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For Amateur & Experimenter

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SPECIAL PHOTOGRAVURE PLATE:

DETECTOR PANELS FOR THE EXPERIMENTER

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

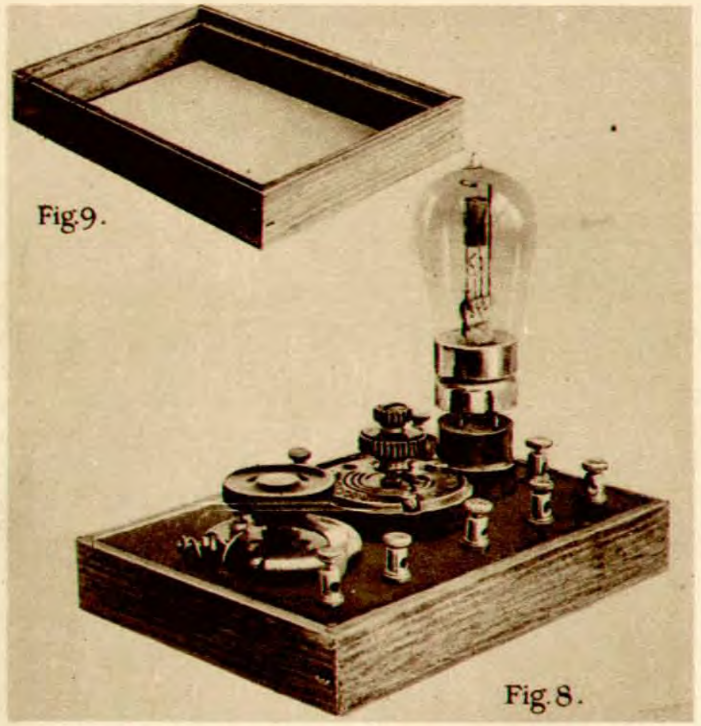


Fig. 8 (right). Complete panel showing simplicity of construction. Fig. 9 (left). Framework for panel

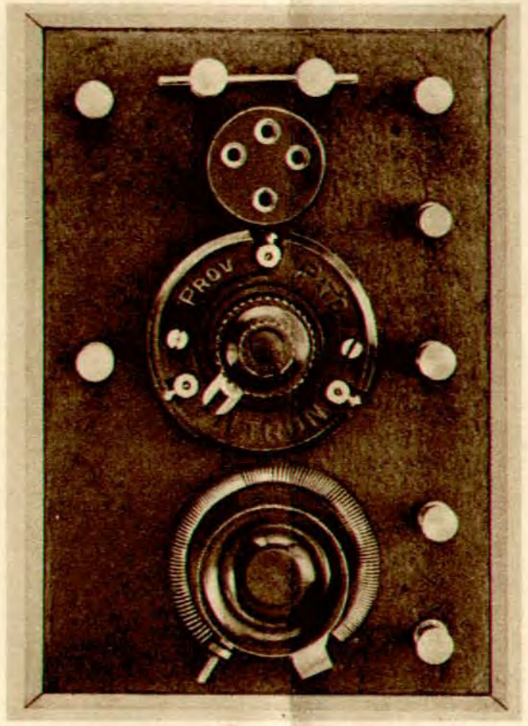


Fig. 10. Top of panel showing variable grid leak and rheostat

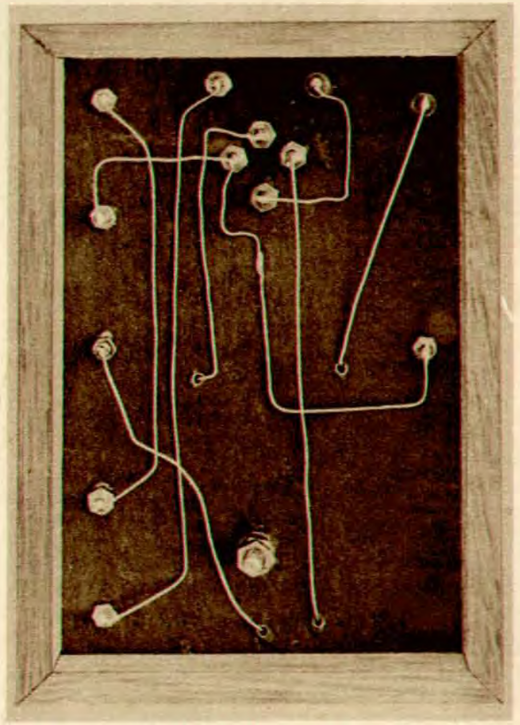


Fig. 11. Underside of panel wired complete, all connexions being soldered

Fig. 12. Alternative panel quickly made and capable of many combinations

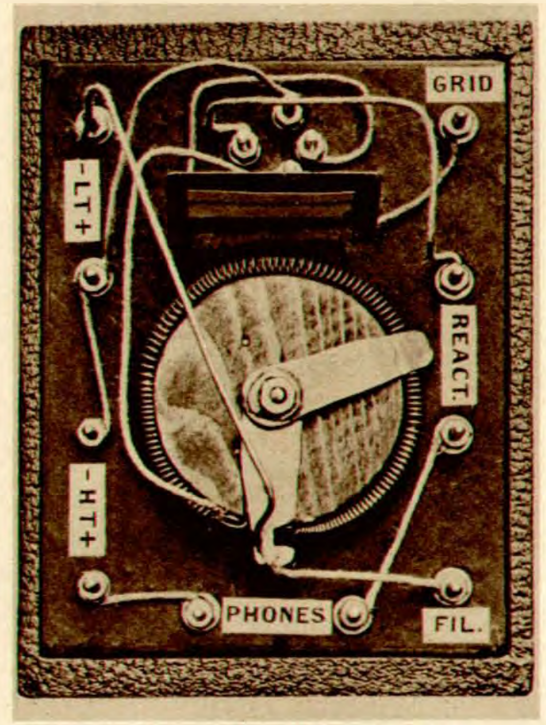


Fig. 13. Wiring of second panel with home-made grid leak, condenser, and rheostat

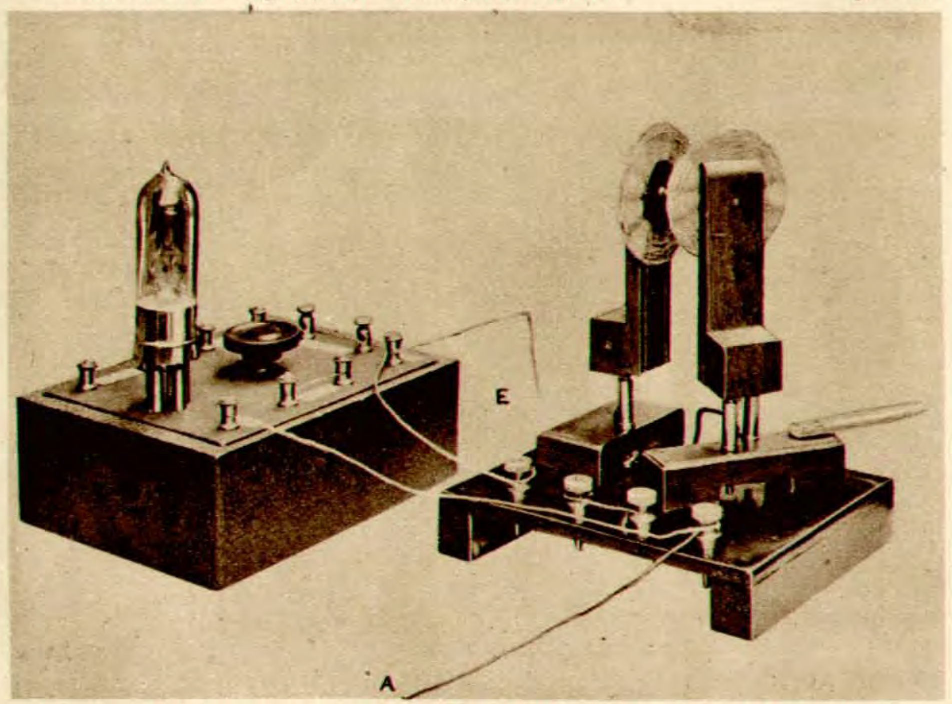


Fig. 14. Detector panel wired up for simple circuit with basket coils as variometer tuning for aerial inductance

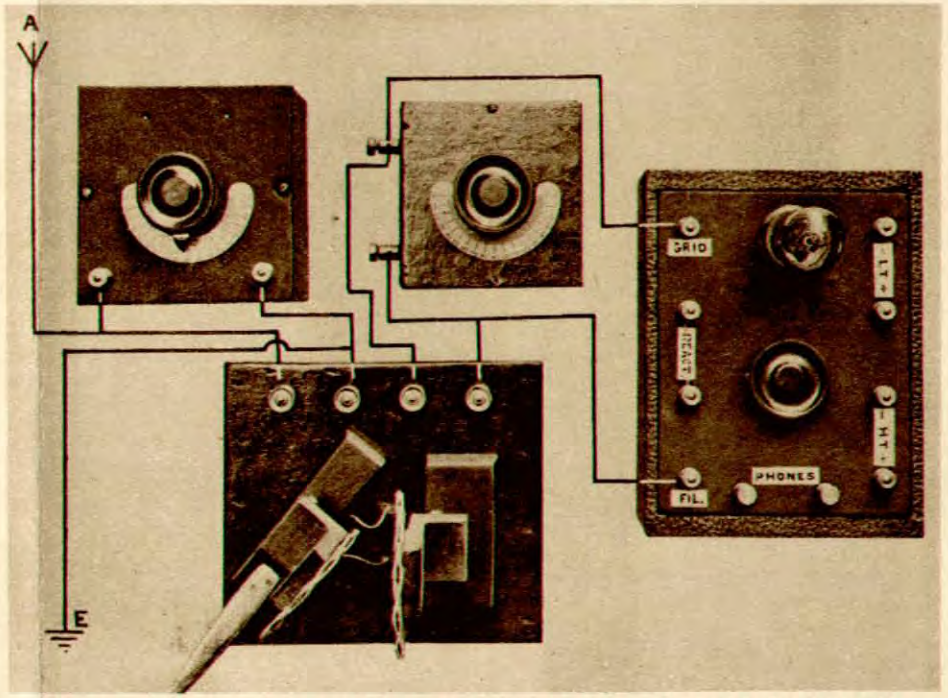


Fig. 15. The panel connected up for loose coupler tuning with basket coils. Two variable condensers are required

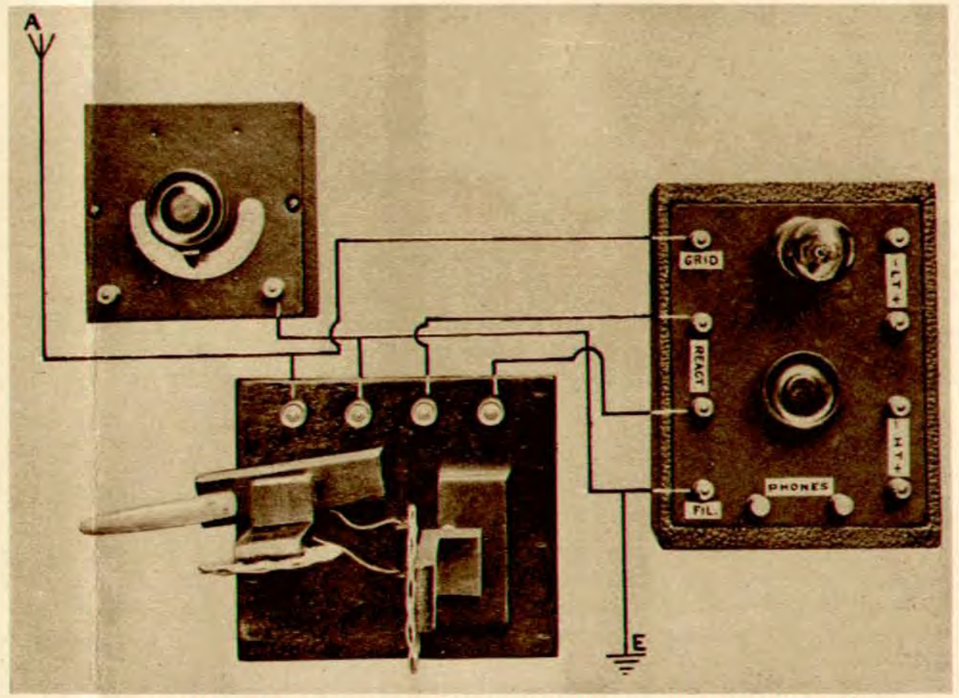


Fig. 16. Third method of connecting the panel when reaction is used, enabling Paris time signals and Continental telephony to be received

DETECTOR PANEL: TWO USEFUL AND SIMPLY-MADE PANELS FOR THE EXPERIMENTER WHICH MAY BE EASILY ADAPTED TO A NUMBER OF DIFFERENT CIRCUITS WITHOUT RE-WIRING

To face page 670

From photos specially taken for HARMSWORTH'S WIRELESS ENCYCLOPEDIA filament then starts to give off electrons. Just above the filament is the screen, S, which is at the same potential as the filament. This screen is a metal plate having a small hole in its centre so that electrons may pass through. T is a tubular anode which is made positive relative to the filament. Any electrons which pass through S are therefore attracted towards T. These electrons acquire considerable velocity, and many of them pass right through the tube, passing between the two sets of plates, P_1, P_2, X_1, X_2, and do not stop till they strike the fluorescent screen on the inside of the top of the bulb; here the bombardment produces a bright green spot which can be clearly seen even in daylight.

If the plate P_1 is now charged from some external source the stream of electrons can be attracted towards it, and when this charge is removed the stream will return to its straight path. The rapid repetition of these two states of charge and discharge to the plate P_1 would therefore bend the stream backwards and forwards, and a bright green line would be noticed on the fluorescent screen.

The other two plates, X_1 and X_2, are at right angles to P_1 and P_2, therefore charge and discharge of the potential to X_1 would again make the stream bend and rule a straight line on the screen, but at right angles to the first one.

If variable potentials are applied to both sets of plates at once the electron stream will trace a curve on the screen.

The very great advantage which this type of instrument has is that its moving parts may be considered as having no weight, therefore the instrument will respond to the highest frequencies. The actual curve, say the wave form of an alternator or the characteristic curve of a valve, may be watched and changed whilst under observation. The curves may be traced off on to a piece of paper resting on the top of the bulb, or they may be photographed.

The modulation of aerial currents in wireless telephony due to the microphone current may be watched and adjustments made whilst watching the effect of such adjustments.

The instrument requires an anode potential of about 300 volts, as against voltages of thousands which were required with former cathode ray oscillographs.

The Neon tube, as developed by Dr. J. A. Fleming, is invaluable as a cymoscope (Fig. 7). This consists of a thin glass tube having two cylindrical bulbs, one at each end of it. Mounted one in either end of these two bulbs are the electrodes. The tube is then evacuated and finally filled with rarefied neon.

When such a tube is held in the hand by one end, and the other taken near to a circuit which is oscillating, a reddish-orange glow will be noticed to emanate from the electrode nearest to the oscillating circuit. As the tube is taken nearer to the circuit, this glow will extend down the tube, all the while becoming more vivid in colour, till finally the whole tube seems to be filled with a brightly glowing gas which is clearly visible in bright daylight.

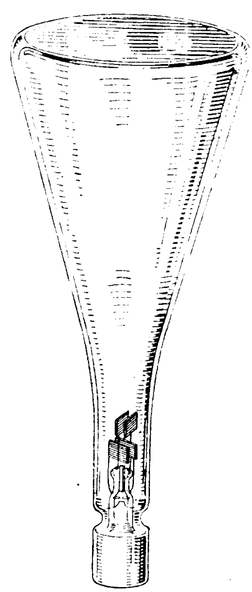
FLEMING'S CYMOSCOPE

Fig. 7. Mounted on either end of a thin glass tube are two electrodes. This neon tube was developed by Dr. J. A. Fleming

If the end of the neon tube is now taken near to any oscillating circuit or wire in which there are standing waves the nodes and antinodes of potential may be easily found.

Whilst far more sensitive than the spark cymoscope, the neon tube is by no means a sensitive detector; it is an indicator when exploring transmitting circuits, but would be no use for detecting feeble oscillations in a receiver.

In the place of neon, other gas-filled tubes may be used, but will be found less sensitive. All the detectors of wireless waves may be so coupled to other pieces of apparatus



OSCILLOGRAPH

Fig. 8. Modern form of cymoscope or cathode ray oscillograph. Diagrams of the tube appear on pages 385 and 640

that they give a " visible " instead of the more usual " audible " indication of the presence of waves. These, however, should not strictly be called cymoscopes, but, rather, detectors, and will be found under that head.—*R. H. White.*

See Cathode Ray Tube ; Wavemeter.

D

DAMPED WAVES. Waves forming successive wave trains in each of which the amplitude, after reaching its maximum, progressively decreases.

Electrical oscillations excited in a circuit by a single impulse do not continue indefinitely, but die away more or less gradually. An electric wave starting with a certain amplitude, is followed by one of a smaller amplitude and gradually dies out, the ratio of the value of one wave crest to that of the succeeding one being a constant value and known as the decrement.

A parallel case may be drawn between the behaviour of a swinging pendulum and a damped wave of electrical energy. After the initial impulse, the pendulum takes up a swing which gradually becomes shorter and shorter until it dies away altogether and the pendulum comes to rest. If there were no frictional losses, the pendulum would go on swinging for ever ; but as these are unavoidable, the oscillations cannot be maintained indefinitely.

In the case of electric waves, the energy which starts the wave is gradually dissipated in electro-magnetic waves and heat until the oscillations die away to nothing, the rate at which this occurs being determined by the damping properties of the circuit. Electro-magnetic radiation and heat due to the resistance of the aerial and earth plate, brush discharges, dielectric hysteresis, and induced currents in neighbouring conductors are accountable for the loss of energy in an oscillating circuit, otherwise a single impulse would set it oscillating indefinitely and there would be no decay or damping of the waves.

The rapidity with which the oscillations of a damped wave die away depend not only on the resistance of the circuit, but on the inductance also. The greater the resistance and the smaller the inductance, the more rapid will be the damping and decay of the waves ; in other words, the wave is less persistent when highly damped. As an example of damped waves, the case of a discharging condenser may be taken. At the start there is a definite amount of energy present in the circuit, proportionate to the energy of the charge imparted to the condenser. This amount of energy depends upon the capacity of the condenser and the square of the potential difference between its plates. The energy exists in the dielectric of the condenser, which is in a strained condition owing to the charge. As soon as current begins to flow on discharging, the condenser gives up some of its energy, which forthwith becomes associated with the current in the form of a magnetic field, principally in the region of the inductance coil forming part of the discharge circuit. As the discharge current increases in value, energy is continually leaving the condenser and being stored in the magnetic field of the inductance coil.

When the condenser has arrived at the stage where there is no potential difference between its plates, the whole energy of the circuit resides in the magnetic field of the inductance coil and none in the condenser. Energy is then drawn from the coil as the current decreases, and is stored up in the condenser as it is again recharged.

If the resistance of the circuit were zero, and no energy were radiated in waves or dissipated in other ways, the total energy of the circuit would be maintained at a constant value and the waves would be undamped. But from causes explained above this is an impossible condition, and the decay rate or decrement will depend upon the circuit conditions.

DAMPING. Damping is a term used to signify the gradual falling off in amplitude of a periodic vibration or train of oscillations. It may be applied to electric waves, or to mechanical matters such as the control of the swing of a galvanometer needle. An undamped oscillation persists indefinitely ; a highly damped vibration or swing comes to rest almost at once. Measuring instruments that are so adjusted that the deflection of the needle comes to its final position with a minimum of swing are referred to as dead-beat, or aperiodic, and a high damping factor is necessary to give them this attribute.

Various means are employed for obtaining the desired damping effect, such as air vanes moving in an enclosed chamber ; vanes arranged to dip into a receptacle containing oil or glycerin ; or magnetic damping, where a low-resistance conducting circuit is made to swing in the influence of a strong magnetic field, and the resulting currents induced act in opposition to the movement which causes them to arise.

An undamped vibration or wave persists for an indefinite time, as represented by the diagram in Fig. 1, the amplitude of the successive crests of the waves being identical in height as well as in frequency. In Fig. 2, however, a diagram of a damped vibration is given, where the amplitudes of the successive waves are shown to be

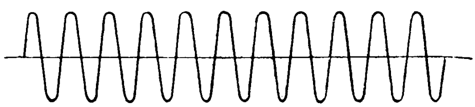


Fig. 1 *Undamped Wave*

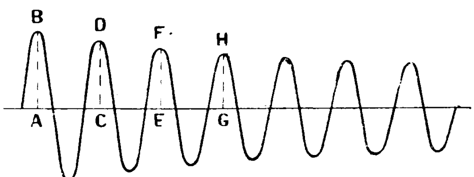


Fig. 2 *Damped Wave*

COMPARISON OF DAMPED AND UNDAMPED WAVES

Fig. 1. Vibrations or waves are here represented undamped, their crests being equal in height. Fig. 2. In this case the wave train is damped

continually decreasing as regards the heights AB, CD, EF, etc. The ratio of the amplitude of any of these half-waves to their immediate predecessors in the same direction decreases in geometrical progression; for instance, if the half-wave represented by CD were 0·7 times the value of the initial half-wave AB, the half-wave EF would be 0·7 times the height of CD, and so on.

Instead, however, of adopting the numerical measure of the rate of decrease corresponding to the fraction of one half-wave to another as a measure of the damping, it is more customary to adopt the natural logarithm of the ratio between the two maximum points of two successive half-waves in the same direction; that is, of two half-waves one cycle apart. This number is termed the logarithmic decrement, and denoted by the Greek symbol δ or delta.

DAMPING DECREMENT. In an oscillating discharge the successive current amplitudes diminish in size until eventually the discharge ceases. The logarithm of the ratio of successive current amplitudes in the same direction is sometimes called the damping decrement, but more usually the decrement (*q.v.*), or the logarithmic decrement. It is usually denoted by the symbol δ.

DAMPING FACTOR. Expression used to denote the product of the logarithmic decrement and the frequency of a damped wave. The amplitude of an oscillation after a time *t* may be calculated if the initial amplitude is known and the damping factor.

