which cannot be done with a current or an electro-motive force. Though it is true that a unit electro-motive force can be defined as that of a single Daniell cell (and this was at first employed), so that subsequently the volt was defined as being as near the Daniell cell as it could be—which has turned out rather unfortunate, and introduced an unintended and rather troublesome complexity. If it had been made approximately equal to ten Daniell cells, then the theoretical unit of current would have been 1 ampere, instead of, as it is now, 10 amperes; and the ninth power of 10 would have appeared in all the other units instead of sometimes the ninth, sometimes the eighth and sometimes the seventh.

Resistance was found by theory to be of the nature of a velocity multiplied by a certain unknown constant belonging to the ether, which in our ignorance of its value had to be conventionally called 1. And as the earth-quadrant, that is the distance from Pole to Equator on the earth, had been employed as the basis of the metric system of mechanical units, an ohm was defined as an earth-quadrant per second, or 10^9 C.G.S. units, since an earth-quadrant is approximately 10^9 centimetres.

The difficulty was to incorporate this definition in a piece of wire; and highly elaborate experiments of a metrical character had to be made before this could be done. Lord Kelvin suggested a method, and Clerk-Maxwell put it into operation. A coil of wire, whose resistance had to be absolutely determined in centimetres per second, was spun in the magnetic field of the earth about a vertical axis, thereby generating in the coil, whose ends were joined together so as to form a closed circuit, an alternating current. And the strength of this current was indicated by the deflection of a compass needle at the centre of the coil, after the manner of a tangent galvanometer. The method is not simple, the calculations are elaborate, and the result was not at first precisely accurate. But it served for a time; and the unit arrived at was called a "B.A. Unit," after the British Association Committee, in consultation with which the experiments were conducted and the results published.

Standards of the "International" Ohm

A better and simpler plan was subsequently designed by G. Lorenz, of Copenhagen, on the basis of Faraday's first dynamo arrangement, with a copper disk spinning in a magnetic field, the electromotive force generated being tapped off from axis to circumference by sliding contacts which were applied to the wire carrying the magnetizing current, as to a potentiometer. The old B.A. units or standard coils hitherto used were corrected by this method, and the corrected unit was called an "ohm." At Siemens' suggestion the unit was incorporated in a column of mercury of known length and weight; so that, even if the wire standards were lost or burnt, posterity could reproduce the ohm by constructing a column of mercury of the given dimensions. And at length all nations agreed to what is called "the International ohm," viz. the resistance of a column of mercury contained in a uniform glass tube, at the temperature of melting ice, the mercury weighing 14·4521 grammes and being 106·3 centimetres in length.

For ordinary use, and for the commercial making of resistance coils, carefully made wire standards are most convenient. The old standards are still in existence. For a long time they were in the custody of Sir Richard Glazebrook, at Cambridge, and were carefully examined by him from year to year to test their absolute constancy. They are now in the custody of the National Physical Laboratory, where a splendid Lorenz apparatus, begun by Ayrton, completed and used by F. E. Smith (President of the Physical Society), is established as a permanent and convenient means of measuring any resistance, in absolute measure, that may be required with great precision.

This brief summary must suffice to show the immense labour and knowledge and ability which have been applied to the determination of even one of the electrical units. The units of resistance, current and potential are connected by Ohm's law; and hence if two are determined, all three are known.

A unit of current can be defined in terms of a tangent galvanometer—that is to say, in terms of the magnetic force which such a current, flowing in a circle, produces at the centre. Or, alternatively, the volt might be defined in terms of the electro-motive force generated by a conductor moving at known speed in a magnetic field.

To incorporate these things into concrete units, an improvement on a Daniell cell, called a Clark cell, was for a long time critically examined by the late Dr. Alexander Muirhead at Latimer Clark's works in Westminster. And this is one mode of defining the practical volt.

Determining Second and Third Primary Units

It was found by the late Lord Rayleigh that a current could be measured very accurately by the amount of electrochemical decomposition which it could produce, especially by the amount of silver which it could deposit in an electroplating operation. Accordingly the international ampere is defined as "that constant current which would deposit silver out of a solution of nitrate of silver in water at the rate of ·001118 gramme per second." And this is taken as the second primary unit, the ohm being the first. The international volt is, then, defined as "the electro-motive force which sends an ampere current through an ohm."

The international watt is the work done per second by an ampere driven by a volt. It equals the 746th part of one horse-power, which is a unit of power introduced by James Watt with his early pumping engines. Similarly the coulomb will be the quantity conveyed by an ampere in a second. And the work done by a watt in a second is called a *joule*, which is a unit of energy equal to 10^7 ergs. The kilowatt-hour is a commercial unit of electric energy ; it is sometimes called a kelvin, and it equals 3·6 million joules.

The farad is the capacity of a condenser which requires a coulomb to raise its potential to a volt. It is 10^{-9} C.G.S. units. The unit of magnetic force is often called a *gauss*. It is the strength of a magnetic field which exerts unit force on unit pole. The unit of magnetic induction, which is μ times a gauss (see later), is sometimes called a *maxwell*. The unit coefficient of inductance or self-induction, which was at first called a *secohm*, was named a *henry* at the Chicago International Conference in 1893, after Joseph Henry of the Smithsonian Institution, Washington. It is defined as the induction in a circuit when the electro-motive force induced is 1 volt and the inducing current varies at the rate of an ampere per second. It equals 10^9 C.G.S. units.

Thus we see that the ohm having been defined as 10^9, and the volt unfortunately as 10^8, to bring it near a Daniell cell, the ampere becomes $\frac{1}{10}$ of a C.G.S. unit instead of 1. So does the coulomb. The watt and the joule become 10^7 instead of 10^9. They might all have been 10^9, which would have been much better.

Some Fundamental Considerations

This summary treatment of units must be supplemented by some more detailed reference to the two conventional systems of measurement which lie at the root of all the units and of every kind of electric or magnetic measurement, and which necessarily involve the inter-relation between ether and matter.

The two most fundamental units of all, though they are not employed in practice, are the unit of charge and the unit pole. These are historically, though not quite wisely, defined in terms of Coulomb's two fundamental laws, the outcome of his experiments with his torsion balance more than a century ago, when by direct experiments he proved the law of inverse square. Calling an electric charge e, and a magnetic pole m, Coulomb's well-known laws are as follow :

$$F = \frac{ee^1}{kr^2}; \qquad F = \frac{mm^1}{\mu r^2}$$

where k represents the dielectric constant of the ether, or of any material in which the charges are immersed, and where μ represents the permeability of the ether, or of any substance in which the poles are immersed. These constants can be compared for different materials by processes which give us the relative specific inductive capacity and the relative permeability ; but their absolute values are wholly unknown. k and μ in vacuo are the two great constants of the ether of space. All we know about them is what Clerk-Maxwell taught us, that the product μk corresponds to the speed with which the ether transmits waves (*see* Waves). The velocity of light is in fact $C = \frac{1}{\sqrt{(\mu k)}}$ a relation which has been proved up to the hilt by a great number of determinations. But what μ is, and what k is, remain for posterity to find out. Hence even in an Encyclopedia of this kind our ignorance must be mentioned and emphasized, since who knows who may be stimulated by the outstanding possibility of discovery ? A treatise on the ether would say more about this subject.

Discoveries in Physics yet to be Made

The conventional basis of the electrostatic system is to consider $k = 1$ in vacuo—in other words, to ignore it. The system is complete in itself on this convention, but the fact of ignoring the constant should never be forgotten.

The conventional basis of the magnetic system of units is to call $\mu = 1$ in vacuo—in other words, to ignore it. This system, again, is internally consistent, and it is on this basis that the practical conventional system of units is founded. But the two systems are quite inconsistent with each other until the constants are introduced. They are connected by the vitally important relation $\mu k c^2 = 1$.

The above separate electric and magnetic relations, based on Coulomb's law, must be supplemented, as a basis for units, by an electro-magnetic relation expressive of the fact that a current in a coil behaves like a magnet, of moment ml, such that

$$ml = nAI\mu,$$

where A is the area enclosed by the coil, n the number of turns of wire, and I the strength of current in absolute units (of which each equals 10 amperes), while μ depends on the material inside the coil, especially on whether it contains iron or not. The right-hand side of the above equation is commonly spoken of as the "ampere turns" for a coil of given size.

In specifying any physical quantity, not only a number is required, but a specification of the unit as well. A length 3 means nothing, but 3 miles is definite. A speed 30 means nothing unless we add miles per hour or centimetres per second. So, also, with electrical quantities; ohm, volt, etc., should always be written after the number, and it is well to write the *name* of the unit or its abbreviation, and not to use a symbol. Algebraic symbols ought to represent the quantity itself—the whole quantity, including both number and units. The velocity of light, for instance, is a definite thing, no matter how or in what units or by what number it be expressed. So is the length of a table.

