A Permanent and Up-to-date Reference Work

12

1s/3d

HARMSWORTH'S WIRELESS ENCYCLOPEDIA

For Amateur & Experimenter

GEN—HIG

CONSULTATIVE EDITOR

SIR OLIVER LODGE, F.R.S.

THIS PART CONTAINS

201 New "Action" Photos & Diagrams

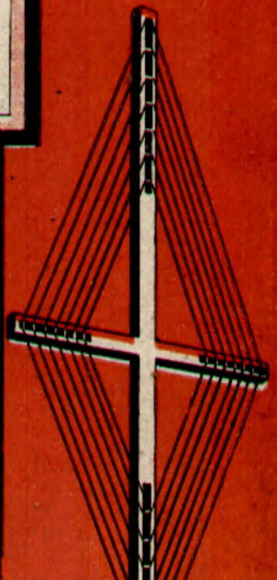
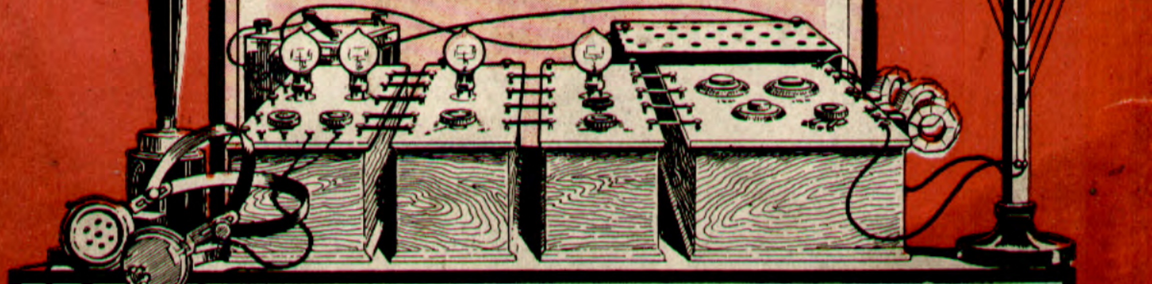
Many 'How-to-Make' Articles

GRID BATTERY
GRID CIRCUIT
GRID LEAKS
HANGING DINING-TABLE SET
(Giving both Light and Music)
HIGH-FREQUENCY AMPLIFIERS
HIGH-FREQUENCY AMPLIFICATION

SPECIAL PHOTOGRAVURE PLATE:

SELF-CONTAINED 6-VALVE HANGING SET

J. LAURENCE PRITCHARD, F.R.Ae.S., Technical Editor, with expert editorial and contributing staff

The Only A B C Guide to a Fascinating Science-Hobby

HARMSWORTH WIRELESS ENCYCLOPEDIA Generator—High Frequency Part 12

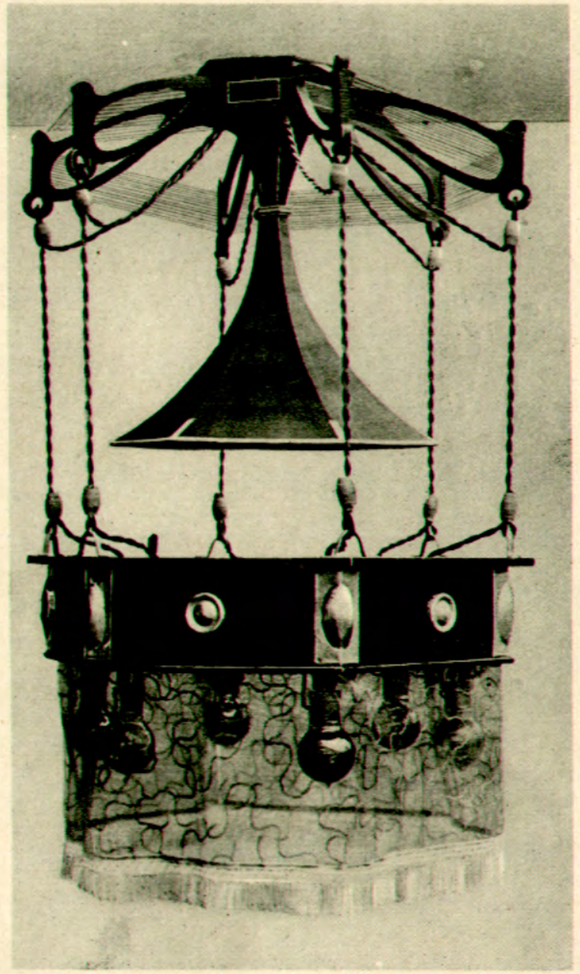


Fig. 7. The set complete, showing aerial near ceiling, loud speaker, frame-holding panel, and shade with valves serving as lamps

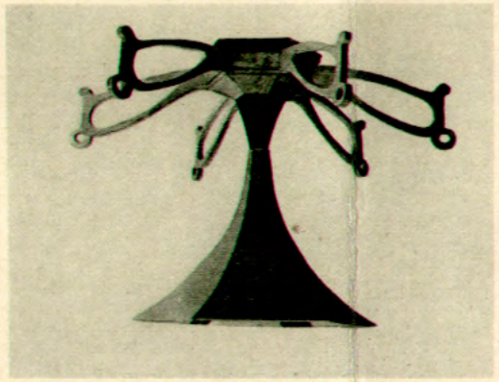


Fig. 8. Aerial framework and loud-speaker trumpet assembled complete

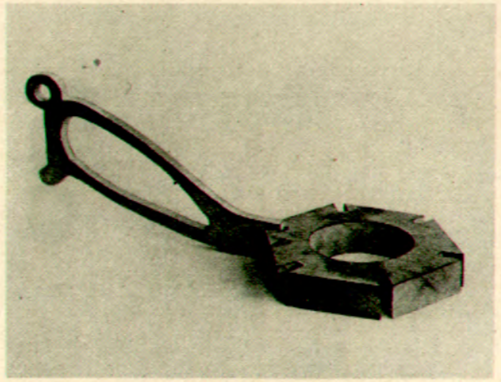


Fig. 9. Arm of aerial framework fitted to bearer block

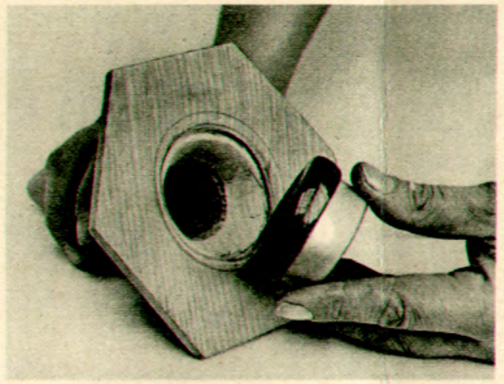


Fig. 10. Hollowed block for receiver of loud speaker

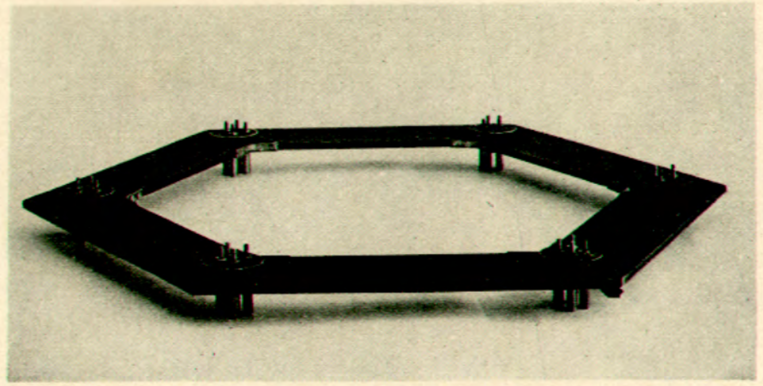


Fig. 11. Ebonite valve panel with valve legs assembled to fit in frame

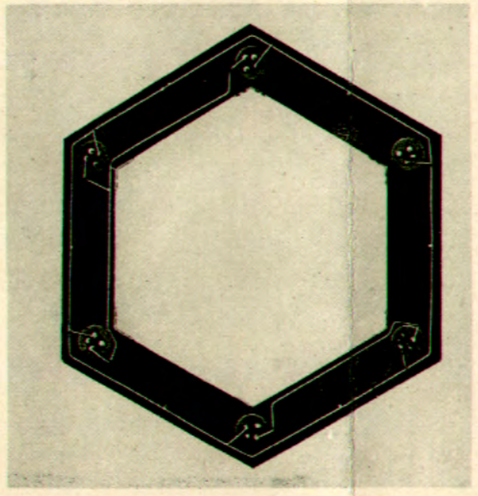


Fig. 12. How filament wires are arranged beneath the panel

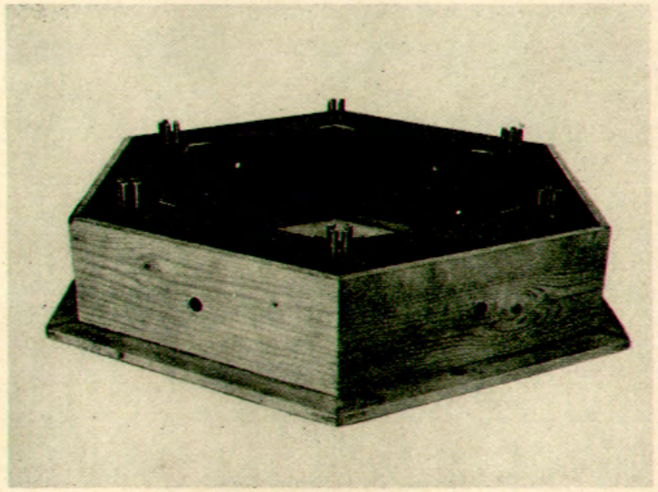


Fig. 13. Panel framework complete with panel in place showing bushes for controls

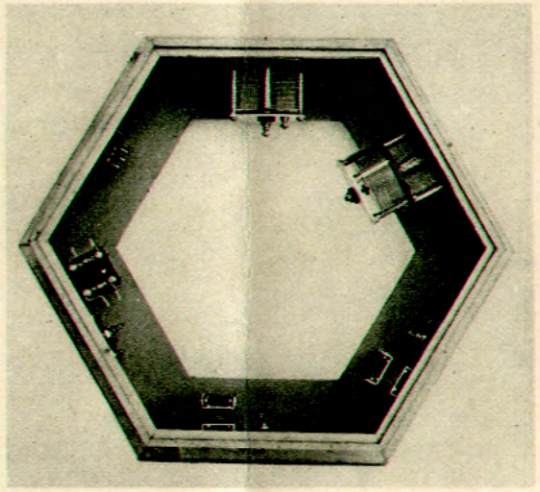


Fig. 14. Principal components fitted in framework, seen from above

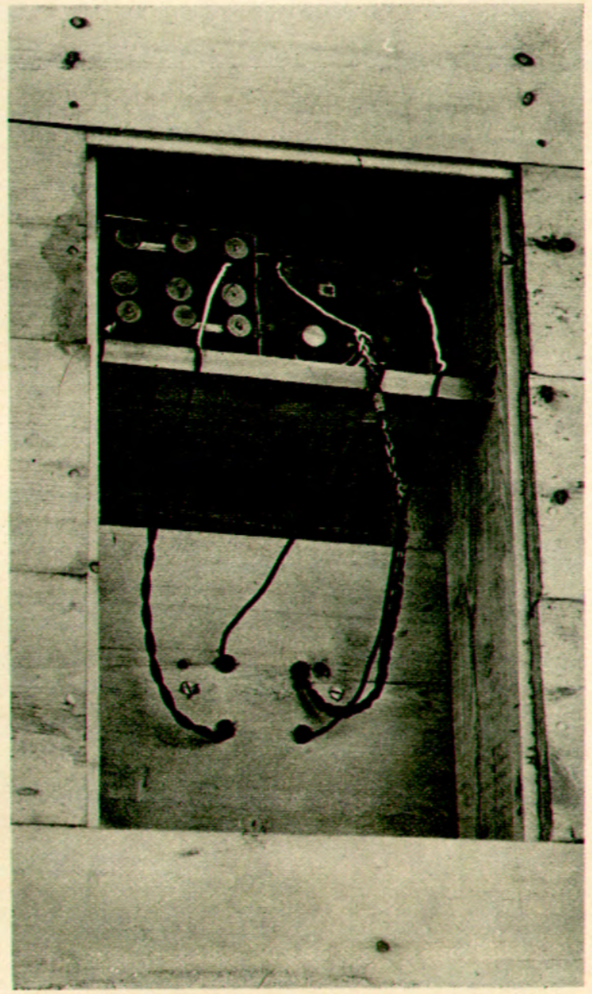


Fig. 19. Trap-door removed to show batteries for the set concealed in floor above

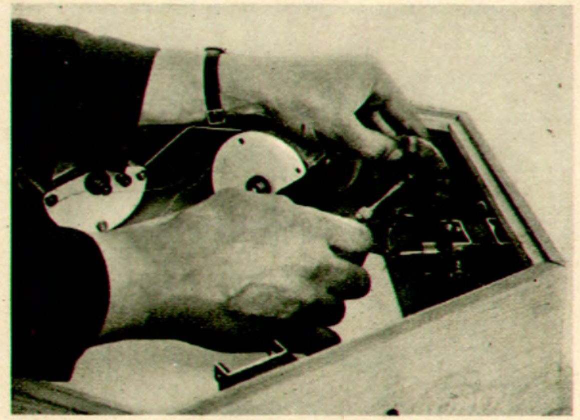


Fig. 15. How anode reaction coils are fitted in ebonite holders

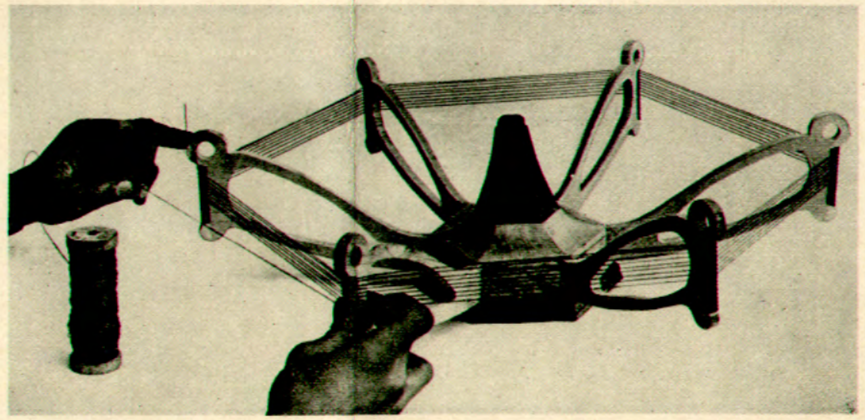


Fig. 16. Wiring the aerial with enamelled wire, 22 gauge. Note ebonite insulating blocks

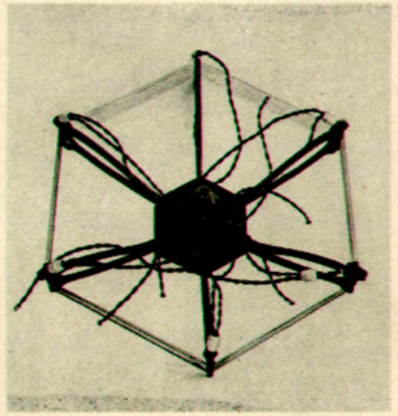


Fig. 17. Frame wired complete with suspension cords

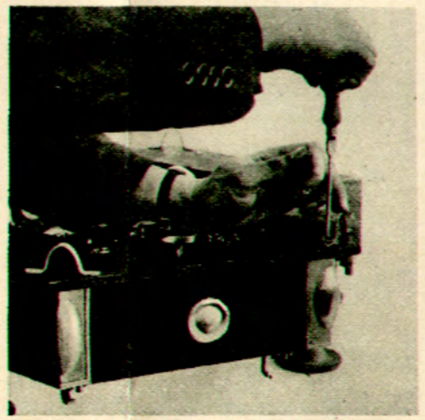
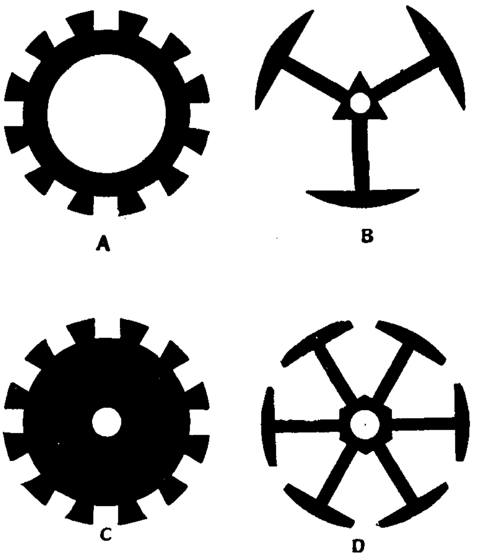


Fig. 18. Fixing loops on frame for suspension cords

HANGING SET: HOW TO MAKE A SIX-VALVE RECEIVING SET WITH SIMPLE CONTROLS SUSPENDED FROM THE CEILING AND GIVING LIGHT FOR THE TABLE AS WELL AS ENTERTAINMENT

To face page 1080

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



ARMATURE CORES FOR GENERATORS

Fig. 9. Armature cores for generators take a wide variety of forms and four examples are here shown. B and C are the most common in use with direct current generators of all sizes. A is mostly used with very small motors and D with alternating current generators

current machine, instead of armature and fields respectively.

Direct current generators may be constructed with either one pair of field magnet poles, or with two or more pairs. In all but very small machines multipolar fields are common, since more efficient use can be made of space and material.

The appearance of a complete direct current generator of the multipolar type will be gathered from the photograph (Fig. 7). Whether designed with two, four, or more field poles, modern generators, almost without exception, have the yoke or frame of circular outline.

A typical armature core, mounted on the shaft complete with its commutator, is shown in Fig. 8. Armature cores take a diversity of forms, a few of which are shown in Fig. 9. The one labelled A is seldom used except for toys and very small motors. The one with six poles, D, is adapted for use in alternating current generators, while the other two, B and C, consisting of slotted ring and slotted drum types, are those most commonly employed in direct current generators of all sizes, having varying numbers of teeth, and slots of either open or semi-enclosed form.

The design of generators to comply with any particular output specification is too lengthy and complex a matter for satisfactory treatment in a short article, and it is only possible to give the briefest outline of the principles involved. According to Figs. 4 and 5, and the explanatory matter accompanying them, certain effects arise under the conditions there illustrated. The relation between cause and effect may be very briefly stated as follows. The fundamental formula relating motion, flux, and induction may be stated :—

Electro-motive force is proportional to *speed, flux strength,* and *length of conductor.* It remains, therefore, to ascertain how to arrive at the necessary field strength and length of conductor to comply with the stated E.M.F. at the given speed. There is, of course, a direct relation between the output required from the generator in watts and the size of the machine as a whole. Various "output coefficients" have been put forward to enable the dimensions of an armature to be quickly arrived at, given a certain performance specification, and one of the simplest may be stated as under :—

$$\frac{E\,C}{N} = \frac{D^2\,L}{K}$$

where E represents volts, C current, and N revolutions per minute. K is a coefficient which varies according to the size of the machine.

This is equivalent to the statement that the output of a generator per minute per revolution is proportional to the square of the diameter of the armature core, to the length of core, to the flux density in the air gaps, and to the ampere-turns per unit length of the circumference.

The electro-motive force generated in a continuous current armature is

$$E = \frac{ZPNT}{2 \times 60 \times q \times 10^8}$$

In the above, P is the number of pairs of poles, N the number of revolutions per minute, T the number of active wires round the periphery of the armature, q the number of parallel paths from brush to brush through which the current can circulate, and Z the strength of the magnetic flux.

The number of armature conductors being determined, the exciting power required from the field coils to drive the requisite flux (Z) through the armature is dealt with by taking each part of the magnetic circuit separately, such as poles, yoke, air gaps, armature teeth, and armature body, with due allowance for magnetic leakage, and summing up the whole in the form of

$$\text{Ampere-turns} = 0{\cdot}8Z\, \Sigma \frac{l}{\mu\, a}$$

l being the length of the circuit, μ the permeability, and a the area. Permeabilities for any value of flux per square inch are obtained from reference tables relating to the particular quality of iron employed, or a table of ampere-turns per inch length for various flux-densities can be worked to instead.

Excitation of direct current generator fields is derived in several ways, according to the performance required. The fields may be separately excited from outside sources, and independent of the speed and voltage variations of the armature, as in Fig. 10, or an independent field circuit may be taken from the generator brushes, as in Fig. 11, called shunt excitation, which is the most customary method. Again, series excitation is sometimes employed (Fig. 12) where the fields and armature are in the same circuit. Any variation in the armature current then affects the field excitation in proportion. Or a combination of shunt and series excitation is often used, as in Fig. 13.

The effect of these various methods of excitation on the voltage characteristic of the generator is shown in graph form in Fig. 14, hence a method of excitation can be chosen which will meet the required performance best. This curve shows the variations in voltage at the terminals of a direct current generator when the fields are excited by the different methods named.

As a rule direct current generators are made self-exciting, but in the case of alternating current machines it is necessary

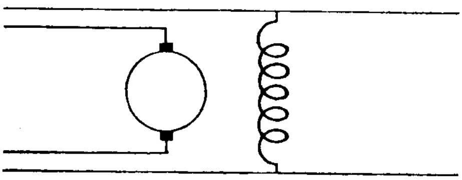


Fig. 10. Separate field excitation in a direct current generator is shown in this diagram

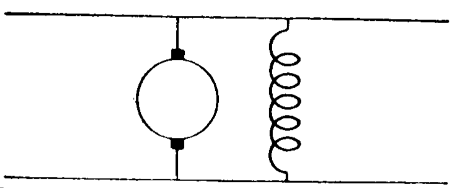


Fig. 11. Shunt field excitation is represented here. This is the most customary method

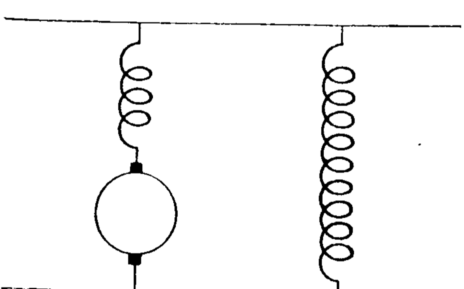


Fig. 13. Compound field excitation, as represented in this diagram, is a combination of the shunt and series methods

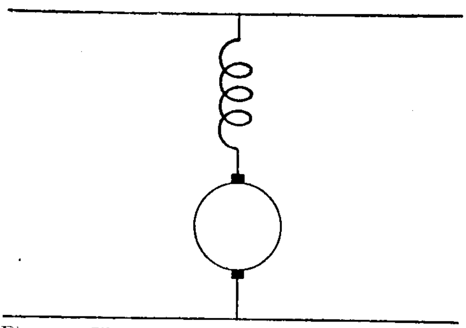


Fig. 12. This method is known as series field excitation, the fields and armature being in the same circuit

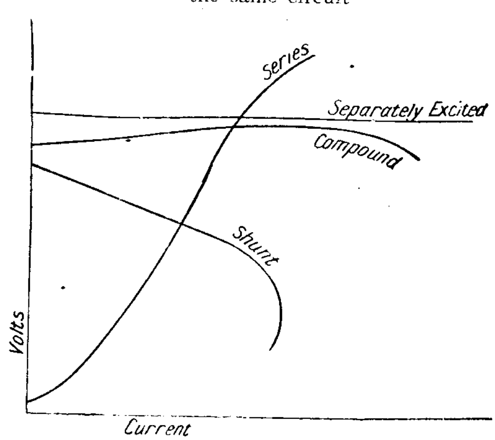
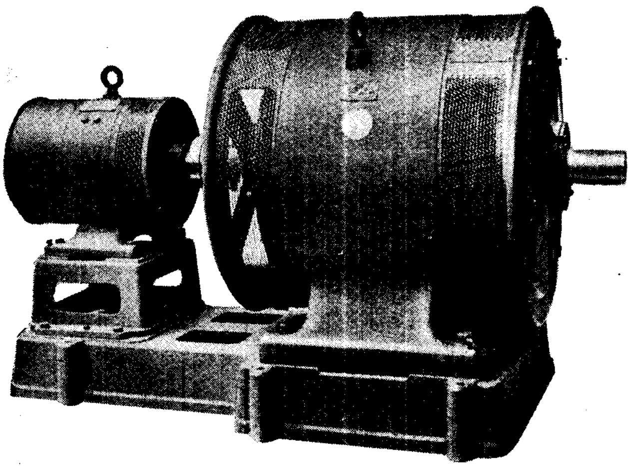


Fig. 14. Characteristic curves of dynamo voltages for the four methods of excitation illustrated in Figs 10 and 13

SIMPLE DIAGRAMS OF THE VARIOUS EXCITATION METHODS USED IN GENERATORS



ENGLISH ELECTRIC A.C. GENERATOR

Fig. 15. Field excitation of this alternating current generator is effected by the small direct current generator seen on the left

Courtesy English Electric Co.

A few representative examples will serve to familiarize the reader with modern examples of generator design. Fig. 17 shows a 110–140 volt direct current 1½ kilowatt generator particularly suitable for battery charging, driven from a single phase alternating current motor, the two forming a rotary converter. In Fig. 18 is a photograph of a similar but reversed combination, comprising a 3 h.p. 110 volt shunt-wound direct current motor, arranged to drive an alternating current generator. Fig. 19 is a large slow-speed direct current generator of another design, driven by a 500 h.p. induction motor running on 440 volts, 50 cycles, at 490 revolutions per minute.

to supply some auxiliary source of continuous current for field excitation, since the polarity of the alternator fields must remain unchanged and they cannot, consequently, be excited from alternating current. This is met by providing a small, entirely separate direct current generator as an "exciter," usually direct-coupled to the shaft of the alternator rotor and series wound. Fig. 15 gives a representative example, the auxiliary source of direct current being seen on the left and the alternating current generator on the right.

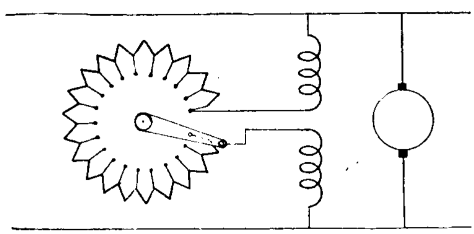
The output of an alternator is controllable by the extent of its field excitation, and can consequently be governed by providing a variable resistance between the exciter terminals and the stator field winding.

The output of a continuous current generator can be similarly controlled in the case of a shunt or compound machine by inserting a variable field rheostat in series with the shunt field coils, so that without any change in the speed the strength of field excitation, and therefore the output, is under control by modifying the ampere-turn effect of the magnetizing field coils. A diagram of this control appears in Fig. 16, and is particularly useful when charging accumulators, since the charging rate in amperes follows the terminal voltage of the generator, hence any change in the latter affects the former. Reference should also be made in this connexion to the heading Field Rheostat.

Again in Fig. 20 appears a 300 kilowatt direct current generator capable of delivering 850 to 1,350 volts at 490–500 revolutions per minute, driven by a 440 b.h.p. slip-ring 50 cycle alternating motor; the feature of this set is the fact that the generator is separately excited by a smaller direct-coupled exciter dynamo wound for 110 volts, which gives a great range of voltage on the larger unit.

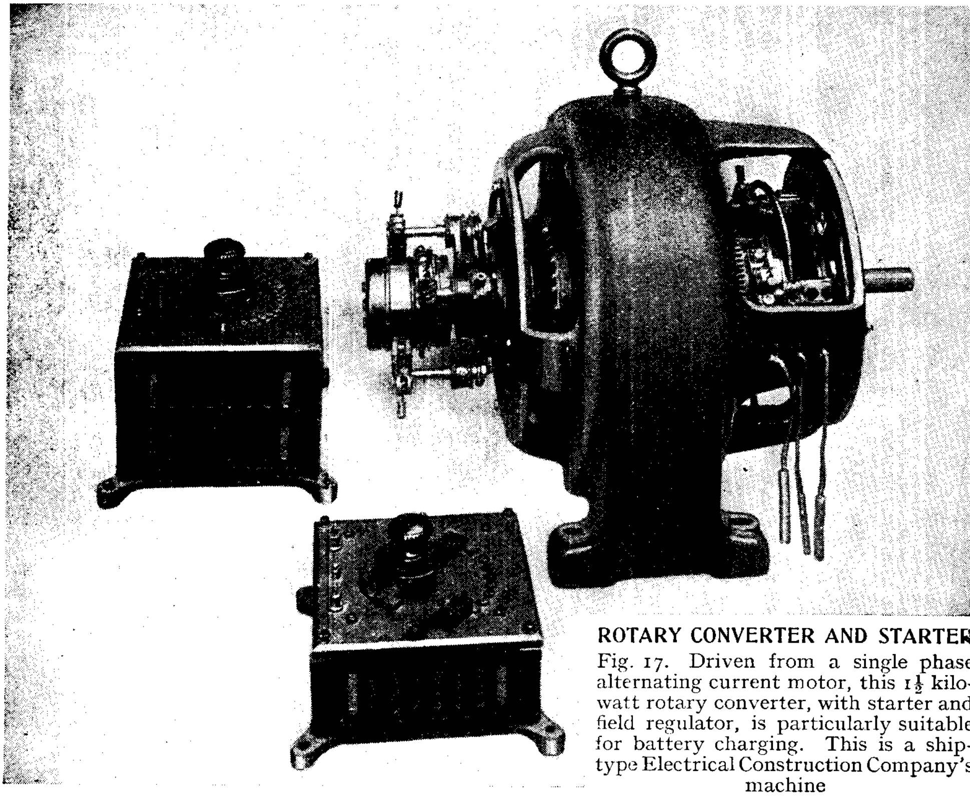
A specially interesting set is shown in Fig. 21; at the back of the picture is a 200 h.p. shunt-wound motor driving a Marconi disk at a speed of 750 to 860 revolutions per minute. In the foreground is a special automatic booster set comprising a 65 h.p. motor for 440 volts, boosting up 160 volts with 300 amperes capacity and a momentary overload capacity of 450 amperes.

The booster set is controlled by a Brown-Boveri regulator, which keeps the direct current supply constant, thus ensuring that with any normal variation of



VARYING GENERATOR OUTPUT

Fig. 16. Output of a direct current generator may be varied by a variable shunt field resistance, as in the above diagram



ROTARY CONVERTER AND STARTER

Fig. 17. Driven from a single phase alternating current motor, this $1\frac{1}{2}$ kilowatt rotary converter, with starter and field regulator, is particularly suitable for battery charging. This is a ship-type Electrical Construction Company's machine

Courtesy Marconi's Wireless Telegraph Co., Ltd.

2 KW. D.C. MOTOR AND ALTERNATOR

Fig. 18. Made to run at 1,800 r.p.m., this 3 h.p. 110 volt shunt-wound direct current motor is arranged to drive an alternating current generator. The alternator capacity is $1\frac{1}{2}$ kilowatts

Courtesy Marconi's Wireless Telegraph Co., Ltd

supply frequency the speed of the Marconi disk remains practically constant. In fact the regulation is so close that the makers guarantee a maximum of not more than one quarter of 1 per cent speed variation on the disk when the supply frequency varies as much as 5 per cent.

At the right-hand side of the figure is seen a main direct current generator for supplying power to the motor booster set and battery. The output capacity is 162 kilowatts at 440 volts, and it is direct-coupled to a 440 volt alternating current 50 cycle motor running at 750 revolutions per minute.

A slightly different composition is shown in the next set, illustrated in Fig. 22. In the foreground will be seen a motor-generator set consisting of a 230 b.h.p. 440 volt 50 cycle

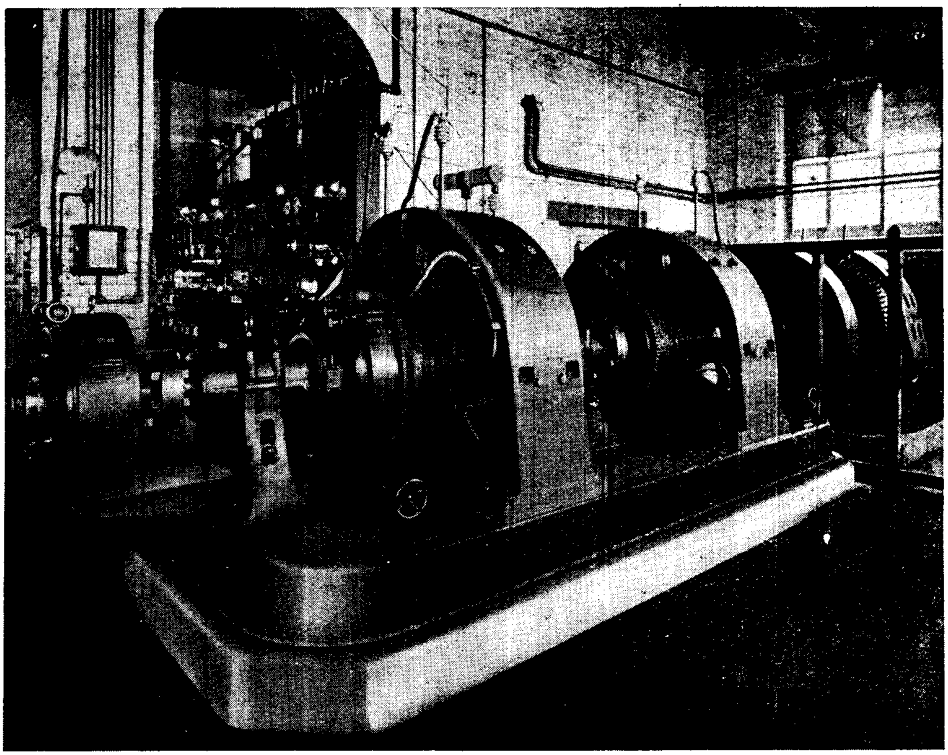


Fig. 19. This generator is installed at the Marconi station at Carnarvon. A 500 h.p. induction motor of the slip-ring type running on 440 volts is direct-coupled to Dick Kerr generators

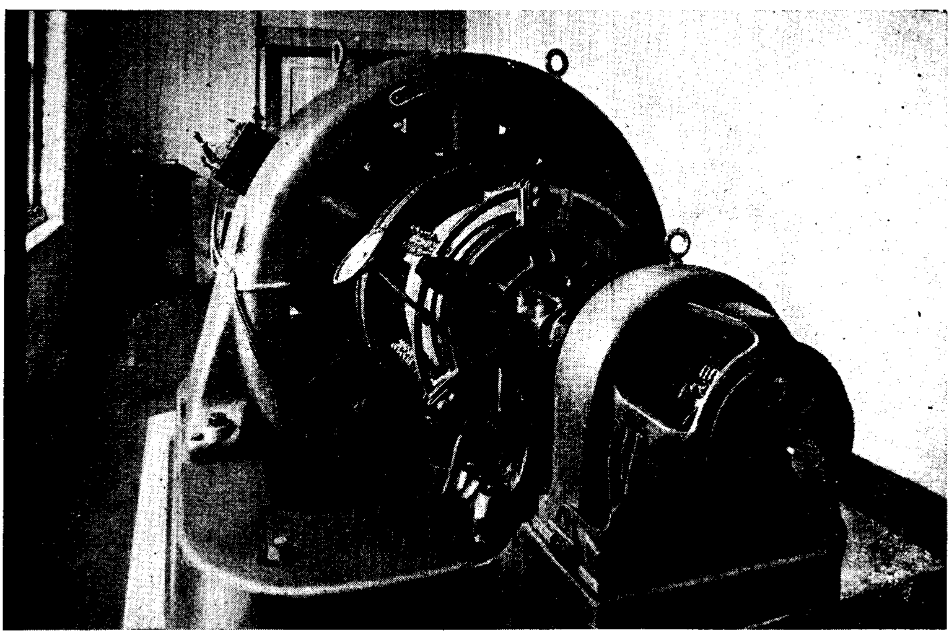
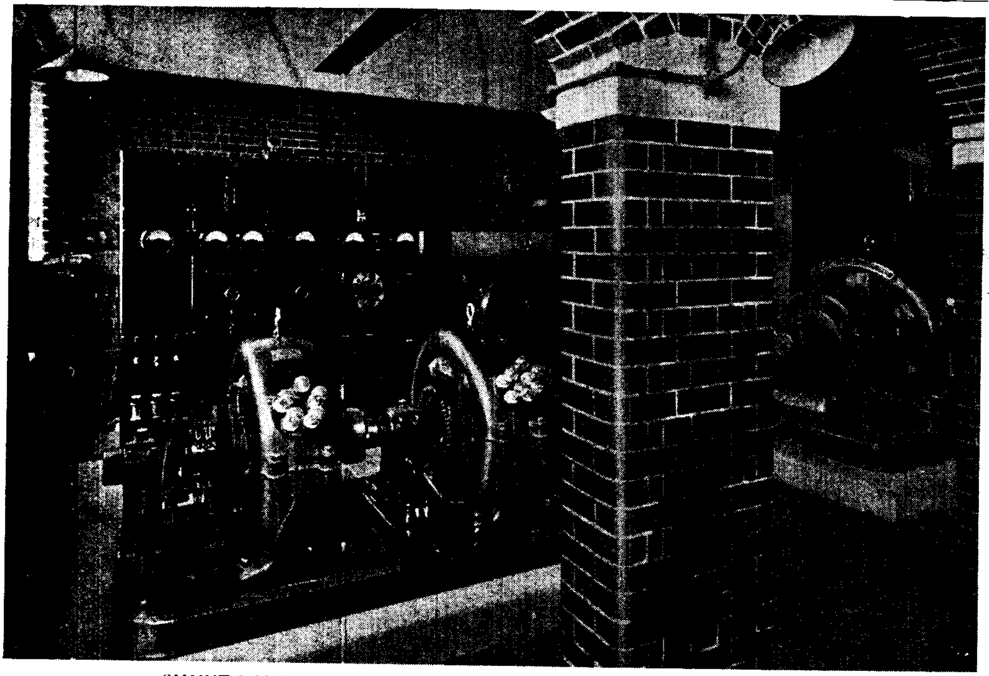


Fig. 20. Separately excited by a smaller direct-coupled exciter dynamo, at Marconi's Carnarvon station is a 300 kilowatt direct current generator capable of delivering 850–1350 volts at 490–500 revolutions per minute. It is driven by a 440 h.p. alternating motor

HIGH-TENSION GENERATOR AND 250 KW. ARC GENERATOR AT CARNARVON

Courtesy Marconi's Wireless Telegraph Co., Ltd.



SHUNT-WOUND MOTOR-DRIVEN MARCONI DISK AND BOOSTER

Fig. 21. At the back in the photograph is a 200 h.p. shunt-wound motor driving a Marconi disk at 750–860 r.p.m. In the foreground is an automatic booster. So closely regulated is this set with its booster that the speed of the disk does not vary more than ·25 per cent. At the right-hand side appears a main direct current generator for supplying power to the booster and battery

Courtesy Marconi's Wireless Telegraph Co., Ltd.

730–750 r.p.m. motor, and a 162 kilowatt 440 volt direct current generator. At the back of the picture is an automatic battery booster set consisting of a 440 volt motor and reversible booster of 0–180 volts and 300 amperes capacity. With an automatic regulator this set controls the power supplied to the motor-driven spark disk, and is also guaranteed to keep the speed of the motor within one quarter of 1 per cent with a 5 per cent variation in the supply volts and frequency.

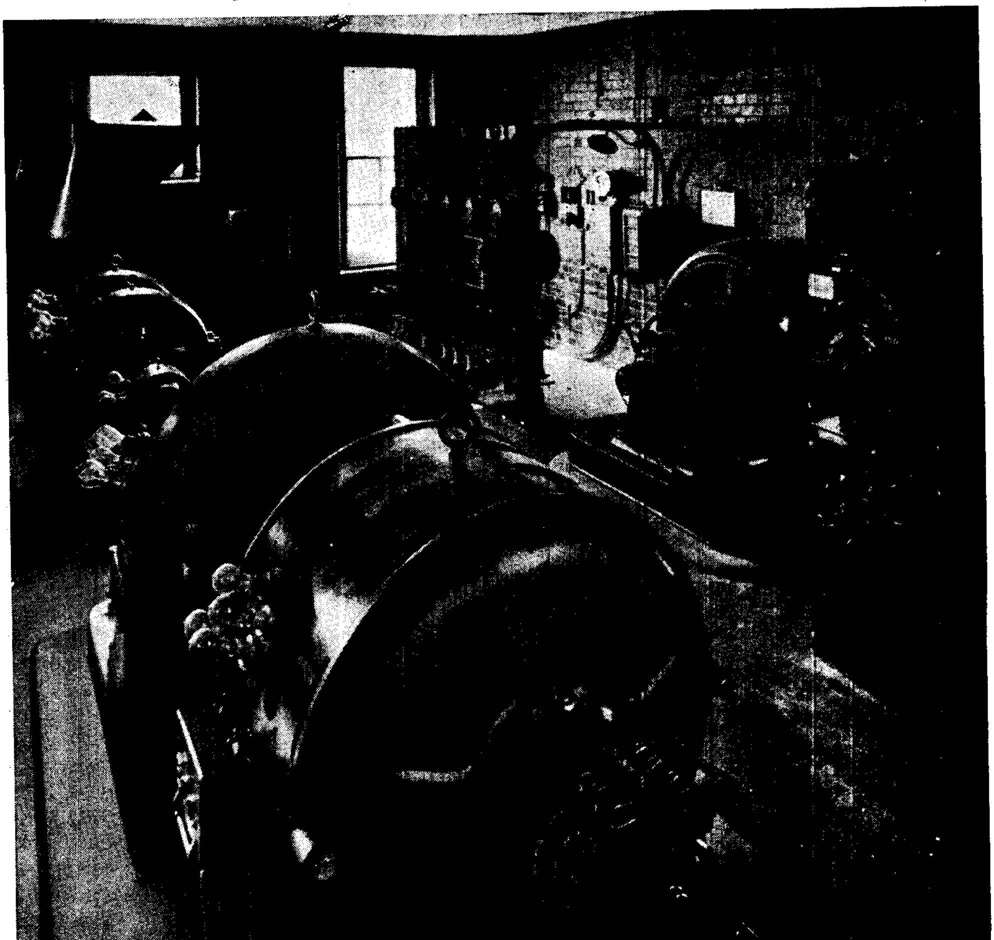
As an example of a set especially designed for the conjoint supply of high-tension and low-tension direct current for wireless purposes, Fig. 23 is given. The set consists of three separate units—a 110 volt $1\frac{1}{2}$ h.p. 1,800 r.p.m. shunt-wound driving motor on the extreme left, direct-coupled to a low-tension 12 volt 24 ampere direct current generator in the middle, and further coupled to a 3,000 volt 120 milli-ampere direct current generator on the extreme right.

The points of especial note in the design of the high and low tension units are: the extreme care taken in proportioning the various parts in order to eliminate unnecessary weight, the adoption of a laminated field magnet, the use of special high-permeability high-resistance material for the stampings, and the general provisions for eliminating the undesirable factor of commutator and voltage ripple, so detrimental to transmission.

In order to minimize the difficulties attendant upon commutation of currents at such high voltages, the high-tension output has been split up into two distinct and separately insulated armature windings, each with its own separate commutator, which, it will be seen, is divided up into an extremely large number of segments. The armature teeth are skewed, and so designed as to give the minimum possible disturbance to the pole flux, while the arrangement of the coils in the armature slots is carried out on a definite colour scheme, resulting in a completely symmetrical winding, and a steady electro-motive force almost entirely free from trace of ripple when examined under the oscillograph. Each half of the winding is elaborately insulated and subjected to a flash-test of 4,500 alternating volts, and the two sets of brushes are afterwards put in series to obtain 3,000 volts at the normal running speed of 1,800 revolutions per minute on full field excitation.

The field excitation for the high-tension generator is derived from the low-tension unit, which also excites its own fields as well as supplying current for external purposes. Both high- and low-tension sets run in ball bearings of the self-aligning double-race type, and the set is practically noiseless in operation. Owing to the division of the high-tension armature windings it is possible to couple up the brushes for alternative outputs of either 3,000 volts 120 milliamperes with the two windings in series, or for 1,500 volts 240 milliamperes with the two windings in parallel.

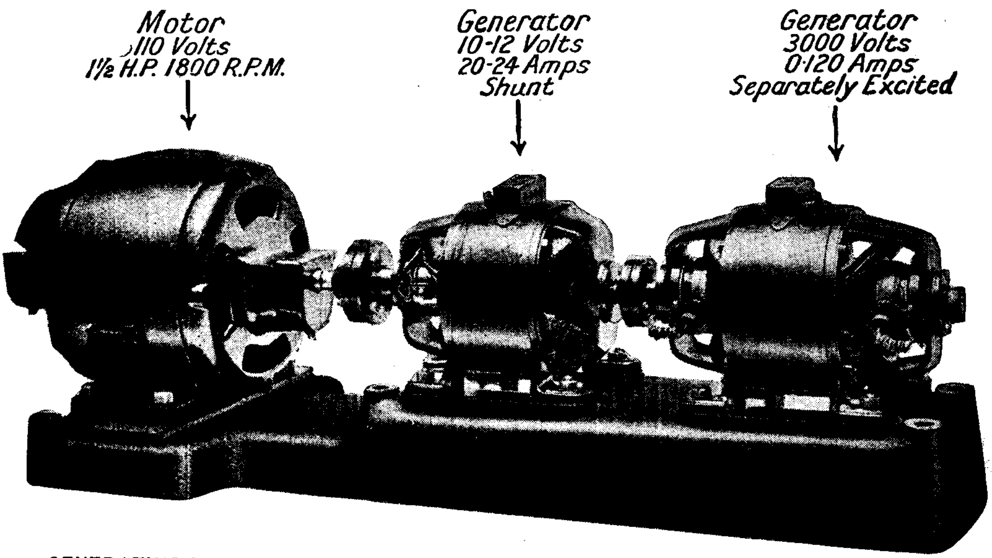
Fig. 24 is an illustration of a twin ½ kilowatt generator by the Radio Communication Co., Ltd. Both machines are identical in design and construction, but the top one is intended to be used as a stand-by, should the other one fail. The machines are motor generators, and convert direct current at a pressure of either 110 or 220 volts (as required) to alternating



CARNARVON STATION BATTERY-CHARGING MACHINES AND BOOSTERS

Fig. 22. Battery-charging machines of the Marconi station at Carnarvon are shown in the foreground. In the background are reversible boosters of 300 ampere capacity with automatic regulation as in the set shown in Fig. 21. On the right is the motor for driving the spark disk

Courtesy Marconi's Wireless Telegraph Co., Ltd.

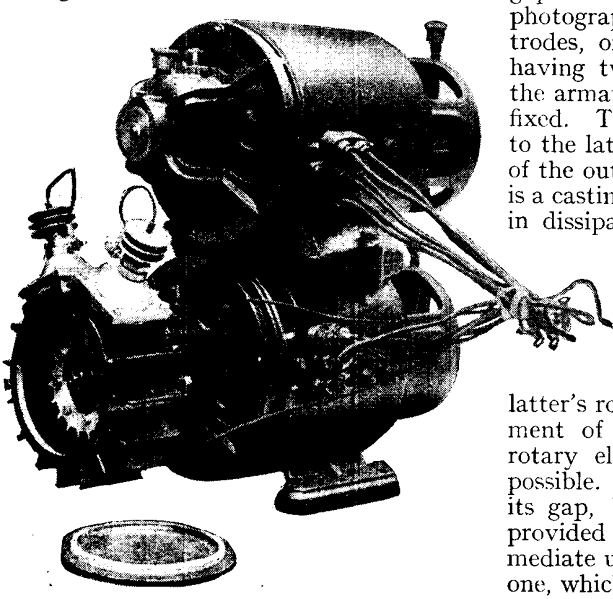


GENERATING SET SUPPLYING HIGH- AND LOW-TENSION CURRENT FOR TRANSMITTERS

Fig. 23. On the left of this three-unit set is a 110 volt 1½ h.p. shunt-wound motor direct-coupled to a low-tension 12 volt direct current generator in the centre, and further coupled to a 3,000 volt direct current generator on the right. This set incorporates many special points of its design

Courtesy George Kent, Ltd.

current at 200 volts, 500 cycles. The direct current is used to excite the alternating current ends of the machines.



½ KW. TWIN GENERATORS

Fig. 24. Twin ½ kw. generators are illustrated. The top generator is a stand-by in case the lower one fails. This is direct current at 110 or 220 volts and converted into alternating current at 200 volts. Note the rotary spark gap on the lower machine

Courtesy Radio Communication Co., Ltd.

The lower machine is unusual in that it is permanently fitted with a rotary spark gap. This feature is well shown in the photograph. The gap has three electrodes, one being a rotary toothed disk having twenty teeth directly coupled to the armature shaft, and the other two are fixed. The leads and insulation attached to the latter may be seen fixed to the top of the outer cover of the gap. This cover is a casting with fins attached, which assist in dissipating the heat generated during discharge.

A means of rotating the cover around the motor end plate is provided. As the fixed electrodes are rigidly attached to this cover, the latter's rotation will mean that an adjustment of phase relationship between the rotary electrode and the fixed ones is possible. Should the lower generator, or its gap, become inoperative, a switch is provided to bring the spare one into immediate use. The gap for this is a fixed one, which is not illustrated, but is fixed in the wireless cabin of the ship.

Fig. 25 shows a generator driven by a 2¾ h.p. Douglas motor-cycle engine. This type of machine was used in very large numbers indeed during the War for trench transmitters. The engine is the standard well-known 350 c.c. horizontally opposed unit, equipped with a petrol tank situated immediately above the cylinders, and having automatic lubrication. No cooling device other than the usual fins is employed, it being found unnecessary, even if the set be used over long periods.