If A_o is the initial amplitude, A_t the amplitude after a time *t* and *d* the damping factor, then

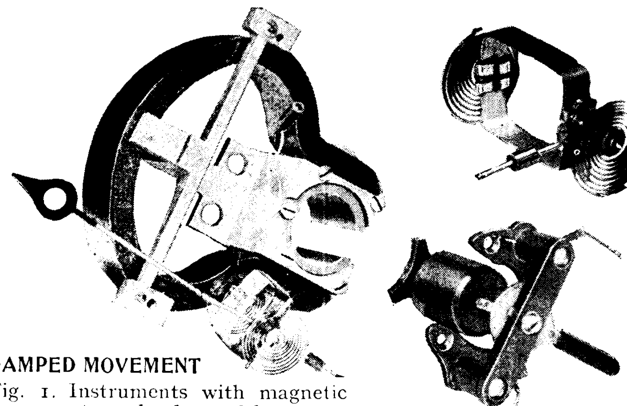
$$A_t = A_o \epsilon^{-dt}$$

where ϵ is the Napierian logarithm base.

DAMPING IN MEASURING INSTRUMENTS. Damping in measurement instruments is the means employed to bring the needle or pointer quickly to rest after having arrived at its correct division on the scale. It will be realized that owing to the momentum of the moving parts of the instrument it would considerably overshoot the correct reading. The control spring, gravity, or other means of control would bring it back again past the correct division but in the opposite direction. Were means to bring it to rest quickly not available, the pointer would swing backwards and forwards over the scale for quite a considerable time before it finally came to rest. Furthermore, were the pressure or current of a slowly fluctuating character, an accurate, instantaneous reading would be rendered impossible, because the meter would probably not come to rest before the pressure or current had altered in value.

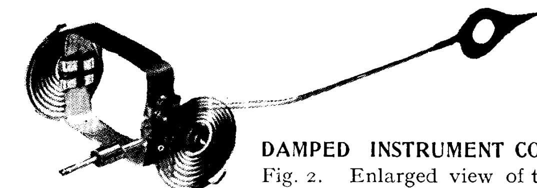
The importance of efficient damping will thus be appreciated, and all the measuring instruments, except the very cheapest, are fitted with a device to perform this function. It is important, however, that the movement is not over-damped, for that would make the movement sluggish in operation, and possibly render it inaccurate by preventing the movement from reaching its proper reading.

The general methods of accomplishing this function of damping are two in number. (1) In the case of moving coil instruments, eddy former currents are set up in the coil, which is usually of aluminium, by the magnetic field which surrounds it. As these currents are set up only when the coil is actually in motion, they tend to bring it quickly to rest.



DAMPED MOVEMENT

Fig. 1. Instruments with magnetic movement can be damped by a magnetic field, as shown in this rear view of an instrument dissembled



DAMPED INSTRUMENT COIL

Fig. 2. Enlarged view of the coil in Fig. 1. This actuates the pointer in the damped measuring instrument

Courtesy General Electric Co., Ltd.

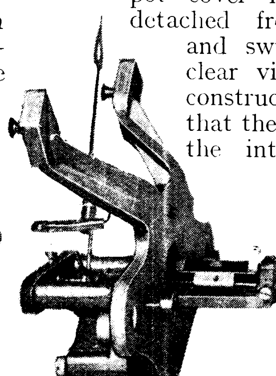
(2) By means of a vane in a dashpot containing air, or by a loose-fitting piston in a cylinder containing a light, non-congealing, non-evaporating oil. The former is known as air damping, and the latter as oil damping.

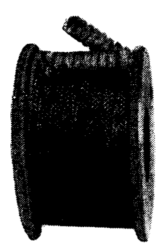
A clear indication of the methods employed in (1) is shown in Fig. 1. The horseshoe permanent magnet is fitted with cast-iron pole-pieces, which have a cylindrical cast-iron core suspended between them, leaving an annular gap between this iron core and the pole-pieces. The square-shaped moving coil shown in Fig. 2 is free to rotate in this annular gap, and is thus in a powerful magnetic field.

Although primarily the coil former is a means of supporting the coil, being made of metal it may be regarded as a closed circuit having one turn only. The movement of the needle causes this single conductor to rotate with it and, being situated in this magnetic field, a current is induced in it as in the armature of a dynamo.

Again, as in the case of the dynamo, energy is expended in this current production, and as insufficient energy is present to drive the armature round, it has the effect of permanently arresting its motion. The limit of applied energy is when that energy equalizes the counteracting force of the control spring, and as this finally brings the coil to its resting point, so the induced current in the former becomes less and less, and when finally the motion ceases, so the current induced in the former ceases, leaving the pointer giving its correct reading upon the scale.

Figs. 3 and 4 illustrate the methods used in air damping. An aluminium vane is rigidly attached to the pointer and swings in the sector-shaped dashpot. The dashpot cover in Fig. 3 is shown detached from the framework and swung away to give a clear view of the internal construction. It will be seen that the vane only just clears the internal sides of the





DAMPING IN MEASURING INSTRUMENTS

Fig. 3. Damping in a gravity-control instrument is effected by air damping. A dashpot and moving vane iron are used. The pointer is attached to an aluminium vane and swings, a close fit, to the sector-shaped dashpot. The cover of the latter has been removed to show construction. Fig. 4. Details of the moving iron instrument are shown. On the right is an energizing coil. The framework is also partly shown. A current through the circuit actuates the pointer, whose movement is sluggish owing to the air damping provided by the dashpot construction

Courtesy General Electric Co., Ltd.

dashpot, and therefore the enclosed air has difficulty in flowing round the vane while the latter is in motion. The method of control used in this particular instrument is by gravity; the controlling balance weights are two little circular nuts threaded upon the cross arms of the pointer. They may be seen in the photograph below and to the left of the pointer spindle.

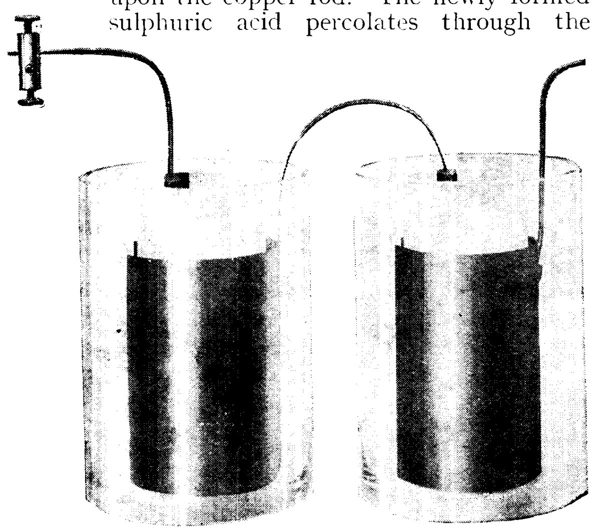
The system of air damping can be fitted to any kind of measuring instrument which employs a swinging motion to indicate whatever electrical property is to be measured. The magnetic damping first described, however, may only be used in the case of moving coil instruments; and these are for direct current measuring purposes only. Oil damping is necessary in instruments such as recording voltmeters and ammeters, where the moving parts are relatively heavy, and when sudden swings on the part of the recording pin (which takes the place of the pointer in an ordinary meter) are not considered an advantage. *See* Dead Beat.

DAMPING MOMENT. Term used for one of the intrinsic constants of a vibration galvanometer. When an alternating current is sent through a vibration galvanometer it causes oscillatory motion, and this motion can be determined mathematically from a knowledge of the value of the current, its frequency, and a number of constants which depend entirely on the construction of the instrument.

When the moving part is displaced through an angle θ by a current of instantaneous value i, then if the torque due to i is Gi, G is called the displacement moment. If $C\theta$ is the torque due to the control forces which tend to bring the moving part back to its zero position, then C is called the control moment. If the moving system is allowed to oscillate freely on open circuit, the damping forces gradually bring it to rest. The damping torque is, in general, proportional to the angular velocity. If the damping torque equals $b\theta$, b is called the damping moment.

DANIELL CELL. One of the primary cells. There are several forms of Daniell cell, but the principle of action in all remains substantially the same. In its original form it consisted of a glass jar in which was placed a zinc cylinder. Within this was a porous pot, which in turn contained a copper rod. The porous pot was filled with a saturated copper sulphate solution, and the outer jar with a dilute solution of sulphuric acid. In some forms the positions of the zinc and copper are reversed, and the sulphuric acid is then placed inside the porous pot and the copper sulphate solution outside.

The action is as follows: The zinc is attacked by the sulphuric acid, and zinc sulphate is formed, hydrogen being liberated at the copper rod. This immediately combines with the SO_4 of the copper sulphate solution to form H_2SO_4, sulphuric acid, copper being released from the copper sulphate solution and deposited upon the copper rod. The newly formed sulphuric acid percolates through the porous pot and maintains the strength of the original acid.



ORIGINAL PATTERN DANIELL CELL

Fig. 1. In the original form of Daniell cell, two of which are shown here, a primary cell is so constructed that it has a constant electro-motive force. The voltage of the Daniell cell is only about 1·1, lower than the voltage of many other forms of primary cell

Courtesy Siemens Bros. & Co., Ltd.

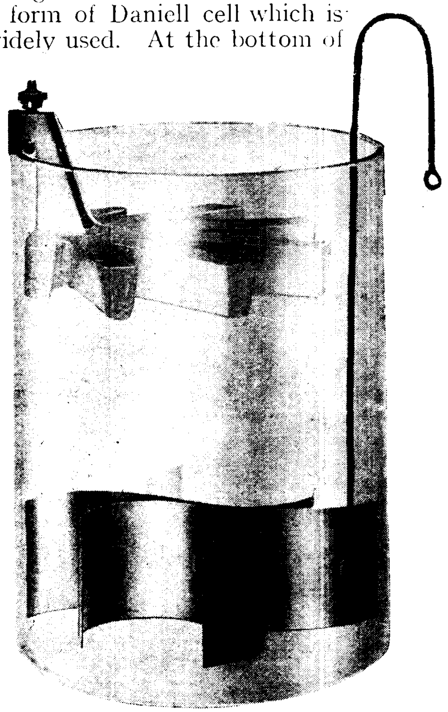
Fig. 1 shows two Daniell cells joined in series, and shows clearly the disposition of the zinc cylinder, copper rod, and porous pot. In order to keep the solution of copper sulphate up to saturation point, a shelf or cage is usually provided in which pure copper sulphate crystals are placed. They dissolve gradually, to replace the copper sulphate used in the formation of the fresh sulphuric acid and copper deposit.

The Daniell cell has the advantage over certain other primary cells of being odourless, developing no poisonous fumes, and of possessing a constant constant electromotive force and a fairly constant resistance. It is for this reason useful where small and constant currents are required. Its electro-motive force, however, is on the low side, being only 1·1 volt, and its resistance on the high side compared with many other types of cells. The resistance varies directly with the distance apart of the elements and the thickness of the porous pot, and indirectly with the area of the elements. It may vary between $\frac{1}{8}$ ohm and 10 ohms.

The cell, to be maintained in good order, should be occasionally washed out thoroughly. The porous pot should not only be washed, but soaked for an hour or so in water, the zincs scraped and re-amalgamated, and the copper rods scraped and polished.

Fig. 2 shows the so-called crow-foot cell, a form of Daniell cell which is widely used. At the bottom of the cell are three copper strips riveted together. One end of the middle strip is riveted to a piece of well-insulated copper wire.

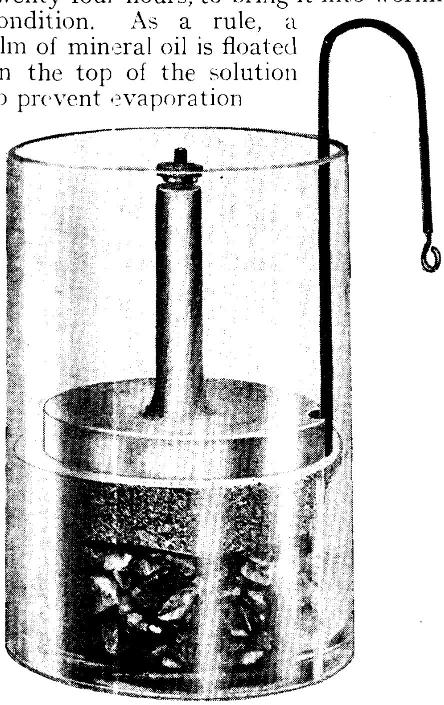
Copper sulphate crystals are packed around the copper strips, and the zinc crow-foot suspended on the inside of the container, as shown. The container is then filled with dilute zinc sulphate or sulphuric acid, and the cell is short-circuited for about twenty-four hours, to bring it into working condition. As a rule, a film of mineral oil is floated on the top of the solution to prevent evaporation.



CROW-FOOT TYPE DANIELL CELL

Fig. 2. No porous pot is used in the crow-foot pattern of Daniell cell. Its name is derived from the foot-like shape of the zinc electrode

Courtesy Siemens Bros. & Co., Ltd



MENOTTI PATTERN DANIELL CELL

Fig. 3. Menotti pattern Daniell cells use central zinc elements, as seen in this example. This rests in damp sawdust, beneath which are the copper sulphate crystals. The copper terminal is seen on the right

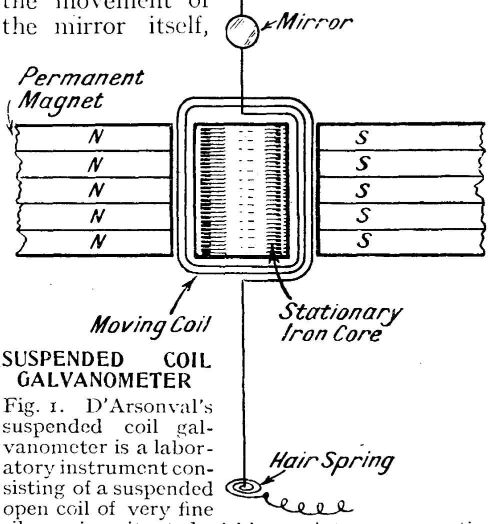
Courtesy Siemens Bros. & Co., Ltd

The resistance of the cell varies considerably with the temperature, and it is best to use it at a temperature of about 70° F. A weak current should always be sent through a high resistance when the cell is not in use, in order to prevent the copper sulphate attacking the zinc. The separation line between the copper and zinc sulphates should be about half-way between the electrodes, and when the copper sulphate begins to turn brown the electrolyte should be renewed.

Fig. 3 shows the Menotti-Daniell cell. The cell has a central zinc element which rests upon damp sawdust, beneath which is a copper cup containing copper sulphate crystals. The copper cup is connected to a terminal as shown. *See* Primary Cell.

D'ARSONVAL GALVANOMETER. This instrument belongs to the class of "suspended-coil" galvanometers, and is one of the best-known and most suitable for laboratory work. It may differ slightly in outward form and arrangement, but consists essentially of a suspended open coil of very fine silver wire which carries the deflecting current, this coil being situated within a very intense magnetic field arising from an enclosing permanent magnet with suitably shaped pole pieces. The direction of the permanent field and that produced by the coil when carrying a current is such that a torsional effect is set up between the two.

By means of a light concave mirror attached to the moving element a beam of light from a distant lamp falling upon this mirror is reflected and focused upon a screen in the form of a spot or line of light, which traverses a metre scale and enormously accentuates the movement of the mirror itself,



SUSPENDED COIL GALVANOMETER

Fig. 1. D'Arsonval's suspended coil galvanometer is a laboratory instrument consisting of a suspended open coil of very fine silver wire, situated within an intense magnetic field. A mirror is attached to the moving element, and this reflects a beam of light from a distant lamp on to a screen, where the movement is recorded

as though the beam of light consisted of a long, weightless pointer.

Compound magnets are usually employed, the diagrammatic view being given in Fig. 1, which also shows the suspension, the mirror, the coil, and the current outlet. In the more modern instruments the new cobalt-chromium steel magnets are employed, as the remarkably high coercive force exhibited by this material adds greatly to the permanency.

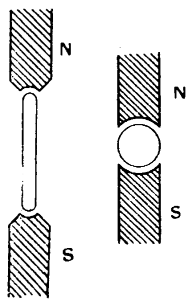
The current is led into the coil, which is sometimes wound upon a silver or aluminium frame, by the torsional head forming one terminal, and passes out by the bottom attachment of the suspension wire through a hair spring. In order to concentrate the magnetic field as much as possible in the gap where the coil hangs a soft iron cylinder is supported from the back, leaving just sufficient air-gap for the coil to swing without touching either magnet poles or internal iron core. The vertical sides of the coil hang freely in these two narrow gaps, the end turns of the coil serving merely as connectors. The force tending to turn the coil when a current is passed through the terminals is proportional to the current, to the number of turns in the coil, and to the intensity of the magnetic field in which it lies, so that the more powerful the magnet and the greater the number of turns in the coil, the more sensitive will the instrument be.

The elasticity of the suspension wire controls the position of the coil when no current is flowing, while the magnetic axes of the coil and of the permanent magnet are at right angles to one another when the coil is not carrying any current.

Galvanometers of this class are independent of the earth's magnetic field, and can be made thoroughly dead-beat by the fact of mounting the coil on a silver frame. The induced eddy currents which are developed in any highly conducting closed electrical circuit such as provided by this frame will form a check upon the natural inertia or tendency to swing beyond the natural deflectional point, since eddy currents operate always in such direction as to tend to oppose the motion giving rise to them.

As with all moving coil instruments, the direction of deflection to right or left of zero depends upon the direction in which current is passing round the coil, hence they can be used to measure not only quantity but direction of current. For obvious reasons they could not be used on alternating currents, even those of so low a frequency relatively as met with in commercial lighting and power circuits, much less with oscillatory currents of radio-frequency.

This type of galvanometer is in very general use for testing in conjunction with the Wheatstone Bridge, especially with "null" or balanced current tests. When used for "zero" testing the magnet pole-pieces would be shaped somewhat as in Fig. 2 in order to concentrate the field upon the position of the coil when at rest; but when employed for deflectional testing—that is, by proportional deflections—the magnet poles would be shaped as in Fig. 3, so as to provide a radial field of nearly equal intensity throughout the working arc of the coil movement. The almost perfect damping effect which can be obtained with this type of galvanometer renders it extremely suitable for rapid work, as the deflection comes to rest on the meter scale almost at once, and its sensitivity is such that a current of the order of one ninety-millionth of an ampere will give a perceptible deflection on the scale.



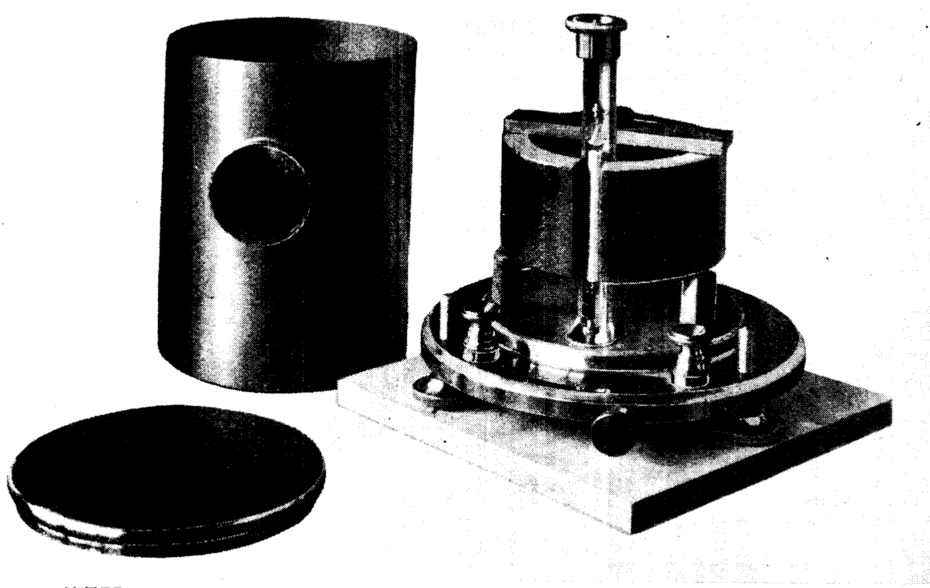
D'ARSONVAL GALVANOMETER

Fig. 2 (left). Pole shaping for small deflection galvanometer, and Fig. 3 for proportional deflection galvanometer

For large currents this type of galvanometer can be "shunted," as in the case of other measuring instruments, by providing a by-pass or shunt circuit bearing a fixed and known ratio to the resistance of the instrument coil; the shunt then passes the bulk of the total current, leaving only a small fraction to go through the instrument coils. Fig. 4 shows a standard example of the D'Arsonval Galvanometer, with the cover removed. *See* Galvanometer.

DAYLIGHT EFFECT. Expression used to describe the difference of normal range of reception during the daylight hours as compared with the night. It is well known that wireless signals are received over greater distances by night than they can be by day, and there have been many theories advanced to account for this phenomenon.

Senatore Marconi was one of the first to observe and study the differences between the range of a station by night and by day, and during these observations differences as great as 700 to 800 miles were noted, signals sent from the same station by day reaching only as far as 700 miles, whereas by night the same station had a range of some 1,550 miles.



INTERIOR VIEW OF STANDARD PATTERN D'ARSONVAL GALVANOMETER

Fig. 4. Cup and cover have been removed to show the interior of this standard pattern of D'Arsonval galvanometer. The permanent magnet can be clearly seen. This is a suspended coil type of galvanometer and is very sensitive. A current of the order of one ninety-millionth of an ampere can be recorded by this instrument

The ranges also varied during the winter and the summer months. The causes for these effects are obviously associated with the possible and effective transmitting range of a station, and are therefore of great importance to all wireless experimenters. Furthermore, there is apparently some connexion between the exceptionally long range receptions that are recorded from time to time. At first it was supposed that the ionization of the atmosphere with the rising of the sun was the cause, and that absorption of energy was the reason for the diminution in the range by day due to losses in transmission. This may be a contributory cause, but examination of the matter tends to the conclusion that the chief consideration is the diffraction of the electro-magnetic waves, which are forced, for various reasons, to follow more or less the curvature of the earth.

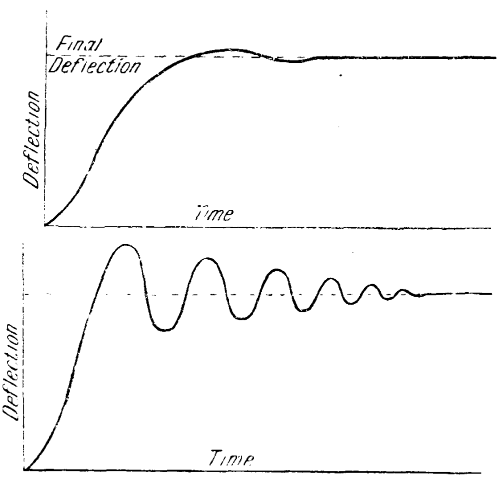
Another cause is the refraction of the waves by reflection by ionized air at high altitudes. The ionic refraction is a variable factor, and to it are attributed the diurnal and annual changes in signal strength. The same causes may tend to, or actually, lengthen or shorten the range of a transmission set. Surface waves such as may be propagated along or through the earth are other contributory causes to this obscure but very real phenomenon. *See* Electron; Fading; Heaviside Layer; Transmission; Valve.