Numerical equations can only be true when the units are specified, but v means a velocity, not a number, and it requires no unit specified. It is complete. So ought I and C and R and L to be complete in themselves, and they ought to be so understood. Algebraic expressions and equations ought to be true in every possible consistent system of units. But, for that to be true, things *must* be expressed in absolute measure; no factor must be ignored or "understood" or neglected. That is the meaning of absolute measure; the quantity so expressed is completely expressed, and then its numerical interpretation can be made in any system of units we please. To understand absolute measure, we must know the "dimensions" of units, and the dimensions are bound to be the same on both sides of every equation.

Dimensions of Units. Since we do not know what an electric charge is, though we are quite familiar with it as an electron or group of electrons, we cannot express its dimensions, *i.e.* its fundamental nature, in mechanical units. But we can say that the dimensions of electric charge are

$$e = l\sqrt{(k\mathrm{F})},$$

where l is a length and F is a mechanical force.

Similarly, we can say that the dimensions or fundamental nature of a magnetic pole are

$$m = l\sqrt{(\mu\mathrm{F})};$$

and that is as far as we can go until we know more.

An electric current, being a charge divided by time, is

$$\mathrm{I} = v\sqrt{(k\mathrm{F})},$$

where v is a velocity.

An electro-motive force, defined in terms of a conductor moving in a magnetic field, is

$$\mathrm{E} = v\sqrt{(\mu\mathrm{F})}.$$

Hence resistance, which is the ratio of E to I, is

$$\mathrm{R} = \sqrt{\left(\frac{\mu}{k}\right)}.$$

And this, by the fundamental relation between μ and k, is equal to μ times a velocity.

All these relations are absolute. They are not conventions. They are true in every system of units. And that is what we mean by saying that resistance comes out as a velocity. It is not really a velocity, nor anything mechanical at all. We do not know what it really is, but it is certainly μ times a velocity. And if, conventionally, we call $\mu = 1$, resistance becomes conventionally a velocity. And so an ohm may be expressed in centimetres per second, or miles an hour, or any other units of speed we please. One ohm is an earth-quadrant, or 10^9 centimetres, per second. Hence 30 ohms is μ times the velocity of light.

Why the Farad is so Large a Unit

If we proceed to specify the dimensions of other quantities, capacity of a condenser comes out

$$\mathrm{C} = kl,$$

and inductance of a coil comes out

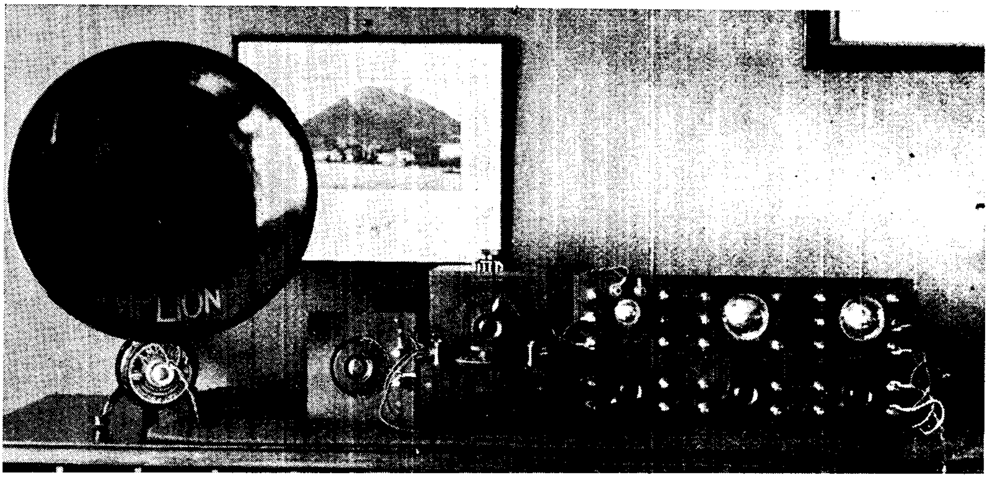
$$\mathrm{L} = \mu l,$$

l being some length representing the dimensions and details of the particular condenser or coil we are dealing with. Hence, on the appropriate conventional system, each of those may be expressed as a length. On the magnetic system, the unit of inductance, 1 henry, is an earth-quadrant, or 10^9 centimetres.

But the unit of capacity is not so simple on the magnetic system. It is simple enough on the electrostatic system, as seen above. But if we express it in terms of μ, instead of in terms of k, we must write it as

$$\frac{\mu k l,}{\mu}$$

and then replace the product μk by $\frac{1}{c^2}$;



FOR AMATEUR CONSTRUCTION: A HIGHLY EFFICIENT UNIT RECEIVER

Fig. 1. Unit components only have been employed in the construction of this receiver, whose excellence has been proved by results. In it are incorporated a detector and two low-frequency valves and a loud speaker

that is, we must divide a number specifying it on the k system by the square of the velocity of light, viz. 9×10^{20}. That is how the 9 comes in, and why the farad is such a big unit. On the magnetic system it is not a length at all; while if expressed on the electrostatic system it is a very big length, because to go back to that system we must re-multiply by c^2. Hence, expressed as a length, the microfarad is 9 kilometres, and the farad a million times that.

The most interesting aspect of these electrical and magnetic units is to see when the unknown quantities cancel out, so as to give us real mechanical results. This will be found to occur in the following cases:

When charge and potential are multiplied together the constants disappear and we get simple energy, showing that electrical energy is interchangeable with other forms. Other expressions which give energy are

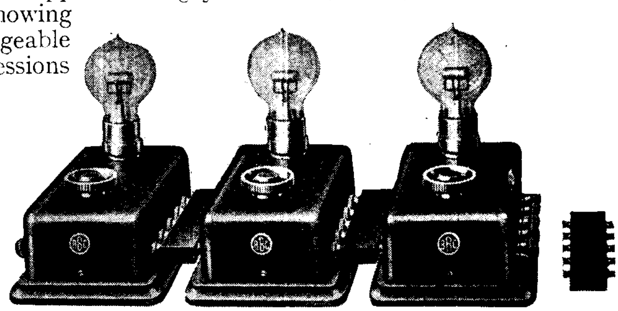
$$RI^2t,\ \tfrac{1}{2}CV^2,\ \tfrac{1}{2}LI^2.$$

Again, certain combinations yield simple time; for instance,

$$\frac{L}{R},\ RC,\ \frac{1}{\sqrt{CL}}.$$

So here, again, we come down to simple mechanical quantities, and accordingly these expressions are of great importance. They are all concerned with the time constants of either a coil or a condenser, or both. Of the above three, the first belongs to a coil, the second to a condenser, and the third to an oscillating circuit consisting of coil and condenser, or, what is the same thing, to an aerial. And upon it depends the frequency of oscillation, and accordingly the wave-length. All which facts naturally appear under their proper headings, Capacity, Frequency, Induction, Oscillation, etc.

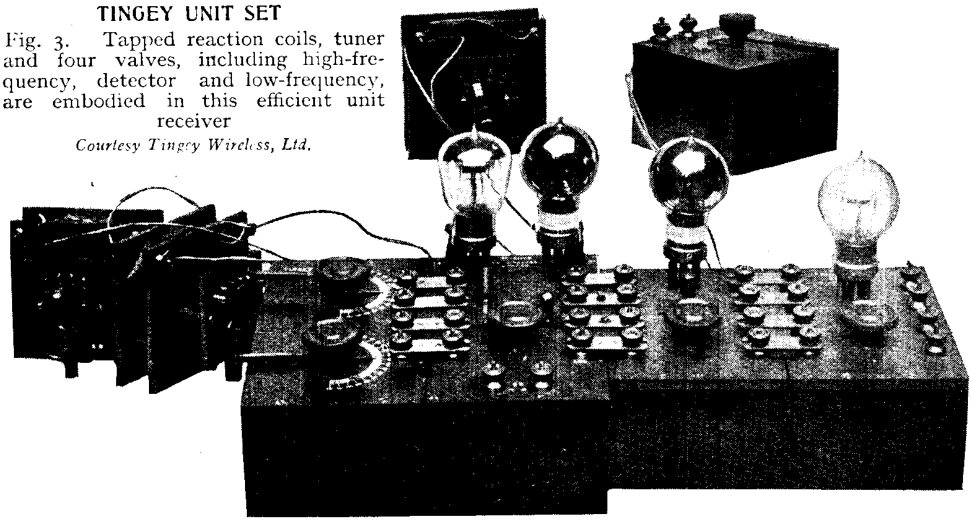
UNIT SET. Expression applied to a receiving or transmitting set built up from a series of individual units. One such arrangement (Fig. 1), comprising a three-valve set consisting of detector and two low-frequency valves, enables loud speaker to be played with good volume. Another example of a unit set, made by the Tingey Wireless, Ltd., is illustrated in



STERLING UNIT SET

Fig. 2. In this set the noteworthy feature is the connecting plugs, which enable each component of the unit set to be quickly joined up to the next

Courtesy Sterling Telephone & Electric Co., Ltd.