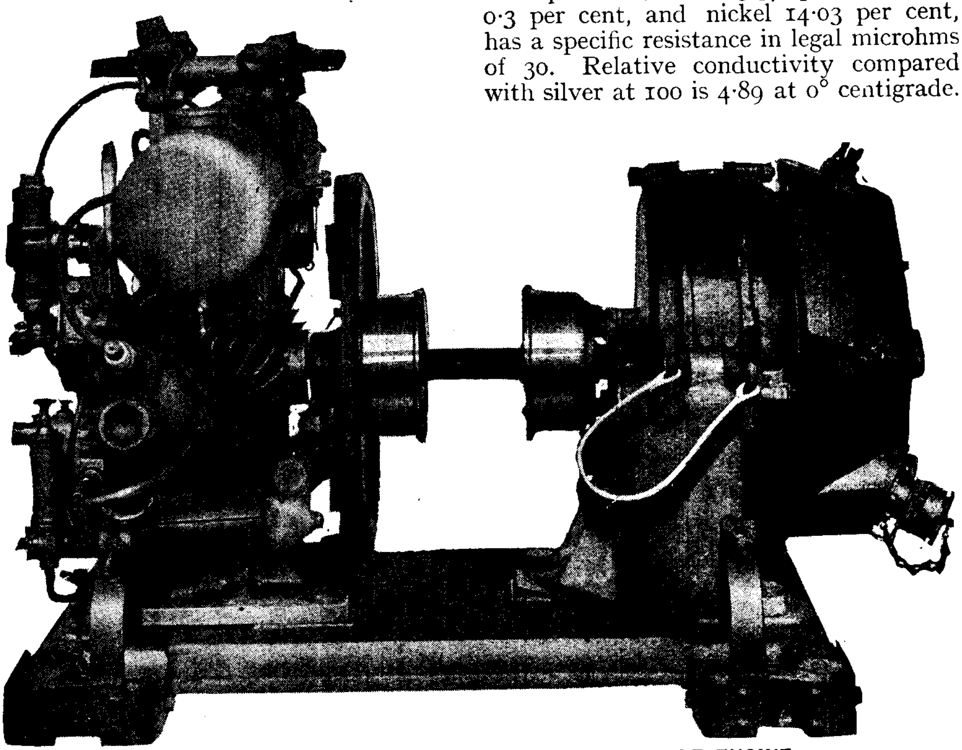
The armature shaft of the generator is directly coupled to the engine crank-shaft, and runs, therefore, at the same speed. The generator is designed for two purposes: it delivers alternating current at a frequency of 190 and at a pressure of 94 volts, and direct current at 24 volts. The output on the alternating current side is 0·75 kilovolt-ampere, and on the direct current side 15 amperes.

Slip-rings for the collection of the alternating current, as well as the commutator for the direct current supply, are all situated at one end of the machine. The large inspection cover may be clearly seen in the picture. There being ten pairs of poles, the machine runs at 1,900 revolutions per minute.

Straps may be seen at various places on the machine. These were used in order that the whole unit might readily be transported on mules or other animals.

GERMAN SILVER. Name of a silvery-coloured alloy. Its composition varies somewhat, but that used in wireless work may contain from 45 to 65 per cent of copper, 5 to 30 per cent of nickel, 15 to 25 per cent of zinc. There is generally a small amount of lead present. The metal is pleasant to work, can be machined similarly to hard brass, and finishes with a bright lustrous polish. Its application to wireless work is limited practically to resistance wires, the electrical resistance varying more or less in accordance with the amount of nickel content. An alloy associated with the german silvers, or nickel silvers, is known as platinoid, and includes in its composition a small amount of tungsten, giving it a greater electrical resistance, about one and a half times greater than ordinary german silver.

German silver composed of copper 60·1 per cent, zinc 25·37 per cent, iron 0·3 per cent, and nickel 14·03 per cent, has a specific resistance in legal microhms of 30. Relative conductivity compared with silver at 100 is 4·89 at 0° centigrade.



CROMPTON'S GENERATOR DRIVEN BY MOTOR-CYCLE ENGINE

Fig. 25. Crompton's generator, as seen in the above photograph, is driven by an ordinary Douglas motor-cycle engine. It was used largely for trench transmitters during the Great War. Alternating current is delivered at 94 volts and direct current at 24 volts

Courtesy Marconi's Wireless Telegraph Co., Ltd.

The thermo-electric force in micro-volts is 11·75 for a difference of 1° at a temperature of about 20°, lead being one of the elements of the couple.

GERNSBACK VARIABLE CONDENSER A type of variable condenser in which the capacity is varied by unrolling flexible plates from two outside drums to a drum placed between them, and vice versa. Three drums of insulating material of the same diameter and length are geared together so that a certain movement on one drum causes a corresponding amount of movement on the other two. The central drum has a spindle and knob attached by which the whole are operated.

The effect of turning the knob in one direction is to unwind a sheet of flexible insulating material and a sheet of flexible metal from each of the outside drums on to the central drum. When half a turn of the knob is made the metallic and the insulating sheets commence to overlap, thus giving a condenser effect between the metallic plates from the two opposing drums. These are prevented from touching by means of the insulating sheets that move with the metallic sheets.

Connexion between the opposing plates is effected by a spring contact operating on the metallic plates.

GIBLIN REMLER COIL. Name of a proprietary inductance coil having cotton spacing between the layers and turns. The Giblin Remler coils are very similar to the Burndept coils, in the form of successive layers of wire wound as a multi-layer solenoid. The cotton spacing is put on as a zigzag lattice, interleaved with the turns. By this method of winding the spacing between the layers increases from nothing at the beginning of a layer to a large value at the end, so lessening the self-capacity.

GIMLET. Tool used by woodworkers for boring small holes in wood. The standard pattern illustrated in the figure comprises a long, hard-steel shank, the upper end pointed and finished to the shape of a wood screw. A spiral groove is formed along the lower half of the shank, and the upper end is squared to form a tang, and passes through the centre of a horizontal piece of boxwood which forms a T-shaped handle. The shank is attached securely to it by means of a washer and rivet.

Several different sizes of gimlet are available at low cost and the experimenter will do well to have at least two, one very small for use with fine screws, and one large for dealing with screws of 2 in. in length and upwards.

HOW TO USE A GIMLET

When boring into wood, as in the photograph, a gimlet must be kept upright. An even pressure should be kept up. Gimlets should not be used on very thin wood, or on ebonite

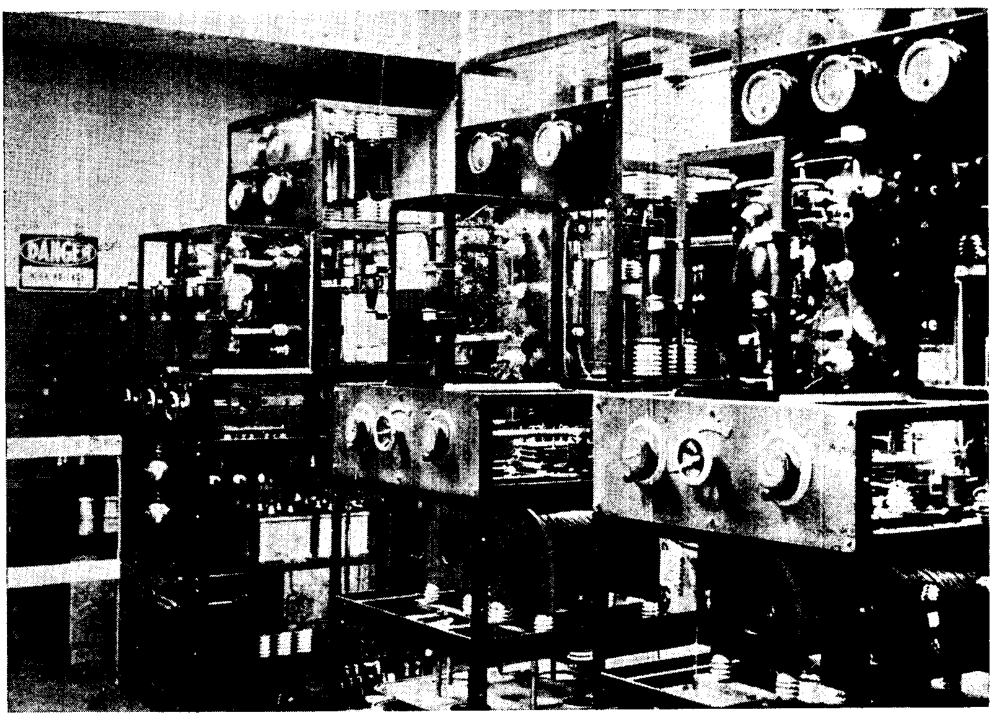
In use, the gimlet is held upright in the right hand, as in the photograph, and pressed firmly into the wood exactly at the spot where it is desired that the hole should be made. The handle is then rotated by twisting the wrist, at the same time maintaining a pressure in a downward direction so that the gimlet can screw its way into the wood. The chips should pass freely upwards through the spiral grooves.

The gimlet is chiefly used for making holes in which screws are subsequently to be driven, for which purpose it is admirably suited, as a hole made by a gimlet has a form of screw thread formed on the walls of the hole. Gimlets should not be used on very thin wood, otherwise the material is almost sure to be cracked or split. A better tool is a small drill or a bradawl. Nor should a gimlet be used on ebonite.

GLAND KEY. A gland key is a spanner, shaped similarly to an ordinary drill-chuck spanner, which is used to adjust the packing gland of a Bradfield deck insulator. It is usually made of forged steel. The semicircular portion is made to fit the circumference of the gland, while a little projection on the tip of the inside radius of the key fits into holes made for it. Considerable leverage is obtained by using this shape of instrument, and slipping of the spanner round the object to be tightened is almost entirely obviated. *See* Bradfield Insulator; Deck Insulator.

GLASGOW BROADCASTING STATION (5 SC). This, the first broadcasting station established in Scotland, was opened on March 6th, 1923. The station proper is situated in the tower of the Glasgow Corporation's power station at Port Dundas, the studio being located more centrally in the city at a distance of about a mile. The power supply is 500 volts direct current from the Corporation mains, this being transformed by a rotary converter to 500 volts alternating current at 300 cycles. After being led to the instrument room at the top of the tower, the alternating current is supplied to a static transformer with two secondaries, one used for high tension at about 10,000 volts, the other for lighting the filaments of the rectifying valves. The high tension having passed through the rectifying valves and become pulsating direct current, is "smoothed" by chokes and condensers until an almost perfect direct current is produced. The high tension is then supplied to the "drive" valve and power valve plates, the purpose of the drive valve being to cause the power valve to oscillate, but not of its own accord (Fig. 1).

The transmitting station is linked with the studio by a cable laid through the existing Post Office conduits. At the studio there is a microphone and also an amplifier of special type, further amplification and modulation being effected at the transmitting station. The aerial is of the cage type, consisting of four wires separated round hoops of about 4 ft. 6 in. diameter, and is about 180 ft. long. The insulators, consisting of porcelain reels strung in series, are about 7 ft. long. The range is given officially as 75 miles, but in practice



INTERIOR OF INSTRUMENT ROOM AT GLASGOW B.B.C. STATION

Fig. 1. About a mile separates the transmitting department from the studio of the Glasgow broadcasting station. In the instrument room, shown above, high-tension current is rectified by valves and "smoothed" by chokes and condensers until almost perfect direct current is produced. Power valves are caused to oscillate by a drive valve, which is supplied by the high-tension current

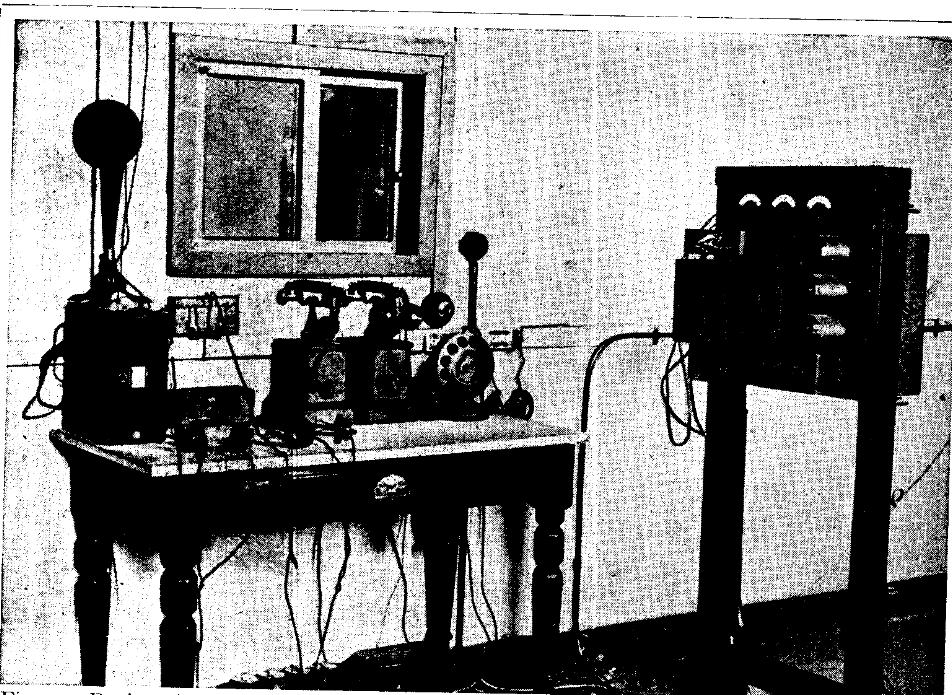


Fig. 2. During the actual broadcasting period the room attached to the studio, which is seen in this photograph, is occupied by the control man, whose duty it is, by the aid of the signal lamps seen on the right and the telephones on the table, to control the technical quality of the transmission. This operator receives the transmission on a special receiver

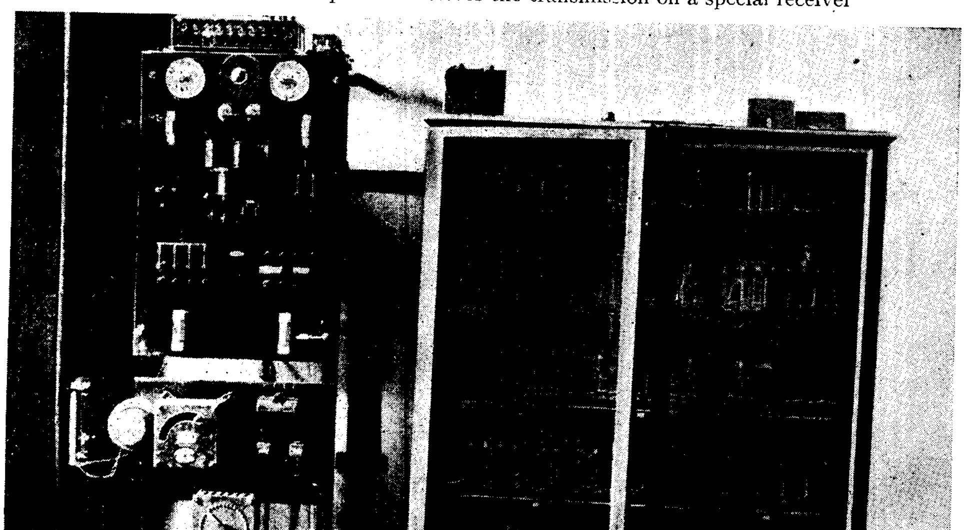


Fig. 3. Switchboard apparatus and accumulators are seen in this photograph. This is one of the several departments which are controlled by the operator in the room seen in Fig. 1

INTERIOR OF GLASGOW BROADCASTING STATION this has been largely exceeded, and the station is a favourite one for reception by English amateurs. The transmitting apparatus was installed by the Marconi Company, while the studio gear is of "Western Electric" manufacture.

GLASS. Brittle transparent mixture of fused silica and two or more alkaline bases, such as lime and soda or potash. When heated it becomes soft and workable. In the hard state it can be cut with a diamond or very hard steel cutter. It can be ground and polished, and is resistant to practically all acids except fluoric acid.

Glass is used in wireless work in several forms, including ordinary sheet glass, made by blowing molten metal into a cylinder which is then cut and flattened. Plate glass is poured on to a table and compacted and rolled to uniform thickness.

There are numerous names given to many different glass compositions, mostly due to the presence of a predominating metallic oxide, as for instance, soda glass, or lead glass, or because of the manufacturing process, such as blown glass, roller glass and the like. Toughened glass is subjected to a chemical and heat treatment calculated to reduce the brittleness.

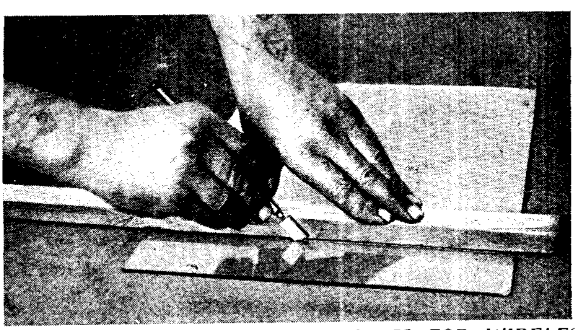
Glass is used for the globes or bulbs of valves, as containers for the electrolyte in accumulators, and as the dielectric in some forms of condensers. The specific inductive capacity of glass varies considerably even for the same kind of glass. That of crown glass lies between 3·11 and 6·96, and of flint glass is from 6·61 to 9·0. Glass has a specific gravity of about 2·9 and a density of some 180 lb. per cubic foot, and the melting point is in the neighbourhood of 2,000° F.

The cutting of ordinary sheet glass for such purposes as the front window of a cabinet receiving set is not a difficult matter. The glass should be placed on a flat surface covered with a piece of felt or cloth. One edge has next to be cut straight by holding a batten or straight edge on the glass and pressing it down firmly with the left hand. The glass is cut with a diamond or a cutter. The diamond is generally considered preferable, but is an expensive tool. Quite satisfactory results are given by a cutter with a small diameter hard steel wheel, and these are inexpensive.

Both cutters are manipulated in the same way, by gripping the handle between the thumb and second finger with the first finger on the top of the handle, as shown in Fig. 1. The cutter is held at a small angle and inclined towards the body; the cut is made by drawing the cutter towards the body. It is important to get the correct angle. This is indicated by the glass making a clean, ripping noise, as against a dull tearing sound when incorrectly held.

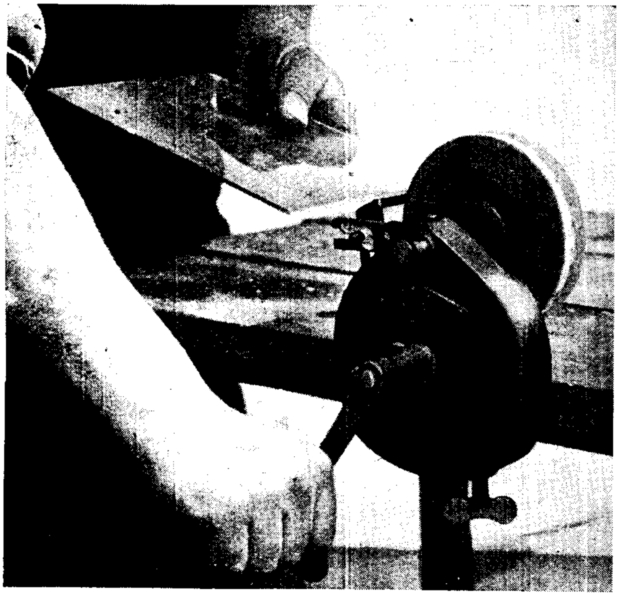
The glass is not cut through by the cutter, but only a shallow scratch made on the surface, and it is necessary only to make one cut. The glass is then rested on a smooth piece of wood with the edge of the wood exactly under the cut. Gently tapping the glass with the back of the holder of the cutter will cause the glass to break. The subsequent cuts are made in the same way, but the lines are marked with a square, and the cuts made to them. Rubbing the surface with a piece of soap will make the marks clear.

A circular piece of glass such as may be needed for a galvanometer case can be cut with a special tool, but in its absence the amateur will find that a disk of wood or metal can be used, as shown in Fig. 2. The size of the disk must be smaller than



CUTTING GLASS FOR WIRELESS COMPONENTS

Fig. 1 (left). Straight cuts can be made in glass with a glass-cutter guided by a wood rule or straight edge. The cutter should make a clean, ripping noise, not a dull tearing sound, if it is being held properly. Fig. 2 (right). A wooden guide disk is used to control the direction of the cutter in making glass disks



REMOVING ROUGH EDGES FROM GLASS

Fig. 3. Rough edges are removed by carefully grinding on an emery or carborundum wheel, as illustrated. Note how the glass is held in the left hand and the handle of the grinder rotated by the right hand. The glass is held on the tool rest

the required size for the glass, the amount depending on the thickness of the cutter head. The diameter of the guide disk ought to be less than the desired diameter of the glass by 1½ times the thickness of the cutter head. The cutter is simply run round the guide disk, and then several cuts made radially from the edge of the sheet of glass to the circular cut and the glass broken away carefully.

Rough edges on the glass can be removed by grinding on a carborundum wheel, such as the bench grinder type shown in Fig. 3. The glass is held in the left hand, and the handle of the grinder revolved with the right. The glass rests on the tool rest or support and is held carefully and steadily. The wheel rotates towards the glass, and the latter is constantly moved to and fro across the grinding wheel to obtain a smooth edge.

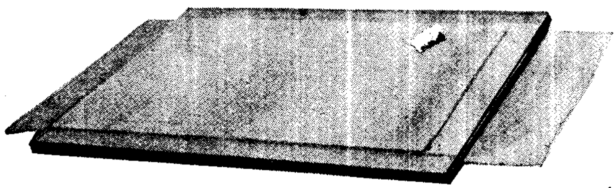
Ground or obscured glass can be made by sprinkling emery powder on the glass and moistening it with water and rubbing with a smooth piece of stone or a piece of glass, such as a solid stopper from a large bottle. The rubbing is carried out with a brisk circular movement all over the surface and the whole kept well moistened with water. The glass should rest on a piece of felt or cloth, and the rubber be slid off the glass and not lifted, as to lift it would be likely to break the glass by the suction between the rubber and the surface. Glass can be etched by sand-blasting, or with hydrofluoric acid, but the process is injurious to health and is best not attempted by the amateur. These processes, as well as embossing and bevelling, are carried out cheaply by the glass merchants.

GLASS PAPER. Paper sheets covered with finely powdered glass. The term is popularly synonymous with sandpaper (*q.v.*), and the paper is used in a similar way.

GLASS PLATE CONDENSER. Type of condenser in which the dielectric is composed of glass.

The most common form of condenser having a glass dielectric is the Leyden jar used for experimental work, mainly with frictional electricity. In this form a good quality flint glass jar is covered inside and outside with a coating of tinfoil, leaving sufficient space at top and bottom of the jar to prevent electrical losses through leakages. In the common form illustrated on page 858 an insulated cap is provided through which a rod having a short length of chain is attached. The chain is allowed to rest on the tinfoil on the inside of the jar. The outer end of the rod is provided with a round brass knob. This type of condenser is largely supplanted by the flat multi-plate condenser, which is used extensively in the large condensers of transmitting stations. Glass is chosen in preference to ebonite or mica mainly on account of its comparative cheapness in construction. Although glass has a high dielectric constant, its dielectric strength is not so good as the other forms of dielectric mentioned.

The accompanying illustration shows the construction of a plate condenser. A number of leaves of tin or lead foil are placed alternate ways between sheets of flat glass, so that no two neighbouring sheets of foil touch or are sufficiently near to break down the insulation between them. Alternate sheets at each end are electrically connected. In large condensers employed in very high tension work, such as would be required in big transmitting stations, the conductors or electrodes of the condensers usually consist of zinc or other metal plates. The



GLASS AND PAPER CONDENSER

In this type of condenser good crystal or flint glass is used, selected as free from blow holes and imperfections as possible. The plates seen are of tin foil placed with the overlap at alternate ends

whole condenser is also generally immersed in an oil tank, which adds to the dielectric strength and assists in cooling the condenser. *See* Condenser.

GLASS SEPARATORS. Glass separators are rods of that material which are used in storage batteries to keep the plates separated. They are usually a little longer than the height of the plates, to enable them to stand on the bottom of the containers. In the case of a small cell only two would be used between each pair of plates, the larger sizes having three or more.

Apart from its inherent brittleness, glass is an ideal material for this purpose, as it is entirely unaffected by sulphuric acid. Furthermore, rod separators have a negligible area in contact with the plates themselves, and thus present a free space between the plates to allow any paste which may become detached to fall to the bottom. This prevents any possibility of internal short circuits. Owing to their brittleness, glass separators are never used in cells which are likely to be moved, except for repairs or other emergency, during their life.

GLASS SILENCER. A glass tube fitted with end pieces of some insulating material fitted over the electrodes of a spark gap, to enclose it and quieten the noise of the spark. The end plates are drilled a convenient size for the insertion of the electrode rods. In fitting this type of silencer it should be seen that the diameter is sufficiently large to prevent cracking through the heat of the spark. It is also essential that the interior of the glass be kept as clean as possible to prevent surface leakages.

GLASS TUBE. Clean dry glass is one of the best insulators, and may be used in a variety of applications where efficient insulation is important. A common use for glass tube is in the construction of enclosed crystal detectors. Glass tube is largely used in the construction of dry batteries to act as vent holes for the escape of gas from the cells. In this case the tube is of very small diameter. Another application is in the glass silencer (*q.v.*).

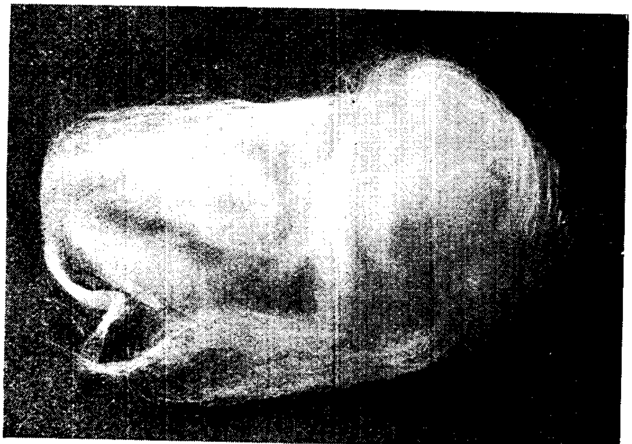
A reason why glass tube is not more extensively used is owing to the difficulty of cutting and working it. A good method of cutting off a desired length from a long tube is to put the tube in the lathe, using any soft medium of uniform thickness between the tube and the lathe chuck jaws to prevent breakage of the tube when tightening the chuck. The place where it is desired to cut the tube is marked all the way round with chalk.

A piece of strong string attached to the back of the lathe bed is turned once round the tube, the string being guided over the chalk mark. The lathe is then run at a good speed and the string pulled tight. Care must be taken to keep the string in the same position. The tube will drop off when the friction of the string heats the tube sufficiently. If difficulty is experienced in breaking the tube at the right spot the string may be rubbed with a little powdered resin to obtain more friction and the tube rapidly cooled with cold water.

If a lathe is not available the operation may be performed with a new three-square file, such as a saw-file. This is held rigidly at the very top of a vice so that one V-side is uppermost. The tube is then rubbed at right angles to the file on the mark where it is desired to cut it. Only a scratch is needed, but it is necessary to see that the scratch extends in a ring all the way round. The tube is then very smartly tapped with one hand on either side of it, when it will break at the weakest spot, where the scratch has been made. The deeper the scratch, the more easily the tube breaks, and experience will show how far it is necessary to go before attempting to break the tube.

Jagged edges may be removed by wet grinding on a hard stone.

GLASS WOOL. A fibrous material made of finely shredded threads of glass mixed with natural wool and shown in the figure. It is used in what is known as the dry accumulator, in which the glass wool forms the separator between the positive and negative plates. The remainder of the container in which the plates are placed is also filled in with the glass wool. The object of the wool is to soak up the electrolyte, thus making an unspillable accumulator. It has been found in practice that this system is not altogether satisfactory, as the wool does not permit a full charge in the case of some accumulators. It is useful in cases where extreme portability is essential.



EXAMPLE OF GLASS WOOL

Glass wool is made of finely shredded threads of glass mixed with natural wool. It is used in dry accumulators to soak up the electrolyte and prevent it from spilling

Courtesy Economic Electric Co., Ltd.

Glass wool is useful in a leaky accumulator, where it may be used to soak up the acid, thus converting the accumulator to the dry type.

GLIDING THEORY. This theory supposes that electro-magnetic waves, such as are used in wireless transmission, follow the curvature of the earth without depending upon reflection. The theory gained at one time considerable support among both mathematicians and physicists, but is now largely discredited owing to the disconcerting results, more especially in regard to strength of signals, which have been obtained in the case of some of the more widely separated stations. In his latest work Dr. Fleming points out that there are now at least half a dozen radio stations, signals from which can be detected by day or night at any point in the world where an appropriate receiving station exists. He adds that all mathematical examination shows that this effect cannot possibly be due to pure diffraction —as the bending of waves round the curvature of the earth is called—but must in some way depend upon the presence of a reflecting surface of some kind at a high level in the atmosphere. *See* Heaviside Layer ; Refraction.

GLOW DISCHARGE. Among the phenomena attributable to the discharge of an electrified conductor are those which manifest themselves by reason of their luminous effects, and the glow discharge is included in this category.

If an insulated conductor is charged to a high potential by means of an influence machine or an induction coil, the electricity so imparted to it does not remain on the body indefinitely, but tends to leak away. In the event of the conductor possessing points or projections, the density of the charge becomes greatest at such places, and will exert such an influence on the surrounding dielectric as to cause the adjacent particles of air to become electrified.

A force of mutual repulsion will accordingly be exerted between the latter and the conductor, with the result that these particles will move away along the lines of force, carrying with them minute portions of the charge, which is thus gradually dissipated by convection.

If the experiment is performed in darkness, a pale blue glow may be observed at such points. As opposed to brush discharge, this phenomenon occurs in perfect silence, and is more easily exhibited in rarefied gases than in air at ordinary atmospheric pressure. The glow will be separated from the conductor by a narrow dark space in the case of a negatively charged body.

GOLD and GOLD WIRE. The use of gold in wireless is largely restricted to the gold cat's-whisker used in conjunction with some crystals for the rectification of radio-frequency currents. In this application a springy wire wound to a coil shape is used, one end of which is straightened and lightly touches the crystal. The gold cat's-whisker is largely used in conjunction with the crystal tellurium. A nine-carat gold spring is usual in this connexion.

In static electricity gold is used in the form of very thin leaves in the construction of gold-leaf electroscopes. *See* Electroscope.

GOLDSCHMIDT ALTERNATOR. One of the earliest types of high-frequency alternators for the production of continuous waves. It was constructed about 1912 by R. Goldschmidt, on the principle of first producing a single-phase alternating current of, say, 10,000 cycles per second—which can be done by pushing ordinary methods of construction to their limit—and multiplying this up to much higher frequencies by taking advantage of Fresnel's theorem.

Tuned circuits are connected to both stator and rotor so as to produce in effect a series of machines in cascade with currents of frequencies in the ratio of 1, 2, 4, and so on. The current of the highest frequency can be put into an aerial wire and employed to radiate long electric waves of corresponding wave-length. The machine in practice has several drawbacks, one being that the air gap has to be kept to a little over $\frac{1}{32}$ in.—a difficult problem with a five-ton rotor revolving at very high speed. Not many machines of this type have been constructed, and alternators have been largely superseded in wireless transmission by valves. *See* Alternator.

GOLDSCHMIDT, RUDOLF. German wireless expert. Born March 19th, 1876, at Neu-Bukow, Mecklenburg, Germany, he was educated at the Wismar Municipal School, and studied engineering at Charlottenburg and Darmstadt Technical High School. He joined the A.E.G. in 1900, and in succession became chief engineer to Crompton & Co. and the British Westinghouse Electric and Manufacturing Company. In 1907 he was appointed lecturer at Darmstadt Technical College, and afterwards practised as a consulting engineer. Goldschmidt is famous for the high-frequency alternators which bear his name, and in 1911 he established two large wireless stations at Eilvese, Province of Hanover, and Tuckerton, New Jersey, U.S.A., for wireless communication between Germany and America. He has written a large number of articles on his alternators and other aspects of wireless transmission, and is also the author of a series of patents.

GOLDSMITH, ALFRED N. American wireless expert. Born in New York in 1887, he was educated at the College of the City of New York at Columbia University.

Goldsmith early took an interest in wireless, and has held many high positions in the wireless world. In 1912 he was appointed the wireless consultant to the United States Department of Justice, in 1914 consulting wireless engineer to the Atlantic Communication Co., and in 1915–17 consultant to the General Electrical Co. From 1917–19 Goldsmith was Director of Research to the Marconi Wireless Telegraph Co. of America, and in the latter year he became Director of Research for the Radio Corporation of America. In 1922 he was appointed a member of the U.S. Federal Radio Telephone Commission.

Professor Goldsmith has carried out a large series of investigations into simplex and duplex wireless telegraphy and telephony, transmission of canal rays, and

PROF. ALFRED N. GOLDSMITH

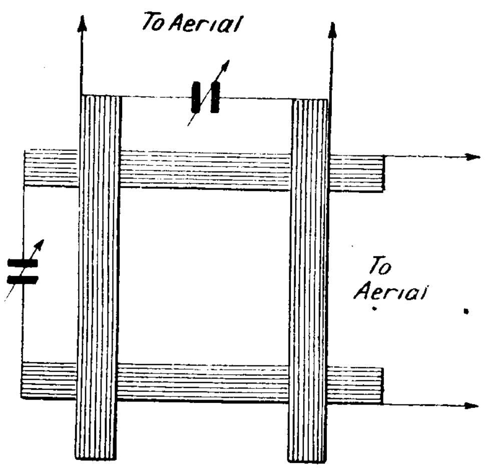
Editor of the Proceedings of the Institute of Radio Engineers of America, Prof. Goldsmith is a prominent wireless expert and well-known writer on radio subjects. His investigations into simplex and duplex telegraphy and telephony and the transmission of canal rays are regarded as notable scientific achievements precision instruments in wireless engineering. He is a member of many wireless societies, and since 1912 has been editor of the proceedings of the Institute of Radio Engineers. Goldsmith is the author of many papers on wireless subjects, and of a number of well-known and authoritative books, including "Wireless Telephony," "Radio Measurements," etc.

GONIOMETER. The goniometer is an instrument designed for use in conjunction with special types of aerials, both for the purpose of determining the direction of a source of incoming signals, and for the propagation of electric waves to a desired point. The term is, however, frequently applied in a broader sense, to embrace the whole of a directive radio system.

The side of directional wireless in which research has shown the greatest advances, and to which particular reference is made in this section, is that of reception. The most important application appears to exist in direction and position finding, though the problem of the elimination of interference and jamming, owing to the rapidly increasing number of transmitting stations, will doubtless lead to further developments in directive transmission.

In this connexion the researches of Senatore Marconi and his band of wireless experts into short-wave transmission are of great importance. The subject is dealt with in this Encyclopedia under the heading Short Wave, and also to some extent under Reflection.

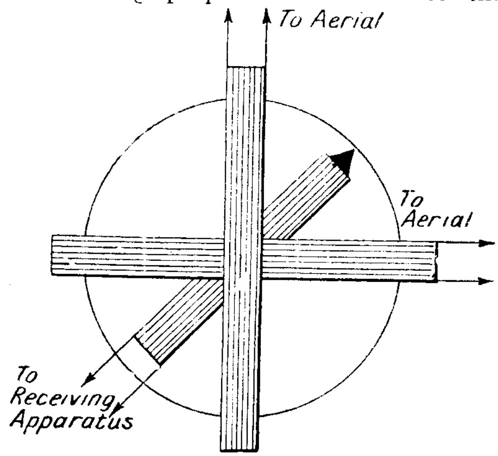
The type of instrument which has been most widely adopted is that based on the



DISPOSITION OF COILS IN GONIOMETER

Fig. 1. Viewed from the top the disposition of coils in a goniometer appears as in this diagram

Bellini-Tosi (*q.v.*) system, and takes the form of a specially designed oscillation transformer. This consists essentially of two fixed coils of wire, mounted exactly at right angles to one another in order that mutual inductive effects between them may be a minimum. Both coils are wound in two equal sections and divided at their centres by a variable condenser for tuning purposes. Reference to the



STATIONARY AND SEARCH COILS

Fig. 2. For simplicity the two sections of each stationary coil are merged into one, and the condensers are omitted. Within the stationary coils is the rotating search coil with pointer

accompanying diagram (Fig. 1) will make clear the disposition of the coils as viewed from the top.

Mounted concentrically inside the two stationary coils is placed a smaller one, capable of being rotated through a complete circle. A pointer is attached to this movable or search coil, as it is usually known, and a scale provided so that its angular position with regard to the fixed coils may be read at a glance.

The diagram, Fig. 2, shows the complete arrangement, where for simplicity the two sections of each fixed coil are merged into one and tuning condensers omitted. Leads, which should be as short as possible and not run too close together, are taken from each fixed coil to its respective directive antenna and from the search coil to receiving apparatus. Each stationary coil is wound continuously in the same direction, due care being taken to ensure that both sections have the same number of turns and that the spacing between each conductor is constant.

A very simple case is provided by a square loop of wire (Fig. 3), mounted so as

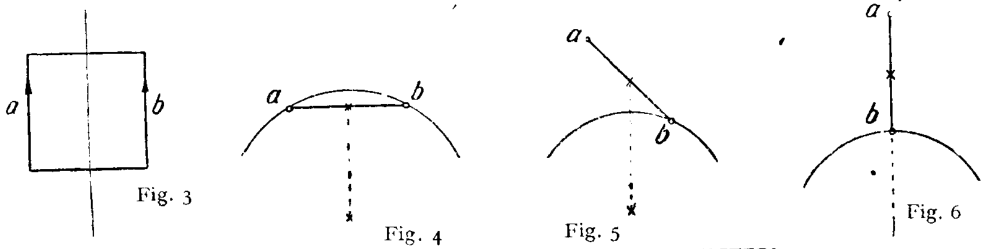


Fig. 3 Fig. 4 Fig. 5 Fig. 6

DIRECTIVE ANTENNA THEORY OF A GONIOMETER.

Fig. 3. Rotating about its vertical axis is a square loop of wire. Arrow heads *a*, *b*, represent electro-motive force induced by a received pressure wave. Being in opposition, they cancel one another. Fig. 4 is a plan view of the loop, and what takes place when the two induced electro-motive forces are out of phase is shown in Fig. 5. In Fig. 6 the loop is rotated to obtain the greatest phase difference and the greatest current will flow

to be capable of rotation about its vertical axis. This is again shown in plan by Figs. 4, 5 and 6. A pressure wave set up in the ether by a transmitter situated on a line perpendicular to the plane of the loop (Fig. 4), in spreading outwards in ever-widening circles, will cut the two upright conductors *a* and *b* simultaneously, with the result that the two electro-motive forces induced in them, whatever their direction and value, will be in phase. Assume that their direction is upwards, as indicated by the arrow heads (Fig. 3); being in opposition, they will cancel one another, and no current will flow in the circuit.

Suppose, now, the loop is rotated to the position in Fig. 5. The waves will excite *b* before *a*, so that the two induced electro-motive forces will be out of phase, and a current will flow as a result of this phase difference. If the loop is still further rotated until its plane comes into direct alinement with the source of wave emission (Fig. 6), we shall have a case where the phase difference will be a maximum and the greatest current will flow.

In the system under consideration the aerials take the form of two triangular loops, one of which is shown in Fig. 7, slung from an insulator at their apex, the plane of each triangle being at right angles to the other.

From a similar train of reasoning to that given above, these antennae are found to possess directional qualities, so that a maximum current is induced when alined with a transmitting station, and a minimum when at right angles. In intermediate positions the value of the current is proportional to the cosine of the angle *a* between the plane of the aerial and the transmitter. Fig. 8 gives a plan of the two loops.

Signals from X will produce a maximum effect upon A, and a nil effect upon B. Similarly transmission from Y will energize B, but not A. For radiation from a point Z the current in A will be proportional to cos *a*, and in B, cos (90 − *a*).

To return to the goniometer itself. The fixed coils, which are merely continuations and reproductions of the external antennae, will accordingly be excited in a similar way and will be

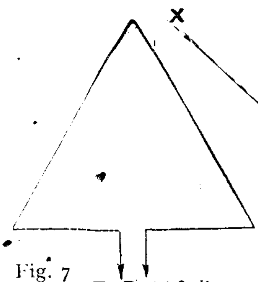


Fig. 7

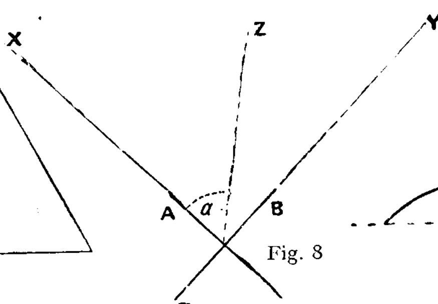


Fig. 8

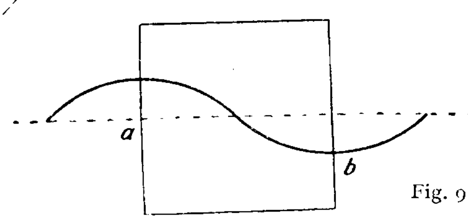
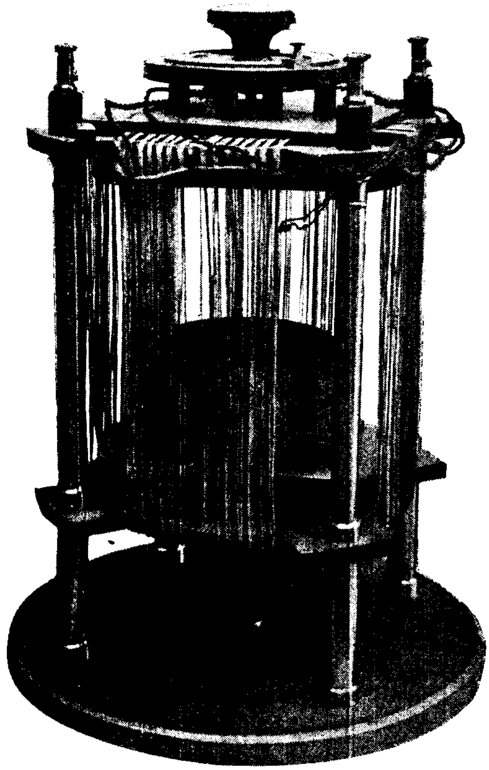


Fig. 9

GONIOMETER TRIANGULAR LOOP ANTENNA THEORY

Fig. 7. Triangular loops are slung from an insulator, the triangles being at right angles to each other. Fig. 8. A plan of the two aerials is given in which one is energized by a transmitter X, and the other by another transmitter, Y. Fig. 9 is a theoretical diagram representing a wave in the act of cutting a loop



FIRST DIRECTION-FINDING GONIOMETER

Fig. 10. This photograph shows the original Marconi-Bellini-Tosi goniometer, with the various coils, which was the first goniometer for the wireless direction finder

Courtesy Marconi's Wireless Telegraph Co., Ltd.

productive of magnetic fields at right angles to the direction of the windings. These will be proportional in value to the strength of the current flowing in them.

It may be proved by mathematical reasoning that, for a given power of transmission, the value of the resultant field is constant, but its direction will vary, and is found to be at right angles to the line joining the transmitting and goniometer stations, provided, of course, the coils of the latter are set parallel to their respective loops. The effects of this resultant field will produce the greatest results on the search coil when the latter cuts the lines of force at an angle of 90°, and if the pointer is alined in the plane of this coil, will indicate the direction of the source of transmission when signals are loudest.

In actual practice it is found somewhat difficult to define accurately the position giving maximum intensity of signal strength, and it is customary to search for two points where signals disappear and bisect the angle between them. Alternatively, the pointer may be set at right angles to the coil, indication of the required direction being obtained when the sound in the headphones is faintest.

It is very convenient to have some means of giving bearings in terms of points of the compass, and for this purpose the scale over which the pointer moves may be divided into 360°, with the zero position indicating north. Once this scale is fixed by trial on the instrument the necessity of keeping the coils in alinement with the aerials disappears, for the position of the search coil with regard to the fixed windings will be the same as that of the transmitting station with reference to the triangular loops.

With the advent of the valve receiver the use of external aerials was obviated to a large extent, and frame aerials came into prominence as direction finders, the low efficiency of such closed loops being compensated by the enormous degree of amplification obtainable by multi-valve sets. By some authorities they are considered to be capable of giving more accurate results than the method just described, particularly on short wave-lengths. Reference to Fig. 9, which shows a wave in the act of cutting the loop, will illustrate why short waves are preferable. As can be seen, maximum phase difference between the two electro-motive forces induced in *a* and *b* can only be obtained if the sides of the frame are spaced half a wave-length apart, a case which is quite impracticable in most instances.

The result is, that if the dimensions of the frame are to be kept within reasonable limits, the only alternative to produce the greatest phase difference possible lies in decreasing wave-length.

The foregoing treats of direction, but not of sense of direction. Only in rare cases, however, is the latter unknown, and moreover, usually owing to some minor inaccuracies of construction which throw the system out of perfect electrical balance, better results are obtained in one sense than in the other. This can be found by practical tests with known stations.

Fig. 10 shows the original Marconi-Bellini-Tosi goniometer. The two field coils, which are connected to the respective loop aerials, are wound upon ebonite end plates. The separate turns in these coils are not all wound together. The end plates are slotted at their edges, each slot being wide enough to accommodate about eight turns of wire. This construction is clearly shown in the photograph. Two further ebonite plates mounted upon a spindle may be seen inside the field coils. The windings on these have been removed for the sake of clearness, and a cylindrical coil is seen resting upon the lower plate. The knob at the top of the instrument is for adjusting the relative position of the inner coils with the outer ones. A circular scale is fitted to enable the position of the inner coil to be noted. The instrument stands about two feet high.—*E. C. Saker.*

See Bellini-Tosi Aerial; Directional Wireless; Direction Finder; Frame Aerial; Reflection; Short Wave.

GOUGE. Name of a cutting tool used in woodwork. The purpose of a gouge is to cut out hollow shapes, and for this reason the gouge is half-round or approximately so in shape. A typical example is illustrated in Fig. 1, known as a firmer or straight gouge.

The blade is made of cast steel tempered and ground to an angle or bevel at the end,

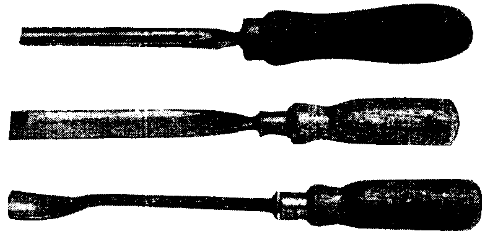
HANDLED FIRMER OR STRAIGHT GOUGE

Fig. 1. For all forms of hollow work in wood this gouge, which has a boxwood carver-shape handle, is invaluable

and brought to a keen cutting edge with the aid of an oilstone. The shank or tang is forged at the other end and is left soft to add to the strength. It has a shouldered portion, which bears against the end of the handle. The latter is made of hardwood, and in various shapes to suit individual fancy. In the pattern illustrated it is known as a carver shape and usually made of boxwood.

The end where the gouge fits in is provided with a brass or steel ferrule, to prevent splitting the wood when the tang is driven home. Three other types of gouge are illustrated in Fig. 2, and named from the top downwards as a handled firmer gouge, a paring gouge, and a spoon or carver's gouge. The latter is used for shaping the bottom of relatively deep holes, and has many uses in pattern-making and carving generally.

The experimenter who makes cabinets and similar containers for wireless sets ought to have a small selection of gouges of different types and sweeps. By sweep



GOUGES FOR WIRELESS WORK

Fig. 2. Three gouges useful to the experimenter are, (top) the straight or firmer gouge, (middle) paring gouge, and the spoon or bent gouge

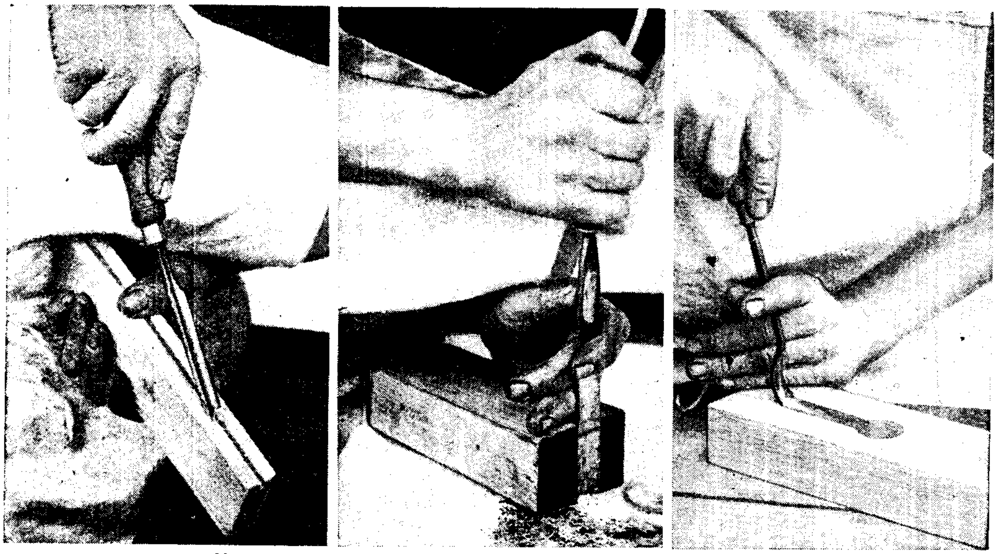
is meant the curvature of the blade. Some are nearly flat, others almost half-round in cross-section.

The width varies usually from $\frac{1}{4}$ in. to 1 in.; and a selection of firmer gouges from $\frac{1}{4}$ in. to 1 in. by $\frac{1}{4}$ in. will cover most amateur requirements, with the addition of a couple of paring gouges and a spoon or front bent gouge.

The method of using an ordinary firmer gouge is illustrated in Fig. 3, and shows the work held in the left hand, with one end resting on the bench. The gouge is always worked downhill, or with the grain of the wood, and it is desirable to always have a good view of the path of the gouge, as this aids in controlling the cut. The tool is gripped in the right hand, with the first finger on the top of the handle to assist in its accurate direction.

The gouge is inclined at an angle to the face of the work, and the amount should be varied, until, by trial, the best is found. This will be shown by the nature of the chips. When these come away freely, and with a clean, ripping sound, the tool is worked correctly. Paring gouges are ground on the opposite side of the blade to the firmer gouges, and are used for cutting across the end grain of timber, as shown in Fig. 4. In this case the gouge is gripped by the right hand, with the thumb on top of the end of the handle.