D.C.C. This is the standard abbreviation for the insulated wire known as double cotton covered wire. *See* Double Cotton Covered; Wire.

DEAD BEAT. When the needle of a galvanometer or similar measuring instrument deflects from its zero position it may behave in two different ways. It may take a smart swing from the impulse received, and overshoot the mark owing to the presence of inertia in the moving parts, in which case it first swings beyond its final resting place, retreats to a point somewhat short, and successively oscillates to and fro in swings of diminishing amplitude until it at last comes to rest. Or it may move away from the zero point, on receiving its impulse, in a more sluggish manner, the rapidity of its motion slowing down as it reaches its final deflectional position, beyond which it passes but a very little way, if at all.

In the first case the oscillations may take quite an appreciable time to die away before the needle comes to rest, owing to the absence of any damping effect. In the second case the needle would come to rest very much more quickly, and would be termed "dead beat." There are degrees between these two extremes which do not fall under one heading more than the other.

To the operator it is a great advantage to work with dead-beat instruments when possible, owing to the great amount of time saved in waiting for the needle to come to rest. The only exception to this is when measuring momentary or transient currents, where the value is estimated by the extent of the first swing, and any artificial damping effect would then seriously impair the accuracy of the observations. Also in cases where the currents are rapidly fluctuating a dead-beat

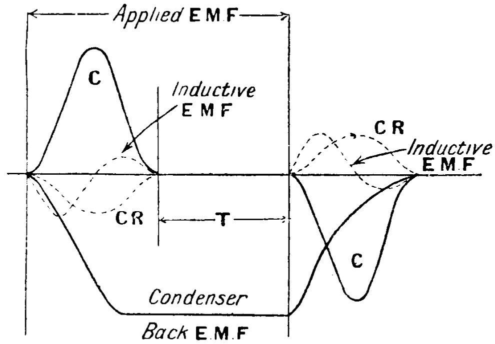


NEEDLE DEFLECTION IN DEAD-BEAT INSTRUMENTS

Fig. 1 (top). Motion of a dead-beat needle is here indicated, the oscillations having been damped. Fig. 2 (below). Damping having been omitted, deflection causes oscillations which slowly die away, as represented by this curve, and the instrument is not dead-beat

movement would be a disadvantage, as it would not respond with sufficient readiness. Fig. 1 represents a dead-beat movement, and Fig. 2 the result of omitting most of the damping effect. *See* Damping.

DEAD-BEAT DISCHARGE. The discharge from a charged condenser may assume either of two characteristics: it may be "oscillatory," or it may be "dead-beat," according to the conditions existing in the circuit itself. The figure shows a circuit containing inductance, capacity, and resistance. If a continuous electro-motive force is now applied to the ends of such a circuit the current variations will take the form shown by the curve C. Energy will first be stored in both the inductance and the capacity, and will be dissipated by any circuit resistance; the curve CR is therefore drawn in opposition to the curve C, indicating that energy is being abstracted instead of stored. As is well known, the inductive or "back" electro-motive force of a circuit acts in opposition to the applied electro-motive force, and another



DEAD-BEAT DISCHARGE OF A CONDENSER

Dead-beat discharge is represented in a circuit containing inductance, capacity, and resistance. The current variations are shown by the curve C. Abstracted energy is represented at CR

curve therefore will need to be plotted, which is indicated accordingly in the diagram, and is partially in a negative and partially in a positive direction.

The reason for the above phenomena is as follows: as the result of the steady increase of back electro-motive force in the condenser exerted by the accumulating charge on its plates, the charging current after rising to a maximum falls to zero again; but as the inductive electro-motive force will always be in opposition to the growth or decay of current—that is, it tends to oppose any change in current value—it first rises to a negative maximum all the while the condenser current is growing, falls to zero when the charging current is momentarily at a stationary value, then reverses its direction and grows to a maximum again as the condenser charging current dies away. Finally, when the latter is at zero there will be no inductive electro-motive force, and this curve will also have arrived at its zero value.

After an interval of time T the external applied electro-motive force is removed, and the back electro-motive force stored up in the condenser starts a current in the reverse direction through the circuit; whereupon the inductive electro-motive force first takes energy from the current, and then returns it, while the resistance present absorbs energy as before until the current ceases to flow. In fact the discharging conditions will be practically the reverse of the charging conditions. Having discharged itself, the condenser is once more inert until it receives another applied electro-motive force, and no further flow of current takes place in either direction in the meantime—in other words, the discharge is "dead beat."

But if the value of the circuit resistance were less than the square root of four times the inductance divided by the capacity, the rise of the current would be greater, and the condenser would discharge more quickly, therefore more energy would be released in the circuit than could be immediately absorbed by the resistance. This excess energy, as a matter of fact, becomes stored in the inductance, which later on returns it to the circuit when the current falls. The result of this condition is that the current does not immediately stop when it reaches the zero value, as it would if it were truly dead beat, but it reverses and recharges the condenser in the opposite direction.

The discharge thus becomes oscillatory in character, and according to the predominance of one or other of the factors inductance, capacity, and resistance, the oscillations may continue for a longer or shorter period of time in a succession of surges which ultimately die away when the condenser is completely discharged.

DEAD CRYSTAL. Name used to describe a crystal without sensitive spots. In appearance there is nothing to distinguish a dead from a sensitive crystal, and a test is the only means of determining the condition. Occasionally a crystal may appear to be dead, especially after a prolonged period of usefulness, when a current has been passed through it, as when a stage of high-frequency amplification is employed. In such cases the fracture of a portion of the crystal will possibly reveal a fresh face with a sensitive spot. There is at present no apparent reason for dead crystals, as according to reported experiments there is no physical, chemical, or optical difference between a good and sensitive crystal and a dead piece, which may incidentally be found in a lump of otherwise efficient mineral. The safest plan is to obtain supplies from reputable dealers who market only those crystals that have been tested for sensitivity. Crystals ought never to be left loose in the experimenter's tool chest or other unsuitable place, or they may become dead, a state that is observable to some extent by the dull and generally lifeless appearance.

This state of affairs is occasionally remediable by cleansing the crystal in alcohol or good petrol, and chipping the surface to reveal fresh and clean facets which may have a sensitive spot.

DEAD EARTH. An expression used with a number of meanings. In one application it is synonomous with a dead short, that is, a complete short circuit.

In wireless the expression may be employed to describe a conductor or conductors that are directly, and often accidentally, connected to the earth or the earth lead. A totally different use of the words has reference to a poorly arranged or inefficient earth connexion, such as wire connected to a painted water pipe, where the paint acts as an insulator and thereby prevents the passage of the current. Consequently the earth is dead, or useless.

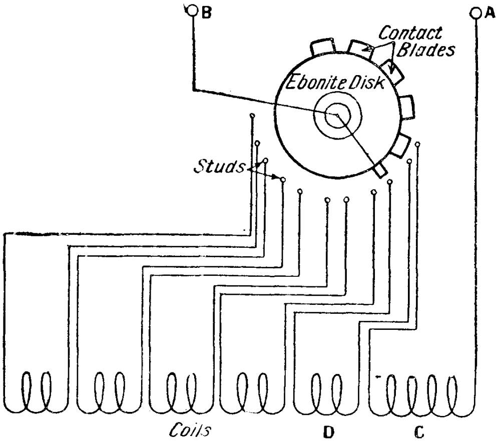
DEAD-END EFFECT. The result on an oscillatory circuit of the presence of idle turns of an inductance. In the ordinary sliding contact tuner, tapped inductances, and so on, there is always present the dead-end effect due to the unused portion of the inductance. This unused part is still in metallic connexion with the part which is being used, and it acts as a small oscillating circuit on its own account.

The effects of such a circuit may be considerable on reaction, and it is more noticeable on large coils than on small. The magnitude of the dead-end effects may be reduced by short-circuiting the unused part of the coil either directly or through a resistance. The use of plug-in, duo-lateral, or other coils wound for the particular wave-length it is desired to receive is a common way of avoiding dead-end effects, since the whole of the inductance is used.

DEAD-END SWITCH. Name given to a switch adapted for cutting out unwanted parts of the windings of an inductance coil. The purpose of any dead-end switch is to control the number of coils that are actually in circuit in an inductance. It follows, therefore, that various methods may be adopted for the purpose. For example, the ends of the wires from each separate section may be considered virtually as tappings and may terminate in sockets and connexions be effected by double-pronged plug-in contacts connecting adjacent ends of the coils, while a single-prong plug is used at one end of the winding and a similar one at the opposite end of the winding of the last coil to be left in circuit.

Such an arrangement is efficient, but necessitates keeping on hand a sufficient number of plug-in contacts, and it is generally more convenient to use the regulation switch. Various commercial patterns are available, but the experimenter can easily construct one in the manner shown in Figs. 3 to 10.

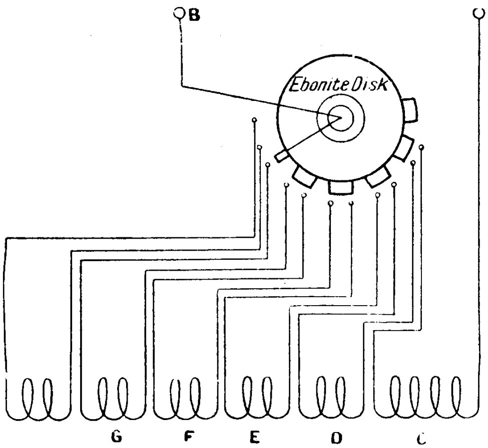
The essential requirements are shown in the form of diagrams in Figs. 1 and 2,



TAPPED INDUCTANCE AND DEAD-END SWITCH

Fig. 1. Inductance with several separate tappings is represented in this diagram, only two coils, C and D, being in use. Contact blades are shown on an ebonite disk. These make contact with the studs to which the coils are wired, thus reducing losses associated with ordinary type inductance switches

which illustrate an inductance with several separate tappings. From this will be seen that the windings of the first coil are taken to a terminal A and a single contact. The inner end of the first coil and the outer end of the second coil are brought respectively to two adjacent contact studs. Each separate coil is treated in the same way. The outer end of the last coil is on a single contact stud. The number of turns of wire in each coil need not be uniform, but may be modified to give either a progressive range of inductance values, or



ACTION OF DEAD-END SWITCH

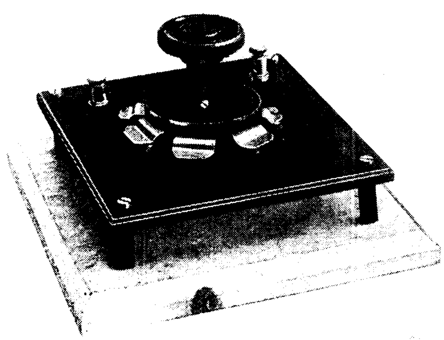
Fig. 2. Contact is in this diagram represented between five of the coils and the terminals A and B by means of the dead-end switch

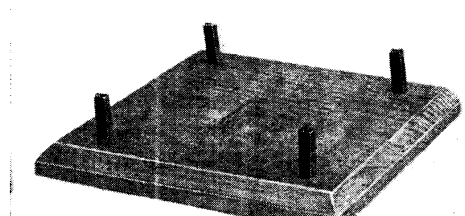
may provide for finer tuning by having coils with few turns of wire in, say, the first three or four sections, and a greater number in the remaining sections. However the coils are arranged, the number and arrangement of tappings is the same in each case. The adjacent ends of each separate coil are brought up to a pair of contact studs. These will be mounted on an ebonite base arranged in a semicircle, and all of the pairs of studs will be uniformly spaced. The switch may be composed of a disk of ebonite free to revolve on a stud fixed to the baseboard. Attached to the edge of the ebonite disk are a number of brass contact blades or plates built up from several pieces of thin, springy copper or brass. A sufficient number of these blades are required to permit of connecting together all the pairs of studs on the switch base when all the coils are used.

With the exception of the first contact blade, they should all be of such width that they will just span across the pairs of contact studs, but the first plate should be half-width, as it only has to make contact with one stud. A study of the diagram Fig. 2 shows the effect of moving the ebonite disk to two different positions.

In Fig. 1 only two coils, C, D, are in circuit in the inductance. In the other diagram, Fig. 2, five coils, C, D, E, F, G, are in circuit. The only connexion that is made between the contact blades and the studs on the switch base is that between the narrow or first blade and the spindle, as by following the diagram, Fig. 1, it will be seen that the current enters by the aerial terminal A, and flows from there to the first two coils, C, D, and reaches the terminal B via the narrow blade and the contact made through the stud on the connecting wire which connects it to the end of coil D. The remaining coils in the inductance are entirely disconnected from the circuit. Further movement of the switch to the position shown in Fig. 2 puts five coils in circuit, and it will be seen that the single contact blade connexion completes the circuit through the fifth coil to the terminal B, consequently any number of coils can be introduced into the circuit as required.

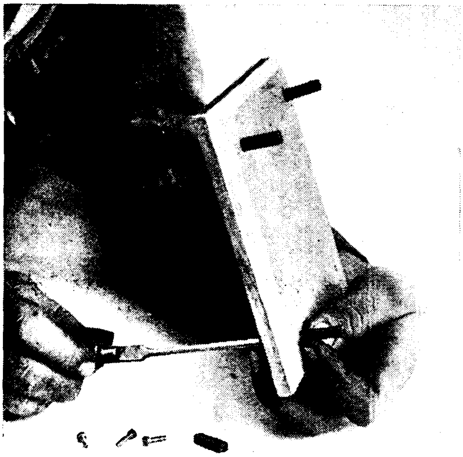
As far as construction is concerned, it should be remembered that the switch has to deal with high-frequency currents, and therefore it should be constructed throughout with good quality ebonite, as in Fig. 3, and the surface well matted. The base, Fig. 4, may be about 6 in. square, and

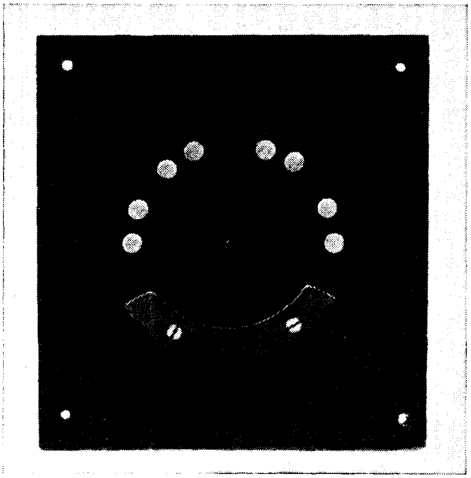




COMPLETE DEAD-END SWITCH AND ITS BASE

Fig. 3. Broad contact pieces are fitted to the dead-end switch shown in this photograph. These are wide enough to make contact with two studs at a time. On the left will be seen one narrow contact piece, making contact with only one stud. Fig. 4. The wood base and ebonite supporting pillars of the switch are shown. The base is about 6 in. square, and the pillars $\frac{3}{4}$ in. in height





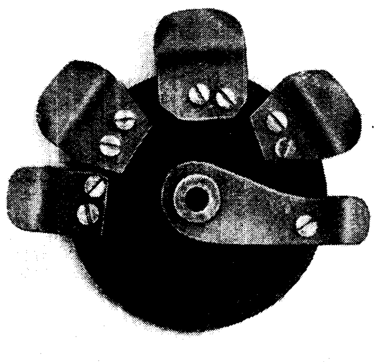
HOW TO MAKE UP A DEAD-END SWITCH

Fig. 5 (left). Pillars of the dead-end switch are here being assembled on the base. The operator is inserting a screw from the underside. Each pillar contains two screws separated by solid ebonite. Fig. 6 (right). The ebonite base, with contact studs fitted and the centre hole drilled and tapped.

should be mounted on four pillars of ebonite, attached to a sub-base of hardwood. The pillars may be about $\frac{3}{4}$ in. in height, and are connected by two screws. One of the screws passes through the ebonite base into the upper part of the pillar, and the second screw through from the underside of the sub-base into the lower part of the pillar, as shown in Fig. 5. These two screws should not touch, but should be separated by solid ebonite.

The next step is to drill a hole through the centre of the ebonite base for the central stud, which may be made from a piece of plain brass rod, screwed at the lower end and tapped into the centre hole in the ebonite, and locked to it by means of a lock nut on the underside. The upper part may be screwed and provided with a small spring washer and nut. The holes for the contact studs are next marked out by means of a scriber, drilled, and the contact studs fitted to them. The corners of these studs should be rounded off slightly and the upper surface polished perfectly smooth. The studs should project from the underside sufficiently to permit of soldering the leads from the inductance coils.

A quadrant of ebonite, shown in Fig. 6, equal in thickness to the height of the studs, is prepared and screwed to the upper side of the base with two small, countersunk brass screws tapped into holes in the base. The next process is to turn up a disk of ebonite, $2\frac{3}{4}$ in. in diameter, with a hole in the centre so that it can turn freely on the centre stud. The edge of this disk should be rounded slightly. The contact blades have next to be made from hard copper, or phosphor-bronze, and screwed to the underside of the disk at the correct spacings, as illustrated in Fig. 7. It should be noted that these plates or contact arms are bent over at the ends, and are carefully filed so that they bear evenly on the two

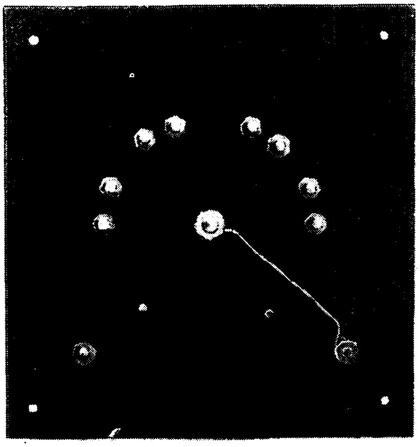


UNDERSIDE OF SWITCH DISK

Fig. 7. Contact pieces are screwed to the underside of the ebonite disk. Note that the right-hand contact piece is smaller than the other four, it being the actual controlling contact

contact studs, and that they raise the ebonite disk slightly.

A single dummy contact arm is fixed diametrically opposite the single contact



CENTRE CONNEXION OF DEAD-END SWITCH

Fig. 8. On the underside of the panel the central connexion is wired to one of the terminal legs, the wire being held at both ends by the nuts

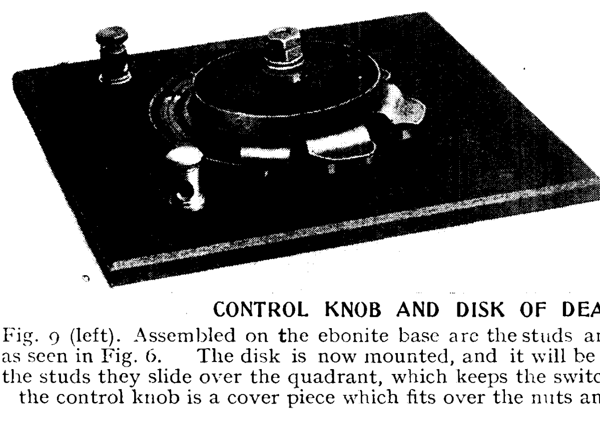
blade, and is merely used to bring pressure on the spring on the centre stud. It bears on the ebonite quadrant and keeps the switch level. Two terminals are then fixed at the front part of the base, and one of them connected by means of No. 18 tinned copper wire to the centre stud, as shown in Fig. 8. The single narrow contact plate should extend to the centre of the disk, but all of the others are short.

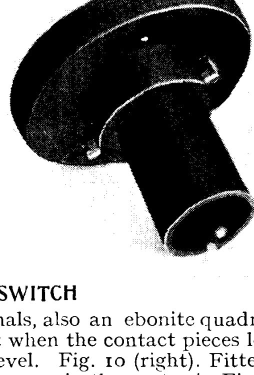
To ensure a good contact between the narrow blade and the stud, the disk of ebonite should be bushed with brass, and then the bush soldered to the contact blade. The bush should be long enough to extend slightly below the contact blade, and should project about $\frac{3}{16}$ in. above the upper surface of the switch disk.

The switch may be assembled by placing a thin brass washer over the centre stud, so that it rests flat on the ebonite base. The switch disk, complete with its contacts, is then placed over the centre stud, a brass washer slipped over it, next a spring washer, and finally, another washer and two lock nuts, as shown in Fig. 9. The tension of the spring is adjusted by these until the switch disk can be turned easily but without the least trace of shake. The contact should be tested by a small battery and buzzer, or any other convenient means, to be certain that perfect contact is made in all possible positions of the switch.

As the projection of the centre stud with the end of the spring washer would be objectionable it should be covered by means of a hollow ebonite knob. This, as shown in Fig. 10, can be turned from a solid piece of ebonite, or may be constructed of a piece of tube and a flat plate or a knob, and when completed the whole may be secured to the disk with two brass screws passed through holes drilled in the walls of the tube and tapped into the bush on the switch disk. The edge of the cap can be knurled to provide a grip.

If desired, this switch can be mounted on a panel, or may be used as a separate unit. If intended for panel mounting, instead of using a fixed stud in the centre of the baseboard, the switch disk may be made up as if it were a condenser dial and knob, and the panel bushed to receive a spindle, which can be rigidly attached to the disk, and contact preserved with a spring washer and nut as before. The underside of this disk will be provided with contact plates in the way already described and works in a similar manner.





CONTROL KNOB AND DISK OF DEAD-END SWITCH

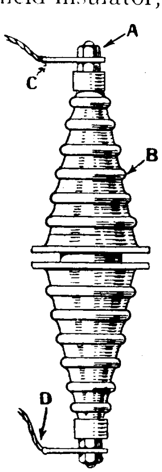
Fig. 9 (left). Assembled on the ebonite base are the studs and terminals, also an ebonite quadrant, as seen in Fig. 6. The disk is now mounted, and it will be seen that when the contact pieces leave the studs they slide over the quadrant, which keeps the switch knob level. Fig. 10 (right). Fitted to the control knob is a cover piece which fits over the nuts and washers seen in the centre in Fig. 9

Alternatively, the whole can be arranged within a cabinet and operated by a knob attached to the outside end of the spindle, the inner end of it being attached to the switch plate. In the latter case pointers should be attached to the knob and the panel calibrated, so that the position of the single contact blade may be known, and the amount of inductance or number of coils in use be clearly indicated by the calibrations.

Other forms of dead-end switch include those of the barrel type, with contact plates attached to the surface of the cylinder, and completing the circuits through the medium of vertical brushes attached to the ebonite baseboard. In others, two concentric rows of contact studs are disposed about a centre stub whereon rotates a circular switch plate or disk similar to the foregoing. *See* Switch.