TINGEY UNIT SET

Fig. 3. Tapped reaction coils, tuner and four valves, including high-frequency, detector and low-frequency, are embodied in this efficient unit receiver

Courtesy Tingey Wireless, Ltd.

Fig. 3, which shows the principal tuning units and other elements arranged to form a four-valve set.

An example of the Sterling unit is illustrated in Fig. 2, which shows their patented system of interconnecting plugs. These consist essentially of a block of ebonite with five contacts on each side. All the units are standardized, and to assemble them in any desired manner it is only necessary to arrange them in order and to connect them with the patent plugs.

There are many other makes of unit sets on the market; all are, however, characterized by the fact that the units can be arranged in various orders. *See* Amplifier; Condenser Unit; Crystal Detector Unit; Detector Unit, etc.

UNIVERSAL TUNER: AN EXPERIMENTAL SET FOR THE AMATEUR

How to Construct an Invaluable Apparatus for Circuit Experiments

In the universal tuner switches enable the experimenter to try out different circuits for different purposes and to select the best circuit for any particular broadcasting station. Reference should also be made to the headings Amplifier; High-frequency Amplifier; Tuning; Valve Sets, etc.

A type of tuner in which a number of circuits or arrangements of the wiring may be made by means of switches. The universal tuner usually has two variably coupled inductances in the aerial tuning circuit for primary and secondary tuning, the inductances being introduced into the circuit by means of a double-pole double-throw switch. This switch, used in this connexion, is called a stand-by tune switch. Another common feature of the universal tuner is a similar switch to the stand-by tune switch, and enables a series or parallel arrangement of the primary tuning condenser with respect to the primary inductance to be made. A third switch is sometimes employed for reversing the current to the reaction coil, which reversal is required when an additional stage of high-frequency amplification is added to the set.

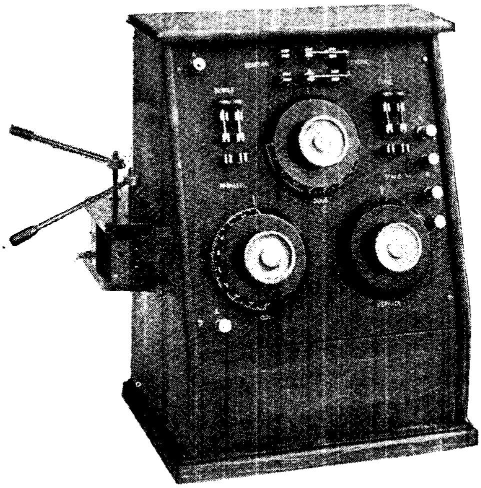
A universal tuner incorporating these features is illustrated in Fig. 1, while an article dealing with the methods of operating and tuning the instrument will be found under Tuning (*q.v.*). A three-coil holder for the primary, secondary and reaction coil is attached to the left side of the case. The reaction reverse switch is centrally situated at the top of the panel, while the series-parallel and stand-by tune switches are fitted to the left and right side of the panel respectively.

Between these switches the secondary circuit tuning condenser is placed. This condenser has a maximum capacity of ·0005 mfd., and has a vernier condenser shunted across it for fine tuning. The condenser in the primary circuit is of ·001 mfd. capacity, and occupies the lower left-hand side of the panel. Aerial and earth terminals are attached to the left of the instrument, and terminals for connexion to the crystal or valve part of the receiver are placed to the right. Between these terminals two reaction terminals are placed.

The dimensioned case is illustrated in Fig. 2. Fillets of wood, $\frac{1}{4}$ in. square, are fastened to the inside of the sides of the case, to which the panel is subsequently attached from the outside.

Provided sufficient depth is obtained for the largest condenser, the case may be made to individual requirements to match other apparatus used in conjunction with it. It is important also to place the coil holder in a position which allows the coils to swing about a vertical axis.

The panel is cut and fitted to the dimensions given in Fig. 3 of the lay-



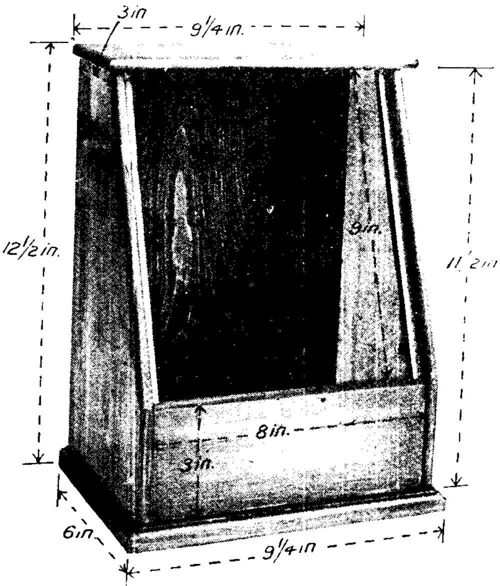
COMPLETED UNIVERSAL TUNER

Fig. 1. This very neat instrument is easily made by the amateur. The tuning coils are attached to the three-coil holder on the left of the instrument

out of the panel. The top and bottom of the panel are filed off at an angle to make a good fit at the top and front side of the case, if the case illustrated is employed.

If the condensers for the instrument are to be purchased, the central fixing type is recommended. In this type all that is required in mounting is to drill a hole, which is usually of $\frac{3}{8}$ in. diameter, in the correct position, and after removing the nut from the screwed bush the latter is pushed through the hole from the back of the panel, after which the nut is tightened down. Fig. 4 illustrates a back view of the panel with the condensers in position.

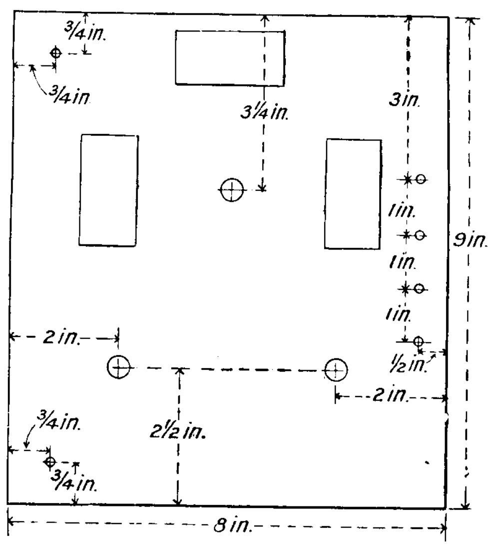
Aerial and earth and reaction terminals are fitted, taking care that the nuts are securely tightened up.



CABINET FOR THE TUNER

Fig. 2. From these dimensions the constructor will find the necessary data with which to proceed to the making of the case

The appearance of the set is largely made or marred in the selection or construction of the switches. The type shown in Fig. 1 is recommended. These were constructed from sets of complete parts of commercial make, and are nickel-plated.