The left hand rests on the work, and presses it down firmly on to the work-bench; or, preferably, on a piece of smooth wood, as this saves the surface of the bench from destruction by the gouge. The second, third, and fourth fingers of the left hand are placed behind the blade, but the first finger surrounds the blade, to prevent it slipping or getting displaced. The cut is made in a vertical manner by pressing the gouge down and,



HOW THE PRINCIPAL TYPES OF GOUGES ARE USED

Fig. 3 (left). Long grooves in a piece of timber are made with a firmer gouge. Fig. 4 (centre). The paring gouge is used for cutting grooves and carving the ends of timber. Note the position of the hands. Fig. 5 (right). A spoon-shaped carver's gouge is used for hollowing recesses. It is manipulated in much the same way as the paring gouge

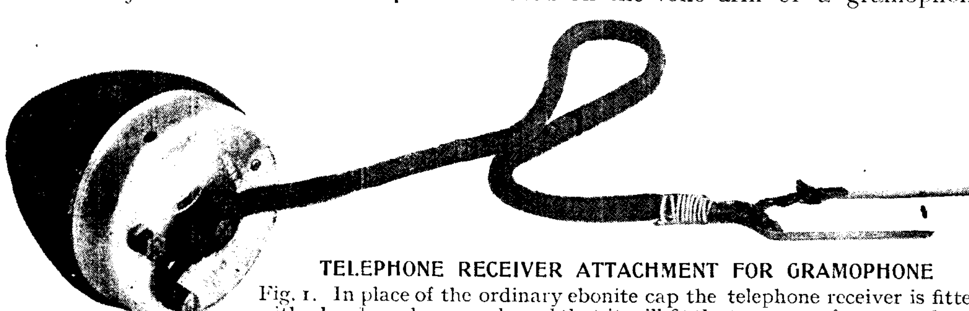
at the same time, keeping it drawn back against the face of the work to keep it in cut. For good work the edge must be very sharp.

The spoon gouge is shown in use in Fig. 5, and is guided and manipulated in much the same way as the paring gouge, except that it has to be worked with a sweeping movement to obtain the desired contour.

Gouges are sharpened by grinding on a grindstone and setting the edge on an oilstone. Hollows are sharpened with a small circular-sectioned oilstone slip.

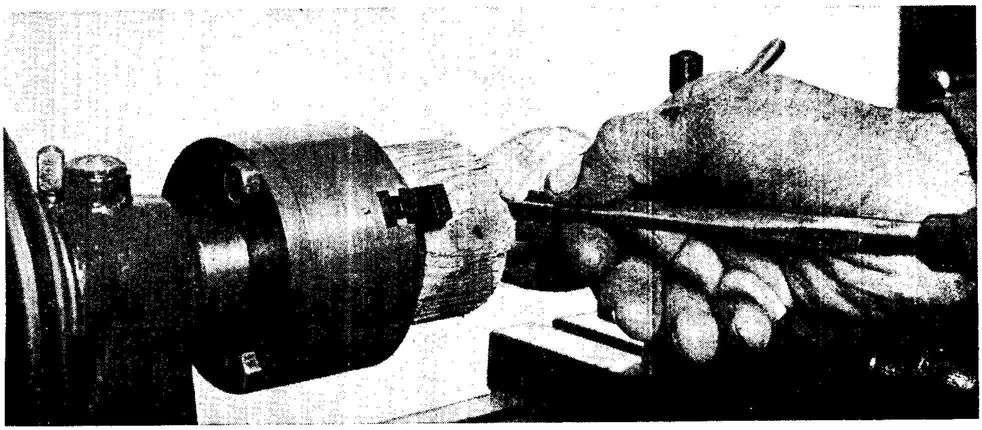
GRAMME RING ARMATURE. The Gramme ring armature is the name applied to a certain form of armature invented by a French electrical pioneer named Gramme. The original armature, for which he took out a patent in the year 1871, consisted of a ring composed of a number of iron wires, over which were wound coils of insulated copper wire. It was from this invention that the modern toothed-ring form of iron armature core developed. Instead of iron wires, it is now general practice to form the armature core of a large number of toothed iron stampings, the windings thereon being wound in the slots between each tooth. *See* Converter; Dynamo.

GRAMOPHONE ATTACHMENT. Expression applied to a variety of different types of telephone receiver, the top of which is so shaped as to permit of its being used on the tone arm of a gramophone



TELEPHONE RECEIVER ATTACHMENT FOR GRAMOPHONE

Fig. 1. In place of the ordinary ebonite cap the telephone receiver is fitted with a hardwood cap, so shaped that it will fit the tone arm of a gramophone. These appliances can either be purchased from wireless retailers or made by the amateur. Commercially made gramophone attachments are supplied in high- or low-resistance values, a transformer being required for the low-resistance attachments



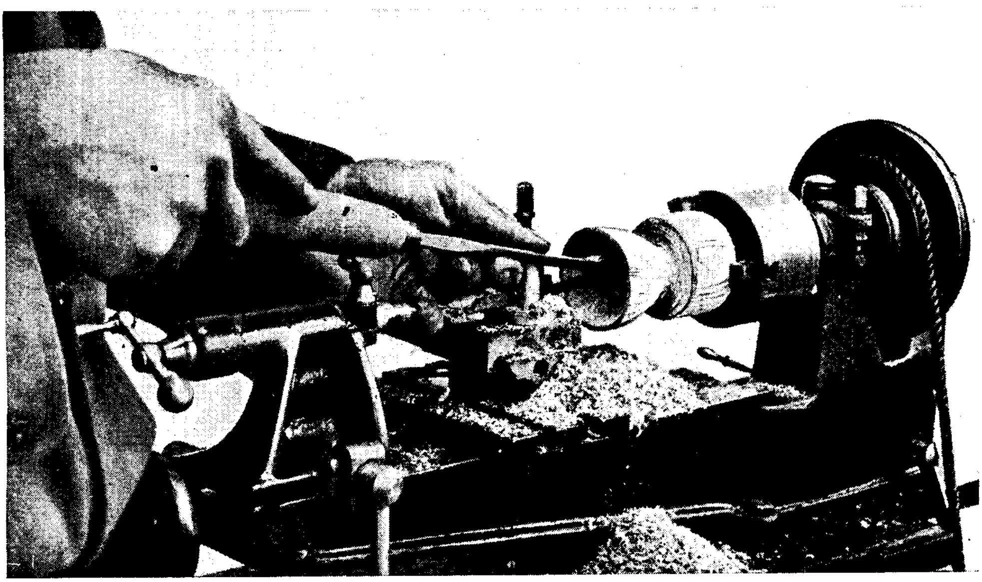
FIRST STAGE IN TURNING A GRAMOPHONE ATTACHMENT

Fig. 2. Fitted to the chuck of a lathe is a block of hardwood, which is first made round. The photograph shows the beginning of the process of turning the cup for the telephone earpiece to fit into the gramophone. A gouge is used to cut away the wood

in place of the ordinary sound box. Most of the leading manufacturers supply such appliances in various resistances, varying from 120 to 4,000 ohms. The former should be used in conjunction with a telephone transformer, and the latter for the ordinary type of receiving set.

The construction of a gramophone attachment is a comparatively simple matter. The first requirement is a good quality earpiece or telephone receiver, such as that shown in Fig. 1, and to turn up a hardwood cap which can be fitted in place of the ordinary ebonite cap, the opposite end being bolted to feet on the tone arm.

The bulk of the work can be carried out in one operation in the turning lathe. Fig. 2 shows early stages, and the method of holding the gouge while turning the exterior of the cap. When this has been turned, its edges are bevelled and the inside hollowed out, somewhat as illustrated in Fig. 3, after which a screw thread is cut on the outer portion to correspond



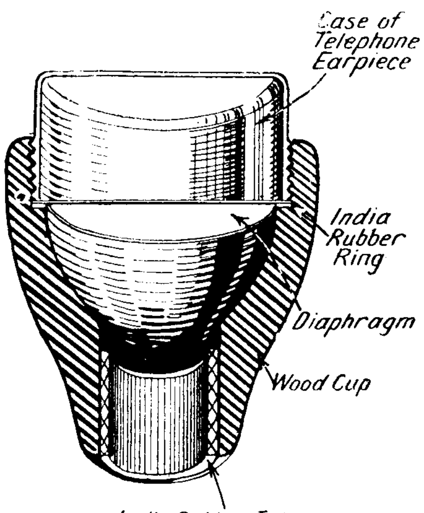
HOLLOWING OUT THE CUP OF A GRAMOPHONE ATTACHMENT

Fig. 3. After the outside of the hardwood cup has been turned the cup is not severed from the main block. The inside is hollowed out in the manner illustrated in the above photograph

in pitch and diameter to the threads cut on the case of the telephone.

A small shoulder must be formed so that when the new cap is screwed in place it holds the diaphragm in its proper place in the manner illustrated in Fig. 4, which shows a section through the completed apparatus, the details of the telephone being omitted for the sake of clearness.

A small ring of indiarubber should be interposed between the diaphragm and the rest of the cap, to obviate any chance of its rattling. The small end of the cap should be bored out slightly larger than the diameter of the tone arm, usually about ¾ in. in diameter. It should then be lined with thin sheet indiarubber; or a small piece of rubber pipe may be cut off and mounted in place with a little rubber solution, and the outer end rounded off to facilitate its easy insertion on to the tone arm.



SECTIONAL DIAGRAM OF GRAMOPHONE ATTACHMENT

Fig. 4. How the gramophone attachment is built up can be seen in this sectional diagram. Fitted into the wooden cup is a rubber tube at the base, and the case of the telephone earpiece at the mouth

The telephone leads should be attached to the terminals of the telephones, and may conveniently end in small tags or, if preferred, a plug-and-socket connector, according to the arrangement of the receiving set. Such an adaptor will act as a miniature loud speaker, and the quality of the music depends considerably upon the excellence of the telephone and the proportioning of the tone arm and trumpet of the gramophone, as well as the power available from the receiving set. *See* Amplifying Telephone.

GRANULE. An expression used to convey the idea of a small lump of any particular substance. In wireless, granules of carbon are used in the construction of microphones, and also in many types of primary batteries. *See* Carbon Granules.

GRAPH. Diagrammatic representation of certain statements of facts, formulae, etc. Graphical methods are increasingly employed in the solution of problems and the results of analysis, not only in science, but in everyday affairs.

In wireless, the experimenter will find a knowledge of curves and curve plotting—the graphical representation, in other words, of the facts he is called upon to deal with—exceedingly useful. For this purpose he should become absolutely familiar with squared paper. This is paper which is divided off into small squares by horizontal and vertical lines, and every tenth line is usually made more distinctive than the others. By this means it is extremely easy to measure off distances horizontally or vertically.

The plotting of curves is dealt with in this Encyclopedia under the heading Curve. *See* also Alinement Chart; Characteristic Curve; Sine Curve.

GRAPHITE. A form of carbon largely used in wireless and electrical work.

Graphite is a black opaque substance, and a good conductor of electricity. It is used for the construction of high resistances, such as grid leaks (*q.v.*).

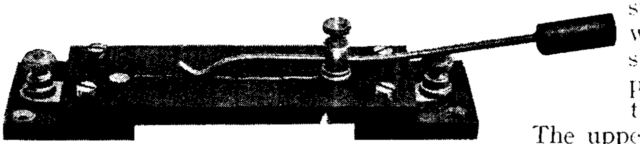
An improvised grid leak may be made by using a graphite lead pencil, and rubbing the lead between two fixed terminals or conductors.

For the reason that graphite is a conductor, marking out wireless panels with a pencil should be avoided.

Among forms of manufactured graphite, its use in electric arc lamps and dynamo and motor collecting brushes is common. Many types of primary batteries use graphite in their construction, including the great majority of dry cells. Graphite is also extensively used in microphones for telephonic transmission, where it takes the form of small granules set in a vertical cup of graphite, or, in some cases, of metal, and kept in position by a diaphragm of soft iron housed in a support just clear of the cup. Owing to the fact that graphite is a conductor an electric current will pass through the granules to the diaphragm. When the diaphragm is moved by the sound waves of speech the granules of graphite are compressed or released from compression, which causes a fluctuation of current value. This fluctuation is used to record sound in the telephone receivers.

GRAPHITE RESISTANCE. Name applied to any high-resistance wire or path, the resistant material of which is composed of graphite. Examples include the high-resistance leak used in some forms of grid leak, and also for resistance capacity coupling. For experimental work a graphite resistance has many advantages. It is capable of very considerable variations in value, from a few hundreds to several million ohms, dependent upon the length of the path and the nature and breadth of the graphite.

A simple method of constructing such a resistance for experimental purposes is by building it up on an ebonite baseboard, and fitting to it a movable contact blade running in a trackway composed of graphite, somewhat on the lines illustrated in Fig. 1. In this case the ebonite base measures 4 in. in length, 1 in. in width, and $\frac{1}{4}$ in. in thickness. To it are attached two separate ebonite blocks, or feet, measuring $1\frac{1}{4}$ in. in length and 1 in. in width. This is done to raise the resistant element above the surface of the baseboard and help to minimize surface losses.

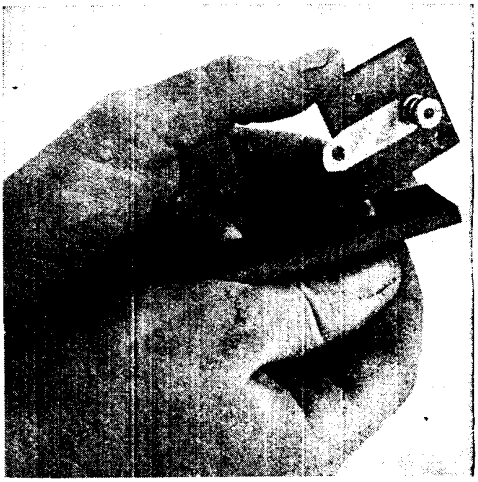


GRAPHITE HIGH-RESISTANCE DEVICE

Fig. 1. High resistance is obtained in a simple device which can easily be made by the amateur. This may be used as a variable grid leak

The first steps in construction are to prepare three pieces of ebonite and screw the two smaller portions to the long strip with four small brass screws tapped into screwed holes in the feet. The next step is to fit terminals to each of the feet and a strip of copper, to act as a conductor, as shown in Fig. 2, to conduct the current from the terminal on the base to a terminal at the end of the resistance path.

Contact is effected by tightening a nut on to the bottom of the telephone terminal,

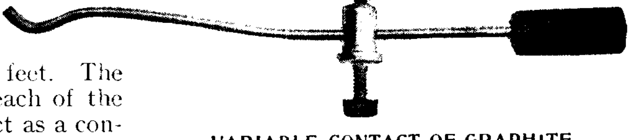


CONTACT STRIP OF GRAPHITE RESISTANCE

Fig. 2. Current is carried from the terminal on the base of the resistance to the terminal which joins up with one end of the resistance path by the copper strip in this photograph

which passes through a hole in the upper ebonite plate at one end. The other end is connected in a similar manner to an ordinary contact stud, which is recessed below the surface of the upper piece of ebonite. The contact arm illustrated in Fig. 3, together with the telephone terminal which acts as a support for it, is constructed from a piece of brass wire about $\frac{3}{32}$ in. in diameter, shaped as shown in Fig. 3, and passed through a hole in the telephone terminal.

The upper end of the wire is provided with a small ebonite knob. A shallow groove is then cut into the upper ebonite plate connecting the two terminal holes. The telephone terminal and the contact stud then pass through these holes, and the nuts are tightened up. A soft lead pencil is rubbed along the groove, thus covering it with a film of graphite. The contact arm is placed in position, and bent so that

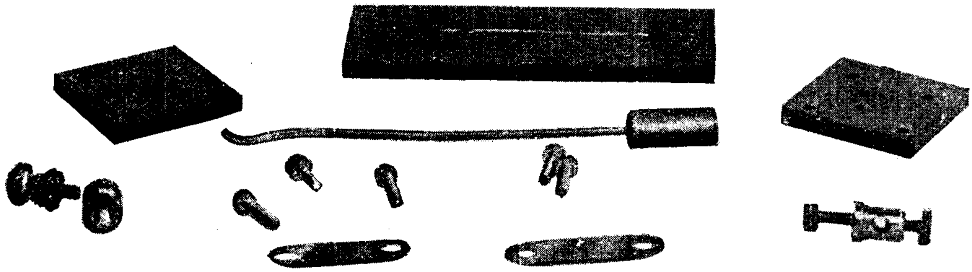


VARIABLE CONTACT OF GRAPHITE RESISTANCE

Fig. 3. Held by a telephone terminal is a bent brass arm with an ebonite handle. The end of this arm runs along the graphite line to vary the point of contact

it springs upwards, making contact with the graphite.

The exact value of resistance can only be determined by experiment and direct measurement, but is readily variable by sliding the contact arm in the groove and, when the desired position is reached, securing it by tightening the knurled knob on the telephone terminal. The whole of the component parts for this simple graphite resistance are shown separately in Fig. 4. *See* Blacklead.



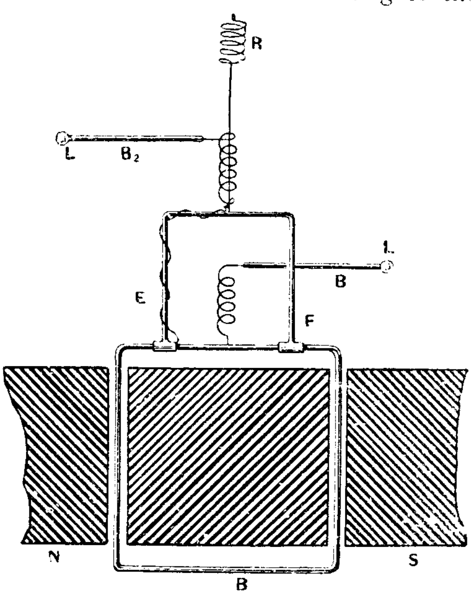
DISSEMBLED COMPONENTS OF VARIABLE GRAPHITE RESISTANCE

Fig. 4. Parts of the variable graphite resistance shown in Fig. 1 are laid out as a guide for the amateur constructor. All the parts required for making this device are three pieces of ebonite, five screws, two copper strips, two terminals, a telephone terminal, and a contact arm

GRASSOT FLUXMETER. For the investigation of magnetic fields and regions round about a magnet pole, and particularly for the rapid measurement of relative strengths of various magnets for comparative purposes, an instrument termed the Grassot Fluxmeter has been designed. The fluxmeter consists essentially of a sensitive moving-coil type of galvanometer, shown in the diagram. The moving coil, B, is suspended by a silk fibre to a shock-proof anchorage, R, consisting of a spring mounting, and current is led into and out of the coil by thin silver brushes B_1 and B_2, the torsional controlling force on the coil being reduced to a minimum. E, F is the suspension stirrup, N, S the poles of the permanent magnet between which the moving coil is suspended, and L, L the terminals. The instrument itself is illustrated on page 949.

If a search coil consisting of a suitable number of turns of copper wire, appropriately shaped for the purpose, is introduced into the magnetic field whose strength it is required to measure, the ends of the search coil being also connected to the fluxmeter terminals, a direct reading on the scale of the instrument will be obtained proportional to the strength of the field in which the search coil is placed for the time being. The resistance of the search coil itself is of no importance, and the design of the fluxmeter is such that the indications of the pointer are to a great extent independent of the rate at which the magnetic field is being cut by the search coil.

The instrument is usually about 6 in. long, and is divided into 50 divisions on either side of a centre zero, and each division represents a definite number of Maxwell-turns (the Maxwell being the unit of flux); this number is usually 20,000, and is marked on the scale. Thus the total number of lines cut by each turn of the search coil is obtained by dividing the deflection on the scale by the actual number of turns according to the



GRASSOT FLUXMETER

This instrument consists of a sensitive moving-coil type galvanometer; the essential parts are represented in the above diagram. The instrument itself is seen on page 949 l used in testing. Also if the mean ea of the search coil is known, it is rfectly easy to calculate the field rength in lines per square centimetre, at is, the flux-density in Gausses.

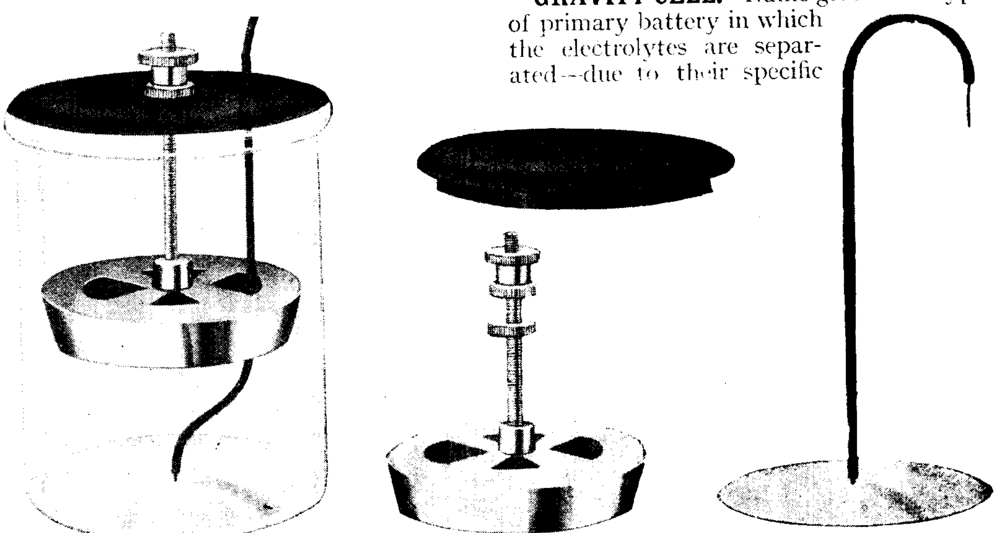
In the commercial testing of magnets t is generally desired to find the total umber of magnetic lines generated by the nagnet itself, and in order to do this it becomes necessary to use a search coil of such shape and dimensions that it is possible to cut all the lines issuing from the magnet being tested. Different coils will be needed for different types of magnet, and they must also contain a sufficient number of turns to give a convenient deflection.

In making a test as to the total lines of force generated by a given magnet, the search coil is first placed over this magnet at a point equidistant from the two poles (the equator), where it will embrace practically all the lines generated in the magnet before they leak away. If the search coil is then removed from the magnet (still connected to the fluxmeter) and taken to a sufficient distance away to ensure its being practically free of the field from the test magnet, it is evident that the coil must have cut the whole of the lines once during this journey. If it is assumed, for instance, that the search coil has 100 turns, and that the fluxmeter indicates 35 scale divisions, each division representing 20,000 Maxwell-turns, then the total flux generated by the magnet under test will be equal to $20{,}000 \times 35 \div 100 = 7{,}000$ lines of force or Maxwells. No allowance need to be taken into account as regards the actual area of the search coil when the total flux is being measured, but if it is necessary to ascertain the flux density in the cross-section of the magnet under test it is simply a question of dividing the total flux registered by the fluxmeter by the cross-section of the magnet in square centimetres in order to arrive at the flux density per square centimetre in Gausses.

A very useful application of the Grassot fluxmeter is the measurement of field strength in the air gaps of motors and generators, which may be done by first taking the deflection value in Maxwell-turns given by the instrument reading, and dividing this by the area of the search coil in square centimetres and the number of turns in the coil.

Many other useful purposes can be served by the fluxmeter, such as the determination of magnetic constants in a magnetic circuit, the study of hysteresis, the measurements of coefficients of mutual induction, the measurements of quantities of electricity and capacities of condensers, etc. It can also be used as a galvanometer for small potential differences and insulation resistance measurement. *See* Fluxmeter.

GRAVITY CELL. Name given to a type of primary battery in which the electrolytes are separated—due to their specific



DANIELL GRAVITY CELL AND ITS CONSTRUCTION

On the left is seen the complete Daniell gravity cell, and on the right the copper plate, zinc plate with supporting rod and terminals, and the cap to which the rod is attached

Courtesy India Rubber, Gutta Percha and Telegraph Works Co., Ltd.

coil used in testing. Also if the mean area of the search coil is known, it is perfectly easy to calculate the field strength in lines per square centimetre, that is, the flux-density in Gausses.

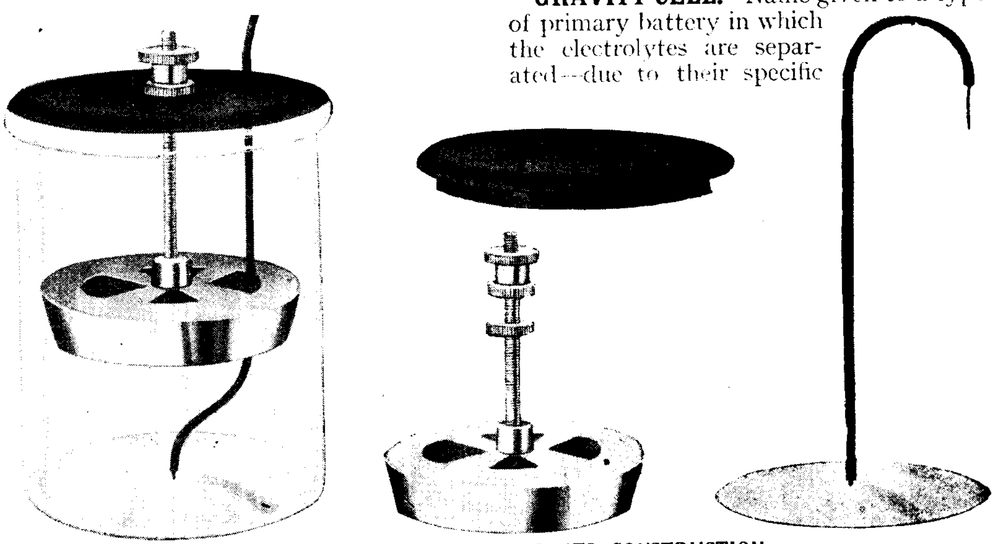
In the commercial testing of magnets it is generally desired to find the total number of magnetic lines generated by the magnet itself, and in order to do this it becomes necessary to use a search coil of such shape and dimensions that it is possible to cut all the lines issuing from the magnet being tested. Different coils will be needed for different types of magnet, and they must also contain a sufficient number of turns to give a convenient deflection.

In making a test as to the total lines of force generated by a given magnet, the search coil is first placed over this magnet at a point equidistant from the two poles (the equator), where it will embrace practically all the lines generated in the magnet before they leak away. If the search coil is then removed from the magnet (still connected to the fluxmeter) and taken to a sufficient distance away to ensure its being practically free of the field from the test magnet, it is evident that the coil must have cut the whole of the lines once during this journey. If it is assumed, for instance, that the search coil has 100 turns, and that the fluxmeter indicates 35 scale divisions, each division representing 20,000 Maxwell-turns, then the total flux generated by the magnet under test will be equal to $20{,}000 \times 35 \div 100 = 7{,}000$ lines of force or Maxwells. No allowance need to be taken into account as regards the actual area of the search coil when the total flux is being measured, but if it is necessary to ascertain the flux density in the cross-section of the magnet under test it is simply a question of dividing the total flux registered by the fluxmeter by the cross-section of the magnet in square centimetres in order to arrive at the flux density per square centimetre in Gausses.

A very useful application of the Grassot fluxmeter is the measurement of field strength in the air gaps of motors and generators, which may be done by first taking the deflection value in Maxwell-turns given by the instrument reading, and dividing this by the area of the search coil in square centimetres and the number of turns in the coil.

Many other useful purposes can be served by the fluxmeter, such as the determination of magnetic constants in a magnetic circuit, the study of hysteresis, the measurements of coefficients of mutual induction, the measurements of quantities of electricity and capacities of condensers, etc. It can also be used as a galvanometer for small potential differences and insulation resistance measurement. *See* Fluxmeter.

GRAVITY CELL. Name given to a type of primary battery in which the electrolytes are separated—due to their specific



DANIELL GRAVITY CELL AND ITS CONSTRUCTION

On the left is seen the complete Daniell gravity cell, and on the right the copper plate, zinc plate with supporting rod and terminals, and the cap to which the rod is attached

Courtesy India Rubber, Gutta Percha and Telegraph Works Co., Ltd.

gravity—the lighter one floating on top of the heavier fluid. An example of this form of cell is the gravity Daniell cell. In this cell copper sulphate solution forms the heavier electrolyte, and a weak solution of sulphuric acid, or zinc sulphate, rests on top of it.

The illustration shows a typical gravity Daniell cell. On the left is shown the complete cell, and to the right the various components going to its construction. A waxed wood or ebonite cap fitting into a flange-topped glass jar supports a cast zinc plate suspended from the cap by a screwed rod on which terminals are placed for connexion to the external circuit. It will be seen from the illustration that the zinc plate is held half-way up the jar. Resting on the bottom of the jar is a thick copper plate, electrical connexion to which is made by an insulated wire drawn through one of the holes in the zinc plate.

In operation the copper plate is covered with a quantity of copper sulphate crystals. A concentrated solution of these crystals is then poured in until a level is found below the zinc plate. The solution must not touch this plate, as deposition would occur and local action ensue. The object of the crystals is to keep the solution saturated. A solution of zinc sulphate is poured in to cover the zinc plate. Owing to the lighter specific gravity of the zinc sulphate it will not mix with the copper sulphate solution, but will remain on the top of it.

This cell is not portable, as shaking tends to diffuse the lower solution.

The electro-motive force of the gravity Daniell cell is not high, and ranges between 1·07 and 1·14 volts. The copper plate forms the positive and the zinc the negative element. *See* Daniell Cell; Primary Cell.

GRID. Name applied in wireless work to the control electrode in a thermionic valve. The details of its construction vary with the different types of valve, but in a standard construction comprise a spiral of wire surrounding the filament and located between the latter and the plate or anode. The ends of the grid wire are suitably supported, and one end is connected to a terminal plug on the lower part or exterior of the valve.

The function of the grid in a valve is to control the steady flow of electrons from the filament to the anode or plate. Take the case of a receiving set tuned to a particular broadcasting station. The incoming pulses of current are collected by the aerial, and handed on to the grid through the agency of the tuning coil or other device. These pulsations of current affect the flow of electrons passing between the filament and the anode, because when the grid potential is negative, some of the electrons will be repelled and will return to the filament.

When the grid potential is positive some of the electrons will be assisted towards the anode, and the anode or plate current will be increased. Normally, when no signals are being received, the grid may be considered as at zero or no potential, and the electrons flow in a steady stream from the filament to the anode. The technical details and scientific reasons for this are closely associated with the whole of the functions of the thermionic valve, and are dealt with at length under the heading Valve.

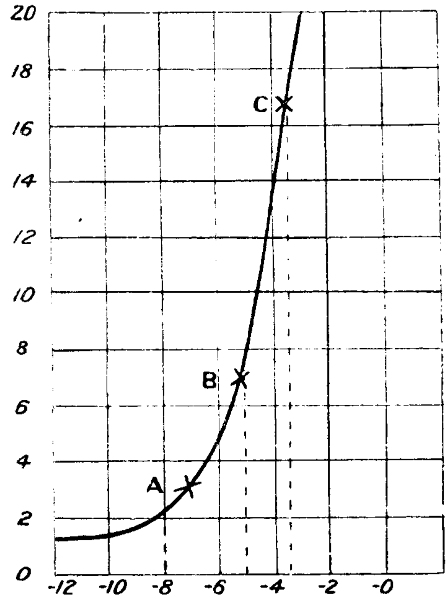
It is important to bear in mind that a very small current flowing in the grid circuit has a great effect on the anode current. Consequently, the tiny impulses of current from the aerial cause a similar, but more appreciable, pulsation in the anode current, with the result that signals are readily detected. The same applies to the grid of a valve used for amplification purposes, as well as in the transmission of messages. The important practical point is that the grid and the grid current control the much larger and stronger anode current. There are many ways in which the grid potential can be varied, as by the use of a grid potentiometer, grid-biasing batteries, coils, and in other ways. *See* Anode; Filament; Grid Leak; Modulation; Valve.

GRID BATTERY. A battery, usually consisting of one, two, or three dry cells, so arranged in a wireless receiving set as to bias the grid of a valve or valves in a positive or negative direction. The usual object of this is to influence the grid in a negative direction, in order to alter the position of its working on the characteristic curve. It is not only desired in a sensitive receiver to obtain a maximum of current, but to obtain as great a change of current as possible. Reference to the graph in Fig. 1 will show how the grid-biasing battery is used in this respect.

On the ordinates is plotted current in micro-amperes, and on the abscissae are plotted negative grid volts. It will be seen from this valve characteristic curve that considerably more current differences occur between B and C than between A and B. The grid battery, therefore, determines the point on the valve characteristic at which the valve will work. Beyond a certain point it will be seen that an increase of negative potential on the grid will adversely affect its operation. Fig. 2 shows a circuit where a grid-biasing battery is applied to a single-stage low-frequency amplifier.

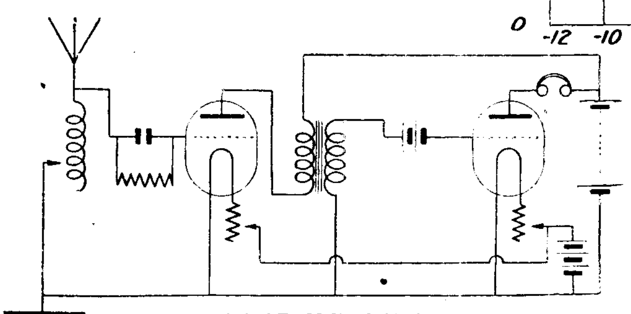
An alternative position for the grid battery is on the other side of the transformer secondary, the negative side being wired to the transformer.

A practical example of the application of single cells in a receiving set is shown in Fig. 3, where two are used in negatively biasing the grids of two low-frequency amplifying valves.



INFLUENCE OF GRID BATTERY

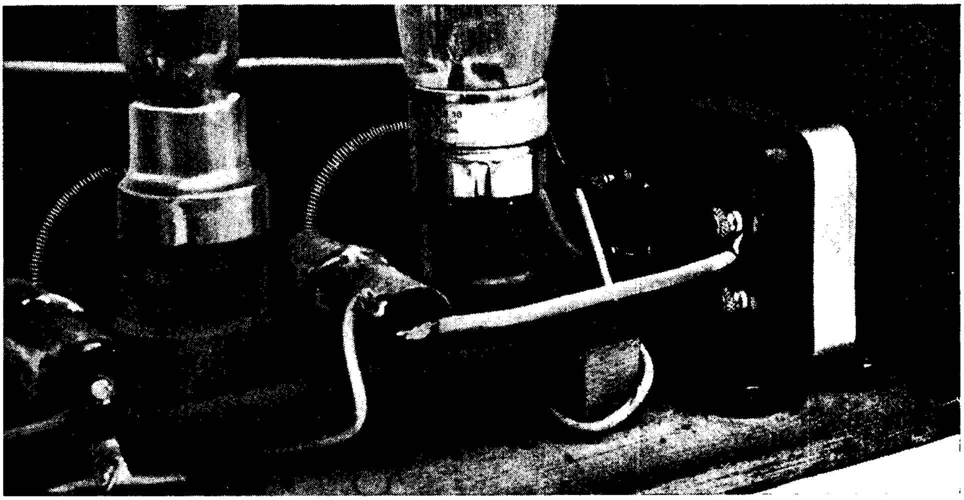
Fig. 1. Reference to the above characteristic curve of a valve will show the effect of a negative grid potential



POSITION OF GRID BATTERY

Fig. 2. In this diagram the position of a grid-biasing battery in a single stage of low-frequency amplification is seen

The grid battery plays an important part in the operation of power-amplifying valves or for other hard valves used in low-frequency amplification. As the anode voltage on such a valve is increased, the characteristic



SINGLE-CELL NEGATIVE BIAS IN GRID CIRCUIT

Fig. 3. The position is indicated in this photograph of two grid-biasing batteries in a receiving set. It will be seen that the negative is attached to the negative of the valve leg, and the positive side of the battery to the transformer secondary

curve is moved to the left, which necessitates a strong negative grid potential. The ordinary R valve working on an anode potential of 50 volts should have a grid value of about zero potential. If the anode voltage is increased to 100 volts, advantage will be found in negatively biasing the valve grid to the extent of 3 volts. Assuming that a valve working under these conditions is giving its maximum efficiency, it will be necessary to use increased power if another stage of magnification is required. This entails a higher anode voltage and a corresponding increase in negative grid potential. A valve working with an anode potential of 300 may require 12 volts on the grid.

An additional advantage of the grid battery is that if it is of sufficient potential it is enabled to overcome the strongest positive potential applied by an incoming signal, and prevents the flow of grid current, which almost invariably means distortion in power amplification.

In certain circuits, such as the Armstrong super-regenerative circuit, it is customary to use a grid battery in place of the usual grid condenser and leak. *See* Frame Aerial; Grid Control; Hanging Set; Regenerative Set.

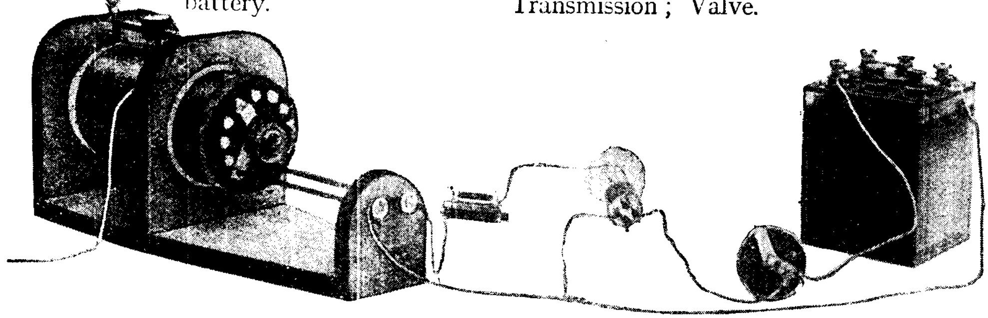
GRID CIRCUIT. Name sometimes given to that part of a circuit which includes the grid of the valve. The pictorial representation given of such a circuit shows that the circuit includes the low-tension battery or accumulator, and commencing from the outside terminal, leads to the filament rheostat, from this to one of the filament terminals of the valve, and through the filament of the valve by another wire to the negative side of the battery.

The second wire leads from one side of the coupled circuit to the grid leak condenser and thence to the grid terminal of the valve. The grid leak and condenser are not always found in this position in the grid circuit, but are so placed when the valve is to function as a rectifier. It is usually possible to pick out the grid circuit, even from the most complicated systems, by commencing from the grid of the valve and tracing the circuit to aerial in one direction, and through the rheostat and batteries to earth. *See* Grid; High-frequency Amplifier.

GRID CONTROL. Term applied in a wide sense to all the controlling devices incorporated in the grid circuit, and in a limited sense to devices for the control of the potential applied to the grid. In the former application the grid leak and condenser are controls, as they affect the incoming pulses of current, and enable the valve to function as a rectifier. In the case of a high-frequency amplifier the transformer or tuned anode arrangement is a controller of the grid in the next valve, as it may affect the fluctuating potential differences impressed on the grid of the next valve.

The greatest use of grid control is effected by the control of the potential impressed on the grid. One of the means that may be adopted to do this is by a potentiometer across the terminals of the filament battery, thus allowing the grid voltage to be varied from zero to a maximum, either positive or negative. Another control along the same lines is to change the polarity of the connexions from the filament battery to the grid.

These alterations are more pronounced with different types of valve, the purpose in all methods being to enable the valve to function at the most efficient portion of its characteristic curve. *See* Grid Battery; Transmission; Valve.



GRID CIRCUIT WITH VALVE AS RECTIFIER

Spread out unmounted to show the wiring are the details of a grid circuit which includes the aerial circuit coupled to a closed circuit, grid leak, condenser and the grid of the valve

GRID LEAKS: FUNCTIONS, VARIETIES & HOW TO MAKE

Clear Explanations of Grid Leak Working and Full Constructional Details

Here are described the theory and practice of the important part played by grid leaks in detector circuits, with illustrations and practical information, covering both fixed and variable leaks. Such headings as Circuits; Detector; Filtron; High-frequency Amplifier; Rectification, etc., should also be consulted

GRID LEAK. The grid leak is a path of high resistance usually shunting a condenser in the grid-filament circuit of a three-electrode valve. The object of the arrangement is to provide a path of sufficient size for leakage of the electrons forming the grid current, so that these do not alter the negative grid potential to an undesirable extent. Any change beyond saturation values in the characteristic curve on which the valve is working destroys its utility as a producer of fluctuations in the plate current proportional to the changes in the grid potential.

Langmuir describes his grid leak as " a wireless signalling device including a discharge device having connected to its grid or control electrode a condenser which has a leakage path connected across its terminals for the purpose specified." This leakage path " is preferably such that in the intervals between the successive trains of oscillations there is just time for the grid to recover its normal potential." This timing of audio-frequency impulses is the basis of grid-leak practice in wireless telephony. A condenser inserted in the grid circuit of a valve will stop the flow of electrons from filament to grid when the potential on the condenser plate attached to the grid obtains a value of about 1 volt, so that a detector valve not receiving electro-magnetic impulses will have normally a slight negative potential.

When radio-frequency oscillations are induced in the grid circuit each positive half-cycle of the first incoming waves makes the grid momentarily positive and draws electrons up from the filament. Without a leakage path the accumulation of negative charge on grid would build up until the plate current is completely cut off and the valve is paralysed as a detector, unless and until the negative potential on the grid again diminishes. The function of the grid leak is to provide this leakage path, which should be proportionate to the capacity of the grid condenser.

This grid condenser often forms part of a secondary tuned (grid) circuit, and its capacity enters into the required reactance of this circuit. The amplitude of the potential variations in the grid depend upon several factors, including the strength of the incoming signals and the grid filament current, but in general these voltage variations must not attain saturation limits on the characteristic curve of the receiving valve, or else distortion will occur. On the other hand, if the condenser is too large the amplitude of the voltage variations in grid is diminished, with reduction in loudness. For ordinary R or French type valves, the capacity of the grid condenser in general use is ·0003 mfd., which is some twenty times the capacity of the valve itself. The corresponding value of the grid leak has a resistance of 1·5 to 2 megohms, this being generally accepted as most suitable for use as a fixed grid leak with a ·0003 mfd. condenser.

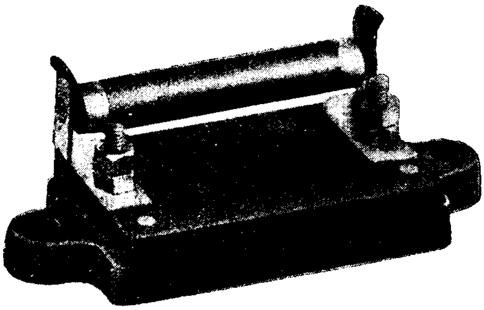
The grid leak is usually connected across the grid condenser to one side of the battery supplying the filament current. It works almost or quite as well across grid and filament.

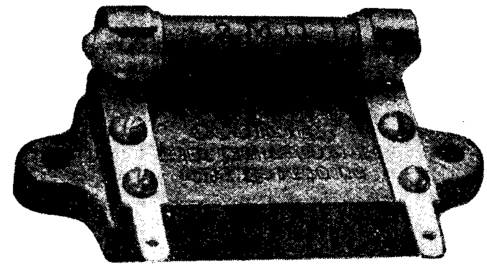
The grid-leak method of rectification is used more frequently than anode rectification, owing to its sensitivity with weak signals. With soft valves a grid leak may not be necessary, as the positive ionization of the gas in the bulb helps to prevent the accumulation of negative electrons on the grid. Buzzing noises, ticking, and howling may be due to a grid leak of too high a resistance, especially when using reaction or regenerative coupling.

Variable grid leaks are gaining ground as a ready means for maintaining grid potential near zero and a cure for noise troubles in sensitive circuits.

A scientific type of fixed grid leak consists of platinum or tungsten deposited electrolytically on glass and embedded in paraffin wax or other waterproof insulating medium. The metal, however, is liable to peel off the support, while the glass mount and connexions make such grid leaks cumbersome.

Practicable and commercial fixed grid leaks, with resistances of definite value

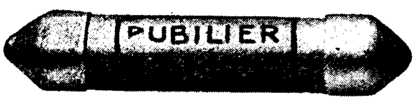




COMBINATION GRID LEAKS AND CONDENSERS

Fig. 1. Suitable for panel mounting or otherwise, this grid leak and fixed condenser has connexions made through the nuts and screwed rod. Fig. 2. In this case the grid leak is held between spring clips and connexions are made through the soldering tags seen in the foreground

unaffected by local conditions, consist of a moisture-proof partially carbonized filament enclosed in a tube and mounted for insertion in clip holders, as shown in Figs. 1, 2 and 3. S. R. Mullard in his patent described such a grid leak made from viscous cellulose or parchmented cotton thread by heating in a graphite

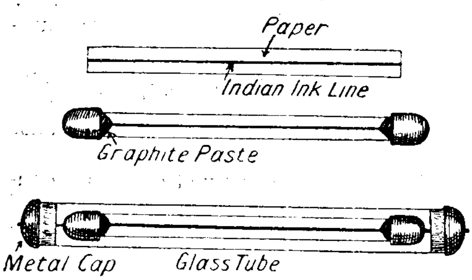


SEPARATE GRID LEAK

Fig. 3. Separated from the combination in Fig. 2, the grid leak appears as illustrated above. This form of grid leak allows quick change to be made by the experimenter

crucible. Charring of the filament, effected by heating at 700° C. for about fifty minutes, should produce a resistance of one megohm in thread 4 centimetres long by 4·9 square millimetres in sectional area. The resistance is isolated from atmospheric humidity by filling the tube enclosing it with paraffin wax.

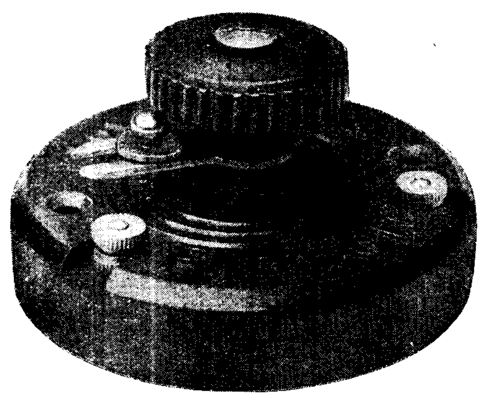
Other commercial fixed grid leaks and home-made grid leaks consist usually of an indian ink or graphite paste line drawn on a strip of stout paper. These are fixed in terminals and mounted in glass tubes, as illustrated in Fig. 4. The claims of makers of this type of fixed grid leak for constancy and accuracy of the resistance values are based upon the use of secret compositions, it is stated, which do not absorb moisture as indian ink does.



INDIAN INK AND GRAPHITE GRID LEAKS

Fig. 4. Indian ink may be used as a means of resistance in making a grid leak. A line is drawn on a strip of paper, which is inserted in metal caps and held by graphite paste; the whole is enclosed in a glass tube.

The graphite grid leak, consisting of a streak of lead pencil graphite in a groove on ebonite plate, is another form of a fixed grid leak. The calibration of the fixed grid leak is done by the maker by means of a megger (*q.v.*).



FILTRON VARIABLE GRID LEAK

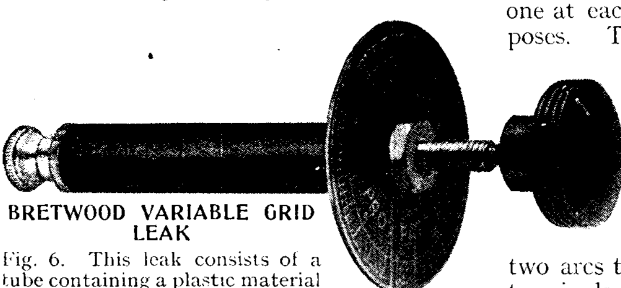
Fig. 5. This grid leak has a spiral groove filled with graphite. The contact moves along the groove, and the resistance may be varied from ·01 to 10 megohms

Courtesy Radio Specialities

The use of a variable grid leak presents the anomaly of being unsound theoretically and giving good results in practice. It is affected by moisture, vibration and hand capacity, but through being adjustable to the conditions of the moment, a variable grid leak is of considerable advantage in damping of oscillations preceding it, particularly in reaction circuits.

The Filtron variable grid leak (Fig. 5) consists of a spiral groove with graphite (from lead pencil) thereon. The central knob can be rotated more than three revolutions (about 1,170°). Approximate calibration with H graphite is given as ·01 to 10 megohms.

The Watmel grid leak consists of carbon pellets in an ebonite tube. Rotation of a screwed plunger alters contact area between these pellets by compression or release, and, consequently, changes the value of the resistance. Control is sensitive, but becomes somewhat delicate between 1·5 and 2 megohms, as resistance tends to rise rapidly to infinity. Another variable grid leak, the Bretwood, is shown in Fig. 6. It is said to give delicate control.



BRETWOOD VARIABLE GRID LEAK

Fig. 6. This leak consists of a tube containing a plastic material into which a plunger is screwed by rotating the knob, which varies the area of the resistance material. Resistance varies regularly from zero to 6 megohms

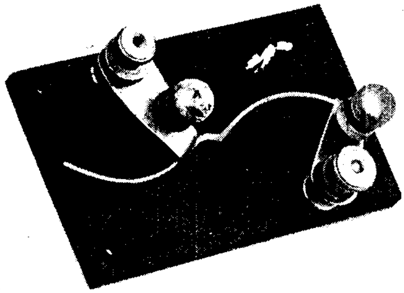
Courtesy Radio Improvements, Ltd

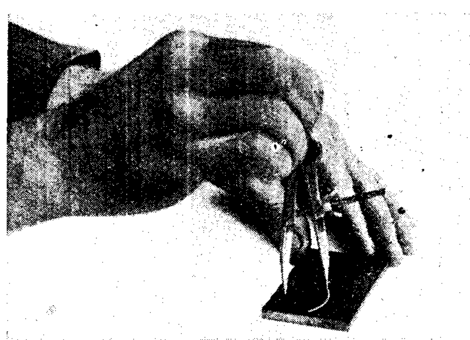
Another form of commercial variable grid leak is a semicircular strip with stud-like projections drawn on cartridge paper with indian ink or graphite paste. Contact studs are placed on the centres of these projections. The resistance is mounted in paraffin between ebonite plates, and the resistance is varied by means of a rotating arm.