DEAD SPACE. Term applied in connexion with the special case of beat reception in which no beats are audible owing to the two frequencies being identical or very near together. *See* Beat Reception.

DECK INSULATOR. Type of insulator used on board ships for insulating the aerial at the point where it is led through the deck or roof of the operating cabin. One such well-known type of insulator is the Bradfield insulator, described under that heading in this Encyclopedia. The figure shows another form of deck insulator. It consists of a brass rod, A. Surrounding this rod are a series of tapering insulating fins, B, of electrose, forming two conical halves, one being fixed below deck and the other above. Threaded collars are used to draw the two halves of the insulator together on to rubber washers, which ensure a watertight joint. The lead-in from the aerial is soldered to the upper lug at C, and the connexion to the instruments to the lower lug, D. *See* Bradfield Insulator; Lead-in.



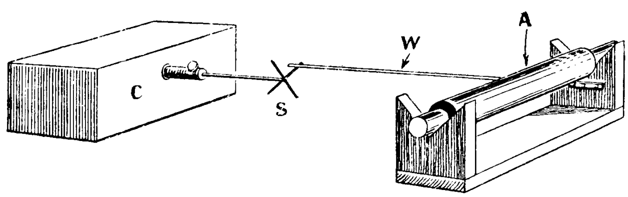
Two corrugated cones are joined with a rubber washer between, in deck insulators used on ships

DECOHERER. Device to tap or vibrate a coherer. It is well known that various metallic filings and borings, when enclosed in a glass tube or otherwise kept in contact, cohere or stick together when brought under the action of electromagnetic waves.

Certain metals, however, show the reverse action, and Professor Bose has demonstrated that if potassium or arsenic powder is confined between two metal electrodes and its electrical resistance measured, this resistance will increase when the powders are subjected to a wireless wave. This is therefore a case of metals which are decoherers.

The various forms of mechanical appliances used to vibrate coherers are better known, however, as decoherers.

A single blow or tap with a pencil on a coherer tube will effectively shake apart the filings, but for anything other than experimental working it is necessary that this action should be automatic, and that immediately the particles have cohered they should be shaken apart. This cohesion and decohesion should go on automatically and rapidly as long as the coherer is being subjected to a wireless wave, and the coherer should stay in its high-resistance state with its particles well shaken apart as soon as the wave ceases.



EARLY FORM OF DECOHERER

Fig. 1. Sir Oliver Lodge carried out experiments in the early days of decoherers with a device made on the lines indicated above, which is operated by clockwork

The earliest decoherers to be used were either electric vibrators of the bell type, or mechanical ones depending on a clockwork-driven cogwheel rubbing on a spring attached to the coherer or its stand.

Lodge employed the latter—Fig. 1, in which C is a clockwork motor driving a four-bladed spider wheel, S. The tips of the spokes of this wheel were arranged so that they just touched the tip of a long arm of whalebone, wood, or ebonite, W, which was rigidly attached to one of the V blocks in which the coherer tube, A, rested.

Lodge preferred the mechanical vibrator to the electrical because of the absence of the small sparks produced at the bell contacts, which he found affected his coherer.

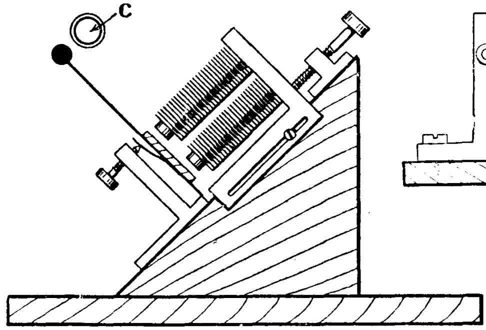
Popoff and Marconi both employed the electrical method, having a relay connected in series with the coherer, so that when the coherer closed the circuit of the relay the tapper started.

In the Marconi apparatus a very sensitive relay of about 1,000 ohms was connected in series with the coherer and additional external resistances, whilst a single dry cell provided the direct current which passed through the coherer and relay.

The tapper (Fig. 2) was mounted on a wedge-shaped block so that it could readily be adjusted to strike the underside of the coherer, C.

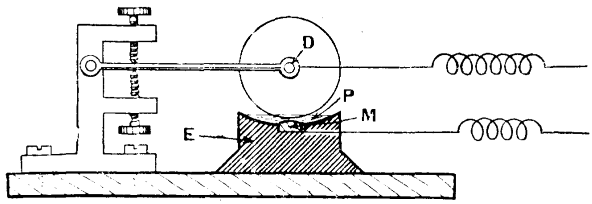
In the Lodge-Muirhead mercury coherer (Fig. 3) a small steel disk, D, having carefully rounded edges, was mounted over an ebonite cup, E. In the bottom of the cup, E, was a small hole which held a pellet of mercury in light contact with the disk. The disk was slowly revolved by clockwork. A few drops of paraffin oil were then placed in the cup, forming a film over the surface of the mercury and also on the steel disk. When a wireless wave passed, the film of oil broke down and the disk and mercury cohered. As soon as the wave passed the revolving disk carried the paraffin over the surface of the mercury, thus effecting decohesion.

S. G. Brown employed alternating current magnetic fields to produce decohesion in iron filings, both by passing alternating currents through field coils placed near the iron filings, and by rotating permanent magnets over the coherer tube. *See* Coherer; Crystal; Lodge Coherer; Valve.



ELECTRICAL METHOD OF DECOHERING

Fig. 2. Mounted on a wedge-shaped block is a tapper which, being adjusted, strikes the coherer, C. This method was employed in the experiments of Marconi and Popoff



LODGE-MUIRHEAD MERCURY COHERER

Fig. 3. Beneath the disk, D, is a mercury pellet, M. These two are separated by a film of paraffin oil, P. The disk is rotated by Morse clockwork. Cohesion occurred when a wireless wave, passing, broke down the film of oil, and immediately following, when the film of oil was replaced by the disk, decohesion occurred

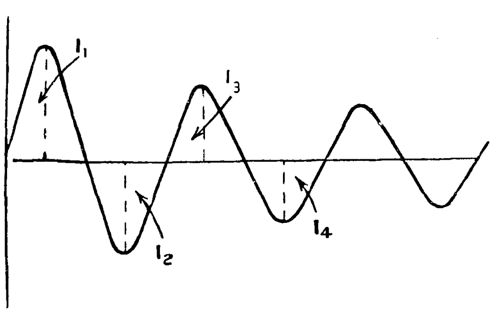
DECREMENT. The decrement of an electrical oscillation may be defined as a measure of the rate of its decay under the influence of damping. Owing to its important effects on tuning at the receiving station it is necessary to have a knowledge of its value from a mathematical standpoint, in order that transmitting apparatus may be so designed as to radiate its energy in the most efficient manner possible.

In any train of damped oscillations, such as may be set up by the discharge of a condenser through a suitable circuit, it is found that a constant ratio exists between the maximum amplitudes of every successive half-cycle. In other words, the ratio of the first to the second is the same as that of the second to the third, and so on.

This may be expressed as follows:

$$\frac{I_1}{I_2} = \frac{I_2}{I_3} = \frac{I_3}{I_4} \quad . \; . \; . \; . \; . \; . \quad \frac{In - 1}{In}$$

where I_1, I_2, etc., represent the highest value of each half-oscillation as shown in the figure.



DECREMENT OF ELECTRICAL OSCILLATION

This diagram serves to illustrate the rate of decay of damped waves

It has been proved that the value of I decreases in accordance with a logarithmic law, and the constant difference between the Napierian logarithms of two successive half-cycles is known as the logarithmic decrement. This is usually represented by a letter of the Greek alphabet: δ (delta).

Thus $$\frac{I_1}{I_2} = \epsilon^{\delta}$$

where ϵ is the base of the Napierian system of logarithms, or

$$\delta = \log_{\epsilon} \frac{I_1}{I_2}$$

The generally accepted method of determining δ is to consider the ratio of one maximum amplitude to the next in the opposite direction, giving the decrement per half period, but in some instances it is based on the ratio of two successive maximum amplitudes in the same direction, in which case the decrement per complete oscillation is obtained.

Reducing Decrement Losses

The value of this constant for a particular circuit is dependent upon its radiating properties and its resistance, and in the case of coupled circuits is still further modified by the degree of coupling. Thus the "plain" aerial system is productive of groups of oscillations of high decrement, owing to its excellence as a radiator and its high resistance, chiefly contributed by the spark gap. Radiation itself is the ultimate aim of the transmitting apparatus, and decrement, on this account, cannot be avoided, but the losses due to resistance may be kept to a low value by the use of an ample gauge of wire in the aerial and by an efficient earthing system.

A further reduction still can be gained by employing a two-circuit transmitter, in which the high resistance of the spark gap is removed from the aerial and placed in a closed circuit. The latter is but a poor radiator, and provided it is supplied with a suitable spark gap it is capable of generating groups of oscillations of which the decrement is a small value.

By coupling this circuit to the aerial, its energy is transferred to the open oscillatory circuit, and the resultant radiated waves will be of a greater persistency than in the case of a "plain" aerial. If, however, too tight a degree of coupling be used, some of the energy is transferred back to the closed circuit, owing to the fact that the spark, in taking an appreciable time to die away, maintains the gap in a conductive state, and permits a considerable interaction between the two circuits. This means that some of the energy is lost to the aerial, and the amplitude of the radiated waves suffers accordingly.

Further, instead of a pure wave form, two distinct wave-lengths are emitted. This interaction may be avoided by the use of a quenched spark gap and by loosening the coupling, so that once the primary has energized the aerial, its own circuit is broken, leaving the aerial to oscillate to its own natural frequency.

It is clear that if a detector in the receiving circuit requires oscillations of a certain amplitude to operate it, a train of oscillations whose decrement is high will contain all its energy, as far as the receiving station is concerned, in the first few oscillations only. Accordingly, these must be of a large amplitude if they are to operate the receiver with as much effect as a greater number of smaller but more regularly occurring impulses, entailing the necessity for a greater primary power to signal over a given range; or, conversely, a shorter effective range is obtained with a given power. In addition, the receiving aerial will be excited by shock and will tend to oscillate at its natural time period, without regard to the frequency of the incoming waves, involving flat tuning, with its attendant evils, the difficulty of eliminating interference and loss of selectivity.

Calculation of Decrement

The majority of formulae for the calculation of the logarithmic decrement of circuits are of a very complex nature, but the following are useful in giving some idea of how it varies in accordance with the principles already discussed.

In a circuit which does not radiate and is not coupled to another

$$\delta = \frac{R}{4nL}$$

where R is the high-frequency resistance, L is the inductance and n the frequency;

but $$n = \frac{1}{2\pi\sqrt{CL}}$$

and by substitution we have

$$\delta = \frac{\pi}{2} R \sqrt{\frac{C}{L}}$$

in terms of capacity and inductance.

Owing to the widely different natures of open and closed circuits, it is to be expected that the decrement of each varies considerably, and the resultant decrement of the radiated waves depends upon a combination of these two and the degree of coupling employed.

$$D_1 = \frac{\delta_1 + \delta_2}{2\sqrt{1-K}}$$

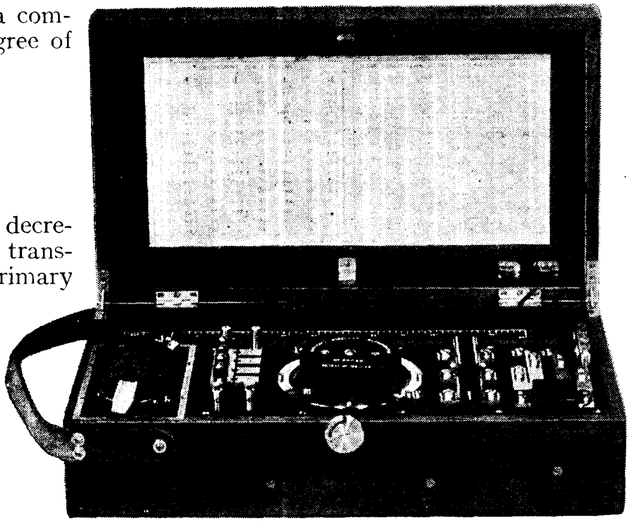
$$D_2 = \frac{\delta_1 + \delta_2}{2\sqrt{1+K}}$$

where D_1 and D_2 represent the decrement of the two wave-lengths transmitted, δ_1 and δ_2 that of the primary and aerial circuits, and K the coefficient of coupling.

To calculate the number of oscillations per train, the following formula may be used

$$m = \frac{4{\cdot}605 + \delta}{\delta}$$

It is assumed that the oscillations are completely damped when the ratio of first to last equals 100.—*E. C. Saker.*



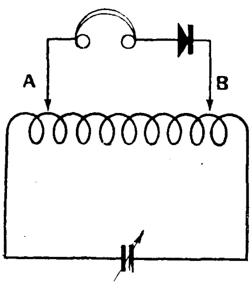
DECREMETER COMPLETE IN CASE

Fig. 2. With certain modifications of calibration, this instrument is designed like a wavemeter. It is used for measuring the logarithmic decrement of an oscillation

Courtesy Marconi's Wireless Telegraph Co., Ltd.

DECREMETER. Instrument for measuring the logarithmic decrement of an oscillation. In design it is merely a wavemeter with certain modifications as regards methods of calibration. Fig. 1 shows the circuit of the instrument, and Fig. 2 a typical instrument. The principles of the operation of a decremeter are as follows:

If the coil be coupled to the circuit whose decrement it is desired to measure, an E.M.F. will be induced across the ends of the coil, giving rise to an oscillating current, which can be detected by the action of the crystal and the telephones. To produce a given signal strength, which for purposes of easy comparison may be taken as that which is just audible, the two movable contacts, A and B, must be placed across more turns of the coil if the current is a small value than if it is large, due to the potential drop across each turn varying with the strength of the current (the resistance of the coil being constant). Thus the number of turns used is a measure of the current flowing in the meter, and C, the current, varies inversely with n, the number of turns.



DECREMETER DIAGRAM

Fig. 1. Circuit diagram of a decremeter. A and B are movable contacts. The coil is coupled to the circuit whose decrement is to be measured

With the movable contacts A and B at extreme ends of coil, tune the meter to the same wave-length as the circuit under consideration. Reduce the distance between A and B until the sound is only just audible in the telephones, and note the number of turns between them and the setting of the condenser. Slightly alter adjustment of the condenser, and again take just enough turns to obtain an audible sound in headphones. More turns will be required, owing to decrease in current due to the meter now being mistuned. Again note number of turns and setting of condenser.

The following formula gives the decrement:

$$D + \delta = \frac{\pi\,(1 - \lambda_1/\lambda_2)}{\sqrt{(C_1/C_2)^2 - 1}}$$

where

- D is decrement it is required to measure,
- δ that of decremeter, which can be made of very low value and neglected,
- C_1 is current in meter when tuned to resonance,
- C_2 is current when slightly mistuned,
- λ_1 is wave-length of meter at first setting, and
- λ_2 wave-length at second.

By definition, λ varies as $\sqrt{KL}$, but as inductance of coil is fixed, λ varies as $\sqrt{K}$, where K is the capacity and L the inductance.

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{\sqrt{K_1}}{\sqrt{K_2}}$$

and, as shown above, C varies as $\frac{1}{n}$

$$\therefore \frac{C_1}{C_2} = \frac{n_2}{n_1}$$

Substituting in original formula, we have

$$D = \frac{\pi(1 - \sqrt{K_1/K_2})}{\sqrt{(n_2/n_1)^2 - 1}}$$

The values of capacity and number of turns can now be substituted and D calculated.

DE FOREST, DR. LEE. American wireless expert. Born at Council Bluffs, Iowa, 1873, he early took an interest in wireless subjects. Originally he worked with a small arc of the Poulsen type, and established communication over short ranges. In 1900, while experimenting with an electrolytic detector for wireless signals, he happened to be working by the light of a Welsbach burner. He noticed that the light varied in intensity as he operated his spark transmitter. Though he quickly discovered the phenomenon was due to acoustics and not wireless waves, it led him to investigate the properties of the Bunsen flame.

He used two platinum electrodes fixed closely together in the flame. To the electrodes was connected a circuit containing an 18-volt battery and a telephone receiver. Later he employed two incandescent lamp filaments in one bulb, from which he developed the hot filament and the cold positively charged plate or anode. This was the two-electrode valve. These experiments led De Forest to add the third electrode or grid, which has revolutionized wireless telegraphy and telephony. De Forest has been responsible for a large number of patents in connexion with wireless transmission. He has developed a successful alternating current system of spark wireless telephony.

In 1902 he founded the De Forest Wireless Telegraph Co., and the De Forest Radio Telephone Co. in 1907. He was awarded the gold medal at the St. Louis Exhibition in 1904 for his telegraphic work. De Forest is the author of many papers on his valve and methods of transmission.

DR. LEE DE FOREST

De Forest invented the three-electrode valve. The introduction of the third electrode, or grid, revolutionized wireless telegraphy and telephony. He has been responsible for many other improvements in wireless apparatus

DE FOREST COILS. A type of honeycomb coil named after Dr. L. De Forest. They are extensively used for inductances, and each coil is provided with a plug-in connexion to facilitate the interchange of one size or value of coil for another. The contact studs are adapted to fit into suitable coil holders (*q.v.*), which, to give the best results, should be adjustable so that the coils can be moved nearer to or farther from one another when it is desired to use two or more for reaction purposes.

The special feature of these coils is the arrangement of the windings, which, although somewhat like the usual honeycomb arrangement, differs in that these coils are wound on the duo-lateral principle, and are so arranged that parallel wires in alternate layers come between those of the preceding and following alternate layers. The result is that the layers are not directly over one another in the sense that they would be if merely wound around a former and the successive layers superimposed. The wires are wound in a diamond-shaped pattern, and the turns of one layer always cross those of the preceding layer at an angle. The claims are that these coils have a minimum distributed capacity and a high efficiency.

The appearance of the coils is shown in the illustration, which also shows that the winding is commenced on a circular former which has a standard width of 1 in. and a diameter internally of 2 in. The outside diameter varies according to the size of the coil, and ranges from $2\frac{1}{4}$ to $4\frac{1}{2}$ in. diameter. The windings are protected by a band of insulating material attached to the ebonite block which holds contact plug and socket.

The coils are known by numbers, and those of greatest use to the experimenter range from No. 25 to No. 1500.

When used in conjunction with the average P.M.G. aerial and in shunt with a variable air condenser of ·001 mfd. capacity, the approximate inductance values and wave-length range is given in the following table :

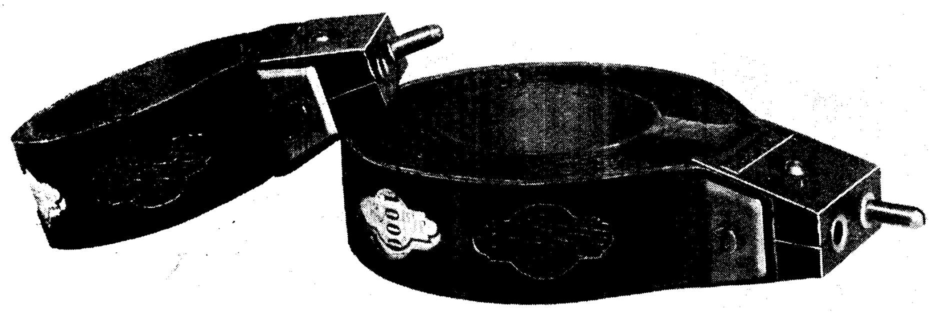
INDUCTANCE VALUES AND WAVE-LENGTH RANGES OF DE FOREST COILS

Coil No.	Inductance Microhenries.	Wave-length Range.
25	40	130 to 375
35	75	180 ,, 515
50	150	240 ,, 730
75	300	330 ,, 1,030
100	600	450 ,, 1,460
150	1,300	660 ,, 2,200
200	2,300	930 ,, 2,850
250	4,500	1,300 ,, 4,000
300	6,500	1,550 ,, 4,800
400	11,000	2,050 ,, 6,300
500	20,000	3,000 ,, 8,500
600	40,000	4,000 ,, 12,000
750	65,000	5,000 ,, 15,000
1,000	100,000	6,200 ,, 19,000
1,250	125,000	7,000 ,, 21,000
1,500	175,000	8,200 ,, 25,000

When it is desired to use several of these coils in a circuit, as, for example, a three-coil arrangement with a primary coil, a secondary coil, and a reaction coil, the following are given as suitable under normal conditions with an average aerial and the primary condenser having a value of ·0015 mfd. and the secondary condenser ·001 mfd. The coils will then generally respond to the following wave-length ranges, the condensers being used in series.

Wave-length Range.	Primary Coil.	Secondary Coil.	Reaction Coil.
150 to 350 metres	35	25	35
300 ,, 700 ,,	75	50	35
630 ,, 1,600 ,,	150	100	75
800 ,, 1,900 ,,	200	150	100
1,400 ,, 2,800 ,,	300	250	100

DELLINGER, J. H. American wireless expert. Born at Cleveland, Ohio, 1866, and educated at the High School there, and at the Western Reserve and George Washington Universities, he became instructor of physics at the former university in 1906. In 1907 he was appointed to the Bureau of Standards. Dellinger has carried out a number of important researches in electricity, notably in wireless, and he was appointed head of the Radio Laboratory of the Bureau of Standards. He is the author of a number of well-known books on wireless telegraphy and telephony as well as numerous papers. In 1921 he was appointed as a delegate at the Inter-Allied Conference in Paris on Radio Communication, and in 1922 Secretary of the United States Government Radio Committee. Dellinger is a member of a large number of scientific societies, including the American Physical Society.



DE FOREST PLUG-IN TYPE COILS

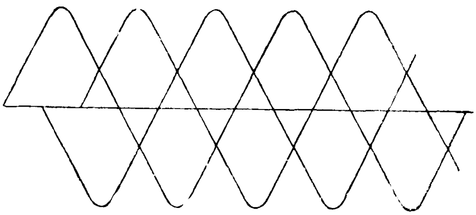
Honeycomb coils as illustrated above are named after the American inventor Dr. Lee De Forest. They are made in various sizes, and are constructed for plug-in connexion on the usual principle of alternate projecting leg, or plug, and socket

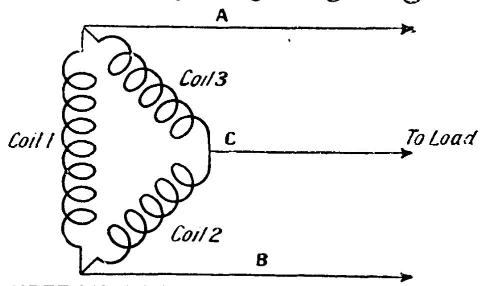
Courtesy Igranic Electric Co., Ltd.