LAY-OUT OF THE PANEL

Fig. 3. Here are given the complete dimensions of the panel, showing the relative positions at which to drill for the different components

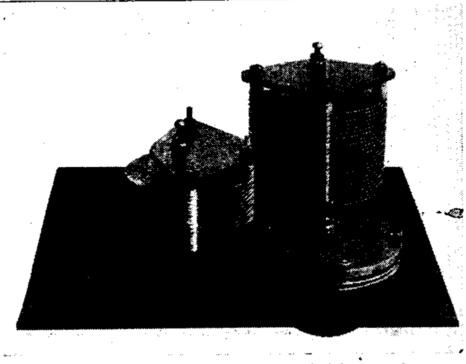


Fig. 4. Positions of the three variable condensers behind the panel. The one on the right to the front is a vernier for fine tuning

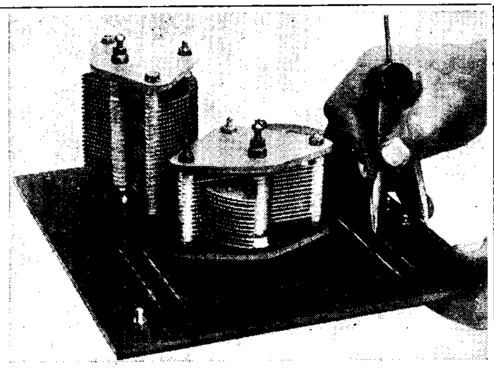


Fig. 5. Scribing the marking-out lines for the switches. One leg of the scriber runs along the panel edge to keep the lines parallel

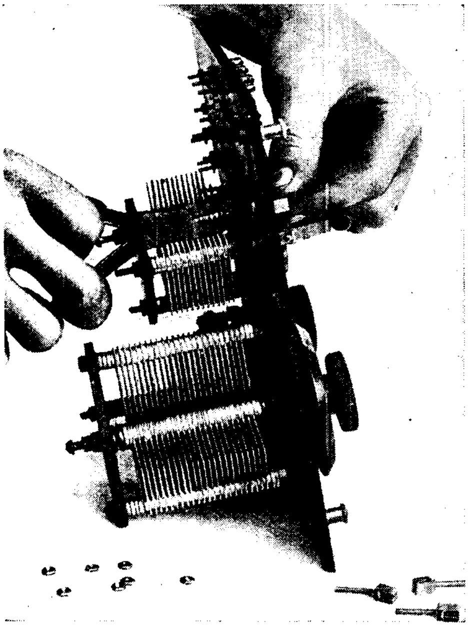


Fig. 6. Here the switch contacts are being fixed in position with a pair of square-nosed pliers

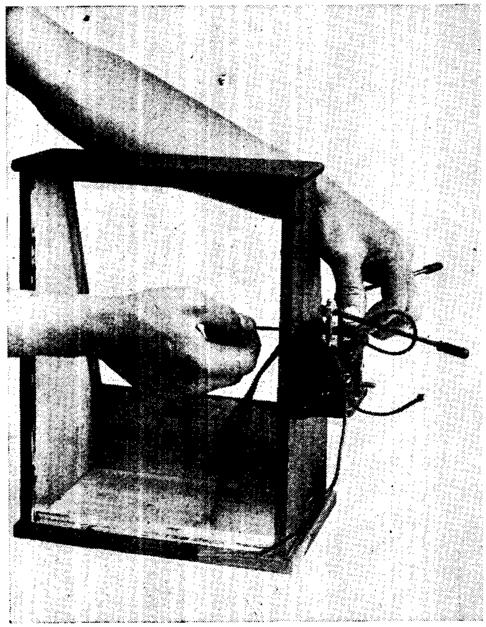


Fig. 7. After the coil holder has been fitted the connecting wires are pulled through

STEPS IN THE CONSTRUCTION OF THE HOME-MADE UNIVERSAL TUNER

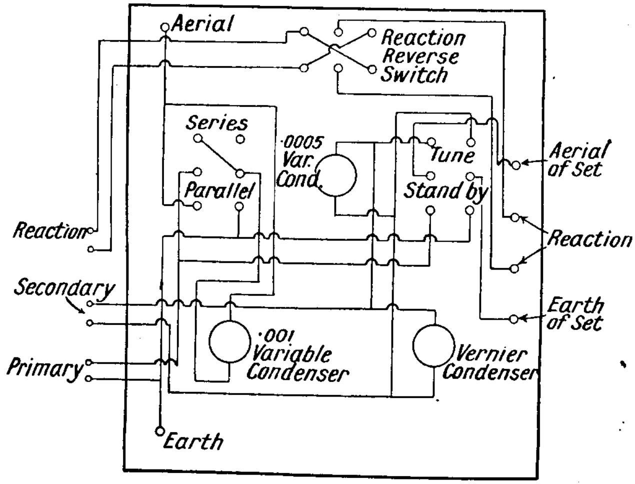
In fitting the switches, care must be taken to set the contacts dead in line. The best method is to scribe two parallel lines in the positions required for each set of contacts, using the edge of the panel as a guide in the manner illustrated in Fig. 5. Holes, marked on these lines to suit the switch, should be drilled out accurately. The positions of the holes at right angles to these are determined by placing a square against the side of the panel and scribing correctly.

In Fig. 6 the switch parts are being assembled, the left hand preventing the contact from rotating while a pair of square-nosed pliers gripped in the right hand tightens the nuts at the back.

Wiring is carried out according to the diagram given in Fig. 8. Any suitable type of three-coil holder to fit the standard duo-lateral coil may be used, and is attached centrally to the left side of the case when viewed from the front. Short lengths of electric light flex are joined to the connecting screws of the plugs, and are then pulled through holes drilled through the side of the case, as illustrated in Fig. 7.

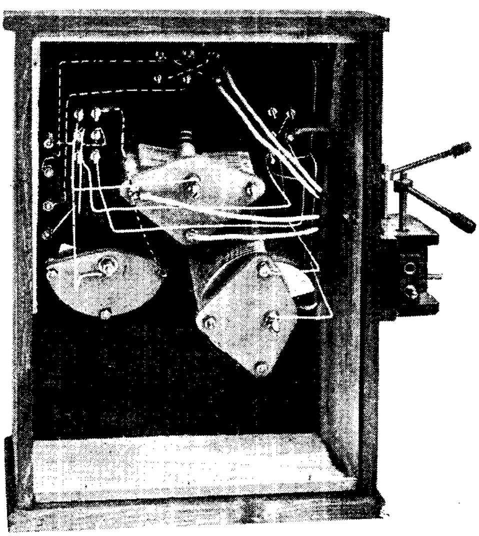
At this stage the panel is attached to the case by means of four round-headed wood screws driven into the fillets. This operation is shown in Fig. 10. The flexible connecting wires should be soldered to their correct points of contact. The aerial tuning secondary coil occupies the centre and fixed plug, while the primary coil is fitted to the plug nearest the front of the instrument.

The completed wiring is given in Fig. 9, which shows the connecting wires from the reaction coil plug, which is that to the back



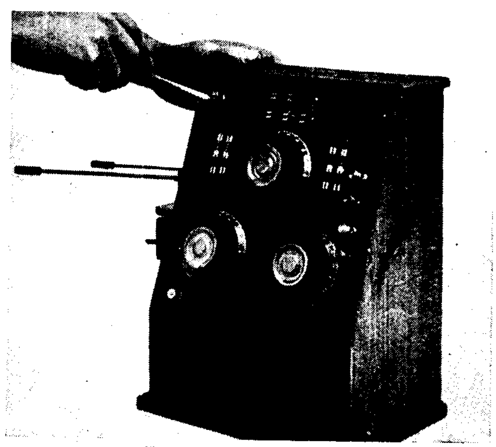
WIRING DIAGRAM OF THE TUNER

Fig. 8. In this circuit diagram full details are given of the connexions to the switches of the universal tuner



COIL-HOLDER CONNEXIONS

Fig. 9. Back view of the completed set before the back is fitted, showing the complete wiring and connexions to the coil holder



FITTING THE PANEL

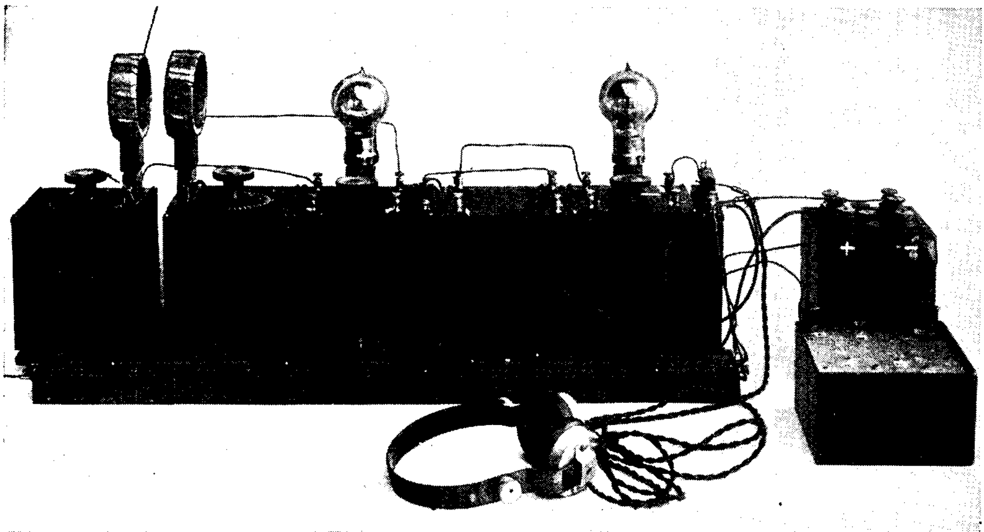
Fig. 10. Wooden fillets are provided in the inside of the cabinet, and to these the panel with its mounted components is fitted

of the case, to the reaction reverse switch. The connecting wires from the secondary coil are shunted across the secondary condenser in the manner employed with the vernier condenser. The leads from the primary coil, as shown in the circuit diagram, connect to a contact on each switch and to earth. *See* Tuner; Tuning.