How to Make Grid Leaks. The construction of a simple but efficient variable grid leak need not occupy much of the experimenter's time. One of the many methods that may be adopted is illustrated in Fig. 7, and comprises a small ebonite plate, 3 in. in length, 2 in. in breadth, and $\frac{1}{4}$ in. in thickness. Four holes are drilled, one at each corner, for holding-down purposes. Two other holes are drilled and tapped to receive the shanks of small terminals, but before these holes are drilled the path for the grid leak should be marked out with the aid of a pair of dividers, as illustrated in Fig. 8, by setting the legs to an opening of $\frac{3}{4}$ in. and striking two arcs through all the points where the terminals are to be fitted, and connecting the arcs by a short, straight portion.

This groove need not be of any great depth—it will suffice to move the dividers backwards and forwards about half a dozen times to incise a sufficiently deep groove. Holes should then be drilled and the two contact arms made up as shown in Fig. 9. Each arm is simply cut from a strip of hard, fine brass, about $\frac{1}{4}$ in. in width and $1\frac{1}{8}$ in. in length, bent over and rounded at the upper ends and provided with a small ebonite knob.

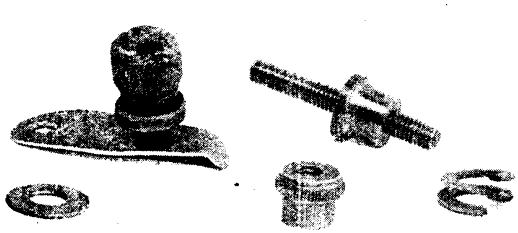
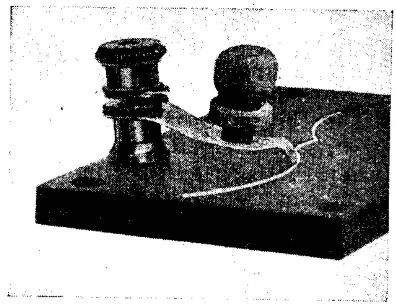
The opposite end is drilled so that it may turn freely on the shank of the





HOME-MADE VARIABLE GRID LEAK OF SIMPLE DESIGN

Fig. 7 (left). Pivoted contacts move along a graphite line in the home-made variable grid leak shown in this photograph. An ebonite panel forms the base. Fig. 8 (right). How the path for the grid leak is marked out on the ebonite with dividers. The path consists of two arcs joined together

CONSTRUCTIONAL DETAILS OF SIMPLE HOME-MADE VARIABLE GRID LEAK

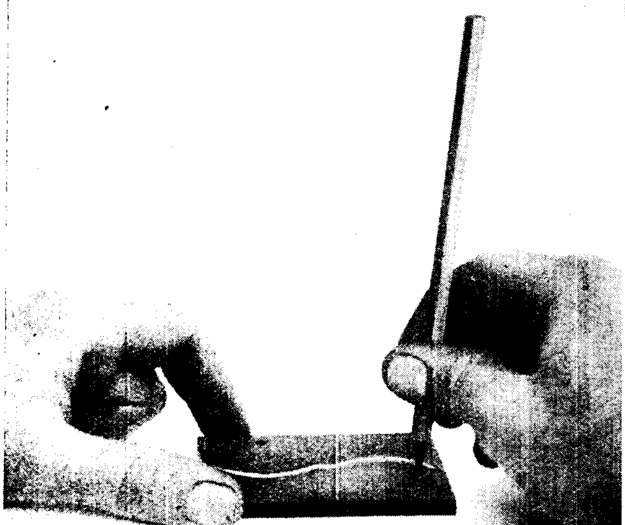
Fig. 9 (left). Details are shown in this photograph of the contact arm for the variable grid leak in Fig. 7. The arm is cut from a strip of brass and bent over to shape. Fig. 10 (right). Here the contact arm is shown assembled on the ebonite base. The arm should move easily along the graphite groove which forms the resistance

terminal. The parts are then assembled, as clearly visible in Fig. 10, by first placing the contact arm over the screwed part of the terminal, placing a washer upon it and then a spring washer, tightening down the upper nut. The arms should be adjusted so that their ends move in the groove already cut in the base. They should then be taken down and the groove filled with graphite by rubbing a pencil along it in the manner illustrated in Fig. 11.

The value of the grid leak can only be determined by experiment and direct measurement, and is easily variable by moving the two contact arms. The value diminishes when the two contact arms are brought close together, and increases to a maximum when they are farthest apart. To increase the resistance use a hard pencil and very little graphite, and to diminish the resistance use a soft pencil and cover the groove thickly with it.

The second variable grid leak, shown in Fig. 12, will be found a handy piece of apparatus to make up, as it will not only serve to obtain critical adjustment in any particular circuit, but may also be used for the rapid adjustment of a leak which may be removed and fitted permanently in position upon the set, with the assurance that the best value of leak has been obtained for the particular detector valve in use.

Prepare a piece of $\frac{1}{4}$ in. ebonite $3\frac{1}{2}$ in. square and drill a central hole to clear a 2 B.A. screwed rod. Fit a couple of terminals at a convenient distance from the top edge, say $\frac{7}{8}$ in. A piece of thin brass is required 1 in. by $\frac{1}{2}$ in. with a hole drilled for one terminal, whilst a thin metal connecting arm from the centre to the other terminal will also be required, as may be seen from the photograph of the back of the panel, Fig. 14. A thin metal moving arm, which is shown in detail, may now be prepared. This may be $\frac{1}{4}$ in. wide and $1\frac{1}{2}$ in. long, one end being drilled to take a short length of hard lead pencil, around which is wrapped for a portion of its length a piece of copper or brass foil.



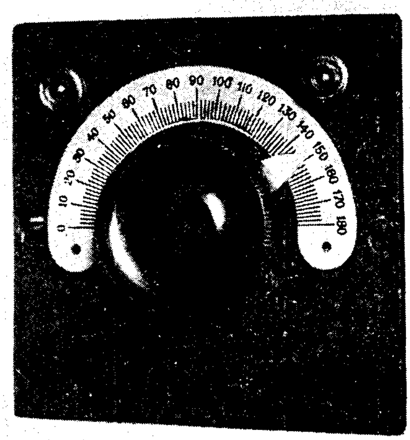
FILLING THE GROOVE WITH GRAPHITE

Fig. 11. An H.B. pencil is used for filling the groove with graphite to form the resistance in the home-made grid leak illustrated in Fig. 6. The pencil is rubbed along the groove

If the hole is drilled on the small side and subsequently enlarged carefully the lead and foil will make a good tight fit without further fixing, though a touch of solder may be used with advantage. At the other end a piece of 2 B.A. screwed rod, ¾ in. long, may be soldered in position. This may now be mounted upon the centre of the panel with a washer both front and back, and a 2 B.A. nut screwed down from the front until sufficient tension is obtained, when it may be locked with a knob and pointer. At this stage do not run the pencil upon the ebonite.

Two pieces of cartridge paper may now be cut with 1 in. radius as centre and of nearly complete circumference, as will be seen from the illustrations. These should be thoroughly immersed in shellac varnish and dried. One of these may now be fitted under the short connexion to the terminal, having first made a pencil mark sufficiently large to allow a pencil line connexion to same just outside the area of the clamping piece. A little pad of tinfoil under the brass clamping piece will afford a sufficient contact. The other end of the paper disk may be held down with a 6 or 8 B.A. screw tapped into the ebonite.

A small box about 1 in. deep will complete the actual preparation of the parts (Fig. 13). If it is desired to prepare a grid leak for removal, the leak may now be connected up to the set, the pencil may be started from the outside terminal end, and with a gentle to and fro motion, a little at a time, may be adjusted to the correct value under actual working conditions. When the received signals indicate that a maximum efficiency has been obtained, the top may be removed and the position of the pencil noted.

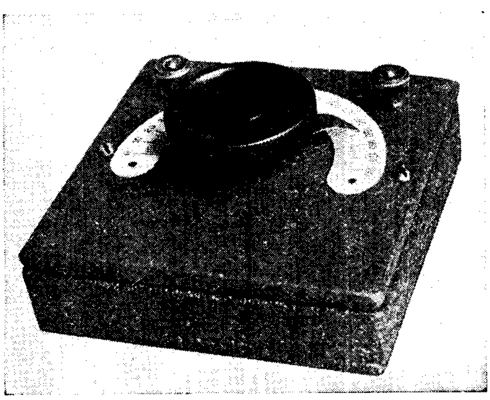


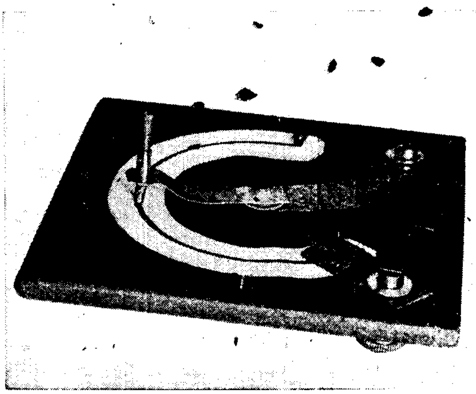
BOX-FORM AMATEUR-MADE GRID LEAK

Fig. 12. On the front of the panel of this variable grid leak is a divided crescent and turning knob with a pointer. This type of leak will be found extremely useful with dual amplification circuits

The paper disk can be loosened, the leak mounted upon a small piece of ebonite with a screw and a little pad of tinfoil at either end, and given a coat of shellac. The connexions may be soldered to the screws.

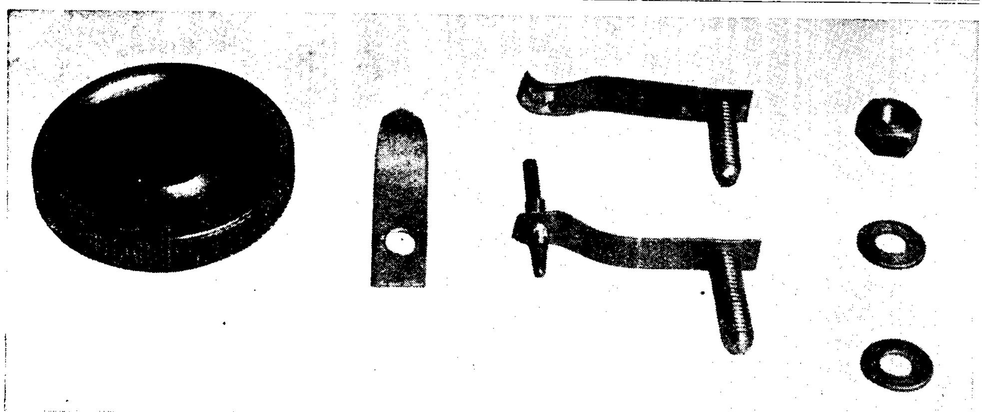
If it is desired to use the leak as a permanently variable one, a disk of shellacked paper may be provided with a line drawn on the same with indian





HOME-MADE GRID LEAK WITH CRITICAL ADJUSTMENT

Fig. 13 (left). This grid leak is not difficult to make, has a neat appearance, and provides critical adjustment. A calibrated scale and pointer record the amount of resistance in circuit. Fig. 14 (right). This photograph shows how the moving arm is connected up to one of the terminals and the circular path of the grid leak



PARTS OF GRID LEAK WITH CRITICAL ADJUSTMENT

Fig. 15. Two types of contact may be used in the variable grid leak illustrated in Fig. 13. One of these will be seen in the above photograph to be like a pointer, the other is made by merely bending the contact arm so that the square end runs along the graphite line. The pointer, knob, and washers are also shown

ink, and a moving arm may be made of a slightly different pattern, shown in Fig. 15. This is made of thin springy brass and shaped so that it will make contact with the indian-ink line. It will be necessary to try one or two different widths of line in order to secure the best result, which is however, arrived at without much difficulty.

It may be added that this little piece of apparatus has also been used successfully as a variable high resistance, as is used, for instance, in the S.T. 100 circuit, in which case a fairly broad band of indian ink, to which has been added a little powdered graphite, or even ordinary blacklead stove polish, may be used. *See* Blacklead; Resistance.

GRINDSTONE AND GRINDING. A grindstone is a circular piece of stone adapted for revolution on an axle. It is a necessary tool for all experimenters, as by its aid the various tools are kept in order. The stones used are chiefly those from Yorkshire and Derbyshire, generally light grey or yellow in colour.

When purchasing a stone choose one that is of uniform colour and texture, as unequal colouring or the presence of dark places generally indicates the presence of hard spots that wear away more slowly than the others and thus call for constant trueing and attention.

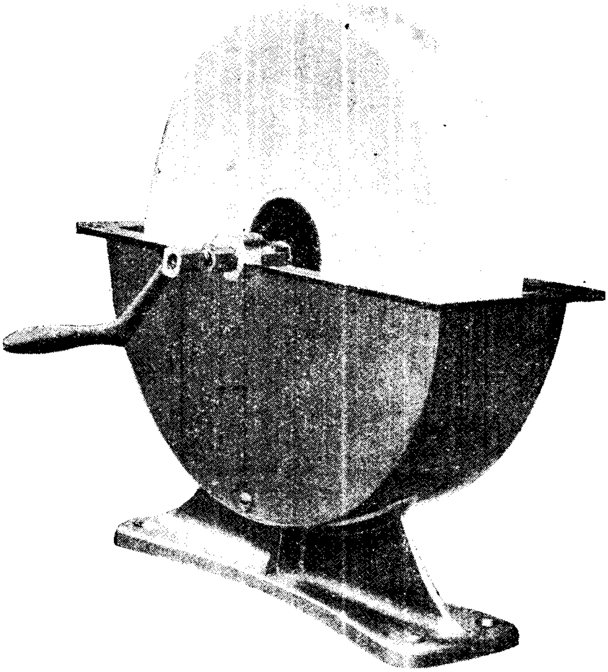
The stone is mounted on the axle by packing the rough hole in the stone with thin wooden slips or with lead, and gripping the sides of the stone with metal flanges tightened with a nut or nuts. The axle should have a squared portion for the wood slips to bear upon and act as a positive drive for the stone, which has a squared hole through it.

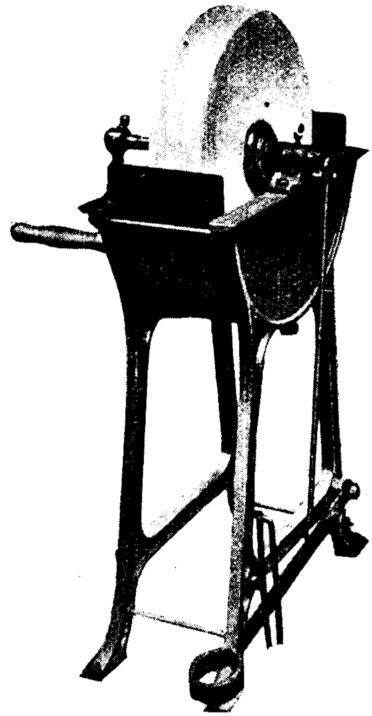
The width of the stone should not exceed $2\frac{1}{2}$ in. to 3 in., and may vary from 12 in. to 30 in. or more in diameter. For many purposes the small bench grindstones mounted in a cast-iron frame are very convenient, and a typical pattern is illustrated in Fig. 1. The case acts as a trough for the water used to keep the stone wet while in use. The wheel is revolved by the crank handle. The combined type, illustrated in Fig. 2, that can be driven by foot power or by hand is preferable, as it leaves both hands free for the grinding operations. The stand raises the stone to a convenient height and the treadle allows of greater power on the stone, as well as assistance when needed from an assistant, who can turn the handle when heavy grinding is in progress.

Wooden stands are also extensively used, as shown in Fig. 3, and can be readily framed up from stout timber about 3 in. square.

A drip can supplies the water for the grinding operations. This type of grinder is often kept outdoors, and should then always be covered when not in use to protect the stone from the detrimental effects of the weather.

Small tools are often ground on a bench grinding machine, using an emery or carborundum wheel, as shown in Fig. 4, and such patterns incorporate a

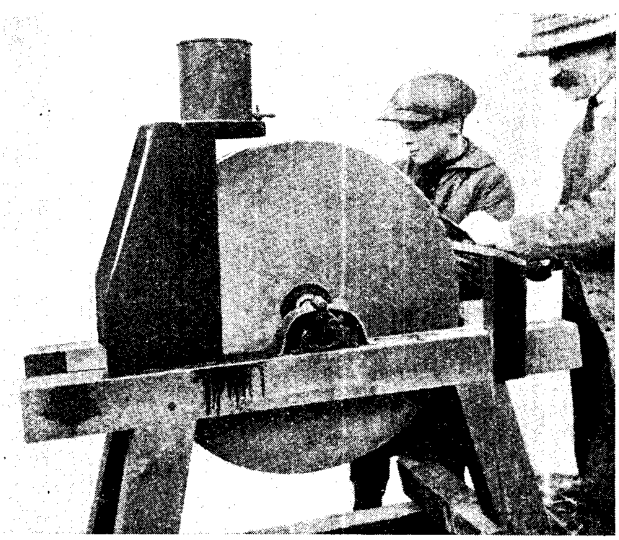




HAND AND TREADLE GRINDSTONES FOR WIRELESS WORKERS

Fig. 1 (left). In small workshops a bench grindstone, of the type illustrated, will be found very useful. It has a cast-iron case and a turning handle. The case acts as a trough for the water used to keep the stone wet in use. Fig. 2 (right). In addition to the handle for operating the grindstone in this photograph there is a treadle, by using which both hands are left free. An iron frame raises the stone to a convenient height

Courtesy G. Buck



GRINDSTONE ON HOME-MADE STAND

Fig. 3. Grindstones may be mounted on a home-made wooden stand. The stone in the photograph is a fairly heavy one, and the home-made stand is provided with a splashboard and drip can

gear drive that drives the wheel at a high speed.

Wet grinding with an ordinary grindstone is done at a relatively slow speed, but the emery type of grinding wheel has to run at high speeds of 1,000 revolutions per minute or more. These wheels cut faster than a grindstone, and consequently tend to heat the tools rapidly. This has to be neutralized by repeatedly dipping the tools in a pail of water kept near at hand on the floor or elsewhere.

This precaution must on no account be omitted, or the tools will be so heated that the temper will be drawn and the tool ruined.

High-speed tool steels can, however, be ground without such regard to the heating of the steel, but such tools are seldom found in the ordinary run of amateur work. The operation illustrated in Fig. 4 is that of grinding a swan-neck tool for use in a turning lathe, and is accomplished by resting the tool on the rest and inclining it at a small angle and rocking the tool to and fro in order to form the rounded edge.

The method of grinding a cold chisel is shown in Fig. 5, and in this case the tool is pointed uphill and the rest adjusted to the correct angle to enable the chisel to rest flat upon it, as shown. The grinding wheel should revolve towards the operator in both these examples.

When a proper grindstone or bench grinding machine is not available a substitute is to use a small polishing lathe, as shown in Fig. 6. The stone is mounted on the polishing spindle and secured with a nut and a flanged plate. Blotting paper is interposed between the sides of the wheel and the flanges to prevent the wheel breaking when the nut is tightened. These small tools are generally treadle-driven, and thus leave the two hands free to manipulate the work, as shown in the grinding of a twist drill illustrated in Fig. 6. In this case the wheel can be revolved towards the worker, as this throws the grit and sparks away from the eyes. The drill is ground by inclining it at an angle to the face or rim of the wheel and rocking it slightly about its own axis to form the curved shape of the end of the drill and to give the requisite clearance.

Another method of grinding is illustrated in Fig. 7, and shows how a wheel can be mounted on a mandrel and driven between centres or chucked in a lathe. The outer end of the mandrel is supported by the tail stock in the usual way. Small tools can be held in the two hands, or a rest can be contrived by placing a bar of metal in the tool post and resting the work thereon.

When the grinding process is finished the lathe should be very carefully cleaned, or the emery grit thrown off in the grinding operations will speedily spoil the lathe and bearings. The correct angle at which to grind a tool is determined by its shape and purpose, but in general the softer the material it has to work the longer the slope of the cutting part, and the harder the material the more the slope approaches the vertical. The grindstone and the emery or carborundum wheels have to be trued from time to time with an emery wheel dresser or similar device.

GRISSON ELECTROLYTIC CONDENSER INTERRUPTER. A form of electrolytic interrupter used for induction coils which dispenses with the supplementary paraffined paper condenser necessary in the case of hammer or mercury interrupters.

Its employment depends on the fact that, if a plate of aluminium with one of carbon or iron is placed in an electrolyte yielding oxygen, the combination will pass current in one direction but not in the other, owing to the formation of a film of aluminic hydroxide on the aluminium, with the result that the aluminium plate offers much greater resistance to the current than the carbon or iron one.

In the Grisson electrolytic condenser interrupter a cell is used consisting of a number of alternate aluminium and carbon or iron plates in an alkaline solution. By inserting this in the primary circuit of an induction coil, and applying an electromotive force in the right direction, a transitory current will be caused to flow through the coil till the electrolytic condenser is charged. By commutation a reverse effect can be produced, and another transitory primary current created, the intermittent magnetization of the core necessary to produce the secondary electromotive force being thus provided. *See* Mercury Jet Interrupter; Rectifier.

GRISSON INTERRUPTER. One of the later forms of electrolytic interrupter used in connexion with induction coils. In the Grisson pattern the primary circuit of the induction coil is divided into two equal parts by a middle terminal which is connected to one pole of the battery, the other two terminals being connected alternately, by means of a revolving commutator, to the opposite pole.

The commutator can be made successively to (1) pass a current through one half of the primary circuit, thus magnetizing the core; (2) pass a current through both halves in opposite directions, thus annulling the magnetization; (3) pass a current through the second half of the primary, thus reversing the magnetization of the core; and (4) pass a current in both halves in opposite directions, as in (2). All these operations being feasible without interrupting a large current through the inductive circuit, sparking at the commutator is reduced, and the speed of commutation can be usefully regulated. *See* Hammer Break.

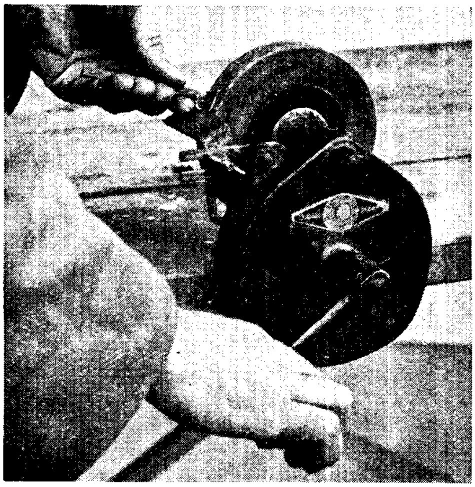


Fig. 4. An emery wheel on a bench grinder is shown in use grinding a swan-neck lathe tool

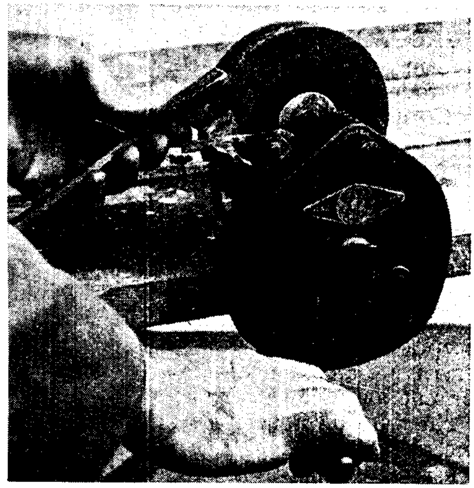


Fig. 5. Cold chisels are ground by resting the tool on the rest and revolving the stone toward it

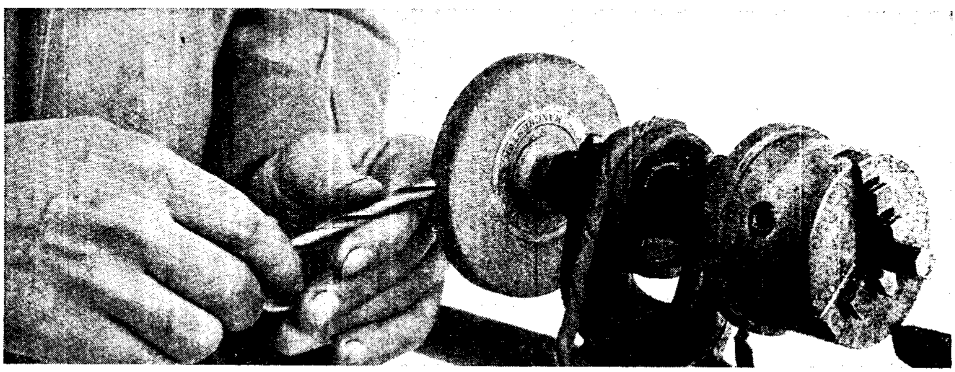


Fig. 6. Mounted on a small polishing lathe head is an emery wheel, shown in use grinding a twist drill. In order to best control the pressure of the work on the wheel the hand should be rested as illustrated

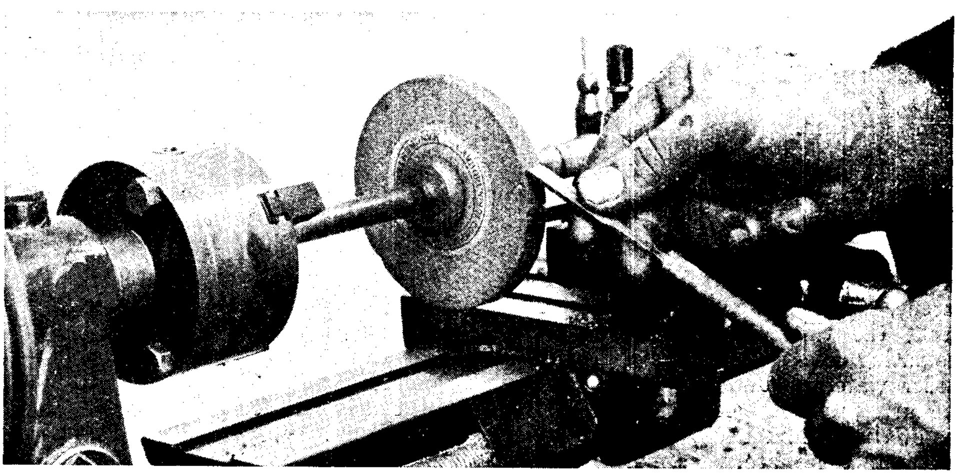


Fig. 7. This photograph shows how a grinding wheel is mounted on a mandrel and driven on a lathe. In this case a scraper for metal-fitting purposes is being ground

GROUND. The expression ground is used in many cases in the place of earth. A ground circuit is one employing the earth as one part of the circuit, for example. Ground wires are those which connect to the earth. *See* Earth.

GROUND AERIAL. Almost any system of electrical conductors, more or less removed from the ground and insulated from it, is capable of absorbing energy from a passing electro-magnetic wave, and is capable of lending itself to wireless reception of signals, provided sufficiently sensitive detecting devices are used in conjunction with it.

The wire on a wire fence, a system of electric light wiring or bell wiring in a house, or even a living tree has successfully been used as an "aerial." Signals can be quite effectively received from a length of well-insulated wire lying on the ground or buried below its surface; it can even be immersed under the surface of water, but in the case of salt water the depth of immersion is very limited.

Although it would seem contrary to the generally accepted principles of radio reception, there is no doubt that the waves do penetrate to a certain depth below the surface, probably modified to a large extent by the nature of the soil and its degree of moisture or otherwise, also upon the wave-length being transmitted.

The amount of power received by a ground aerial is considerably less than would be picked up by the usual overhead aerial, and considerable amplification is usually necessary to get satisfactory reception. But there is no doubt it also possesses appreciable advantages as regards the elimination of strays and atmospherics, in comparison with other forms of aerial.

The best length of wire to use as a ground aerial depends upon the wave-length to be received; for long waves, shorter wires are used than for short wave-lengths. The best working wave-length of a given wire depends, to some extent, upon the diameter of the wire itself, the thickness and nature of its insulating covering, whether it is situated under water or under ground; and, if the latter, upon the condition and character of the ground itself. It is therefore apparent there are very many variables to take into consideration. It has been stated that the best working wave-length of a given ground aerial is inversely proportional to the capacity of the wire per unit length of wire. In other words, with a given size of wire, the thicker the insulation, the longer the most effective wave-length will become; and with a given thickness of insulation, larger wires will work more effectively on a short wave-length.

With average conditions of the ground, a No. 14 solid wire, or the equivalent section in stranded wire, with good vulcanized rubber insulation, buried in a shallow trench not more than 12 in. deep, may be expected to give satisfactory reception of waves from 150 to 500 metres if it is about 75 ft. long. For long waves between 6,000 and 15,000 metres the length of the ground aerial may be increased to 1,000 or even 1,500 ft.

The reception of signal strength appears to be more consistent if the aerial is under water than if under ground, probably owing to the more stable conditions of fluids than solids. In salt water the signal strength is found to fall off rapidly with increasing depth, no doubt due to the conductivity of the saline constituents. But in fresh water the range of depth seems to be much increased, and signals have been received with underwater aerials even at so great a depth as 60 ft. *See* Aerial; Atmospherics; Frame Aerial.

GROUP FREQUENCY. Name given to the number per second of the periodic changes of amplitude or frequency of an alternating current. *See* Sine Curve.

GROVE CELL. The Grove cell is a standard primary cell of the double-fluid type. The photograph shows a complete cell, and the three elements which are used in its construction.

The third item in the photograph is the positive electrode, which consists of a stout sheet of zinc, bent into the U shape shown. The surface of the zinc is heavily amalgamated with mercury.

The porous pot, which is illustrated on the left of the zinc, is contained within the U shape of the latter. It will be seen that the top of the pot is extended on either side to fit on the top of the outer container, which is of ebonite. On the extreme right of the picture will be seen the negative element. This is a thin sheet of platinum.

The electrolyte, which is contained within the outer container, is a solution of dilute sulphuric acid. A solution of one part of acid to twelve parts of water, by weight, should be used. Nitric acid is used in this cell as a depolarizer, this being contained in the porous pot. The cell shown, the dimensions of which are 5 in. by $3\frac{1}{4}$ in. by 2 in., has an electromotive force of 1·96 volts and an internal resistance of 0·20 ohm.

GUARD LAMP. A straight filament lamp, usually connected in shunt across the armature and field leads of a rotary converter. Such lamps protect the windings from the effects of oscillatory surges which might be induced from the high-frequency circuits during wireless transmission. *See* Rotary Converter.

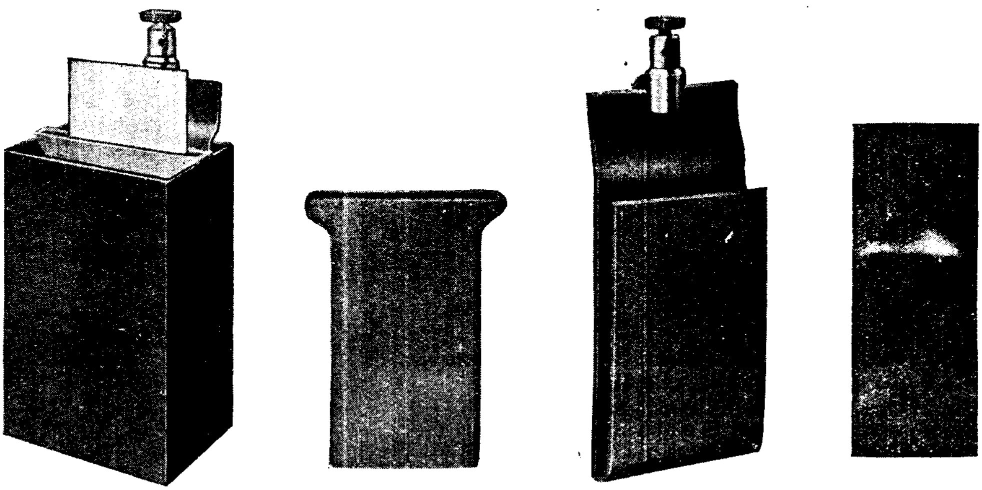
GUY. Guy is the term given to the wire or rope which is used to support aerial masts, or attached to aerial spreaders to keep them in a horizontal position.

All forms of light aerial poles or masts require other support than that which they obtain through having their ends buried in the earth, and it is general practice to give them this necessary support by stretching a number of ropes or wires from the top of the mast to points situated on the ground. These points are preferably spread out around a circle, the diameter of which should never be less than one half the length of the mast.

The number of the guys used, their disposition, and size depend entirely on individual circumstances. It is impossible to form any hard-and-fast rule on these points. But, generally speaking, it is easy for the amateur to tell from the conditions which obtain, and from the mast at his disposal, exactly what kind and strength of support is required.

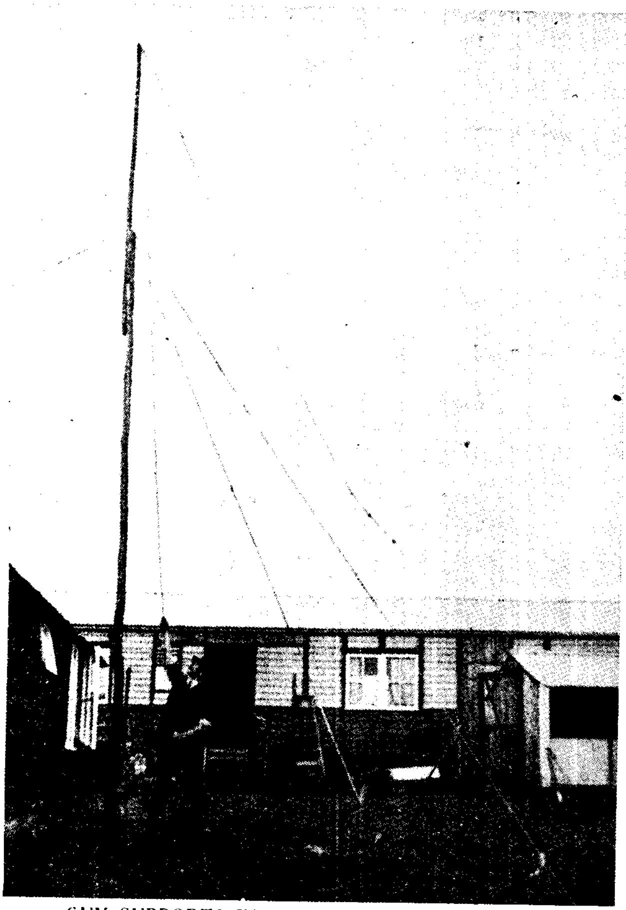
As a guide, however, one or two rules may be given. In the first place, it is always advisable to place a guy at the back of the mast to take most of the pull of the aerial. Although the distributed weight of an aerial is usually only a few pounds, the actual strain on the top of the mast is considerably more, particularly where multi-wired aerials are used, and spreaders become necessary. Furthermore, if the aerial lanyard is of rope, and by accident it is left taut in dry weather, the coming of rain, or even dew, will cause that rope to shrink very considerably. Should this happen, very severe strains may be imposed upon the mast. If the latter is not guyed to take that strain, it is extremely probable that it will either buckle or fall, with consequent severe damage both to itself and anything that may lie beneath it.

Fig. 1 illustrates the method of guying a mast in the manner just described. Such a system as this is only applicable to fairly substantial wooden masts, which may otherwise buckle in the middle. The



GROVE CELL AND ITS THREE ELEMENTS

Three elements are used in the construction of the Grove cell, as shown above. Next but one to the complete cell is the positive electrode, which is a stout U-shaped piece of zinc, and the porous pot which fits into the U is shown on its left. The negative element, which is a thin sheet of platinum, seen on the right, is inserted in the porous pot. The three elements are placed in electrolyte in the ebonite container



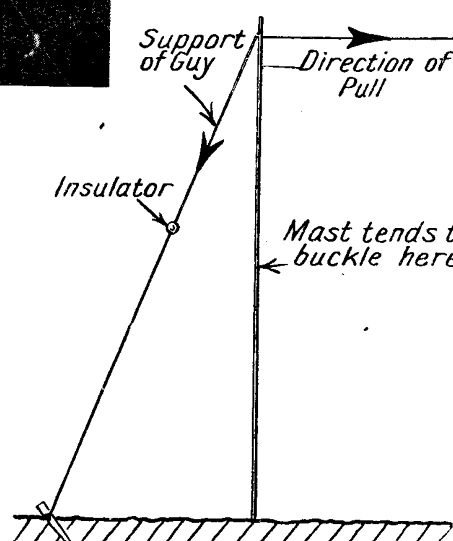
GUY SUPPORTS FOR AERIAL MAST

Fig. 1. How an aerial mast should be supported by guys may be seen in this photograph. The guys should be spread out at as wide an angle as possible, and means provided to strain them when they slack off through the stretching of the wire or rope

latter strain is one frequently overlooked by the amateur, but the reason for it is illustrated in Fig. 2. Reference to this diagram will show that as the top and bottom ends of a mast are firmly held by the guy and earth respectively, and as there is a pull on the top in the opposite direction from that from the guy, there is a distinct tendency for the mast to buckle in the centre where it is unsupported, and a further guy should be placed at this point to resist it.

Again, with wooden masts it will generally be found that it is unnecessary to place the guys right at the top. All the support necessary in most cases will be given if the highest points of the guys are fixed about two-thirds of the height of the pole.

Steel masts, if in one length, which is unusual, should be considered in the same way as for wooden ones, as far as their need for support by guys is concerned. Sectional steel masts, however, call for very thorough treatment. In the first place, three-point guying on the ground is necessary with almost all masts. The points from which the guys are located on the ground should be evenly spaced at 120°, and they should be so arranged that two guys should normally be behind the mast when regarding it from the aerial side. Spacing the guys in this manner will ensure sufficient support against the pull of the aerial, and from wind. Again, where a sectional steel mast exceeds twenty feet in height it is necessary to guy it with at least six guys, three being at the top and three at the joint nearest the centre. A good general rule with



WHY AERIAL MASTS BUCKLE

Fig. 2. Masts sometimes buckle in the middle, and the reason can be seen from this diagram. The top and bottom are held by the guy and earth respectively, and if the pull of the aerial is excessive the mast gives in the middle. A guy at the middle point will prevent buckling

CHOCK METHOD OF GUYING A MAST

Fig. 3. An efficient way to guy a mast is by fastening wooden chocks on it and forming a loop or a bight in the guy, as shown

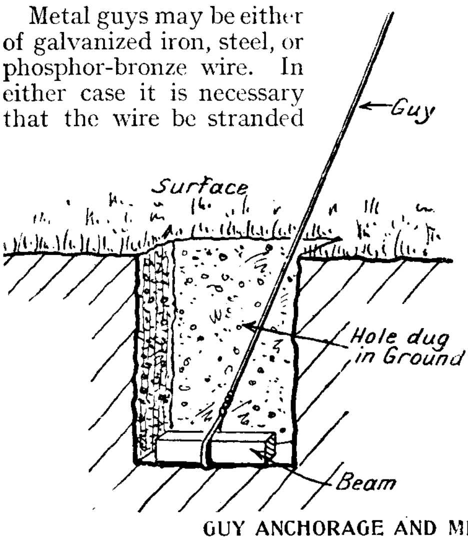
sectional masts is to use three guys for every 20 ft. of length.

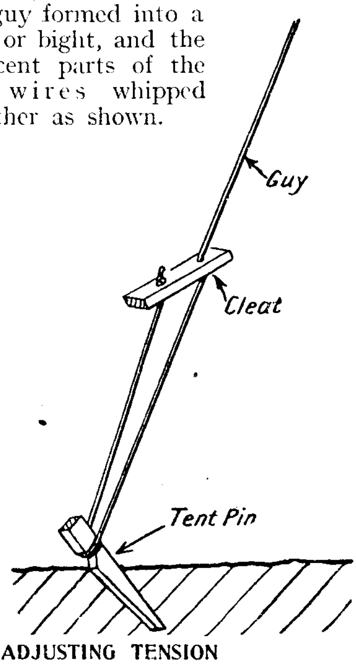
Guys themselves may be either of rope or of metal. The former should never be used where the length exceeds 30 ft., as above that figure the changes in length due to moisture are so great that adjustment would have to be made to allow for every change of weather. Above this length, too, it should be remembered that with a metal rope there is a good deal of contraction in cold weather.

Metal guys may be either of galvanized iron, steel, or phosphor-bronze wire. In either case it is necessary that the wire be stranded if the best results are to be obtained. Phosphor-bronze is to be preferred to steel on account of its rust-proof qualities, but it has not the tensile strength of the latter metal. For all-round use, however, the best material is a wire rope specially made for the purpose. This consists of a rope core, surrounded by six ropes of stranded steel wire. The construction of this form of wire rope is such that it is very flexible, which allows of ease in handling, and, furthermore, its cost will not generally be found prohibitive.

Where metal guys are used, it is desirable that they should be broken occasionally throughout their length by insulators. If this is not done they will form aerials in themselves, and reduce both transmitting and receiving signal strength considerably. Insulators of the shell or egg type should be used, because in the event of their breaking the guys are not allowed to part company. Again, their construction is such that they are always under compression, and on this account they are not likely to break.

One efficient way to attach a guy to a mast is shown in Fig. 3, and comprises two wooden chocks attached to the mast, the guy formed into a loop or bight, and the adjacent parts of the two wires whipped together as shown.



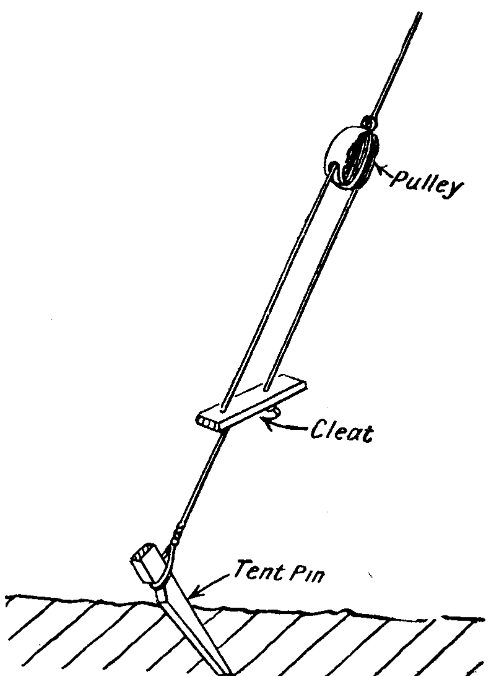


GUY ANCHORAGE AND MEANS OF ADJUSTING TENSION

Fig. 4 (left). Metal guys can be anchored in various ways. In the photograph a wood beam is buried at a reasonable depth in the ground, and the guy attached by forming a loop round the beam. Fig. 5 (right). Rope guys may be held to the ground by tent pegs, and the tension can be adjusted as illustrated by means of wooden cleats

Metal guy wires should never be bent double on themselves, but worked around a thimble or ring as described under the heading Cordage. The lower ends of the guys are anchored to the ground in various ways. One is to attach them to a stake driven into the ground, another is to place a horizontal beam of wood in the ground well below the surface and attach the guy to a long iron bar looped around the beam. The bar should have an eye at the top for attachment of the guy. Alternatively the Post Office method, as shown in Fig. 4, can be adopted. The method is similar, but the guy wire itself is wound around the log in the ground. The earth has to be well rammed home into the hole when the log is embedded.

Means for adjusting the tension on a guy are desirable, and Figs. 5 and 6 show two simple methods, the former a tent peg and runner suitable for light masts; the latter a modification embodying a pulley and runner, giving greater purchase. A method of attaching a guy to the wall of a house is shown in Fig. 7, where a stout iron spike, with an eye in the head, is driven into the brickwork



CLEAT AND PULLEY GUY ADJUSTMENT

Fig. 6. When greater purchase is required on a rope guy, the method in Fig. 5 can be used with a pulley added by attaching the cleat to a separate piece of rope, as illustrated above

WALL ANCHORAGE FOR GUY

Fig. 7. How a guy may be attached to the side of a house is shown. An iron spike with an eye in the head is driven into the brickwork and secured with cement. A strainer is fixed as shown, and a guy-rope passed through

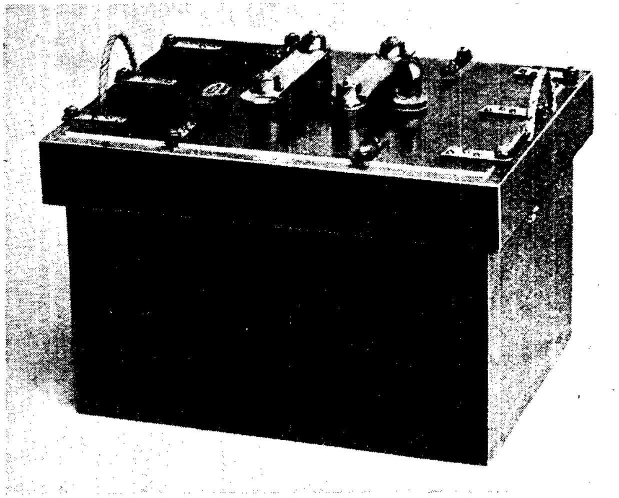
and secured with neat cement. The end of the guy is attached to a strainer, and this permits of adjustment. Other methods of fixing guys to masts are by straps and plates, eyebolts, or mast bands, as described in the article on aerials.—*R. B. Hurton.*

H

H. This is the chemical symbol for hydrogen (*q.v.*). It is also used as the symbol for the henry and, in italics, as the symbol for magnetic field, both uses being proposed by the International Electrotechnical Commission. *See* Abbreviations and Symbols.

HALF-PLATE CONDENSER. The condenser shown complete in Fig. 1, and in parts in Figs. 2 and 3, is known professionally as a half-plate fixed condenser. It is an instrument used in transmitting apparatus, and is of the oil-filled variety. Its external appearance is seen in Fig. 1. The top panel is closely fitted to the cabinet sides, and is surrounded by a form of putty in order to prevent any possibility of oil leaks. Strip connexions are fitted to enable various capacities to be obtained at will. To the right of these strips is a plug, which is for the purpose of allowing the oil to be renewed as occasion demands. Rope handles are fitted for carrying purposes, as the condenser is necessarily very heavy.

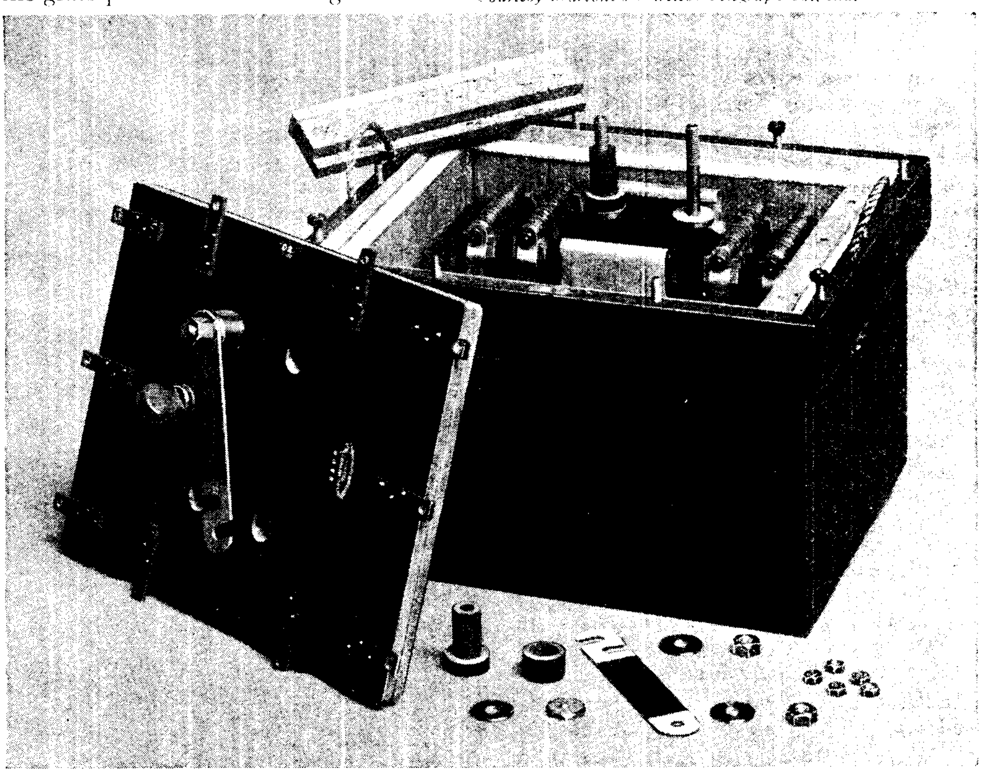
Fig. 2 is a view of the same instrument with the lid removed. The plates and the manner in which they are disposed in the cabinet are clearly shown. Note the method of conveying the current from the terminals to the plates by means of strips. It will be seen that the top ledge is packed with strips of fabric, in order that the lid may seat firmly and form a good oil-tight joint. Cork is used to prevent the glass plates from becoming



MARCONI HALF-PLATE CONDENSER

Fig. 1. Transmitting apparatus sometimes employs a condenser of this kind, which is oil-filled. Strip connexions are fitted so that the capacity may be varied as required. The rope handles are to enable the condenser to be carried, as the instrument is heavy

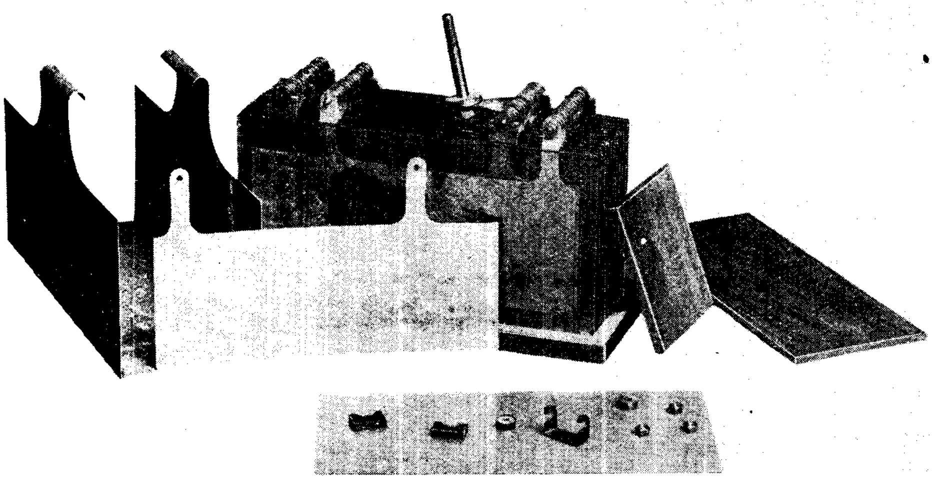
Courtesy Marconi's Wireless Telegraph Co., Ltd.