DELTA CONNEXIONS or GROUPING.

If three coils mounted symmetrically round a shaft are rotated in a magnetic field, an alternating voltage of the same amplitude is induced in each coil. There would, however, be a difference of phase of 120° between each pair of coils. Such a combination is called a three-phase system, and the induced E.M.F.'s can be represented by curves shown in Fig. 1.

A method of connecting the three coils of the simple alternating current generator is that known as the mesh or delta connexion, and consists of connecting the rear end of coil 1 to the front end of





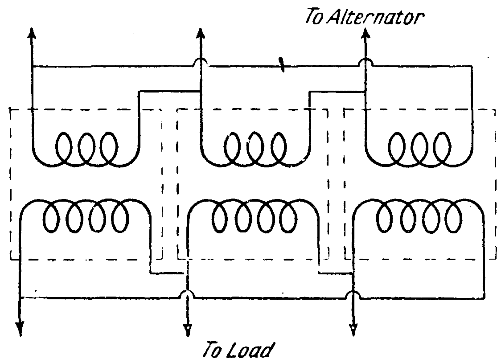
THREE-PHASE SYSTEM AND INDUCED E.M.F.

Fig. 1 (above). Electro-motive force induced in a three-phase system is represented by this curve. Fig. 2 (below). Three coils symmetrically mounted around a shaft rotating in a magnetic field as shown constitute delta grouping

coil 2, the rear end of coil 2 to the front end of coil 3, and the rear end of coil 3 to the front end of coil 1. A closed circuit is thereby formed, the connexions being taken as in Fig. 2.

If the E.M.F.'s of the coils at any instant are added together, the result is zero—that is, the sum of the E.M.F.'s of any two coils is equal and opposite to the E.M.F. of the third coil; hence the line voltage will be equal to the phase voltage. The current in each line is the sum of the currents in two coils, or the current flowing out of line A is the vector difference between the currents in coils 1 and 3 and equals $\sqrt{3}\, I_1$.

Three-Phase Transformers. Instead of the three-phase alternator being connected directly to the load, a three-phase transformer can be included in the circuit to transform the generator voltage to either a higher or lower value. This can be accomplished by the use of three single-phase transformers connected as shown in Fig. 3. It should be noted that both the primaries and the secondaries are delta-connected. In the delta method of

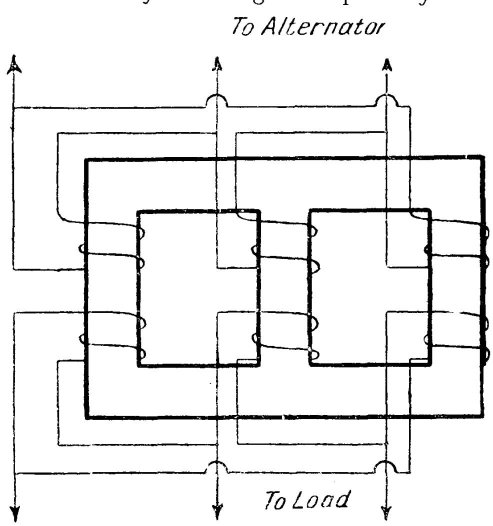


DELTA CONNEXIONS IN THREE-PHASE TRANSFORMERS

Fig. 3. Three single-phase transformers are here connected as a three-phase transformer, taking the place of a three-phase alternator connected directly to the load

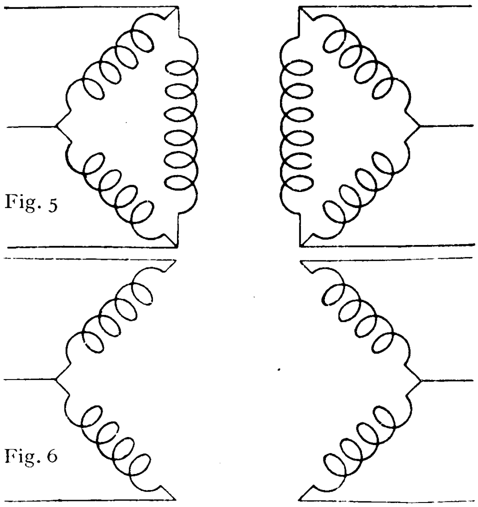
connecting transformers the ratio of transformation of the line voltage will equal the ratio of the primary to the secondary turns.

A three-phase transformer can be constructed by winding the primary and



THREE-PHASE TRANSFORMER COILS

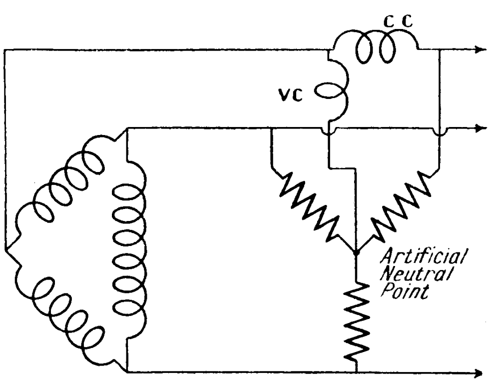
Fig. 4. Three-limbed iron core is represented in this diagram, with the limbs wound separately for the three phases of a transformer. Connexions are made on the delta method



TWO METHODS OF CONNECTING TRANSFORMERS

Fig. 5 (above). Delta method of connecting primary and secondary windings of a three-phase transformer. Fig. 6 (below). Two transformers only are required in this case, which is another method of connecting a three-phase transformer

secondary coils for each phase on a separate limb of a three-limbed iron core as shown in Fig. 4. The primary and secondary coils can then be either star or delta connected. Fig. 5 shows the delta method of connecting both the primary and secondary windings of a three-phase transformer.



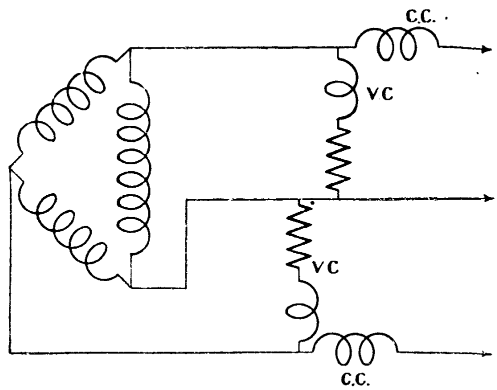
POWER MEASUREMENT OF DELTA-CONNECTED SYSTEM

Fig. 7. Three high resistances are connected as shown in this diagram for the purpose of employing one wattmeter only to measure the power in a balanced delta-connected system

A new method of connecting three-phase transformers is that shown in Fig. 6, only two transformers being required. The three-phase supply is maintained by virtue of the phase difference between the two secondaries being the same as that between the two primaries.

Three-Phase Power. The power in the three-phase system is equal to the sum of the powers in the three phases, and equals $\sqrt{3}E_L I_L \cos\theta$, where E_L is the line voltage, I_L the line current, and $\cos\theta$ is the phase difference between the coil voltage and the current.

If the system is a balanced one—that is, equal power in each of the three phases—then, provided the neutral point is available, one wattmeter can be used, the total power being obtained by multiplying the reading by three. In a delta-connected system an artificial neutral point is provided by three high resistances connected together in star form. The



MEASUREMENT BY TWO WATTMETERS

Fig. 8. Circuits of a three-phase system being seldom balanced exactly, a method as here shown is usually adopted for power measurement by the use of two wattmeters

connexions for employing one wattmeter to measure the power of a delta-connected system are shown in Fig. 7.

It is seldom, however, that the circuits of a three-phase system are exactly balanced, and the usual method of measuring the total power is by the use of two wattmeters. The method of connecting two wattmeters is shown in Fig. 8. Generally the volt coil of each wattmeter is mounted on a common spindle, and the wattmeter is provided with one scale calibrated to read the total power independently of the balance or wave-form.

DENNIS DETECTOR. Well-known form of crystal detector largely used in the Signal Service. The detector is, in reality, three detectors in one. The three crystals are separately mounted on an ebonite base on pillars provided with brass pegs which project from a circular ebonite base, to which the pillars are fastened. The brass pegs make contact through springs on a square ebonite panel to which the circular base is attached. A circular ebonite cap fits over the pillars, and this cap may be locked in position and then rotated to bring each crystal in turn into operation. The tops of the pillars are removable, and carry crystal cups screwed into them, so that the crystals may quickly be interchanged. Carborundum–steel, and zincite and pyrites are the usual crystals used with this form of detector.

DENSITY. The amount of matter in a given volume of a substance. Absolute density is the amount of matter in unit volume of a substance; relative density, or specific gravity, is the ratio of the mass of a given volume of a substance to the mass of the same volume of another substance usually taken as standard. In actual practice the specific gravity of substances, *i.e.* the relative density, is the only thing that is used.

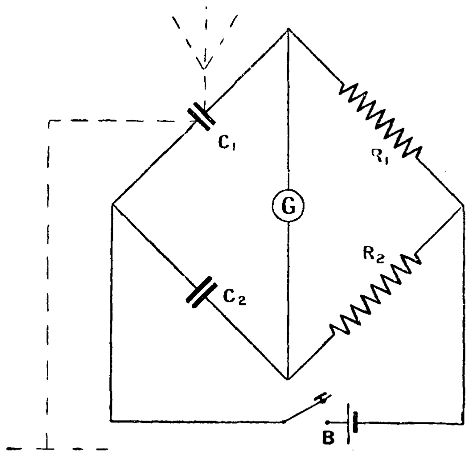
The term is also used in electricity in such expressions as current density, flux density, etc., dealt with under their proper headings. *See* Specific Gravity.

DEPOLARIZATION. Term used in electricity to denote the more or less complete removal of the polarizing ion, in practice, hydrogen, from an electric cell. The most effective method of depolarization is to substitute a harmless ion for the hydrogen ion, as in the case of the Daniell Cell. *See* Depolarizer.

DEPOLARIZER. The substance employed to check the local action in primary cells due to the formation of bubbles of hydrogen on the negative plates. These bubbles are produced by the interaction of metallic impurities, which set up minute currents in the negative plates, with the result that the polarity of the cell is modified. The process can be checked by amalgamation with mercury.

Other methods of depolarization are: (1) oxidation of the hydrogen by potassium bichromate, as in the bichromate battery, or by nitric acid, as in the Grove and Bunsen batteries; (2) substitution of the hydrogen by some other substance which does not give a counter electro-motive force of polarization, as in the Daniell cell by replacing the copper in the copper sulphate by the hydrogen, with the result that the copper is deposited on the positive pole. Here the depolarizer is $CuSO_4$. In the Leclanché cell the depolarizer is a packing of manganese dioxide and crushed carbon round the carbon rod. The same method is adopted in the so-called "dry" cells.

DE SAUTY BRIDGE. Resistance method of measuring the capacity of a condenser. The figure shows the form of the bridge. C_1, C_2 are two condensers, R_1,



DE SAUTY METHOD OF CAPACITY MEASUREMENT

Condenser capacity can be measured by an arrangement of resistances as here indicated, which is known as a De Sauty bridge

R_2 two variable resistances, G a galvanometer, B a battery and key.

The condenser C_2 is of known capacity, and C_1 is the capacity it is required to find. The resistances R_1, R_2 are variable, and the ratio of the two is varied until there is no deflection in the galvanometer when the battery circuit key is closed. Under these conditions,

$$C_1R_1 = C_2R_2$$

an equation which gives C_2 in terms of the known capacity and the two known resistances.

A telephone receiver may be substituted for the galvanometer, and the battery replaced by a battery and buzzer. The resistances are then adjusted until the least sound is heard in the telephones, when the same equation holds. The De Sauty bridge is also useful for measuring the capacity of an aerial circuit, the aerial and earth wires being substituted for the unknown condenser in the way indicated by the dotted lines. The known condenser should be chosen, if possible, with a capacity approximating to the capacity it is required to find. *See* Capacity.

DETECTOR. An appliance for converting high-frequency oscillating current (or voltage) into a form capable of affecting an instrument such as a telephone receiver or galvanometer.

As the ether waves associated with wireless work cannot affect the ear directly, they can only be detected by some change they effect in a material substance, and all devices for detecting such waves are instruments for the detection of high-frequency currents or high-frequency oscillations of potential. For them to be effective and operative they are generally connected in a suitable manner to an aerial. The function of the aerial is to collect the ether waves and convert them into alternating currents, enabling them to be detected.

The fluctuating electric and magnetic forces which constitute the wave set up high-frequency currents in the wire, and the function of the detector is to indicate to the observer the nature of the induced current, or if there be a feeble oscillating current set up in the wire, or if an oscillation of potential is set up across any capacity in it.

Many devices have been invented to do this. Those mostly employed in wireless work are the numerous forms of the crystal detector, and the thermionic valve. These and other detectors are dealt with at length under their respective headings in this Encyclopedia.

Simplest Form of Detector

The earliest form of detector is that which is known as the spark detector, which, in one form, comprises two adjustable metal rods having short arms or cranks at their adjacent ends. These arms are provided with small spark balls, and when the two rods are in line, and properly adjusted, a minute electric spark will appear between the two balls. Another class of detectors comprises the coherers or contact detectors, which function by virtue of the change in the conductivity of a material when in a finely powdered form but loosely compressed or packed together.

Professor Branly observed and noted the fact that a discharge of electricity in the form of a spark at some distance from a coherer could affect the conductivity of a loose mass of powdered conducting material such as iron filings. As the conductivity increases suddenly and simultaneously with the electric spark discharge, it follows that if a simple circuit be arranged with some such instrument as a galvanometer in it, the increase of conductivity will be rendered visible in the form of a deflection of the needle of the galvanometer. When the coherer is suitably devised and incorporated into a circuit, it can be arranged to operate a sensitive relay which can be made to close a circuit through any form of recording telegraphic instrument, such as a Morse inker. A telephone receiver can be incorporated into a suitable circuit, and when the high-frequency waves strike the aerial a click is heard in the telephones, and messages can be read by the Morse or other similar code.

How Magnetic Detectors Function

Magnetic detectors are somewhat different, as they function by virtue of the fact that one of the effects of an oscillatory discharge is to magnetize a piece of metal. In a Marconi system an iron wire is placed in a magnetic field of varying intensity. This iron wire core is surrounded by a coil of insulated wire, and when an oscillating current passes around the coil it changes the magnetization of the iron core. The coil of wire is surrounded by a second winding insulated from the first, and this is connected into the telephone circuit, with the result that when the primary coil is traversed by an oscillating electric current the magnetization of the iron wires changes and a click is heard in the telephone.

A horseshoe type of permanent magnet is arranged with its poles near to the ends of the core, and this magnet is rotated by clockwork mechanism. When trains of oscillations are sent for varying times through the coil the clicks in the telephones merge into one another, and a more or less continuous sound is the result. By making the oscillations of long or short duration, corresponding sounds are heard in the telephones, and messages can be detected and read on the Morse system.

Electrolytic detectors depend for their action on the fact that the passage of an oscillating current through an electrolyte alters the conductivity, and signals can be read through the agency of a suitable circuit and telephone when energized by an independent and unidirectional electric current which passes through the electrolyte.

Thermal or thermo-electric detectors act on the property possessed by high-frequency oscillations of raising the temperature of a very fine wire resistance conductor, the presence of the wave being detected by the heat generated. This class of detector does not give such sensitive results as the coherer or magnetic type.

The foregoing are, practically speaking, noticeable for the fact that they have no effect on the current received or detected, but in the case of the mineral detectors, more familiarly known as crystal detectors, another property becomes apparent, and that is the power they possess of rectifying the current that passes through them. This is a matter of the greatest importance to the wireless experimenter, as it then becomes possible to detect the high-frequency currents and to so affect them that the audio waves that are impressed on the transmitted H.F. currents can be detected and passed to the telephones and there heard as speech or music.

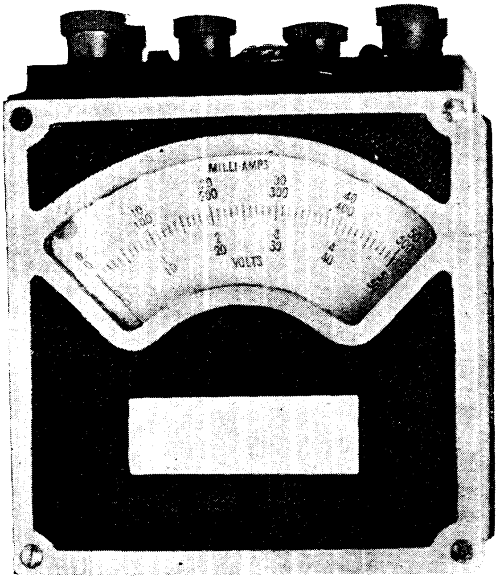
This is explained by one theory on the basis that the junction of two dissimilar conductors, when the contact area is small, has a unilateral conductivity for electricity. Consequently, the high-frequency currents can pass more readily in one direction than the other through the junction, and the current is thereby rectified. This important matter is dealt with in the article on Crystal (*q.v.*).

The thermionic valve in one of its many forms is probably the greatest advance in the science of wireless telephony and telegraphy that has yet been made, as not only does the valve detect the presence of high-frequency currents of electricity, but it also rectifies and amplifies them. There are many more important and interesting features connected with the thermionic valve, all of which are dealt with in the article on Valves.

The detector in any form is one of the most important items in the receiving set, and upon its accuracy and perfection of design, as well as on its operation, will depend to a large extent the success of the whole instrument, especially for the reception of wireless broadcasting of concerts and speech.—*E. W. Hobbs.*

See Crystal ; Crystal Detector ; Detector Panel ; Fleming Valve ; Valve.

Detector for Small Currents. A form of detector used as a measuring instrument is known as the G.P.O. detector, a term that is applied to a certain

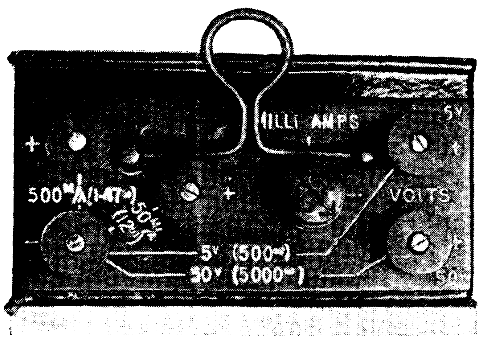


G.P.O. DETECTOR

Fig. 1. This instrument is put to many applications. The G.P.O. detector, of which the external appearance is shown above, is used frequently for wireless apparatus testing

Courtesy General Electric Co., Ltd.

instrument in universal use for the measurement and detection of small electrical currents and pressures. An external front view of the instrument is shown in Fig. 1, from which it will be seen that the meter is scaled for four ranges, two being in volts and two in milliamperes. The arrangement of the terminals on the top of the instrument is shown clearly in the illustration Fig. 2, which depicts the terminals and the connexions between them as required to give the individual ranges.



TOP OF THE G.P.O. DETECTOR

Fig. 2. Terminals and connexions are shown in this photograph of the instrument seen in Fig. 1. Ranges and purposes are clearly marked

Courtesy General Electric Co., Ltd.

The instrument consists of a moving coil type of movement, fully dead beat and with spring control. A knife-edged pointer, allowing of extreme accuracy of reading and an external zero adjustment, are also provided. Contained within the case, which is made of cast aluminium, are the resistances and shunts for the various volt and milliampere readings respectively.

It is probable that no other one measuring instrument is of more use to the wireless experimenter than this.

The voltage readings are scaled from 0 to 5 and from 0 to 50. Thus it is adaptable for both low-tension and high-tension readings or valve-pressure measurements. The scale is evenly divided, and this provides uniform accuracy over the whole range. The milliamperes range from 0 to 50 and 0 to 500.

These ranges will be found useful in ascertaining the current consumption in the anode circuit of valves. The detector will function well as a modulation meter on reasonably near-by and powerful stations. As the instrument is of the moving coil type it is unsuited to the measurement of alternating currents or pressures.

Apart from the uses of this instrument for purely wireless work, it has many uses in the field of ordinary telegraphy and telephony; and amongst other applications that will have to be dealt with by the experimenter are such things as testing the leakage of current from lines to earth and between telegraph conductors. The measurement of the actual current taken by telegraph and telephone instruments can also be ascertained.

When used in conjunction with an energizing source of electricity, the resistance of coils and transformer windings, and the like, may be found without any difficulty.

DETECTORITE. A name given to a proprietary crystal sold by the Grafton Electric Co. It is claimed to give very good results, and does not require the boosting effects of a local battery. In appearance it is not unlike hertzite or silicon. It is used to best advantage with a cat's-whisker of gold, phosphor-bronze, or silver.

DETECTOR PANELS, THEIR USE & CONSTRUCTION

How to Make Simple Valve Detectors Capable of Numerous Uses

This section, which is illustrated with a special three-fold plate in photogravure, describes a form of receiving unit of considerable flexibility and with great possibilities for amateur and experimenter. See also Detector Unit, and such articles as Amplifier; Condenser Unit; Tuning Unit, etc.

A detector panel is the name given to a unit comprising either a valve or crystal detector or other rectifying device, together with terminals for connexions, and, in the case of a valve panel, the necessary filament resistance and control switch. In the case of a valve detector, such a panel has many uses. It may form the basis of the experimenter's receiving set. He would generally use it with a condenser unit (*q.v.*) and a tuner unit (*q.v.*), together with the necessary batteries and telephones, when it would become a complete receiving set. For experimental purposes a self-tuned detector panel is very convenient, as by its aid many circuits can be quickly wired up and tried out.

A typical example is illustrated in Fig. 1, which shows a detector panel as supplied by the Economic Electric Co. This is conveniently mounted in a polished hardwood case, the top of which is covered by means of a stout ebonite plate screwed to the sides. At one end of the panel is mounted the valve holder, and opposite it a knob which controls the filament resistance. This is located beneath the panel, and the necessary connexions from it to the valve holder, and also those for the grid leak and condenser, are similarly made beneath the panel, brought out to terminals attached to it and arranged on either side. The two on the front part on the side of the rheostat knob are for connexion to terminals, and others are for the grid and anode connexions for the high-tension and low-tension batteries, all of which are carried out in the usual way.