UNIVERSAL UNIT SET. Expression applied to wireless receiving components characterized by the facility that they offer for the ready construction of receiving sets with different circuit arrangements. There are many commercial unit sets, such as the Polar, which has been described in this Encyclopedia under that heading, Radio Brix, marketed by the Metropolitan-Vickers Co., Ltd., and others.

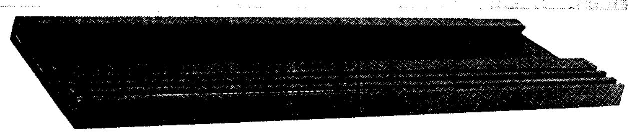
One admirable method for the amateur constructor is that illustrated in Fig. 1, which shows a few units suitably connected for a two-valve circuit. The essential feature of this design is that all the components are contained in square-shaped cases, this being done to enable the components to be placed side by side in any desired combination, and also for other reasons which will become apparent later.

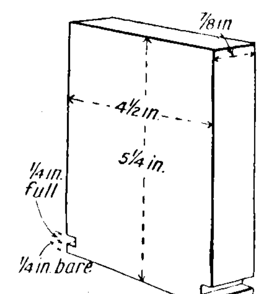
The system adopted is to provide a baseboard to which these components may be

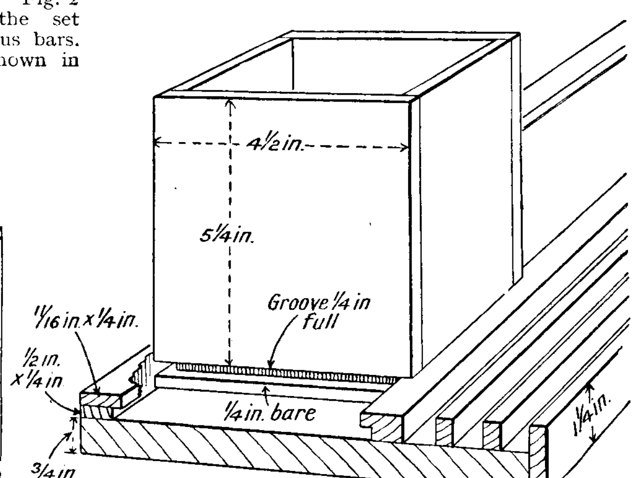


UNIVERSAL UNIT RECEIVER

Fig. 1 (above). Here the units are set up as a two-valve set, comprising one stage of tuned H.F. with reaction, crystal detector, and one stage of L.F. amplification. Fig. 2 (right.) Baseboard for the set showing troughs for the bus bars. These troughs are also shown in section in Fig. 4





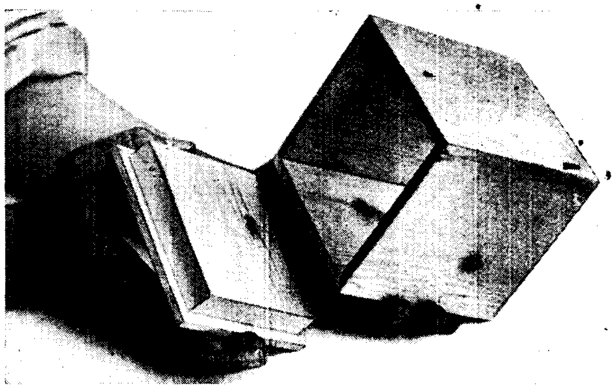


DIMENSIONS NECESSARY IN CONSTRUCTING THE UNIVERSAL UNIT SET

Fig. 3 (left). Dimensions of the block used for supporting the fixed condensers. Fig. 4 (right). Here the grooves are shown in which the units move, and also those for the sliding contacts

easily attached by simply sliding the bottom part of the case in the grooves in the baseboard. When this has been done, the whole virtually becomes a complete receiving set that can readily be transported. In preparing these units and during their construction it is imperative that the basic sizes be scrupulously adhered to, so that the parts will be interchangeable. This need not, however, call for very elaborate workmanship, as the only parts that are vitally important are the regularity of the bottom grooved portion of the case and the width of the baseboard groove.

The heights of the cases should be uniform, to give a neat appearance. To ensure interchangeability, a metal template should be prepared for gauging the baseboard, and another for gauging the bottom of the cases. The dimensions of the groove in the baseboard and the dimensions for the case are given in the outline drawing, Fig. 4, and are suitable for a whole range of components which have to be enclosed within the cases. The dimensions for the block for the support of the fixed condensers and other small units are given in the outline diagram, Fig. 3, the widths of any of which are such that they can be mounted directly on the top of the panel.

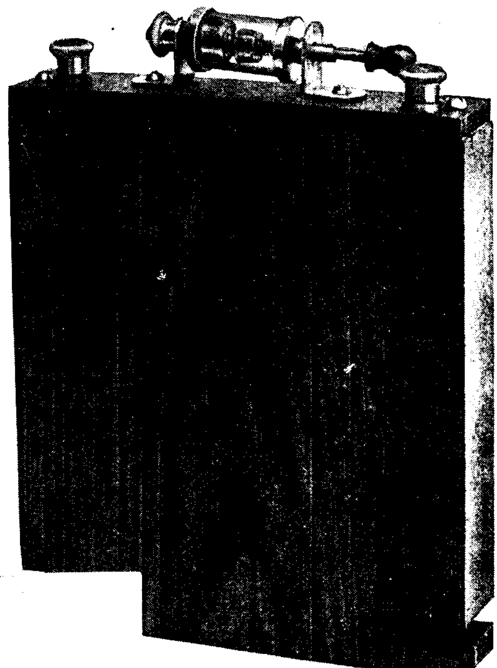


PREPARING THE CASE

Fig. 5. Five cases, at least, such as this should be constructed, all being exactly of the same size

The baseboard may be of any desired length. For practically any combination circuit up to and including two valves and crystal detector, a length of 26 in. will be sufficient. The baseboard itself comprises a lower portion made from mahogany or other sound timber clamped at each end and measuring $7\frac{1}{2}$ in. wide and $\frac{3}{4}$ in. in thickness. To one edge of this is attached an upright strip of wood $1\frac{1}{4}$ in. in width and $\frac{1}{4}$ in. in thickness. On the top of the baseboard and at the opposite side is attached a strip of wood $\frac{1}{2}$ in. in width and $\frac{1}{4}$ in. in thickness. Another similarly sized strip is attached to the upper part of the base at the correct gauge distance apart, namely $4\frac{9}{16}$ in. These should be glued to the base and be secured with screws from the underside, and covered by other strips $\frac{11}{16}$ in. wide.

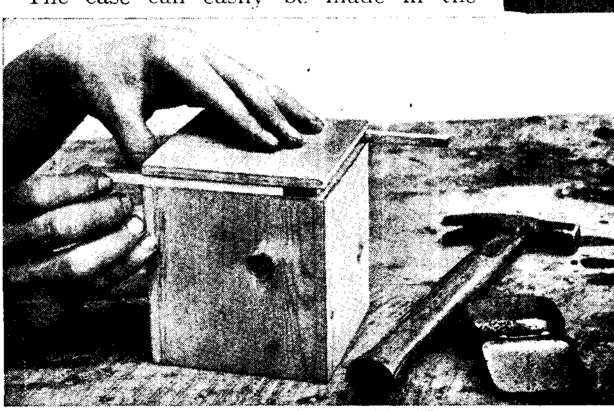
Two other strips of wood, $\frac{1}{2}$ in. high and $\frac{1}{4}$ in. thick, are then equally spaced between the second strip and the narrow upright edge, thus forming three grooves or troughs, as can clearly be seen in Fig. 4.