INTERIOR OF OIL-FILLED HALF-PLATE CONDENSER

Fig. 2. With the top removed the construction of the interior of the half-plate condenser can be seen. The plates are of glass and zinc. The top ledge is packed with strips of fabric to form an oil-tight joint. This type of condenser is particularly suited to marine outfits

Courtesy Marconi's Wireless Telegraph Co., Ltd



GLASS AND ZINC PLATES OF HALF-PLATE CONDENSER

Fig. 3. From this photograph, which shows the glass and zinc plates of the oil-type transmitting condenser, the method of connecting the plates can be seen. Alternate zinc plates are reversed to ensure individual clearance of the connexions; the lugs, it will be seen, are not placed equidistant from the ends. On the right are packing pieces. Oil with a very high flash-point is used

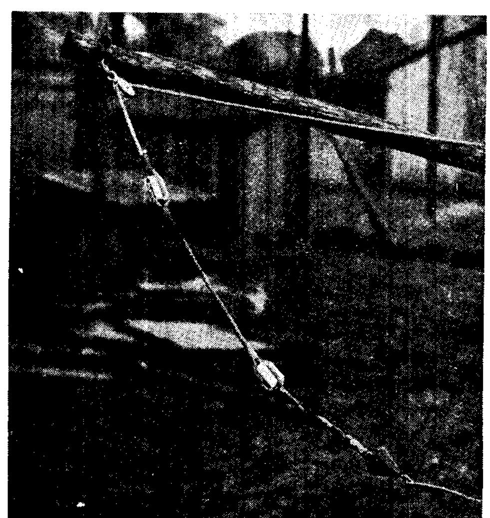
Courtesy Marconi's Wireless Telegraph Co. Ltd.

loose, this being clamped down firmly on the top of the edges of the glass. One of the cork-lined strips is shown removed and lying across a corner of the cabinet.

In Fig. 3 will be seen all the component parts of the condenser. The dielectric is of glass, and the condenser plates of sheet zinc. The latter are all of identical shape and size, but the lugs are not placed at points equidistant from the ends, in order that alternate plates may be reversed and, at the same time, ensure individual clearance of the connexions. The plates are all contained in position in a form of metal clip or cradle. This may be seen on the extreme left of the picture. On the right are two packing pieces which are used to prevent dislocation of the plates should they receive rough treatment from external causes, such as being flung about a cabin during a storm at sea. All the space within the cabinet that is not taken up by the condenser parts is filled with oil of a very high flash-point.

HALYARD. Name given to a rope used for hauling and lifting an object. In wireless work it generally refers to a rope reeved through a pulley on the top of an aerial mast, one end of the rope being attached through the medium of insulators to the end of the aerial, and the other end of the rope secured by a cleat or other fixing, near the bottom of the mast.

For the average light, amateur aerial, a halyard may consist of the thickest and best quality sashcord. Such cord is obtainable in knots, averaging about



HALYARD FOR WIRELESS AERIAL

Attached to the masthead is a halyard for hoisting the aerial. Three insulators are used, so that there is no risk of leakage

12 yds. in length, from most ironmongers. Customarily, the length of sashcord contains 6 knots, and it is usually cut off as required. Two knots would, therefore, be about 24 yds. long, and so on.

Before working the cord, it should be well greased or treated with liquid oil, to help to protect it from the effects of the weather. The length of the halyard should be twice the height of the mast, to permit of attachment of the aerial and to allow of the raising or lowering it, as occasion requires. The surplus length of cord, when the aerial is in position, should be neatly coiled up and hung on a hook on the mast, and preferably covered with a small roof composed of a couple of boards nailed together at an angle of 45°. The insulators, or other fittings, should be attached to the halyard by splicing the latter around a thimble, eye, or similar fitting, to prevent the rope being chafed.

HAMMER. Word used in several senses. As commonly applied, the word refers to a hand tool consisting of a shaft of wood and usually a transverse head of metal fixed to one end of the shaft. Other applications of the hammer are found in the hammer of an electric bell. The wireless experimenter is, practically speaking, limited to the use of a comparatively small selection of hammers, of which some useful patterns are illustrated in Fig. 1.

For general work, the selection illustrated will enable almost any class of wireless construction work to be carried out successfully. For heavy purposes the engineer's ball peine hammer, with a cast steel head weighing about $1\frac{1}{4}$ lb., will be sufficiently heavy; but if any large forging has to be done, the use of a $3\frac{1}{2}$ lb. hand sledge-hammer is desirable.

For lighter work, such as riveting and the like, a small ball peine pin-hammer, weighing about 4 to 6 oz., will prove quite effective. Sheet metal work is best dealt with by a hide-faced hammer, which consists usually of a cast-iron head fixed transversely to the wooden handle or shaft, and the ends, or faces, of the head recessed, these recesses being filled in with plugs of raw hide. In other patterns the head is made up entirely of raw hide, and sometimes the raw hide is driven through a tubular-shaped head. The purpose of using the raw hide is to prevent the bruising of the metal. For planishing, or the working of curved shapes in sheet metal to drive chasing tools and the like, a pattern of hammer known as repoussé hammer, weighing about 4 to 6 oz., is distinctly useful. These hammers have a very light lancewood shaft. For general rough woodwork a claw hammer, of the type known as the Kent claw, is preferable. This comprises an ordinary flat head on one side, and a claw or prong on the other. The head is extended in the form of two metal straps, which are riveted to the handle or shaft.

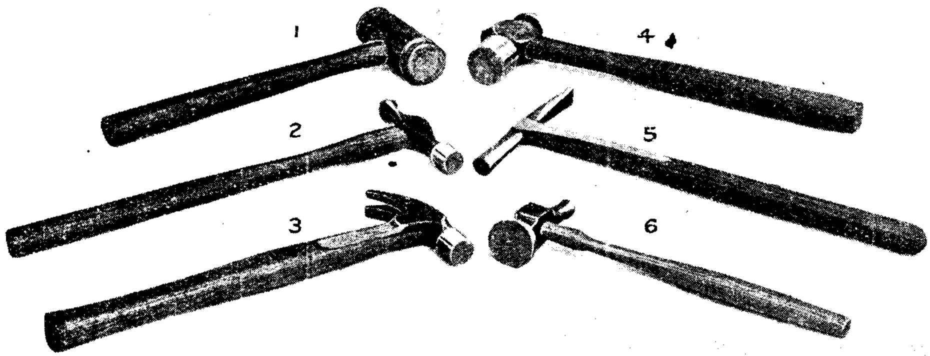
In wireless work it is often necessary to have a hammer with a long head, so that objects can be struck with it in awkward positions, for which purpose the ordinary upholsterer's hammer is useful.

In choosing a hammer, always select one with a good quality cast-steel head, the face of which should be quite flat, true, and free from any surface cracks. The edges should be very slightly rounded, and in some hammers the face is customarily made slightly rounded, or convex. For general purposes the ball peine is as useful as any. It consists, practically speaking, of a hemisphere. Carpenter's and joiner's hammers generally have a cross peine, generally similar in shape to that shown on the upholstering hammer in Fig. 1, or the straight peine, which is simply an oblong-shaped head in line with the shaft.

How the Shaft is Fitted to the Head

The novice will do well to purchase hammers already handled, as there is an art in fixing the shaft properly to the hammer head. The method consists, essentially, of carefully shaping the end of the shaft so that it will fit into the double-tapered hole in the head, the smallest part of the hole coming in the middle of the head. The end of the shaft is then provided with a slot, in the direction of the grain of the wood, for a length equal to the length of the hole in the head.

The shaft is then driven into the hammer head, and a hardwood wedge prepared and driven into the slot, thus forcing the ends of the shaft apart and securely gripping the walls of the hole in the head. The slightly projecting end of the wedge is then cleaned off flush. In the case of claw and upholsterer's hammers, and others with side straps, some of these patterns are made with a hole through the head, and others with a blind hole. In any case, the method of fixing is similar, with the



SELECTION OF HAMMERS USED FOR WIRELESS WORK

Fig. 1. Six hammers used for various purposes are illustrated. They are adaptable to the many branches of work which the construction of wireless sets and systems covers. No. 1 is a hide-faced hammer; 2, a ball peine pin-hammer; 3, a Kent claw; 4, an engineer's ball peine; 5, an upholsterer's hammer; and 6, a chasing hammer

addition of riveting the straps together by passing rivets through both of them and through the wooden shaft.

Proper command of the hammer is an art that can only be obtained by experience. A simple experiment is to place a long, fine nail upright on a piece of wood and tap it into the wood sufficiently for it to stand upright. It will then be found that if it is struck a random hard blow with the hammer, the nail will be doubled over or driven in at some angle. To drive it straight into the wood necessitates the face of the hammer striking the head of the nail in a plane exactly at right angles to the centre of the nail. Until this can be done, command of the hammer has not been obtained.

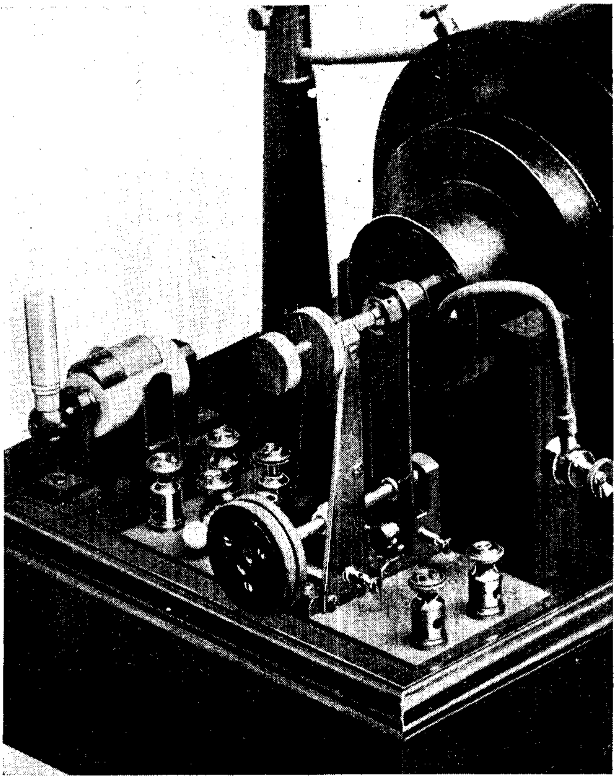
A little practice at driving nails into a piece of wood in this way will soon show that at the moment of impact the head of the hammer must strike the head of the nail fair and square in every direction. The hammer should be gripped in the hand between the fingers and palm, as shown in Fig. 2, with the thumb at the side of the hammer handle. The thumb should not rest along the shaft. The hammer should be held so that it cannot twist sideways, but is free to move slightly in the direction in line with the head of the hammer.

The blow should be struck somewhat as if throwing the hammer at the object to be hit, as it is the impact of the hammer that gives the force of the blow. If the hammer is held too rigidly and the wrist is not brought into play, hammering will become a very tedious business, and progress will be slow in some kinds of work.

In such processes as cutting a piece of metal with a chisel, which is illustrated in Fig. 2, the chisel is held at an angle to the work, and is struck by the hammer so that the chisel is driven forwards into the metal and also along the line of the

HOW A HAMMER SHOULD BE HELD

Fig. 2. In order to obtain a firm grip, placing the finger along the handle must not be practised. The thumb may be placed along the handle, but when using the heavier hammers the method illustrated is correct



HAMMER BREAK WITH INDUCTION COIL

Fig. 1. Primary current of a spark coil is interrupted by the hammer break above. The end of the coil may just be seen on the right of the photograph

Courtesy Marconi's Wireless Telegraph Co., Ltd.

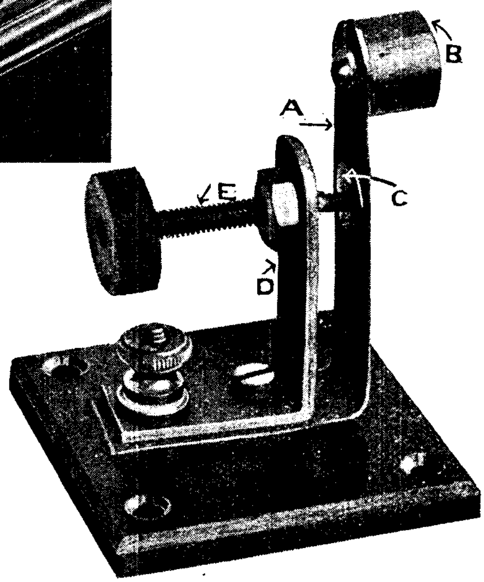
cut, so that repeated blows gradually drive the chisel forwards. The force of the blow and its nature should be governed by the work in hand, and, generally, the heavier the object to be struck, the more the force that can be put into the blow.

For riveting, the hammer blows should be delivered rapidly and with a kind of rapping action, the whole object being to form the head of the rivet, and not to move the object bodily. When hammering an unsupported object, or anything that is springy, a light hammer should be used, and the object supported by holding a much heavier hammer behind it.

One of the common mistakes of the amateur is to use a hammer where a mallet should be used. When loosening the iron of a plane, for example, a mallet is better than a hammer, as well as when driving a wood chisel.

HAMMER BREAK. Type of magnetically operated mechanism for the automatic making and breaking of electrical continuity in a circuit. The device is largely used in induction coils and electric annunciators. A standard hammer break for use with an induction coil is shown in Fig. 2. It consists of a springy strip of brass, A, to the top end of which is secured a soft iron head, B. At about a third of the length of the strip from the top a platinum contact, C, is riveted to the brass strip.

The lower end of the strip is bent at right angles and is secured to an ebonite base by a stout brass right-angle bracket, D. The strip is insulated from the bracket by a piece of sheet fibre, holes being provided in the base of the strip to clear the screws securing the bracket



SIMPLE FORM OF HAMMER BREAK

Fig. 2. Electrical continuity of a circuit is automatically broken by a device of which this is one of the simplest forms

to the base. At the top end of the bracket a platinum-pointed screw, E, is so arranged that its end meets the platinum "point" in the brass strip. A lock nut is provided on this screw to lock it in position when it has been correctly adjusted.

This piece of apparatus is screwed to the base of the induction coil, so that the hammer head on the brass strip coincides with the iron core of the coil, a distance of about $\frac{1}{16}$ in. separating these parts.

One end of the primary winding of the coil is connected to the brass strip and the other end to a battery terminal on the base. The bracket is similarly connected to a battery terminal. When the circuit is completed by connecting up a suitable battery to these terminals, and adjusting the screw E so that it makes contact with the hammer strip, the iron core of the coil becomes magnetized and attracts the iron hammer. It is arranged that the effect of this attraction is to cause discontinuity of the circuit at the platinum points. Owing to the natural springiness of the brass strip, and the fact that the iron core no longer attracts the hammer head, it flies back to its original position. This causes another flow of current, when the cycle is repeated.

The frequency of the vibrations thus caused is largely determined by the flexibility of the brass strip, the weight of the hammer head, and the distance of its travel.

A stoppage of the moving arm is sometimes occasioned by oxidation, or the introduction of dust or dirt, at the platinum points. These should be cleaned with a piece of clean rag dipped in petrol, and the use of a coarse abrasive should be avoided.

A form of hammer break in general use is shown in Fig. 1. This type is used to interrupt the primary current of a spark coil, in order that direct current may be used to operate it. It consists of a springy phosphor-bronze strip, fixed at its lower end, and having a circular iron armature attached to the top. This piece of iron is situated immediately opposite to the core of the coil, and when current is passing is attracted to it.

A platinum contact is fitted to the lower end of the armature strip, which makes contact with a fixed contact attached to a pillar. The arrangement of these contacts is such that when the armature flies towards the core, contact is broken. As the circuit is then broken, the core loses its magnetism, with the result that it immediately returns to its former position and again makes contact. The process then repeats itself indefinitely so long as the supply current is applied. The brass knobs at the top of the pillar immediately behind the armature strip are for controlling a stop which limits the amount of movement of the armature, and, therefore, the frequency of the interruptions. The lower knob is attached to the rod holding the stationary contact, and is for the adjustment of that. These two controls must usually be used together, for the adjustment of one will generally throw the other out of adjustment.

A locking nut is found necessary to the top control because of the vibration set up by the rapidly moving armature.

HAMMOND, JOHN HAYS. American wireless expert. Born in San Francisco in 1888, he was educated at the Sheffield scientific school, Yale, and the George Washington University.

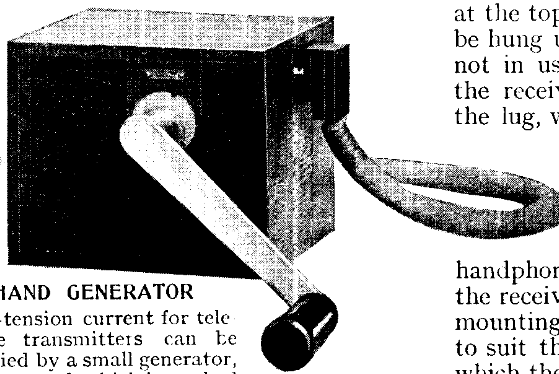
Hammond is chiefly famous for his researches into wireless control at a distance. He invented a wireless-controlled torpedo for coastal defence, and the wireless control of ships which was employed on the U.S.S. Iowa for target practice. He is the author of over two hundred and forty patents in connexion with wireless telegraphy and telephony, and in 1912 was the United States delegate to the Radio-telegraphic Convention held in London. He is a member of numerous scientific societies and advisory bodies.

HAND GENERATOR. Generator of a type suitable for very small power wireless telegraphic or telephonic transmitters, and designed to be driven by hand. A typical generator of this description is shown in the figure. This machine is supplied by Messrs. Marconi's Wireless Telegraph Co., Ltd., for use with their small-powered telephonic transmitters, and is used to supply the high-tension current for the transmitting valves.

The armature is geared from the handle, which is intended to be driven at a speed of approximately 80 r.p.m. An idea of this speed will be formed by comparison with the speed of the turntable of a gramophone, which is nearly always driven at this number of revolutions per minute.

The case which surrounds the generator is made very substantially in order that no trace of gear or other noise shall be able to interfere with conversation. Inconsistency of speed, which is very probable with such generators, is allowed for in the design of the machine, which practically eliminates the human element.

The leads from the generator to the set are enclosed in a heavy rubber sheath, impervious to insulation losses and



HAND GENERATOR
High-tension current for telephone transmitters can be supplied by a small generator, as illustrated, which is worked by hand. The armature is driven at a speed of 80 revolutions per minute

mechanical injury. Plug connexions are used at both ends, thus rendering the connexion of the generator to the transmitter a simple matter. *See* Generator.

HANDLE. That part of an object intended to be grasped with the hand in lifting or using, as a haft, helve, knob, etc. In wireless work, handles are generally small and circular in shape, and are customarily known as knobs, so far as they apply to the control of condensers, tapped inductances and the like. Long handles for reducing body capacity effects are usually made of ebonite, and are known as anti-capacity handles. Others, fitted for the purpose of imparting slow motion or fine adjustments, are known as extension handles and fine tuning devices (*q.v*).

Other handles are employed in connexion with portable sets and on cabinets, the latter known as cabinet handles when they are incorporated with a simple form of catch. Innumerable patterns are available for the amateur.

HANDPHONES. As their name indicates, handphones are telephones which are designed to be held in the hand. The advent of broadcasting was responsible for a great number of women becoming interested listeners-in, and therefore users of wireless type telephone receivers. Unfortunately the standard form of head-gear is unsuitable for women because it tends to disarrange the hair. Handphones represent the results of efforts by manufacturers to eliminate this drawback.

On the right is a standard type of handphone by Messrs. The Sterling Telephone and Electric Co., Ltd. It consists of a standard earpiece, of either high or low resistance, mounted upon an ebonite rod, which serves as a handle. A loop is fitted at the top of the instrument to enable it to be hung upon any convenient hook when not in use. The cord is led away from the receiver through a loop attached to the lug, which forms the support for the handle. It will be realized that this instrument is quite free from any of the defects mentioned above.

A double receiver type of handphone is illustrated on the left. Here the receivers are held on a gimbal form of mounting, which allows of free adaptation to suit the wearer. The long strip upon which the gimbals are mounted is made of hard-drawn aluminium, and is sufficiently springy to allow of the requisite amount of pressure upon the ears to keep out external noises. The cords are led round the aluminium band and held in position by metal bands which surround them.

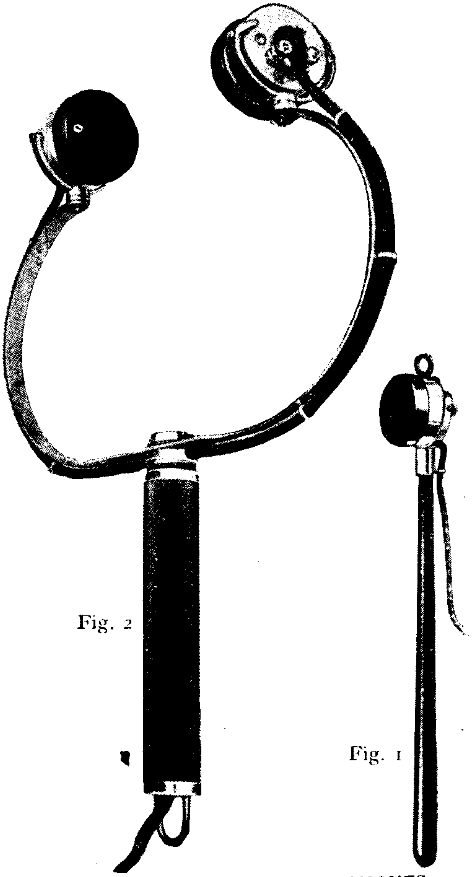


Fig. 2

Fig. 1

SINGLE AND DOUBLE HANDPHONES
Fig. 1. Single handphones are made with long handles for listening with one earpiece. Fig. 2. Double handphones are used when headphones are not desirable, particularly for women

HAND-SAWING WITH THE GRAIN

Fig. 1. Ripping or cutting with the grain of the wood is being carried out in this photograph. A cross-cut hand saw is the best for general all-round use

The handle at the bottom is hollow, and the cords are led through it, and thus are kept well out of the way of the wearer.

HAND SAW. In carpentry, the hand saw has a hand grip at one end of the blade, with the latter tapering somewhat from the handle end to the opposite end, and the back of the blade is narrower than the teeth. Commonly, the expression is applied to a variety of patterns of saw, all of which can be manipulated by one hand, such as a tenon saw, which has a parallel blade strengthened on the back with brass or steel. Hand saws are grouped into special divisions, including cross-cuts, rip saw, and the so-called farmers' saw.

The cross-cut has relatively fine teeth, and is used for cutting across the grain of the wood. The rip saw has coarser teeth with a wider set, that is, alternate teeth are splayed or bent outwards. The former saw has notches in the cutting edge of the blade, and the teeth are differently shaped, and are usually set very considerably.

For general use, the hand saw may be about 27 to 30 in. long, and if only one is obtained, it should be of the cross-cut variety, as if carefully used it can be employed for ripping, as in Fig. 1, or cutting with the grain. The farmers' type of saw is intended for cutting wet timber and poles, and on such work as the preparation of an aerial mast and outdoor timber, where the wood may be cut wet.

The correct way to use a hand saw is practically a matter of holding it properly. The handle should be gripped between the second, third and fourth fingers of the right hand and the palm, as in Fig. 2. The right thumb should be on the left-hand side of the handle as the worker holds the saw pointing away from him. The first finger of the right hand is extended along the handle on the right side, and should point along the line of the back of the saw blade. The saw cut should be made by inclining the saw as shown, and moving the saw with a combined movement of the arm from the shoulder and elbow. The right fingers should be considered as pointing along the line to be cut, as this greatly assists in accurate working.

The action should be perfectly easy, and some pressure should be brought to bear

CROSS-CUTTING WITH HAND SAW

Fig. 2. Cross-cutting, or cutting across the grain of the wood, is accomplished by holding material and saw in the manner illustrated

on the downward stroke and released slightly on the upward stroke. The maximum length of saw should be employed, so that the greatest number of teeth may pass across the wood at each stroke. This minimizes wear of the saw blade and makes for faster cutting. To start a cut, the thumb of the left hand should rest on the work on the side of the line indicating where the saw cut is to be made. The saw blade should rest against the thumb and the cut be commenced by drawing the saw backwards over the wood and starting carefully, particularly noticing that the saw cuts are made in the right direction and with the blade perfectly upright. Too much pressure must not be applied, or the saw blade may buckle.

When not in use, the saw blade should be greased and the saw preferably kept in a case and hung up on the wall, or in some other convenient dry and secure place. The teeth should be sharpened and set whenever they become dulled. The wireless experimenter will find plenty of uses for a hand saw, and to get the best from it, it must always be kept in the best possible condition.

HANGING SET: A SET FOR THE DINING ROOM

An Ornamental and Useful Receiver which gives Light and Music Simultaneously

This is a six-valve receiving set simple in control, specially designed for this Encyclopedia, which is ornamental as well as useful. It works a loud speaker with great clarity of tone 40 miles or more from a broadcasting station. Such articles as Frame Aerial; High-frequency Amplifiers; Low-frequency Amplifiers, etc., should be consulted, and also articles dealing with construction, as Ebonite; Cabinets; Lathe

The construction of a wireless receiving set that comprises the functions of an efficient wireless set with those of a musical instrument and a table lamp is a task that is out of the common, and one that calls for a considerable amount of care and attention to detail. The result is, however, so handsome and striking, that it is well worth while giving it the consideration it requires.

Some idea of the charming appearance of an amateur-made set is given in Fig. 4 and the other illustrations, both in the text and as the subject of the photogravure plate. The scheme embodies a six-valve receiving set worked by storage batteries concealed above the ceiling in the space under the floor of the room above that in which the set is fixed. The aerial is a horizontal frame forming the basis of the upper part of the design and surrounds a centrally disposed loud speaker, the trumpet hanging downwards from the centre of the aerial frame. Six cords attached to the ends of the six arms forming the frame act as supports for the framework of the set, and also carry the low- and high-tension current from the batteries.

Two of the cords are used as the aerial lead wires, consequently the set becomes self-contained. The valves are the ordinary bright emitter type, those used on the set illustrated being Marconi-Osram R valves, but other makes should answer satisfactorily. The purpose of using bright emitter valves is to utilize the light they give to illuminate the dining-table. Thus the set lights up the table and provides music during meals or at any other times during the broadcast hours.

The design of such a set provides considerable difficulties that only become fully apparent when the task is undertaken, and the constructor should not under-estimate them if desirous of success.

One important consideration is the proximity or otherwise of a broadcasting station, as the horizontal aerial is largely robbed of its directional effects. Another matter is to eliminate all superfluous metal in the construction, and to earth everything possible to eliminate or minimize capacity effects.

The set illustrated was intended for use some 35 miles from a broadcast station, and to play with clarity rather than mere loudness. Should this be needed, use the set on an ordinary outdoor aerial and earth, when all B.B.C. stations can be received at loud-speaker strength. Six valves were chosen as a minimum, and also as a convenient number for the purposes of the design, but when in the vicinity of a broadcasting station a smaller number might be adequate, and in that case the spaces otherwise intended for valves should be occupied by ordinary 4 or 6 volt electric bulbs, which, if controlled by a separate switch, could be used for light-giving at any time.

Probably the best course to adopt is first to arrange the various components of the set in their relative places on a temporary base and rig up a temporary frame aerial, setting this the correct distance above the baseboard, and then to make some experiments to ascertain the best values for all the parts. The circuit is shown in the form of a theoretical diagram in Fig. 1, and comprises two stages of tuned anode high-frequency amplification with single condenser control, one detector valve and three stages of low-frequency amplification. If preferred, it is probable that three stages of transformer-coupled high-frequency amplification, followed by a detector and two stages of low-frequency amplification, would answer satisfactorily.

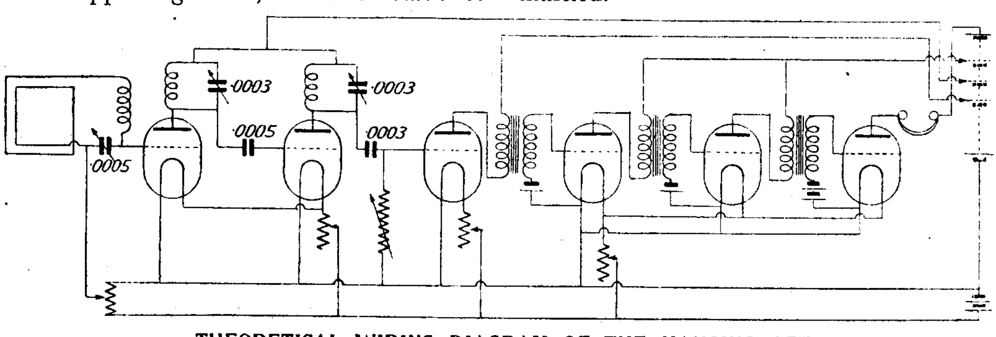
The matter is one largely for individual preference and the local requirements. The values used in the set described are given on the circuit diagram, but might have to be modified by trial on some other but similar set, as the stray capacity effects and other details that might be altered by the individual constructor have to be taken into account. When the trial parts have been assembled and the set tested, as suggested, in the experimental stage, and some familiarity gained from its use, these minor points will be settled, and when the set is properly completed the result is an assured success.

The first step in construction is to prepare a full-size drawing as in Figs. 2 and 3, giving the leading dimensions, and to adhere carefully to them in all succeeding stages in the work. This applies particularly to the spacing of the aerial frame and the main framework, as well as the shaping of the loud-speaker trumpet. Accuracy of work to the dimensions given is necessary in the making of the supporting arms, as these have to carry the full weight of the set, and smaller dimensions would probably result in the whole crashing to the floor.

The best plan is to divide the work into sections, commencing with the aerial frame and loud speaker, shown assembled in Fig. 5, following with the main framework, and finishing by wiring the set and dealing with the purely wireless apparatus part of the work.

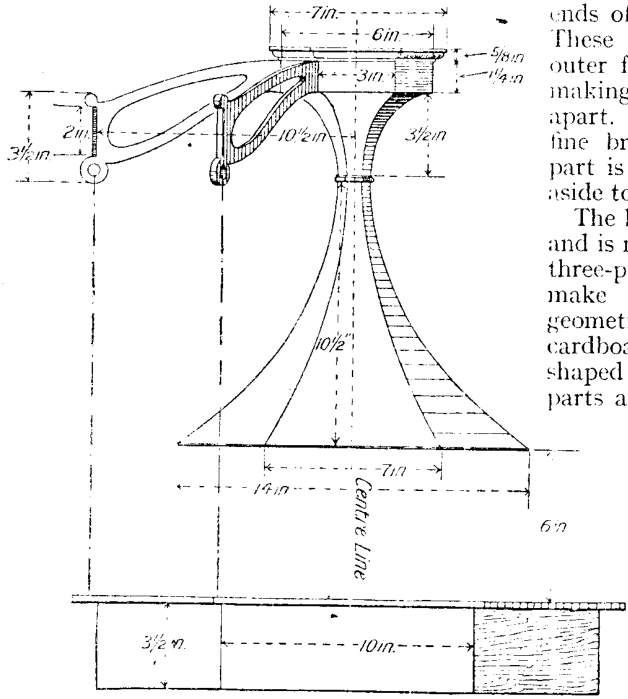
First prepare the top block and the bearer block as shown in Fig. 17. The former is a piece of mahogany $\frac{5}{8}$ in. thick, and cut to an hexagonal shape. This is done by describing a circle with a radius of $3\frac{1}{2}$ in. and then spacing off around the circle with the dividers set to a distance of $3\frac{1}{2}$ in. between the points, which will divide the circle into six equal parts. Straight lines are then drawn between each of these points, thus forming the hexagon.

Next work a moulding on the edge, either with a moulding plane or with carving tools. The bearer block is made of hardwood $1\frac{1}{4}$ in. thick and shaped from a circle of 3 in. radius. A large hole is cut through the centre, as shown in Fig. 4, and slots $\frac{5}{16}$ in. wide cut radially into each corner. These are to accommodate the six arms for the aerial wire, and must be equally spaced and accurately cut to ensure the requisite stability. The arms are sawn to shape and size, as shown in Figs. 2 and 9, from hardwood $\frac{5}{16}$ in. thick when finished. This is done with a bow or pad saw, and then the edges are smoothed and finished with chisel, spokeshave, and gouge, and finished by fine sandpapering. They are then fitted to the slots and alined by resting them on a smooth, flat table, and their positions marked.



THEORETICAL WIRING DIAGRAM OF THE HANGING SET

Fig. 1. Before making the connexions of the set permanent they should be carefully compared with this diagram in order to ensure that the circuit has been satisfactorily wired. Note the positions and capacity values of the condensers, which may be varied if required



SKELETON DIAGRAM OF CHIEF FEATURES

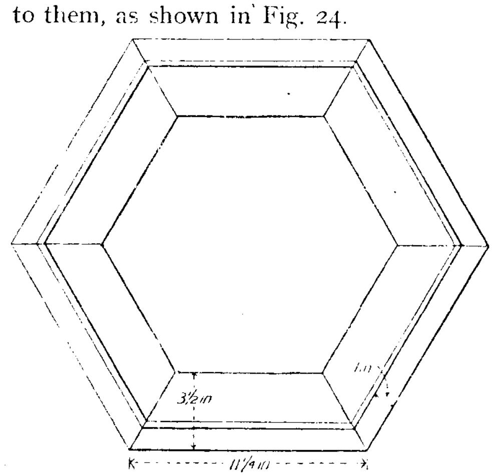
Fig. 2. Details and dimensions of the hanging set in outline are given. This is only a skeleton diagram to include the principal parts

The next step is to make the loud-speaker blocks, the larger from a piece about 1¼ in. thick, the smaller from a piece about 4 in. square and 3 in. long. They are set out as before, and shaped with saw and chisel and gouges, as shown in Fig. 6, but guiding the chisel with the left hand while taking heavy cuts. Cut a central hole through the larger block and drill out the smaller one. Glue them together, and hollow the interior after the glue has set hard, as shown in Fig. 10, to accommodate a high-grade telephone ear-piece of high resistance, unless a telephone transformer is added to the set, when a low-resistance telephone can be employed.

The wood has to be hollowed out until the earpiece is flush with the upper surface. Place three of the arms in place and mark them for the exact position of the shaped block, as shown in Fig. 5, and then cut notches into the ends of the arms, as shown in Fig. 20, having previously screwed the top block into place. Next prepare six strips of ebonite and fit them to the outer ends of the arms, as shown in Fig. 21. These blocks are to be slotted on the outer face to receive the aerial wire, making 16 slots, slightly less than ⅛ in. apart. The blocks are secured with two fine brass pins. The whole of this part is then glued and pinned and set aside to dry.

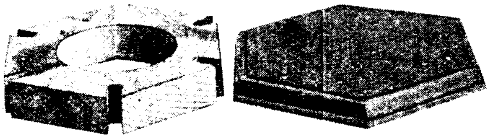
The loud speaker is shown in Fig. 22, and is made from six pieces of 3 mm. three-ply wood. The exact shape to make these pieces can be set out geometrically or a pattern made in cardboard, and the wood cut and shaped accordingly. When shaped, the parts are glued together and reinforced on the inner side with strips of linen glued across the joints, as shown in Fig. 23. The upper end should be fitted to the lower end of the loud-speaker block, but not fixed to it at this stage. A small moulding should be mitred around over the joint, and fixed at a later time when the aerial wiring is finished. The next process is to make up the main framework.

This should be made throughout of matted ebonite, otherwise use good dry hard-wood well impregnated with paraffin wax. The dimensions of the framework are given in Figs. 2 and 3. The first step is to make the six pieces for the flat part of the frame and to mitre the corners and fit feathers to them, as shown in Fig. 24.



PLAN OF THE MAIN FRAMEWORK

Fig. 3. Measurements of the main framework are given above. This diagram represents the structure as seen from below



TOP BLOCK AND BEARER BLOCK

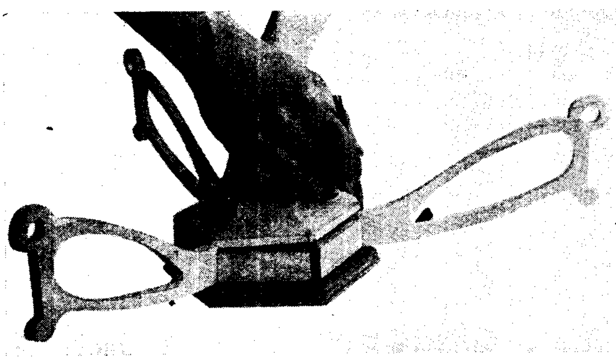
Fig. 4. Mahogany is used for the top block, which, like the bearer block, is hexagonal in shape

Plough a groove $\frac{5}{16}$ in. wide and $\frac{1}{8}$ in. deep at a distance of 1 in. from the outer edge, and fit the side pieces of the frame into it, as shown in Fig. 25, carefully mitreing the corners, and glue and pin them together. The next step is to mark out the positions for the three filament resistances, the potentiometer, and the two condenser spindles. These are all located in the centre of a panel, and all these holes will have to be bushed with ebonite to avoid surface leakage of high-tension current. The bushes are turned from ebonite rod and made a push fit into the holes in the sides, as shown in Fig. 26.

The next process is to make an hexagonal valve panel, and this must be made from ebonite. The pieces are set out as described for the top plate, but have to fit closely into the inner part of the wooden framework. The careful testing of the angles at the ends of the six pieces of ebonite that comprise the framework with a bevel square set to 60°, as in Fig. 27, will ensure good joints.

To strengthen the corners small plates of brass are screwed to the inner edges, and as a further support disks of ebonite are turned and fitted half on one part and half on the other, as shown in Fig. 28. These disks and the panel are then drilled for the valve legs, and the latter secured with nuts in the usual way. The result of the work to this stage then appears as shown in Fig. 11, on the plate facing this page. To prevent the valves possibly falling out, security clips of thin springy brass are fitted beneath the negative side of the filament valve leg, as illustrated in Fig. 29.

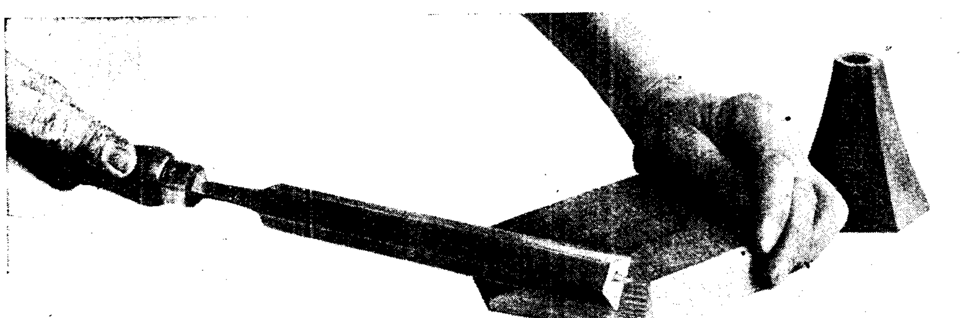
The wiring of the filament circuits can now be carried out, as shown in Fig. 9, with square tinned copper bus-bar. To prevent the longer sections of wiring sagging, it can be soldered to short pieces of screwed rod screwed into the ebonite. The valve panel is then fitted to the framework by screws into filets



MARKING ARMS TO TAKE BLOCK

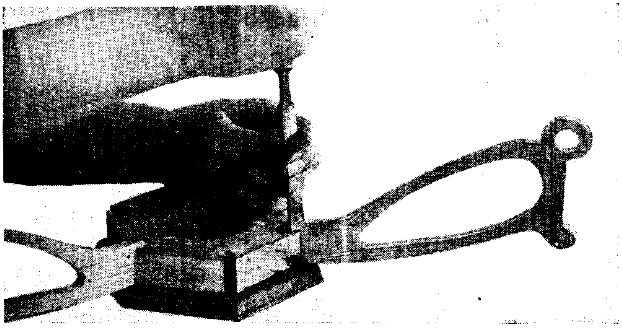
Fig. 5. Three of the arms are placed in position and marked for the exact position of the shaped loud-speaker block

attached to the inner side of the frame, bringing the panel flush with the top, as shown in Fig. 13. This part of the set naturally stands upside down, and it



SHAPING LOUD-SPEAKER BLOCK FOR HANGING SET

Fig. 6. Holding the block firmly down on the bench, the operator is making light cuts with a chisel. In making the loud-speaker block the rough material is cut out with a saw and then shaped accurately, first being carefully marked out



SHAPING ARMS TO RECEIVE BLOCK

Fig. 20. Notches are cut into the ends of the arms in order to accommodate the loud-speaker block. The operator is here seen cutting one of the notches with a chisel

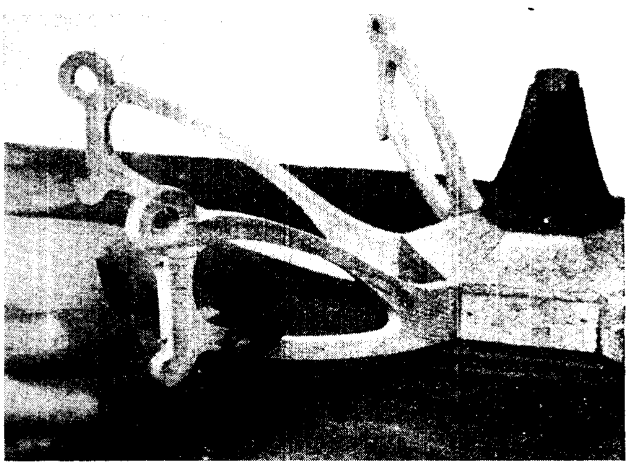
must be remembered that the valves hang vertically downwards and that the broad part of the frame is at the top.

The only feature of the wireless part of the work that calls for especial mention is the dual condenser used for tuning the two anode reaction coils simultaneously. This is shown in Fig. 30, and is made from two standard variable condensers. The top plate of one is used as the top plate for the dual condenser, and the bottom plate at the opposite end. The end plates from the other condenser are not used at all. The whole of both sets of condenser fixed plates are used in the ordinary way, and attached to a central plate or disk of ebonite, but on opposite sides, and opposite to each other.

The moving plates are made into blocks by soldering two wires along the centre part, as shown in Fig. 30. They are then mounted on a long central spindle by means of two lock nuts to each portion, one of which is illustrated in Fig. 31. The ebonite centre disk should be drilled with the two end plates clamped to it to serve as a guide and to ensure alinement. The illustration Fig. 32 shows how this can be done without difficulty. The aerial tuning condenser is of the usual pattern, and this and the dual condenser are simply fitted to the bushed holes in the usual way, but with the addition of flat ebonite sheeting between the end plates and the surface of the wooden side pieces of the frame, as is visible in Fig. 33.

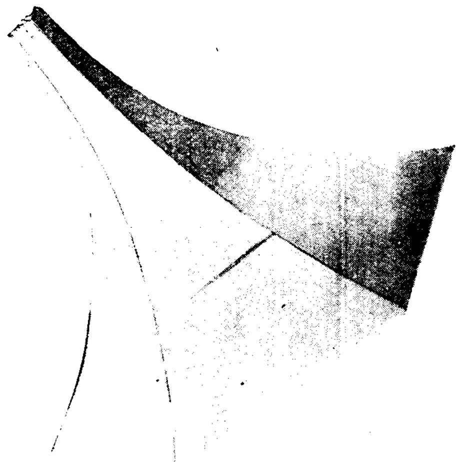
The filament resistances and the three transformers are then fitted to the framework in the ordinary way, but mounted on ebonite bushings and plates where necessary. The components should be of good quality. The last transformer ought to be suitable for power amplification purposes. The aerial tuning inductance and the anode reaction coils are ordinary basket coils covering appropriate wave - lengths. They are fixed, as shown in Fig. 15, on the plate, by means of disks of thin ebonite and a central brass screw which secures them to an ebonite pillar on the framework. The grid biasing batteries are made from cells from ordinary flash-lamp batteries and encased in sheet ebonite secured in place with straps screwed to the framework.

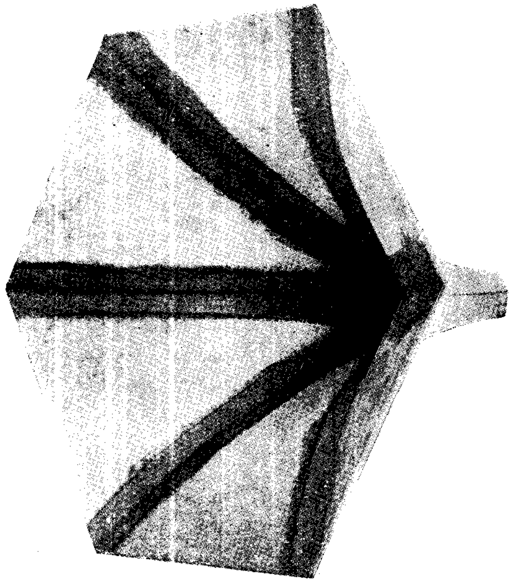
Mullard grid leaks and Dubilier fixed condensers are used, and the wiring carried out with tinned copper wire as far as feasible, and all connexions soldered. Every stage in the wiring is tested as the work proceeds. As much of the wiring as possible is done before finally fixing the panel, as the last part is somewhat difficult owing to restrictions of space. The panel is finally secured with a mitred slip of wood temporarily attached with pins, as shown in Fig. 35. The whole of the



FITTING INSULATORS TO THE ARMS

Fig. 21. Ebonite insulating blocks are fitted to the ends of the aerial frame arms. One of these blocks is seen being placed in position



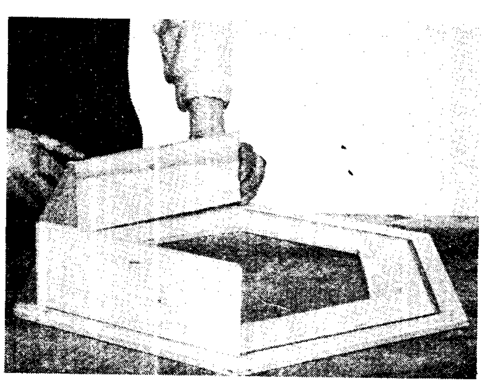


DETAILS OF LOUD-SPEAKER TRUMPET FOR HANGING SET

Fig. 22 (left). Three-ply wood is used in making the trumpet. The shaped pieces of three-ply are bent and strengthened with glue or linen inside. Fig. 23 (right). In this photograph the interior of the trumpet is shown, and the strips of linen can be seen reinforcing the joints of the sections of three-ply wood

framework is stained, or coloured with a non-metallic black stain, which should dry with a dull matt black to match the ebonite. The illustration, Fig. 16, shows how the aerial is wired with No. 22 gauge enamelled copper wire, the ends of which are bared and attached to opposite suspension cords as shown in Fig. 35.