Another detector panel is illustrated in Figs. 2 and 4, the former showing the external appearance of the panel, and Fig. 4 showing the internal arrangement of the back of panel wiring. Fig. 3 shows a standard theoretical circuit diagram for a valve detector panel. In all cases, the most useful arrangement comprises a type of filament resistance which may be screwed to the underside of the panel,

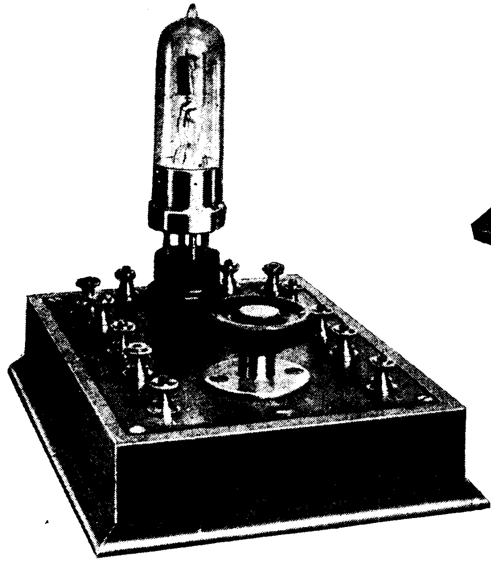


Fig. 1. Such a panel is extremely useful to the wireless experimenter, enabling many circuits to be wired up quickly and tested out
Courtesy Economic Electric Co.

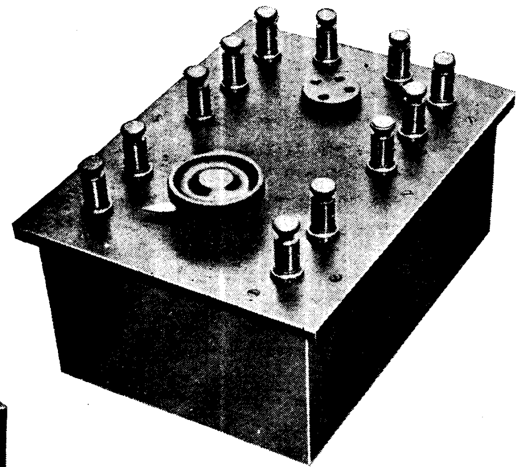


Fig. 2. Another type of detector panel. This has a sunk valve holder and the rheostat movement is indicated by a pointer

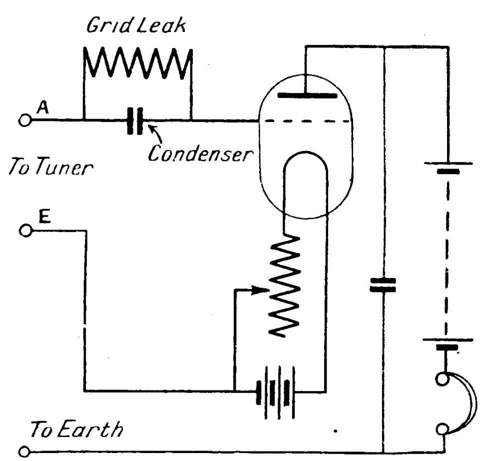


Fig. 3. Standard wiring is adopted in the detector panel, and may be carried out from the above diagram, all connexions being soldered

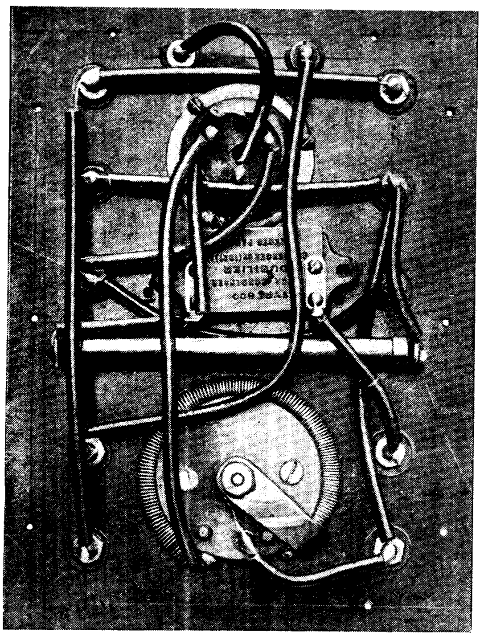


Fig. 4. Wiring of the underside of the panel of the detector shown in Fig. 2. Note the position of the rheostat, the grid leak and the condenser

SINGLE-VALVE DETECTOR PANEL FOR THE EXPERIMENTER

while the knob and pointer are located on the outside of the panel. The fixed condenser and grid leak are screwed to the underside of the panel and connexions made to them by soldering.

The valve holder can be of the flange type or flush type, as desired, or separate valve sockets can be used and secured to the panel by means of nuts on the underside. The connexions are best made by means of No. 18 gauge tinned copper wire, and may be covered with systoflex or rubber tubing. All connexions are made by soldering.

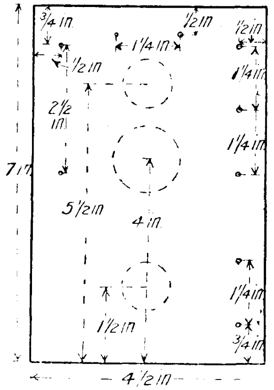
In cases where it is intended to use the panel for experimental purposes, it is convenient to duplicate some of the terminals for the high- and low-tension battery connexions, as often this obviates the necessity of running connecting wires across the panel. This arrangement is shown incorporated in the example illustrated in Figs. 2 and 4.

The only difference in the wiring is that instead of connecting to one point of the single terminal, as, for example, that of the high-tension plus, the two high-tension plus terminals are connected to each other by means of a springy piece of wire, and are then considered as one terminal so far as general circuit arrangements are concerned.

When the connexions are soldered to the underside of the screwed shank on the terminals of the telephone type, it is important to note that the holes in them are opening straight towards the sides of the panel, and that the terminals themselves are very securely locked by means of other nuts to the ebonite panel. After the connexions have been soldered, the nuts should be again gone over, and they will probably require slight additional tightening, as the heat from the soldering will cause the ebonite to shrink slightly. If the terminals are not tight there is grave risk of their being accidentally twisted from the outside, and thereby breaking one of the connexions, the set then ceasing to function. A convenient size for such a panel would measure 7 in. long and 5 in. wide, while the case may have a depth of 2 in. to 3 in.

Another type of panel that is particularly useful for the experimenter is illustrated in Fig. 8 on the plate facing page 670. In this case the whole of the appliances are arranged on the exterior of the panel, and only a minimum number of terminals are provided. A special feature is the use of a Filtron variable grid leak and a variable condenser. This is used in place of the ordinary pattern of fixed condenser and fixed value grid leak, as it enables the best possible reception to be obtained, because, by varying the value of the resistances of the grid leak, and also by varying the value of the condenser, it is possible to obtain the loudest signals and also the purest reproduction of broadcast concerts.

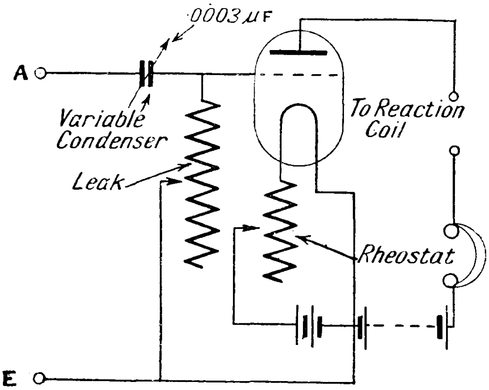
The panel is made from a sheet of ebonite about ¼ in. thick, and all connexions are made on the underside of it. To raise it off the table it can be mounted in a moulded framework something like a picture frame, as shown in Fig. 9. This frame can be made from hardwood by turning up a sufficient length about 1 in. in depth and ¾ in. in width. A rebate should be worked on one edge. The frame is made by mitreing the corners in the usual way and gluing and screwing them together. The ebonite panel is cut so that it will drop into the rebate, and is held there by means of four small countersunk brass screws. The sizes may be varied to suit any particular apparatus, but those given in Fig. 5 are convenient and will enable the panel to be marked out without difficulty.



SIZES FOR DETECTOR PANEL

Fig. 5. Although these dimensions may be varied as required, they are suggested as being convenient in most cases

The holes for the different terminals and for attachment of the valve holder and rheostat are then drilled and tapped as necessary, the various parts assembled and wired up as shown in the wiring diagram, Fig. 6. The various components are then assembled in their places, as in Fig. 10, and all connexions made by means of tinned copper wire, soldering to the underside of the terminals, as in Fig. 11 on the plate facing page 670.



DETECTOR PANEL WITH FILTRON GRID LEAK

Fig. 6. Wiring in this case is carried out with the components arranged according to the provision made on the panel, Fig 5, and a Filtron variable grid leak is employed

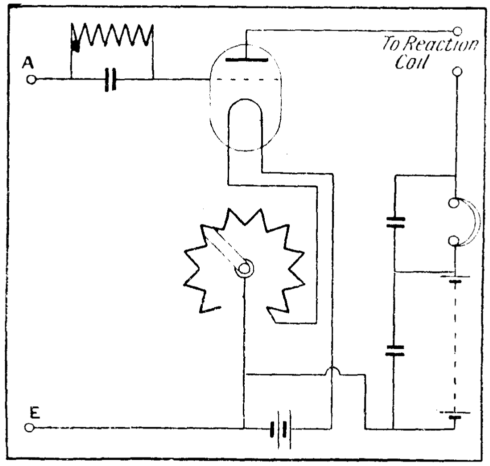
In cases where it is desired to use reaction in the anode circuit of any of the foregoing, two additional terminals should be provided and the wiring modified in accordance with Fig. 7. When reaction is not required the two reaction terminals should be short-circuited by means of a short brass contact bar.

Single-Valve Detector Panel: How to Make. The valve detector panel to be described is the most simple way in which a valve may be used for general reception. The panel and fittings may be made up in a few hours, and when finished will be of considerable assistance to the experimentally inclined in giving a good idea of the use of a valve as a detector and, with perhaps some alteration to the wiring below, it will be invaluable in testing out many circuits and combinations which are already available and which will no doubt in the near future be greatly extended.

Various units of this kind are described throughout this Encyclopedia, and the experimenter who has constructed one or two of them will find it easy to test out new circuit ideas.

For the reception of general amateur telephony, ship, aircraft, time signals, and the rest, reaction terminals are provided, thus allowing very much greater volume and range to be obtained, but these terminals should be shorted with a piece of wire when receiving British broadcasting, as the use of reaction upon the aerial circuit during broadcasting hours is likely to cause disturbance to neighbours who may be listening in, by inexperienced adjustment of the reaction coil.

With regard to the results obtained from a single valve used without reaction, there is not much improvement in signal strength over a good crystal receiver, but one is saved the bother of setting the crystal upon its most sensitive point, and a detector valve set only needs connecting up with the batteries, and the filament current adjusted, when reception is automatic. From the photograph of the front view of the panel, Fig. 12 on the plate, which is $4\frac{1}{2}$ in. by 6 in., it will be noted that four terminals are spaced upon either side, whilst at the bottom two terminals are provided for telephones. The filament resistance knob is on the centre line $2\frac{1}{2}$ in. from the bottom, whilst near the top edge the valve sockets or valve holder are mounted, the latter being the simplest method.



WIRING DIAGRAM OF DETECTOR PANEL

Fig. 7. When a detector panel is required to be used in a circuit with reaction in the anode circuit, wiring may be modified as here indicated

The containing case is $2\frac{1}{4}$ in. deep, and of sufficient size to allow the panel being recessed flush with the top. It is a good plan at the outset to cut out the panel and make the containing box, fitting supports at all four corners to prevent the panel going too far into the box. It will be found a very convenient support for the panel in drilling and wiring up, the panel being easily reversed without doing any harm to anything fitted on either side.

The filament resistance may either be made or purchased. If made, a piece of $\frac{1}{8}$ in. 3-ply, 3 in. in diameter should be cut, then a piece of wood $\frac{1}{4}$ in. thick by $2\frac{1}{2}$ in. in diameter should be prepared with a slight undercut to one side. These two pieces should be glued and pinned concentrically, when the undercutting of the thicker wood and the larger diameter of the 3-ply will form a good seating for the resistance wire. A piece of No. 2 B.A. rod should now be cut $1\frac{1}{2}$ in. long, and should be provided with a nut at one end. Under this nut is fitted a piece of thin, springy brass 2 in. long by $\frac{1}{2}$ in. wide, slightly tapering, which should be soldered with the nut to the rod. A short piece of brass tube should now be obtained of sufficient diameter to fit over the No. 2 B.A. rod. This will need to be $\frac{3}{4}$ in. long.

The other brass strip should now be prepared $\frac{1}{2}$ in. wide and 2 in. long. This should be drilled at one end to accommodate the small tube which forms the bush. This should be soldered into position flush upon the outside. It will be noticed that this strip is fixed to the resistance former, whilst the tube passes through the same and projects about $\frac{1}{4}$ in. upon the front side. A spring washer forms the metallic connexion between the moving and stationary arm, one connexion being soldered to the latter.

The filament resistance wire, which can be purchased already wound, should be placed in position, the pointed end being without a connexion and on the left, as shown in the photograph, Fig. 13, of the back of the panel; whilst the other end is soldered to the other filament lead. A small brass angle piece is necessary to act as a stop when the resistance wire is all cut out. Care should be taken that no short-circuit is likely to occur between the fixed arm and either end of the resistance.

How the Grid Condenser is Made

The slot in the fixed arm allows the moving arm to pass right off the wire, thus acting as a switch. It is essential, in making a resistance in this manner, to ensure that the contact between the resistance wire and moving arm is on the top side and not upon the edge. It does not then matter if the circle is not quite accurately cut. A locking nut and washer is fitted below the knob upon the front of the panel. It now only remains to prepare the grid condenser and grid leak and wire up, when the panel will be completed.

The grid condenser may be made with five thin mica sheets, 2 in. by 1 in., and four tin or copper foils $2\frac{1}{4}$ in. by $\frac{1}{2}$ in. Commence by fastening one foil with shellac varnish to a mica sheet with an even margin of mica on three sides and an overlap, say on the right; then a second sheet of mica, then another foil with overlap on the left; another mica, then another foil exactly over the first; the fourth mica, the fourth foil as the second foil; and, finally, the top mica. If this is placed under a slightly warm flat iron for a few hours, the shellac will be found to have set firmly.

The foils projecting at either end should be bent flat against the outside mica. A piece of thin, plain postcard is shellacked and cut to the length of the condenser, and about $\frac{1}{4}$ in. wide. Upon this is drawn a thin line with a soft lead pencil, making a good pencil circle about $\frac{1}{8}$ in. diameter at either end. This is clamped to the condenser by wrapping two small pieces of thin brass or copper foil over each end, to which the leads may be soldered. The pencil line is afterwards adjusted in width when the set is in use, to give the resistance required.

The wiring may easily be followed from Fig. 13, the grid valve being nearest the grid terminal. It now only remains to consider some of the circuits which may be tried with this set, and to indicate the mode of operation. Any type of tuning unit may be used, and a single-slide coil will be quite satisfactory.

Basket coils are as good as any, being cheap, easy to mount, and efficient. Fig. 14 on the plate facing this page shows the basket coils wired up for variometer tuning. These coils are particularly satisfactory, used in this manner, and have the additional advantage that no condenser is required. Note the two reaction terminals are bridged and the two centre terminals of the tuning stand are also bridged, which results in the impulses from the aerial passing first through the left-hand coil and then through the right-hand coil, very fine tuning being obtained by adjusting the separation of the two coils.

Testing Out the Set

The batteries, telephones, etc., are not shown in the photograph, for the sake of clearness; but they may now be connected up, the set tried, and the grid leak adjusted. If the grid leak and condenser are fitted with long leads temporarily, so that they may be outside the case, so much the better. It will probably be found that signals are weak, especially if the valve be a hard one, when a little more lead should be rubbed upon the pencil line. It will be found that there is a point where best signals are obtained, when the paper may be given a light coat of shellac varnish, the leads shortened to a convenient length, and the grid leak and condenser stowed away in its proper position.

In many cases a large capacity fixed condenser may be used across the high-tension battery with advantage. This may be tried, if desired, by connecting one lead of a fixed condenser to each of the high-tension battery terminals, in addition to the high-tension battery itself.

The high-tension battery should not be less than, say, thirty to sixty volts.

Pocket flash-lamp batteries connected in series may be used, and they have the advantage that a used cell may be removed easily. They should each be separated by a piece of stout cardboard, soaked in hot paraffin wax. One lead may be provided with a common slip-on paper-fastener, which may be easily pushed on the battery strips at any position, thus giving a means of adjusting the high-tension supply. The correct amount for the particular valve will soon be found. The low-tension accumulator should be either a four or six volt.

Fig. 15 shows the set wired up as a loose coupler. In this case, two variable condensers are required, one for tuning the aerial coil either in series for short waves, *i.e.* the aerial wire to one side of the condenser, other side of condenser to coil and other side of coil to earth; or in parallel, *i.e.* one side of condenser to aerial terminal and the other to the earth terminal, as shown in the photograph. The condenser may have a capacity up to say, ·001 mfd. The condenser upon the secondary side is usually connected in parallel, and may have a capacity of ·0005 mfd. This arrangement gives greater selectivity and generally better results than a single coil. A standard pattern loose-coupled tuner may be connected in the same way.

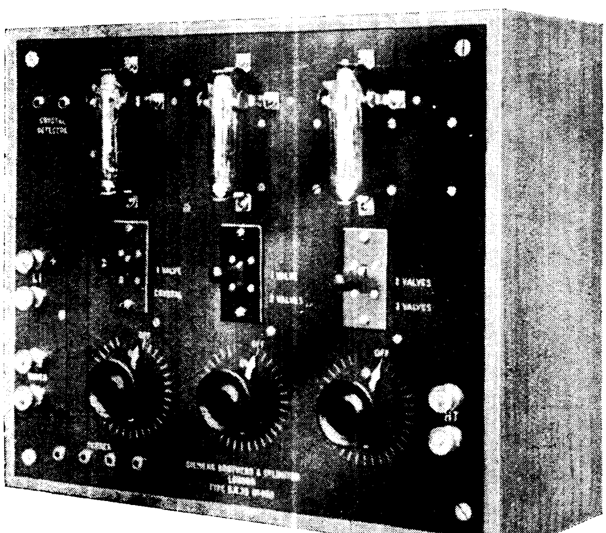
Fig. 16 shows the set wired up for reaction. This can be tried upon ship signals, which may be found in abundance on 600 metres at any time of the day, or on the Paris time signals, 2,600 metres, at 10·44 and 22·44 G.M.T. And on a good aerial some of the continental telephony should come in well. If reaction does not result on coupling the coils, reverse the leads of the reaction coil.

It will thus be seen that a simple valve panel used purely as a detector unit has many uses. Indeed, its possibilities are only just outlined above. It is readily adaptable to most circuits involving a single valve, and also a single valve and crystal; as well as dual amplification of the type in which a tuned anode coil and low-frequency transformer are used, slight alterations to the wiring below the panel being perhaps necessary.

The three-valve detector panel shown in Fig. 17 is as supplied to the Berengaria. It comprises one detector valve and two low-frequency amplifiers, whilst a convenient plug-in arrangement allows of a change over to crystal reception, should the valves fail for any reason. Valves and telephones are plugged in as required into convenient sockets, and the valves controlled by rheostats, the handles of which are seen below the inter-valve switch handle. An emergency crystal detector is also provided and put into circuit when necessary.

DETECTOR UNIT. Figs. 1–10 show the detector unit of the series of units supplied by the Peto-Scott Co. This is a valve detector unit, and should not be confused with the crystal detector unit which is a part of the series. Either one or the other is used, but they cannot be used together. The valve detector usually gives louder signals and has a longer range than the crystal, but its cost and upkeep are very much greater, for there are, of course, the high- and low-tension batteries which have to be recharged or renewed at regular intervals. The valve itself, too, deteriorates in the course of time.

The valve detector consists essentially of a thermionic valve, to the grid of which is attached a small condenser, usually of ·0003 mfd. capacity, and a grid leak.



THREE-VALVE DETECTOR PANEL FOR SHIPS

Fig. 17. Two low-frequency valves are added to the detector valve in the panel shown above. This apparatus is used on board the Berengaria and other seagoing ships

Courtesy Siemens Bros. & Co., Ltd.