CRYSTAL DETECTOR UNIT

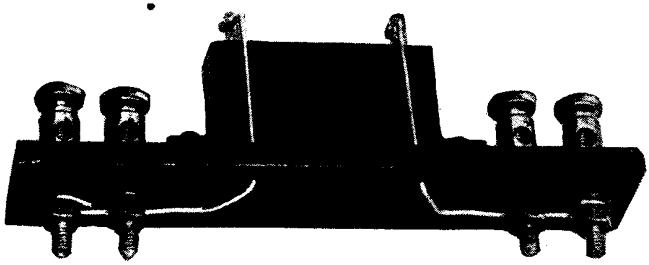
Fig. 6. The shape of the grooved block is well shown here. The crystal detector and terminals have been fixed in position

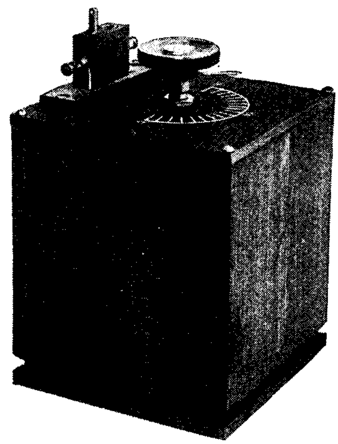
The case can easily be made in the manner illustrated in Fig. 5. This is best accomplished by cutting four pieces of material, with the grain running upwards, to the heights given in Fig. 4. Two of these pieces should be 4 in. in width, and the other two $4\frac{1}{2}$ in. in width. They are simply



GAUGING THE GROOVES

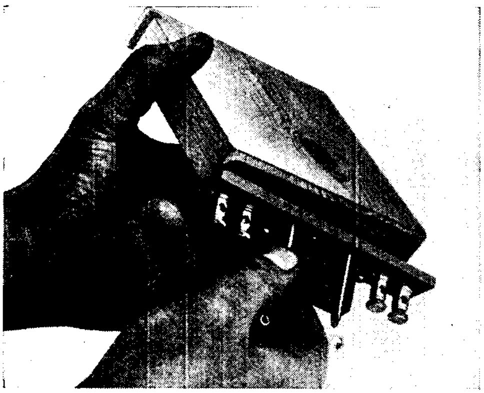
Fig. 7. During the assembly it is important that the grooves be gauged, for if the rebate is not of the same thickness throughout, the cases will not run freely





TELEPHONE CONNEXION UNIT

Fig. 8 (above). As is clearly shown here the fixed condenser is shunted across the telephones. Ebonite is the material used for the base on which terminals and condenser are mounted. Fig. 9 (right). Complete tuning unit, showing the plug-in coil holder



MOUNTING THE TELEPHONE CONNEXIONS

Fig. 10. As indicated, the block is grooved so that the undersides of the telephone and condenser connexions do not touch the wood

glued and pinned together at the corners to make a rectangular case. The bottom is made from a piece of 1 in. prepared timber, which when planed up on both sides will finish up $\frac{7}{8}$ in. thick. This has then to be rebated on all four sides to the dimensions already given. The rebate should be of such a size that the bottom will just fit into the case, the appearance at this stage being seen in Fig. 5.

A sufficient number of cases should be prepared at the same time. The base is fixed to the sides by simply gluing the interior lower part of the case, standing it erect on the bench, and inserting the bottom into the opening. The width of the groove can best be made exact by inserting two slips of wood, as shown in Fig. 7, these slips having been prepared to the correct width of the groove. Fine pins or small oval brads are then driven in through the sides into the bottom, and when the glue has set the result will be a sound case.

The same size of case is used for the valve unit, low-frequency transformer unit, and, if required, for the high-frequency transformer unit.

In addition to these cases; it is necessary to provide several wood blocks with a width and height corresponding with those of the cases, and notched at their lower ends to slide into the grooves. The thickness of the blocks may conveniently be $\frac{7}{8}$ in. They are used for the fixed condenser, crystal detector and telephone connexion units. To finish these, small strips of ebonite should be cut to such a size as will just cover the tops of the blocks, to which they are screwed.

In the case of the crystal detector, which is illustrated complete in Fig. 6, a small enclosed type can be obtained and mounted directly on to the ebonite block. Connexions are made from the two supports for the crystal, and attached respectively to the two terminals near the other end of the ebonite strip, the connexions being made beneath the ebonite. The fixed condenser units are made in the same way, and are connected, in the case of the telephone unit, to two pairs of terminals, as is clearly shown in Fig. 8. The condenser in this case should have a value of ·001 mfd., and be of the Dubilier type 600 A.

A groove will have to be cut in the upper part of the block so that the undersides of the terminals and the connecting wires do not touch the wood. This groove, which can easily be made with a gouge, is clearly shown in Fig. 10, which also illustrates the telephone bar.

Similar units should be provided for the fixed value condensers to be used across the transformer and in other parts of the circuit. These, however, only require one pair of terminals, one side of the condenser being connected to one terminal and the other side of the condenser to the opposite terminal. A similar construction is adopted for the grid leak and condenser unit, with the addition of the clips of the grid leak, which should be of the detachable type.

The tuning unit is erected on an ebonite panel $4\frac{1}{2}$ in. square and $\frac{3}{16}$ in. thick, which is ultimately screwed to the top of the square case. To the underside of this panel is attached an ordinary variable air condenser, and to the upper side of the panel is connected an ordinary standard plug-in coil holder. The condenser should be of the single-hole fixing pattern, which is very quickly fitted.

The connexions are then made by ordinary tinned copper wire from the fixed plates to one side of the coil holder and from the moving plates to the other side of the coil holder. In the usual pattern of coil holder the terminals are attached thereto, and these, if fitted, should be connected, as already described,

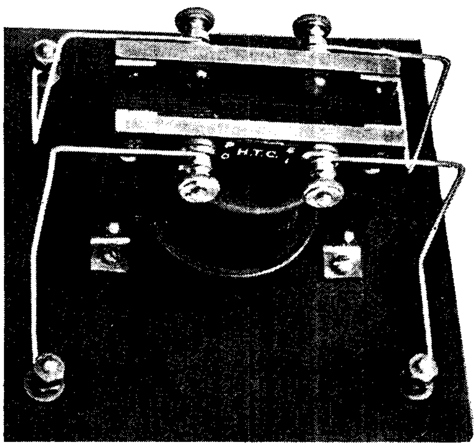


Fig. 11. Underside of the L.F. transformer unit, showing the connexions

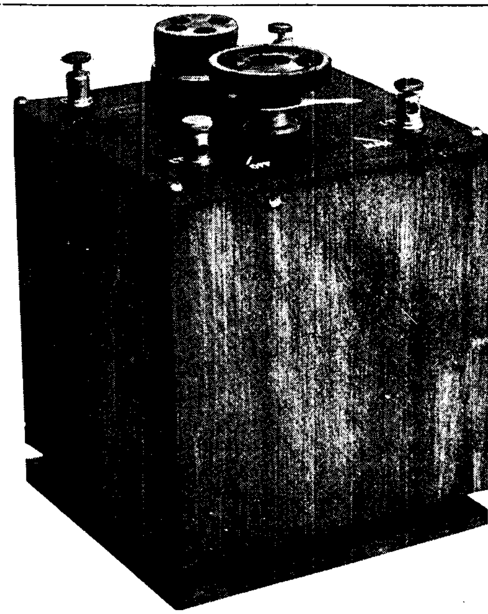


Fig. 12. Valve unit, with standard valve holder and filament resistance

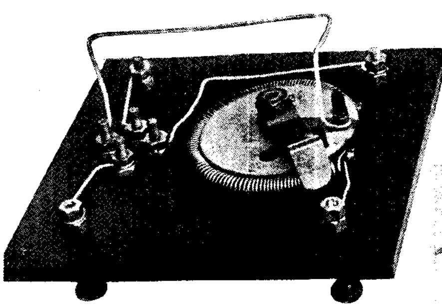


Fig. 13. Connexions of the valve unit, showing wiring to the filament resistance and valve terminals

Fig. 14. Flexible connexions used with the universal set, showing the sliding contact

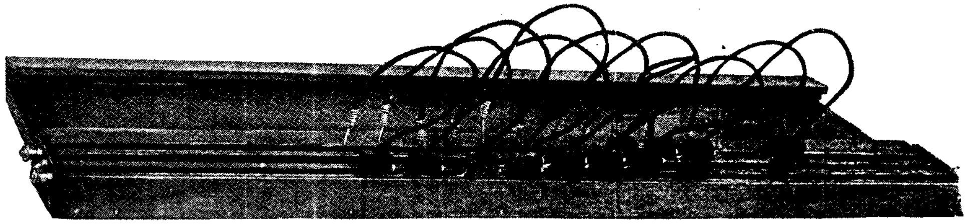
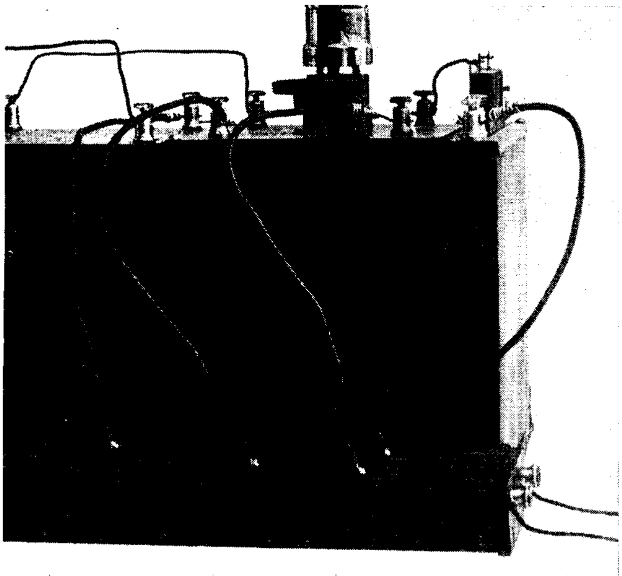