The bobbels are made from long tapering strips of paper rolled and pasted up as shown in Fig. 36 and attached to the suspension cords as shown in Fig. 17. The suspension cords are stout twin lighting flex, and act as the battery connexions and other purposes, being connected at the lower ends to terminals on the panel, and at the upper end to the batteries. The framework is ornamented by embossed panels of pewter, shaped as shown in Fig. 37, by outlining with a bone stylus while resting the pewter on a pad of blotting paper. The centre boss is hammered up while resting on a felt pad, and working out the creases by rubbing with



FITTING SIDE PIECES AND FEATHERS OF THE FRAMEWORK

Fig. 24 (left). How the feathers are fitted to the mitred corners of the framework of the hanging set is illustrated; a perfect joint should be made. Fig. 25 (right). Sidepieces are here seen being fitted to the framework. The groove into which the side pieces are fitted can be clearly seen in Fig. 24

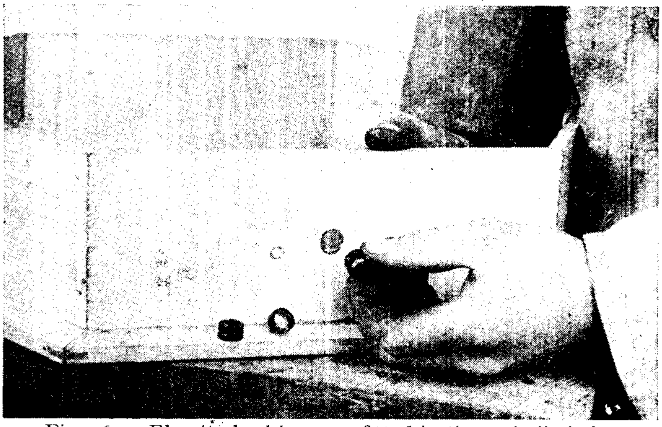


Fig. 26. Ebonite bushings are fitted in the spindle holes in the side of the frame

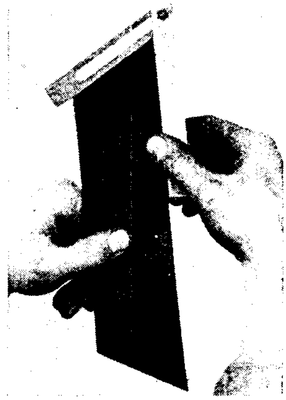


Fig. 27. An angle of 60° is required for the panel element

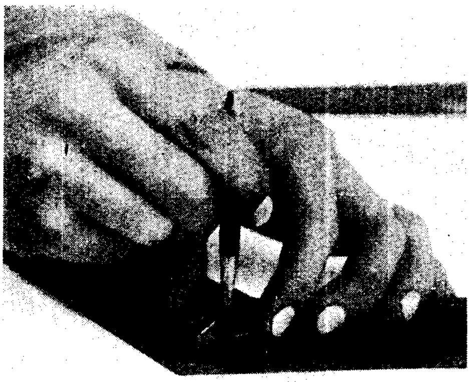


Fig. 28. Ebonite disks are fitted over the corners of the valve panel

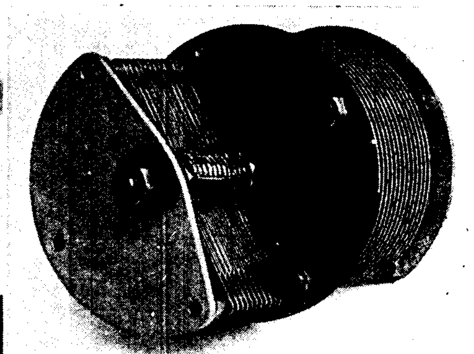


Fig. 30. A special dual condenser is used to tune simultaneously the two anode reaction coils

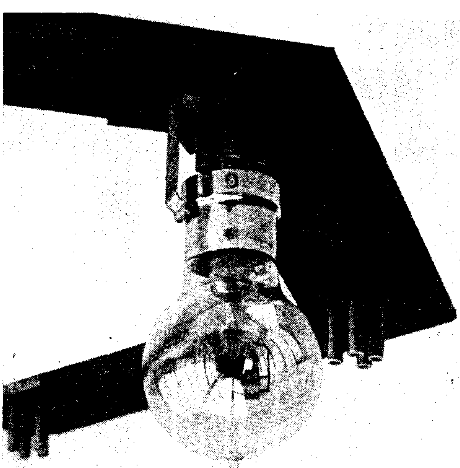


Fig. 29. Security clips are used to hold the valve in place, the valve, when in use in the set, being inverted

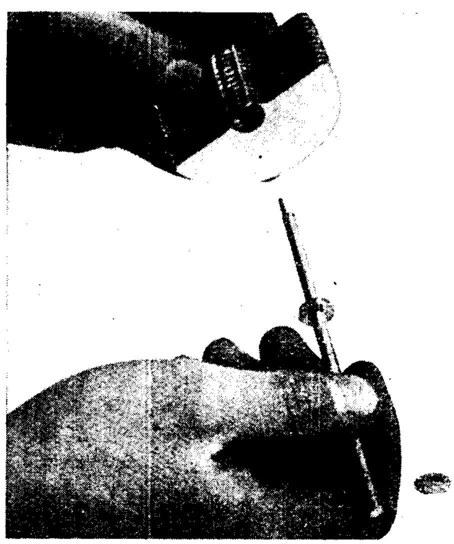


Fig. 31. How the condenser moving plates are secured to the spindle may be seen in this illustration

VALVES AND CONDENSER MOUNTING FOR HANGING SET

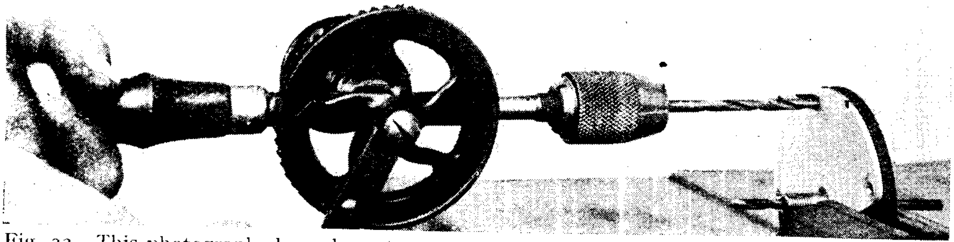


Fig. 32. This photograph shows how to use the end plates of the condenser as a guide in drilling the ebonite disk

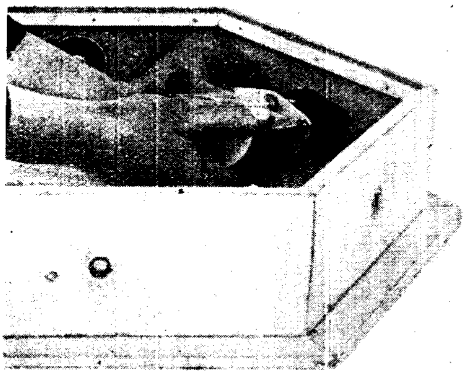


Fig. 33. The aerial tuning condenser is fitted to the ebonite face on the framework

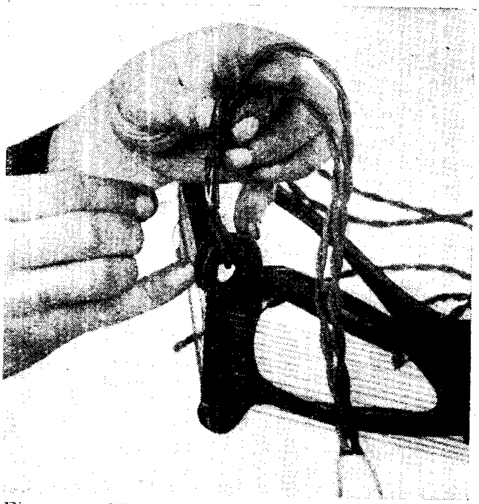


Fig. 34. How the aerial is connected to its particular suspension cord is shown in this photograph

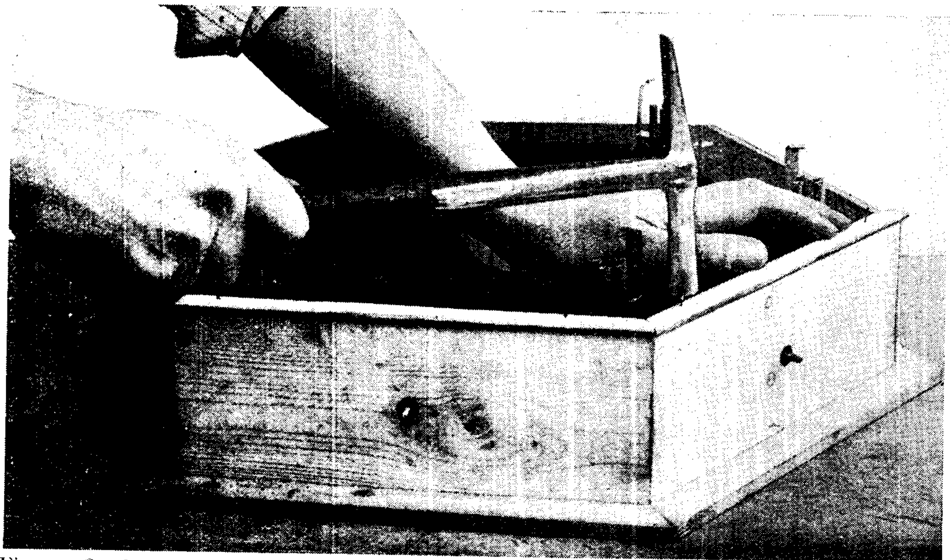
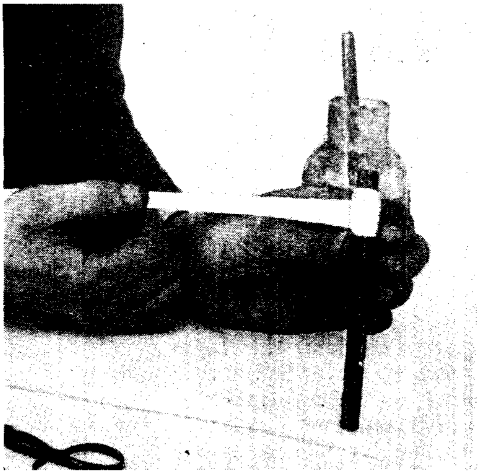


Fig. 35. On the upturned lower edge of the framework the operator is nailing a wooden bead which secures the panel and also, when the set is actually ready for hanging, holds the silk shade

PROCESSES IN THE CONSTRUCTION OF THE HANGING SET



PAPER BOBBLES FOR HANGING SET

Fig. 36. Paper bobbles for the suspension cords of the hanging set may be rolled round a fountain pen as shown in this photograph

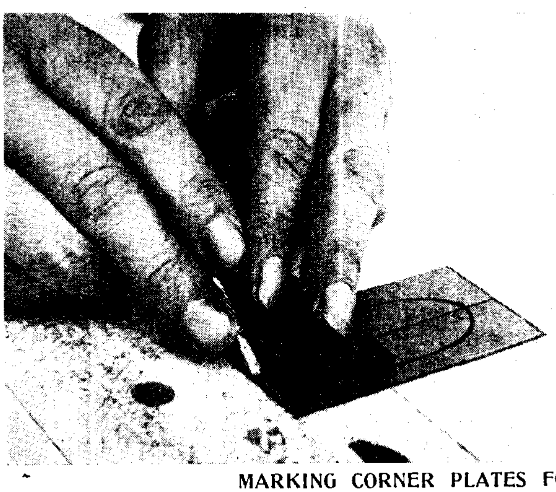
the peine of the hammer as shown in Fig. 38. The control knobs are covered with pewter worked in the same way. The suspension cords are attached to loops of brass screwed to the top of the framework as in Fig. 18, on the photogravure plate which also shows the corner plates and the covered knobs. The silk shade is then prepared and edged with a narrow fringe, and attached to the frame-work by the slips already mentioned.

The loud-speaker trumpet is attached to the block, the whole coloured and lined out, and the top frame, complete, is then suspended from the ceiling. The lower framework is rested on supports at the correct distance from the upper part and the suspension cords fixed and wired up. The set is attached to the ceiling by screws passed through a cross-piece of wood attached to the floor joists as shown in Fig. 19, this also showing the batteries in place in a partitioned portion beneath the floor. Access is provided by a small trapdoor. Other means of supplying the battery power is by accumulators in any convenient part of the room, and by running the connecting wires in a moulded casing in the usual way as if fitting the electric light. This has the advantage that there is no need to disturb the floor or ceiling of the room, and is perhaps a simpler way of energizing the set. The work must, however, be carried out very neatly and the casing employed to protect the wires should harmonise with the general character of the room.

In such a case the batteries could best be stored in a neat stained wooden case. A simple double-pole switch should be provided to sever the connexions in the low-tension circuit, and should be mounted on the exterior of the battery box, and connexions made from it to the battery terminals.

To avoid risk of polarity reversal these connexions should have proper tags attached to them and marked + and −, or otherwise clearly distinguished. The high-tension battery is best accommodated in a separate compartment with ordinary wander-plug connections.

The negative side of both batteries being connected together, the low-tension switch should be placed in circuit so that it cuts off



MARKING CORNER PLATES FOR HANGING SET

Fig. 37 (left). Pewter corner plates are marked out by means of a stylus on a pad of blotting paper. Fig. 38 (right). The corner plates are embossed on a felt pad by using the peine end of a hammer, as illustrated, to smooth out the creases both the low-tension and the high-tension negative side when the switch is thrown over. This arrangement could also be adopted on the battery boxes if they are located within the floor space above the ceiling—either arrangement enables the set to be tuned, and when needed simply switched on or off as desired.

The set works with tremendous volume on an outdoor aerial, and this modification can be made, if so desired, without deviation from the design other than the omission of the frame aerial wiring.—*E. W. Hobbs, A.I.N.A.*

HARD-DRAWN WIRE. Expression used to describe a quality of wire, usually made of brass or some other non-ferrous metal. By a manufacturing process, such wire is made finer and more resilient than that made by another process and known as soft wire. Hard brass wires are best used for the construction of contacts and the like, where resiliency is all-important, and also for such purposes as the wiring up of receiving sets. As the result is more permanent and durable, when finished, than is the case with soft wire, the extra trouble is worth while in the wiring.

HARD VALVE. A valve in which the vacuum is of a high order. Valves of this type are specially used for high- and low-frequency amplification, and also for transmitting purposes. A hard valve is able to take a very much higher anode voltage than a soft valve. In the latter case the vacuum is poor, and its use is largely restricted to purposes of rectification.

In the construction of hard valves particular care is taken to ensure a high vacuum. Langmuir pumps are largely used in obtaining the necessary vacuum, but owing partly to the occlusion by the metals used in the valve, the latter is subjected to a process known as bombardment. By occlusion, is meant the property possessed by a metal of absorbing gases.

These gases would be given off later if they were not driven out when the valve was being exhausted. The result of this would be to turn a hard valve soft. In the bombardment process the filament is kept at a high temperature and a powerful electric field is maintained between the metal parts of the valve. This causes a violent bombardment of electrons against the grid and anode, which results in the occluded gases being driven out. Furthermore the grid and anode become intensely hot, which also assists in the removal of gases.

Opinion is still divided, however, on the merits of the hard valve as against those of the soft valve. Many of the early valves were highly exhausted, but it is known that the filaments burn better when the valves is filled with nitrogen or argon, and the gas-filled valve is certainly an extremely sensitive detector. German valves are exhausted by the mercury pump and with charcoal and liquid air finally. While exhaustion is going on the filament is highly heated to drive out any occluded gas. A special vacuum meter is used to indicate when the highest vacuum is reached, and when further pumping has no effect the bulb is sealed.

The softening of a hard valve may often be shown if it assumes a bluish tint when its full anode and filament voltage is applied. A valve developing this symptom is not efficient as an amplifier, but may be used as a detector until it is too soft to use at all. *See* Valve.

HARMONIC MOTION. Term which may be used as the general description of the periodic oscillatory type of motion which occurs in many forms, as the vibration of a string, the beating of a pendulum, etc. Harmonic motion may be more closely defined as follows:

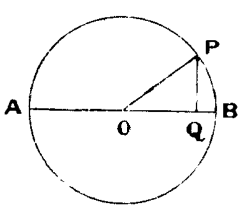
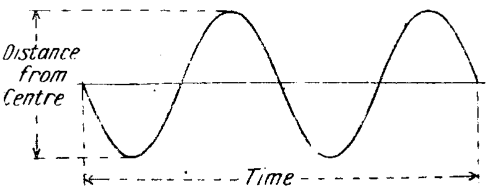


Fig. 1. Diagrammatic representation of simple harmonic motion

Let a point P describe a circle APB at a constant speed. Let O be the centre of the circle, and PQ the perpendicular from P on a diameter AOB. Then the oscillation of Q to and fro along AB is simple harmonic motion. OB is called the amplitude of the oscillation, and a complete oscillation is the path described by Q while P completes a circle. The time taken for a complete oscillation of Q backwards and forwards is known as the periodic time, or the period of the oscillation. A diagrammatic representation of simple harmonic motion may be obtained by plotting the distance from the centre O against the time. The resulting curve is shown in Fig. 2, and is a sine curve.

This curve is very important in wireless, and, indeed, in electricity generally, for it is the curve which represents the oscillating to and fro of an alternating current. It is dealt with at further length



CURVE SHOWING HARMONIC MOTION

Fig. 2. Sine curves, as the example above, which represents harmonic motion, are important in wireless, as they represent the oscillations of alternating current

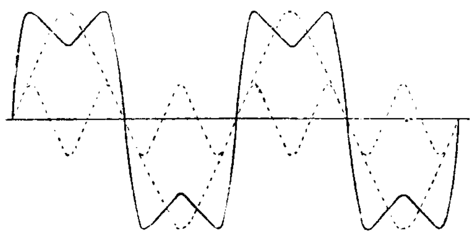
under the headings Alternating Current, Sine Curve and Wave Motion in this Encyclopedia. But since alternating currents can be dealt with as forms of harmonic motion, many problems of alternating current can be resolved into problems which may have an answer found for them by consideration of this form of motion.

A flat loop of wire with its terminals connected to two collecting rings gives a harmonic electro-motive force when it is rotated at constant speed in a uniform magnetic field, and this is the principle of the generator. *See* Alternating Current; Frequency; Generator; Sine Curve; Wave Motion; etc.

HARMONICS. In sound, harmonics are secondary tones which accompany the fundamental or primary tone of a vibrating reed, string, etc. If a low note is struck on a piano, for example, notes of a higher pitch will be heard at the same time, though they are not so distinct. The more important of these harmonics are the third, fifth, seventh and octave.

In wireless a similar kind of thing occurs. A circuit may not only respond to oscillations of its own frequency, but oscillations with frequencies of one-third, one-fifth, or one-seventh its natural frequency may be set up in it. These harmonic oscillations do not produce anything like the effect of the fundamental frequency. Or the circuit may respond to frequencies of double or treble, etc., the original frequency. The former type of harmonics are very often known as sub-harmonics.

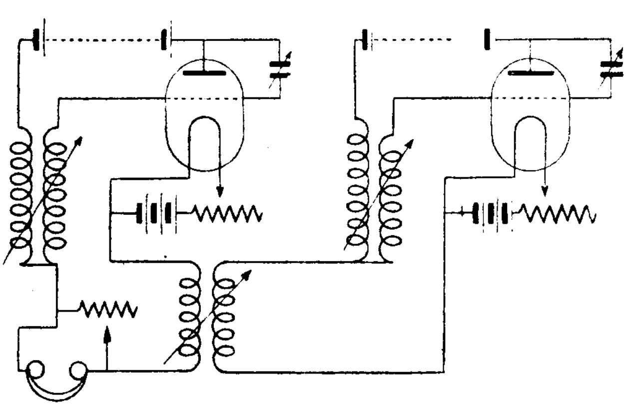
Fig. 1 shows the ordinary form of an oscillating current sine curve, and a third harmonic in dotted lines. The firm line shows the combination of the two. Such harmonics represent a loss of energy in transmitting. When a receiving valve is oscillating, the oscillations are usually accompanied by harmonics and sub-harmonics. Stanley, in his "Text Book of Wireless Telegraphy," gives an interesting experiment to show how the existence of these harmonics may be demonstrated.



OSCILLATING CURRENT SINE CURVE

Fig. 1. In the above diagram is given an ordinary form of oscillating current sine curve and third harmonic, shown dotted. The resulting curve is shown in full line

The circuit diagram in Fig. 2 shows how this may be accomplished. Two valve oscillating circuits are coupled together, and are tuned to slightly differing frequencies, which results in the heterodyne note being heard in the telephones. When the valves are tuned to oscillate at low, inaudible frequencies, the fundamental beat note may be heard however the condensers are set. By keeping one condenser fixed and varying the other, there will be clearly heard, under the primary beat note, each harmonic of one circuit coming into beat action with the same harmonic of the other circuit. *See* Beat Reception; Heterodyne; Impure Wave.



PRODUCTION OF HARMONICS

Fig. 2. From this diagram may be seen how two valve oscillating circuits are coupled together to produce harmonics

HART ACCUMULATOR. A well-known commercial type of accumulator. There are one or two constructional features of this cell which are interesting. The active material is held in the positive plates by means of horizontal ribs upturned at their edges. The paste used in the positives consists of a mixture of pure sulphuric acid and pure red lead, the former having a specific gravity of 1·1. Air-drying is resorted to after filling. A thin solid core of lead left in the centre of the Hart positive plate is a sufficient prevention of buckling, providing the discharge rate recommended by the makers is not seriously exceeded. Planté positives may be obtained if required.

The negative grid is a kind of cage-like structure with horizontal rectangular openings. The paste of these is made up of pure ground litharge and sulphuric acid, the latter having a specific gravity of 1·2 when cold.

The Hart Accumulator Co., Ltd., manufacture a very comprehensive range of batteries and cells, both for portable and central station work.

A type of 6 volt accumulator, useful to the experimenter for lighting the filaments of valves requiring from 4 to 6 volts, is shown in Fig. 2. It has a large capacity, and will run a multi-valve set for a considerable time before it requires recharging. As shown in Fig. 2, a substantial carrying crate, having a leather handle, is provided for carrying the accumulators. At one side two ebonite bushes are let into the crate to enable the connecting wires to be attached easily.

A small, compact cell is shown in Fig. 1, and is intended for use with dull emitter valves. This type of accumulator is useful where portability is desired. It is desirable, where an accumulator is fitted into the receiving set itself, that it should occupy a compartment completely shut off from the remainder of

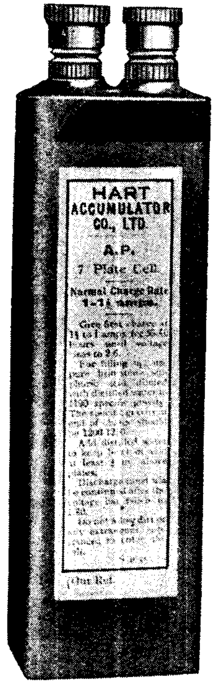
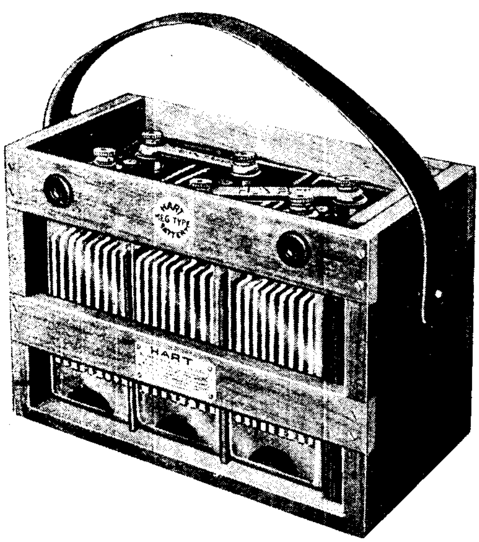
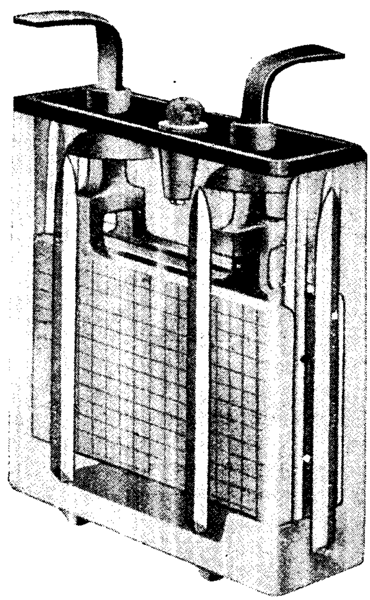


Fig. 1. Hart accumulator suitable for use with dull emitter valves

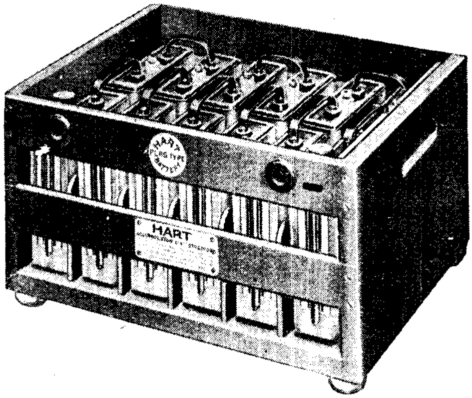




HART ACCUMULATORS DESIGNED FOR WIRELESS PURPOSES

Fig. 2 (left). Meg-type accumulators are made for use with ordinary 4–6 volt valves. This is a 6 volt accumulator provided with a strong crate and carrying handle. Fig. 3 (right). A single cell of a high-tension battery is illustrated. Owing to the extremely small discharge rate a single positive plate is found to be sufficient

Courtesy Hart Acccumulator Co., Ltd.



HART HIGH-TENSION ACCUMULATOR

Fig. 4. Twelve cells are wired in series to give a total of 24 volts. This is a PLRG type high-tension battery

Courtesy Hart Accumulator Co., Ltd.

the set, as any acid vapour given off would corrode adjacent metal work.

Where facilities for recharging are available a high-tension battery may be made up from units which are specially designed for this purpose. Fig. 3 shows one of these units, which consists of an oblong glass container housing a single-plate positive element and a two-plate negative element. A feature of this cell is that no separators are used, the plates being kept in position by means of stout ribs cast in the glass container. Two ledges are provided at the bottom of the container on which the plates rest.

External ribs are also provided on the bottom and sides of the glass container. A battery of twelve of these cells is illustrated in Fig. 4, housed in a crate, partitioned off to prevent the cells being jolted together. *See* Accumulator; Storage Battery.

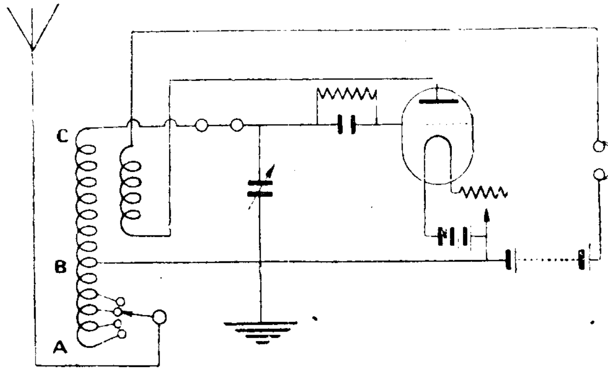
HARTMANN-KAMPF ALTERNATOR. A type of high-frequency generator in which no exciting current is used. In place of the customary electro-magnets energized by a separate dynamo, permanent magnets are used. Twenty-four of these are arranged in ring formation so that their poles face inwards and surround a slot-wound armature. Both the ring of magnets and the armature are revolved, and in opposite directions to each other, at a speed of 4,000 revolutions per minute each. The output of the alternator has a minimum of 500 watts.

HAYNES CIRCUIT. Simple type of regenerative receiver, a feature of which is the conductive coupling between the primary and secondary tuning inductances. In its usual form the Haynes circuit is a single-valve receiver, and, as shown in the illustration of the theoretical circuit diagram, follows the standard wiring of an ordinary detector circuit.

The primary tuning circuit, shown in the diagram as AB, consists of a few single-tapped turns of wire. The tuning of this circuit is semi-aperiodic, by which is meant that the tuning is very coarse. The secondary tuning coil, represented by BC in the illustration, is shunted by a small variable condenser of maximum capacity of ·00025 mfd. This condenser is of extreme importance, and the experimenter is advised to see that this component is of good quality.

For the aerial tuning inductance a 3 in. cylindrical former is recommended. The reaction coil should consist of a small piece of ebonite tube of a diameter to secure free rotation inside the inductance. Providing the coupling is fairly tight, 35 turns of wire for the reaction coil will be found to be about right.

Wiring of the set is best carried out with a stout gauge tinned wire, and possible capacities are avoided by the use of insulated sleeving. It is particularly important in the construction of this set to avoid the detrimental effects of self-capacity, and to this end care should be taken in the choice of all component parts. *See* Regenerative Set.



HAYNES REGENERATIVE RECEIVER

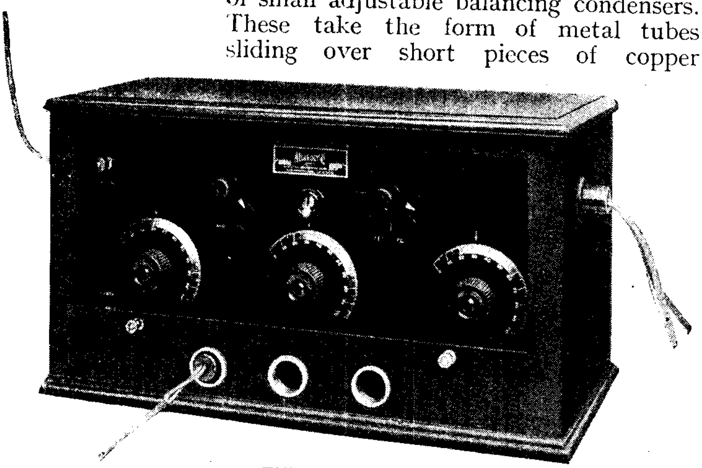
Conductive coupling between primary and secondary tuning inductances is a feature of this simple type of one-valve regenerative receiver

HAZELTINE NEUTRODYNE RECEIVER. Name given to a specific form of receiving set, due to Professor Hazeltine.

In any circuit embodying one or more stages of high-frequency amplification the coupling due to the small grid to plate capacity of each high-frequency valve causes the various circuits to interact, and when more than one stage of high-frequency is employed the set becomes very unstable, resulting in self-oscillation, with consequent distortion of speech and music.

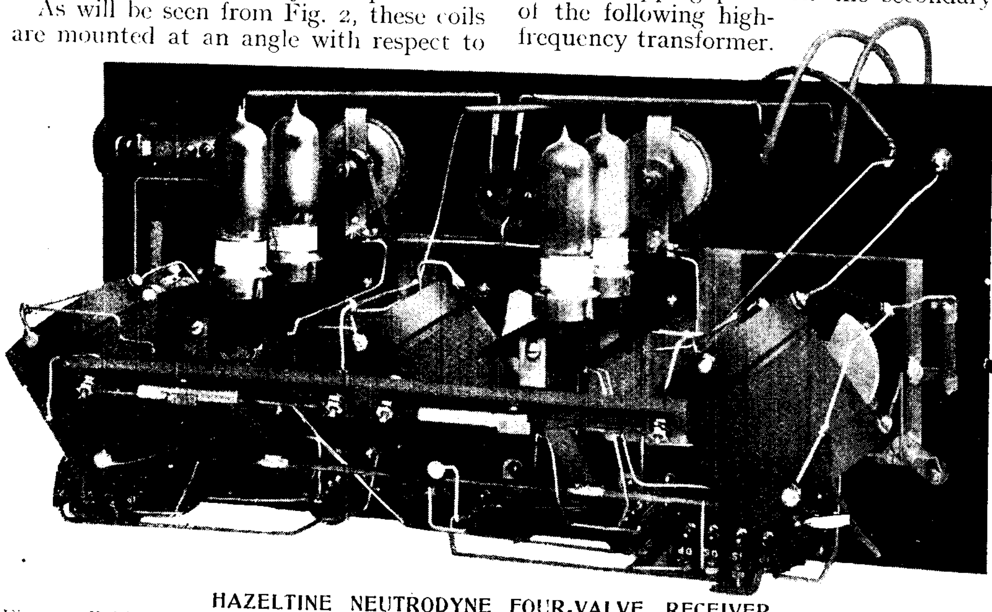
Many attempts have been made to overcome this inherent trouble, and of these the neutrodyne principle of Professor Hazeltine has proved extraordinarily effective. In the neutrodyne receiver the aerial and other high-frequency circuits consist of aperiodic primaries tightly coupled to tuned secondaries, by which means extreme selectivity is obtained, together with easy manipulation.

As will be seen from Fig. 2, these coils are mounted at an angle with respect to the horizontal to minimize magnetic coupling. The inter-electrode capacities of the valves are neutralized by means of small adjustable balancing condensers. These take the form of metal tubes sliding over short pieces of copper wire, the condenser plates thus formed being separated by a glass dielectric. These balancing condensers are connected between the grid of one valve and a suitable tapping point on the secondary of the following high-frequency transformer.



EXTERIOR OF HAZELTINE RECEIVER

Fig. 1. Distortion of speech and music is eliminated in the Hazeltine four-valve neutrodyne receiver, the external appearance of which is seen above

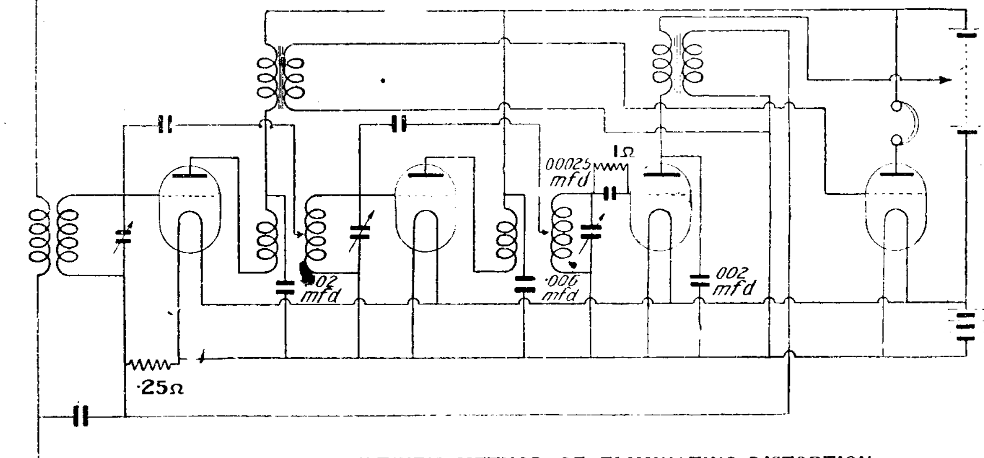


HAZELTINE NEUTRODYNE FOUR-VALVE RECEIVER

Fig. 2. Behind the panel of the Hazeltine receiver in Fig. 1 the arrangement of the components is seen. Note how the three tuning coils are sloping, also the position of the transformers, one of which is seen at the bottom right-hand corner, and another at the bottom left-hand corner. The valves are mounted on bridges. On the extreme right is the grid leak

The external appearance of a four-valve set is given in Fig. 1, and the internal arrangement of the parts is shown in Fig. 2. The disposition of the parts permits of a compact receiving set. The valves are supported on platforms, the balancing condensers on the underside of the slanting ebonite plate in the foreground.

The circuit diagram is given in Fig. 3, and this, with the aid of the detailed photograph (Fig. 2), should make the arrangement of the components clear. *See* Neutrodyne.



PROFESSOR HAZELTINE'S METHOD OF ELIMINATING DISTORTION

Fig. 3. Distortion due to self-oscillation in unstable circuits led Professor Hazeltine to establish a principle which is incorporated in the above arrangement. By the means here employed elimination of distortion has been successfully accomplished. Extreme selectivity is aimed at. The principle can be applied to other high-frequency amplifiers as well as the four-valve set illustrated

HEADPHONE. Expression used to define all types of telephone receivers adapted to be worn on the head. Typical patterns are illustrated in Figs. 1

EXAMPLES OF HEADPHONES USED FOR WIRELESS RECEPTION

Fig. 1 (left). Aluminium connecting strips in these Sterling headphones hold the earpieces together, and have the advantage of being very light. Adjustment is provided by means of tightening screws. One earpiece is shown dismantled. Fig. 2 (right). Earpieces are connected by flat strip springy steel in these headphones, made by the Economic Electric Co., Ltd., and the steel is covered with leather to protect the wearer's head. Note how the earpieces are easily adjusted and 2, and show a pair of earpieces connected together in Fig. 1 by two pieces of aluminium, and in Fig. 2 by steel protected with leather. For comfort, adjustments are provided to enable the two head-bands to be placed in the best position for individual wear. Usually, one of the bands is placed vertically over the top of the head and the other horizontally around the back of the head, as shown in Fig. 3.

The earpieces should be separately adjustable, so that they can be placed in the most comfortable position. They should also have some form of flexible joint between them and the head-bands, so that they may conform to the shape of the head. The pressure of the spring band, or the natural resiliency of the head-bands themselves, should not be excessive, and should be adjustable. For continual wearing, a pattern made of aluminium, or a steel band covered with leather would be desirable.

The method of locking the head-bands on to the earpieces varies with different makers' practices. In some a washer is used, and this washer has a D-shaped hole, a small protecting peg, or some similar arrangement for holding it in place. If the headphones are taken apart for any purpose, they should be carefully reassembled in their proper positions, particularly noting whether the washers are in their right places, as when properly adjusted the head-bands and the earpieces should be rigidly attached to one another. The function of the earpieces and methods of connexion are dealt with under Telephones. *See* particular makes of headphones, *e.g.* Brandes, Brown, Ericsson, etc.

HOW TO WEAR HEADPHONES

Fig. 3. Headphones should be worn with one connecting piece over the top of the head, and the other round the back of the head, as illustrated

HEAVISIDE LAYER. A theoretical or assumed layer of ionized gas about 50 to 100 miles above the surface of the earth, which acts as a gigantic reflector of wireless waves, and so makes them follow the contour of the earth.

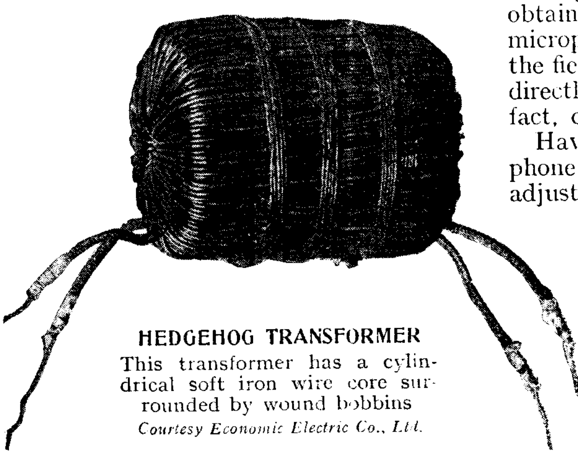
It was in 1900 that Heaviside suggested that at a considerable height above the surface of the earth there may be a permanently conducting layer which would reflect the wireless waves in the same way as a ceiling might reflect sound, or a gigantic mirror reflect light waves. This Heaviside layer has the support of many eminent scientists and has been attacked by an equal number. The Heaviside layer was suggested because of the difficulty of understanding why wireless signals should be heard over great distances, when the waves, since they normally travelled in straight lines, should apparently have been radiated off into space and lost. It clearly becomes much simpler to understand why signals are heard if, all round the earth, there is a gigantic reflecting layer which turns the waves back, as it were, and compels them to follow a path more or less round the earth. The theory has the support of such scientists as Sir Oliver Lodge, Professor J. A. Fleming, Dr. W. H. Eccles, and others.

Elihu Thomson, however, has pointed out an alternative theory, the gliding theory, which may also account for the fact that wireless waves move round the surface of the earth. By the gliding theory it is suggested that the propagation of wireless waves is not strictly on the lines of real Hertzian waves, but, on account of the grounding of the base of the aerials, of only half Hertzian waves.

By the gliding theory these waves are in reality attached to and guided by the earth's surface. Neither of the theories is without flaws, and their full explanation and attempted proofs involve too great a knowledge of mathematics to be given in this Encyclopedia. The fundamental fact is that the waves are carried round the surface of the earth but how has not been definitely settled. *See* Distortion; Reflection.

HEDGEHOG TRANSFORMER. Type of transformer, so called because of its appearance, which is not unlike that of a hedgehog. The photograph shows a typical transformer of this type. It consists of a cylindrical iron core, made up of a number of soft iron wires, surrounded by a bobbin containing the windings.

The core itself is made three or four times longer than would normally be necessary.



HEDGEHOG TRANSFORMER
This transformer has a cylindrical soft iron wire core surrounded by wound bobbins
Courtesy Economic Electric Co., Ltd.

The windings on the bobbin are wound after the manner of a small spark coil, *i.e.* they are simply layers of wire wound upon each other. In the case of an intervalve transformer the primary is of heavier gauge wire than the secondary, and wound next to the core, and the secondary, of much finer wire, is wound on top of this. In a telephone transformer, which is a step-down instrument, the reverse would be the case.

After winding and impregnating, the ends of the core, which now project, are bent back over the bobbin, so that they completely surround the windings. The loose ends are held in place by three bands of iron wire. This construction is quite clear from the illustration. If the core is earthed, as it should be, it forms a very good shield for screening adjacent apparatus from the magnetic field inseparable from iron-cored transformers.

This feature is of great utility where more than one stage of low-frequency amplification is used, as two unshielded transformers in close proximity are a prolific cause of distortion and howling.

HEISING MODULATION. System of modulation control due to R. H. Heising and patented by him.

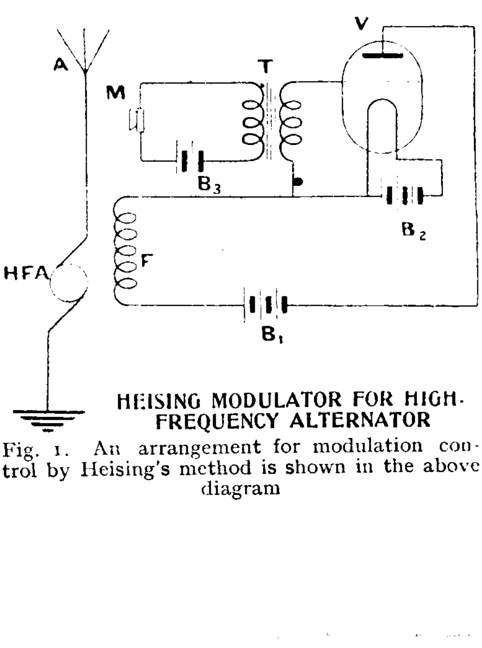
One arrangement is shown in Fig. 1, and consists of an aerial A in series with a high-frequency alternator, HFA, and the earth.

The field winding of this alternator is connected through a battery to the anode and filament of a valve, whilst the grid of that valve, V, is connected through a transformer, T, to a microphone, M.

The microphone is not placed directly in series with the field winding and the battery, as the best results are only obtained when the power absorbed in the microphone is equal to that absorbed by the field. With the microphone connected directly in the field there would be, in fact, considerable distortion.

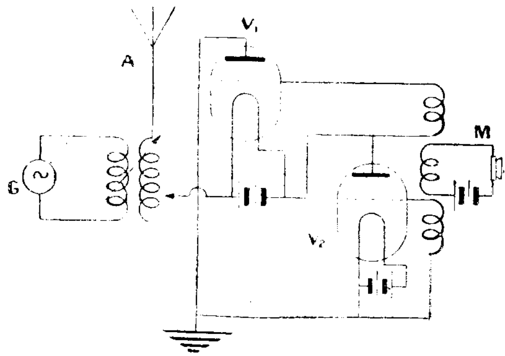
Having the valve between the microphone and the field coil, it is possible so to adjust the impedance of the field winding and the valve that they are equal, or may be adjusted to other fixed values.

Modulation by means of this system is quite straightforward. Speech coming to the microphone varies its resistance; a variable current, therefore, flows from the battery B_3 through the transformer, T, the result being a variation of the potential of the grid of the valve, V. As the potential of this grid is changed, so the current flowing from the battery B_1 through the circuit B_1 V F will vary, and as F is the field winding of the



HEISING MODULATOR FOR HIGH-FREQUENCY ALTERNATOR

Fig. 1. An arrangement for modulation control by Heising's method is shown in the above diagram



TWO-VALVE HEISING MODULATOR

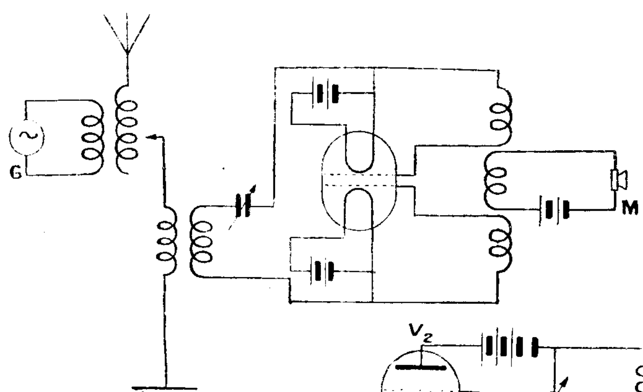
Fig. 2. Heising modulator with two valves has the microphone coupled to the two grids

alternator, it necessarily follows that the aerial current will also be modulated.

Other arrangements due to Heising are illustrated in Figs. 2, 3, and 4.

Fig. 2 illustrates the aerial coupled to any high-frequency generator, G, whilst the path to earth from the aerial A is via the two valves V_1 and V_2 in parallel, but connected in opposite sense, whilst the microphone is coupled to the grids of both valves.

The object of placing the two valves back to back in this manner is so that the aerial may be free to oscillate in either direction.



The two valves thus become a resistance in series with the aerial, which can be rapidly varied in value by means of the microphone current, which acts on the grids of the two valves.

Fig. 3 is a modification of the same arrangement, but by the use of a special valve having two filaments and two grids the second valve is dispensed with as are the plates of the valves.

So far, it will be noticed all the valves in Heising's circuits have been inserted as resistances directly in series with the aerial. The resistance of the valves is high in comparison with the aerial resistance, and there is introduced a transformer between the aerial and the valve, so that the aerial may be directly earthed through one winding of this transformer (see Fig. 4). This is similar to Fig. 3, except that the valve circuit is coupled to the aerial instead of being directly in series with it. The two-valve arrangement of Fig. 2 may be included in Fig. 4 in place of the special valve.

Another modulating circuit which has been patented by Heising is illustrated in Fig. 5, which shows the microphone

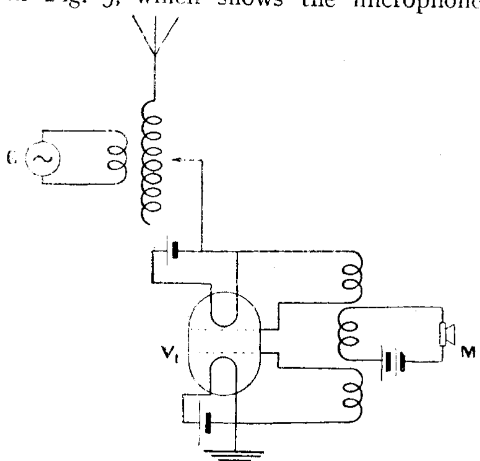
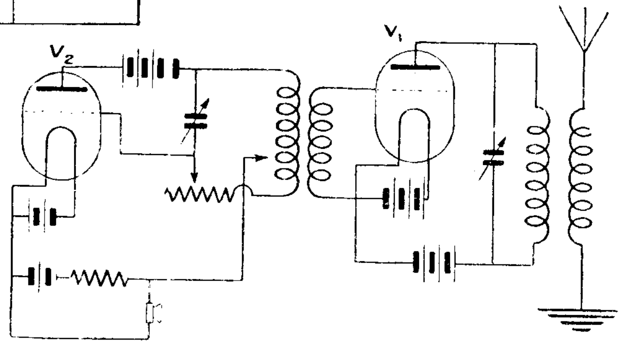
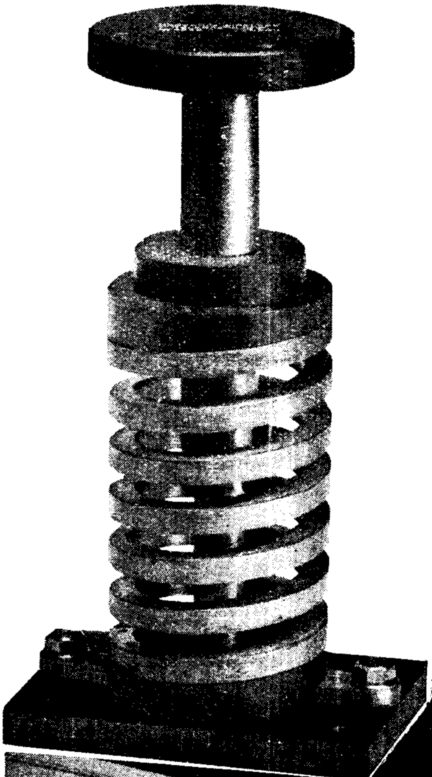


Fig. 3 (above). One four-electrode valve is used in this Heising modulator. Fig. 4 (left). Another Heising modulator has a four-electrode valve coupled to the aerial



HEISING MODULATOR AND AMPLIFIER

Fig. 5. Coupled through the circuit V_1, which is a single-valve amplifier, is the circuit V_2, which is a Heising modulator



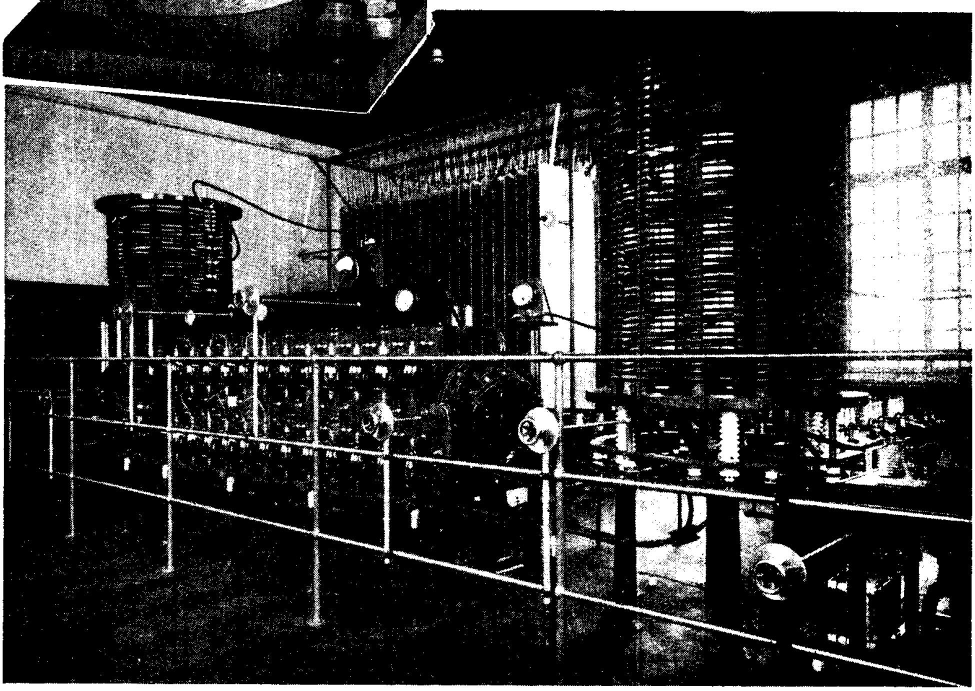
controlling the aerial, through coupled circuits and through the medium of an amplifier circuit, V_1.—*R. H. White.*

HELIUM. One of the gaseous elements, chemical symbol He, atomic weight 3·96. Helium is one of those gases which are important in the investigation of the ultimate form of matter. It is relatively abundant in the radio-active minerals, and is a constituent of the gases given off by many thermal springs. It is present in the atmosphere in the proportion of about one part in four million. *See* Electron.

HELIX. Line, thread, wire, or the like curved into a shape such as it would assume if wound in a single layer round a cylinder. Loosely the term is used for any form of spiral.

In electricity a helix is the name given to various forms of coils of wire, as a solenoid. Specifically it is the name given to the great coils such as those illustrated in Figs. 1 and 2.

A small helix, suitable for inserting in a transmitting circuit in order to vary the inductance, is illustrated in Fig. 1. Here



LARGE AND SMALL HELIXES FOR TRANSMITTERS

Fig. 1 (above). Suitable for inserting in a transmitting circuit to vary the inductance is a small helix, as illustrated. Heavy square-sectioned copper is used for the helix and ebonite for the insulation. Fig. 2. At the Marconi station at Berne is the 25 kw. valve transmitter in the above photograph, and on the left and right will be seen two helixes. These are composed of heavy copper strip wound on insulating uprights

Courtesy Marconi's Wireless Telegraph Co., Ltd.

ebonite is used throughout as the material for insulation. The resistance of the instrument is cut down to a minimum by the use of very heavy square-sectioned copper for the helix itself. The spacing between each layer is sufficient to prevent any possiblity of arcing. Terminals are fitted at the base of the apparatus to allow of easy insertion and permanent connexion in whatever circuit it is desired to be inserted.