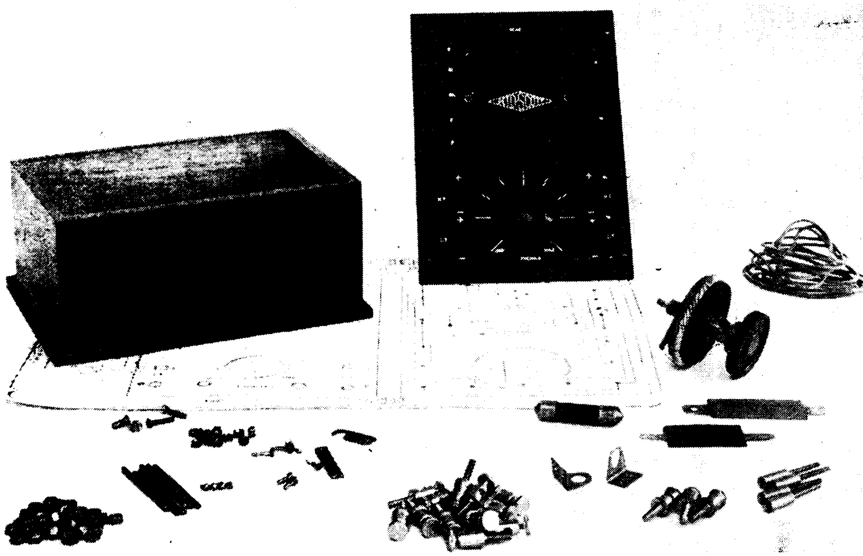


Fig. 1. Laid out with the diagrams are a complete set of parts for constructing a Peto-Scott valve detector unit. This forms part of the unit system described in this Encyclopedia

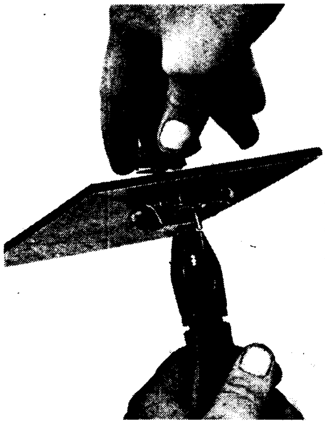


Fig. 2. Contact arm and rheostat pointer must be adjusted together

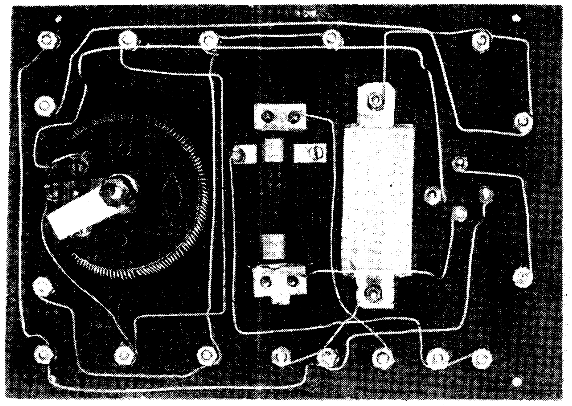


Fig. 3. Wiring is shown in this view of the underside of the panel. Note relative positions of grid leak condenser and rheostat

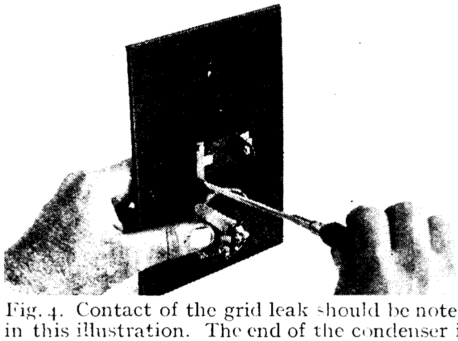


Fig. 4. Contact of the grid leak should be noted in this illustration. The end of the condenser is not connected to the bracket of the grid leak, but to a brass strip

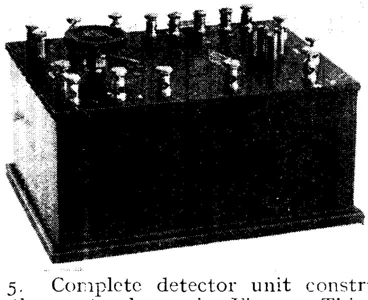


Fig. 5. Complete detector unit constructed from the parts shown in Fig. 1. This is a Peto-Scott apparatus

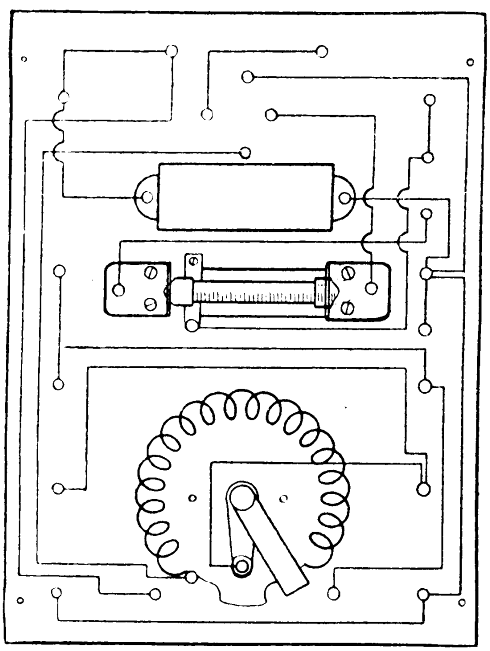
COMPONENTS AND ASSEMBLY OF A DETECTOR UNIT

The former is wired to the aerial and the latter either shunted across the grid condenser or the free end connected to earth via the high-tension negative. A variable resistance controls the low-tension current for lighting the filament of the valve. The anode connects through the telephones to high-tension positive.

Where low-frequency amplification follows the detector, the primary winding of the transformer takes the place of the telephones. Regeneration is obtained by including an inductance in the anode circuit which is variably coupled to the grid circuit. This effect is usually known as reaction, and when not required a short strip is inserted between the terminals normally connecting the reaction coil, in order to complete the circuit.

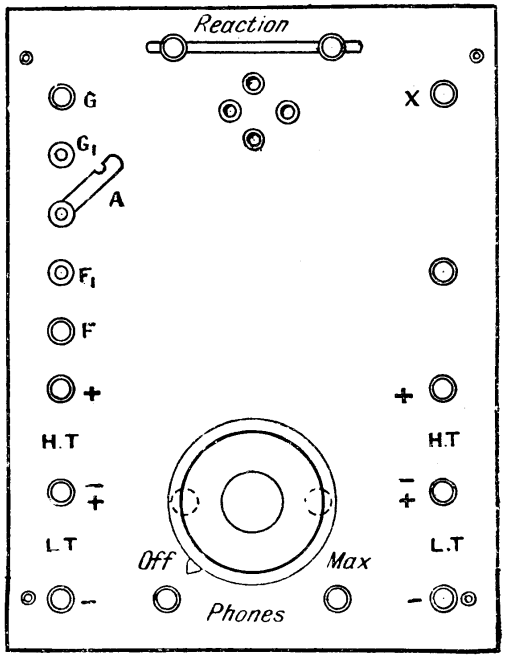
Fig. 1 shows the set of parts supplied, with a copy of the wiring diagram. In assembling the parts the filament may first be attached to the panel by two countersunk screws from the top of the panel. This can be done when the contact arm and its locking nut have been removed. Fig. 2 shows the reassembly of the contact arm.

The spindle, with knob attached, is pushed through the bearing and a spring



WIRING OF DETECTOR UNIT

Fig. 6. Wiring and connexions are made in accordance with this diagram, which represents the back of the panel



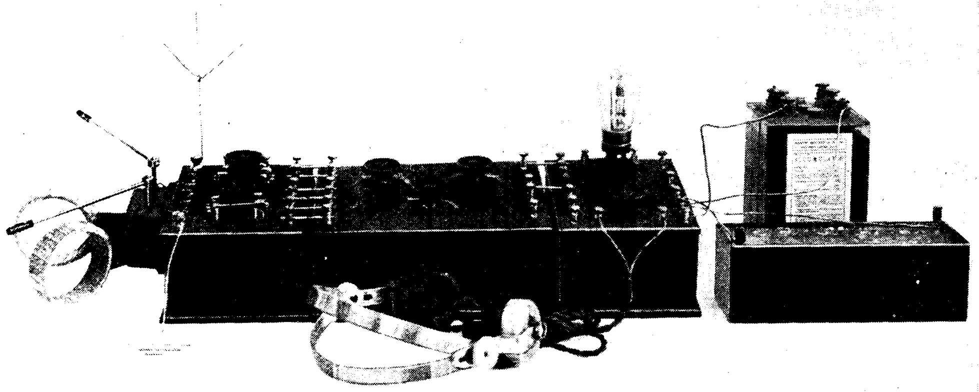
PANEL TOP OF DETECTOR UNIT

Fig. 7. Marking is not only for reference in construction, but the actual panel is engraved, or indication tabs attached, to show the uses of the various terminals

washer slipped over it, the contact arm is screwed on, and when in a position making contact with the resistance spring, the lock nut is tightly screwed up with a pair of pliers. The pointer is arranged to come over the contact arm so as to indicate its position relative to the spring.

The grid condenser is secured by bending back the foil under the grid leak bracket on the right-hand side. Care must be taken not to bend back the foil of the other side of the condenser under the other grid leak bracket. It is bent back and held in position by a short strip of brass. This operation is shown in Fig. 3.

When inserting the grid leak in its brackets, it must be made a tight fit. If it is not, bend the brackets a little closer. No difficulty should be found in mounting the by-pass condenser, the position of which is just above the grid condenser. The valve legs are mounted by screws from underneath, after which the terminals are similarly assembled. Terminals marked G_1, A, and F_1 are of square pattern, the centre one holding a brass strip capable of attachment either to terminal G_1, or F_1.

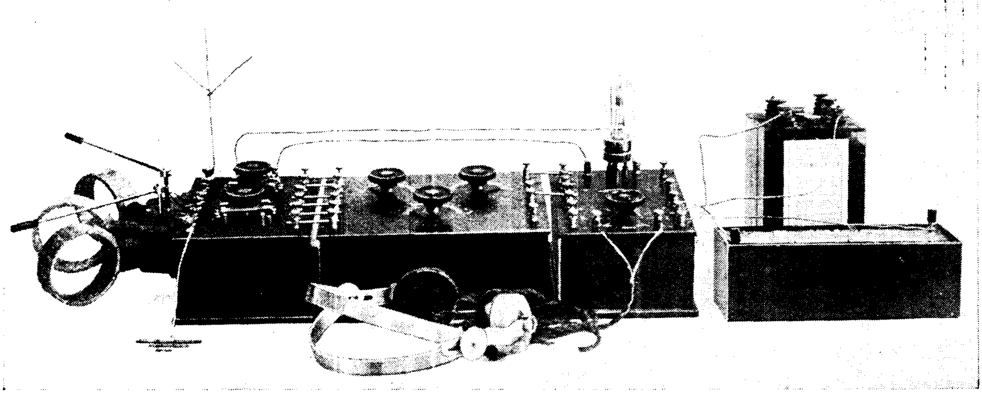


DETECTOR UNIT IN POSITION IN A RECEIVING SET

Fig. 8. Three units are connected up in this set. On the left is a tuning unit with plug-in movable coils, in the centre a condenser unit, while the detector unit has a valve mounted. Aerial and earth connexions are indicated by symbols made in wire

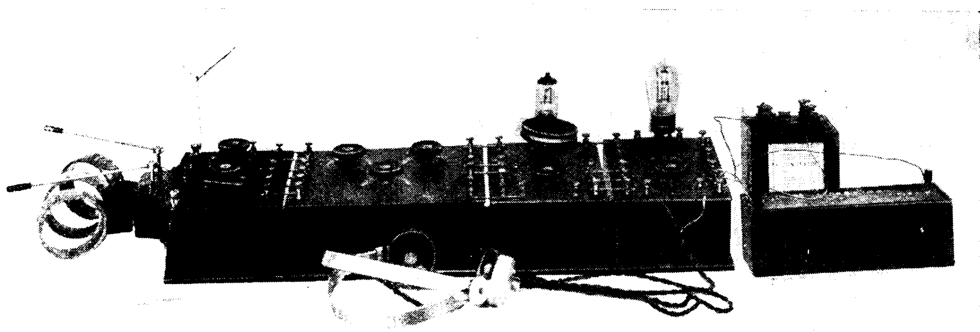
When high-frequency amplification is used, the brass strip is joined to F_1, but used as a detector alone or followed by low-frequency units, it is connected to G_1. Rubber-covered wire is supplied for connexion to terminals. It is advisable, unless the experimenter is well accustomed to working to wiring diagrams, to make connexions first with a bare wire clamped under each terminal with the extra nut provided. Care should be taken to avoid any wires touching one another. The unit is tested out for correctness of wiring, after which the bare wire may be removed piece by piece and replaced with the rubber-covered wire, soldering all connexions. By this method perfect connexions are assured and no time is wasted in unsoldering. The wiring is shown in Fig. 3, and a wiring diagram of the back of the panel is illustrated in Fig. 6.

Before screwing the panel down to the case, the interior should be wiped out with a clean rag, removing all traces of soldering paste and foreign matter. It is remarkable how many home-made sets fail to work properly through neglecting this. The completed unit is shown in Fig. 5. Only two strips are necessary to connect the detector unit to the aerial tuning apparatus, which, in the Peto-Scott series, comprises the tuner, followed by a condenser unit. These terminals are marked G and F in Fig. 7 of the top of panel.



THREE-UNIT SET WITH REACTION ADDED

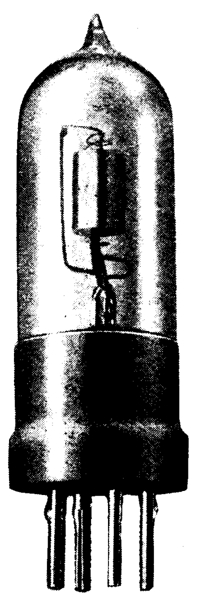
Fig. 9. Added to the three-unit set as seen in Fig. 8 is a third plug-in coil, the reaction coil. Additional wiring between the tuning unit and the detector unit provides the reaction in the anode circuit. The reaction coil is seen at the rear. No internal alterations are necessary in adding reaction



DETECTOR UNIT COUPLED TO HIGH-FREQUENCY UNIT

Fig. 10. Two valves are now included in the set. One is mounted on the detector unit, and the other on a high-frequency unit added by the simple process of connecting adjacent terminals. A tuner unit is seen on the left, and the next unit is a condenser unit. In front of the high-frequency valve is a plug-in transformer coupling the high-frequency and detector units

Fig. 8 illustrates this combination with batteries and telephones attached. In this set the reaction terminals are shorted. Fig. 9 shows the same combination, but with the reaction coil in the anode circuit. The wires connecting it from the tuner to the detector unit are clearly seen at the back of the set.



EDISWAN A.R. DETECTING VALVE

Fig. 1. Standard type A.R. detecting valves, as illustrated, are also suitable for amplification. The valve legs are divided and opened slightly in order to make a spring fit and ensure perfect contact with the valve holder

In both Figs. 8 and 9 terminals G_1 and A are connected, but in Fig. 10, which incorporates a high-frequency unit, the brass strip joins F_1 and A. Although reaction connexions are not shown in Fig. 10, it may still be used with the high-frequency set, but it will be necessary to reverse the wires in the reaction terminals to their previous arrangements with the rectifier alone. When a high-frequency unit is inserted in the set battery connexions must be made to it from the detector unit.

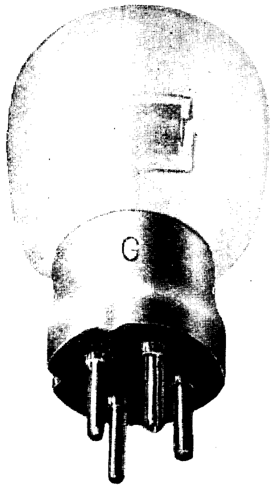
DETECTOR VALVE. A thermionic valve used for rectifying radio-frequency oscillations. It consists of a filament, a grid, and an anode, the whole enclosed within a glass bulb. Connexions to these parts are made by means of split pins protruding from a metallic holder attached to the bulb, and filled in with an insulating material such as pitch. It is becoming common practice now to use an ebonite holder drilled to take the valve legs. This is kept in position by burring over the metallic cap.

With the exception of the "Cossor" and a few other distinctive types, the grid consists of a spiral metallic spring surrounding the filament. The anode, also known as the "plate," usually takes the form of a thin sheet of metal bent round to form a nearly complete cylinder, and so enclosing the grid. These parts are usually fixed by stiff wire, led into a projection of the glass bulb on the inside.

In some forms of valve the straight filament is spiralled at the end so that its springiness takes up any sag when the filament is heated. For this reason it is better, where possible, to arrange the filament in a vertical position, so that it cannot drop when in use and touch the grid, a trouble which is difficult to detect in a faulty set.

Fig. 1 shows a standard type of detector valve known as the Ediswan A.R. Valve. This valve, as is the case with most valves belonging to this class, is very suitable for high- or low-frequency amplification.

The valve shown in Fig. 2 is a Marconi R2A valve. It has the unusual feature of being gas-filled instead of having the usual high vacuum common to other valves. In other respects it follows standard practice. It is useful for detecting only. Other valves sharing this feature are made with a low vacuum, that is, the glass is sealed before all the air is extracted.



MARCONI R2A VALVE

Fig. 2. Useful as a detector valve, but not for amplifying, this valve has not the usual high vacuum, but is gas-filled

Courtesy Marconi Wireless Telegraph Co., Ltd

The valve is a very delicate piece of apparatus and requires careful handling. Even a slight blow is sometimes sufficient to upset its operation. When used with a portable set it is advisable to remove the valves from the set and pack them for travelling in their original boxes. Owing to the fact that a high voltage is supplied to the anode, particular care must be taken to prevent this voltage from reaching the filament. Any excess over 4 to 6 volts will burn out the filament. For this reason it is important to bring the legs of the valve to the valve-holder sockets so that they will register directly. The anode leg is set farther out for this purpose. Care should be taken to avoid touching the high-tension sockets with the filament legs of the valve.

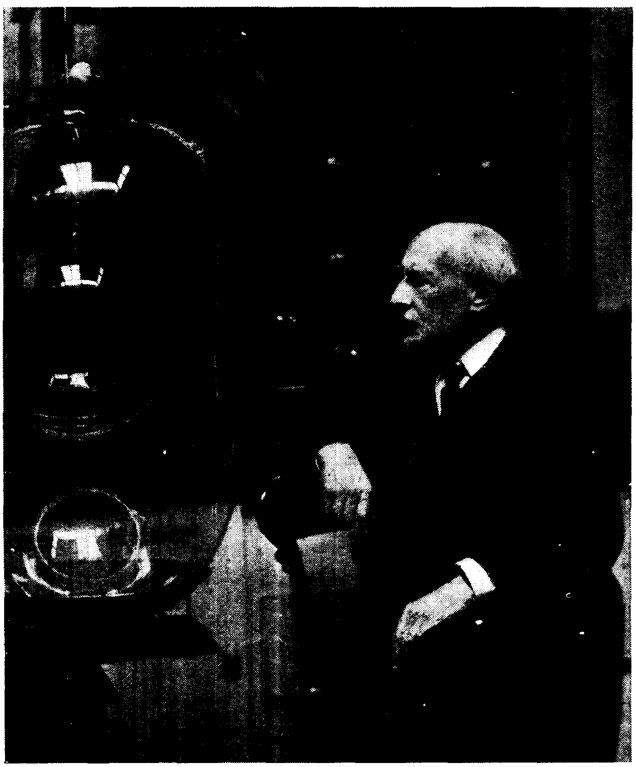
In operating the valve both high- and low-tension batteries require adjusting to suit the particular valve in use. And in many cases it is preferable to use a separate tap from the high-tension battery for the detector valve.

Special valves are made with thoriated filaments capable of operation with a very small battery voltage. These are known as dull emitter valves, and operate on three volts or less. They are very useful in a portable set, as the use of small dry batteries is possible. *See* Dull Emitter Valve; Valve, etc.

DETUNING. The act of varying the inductive or capacity value of a circuit in order to decrease the signal strength of a station being received or to lose it altogether. In heterodyne or beat reception the heterodyne circuit is slightly detuned from the frequency of the incoming waves, and this detuning has the effect of imposing oscillations of slightly different frequency upon the aerial wave frequency, giving rise to Beat Reception (*q.v.*).

Detuning is used sometimes to prevent interference from another station on a close wave-length. Although quietening a little the station being received, the interfering station may often be entirely suppressed. *See* Tuning.

DEWAR, SIR JAMES (1842-1923). British chemist and physicist. Born at Kincardine-on-Forth, Scotland, Sept. 20th, 1842, and educated at Edinburgh University, he was elected, in 1875, Jacksonian professor of natural experimental philo-



SIR JAMES DEWAR, F.R.S.

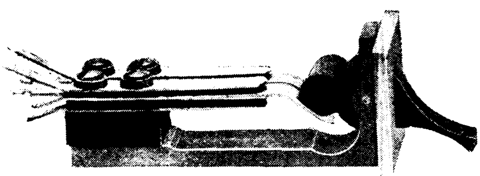
Born in Scotland, this great scientist was honoured in many countries, being awarded a number of foreign and British scientific distinctions. He was the author of a brilliant series of investigations relating to the electrical conductivity of metals at low temperatures sophy at Cambridge. In 1877 he became Fullerian professor of chemistry in the Royal Institution, London. He had then begun his brilliant series of investigations into the liquefaction of gases and, with J. A. Fleming, the properties of matter at extremely low temperatures. He was the first to liquefy and afterwards solidify hydrogen and show the great increase in electrical conductivity of metals at such low temperatures.

In 1894 he was awarded the Rumford medal of the Royal Society, and in 1899 was the first man to receive the Hodgkins medal of the Smithsonian Institution, Washington. He was the first British subject, too, to receive (1904) the Lavoisier medal of the French Academy of Sciences, and the first to be awarded, in 1906, the Matteucci medal of the Italian Society of Sciences. In 1916 he received the Copley medal of the Royal Society, and in 1919 the Franklin medal of the Franklin Institute of Philadelphia. Knighted in 1904, he died in 1923.

DEWAR SWITCH. A special type of switch adapted for telephone work. As applied to wireless work it is extensively employed for the control of various parts of the wiring system, as, for instance, the disconnexion of one or more amplifiers from a circuit.

Dewar switches are made in various forms suited for control of one or both sides of a circuit. The latter types are known generally as double-pole Dewar switches. Other varieties are arranged as two-way switches, and with one or more sets of contact blades.

The switch illustrated shows a double-way type with double poles. The body provides a support for the ebonite switch arm at the top. This projects through the panel on the instrument case. No separate cover plate is needed for the switch, as the flange-like portion permits of fitting the whole to the face of the panel.



DEWAR TELEPHONE SWITCH

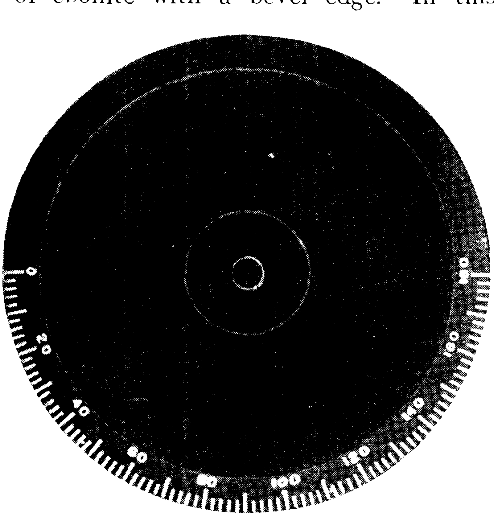
Dewar switches as adapted for telephone work, often used in wireless apparatus. Central contact strips connect to the flat outer strips, to which the wires of the circuit are joined by soldering

The switch lever is pivoted by a central pin attached to the top of the body. The end of the lever is so shaped that when the handle is depressed it moves the long central strip which is secured to the insulating block at the inner end of the body. These and the other flat strips are provided for the terminals of the connecting wires, which have to be soldered to them. All these strips are separated by insulation, and the screws are also insulated by means of bushes and washers. This type of switch is very reliable in use, though capacity effects are liable to arise if used in high-frequency circuits. *See* Anti-capacity Switch; B Battery Switch; Knife Switch; Switches.

D. F. This is the usual abbreviation for direction finder (*q.v.*).

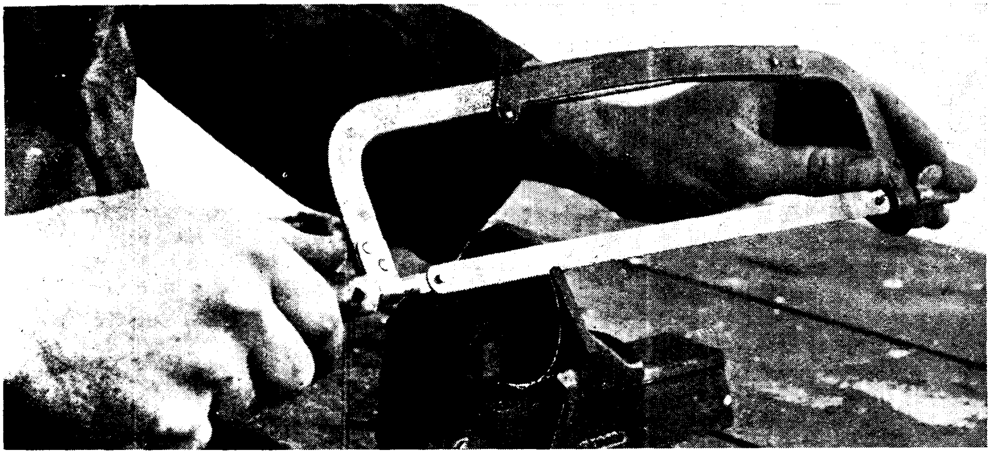
DIACATHODE RAYS. Rays produced by passing cathode rays through a negatively electrified wire screen. The positively charged ions constituting these rays move at a much slower speed than the electrons thrown off by the cathode itself. *See* Cathode Rays.