Fig. 15. Baseboard, showing the connexions and the sliding contacts

CONSTRUCTIONAL DETAILS OF THE UNIVERSAL UNIT SET



CLOSE-UP VIEW OF THE CONNEXIONS

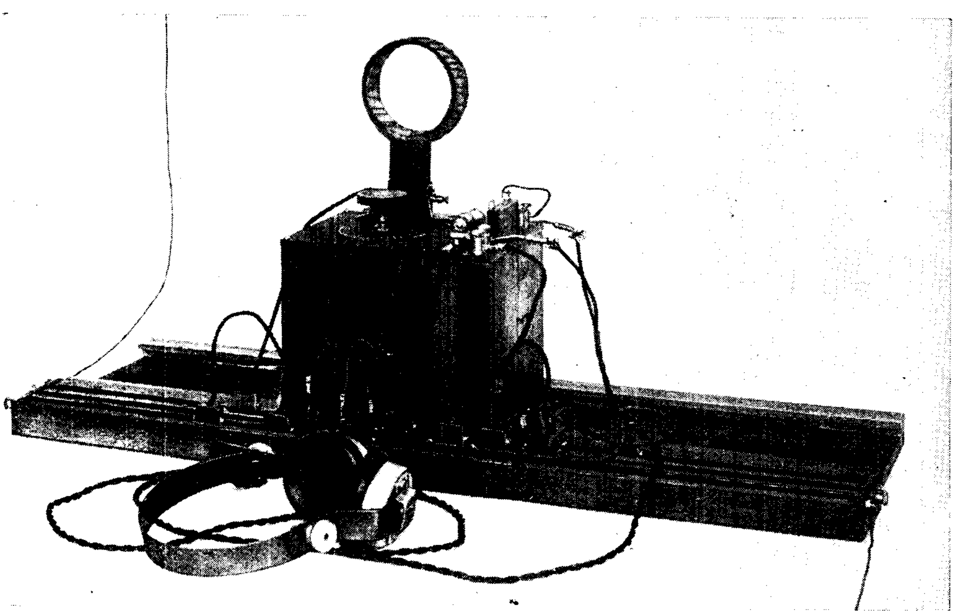
Fig. 16. This illustration is of use in showing how the connexions are made with the contacts in the universal unit set

size of condenser dial is too large to clear the coil holder. When this unit is used with a coil, connexions need only be made to the two terminals on the coil holder. If the condenser alone is required, the coil is removed.

The low-frequency transformer unit merely consists of an ebonite panel for the top of the case, to the underside of which is attached a low-frequency inter-valve transformer, the four terminals of which are connected to four telephone terminals located near the corners of the panel, as shown in Fig. 11. The terminals on the top of the panel should be marked to correspond with those on the transformer itself.

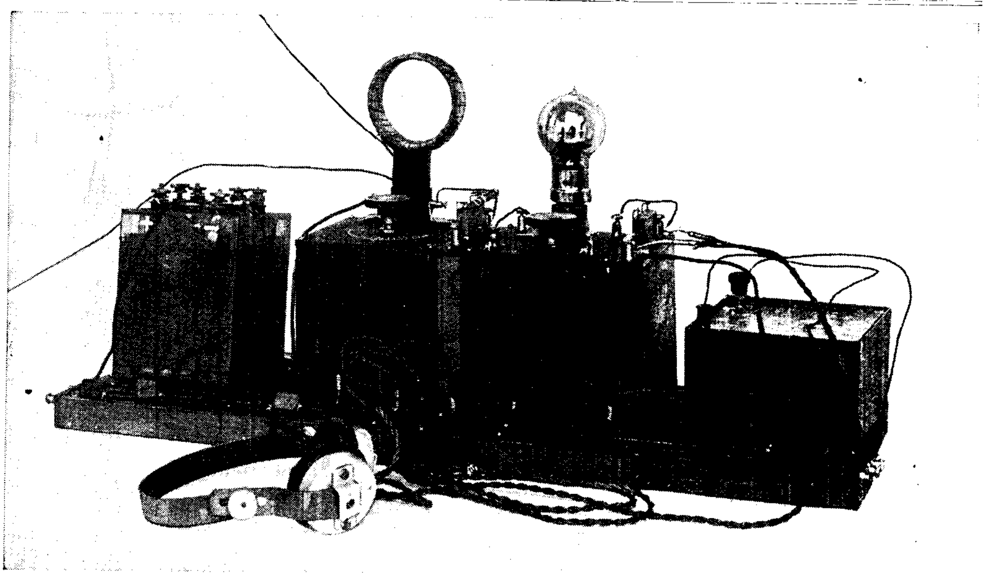
The valve unit is illustrated complete in Fig. 12, and comprises a standard valve holder on the upper side of the panel, and an ordinary filament resistance of suitable value for the valves which it is intended to use on the other side of the panel, connexions being brought out to four telephone pattern terminals arranged

to the condenser, in which arrangement the condenser is in parallel with the coil holder. A pointer and knob should be provided for the condenser and a scale marked on the upper side of the panel, as is shown in Fig. 9, as the ordinary



UNIT SET IN USE AS A CRYSTAL DETECTOR

Fig. 17. Here three units are used, these being a tuner, crystal detector unit, telephone and condenser unit



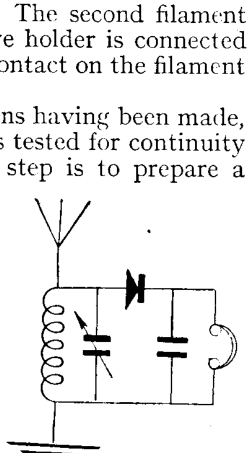
SINGLE-VALVE SET BUILT UP FROM UNITS

Fig. 18. Four units are used here: a tuner, valve unit, grid leak and condenser, and telephone and condenser unit. The usual batteries are employed

on the upper side of the panel. The connexions are shown in Fig. 13, and are made with tinned copper bus bar.

One wire is taken from the plate terminal of the valve holder to one of the telephone-type terminals; another connexion is similarly made from the grid terminal of the valve holder; one of the filament terminals of the valve holder is connected directly to the third telephone-type terminal. The fourth terminal is connected to the resistance wire of the filament resistance. The second filament terminal of the valve holder is connected to the moving arm contact on the filament resistance.

All these connexions having been made, and the separate sets tested for continuity of circuit, the next step is to prepare a sufficient number of sliding contacts for use in connexion with the baseboard. The contact can be made as shown in Fig. 14, and consists of a length of heavily insulated single flexible wire about 10 in. in length, one end provided with a terminal tag; while the other end passes through a hole drilled diagonally through a small block of ebonite $\frac{3}{4}$ in. in length, $\frac{1}{2}$ in. in width, and $\frac{3}{16}$ in. in thickness.



THEORETICAL CIRCUIT

Fig. 19. Circuit diagram for the crystal receiver unit set

To the underside of this block is attached a tubular brass contact. This is made from brass tube $\frac{1}{8}$ in. bore, about $\frac{3}{16}$ in. outside diameter and about $1\frac{1}{4}$ in. in length. One end is slit with a hack-saw for a distance of about $\frac{5}{8}$ in., and the parts squeezed together with a pair of pliers. The other end has a saw cut made about half-way through the tube at a distance of $\frac{1}{4}$ in. from the end. Another saw cut is made lengthways to the tube to break into the cross cut. The piece of tube which then remains is then flattened and carefully bent over at right angles, thereby forming a fastening tag. A hole is drilled through this for a small brass screw which is tapped into a hole in the end of the ebonite block.