Fig. 2 shows two large helixes at the Berne station of the Marconi Company. An idea of the immense size of a high-powered transmitting helix will be gathered from this illustration. It will be seen that the one on the right is really part of a vario-coupler (*q.v.*), the rotor of which can be seen inside the helix, and is controlled by the extension rod and handle projecting through the railings.

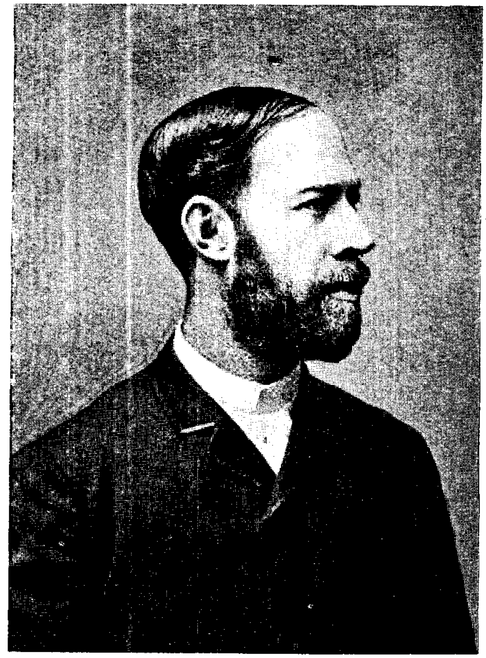
The helix itself is composed of very heavy copper strip wound upon insulating uprights, the dielectric strength of which is of a very high order. The whole of the apparatus is supported on metal pillars, secured to the floor, having very large ribbed insulators at their upper extremity. *See* Skin Effect; Solenoid.

HENRY. Name given to the unit of inductance, and so called after Joseph Henry, the first secretary of the Smithsonian Institution, a distinguished American physicist. A coil is said to have an inductance of one henry when, if a current through it changes at the rate of one ampere per second, an electro-motive force of one volt is induced.

From the above definition we get the fact that the induced electro-motive force in volts equals the rate of change of current in amperes per second multiplied by the inductance in henries. The henry is rather a large unit, and inductances for use in wireless are measured usually in subdivisions of the henry. The millihenry is the thousandth part of a henry; the microhenry, often abbreviated to mic, is the millionth part of a henry; and the centimetre, the electro-magnetic unit, is a thousand-millionth part of a henry.

The usual abbreviation for henry is H or Hy. *See* Inductance.

HERTZ, HEINRICH RUDOLF. German physicist. Born at Hamburg, February 22nd, 1857, Hertz studied science under Kirchoff and Helmholtz, paying special attention to electrical problems. In 1880 he won the prize offered at Berlin University for his paper on "Kinetic Energy of Electricity in Motion," and the same year received his degree for a brilliant investigation on induction in rotating spheres.



HEINRICH RUDOLF HERTZ

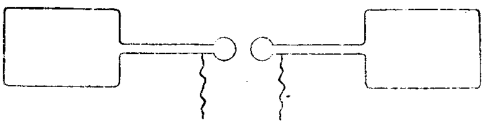
Working upon the important theory of Clerk-Maxwell, Hertz showed how electro-magnetic waves were propagated through space. In this way Hertz began a series of brilliant experiments which were, in effect, the basis upon which the whole of the modern science of wireless communication has arisen

The brilliancy of Hertz brought him directly under the notice of Helmholtz, who appointed him his assistant, and for three years he carried out researches in the physical laboratory of the Berlin Institute on electrical discharge through gases, etc.

In 1883 he went to Kiel, and there began the study of Clerk-Maxwell's electro-magnetic theory, which was to have a profound effect on wireless, and was to make Hertz famous.

It was not until 1885-89 that Hertz, while professor of physics at Karlsruhe, converted the theories of Maxwell into experimental facts. He showed how electro-magnetic waves were propagated through space, and measured their length and velocity, as well as showed their exact correspondence with the waves of light and heat. By his researches Hertz laid the foundations for modern broadcasting and wireless in all its forms, and to him and Clerk-Maxwell are due all the pioneer work which has enabled the science to advance so rapidly. In 1889 he was appointed professor of physics at the University of Bonn, and he died there on January 1st, 1894. He wrote "Electric Waves," which was published in English in 1893, with an introduction by Lord Kelvin.

HERTZIAN OSCILLATOR. Early type of radiator of radio-frequency oscillations, invented by Hertz in 1887. At the outer sides of two opposing spark balls, two horizontal rods were arranged in line with each other, at the ends of which were fixed two large plates acting as condensers.



HERTZ RADIO-FREQUENCY OSCILLATOR
Diagrammatic representation of the Hertz oscillator and spark gap for producing Hertzian waves

When the primary circuit of the induction coil is completed, the plates of the oscillator are charged in a positive and negative degree respectively. Electrical oscillations take place when the value of the charge is sufficient to break down the resistance of the air dielectric at the spark gap. The arrangement of the oscillator is shown in the illustration.

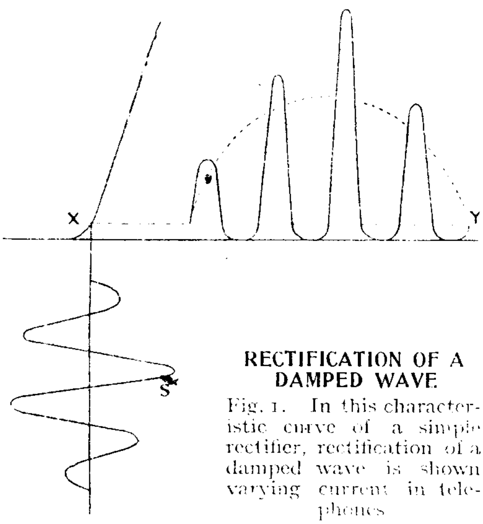
HERTZIAN WAVES. Name given to the electro-magnetic waves propagated in all directions by the Hertz oscillator. These waves are propagated in straight lines. *See* Electrolines; Hertzian Oscillator; Oscillation.

HETERODYNE. The term heterodyne was applied by Fessenden to the method of beat reception for rendering audible continuous-wave signals.

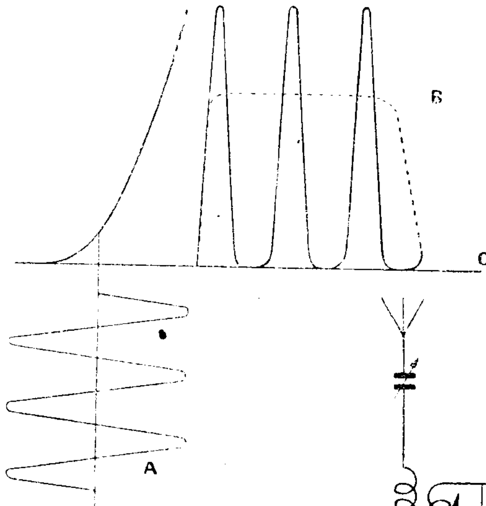
The reception of a damped wave, *i.e.* one which has a wave-train frequency, and telephony, where the wave is of varying amplitude, can be accomplished by the use of a simple detector in the form of a crystal, a valve, or a similar rectifier. In a simple detecting circuit the mean current in the telephone depends on the difference between the amplitudes of the positive and negative halves of each cycle after rectification. If there is perfect rectification, one half-cycle will be entirely suppressed, and the mean current in the telephones will be due to the different amplitudes of high-frequency waves. Thus, in effect, the telephones will respond to the fluctuations of the amplitude of the incoming signal, whether they be due to a spark transmitter or to a telephone transmitter.

In Fig. 1 is shown the characteristic curve of a simple rectifier. Let S represent the voltage curve of a damped wave induced in the aerial and applied to the detector. If X is the rectifying point of the detector, then one half of each oscillation will cause a greater current to flow through the detector than the other half of the oscillation. In the diagram the curves above the line XY represent the increase in current, and the curves below XY show the small current due to imperfect rectification. The current in the telephones will then be the mean difference between the two halves of the oscillation, as shown by the dotted line.

A continuous-wave transmitter, however, sets up oscillations of constant amplitude which, on energizing a receiving aerial, will induce oscillations of constant amplitude in that aerial. If this constant oscillation were applied to a rectifier, the only effect produced on the telephones would be a deflection of the diaphragm on the commencement and finish of a signal, which would be useless for receiving purposes. In Fig. 2 let the curve A represent a continuous wave-signal which after rectification is converted into form BC, where B represents the rectified current. The current in the telephones would then be equal to the difference in the amplitudes of B and C, and can be represented by the dotted line. The



RECTIFICATION OF A DAMPED WAVE
Fig. 1. In this characteristic curve of a simple rectifier, rectification of a damped wave is shown varying current in telephones



HETERODYNE RECTIFICATION

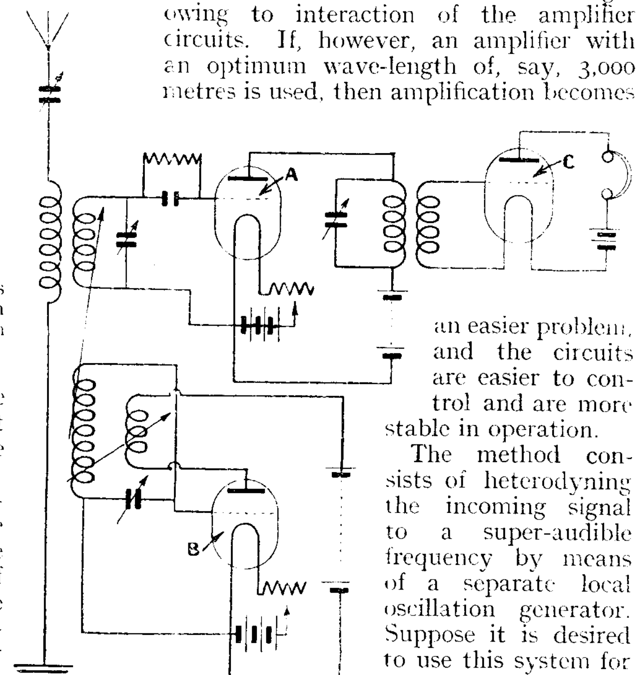
Fig. 2. Rectification of continuous waves showing steady current in the telephones is represented in the above curve

only variation in the telephone current would therefore be at the beginning and end of the signal.

In order to receive a continuous wave, means must be adopted for imparting to the incoming wave an amplitude of varying frequency, and the method employed for this purpose is to set up at the receiver end a continuous wave of a frequency nearly equal to that of the incoming signal. If the signal oscillations and the oscillations generated locally are superimposed in a common oscillatory circuit, and the frequency of the incoming oscillations is equal to N and that of the local oscillations equal to n, then the two oscillations will periodically help and oppose each other and produce beats, the frequency of which will equal $N - n$. When these beats are rectified a unidirectional current is produced in the telephone receivers. The constant amplitude of the incoming wave is therefore modulated, or has been imparted to an amplitude of varying frequency suitable for telephone reception.

The local oscillations can be generated by a separate three-electrode valve, so connected to act as a miniature transmitter, or the detector valve can be used if the anode and grid circuit are coupled together by a suitable coupling coil.

The method of a sequence of heterodyne circuits was proposed by Arco and Meissner in 1914, and has recently been applied by Armstrong to the reception of short waves. Amplification of signals of a wave-length of the order of 300 metres (a frequency of 1,000,000 cycles) can only be carried a limited number of stages owing to interaction of the amplifier circuits. If, however, an amplifier with an optimum wave-length of, say, 3,000 metres is used, then amplification becomes an easier problem, and the circuits are easier to control and are more stable in operation.

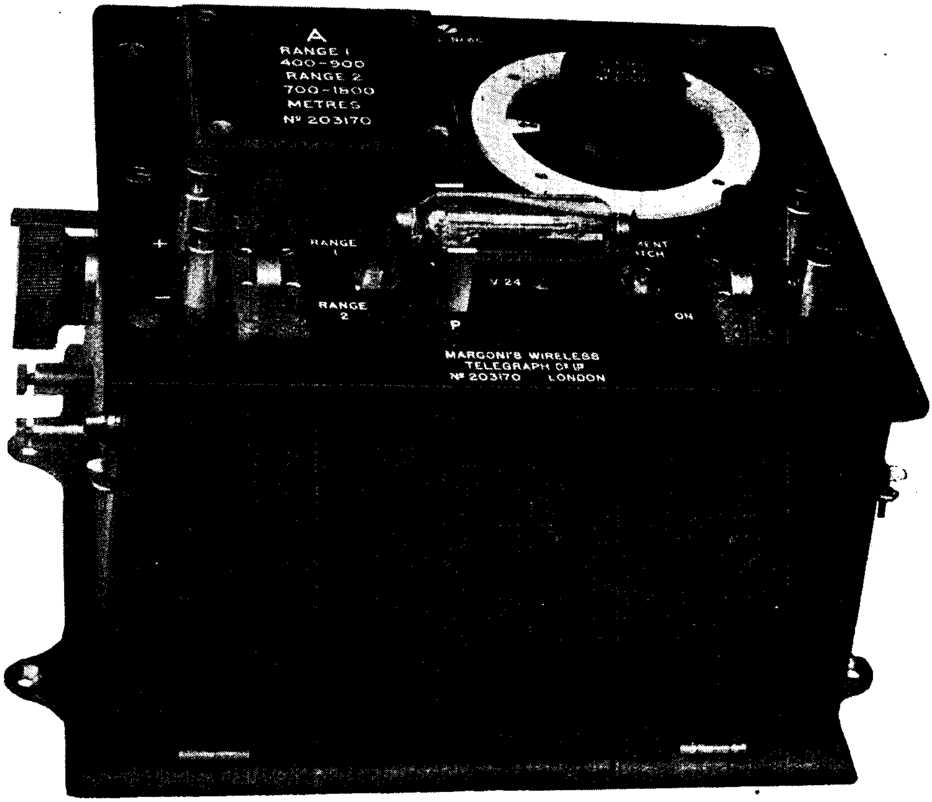


CONNEXIONS OF HETERODYNE RECTIFIER

Fig. 3. Connexions of the heterodyne method for short wave reception are given in this simplified diagram

The method consists of heterodyning the incoming signal to a super-audible frequency by means of a separate local oscillation generator. Suppose it is desired to use this system for receiving a wave-length of 300 metres (1,000,000 cycles), and that the amplifier has maximum amplification round about 3,000 metres (100,000 cycles). Then in order to change the frequency of the incoming signals from 1,000,000 to 100,000, it would be necessary to generate local oscillations of 1,000,000 + 100,000 or 1,000,000 − 100,000 = 1,100,000 or 900,000.

In other words, the local oscillations of 1,100,000 or 900,000 will heterodyne the signal frequency to produce a beat note of frequency equal to 100,000 cycles. Fig. 3 is a simplified diagram of connexions to show the principle. The circuits of the valve A are the usual detector-valve circuits, with the exception that in place of the telephones in the plate circuit a high-frequency closed oscillatory circuit



MARCONI HETERODYNE UNIT FOR RECEIVING SETS

Fig. 4. This instrument, which has a range between 400 and 20,000 metres, is designed to be added directly to crystal and other receiving sets for the heterodyne method of reception. The connexions are made from the terminals on the left-hand side of the cabinet, just below the ebonite control knob

is included, the inductance forming one winding of a transformer. The second winding is connected to the usual grid and filament terminals of the amplifier. The local oscillator is in the usual manner, as shown in B, and coupled to A.

The incoming signals are heterodyned by B to produce the beat frequency. These beats are then rectified by A, and cause a beat-frequency component in the transformer winding. This produces an oscillatory current equal to the beat frequency in the amplifier circuits. The oscillatory electro-motive force applied to the amplifier is then amplified, and finally rectified by the detector valve.

It will, of course, be understood that for receiving telephony by this method the beat frequency used must be sufficiently high in order not to interfere with the modulation, and it is found that if the beat frequency is not less than 50,000, distortion of the speech wave is not produced.

Specially designed units are available for use in connexion with existing receivers which, when correctly adapted, make such a combination capable of continuous-wave reception by the heterodyne method.

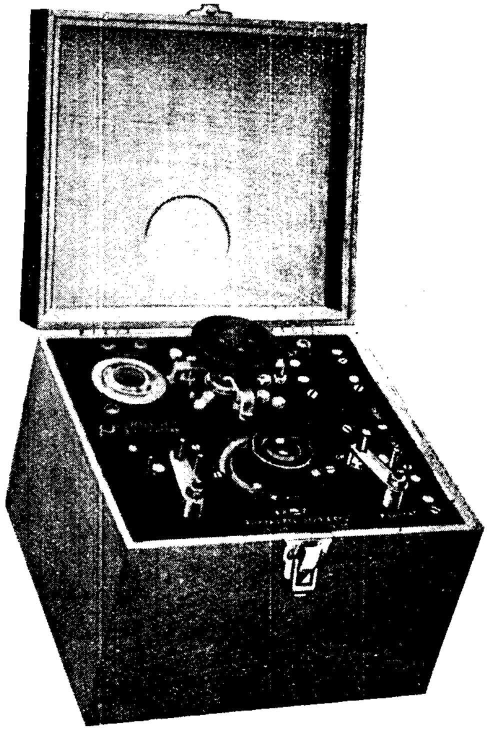
Fig. 4 shows a commercial heterodyne unit by Messrs. Marconi's Wireless Telegraph Co., Ltd., primarily designed for use with crystal and other receiving sets, for the reception of continuous waves.

This instrument is intended to be connected in series with the earth lead of the receiver. The terminals for making this connexion are shown on the left-hand side of the receiver cabinet. An ebonite knob, fitted with a stationary indicating strip, is mounted immediately above these terminals. This knob controls the position of a ball former, the winding upon which is connected to the terminals previously referred to.

The square engraved ebonite block shown on top of the panel contains a winding having two tappings for different wave-lengths. A key switch on the left-hand side of the panel controls these tappings. The disposition of this coil with the ball-former winding is such that they are inductively coupled, and this coupling is variable at will by the rotation of the ball. The tuning condenser, which is shown surrounded by the white dial, is connected across the windings in the ebonite block. The second key switch is for the filament and high-tension currents.

This instrument is very simple to operate. The valve, which is a V24, is made to oscillate at any desired frequency by the rotation of the variable condenser, which alters the fundamental periodicity of the circuit. These oscillations induce a current of the same frequency in the ball winding contained within the cabinet. As this is connected directly in the earth lead of the receiver, it follows that the latter will be impressed with the particular frequency set up.

Thus there will be two distinct frequencies in the receiver, (*a*) the ordinary radio impulses, and (*b*) the local oscillations produced by this unit. A third series of oscillations will therefore be produced, this time of audio-frequency, which will render the signals capable of being heard by the operator. *See* Beat Reception.



INSTRUMENT FOR MEASURING WAVE-LENGTH
Wave-lengths may be measured by the heterodyne wave-meter above, which is inductively coupled with a suitable inductance and receiver
Courtesy Siemens Bros. & Co., Ltd

HETERODYNE WAVE-METER. A wave-meter which uses the heterodyne principle as a means of indicating true wave-length is known as a heterodyne wave-meter. Wave-length and frequency are directly connected with one another, therefore it is possible to ascertain the wave-length if the frequency is known, and vice versa. Practically any separate heterodyne unit, such as the one just described under the heading of Heterodyne and illustrated on page 1099, may be used as a wave-meter if the condenser is suitably calibrated and standard inductances are used. The ordinary arbitrary condenser divisions, used in conjunction with a table giving correctly calibrated wave-lengths against the condenser reading, may be used, or the condenser itself may be calibrated against a scale reading directly in wave-lengths.

In practice the instrument would be calibrated so that, when the silent point is obtained, the wave-length of the incoming signals is that which the condenser setting indicates. In all heterodyne systems it will be noticed that as the frequency of the separate oscillator approaches that of the radio impulses the beat note obtained will decrease in pitch until a point is reached when nothing is heard.

Further rotation of the condenser will make the note ascend the scale again until the pitch is above audio-frequency. It is this central or silent point which is used for the purpose of calibrating the instrument, and it is at this point, therefore, that the condenser reading is taken.

A typical heterodyne wave-meter is illustrated in the figure. This instrument is not intended to be connected in actual metallic circuit with the receiver, but to be inductively coupled with other apparatus of the same make for which it has been expressly designed. On the right-hand side edge of the panel is engraved "Couple here," and it is therefore along this edge that the coupling takes place, by being placed against a suitable inductance on the receiver. The valve in this instrument is placed inside the cabinet, and may be seen by looking through the peep-hole in the top left-hand corner. The four-arm stud switch is to enable different ranges to be obtained.

In front of this will be seen the variable condenser, calibrated with a fine-reading scale. In operation the user would compare his condenser reading with a suitable chart provided, and would thus read the correct wave-length from this condenser setting in accordance with the stud-switch range used. Single-way switches are provided for cutting on or off the valve supply current. *See* Wave-meter.

HEUSSLER ALLOY. Non-ferrous alloy having magnetic properties. Iron and steel are the only common metals possessing the properties of magnetism. A powerful magnet has a slight attraction for the metals nickel and cobalt, but it is insufficient for any useful purpose.

Recent discovery has shown, however, it is possible to produce magnetic alloys from non-magnetic substances. These are known as Heussler alloys, and are composed of copper, manganese, and aluminium. A good mixture exhibiting magnetic properties is 57·1 per cent copper, 28·6 per cent manganese, and 14·3 per cent aluminium.

H.F.C. Abbreviation for high-frequency current. In wireless the expression is synonymous with radio-frequency current, where valve or ether wave oscillations are indicated. *See* Amplifier; Crystal Receiver; High-frequency Amplification; Skin Effect; Valve.

HIBBERT CELL. Name applied to a 1 volt standard cell due to Dr. Hibbert. In general construction it is like the Clark cell, but chlorides are substituted for the sulphates used therein. Zinc and mercury are employed as the active metals and immersed in a solution of chloride of zinc, and pasted with mercurous oxide. The density of the solutions is an important matter in determining the voltage, and is usually of the value of 1·38. The internal resistance of the cell is constant, the temperature coefficient is ·0002 volt per degree C.

The Hibbert cell can be made to give an electro-motive force of 1 volt exactly at any given ordinary temperature. The cell possesses the property of recovering rapidly after short-circuiting.

HICKS HYDROMETER. Type of hydrometer with which readings are obtained by the ascension of beads floating in the liquid. These hydrometers are made for one specific purpose only. The most useful one for wireless work is the one made for ascertaining the specific gravity of accumulator electrolyte. The beads in this instrument have a specific gravity of such a value that one will ascend if the acid, when not in the battery, is of the correct gravity. Another will ascend when the battery is fully discharged, and another when it is fully charged. The beads are coloured in order that the correct one for the purpose required may be readily distinguished. For small batteries it is usual to employ the syringe type of hydrometer. *See* Hydrometer.

HIGH FREQUENCY. Expression used in various ways. As applied to wireless telegraphy and telephony it refers to alternating currents of electricity, the frequency of which is reckoned in thousands.

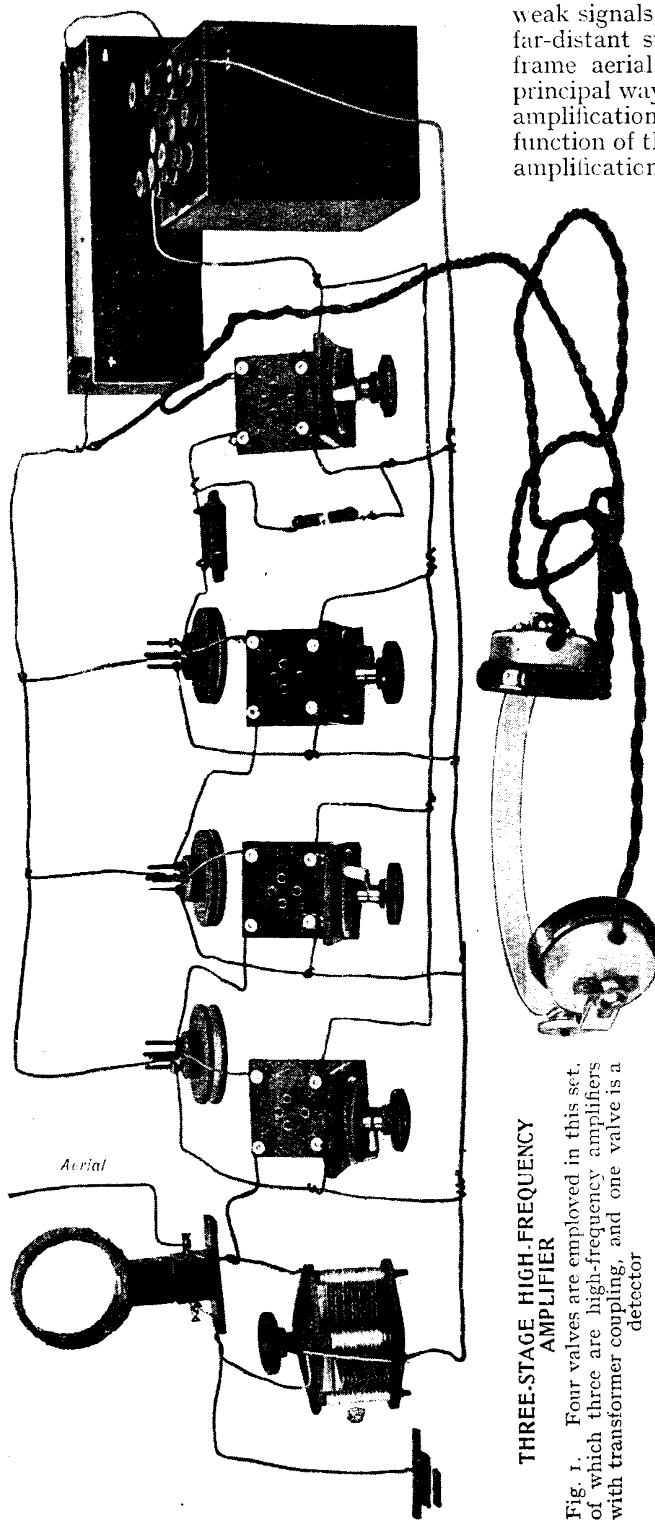
In general, an alternating current is reckoned as of a high frequency when the number of periods per second is greater than 1,000 per second. When the frequency is extremely high—as, for example, in hundreds of thousands per second—it is often termed an electric oscillation. There is, however, no definite line of demarcation between high and low frequency.

HIGH-FREQUENCY AMPLIFICATION: THE BEST METHODS

How Valves are Coupled as Radio-frequency Amplifiers, Fully Explained

Here the principles and methods of amplifying received waves before rectification are explained, with photographic lay-out diagrams. Reference should also be made to associated articles, as Amplifier; Crystal Receiver; Low-frequency Amplification; and to special circuits, e.g. Armstrong Receiver; Cascade Amplification; Heterodyne

High-frequency amplification is a term used to define several different systems for increasing the amplitude of incoming current pulses in a receiving set prior to rectification. Many amateurs who have tried adding high frequency to an existing set have failed through misunderstanding this fact, and have assumed an addition can be made to a set in exactly the same way as for low-frequency amplification; in the latter case, however, the signals are amplified after rectification. The chief use of high-frequency amplification is to increase the effectiveness of very



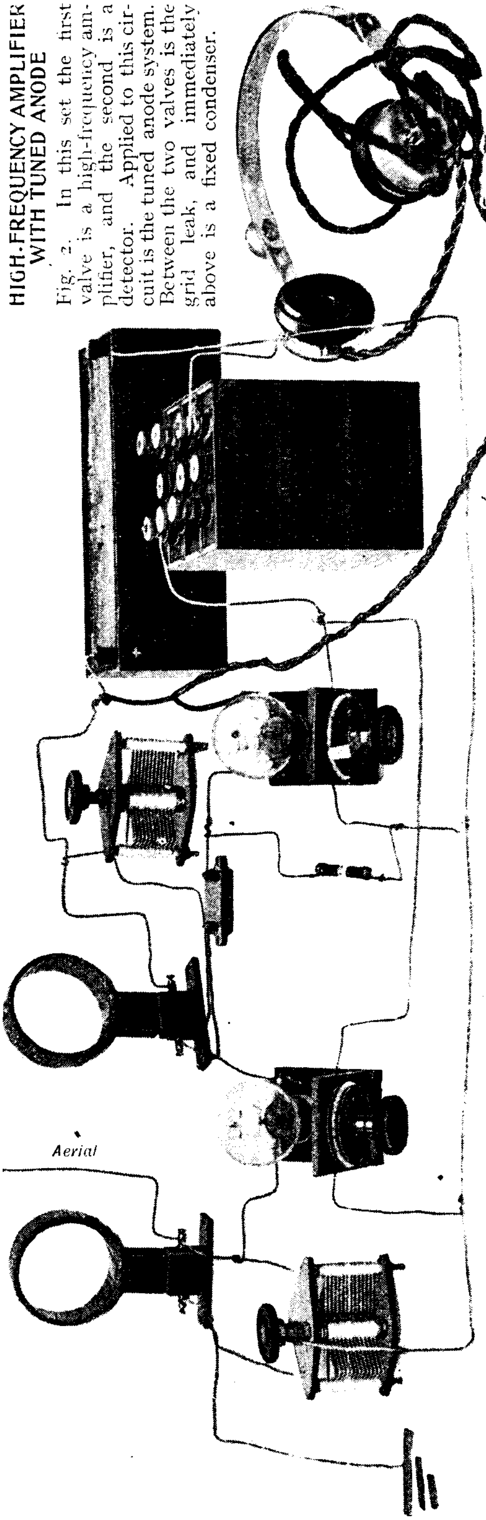
THREE-STAGE HIGH-FREQUENCY AMPLIFIER

Fig. 1. Four valves are employed in this set, of which three are high-frequency amplifiers with transformer coupling, and one valve is a detector

weak signals, as, for instance, those from far-distant stations, or when an indoor or frame aerial is used. There are three principal ways of securing high-frequency amplification, apart from the amplifying function of the valve, as all high-frequency amplification is carried out in conjunction with a valve. Essentially, two or more valves are required for amplification and detection purposes, respectively, to render the signals audible in the telephones. The incoming signals are tuned in the usual way, and the current pulses applied to the grid of the first valve, where they affect the anode current, and this in turn hands on to the detector valve grid an amplified but exactly similar series of pulses. This amount of amplification is practically dependent on the amplifying factor of the valve, or the natural amplifying function of the valve.

This degree of amplification is, however, common to any valve in greater or less amount, and to the connexions of the apparatus incorporated in the anode circuit of the high-frequency valve or valves any additional amplification must be due. Neglecting the more complicated dual amplification circuits, where one valve is made to perform the function of two valves, normal high-frequency amplification methods resolve themselves into different ways of coupling the valves.

It has first to be remembered that the anode current is at a positive potential, and the negative side is represented by the grid circuit, consequently any coupling must be such that the steady current flowing in the anode circuit (given by the high-tension battery) cannot flow



HIGH-FREQUENCY AMPLIFIER WITH TUNED ANODE

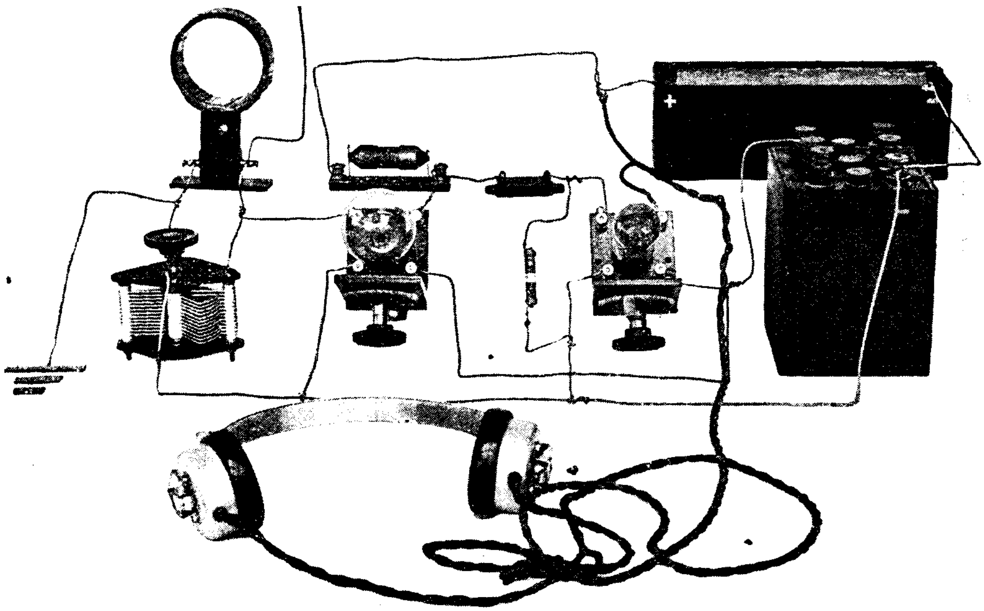
Fig. 2. In this set the first valve is a high-frequency amplifier, and the second is a detector. Applied to this circuit is the tuned anode system. Between the two valves is the grid leak, and immediately above is a fixed condenser.

directly to the grid. Of the three methods adopted in common practice the transformer coupling is the simplest, the tuned anode gives the loudest signals, and the resistance capacity coupling is used for long-range work on high wave-lengths of 1,000 metres or over. There are exceptions, but generally these are the usual applications of the systems.

Transformer coupling consists essentially of two coils of wire wound on to the same or separate formers and placed in close proximity to each other. The primary winding is connected in the anode circuit, the secondary in the detector circuit, or in the grid circuit of a second valve if further amplification is desirable. This method is sometimes known as cascade amplification (*q.v.*).

Several stages of transformer-coupled amplification can be arranged in this way, and the disposition of the components is shown in pictorial diagram form in Fig. 1, which illustrates a four-valve set with three stages of high frequency and one detector valve. The transformers can be of the plug-in type, shown without the holders in the illustration for the sake of clearness. The valves have been left out of their sockets for the same reason. The aerial tuning arrangements may be of any type, and reaction can be arranged from the anode circuit of the detector valve to the last transformer or to the aerial tuner coil, thus increasing the signal strength. These and other modifications are all well exemplified in various receiving sets described in the pages of this Encyclopedia. In particular the reader should study the sets which are described under the headings Frame Aerial and Hanging Set, as well as the various articles dealing with reaction.

The tuned anode system is pictorially illustrated in Fig. 2, as applied to a two-valve set, with the first valve as a stage of high frequency and the second as a detector. The incoming signals are tuned in the usual way and delivered to the grid of the first valve; the anode circuit of the first valve includes an inductance and a capacity. The inductance may be any suitable value of coil and take any form, such as a sliding contact coil, a basket coil, or a plug-in coil, or may be a tapped inductance. The important point is that the value of the inductance should be correct for the particular set and usually



RESISTANCE-CAPACITY-COUPLED HIGH-FREQUENCY AMPLIFIER

Fig. 3. Two valves are included in this arrangement in which non-inductive resistance is coupled in the same circuit as the small condenser. One valve is a high-frequency amplifier, and the other a detector. This method is particularly suitable for the higher wave-lengths

slightly higher than the aerial inductance. This inductance is tuned with the variable condenser to be in resonance with the incoming signals, and is to a large extent a copy of the aerial tuning system.

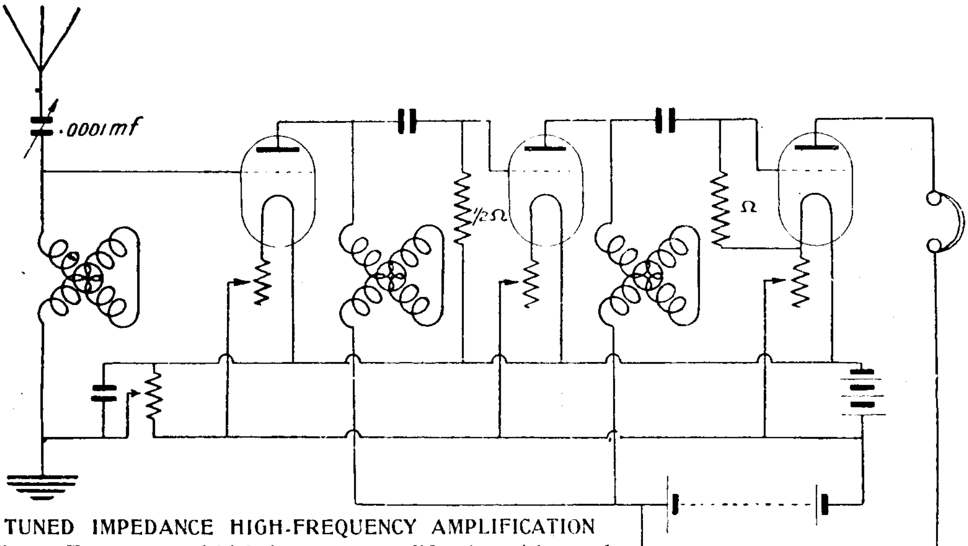
Connexions are made from this tuned circuit to the high-tension positive side of the high-tension battery and to the grid of the detector valve. The customary grid leak and condenser form a part of this secondary circuit. With this type of high-frequency amplification the difficulties of tuning are slightly increased, as there are two circuits to be tuned simultaneously, and as it is imperative that in multi-stage high-frequency amplifiers of this type the inductance and capacity values be alike, it is seldom that more than two such stages are provided. A means for reducing the tuning difficulties is to employ coupled condensers of equal value operated by one knob.

The arrangement of the third system is shown pictorially in Fig. 3, and is known as the resistance-capacity method. In this a non-inductive resistance of about 50,000 to 80,000 ohms is included in the anode circuit of the amplifying valve. Oscillations of potential are set up about this resistance and the small condenser in same circuit, and the oscillations on the other plate of the condenser, opposite to that which is first reached by the incoming signals, will be induced and act on the grid of the second valve with higher value.

This type of amplifier is generally considered as only effective on high wave-lengths of the order of 1,000 metres and over.

Another type of high-frequency amplification is illustrated in diagram form in Fig. 4, and shows a three-valve set with tuned impedance regenerative coupling. Variometers are included in the anode circuits of the first and second valves. These provide the means of tuning and also have a feed-back or regenerative effect. The tuning is very sharp and selective. The variometers should be of equal value.

There are many detail variations of the methods outlined here. For example, the transformers of a transformer-coupled set may have the primary or secondary or both sides tuned with variable condensers. Tapped inductances can be employed in conjunction with the tuned anode circuit and a variable condenser. In some cases, especially when several stages of high-frequency amplification are employed, it may be desirable to employ grid-biasing batteries or a potentiometer



TUNED IMPEDANCE HIGH-FREQUENCY AMPLIFICATION

Fig. 4. Two stages of high-frequency amplification with tuned impedance are used in this set. Variometers are included in the anode circuits of the first and second valves, and should be of equal value. These have a regenerative effect, and provide a means of sharp and selective tuning

to stabilize the circuit and reduce or eliminate undesired oscillation.

Many practical difficulties arise when making sets with several stages of high-frequency amplification work successfully, especially when a multiplicity of circuits have to be tuned, but these are dealt with as they apply to specific circuits and receiving sets under their proper titles in this Encyclopedia.

HIGH-FREQUENCY AMPLIFIERS: HOW TO USE & MAKE THEM

The Best Apparatus for Increasing the Range of Receiving Sets Fully Illustrated

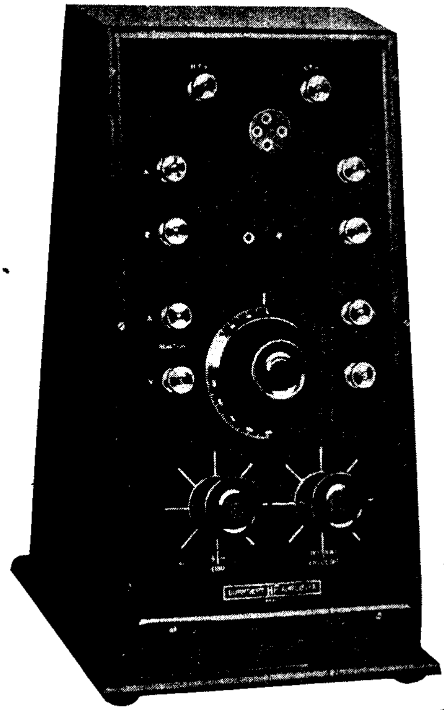
Here are described and illustrated the best types of commercial high-frequency amplifiers for addition to existing sets, and full instructions are given for the construction of high-frequency amplifiers for both valve and crystal sets. The illustrations include a photogravure plate. See Amplifier; Crystal Receiver; and associated headings, as High-frequency Transformer, etc.

A high-frequency amplifier is an apparatus adapted to the purpose of amplifying the incoming pulses of current intercepted by the aerial prior to rectification.

As a general rule a high-frequency amplifier should form part of a complete receiving set, or at least be designed to harmonise with an existing set. This is because the available methods of amplification are largely dependent on the actual values of the various components, and the materials of construction have to be appropriate to the requirements of high-frequency currents.

The normal position of a high-frequency amplifier is between the tuning unit and the detector. The incoming waves have to be tuned to the desired wave-length for reception, and the amplifier circuits and component values adjusted to the same wave-lengths. The original receiving set has also to be in tune, and to do this may in some cases not be possible without a new or additional inductance or tuning device. Insulation must be perfect, as unless ebonite or bakelite or some other good insulator is used with a matted surface, the H.F. currents will leak away over the surface and signals be very weak.

When the conditions are favourable, however, a stage or stages of high-frequency amplification can be added to existing receiving sets. One commercial pattern of this type is illustrated in Fig. 1, known as the Burndept H.F. amplifier. This is only intended for use with other Burndept components and sets, and comprises a reactance-capacity-coupled instrument.



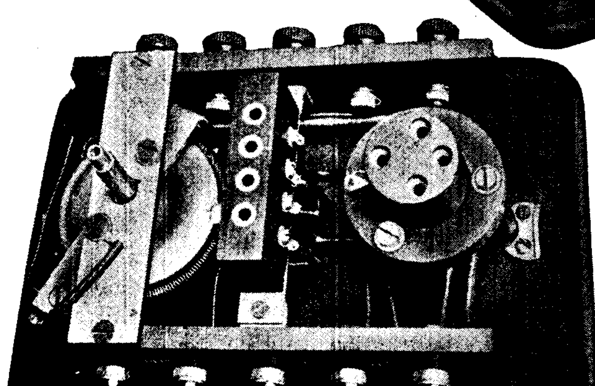
The reactance is an ordinary Burndept plug-in coil, and tuned by a variable condenser, with a value of some ·00025 mfd., contained within the instrument, and operated by the central knob and dial. A potentiometer and filament rheostat are controlled by the two lower knobs. The valve is plugged into the holder at the top of the panel.

The Sterling system, as shown in Fig. 2, is a unit type of high-frequency amplifier. This instrument is uniform in size, shape, and its method of connexion with other units either of the same purpose or as rectifiers or low-frequency amplifiers.

The outer case is a neat metal stamping, free from sharp edges and forming a shield. The valve holder, the plug mounting for the transformer, and the filament resistance project through the top of this case.

HIGH-FREQUENCY AMPLIFIER UNITS

Fig. 1 (above). Made by Burndept, Ltd., the above unit may be added to a receiver. This amplifier is reactance-capacity coupled. Fig. 2 (right). In the centre of the amplifier on the right, which is made by the Sterling Telephone Co., Ltd., is a plug-in transformer, on the right of which is the valve holder



INTERIOR OF STERLING HIGH-FREQUENCY AMPLIFIER

Fig. 3. Connexions to the filament, transformer and valve are seen here of the amplifier in Fig. 2

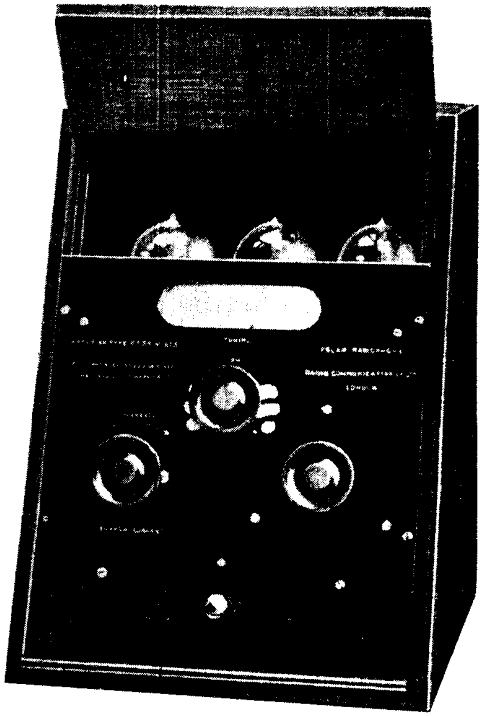
The transformer used is of the honeycomb variety, contained within an ebonite case. The connexions to the windings are brought out to four pins situated at and projecting through the ebonite case at the bottom. These are all concealed when the transformer is in position, as shown.

Fig. 3 is a view of the interior of the instrument, showing the connexions. It will be seen that a filament resistance of the rotary core type is fitted, giving a smooth action, which is highly desirable in high-frequency work. The external connexions are interesting in that they are adapted to be used either as terminals for the connexion of wires or plugs for direct coupling to another instrument.

A further type of high-frequency amplifier and valve detector is illustrated in Fig. 4. This instrument is of the type made by The Radio Communication Co., Ltd., for use in their marine installations. The first two valves are high-frequency amplifiers, the last being a detector. In this instrument a novel method of wave-length indication is used. The tuning condenser is controlled by the right-hand knob. This is geared to the pointer, which can be seen in front of the white scale.

This pointer moves over the scale, the latter being calibrated directly in wave-lengths. By this means considerable operating time is saved, because the tuner which is supplied is calibrated in the same manner, and therefore all the operator has to do is to bring his signal to maximum strength on his tuner, take the wave-length reading from that, and then proceed to set his high-frequency condenser on this instrument to the same value.

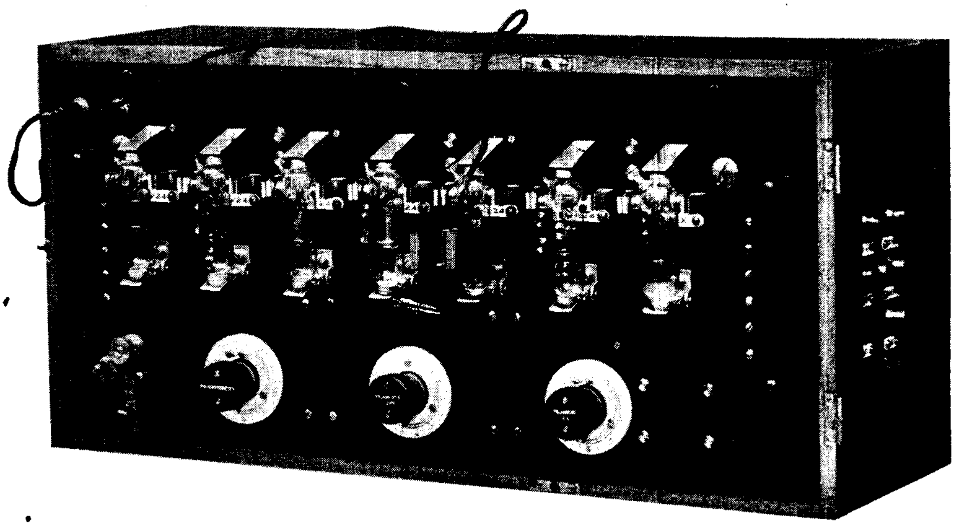
The switch shown in the centre of the panel is for cutting out or in the filament and high-tension current. On the left of the panel is the filament resistance, fitted with an arrow showing the direction of rotation, for increasing the current at will.



POLAR RADIOPHONE HIGH-FREQUENCY AMPLIFIER

Fig. 4. This instrument consists of one detector valve and two stages of high frequency. By the calibrated scale the wave-length to which the set is tuned is indicated, making tuning easy

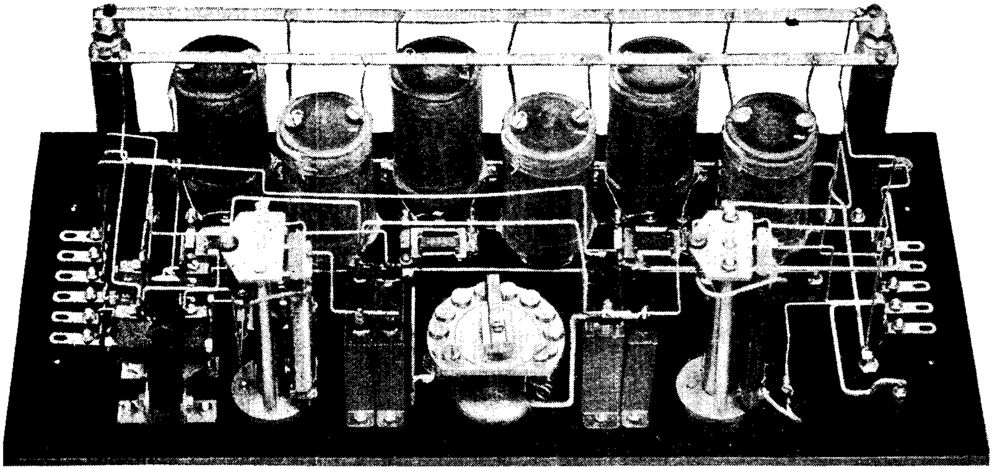
Courtesy Radio Communication Co., Ltd.



SIX STAGES OF HIGH FREQUENCY IN A MARCONI AMPLIFIER

Fig. 5. Seven valves are employed in this receiver. By means of a wander plug the number of valves in use may be varied according to the degree of amplification required. This enables the operator to eliminate distortion and howling

Courtesy Marconi's Wireless Telegraph Co., Ltd.



UNDERSIDE OF PANEL OF MARCONI HIGH-FREQUENCY AMPLIFIER

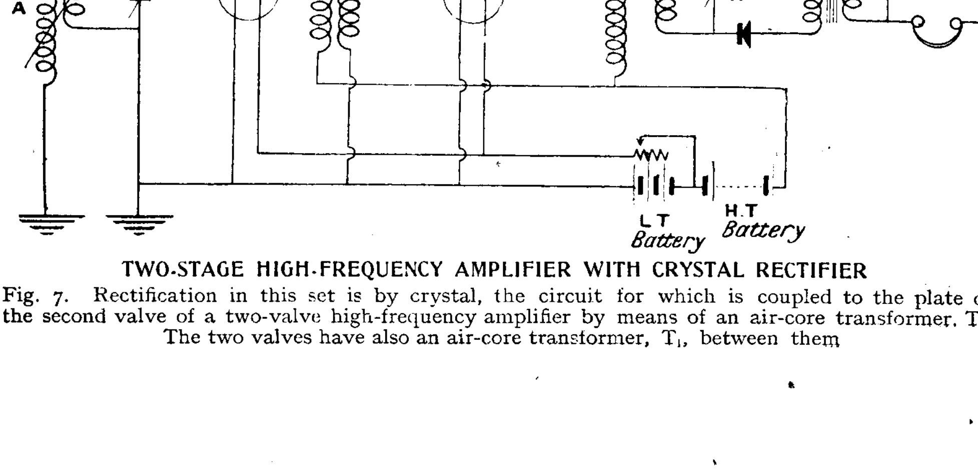
Fig. 6. Behind the panel of the set in Fig. 5 can be seen the transformers, which are connected by bus bars at the back. On each side of the studded filament resistance in the foreground are large condensers, and on the extreme left is the telephone transformer

Courtesy Marconi's Wireless Telegraph Co., Ltd.

The sloping cabinet in which the set is fitted is uniform with the tuner cabinet which precedes it and the low-frequency amplifier cabinet which follows it. A hinged cover at the top renders internal inspection and the removal or replacement of the valves an easy matter. Connexions between the instrument and its fellow units are made at the rear.

The illustrations (Figs. 5 and 6) show one of the latest types of high-frequency amplifier by Marconi's Wireless Telegraph Co., Ltd. It is a seven-valve instrument, having the last valve arranged as a rectifier. The six amplifying valves are of the V24 type, the last one, *i.e.* the rectifier, being a Q.X. Both the Q.X. and V24 valves are similar in appearance, with the exception that the former, for purposes of distinction, has one end of the tube frosted. The Q.X. valve is of the three-electrode type and takes a current up to 5 volts.

A feature of unusual interest will be seen by reference to this illustration. On the extreme left are two plugs with flexible leads attached. On the end of both leads will be noticed a clip, each of a different type. One of these clips is shown attached to the first valve. This may be considered a kind of wander plug,



TWO-STAGE HIGH-FREQUENCY AMPLIFIER WITH CRYSTAL RECTIFIER

Fig. 7. Rectification in this set is by crystal, the circuit for which is coupled to the plate of the second valve of a two-valve high-frequency amplifier by means of an air-core transformer, T_2. The two valves have also an air-core transformer, T_1, between them

and is for the purpose of plugging the aerial connexion to any valve desired, according to the amount of amplification considered necessary. The other clip is shown attached over the bulb of the fifth valve. This is an entirely new device, having for its object the prevention of distortion and howling.

Research has proved that these faults may be reduced and practically eliminated by the use of this unique arrangement. The control knobs at the bottom of the panel are (1) potentiometer; (2) high-frequency valve filaments; and (3) rectifier filaments. On the right-hand wall of the cabinet will be seen the battery terminals of the instrument.

A rear view of this instrument is given in Fig. 6. The manner in which all the component parts are laid out is worthy of particular note. It will be seen that they are well spaced, and laid in such a manner that all connecting wires are as short as possible. Interference between connexions and self-capacity are thus reduced to a minimum. A particularly interesting feature is the manner of connecting all the transformers by means of common leads or bus bars. The transformers used are of the aperiodic type, and therefore require no tuning. The two filament resistances and potentiometer may be seen in the foreground. The one controlling the amplifying valves is of the studded variety, the rectifier resistance, calling for finer adjustment, being of the Marconi worm type. The potentiometer is very similar in construction to the latter filament resistance, the only difference being that it has finer wire and a third connexion. The high-tension supply is provided with large condensers. These are shown on either side of the studded filament resistance. A telephone transformer is fitted, this being shown on the extreme left of the panel.—*R. B. Hurton.*

Adding High Frequency to Crystal Sets. Three or four stages of high-frequency magnification may be added to a crystal detecting set, and the resultant signals will be equal, if not superior, to those obtained with a receiver employing valves for rectification as well as for high-frequency magnification.

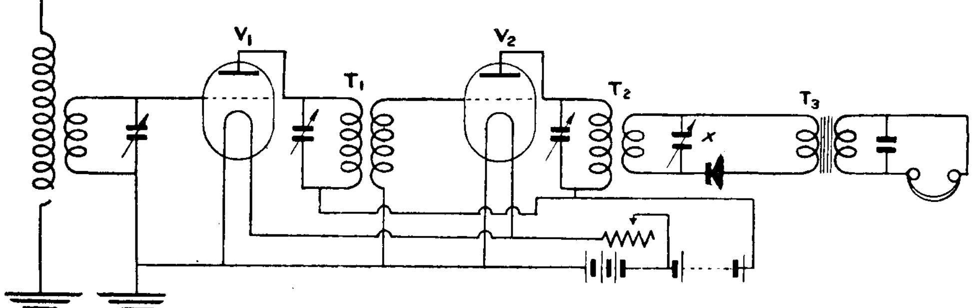
Low-frequency or note magnification may also be added on the other side of the crystal.

A good crystal is still one of the best rectifiers to use, and the quality of music received on a crystal set cannot be surpassed by a valve receiver.

The disadvantage of a crystal set is its limited range of reception. This, can, however, be increased by the addition of high-frequency magnification whilst still retaining the advantages of crystal rectification.

Fig. 7 shows the theoretical circuit diagram for a normal valve high-frequency amplifier with crystal rectifier.

The aerial circuit, A, consists of aerial, aerial tuning condenser, and aerial tuning inductance and an earth connexion; coupled to the aerial tuning inductance is a tuned secondary circuit, consisting of coupling coil and condenser. One side of this condenser is taken to the grid of the first valve, whilst the other side is connected to earth. The anode of each valve is connected to the winding of its own transformer, and through that to the high-tension battery.



TWO-STAGE HIGH-FREQUENCY AMPLIFIER WITH TUNED TRANSFORMERS

Fig. 8. Comparison with Fig. 7 will show that variable condensers have been added to the two air-core transformers. By means of these condensers the transformers can be tuned, thus producing greater efficiency than with non-tuned or resistance transformers. This method should normally not be adopted with more than two stages of high frequency

The transformers, T_1 and T_2, are constructed with air cores. If two transformers only are to be used, the windings may with advantage be made of copper and of low resistance, whilst if care is taken the transformer windings may be tuned by the addition of condensers, as shown in Fig. 8. Amplifiers constructed with tuned transformers are much more efficient than those with non-tuned or resistance transformers, but if more than the two stages are attempted trouble due to oscillation will usually be experienced, unless great precautions are taken to shield each transformer.

The design of the intervalve transformers will depend on the wave-length which it is desired to receive and the number of valves which it is proposed to employ.

With two valves the windings may well be placed on small ebonite tubes and may be of double silk insulated copper wire, the primary and secondary windings being wound one over the other, with a layer of waxed paper between them. If it is only intended to receive one wave-length the transformer windings may be so designed that the transformer, when connected to its valve, will be in tune with that wave. The tuning will be comparatively sharp, and is best found by trial and error. With tuned transformers of this type very considerable amplification can be obtained from only two stages, and provided that rapid changes of wave-length are not necessary, this form of amplifier is to be recommended.

When, however, reception over a large band of wave-lengths is desired without constant tuning, then the transformer windings should be constructed of very fine wire and of high resistance.

The crystal circuit should be tuned by the addition of a small adjustable condenser at *X*, Figs. 7 and 8.

In a practical design of receiver it is an advantage to provide a potentiometer circuit for the crystal, so that carborundum may be used instead of one of the many crystals which will give good rectification without additional potential.—*R. H. White.*

How to Make a High-frequency Amplifier. The construction of a single-stage high-frequency transformer-coupled amplifier, as combined with a crystal for rectification purposes, is illustrated in Fig. 9 on the photogravure plate facing this page, and forms a complete receiving set adapted for reception of stations comparatively remote, as, for instance, at 30 miles or so from the broadcasting station. The signal strength under such conditions should be sufficient for clear reception with ordinary telephones when the set is properly tuned and adjusted.

The first step is to make the cabinet, which can be easily constructed from good quality thoroughly dry deal or hardwood. Provided that all of the electrical apparatus is mounted on ebonite bases or otherwise insulated from the wood, there is no occasion to use an ebonite panel at all, although the latter may be incorporated if preferred.

The general arrangement of the parts of the case is clearly shown in Fig. 10, which shows the sides and top mounted in place on the base and the back panel in position. The leading dimensions are given in the illustration, and should be suitable for the use of most component parts readily obtainable from wireless dealers, or the size may be modified as necessary to meet individual requirements. The sides are made from material ⅜ in. in thickness, and the base ¾ in. in thickness, and the panel and back ¼ in. in thickness.

The base should be prepared first, and may be finished with a simple ovolo or other moulding. A sufficient length of moulding should be prepared for the five parts which comprise the sides and the top, and a rebate worked on each edge. The lengths are then cut off and the edges of the two lower pieces are squared up. All the other joints are simple mitres, and may be glued and pinned together, the back panel and the sides planed up to fit neatly into the rebated recess and held temporarily in place with a few pins. The side pieces are secured to the base by glue and fine screws, and the whole of the exterior should then be carefully sand-papered, as shown in Fig. 11, and may be stained or polished as desired.

The next step is to prepare the inductance coil, as shown in Fig. 12. This should be wound on an ebonite tube former, 2 in. long and 3½ in. in diameter. Two small holes are drilled at each end for the starting and finishing ends of the wires, which are clearly visible in Fig. 12. Enamelled wire of No. 24 gauge is suitable for the inductance.

The next step is to mark out the positions of the various fittings on the front panel, and mount the inductance on it. This is readily accomplished by simply providing a cross-bar of ebonite, pierced with a hole in the centre and two smaller ones at the sides. Two long, thin screws are passed through these holes into the back of the panel, and thus clamp the inductance firmly to it, as shown in Fig. 13.

The next step is to prepare the control knob and spindle, as shown in Fig. 14. The knob is an ordinary standard ebonite fitting and screwed to a $\frac{3}{16}$ in. diameter brass rod, which is notched on the upper surface in $\frac{1}{2}$ in. spacings, and separately subdivided, as clearly shown in Fig. 14.

A hole is then drilled through the panel exactly in the centre of the inductance, and the rod passed through from the front through the central hole in the cross-bar, and the outer end provided with two lock nuts. A hard brass contact strip is then bent to an "L" shape and clamped between these nuts with the upper part adjusted to bear lightly but firmly on the top of the inductance winding. The insulation should be carefully scraped or sandpapered off to form a path showing bare copper wire. To prevent rotation of the contact arm, two thin ebonite rods are screwed into the back of the panel and form a passage for the contact arm.

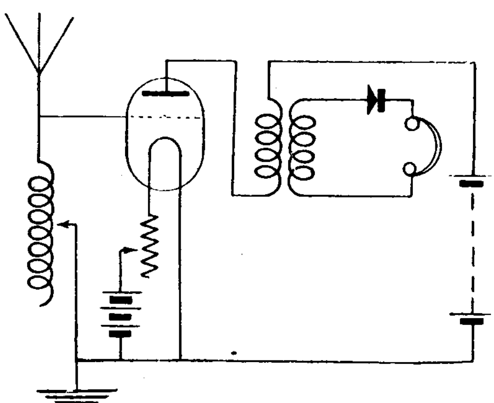
Tuning in this case is effected by pushing the knob in or out, thus sliding the contact over the bared part of the inductance. The next step is to provide a continuously variable filament rheostat and automatic switch, such as that illustrated in Fig. 16, and mounting them, as there shown, on the back of the panel, insulating them with a thin piece of ebonite sheet cut to the same shape as the base of the filament rheostat. With this particular pattern, by pushing the knob in or out the low-tension circuit is broken, and by rotation of the knob the resistance on the filament circuit is varied.

An ordinary standard valve holder must now be mounted on the top part of the panel by drilling a hole through it and making it a tight fit with the holder, securing the latter by means of a small brass clip plate and wood screw, as in Fig. 18. The ornamental opening for the peep-hole may be cut out and the edges cleaned up true with sandpaper. Four terminals are then fitted into ebonite bushes and clamped to the panel. Those at the lower bottom corners are for the aerial and earth connexions respectively, and those in the middle for the telephone connexions.

A crystal detector of any standard make is fitted to the lower centre on the outside of the panel, and should also be mounted on a thin strip of ebonite cut to the shape of the supporting plates of the crystal detector. The valve illustrated is mounted on the centre part of the base and is shown in Fig. 19. It should be mounted on an insulating disk of ebonite to prevent any chance of the high-frequency current leaking away over the surface of the wood. The ebonite disk may be secured with a couple of fine screws to the baseboard of the holder and by means of a screw through the baseboard into a small hole drilled and tapped in the centre of the holder.

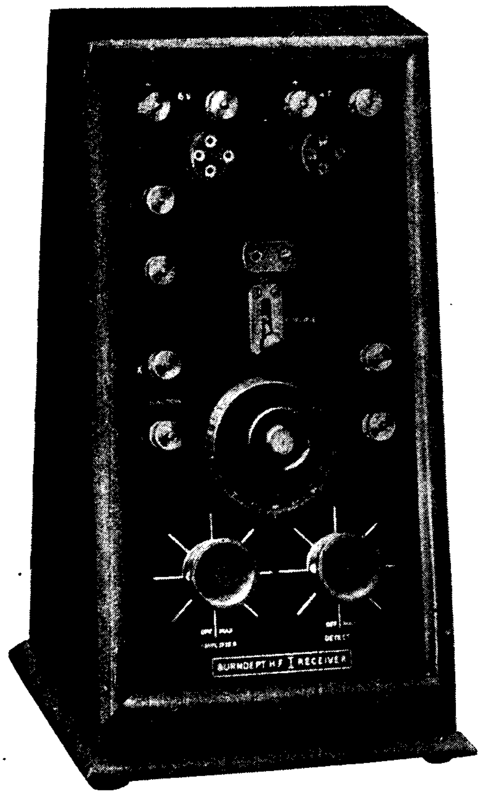
Connecting wires are soldered to the lower ends of the socket pins in the usual way, and the backboard, or back of the case, should be provided with a little tongue of tape or leather, and with four telephone terminals for connexion to the high- and low-tension batteries respectively, as shown in Fig. 17, connexions from the inner sides of these terminals being effected by flexible wires, so that the back may be folded over as shown in Fig. 20. These terminals should also be fitted into ebonite bushings in the backboard. The wiring may then be carried out in accordance with the wiring diagram in Fig. 21, and is shown complete in Fig. 20.

To complete the set, an accumulator with a voltage to suit the valve used with



SINGLE STAGE HIGH-FREQUENCY AMPLIFIER

Fig. 21. Wiring is shown in this diagram of the single-stage high-frequency transformer-coupled amplifier with crystal detector



BURNDEPT HIGH-FREQUENCY RECEIVER

Fig. 22. One high-frequency amplifying valve is added to a detector valve in a way so that the additional valve may be cut out if required. The switch in the centre cuts out or includes the amplifier

Courtesy Burndept, Ltd.

the set is connected to the low-tension terminals and high-tension battery connexions to their terminal at the back of the set. A standard plug-in high-frequency transformer suitable for broadcast reception is plugged into the valve holder at the top of the set and the telephones connected to the telephone terminals. Aerial and earth leads are connected to the terminals provided for this purpose, as shown in Fig. 15.

To operate the set, the filament resistance should be adjusted to suit the valve, the crystal adjusted to the most sensitive spot by means of the usual buzzer test, and the tuning knob pushed in and out slowly until signals are heard.

H. F. Amplifiers for Valve Sets. The application of a high-frequency amplifier to a valve detector follows the same general lines as for a crystal. The results obtained will vary considerably, according to the circuit and design of the tuner and components as a whole, but, customarily, a well-handled two-valve set, with one valve as a high-frequency amplifier and the other as a detector, using the tuned anode circuit for the high-frequency amplifier and a reaction coil in the detector circuit, should bring in most of the B.B.C. stations with fair strength. A typical commercial example of a two-valve set is shown in Fig. 22, known as the Burndept H.F. 1 receiver. This has a sharply tuned coupling between the high-frequency valve and the detector, thus increasing the selectivity. The first valve is a high-frequency amplifier with a tuned reactance capacity coupling to the detector, tuned by means of a ·00025 mfd. variable condenser.

A switch is provided to cut out the first valve when required, and only one set of coils is needed, as the one set of coils serves for the anode reactance and the aerial tuning inductance.

The application of the high-frequency amplifier as a component in a four-valve receiving set is illustrated in Figs. 23–26, which show the complete set mounted in

HIGH-FREQUENCY AMPLIFIER BUREAU

Fig. 23. This bureau contains the four-valve high-frequency amplifier shown in the next three photographs. It was constructed by an amateur specially for this Encyclopedia. The low-tension accumulator can be seen on the right

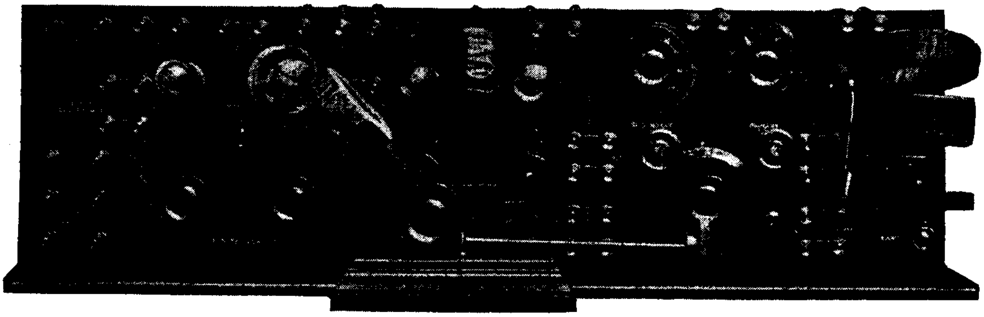


Fig. 24. When the bureau is open the panel appears as in this photograph. It will be seen that beside the separate coils in the foreground there are five units mounted on a common base. The units are joined up by means of connecting strips

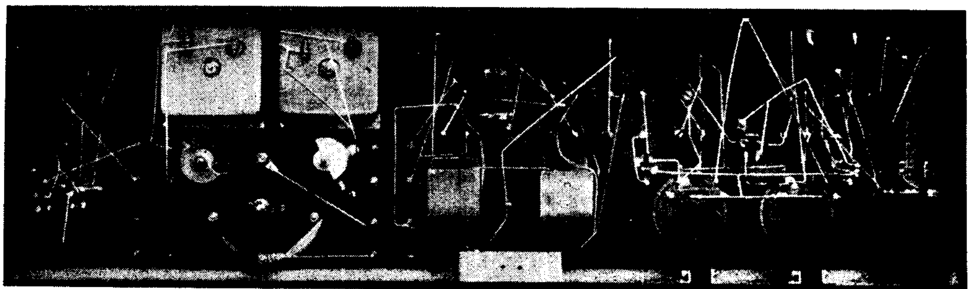


Fig. 25. On the opposite side of the panel the wiring arrangement is seen. Each unit is wired independently, and by disjoining the connecting strips on the front of the panel any one unit can be dissembled from the set without disturbing the others

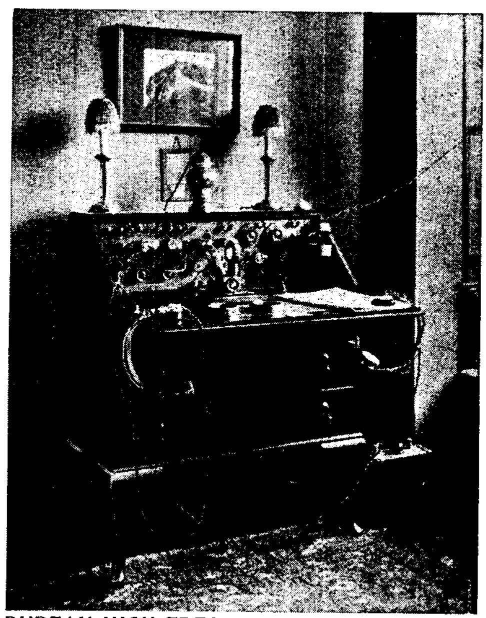
BACK AND FRONT OF THE BUREAU HIGH-FREQUENCY AMPLIFIER PANEL

a handsome bureau, the whole being the work of an amateur constructor. The circuit diagram is given in Fig. 27, and the high frequency is obtained by the well-known tuned-anode system, comprising one stage of H.F. amplification, a detector valve, and two stages of L.F. amplification.

The coils on the right-hand side of the set are the aerial tuning coil and closed-circuit coil. Between these are two switches, one for connecting the aerial tuning condenser in series or parallel, and the other for aerial tuning coil only or closed circuit tuning. The anode and reaction coils are fitted to a mahogany base and stand in front of the instrument, being connected by flexible leads to terminals on the main panel.

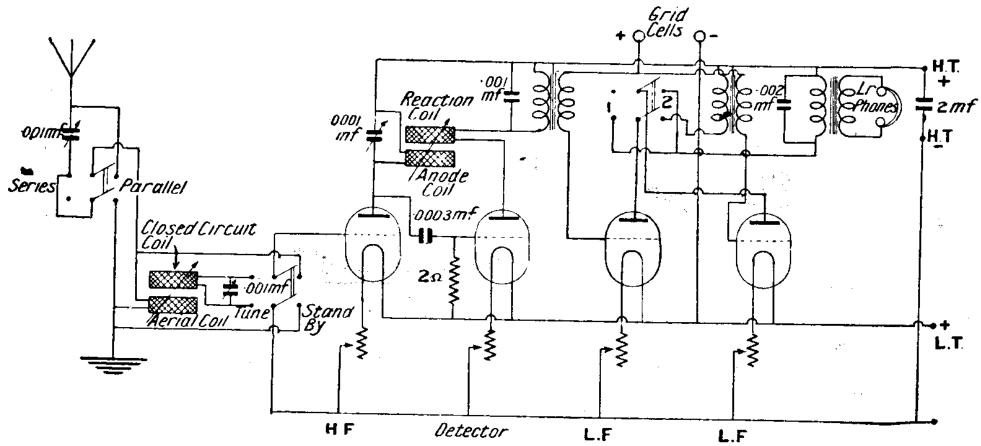
The two low-frequency note magnifiers have a Dewar two-way switch, seen in the centre of the panel, so that one or two may be used at will, and this panel is cut entirely out by means of two sockets and jacks connected by flexible wire across the front of the panel, so that two, three, or four valves may be used at will.

The telephone transformer is on the left, and is fitted with several terminals, so that



BUREAU HIGH-FREQUENCY AMPLIFIER OPEN

Fig. 26. Reception is obtained and tuning is carried out with the desk or sloping front of the bureau down as in the above photograph, which shows the general appearance of the set open



CIRCUIT DIAGRAM OF BUREAU HIGH-FREQUENCY AMPLIFIER

Fig. 27. One stage of high-frequency amplification and two stages of low-frequency amplification are included with a detector valve in the circuit arrangement of the bureau set illustrated in Fig. 23, the diagram for which is given above. High frequency is obtained on the tuned anode system

three or four pairs of phones may be used at one time. The set has been constructed on the panel system, and all connexions between panels have been brought out to terminals on the front and connected together with links, so that any panel can be easily disconnected and taken out. The baseboard supports the panels and slides back into the space formerly occupied by pigeon-holes, to enable the front of the panel to close.

The aerial used with this set is a single wire 52 ft. from the ground and 22 ft. above the roof at the high end, from which the lead-in is taken, and 15 ft. from the ground at the low end, this end being fixed to a tree.

The earth connexion is made from a terminal fixed in the floor in the corner of the room, and a wire earthed from this through the floor to the yard below and soldered to an old bucket perforated with holes and filled with stones. This is buried 3 ft. in the ground and a lead pipe is fixed from the centre of the stones to just above the ground, so that the water may be poured down in dry weather to ensure a damp earth.

The high-tension supply is provided from a set of high-tension accumulators located in the workshop in the garden and connected to terminals on a small ebonite panel on the wall on the right of the bureau. The panel has a selector switch so that the voltage can be regulated from 33 to 66 volts. The accumulators are arranged with change-over switch to the main lighting supply for charging purposes.

The low-tension supply is the usual form of 6 volt 3 cell accumulator, and is contained in a mahogany box seen standing on the floor at the right, with terminals on top and provided with a control switch.—*E. W. Hobbs.*

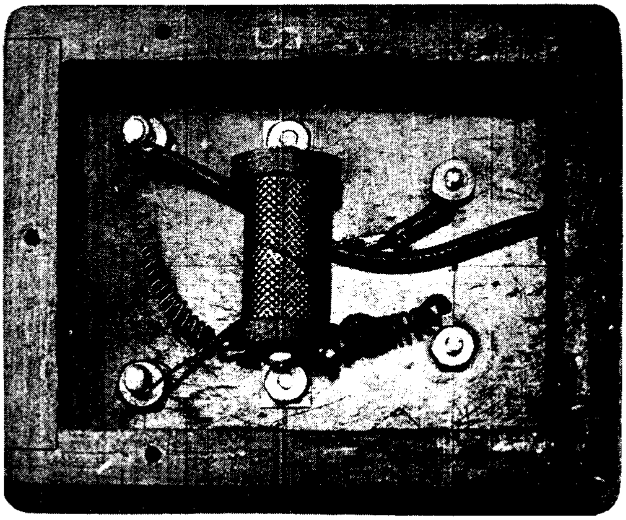
HIGH-FREQUENCY BUZZER. Any buzzer designed to produce a very high-pitched note is described as a high-frequency buzzer. In this case the term "high-frequency" is used in a purely comparative sense, *i.e.* in comparison with other buzzers, and not in the sense that the frequency produced is above audio-frequency.

A very common type of such a buzzer is shown in Figs. 1 and 2. Fig. 1 illustrates the buzzer with the cover removed. The latter is a bayonet cap fitting and quietens the noise produced considerably. The buzzer field coils, which are two in number, are of rectangular formation, wound on bobbins, round long thin pole-pieces. The armature is a very thin piece of sheet iron having a platinum contact fixed directly on top of it.

A V-shaped spring is fitted beneath the armature, having an adjusting screw for varying the pressure. This forms one means of altering the note produced. A further screw is fitted over the contact on the armature. This also has a platinum contact attached to it. The adjustment of this screw also forms a means of varying the pitch of the note to suit particular requirements. In neither case has it been considered necessary to have locking screws, such as are fitted to larger buzzers, because in this case the vibration is almost negligible.

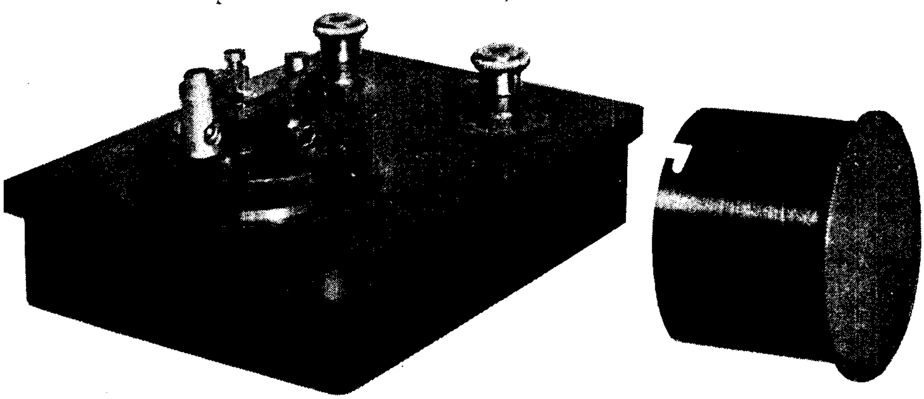
The whole buzzer is mounted upon an ebonite base, surrounded by a brass flange. A further base, also of ebonite, is fixed beneath the buzzer base. This carries the terminals for battery connexion, and also the inductance which is used in conjunction with the buzzer. In order to see this, reference should be made to Fig. 2.

It will be seen from this illustration that the inductance fitted is of very small dimensions. The object of this inductance is to tune the instrument in the electrical sense, *i.e.* not in the sense of pitch or musical note. Inductance in a circuit possesses a property very similar to the mechanical one of momentum. The current being suddenly interrupted at frequent intervals by the buzzer, its energy due to momentum may be considered to be suddenly liberated.



BACK VIEW OF HIGH-FREQUENCY BUZZER

Fig. 1. The inductance which is used in this form of buzzer is in the centre, and the various connexions are also shown



HIGH-FREQUENCY BUZZER WITH HIGH-PITCHED NOTE

Fig. 2. Mounted on an ebonite base is a raised disk, as seen in the above photograph. On this are the buzzer field coils. The metal cap which encloses the disk is shown removed. Connexion is made to the two terminals on the base in the rear. This is a buzzer designed to produce a very high-pitched note

This rush of current is directed into an oscillatory circuit in which the inductance is connected. The result of this action is to make this oscillatory circuit oscillate at its own natural frequency, and it becomes, in fact, a minute transmitter of radio impulses. Should this apparatus be placed in proximity to a receiver, these impulses will be received by it.

Such a buzzer and combined inductance is frequently used to test crystal sets. *See* Buzzer; Wave-meter.

HIGH-FREQUENCY CHOKE. An iron-core choking coil employed in high-frequency circuits. A common application of the high-frequency choke is in transmitting circuits, of which the Telefunken Company's arrangement affords one example. Two chokes are arranged in series with an inductance in a ferro-magnetic method of control, where the inductance is used to control the inductance of a radio-frequency alternator and an aerial inductance to which it is also coupled.

NON-INDUCTIVE RESISTANCE

High-frequency circuits sometimes use a non-inductive resistance, as illustrated. Contact is made through metal blades and caps at the end of the resistance

Courtesy Economic Electric Co., Ltd.

The object of the chokes is to choke off the radio-frequency currents which are induced into the control inductance from the alternator inductance. This is essential, as the radio-frequency currents would damage the battery and microphone in the control circuit. Different ways have been found of coupling the high-frequency choke, and in the majority of cases their effect is the same. *See* Choke.

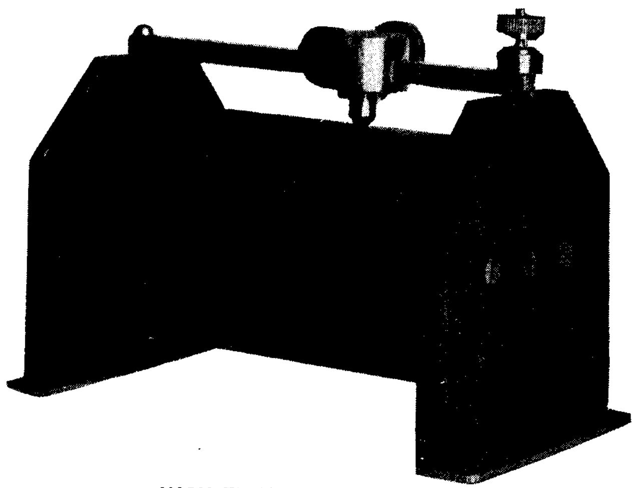
HIGH - FREQUENCY GENERATOR. Term applied to a machine adapted for generation of alternating current of high frequency. *See* Generator.

HIGH - FREQUENCY INDUCTANCE. This is the name given to an inductance used in a high-frequency circuit. *See* Inductance.

HIGH - FREQUENCY RESISTANCE. Name given to a non-inductive resistance in the high-frequency circuit, as, for example, the resistance element in a resistance-capacity-coupled high-frequency amplifier. A typical example by the Dubilier Company is illustrated, and comprises an ebonite base carrying metal contact blades set vertically and incorporating an ordinary type of screw-down terminal. Between these blades are mounted resistances, which comprise two metal caps with conical-shaped ends, fitting into holes in the blades. The space between the caps is filled with a carton containing the resistance element, the value of which may vary according to the requirements of the circuit.

HIGH-FREQUENCY SLIDER. Name sometimes applied to the slider of an inductance coil used in a high-frequency circuit. In the example illustrated the slider works along a bar by rotation of a small ebonite knob, which rotates a pinion engaging a rack cut on the slider bar, thus providing for very fine adjustment. With apparatus of this class the materials must be of the highest quality. The end cheeks are of ebonite and the winding is on an ebonite or bakelite former. The surface should be matted to obviate high-frequency current surface losses.

HIGH-FREQUENCY SLIDER INDUCTANCE. Apparatus used for making the final fine adjustment in a closed oscillator circuit. In the example illustrated on the opposite page it comprises two brass rods mounted on ebonite posts on a mahogany base. Connexion is made to the two brass rods by means of terminals to the left-hand end. The rods are bridged by a sliding brass plate. The inductance value can be varied by sliding the plate along the rods.



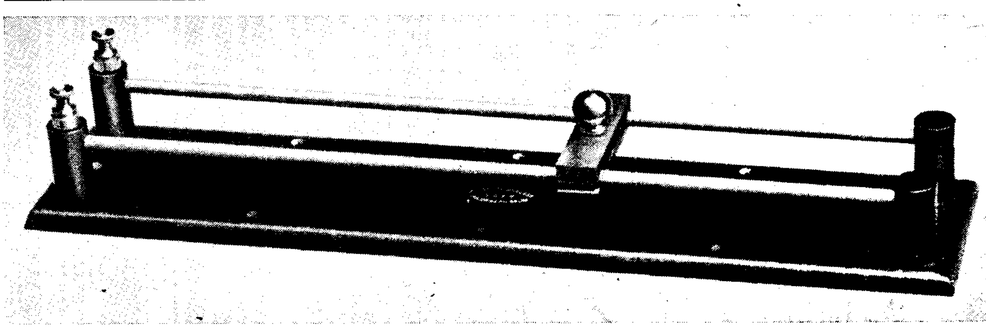
HIGH-FREQUENCY SLIDER COIL

An inductance coil of this kind can be used in high-frequency circuits. It is mounted on an ebonite former, with ebonite end cheeks, and the slider admits of very fine adjustment

Courtesy Economic Electric Co., Ltd.

HIGH-FREQUENCY SPARK SYSTEM. Term applied to a variety of specific methods of transmission by means of an electric spark. Several systems are described in this Encyclopedia, such as the Chaffee. In essentials an electrical discharge in the form of a spark occurs between the poles of two electrodes.

The spark gap is part of a circuit embodying a source of electro-motive force, a choke-coil inductance, and capacity



HIGH-FREQUENCY FINE ADJUSTMENT SLIDER INDUCTANCE
Apparatus as illustrated is designed for making the final fine adjustment in a closed oscillator circuit. The inductance is varied by a movement of the slider
Courtesy Marconi's Wireless Telegraph Co., Ltd.

in the form of a variable condenser. A variable resistance is incorporated, and the whole forms a closed circuit inductively coupled to the aerial circuit. The radiated energy is modulated by a microphone in the aerial circuit. When a spark frequency of one-half the oscillation frequency is employed the oscillations are practically undamped, and when heterodyned at the receiver gives a practically pure C.W. note. *See* Beat Reception; Chaffee; Moretti; Oscillation.

HIGH-FREQUENCY TRANSFORMERS: VARIETIES & USE

The Best Types of Couplings for the Radio-frequency Side of Receivers Described

Finer and more accurate methods of design and construction are required on the high-frequency side than in any other part of the receiving set. Here the best apparatus is illustrated and full instructions given to enable the amateur to make his own high-frequency transformers. See Amplifier; Frame Aerial; High-frequency Amplifier; Intervalve Transformer, etc. See also Coil

High-frequency transformer is a name applied to all forms of transformer intended and adapted for use in the high-frequency circuits of a receiving set. Customarily such transformers are of the air-core type, and consist of fine wire wound on an ebonite former. The same effects are obtainable with two basket coils, or with two windings similar to a small inductance but wound one on top of the other, thus making two layers separated by an insulator. Transformers may be tapped or tuned with a small variable condenser or a metal plate brought near to control the action.

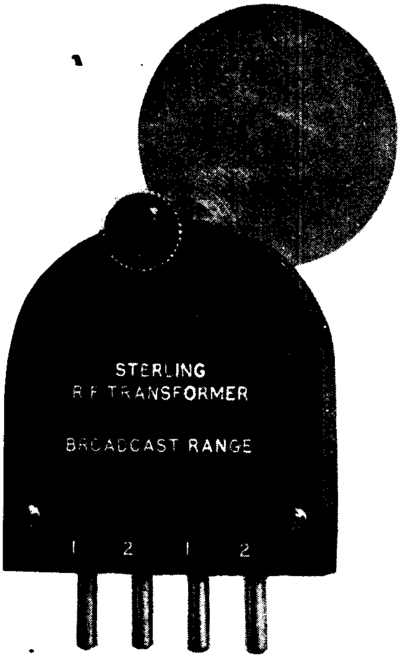
Essentially, a high-frequency transformer consists of two coils arranged so that they are close to each other, or tightly coupled. The quantity of wire with which it is coiled and its resistance all have a bearing upon the efficiency of the appliance. In practice the different arrangements of such coils resolve themselves into several classes.

A simple arrangement is to use two basket or plug-in coils, each of which can be rotated as required independently on a movable holder. This permits of the use of variable coupling, and to some extent has a similar effect as tuning the coils to the wave-length appropriate to that of the station to be received.

Commercial types of high-frequency transformer are usually of the plug-in variety. In one pattern an ebonite disk has two grooves turned in the rim, and each has a winding of fine gauge wire. The two ends of each coil are brought out to the four-prong plug attached to the centre of the disk, so that the whole can be plugged in an ordinary valve holder.

This class of transformer is semi-aperiodic, and gives its most critical amplification on the particular wave-length for which it is designed. In practice, these transformers can be purchased in various sizes appropriate to the broadcast and other popular wave-length bands.

Normally, the primary winding is connected to the grid and anode plugs, and the secondary winding to the two filament plugs. Approximate windings are 50 turns of No. 38 S.S.C. wire for the primary and also for the secondary. These cover a wave-length ranging from 300 to 400 metres, being tuned with a ·0003 mfd. variable



STERLING RADIO-FREQUENCY TRANSFORMER

Fig. 1. At the top of the transformer is a tuning knob by means of which the centre disk is withdrawn as required. This transformer is designed for receivers covering the broadcast wave-lengths.

condenser shunted across the primary winding. With the same condenser, a wavelength range of from 400 to about 700 metres is obtained by making 75 turns in the primary and secondary windings with No. 38 S.S.C. wire. Windings for a high-frequency transformer for the Eiffel Tower signals, or for reception on a wave-length of 2,000 to 3,500 metres, would have about 200 turns each in the primary and secondary. The wire used is No. 44 single silk covered.

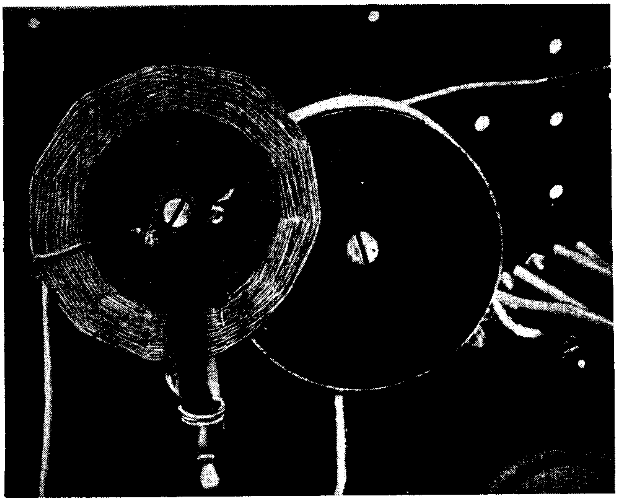
An improved form of high-frequency transformer is illustrated in Fig. 1, which shows the Sterling pattern suitable for broadcast range. In this case the four pegs which form the terminals of the primary and secondary winding are arranged in a straight line, alternative pegs being connected to the primary and secondary winding, generally in the form of a small honeycomb coil waxed into a recess formed in the two halves of the ebonite holder which forms the body of the appliance, and is clearly shown in Fig. 2.

For tuning purposes a simple metal disk, known as a damping plate, is pivotally mounted on the upper part of the instrument, and can be rotated by means of a small knob. Tuning is effected by turning the knob so as to bring the disk more or less central with the coils. Another method of using a high-frequency transformer and incorporating with it a reaction coil so as to react upon the primary or secondary windings is illustrated in Fig. 3, which shows part of the ordinary receiving set incorporating a stage of high-frequency amplification.

Various methods of reacting on to the transformer can be used according to the requirements of the particular set. The method illustrated consists of utilizing the basket coil, the ends of the wiring being taken to the terminals and forming part of the plate or anode circuit of the detector valve. The supporting arm is mounted on an insulating block, and can

INTERIOR OF STERLING RADIO-FREQUENCY TRANSFORMER

Fig. 2. How the input and output connexions of the two coils are attached to the plug legs may be seen in this view of the dissembled transformer, which is shown complete in Fig. 1



HIGH-FREQUENCY TRANSFORMER COUPLING

Fig. 3. Reaction coupling is effected in this arrangement, the coil is shown entering the field of the high-frequency transformer, which it partly obscures

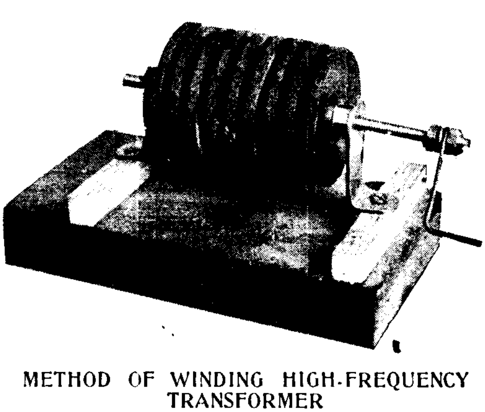
be turned upon a pivot so as to bring the coil nearer to or more remote from the transformer, and increasing or reducing the coupling effect. Considerable increase in signal strength is often possible with this device, and it has the merit that it does not cause detrimental re-radiation, as there is no direct coupling to the aerial inductance.

Other forms of high-frequency transformer used for amateur reception include the tapping varieties, which enable various turns in the primary, and in some cases both the primary and secondary windings, to be used or cut out as circumstances require, each coil in this case becoming virtually a small tapped inductance coil wound with fine wire, the tappings being taken at the most convenient points in respect of the particular wave-lengths to which it is most desired to listen. *See* Anode Reactance.

How to Make a High-frequency Transformer. The amateur may undertake the making of high-frequency transformers with the assurance that an efficient instrument will result without any undue tax upon the patience or the necessity of tools other than those usually found in most households. The transformer which is here described and illustrated has given good results over a wave-length of from 360 metres to 2,600 metres, and consists of an eight-slot ebonite bobbin, four sections of which are used as primary and four as secondary, both primary and secondary being tapped out to studs upon the panel.

Cut out nine circles of ebonite $\frac{1}{8}$ in. thick by $1\frac{3}{4}$ in. in diameter, and eight circles $\frac{3}{4}$ in. in diameter. These can be sawn out with a fret saw if such a tool be available; otherwise a good plan is to cut the ebonite into square pieces a little larger than the diameter desired with an ordinary tenon saw. The angular corners are then sawn off, thus making the ebonite octagonal, the edges being afterwards filed to a circle. The exact size of the circle is best heavily incised with a pair of sharp dividers to indicate clearly the edge to be worked to. The whole of these circles are drilled through the centre with a hole to clear 2 B.A. rod. A piece of 2 B.A. rod 6 in. long is then cut and the eight large circles, alternating with the smaller ones, are clamped together with a nut and washer on either end. Two small temporary brackets are then made up from scrap brass with clearing holes for 2 B.A. rod, and the bobbin is mounted on a temporary wooden stand as shown in the illustration Fig. 4. A wire handle is then bent to shape and clamped between the nuts, the bobbin being easily revolved for winding.

The grooves have now to be filled with fine double silk-covered copper wire of 40 gauge, 375 turns being wound in each

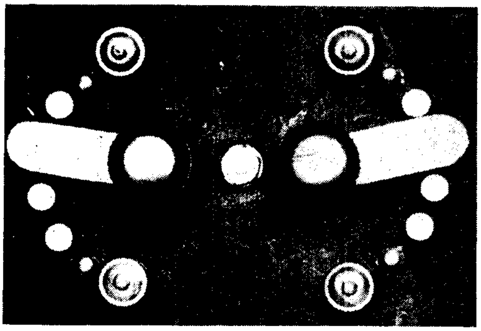


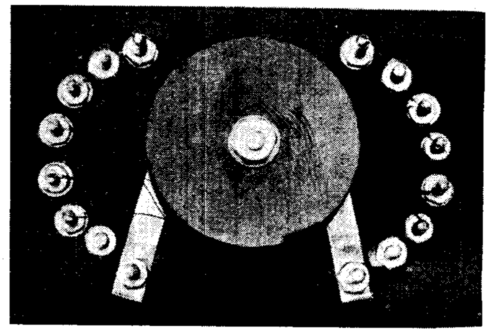
METHOD OF WINDING HIGH-FREQUENCY TRANSFORMER

Fig. 4. To facilitate winding, the former for the transformer is mounted on a wooden stand. Note the wire bent to shape to serve as a handle

groove, the wire at the commencement and end of winding each groove being fastened temporarily to the ebonite disks with a touch of sealing wax, sufficient wire being left in each case for wiring up to studs later on. These ends may be tucked away within the slot for the time being, in order that the bobbin may revolve freely for the completion of the windings.

either side of the centre hole, and are also drilled for 2 B.A. clearance. At 1 in. radius eight holes either end are drilled for contact studs, stops, and terminals. The spindles are 1 in. lengths of 2 B.A. rod at one end of which a thin nut is soldered, a strip connexion being made from the switch arm centres to one terminal on either side, as is shown in the photograph of back of panel, Fig. 6, the switch arm rod





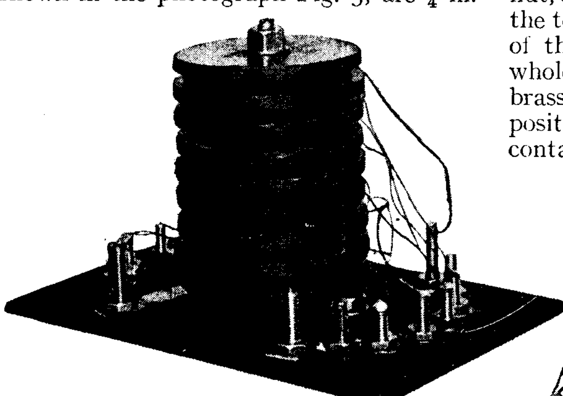
DETAILS OF HIGH-FREQUENCY TRANSFORMER PANEL

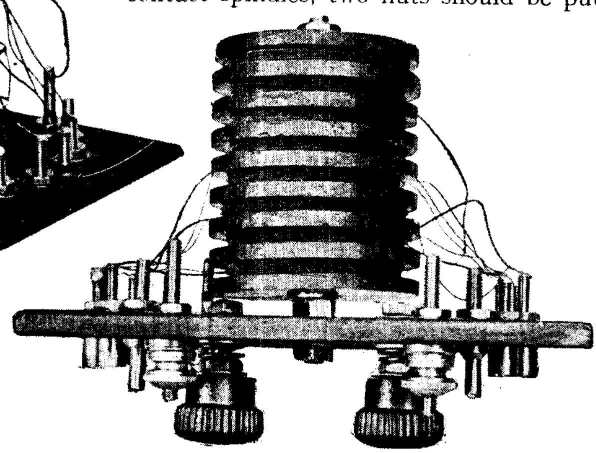
Fig. 5 (left). Two sets of studs and two switch arms are mounted on the panel of the high-frequency transformer. The contact arms are rotated by the ebonite knobs attached to the spindles. Fig. 6 (right). This photograph shows the back of the panel in Fig. 5. The strip leads to the moving arms can be seen, also the connexions to the various studs

The ebonite panel may now be prepared. This is 4 in. by 3 in. and $\frac{1}{4}$ in. thick. In the centre a hole should be drilled to clear 2 B.A., through which the centre supporting rod will ultimately project, being held in position with a nut and washer. The holes for the switch arms, which are clearly shown in the photograph Fig. 5, are $\frac{3}{4}$ in.

and soldered nut being free to move upon this with a rubbing connexion. Two flat strips of brass, $1\frac{1}{2}$ in. long, form the contact arms.

The spindles being put into position from the back of the panel, the front side is provided with a flat washer, spring washer, nut, contact arm, and, finally, ebonite knob, the tension being nicely adjusted by means of the spring washer and brass nut, the whole being locked with the knob. The brass centre knob may now be tried in position. If the bobbin does not clear the contact spindles, two nuts should be put





HIGH-FREQUENCY TRANSFORMER MOUNTED

Fig. 7 (left). Connexions can be seen from the studs to the transformer. Fig. 8 (right). The switch control knob is shown, and the method of attaching the transformer to the

CONTENTS OF PARTS 1—10

OF

Harmsworth's Wireless Encyclopedia

This list of the more important articles which appear in back numbers of "Harmsworth's Wireless Encyclopedia" is published for the convenience of readers who may wish to refer to particular subjects. It also shows the comprehensive nature of the work and gives an indication of its outstanding value to both amateur and experimenter as the only encyclopedic work of reference in an entirely new science.

The first 10 *parts of the "Wireless Encyclopedia" here listed include the striking total of nearly* **750 articles and 2,000 photographs and diagrams,** *all of which have been* **specially prepared** *for the "Wireless Encyclopedia" and are now* **published for the first time.**

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. April 8th, 1924.
D/R