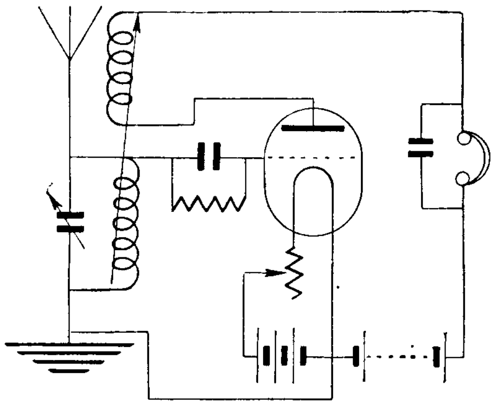
This holds the brass contact to the block at one end, the bared ends of the flexible wire being carefully soldered to the upper side of the tube at the front end. For this reason the hole for the wire is drilled diagonally, commencing it at about the centre of the top of the ebonite block and coming out at the lower front corner. Arranged in this way, the contacts are quite firm and durable. These contacts are then threaded on to a length of $\frac{1}{8}$ in. diameter brass wire, and fitted closely thereto so as to make good contact.

Three of these bus bars are required, and should be screwed at each end. They are mounted centrally in the three grooves in the baseboard, and are supported at each end by ebonite plates having three holes drilled through them, through which the bus bars are passed. The ebonite plates are screwed to the end of the baseboard, and the bus bars placed through the holes and secured firmly with lock nuts at each end, terminal nuts being provided at either end as required.

To avoid any chance of the tags short-circuiting, holes should be drilled through the baseboard so that the contacts can be plugged in when they are not in use, the whole arrangement being clearly shown in Fig. 15. Normally it will be found that the best arrangement for these three bus bars is to use the centre one for the low-tension negative, high-tension negative and earth connexions, using the inner bar for the high-tension positive and the outer for the low-tension positive.

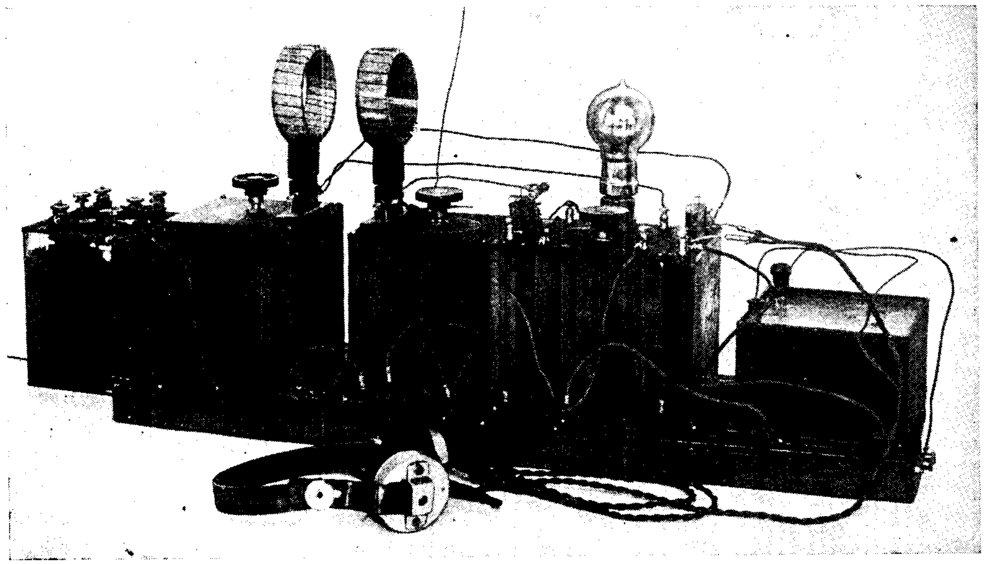
To prove that all the contacts are good, a battery can be connected to one end of one of the bus bars and the circuit completed through a buzzer or telephone to each of the contacts in turn which slides upon that bar.

Apart from the provision of the usual batteries and valves, the units are now ready to be assembled, and a great many circuits can be tried. The principle of the connexions is shown in Fig. 16, which illustrates a close-up detail of one end of the baseboard and some of the units. Connexion of the high-tension positive, for example, to the telephones, is instantly effected by sliding one of the contacts on that bar to one of the telephone terminals. For the filament-lighting circuit, for example, the connexion from the low-tension positive bar is made to one of the filament telephone-type terminals, and another connexion made to the centre bus bar, this being seen in Fig. 16, any unwanted connexions being plugged into



CIRCUIT DIAGRAM

Fig 20. Here the connexions are shown that are employed in the single-valve set shown in Fig. 18



UNIVERSAL UNITS IN A REACTION SET

Fig. 21. To all appearances this set would seem to differ but little from that shown in Fig. 18, except in the use of two tuning units instead of one, to obtain reaction

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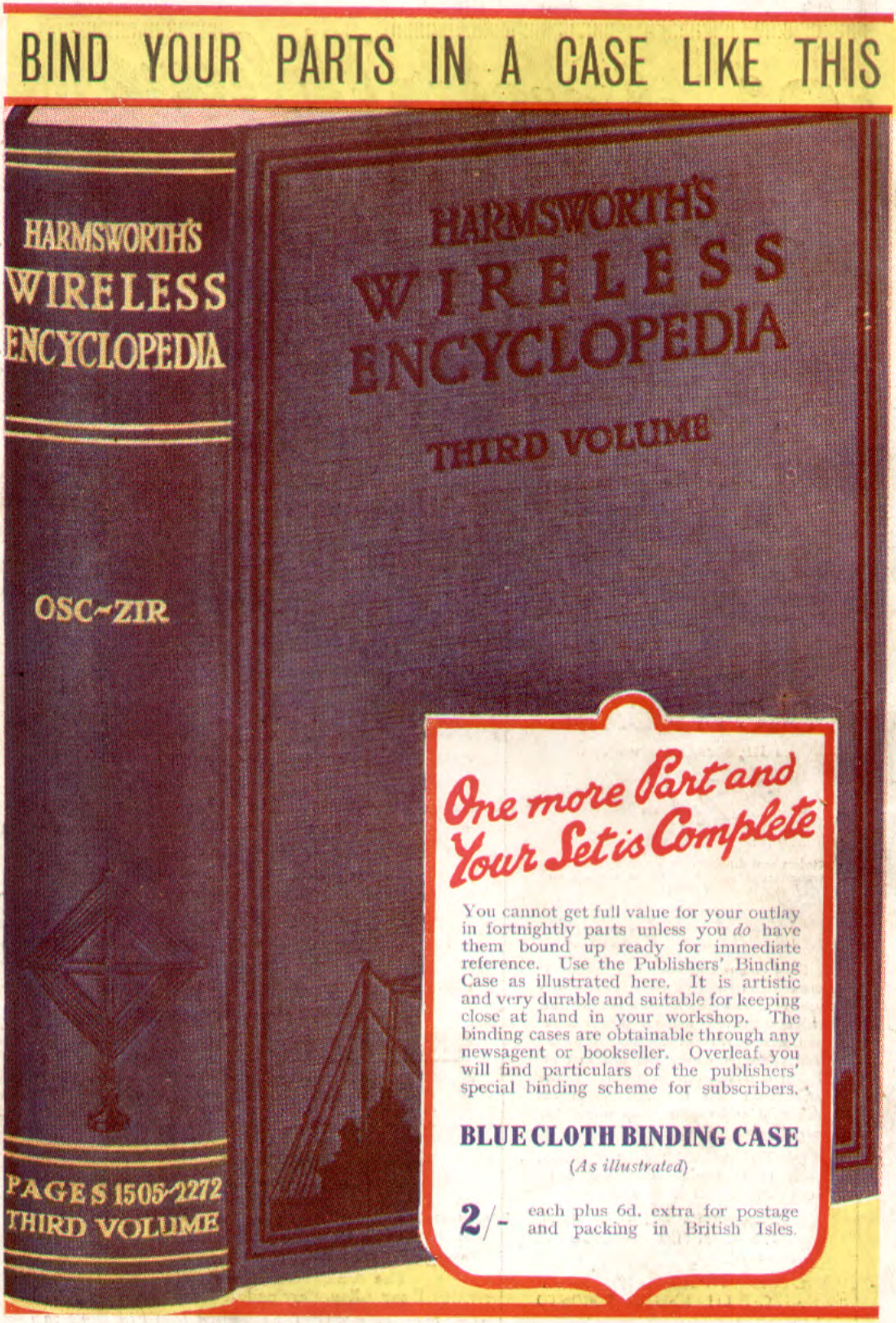

Printed and Published every alternate Tuesday by the Proprietors, The Amalgamated Press (1922), Ltd., The Fleetway House, Farringdon Street, London, E.C.4. Sole Agents for South Africa: Central News Agency, Ltd.; for Australasia: Messrs. Gordon & Gotch, Ltd.; and for Canada: The Imperial News Co. (Canada), Ltd. Subscription Rates: Inland and Abroad, 1s. 5d. per copy. September 9th, 1924.
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