DIAL. In wireless work dials are used to control the movement of condenser plates, and various other movable portions of a wireless set, and should be calibrated. A simple pattern is shown in Fig. 1, and this consists of a circular disk of ebonite with a bevel edge. In this



CALIBRATED DIAL

Fig. 1. Calibrations from 0° to 180° are engraved on this simple form of flat dial. This type of dial is commonly used for condensers in wireless receiving sets



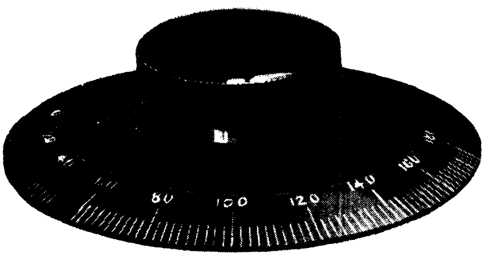
CONSTRUCTION OF A HOME-MADE CONDENSER DIAL

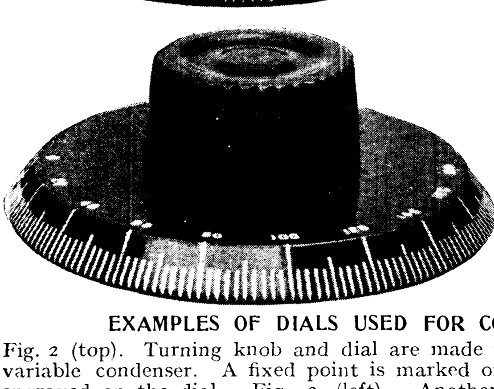
Fig. 5. Fixed in the vice is a sheet of ebonite marked with a circle, and the operator is seen cutting the disk out roughly with a hack-saw. When making the circle plenty of margin must be allowed for trimming the edge. The roughly cut disk is afterwards turned in a lathe

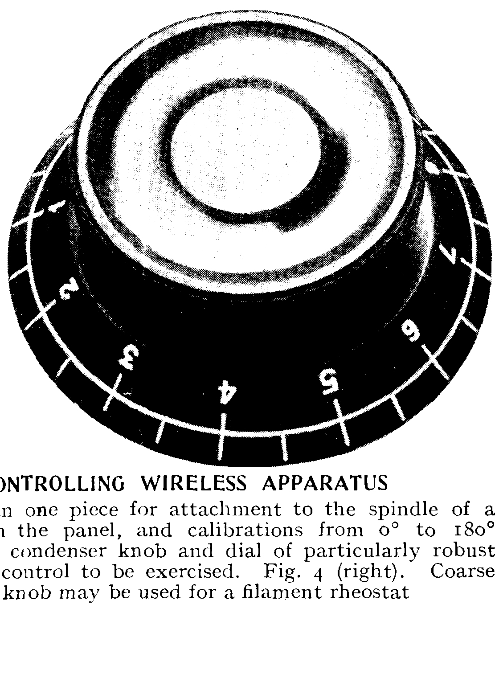
instance half the periphery is calibrated in degrees, ranging from 0° to 180°. Such dials are usually made in moulded ebonite composition with a single central hole, and may be screwed for a spindle and be secured with lock nuts.

A more convenient pattern is that illustrated in Fig. 2, which shows another form of condenser dial similarly calibrated as the foregoing, but provided with a milled edged knob with which to rotate the condenser plates. Such dials are usually secured to their spindle by means of a small set screw tapped through the boss of the knob.

Fig. 3 shows another condenser dial which has a particularly robust knob, enabling a firm and sure grip to be obtained. For the control of filament rheostats a knob and dial combination is a particularly useful feature, as illustrated in Fig. 4. In this case the calibrations are fairly open and may run from 1 to 15.







EXAMPLES OF DIALS USED FOR CONTROLLING WIRELESS APPARATUS

Fig. 2 (top). Turning knob and dial are made in one piece for attachment to the spindle of a variable condenser. A fixed point is marked on the panel, and calibrations from 0° to 180° engraved on the dial. Fig. 3 (left). Another condenser knob and dial of particularly robust design. This type of knob enables a very firm control to be exercised. Fig. 4 (right). Coarse calibrations are engraved. The dial and knob may be used for a filament rheostat

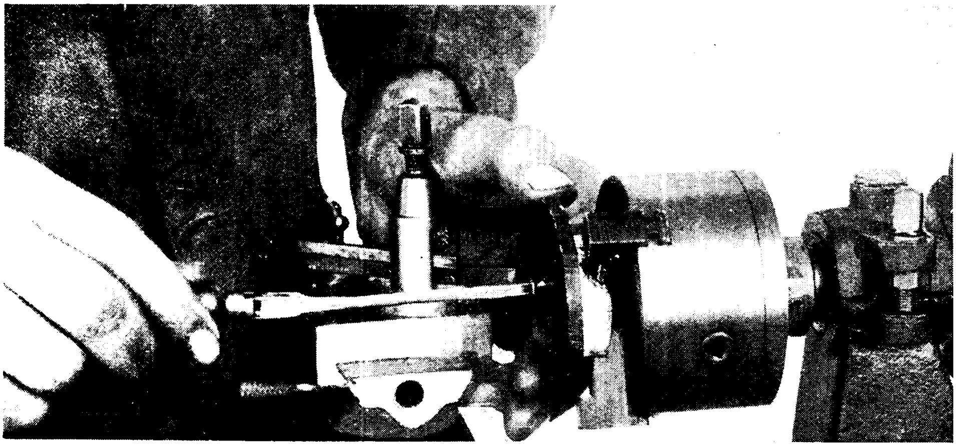


Fig. 6. Fixed in the wood chuck of the lathe is the ebonite disk. The operator is seen making the disk secure before the processes of chamfering and calibrating are commenced

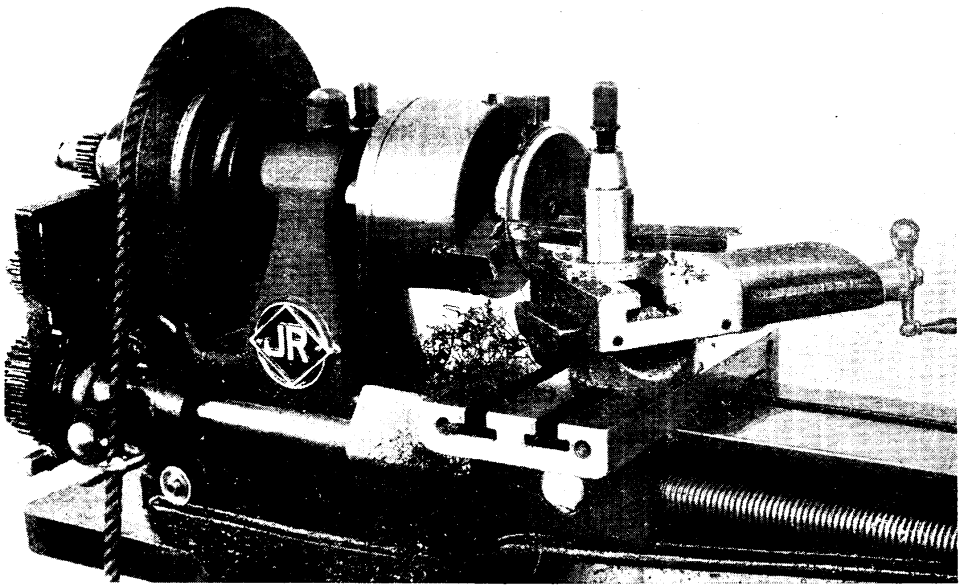


Fig. 7. Set at an angle across the lathe bed is a slide rest, and the operation in progress is known as chamfering. The edge of the dial is to be bevelled and calibrated. The tool used in the operation shown here can be set to produce a bevel at any angle desired

LATHE OPERATIONS IN THE CONSTRUCTION OF A DIAL

This enables the position of the contact arm on the filament rheostat, if of circular pattern, to be determined and recorded.

The experimenter who desires to make all possible parts of his own apparatus can easily construct a dial in the following manner, and as it is then possible to select the highest grade of ebonite, satisfactory results should follow. The exact size of the dial, and the nature of the calibrations, can be made to suit a particular instrument. The first step is to cut from a piece of $\frac{1}{4}$ in. thick ebonite sheeting circular disks of the desired diameter, say, 3 in.

To do this, a circle is scribed on the material and then sawn to shape with a hack-saw in the manner shown in Fig. 5, cutting slantwise, as it were, across the corners of the material until it is as nearly round as possible. The next step is to

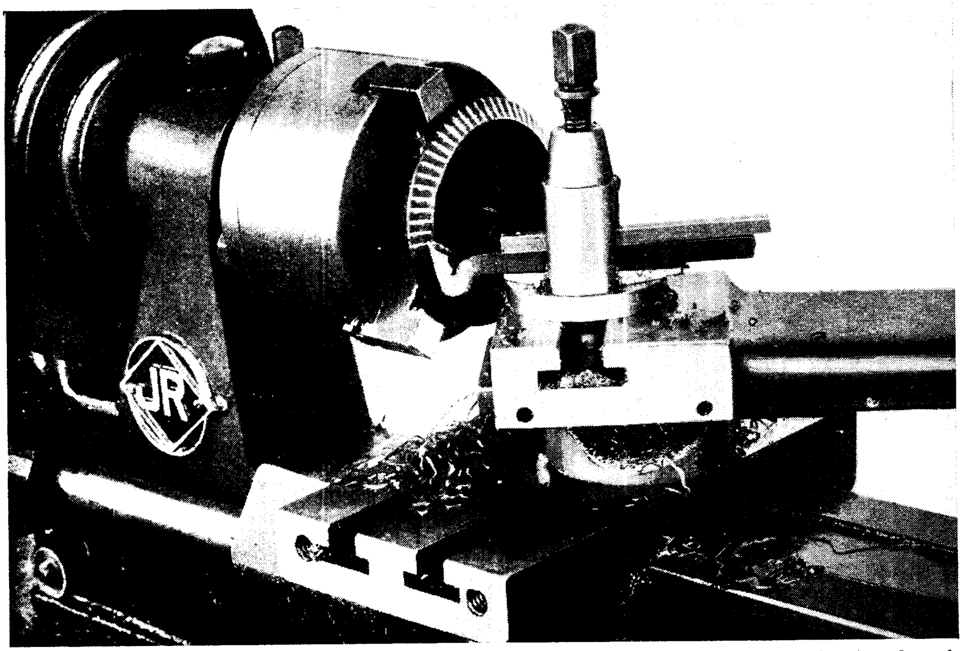


Fig. 8. Calibrations are cut on a bevelled edge of a condenser dial with a V-pointed tool. This process is carried out without taking the dial off the chuck. The tool is held in the slide-rest tool clamp, and instead of rotating the chuck as for turning, the work is held fast and the cutting tool moved, the chuck being rotated one degree space after cutting a division

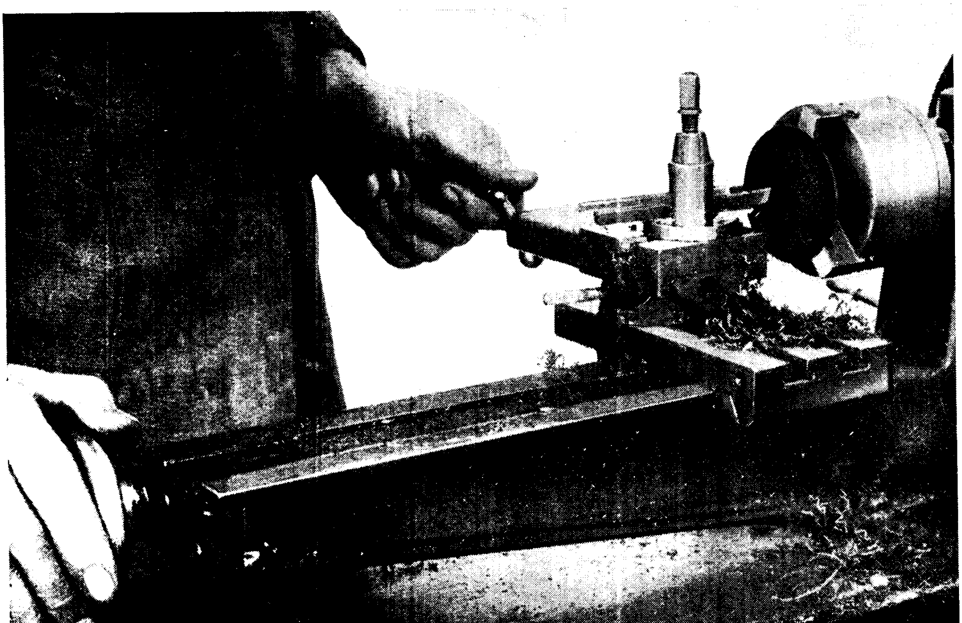
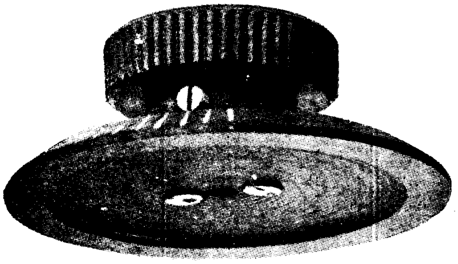


Fig. 9. Provision is made on the underside of the dial for accommodating the screw heads, by recessing the centre portion. Here the dial is seen reversed on the chuck and the process of recessing is in operation

CALIBRATING AND TURNING A CONDENSER DIAL grip a circular block of wood in the chuck of a lathe, and screw the ebonite disk on its face, as shown in Fig. 6, after having turned up the face of the wood block so that it runs perfectly truly. To set the disk true on the face of the block, drill a central hole in the disk and locate it by means of a small peg driven into a central hole in the wood block.

The next step is to take a round-nosed tool with a good top rake and trim up the edge of the disk until it runs true, and then set over the top slide of the slide



FINISHED DIAL WITH KNOB ATTACHED

Fig. 10. In this photograph the dial is complete and the knob attached, being held by a screw. The dial is tilted to show the recessed underside

rest and turn a chamfer, as shown in Fig. 7. The top slide will be set over to whatever angle it is desired to turn the chamfer or bevel on the disk. When a dividing head is available, the calibrations may be cut by setting a swan-neck or other type of V-pointed tool horizontally in the tool holder and traversing it across the face of the bevel, so that it just incises a line. This is illustrated in Fig. 8, which should make the method clear.

If a division plate is not available, a suitable change wheel can be used instead. The disk can then be polished by running the lathe at top speed and using fine emery paper and finishing with rottenstone, tripoli powder, and tallow.

The disk is removed from the wood block, reversed, and replaced as before. The underside of the disk is now accessible, and is recessed as shown in Fig. 9, this being done to facilitate fitting the disk so that it can rotate freely on the face of the panel. The work should be completed by turning up an ebonite knob and screwing this firmly on to the disk with two countersunk brass screws, which should be tapped into holes in the knob in the manner shown in Fig. 10, the knob being provided with a set-screw to secure it to the spindle.

The calibrations are made more apparent by filling the cuts with white paint and wiping the surface while the paint is still wet; this removes the surface colour, but leaves it in the scratches or incisions for the calibrations.

DIAMAGNETIC MATERIALS. Materials which diminish the magnetic induction by their presence in a given magnetic field. Diamagnetic substances, therefore, have a permeability less than unity. *See* Magnetism; Permeability.

DIAPHRAGM. A thin disk, usually of soft iron, found in telephones and microphones for the production or detection of electrical pulsations. The most common form of iron diaphragm is found in the telephone receiver. In this case it is used as a detector, turning current pulsations into audible sounds. It is arranged so that its centre is almost touching a permanent magnet round which is placed a coil of wire.

The diaphragm is rigidly housed around its edge, allowing no movement other than the flexibility of the diaphragm itself. Ferrotype is often used as a diaphragm, but better results are obtained with stalloy, a metallic alloy having a high magnetic permeability. A feature of this material is its extremely rough surface, as is shown in the photograph.

STALLOY TELEPHONE DIAPHRAGM

Stalloy diaphragms are used in wireless telephone receivers. The extremely rough surface of the diaphragm, as compared with ordinary ferrotype diaphragms, is clearly seen

A similar type of diaphragm is often used in microphones, where it confines a quantity of carbon granules in a cup made of the same material. When sound waves impinge against the diaphragm the resulting vibrations cause current pulsations in a current flowing from the carbon cup to the diaphragm. These pulsations actuate the diaphragm of the telephone receivers.

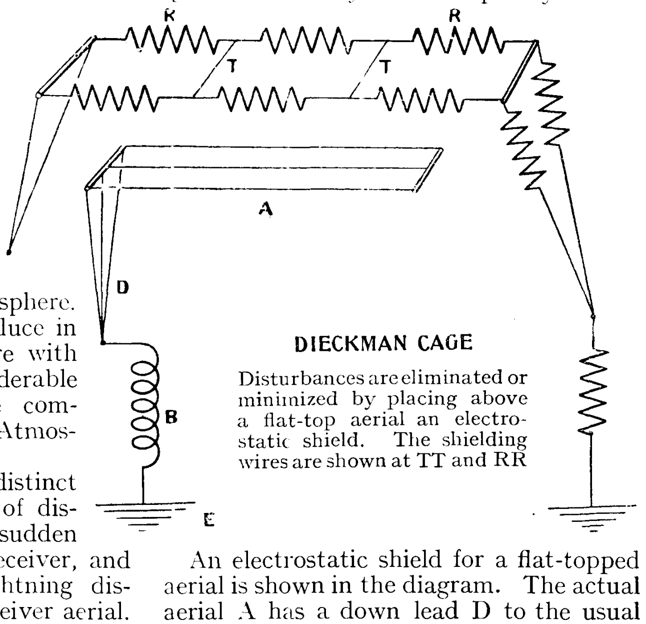
In cases where a large volume of sound is being recorded, the diaphragm is often ridged to prevent dithering. Various other methods are employed to overcome this trouble, which is especially prevalent in loud speakers. Other types of diaphragm consist of a non-metallic material, such as parchment, bearing a soft iron centre. An adaptation of this method is used in a wireless telephone receiver made by S. G. Brown & Co. An iron armature is free to vibrate before the poles of the magnets. To the armature is attached a very thin spun aluminium diaphragm, secured to the case at its periphery. In order to secure a larger area, allowing extra displacement of air when vibrating, the diaphragm is conical in shape. In the older forms the diaphragm was supported at its edge by a ring of goldbeater's skin. This has been replaced by an all-aluminium diaphragm in the present design. *See* Microphone; Telephone; and under the names of the various proprietary headphones, as Brown, Ericsson, etc.

DIECKMANN CAGE. Name given to a type of shielding used to eliminate or lessen atmospherics, strays or "x's." One of the most serious handicaps in wireless signalling, especially in the tropics, is the disturbance due to abnormal conditions of the atmosphere. The irregular noises these produce in the telephone receiver interfere with the regular signals to a considerable extent, and such noises are comprehensively referred to as "Atmospherics," "Strays," or "X's."

There appear to be three distinct kinds of strays; one consists of disturbances which give rise to sudden loud clicks in the telephone receiver, and these are usually due to lightning discharges within range of the receiver aerial. Another disturbance is in the nature of a continual hissing noise, and is considered to be due to the passage of low-lying clouds, electrically charged, in the neighbourhood of the receiver. The third kind gives an impression of rattling or bumping noises, and is probably due to ionization effects in the upper regions of the atmosphere above the cloud strata.

The interference with commercial signalling is sufficiently troublesome to demand serious attention; strays are particularly prevalent during the afternoon of hot summer days. Dieckmann was the first to suggest that the receiver aerial could be shielded from these aperiodic strays by surrounding it with a periodic cage consisting of hoops of wires all connected together and to the aerial by a high resistance wire. This device was consequently known as the Dieckmann Cage. Since these hoops or wires are at right angles to the aerial itself, they do not screen it from the reception of the periodic ether strain effects, but are fairly effectual against static or aperiodic ether strains.

The great disadvantage of strays is that they necessitate a great increase in the amount of transmitting energy to overcome their jamming effect, and it is therefore a matter affecting greatly the capacity of the transmitting station for producing signals of perhaps some five or six times the normal strength that would be required when strays were completely absent



DIECKMAN CAGE

Disturbances are eliminated or minimized by placing above a flat-top aerial an electrostatic shield. The shielding wires are shown at TT and RR

An electrostatic shield for a flat-topped aerial is shown in the diagram. The actual aerial A has a down lead D to the usual tuning inductance B and earth E. The shielding wires are shown at T T, and R R represents the equalizing connexions with inserted resistances, so that the entire shielding system is aperiodic and incapable of being set in resonant oscillation by incoming energy. The whole system is earthed at U through a large inductance or a resistance. *See* Atmospherics.

DIELECTRIC. In electricity the word dielectric usually indicates a non-conductor of electricity, *i.e.* an insulator. It is more generally confined to non-conductors when their function is to separate neighbouring conductors at different potentials.

Dielectrics may be solid, liquid, or gaseous, and among the more commonly used dielectrics in wireless are mica, glass, air, ebonite, wax, waxed paper, and oils. There is no hard and fast dividing line between dielectrics and conductors. It is probable that the best dielectrics allow a certain leakage of current, but this leakage is usually so small that it is not detectable by the ordinary measuring instruments. Dielectrics are affected by temperature. Many substances which are efficient insulators at normal temperatures break down when the temperature is raised, and at a temperature of 2,000 ° C. or more practically every substance ceases to be an insulator.

A substance in a pure state may be a good dielectric, but when mixed with other substances becomes a conductor. The commonest example of this phenomenon is water. Pure water is an insulator, but salt water is an excellent conductor of electricity.

The dielectric strength of a substance is the measure of its insulating qualities. The greater the dielectric strength the better the material is from an insulating point of view. The dielectric strength is usually measured by the voltage which will break down the insulation of a unit thickness of the material.

The table in the next column, due to Gray, gives the dielectric strengths or puncturing voltages of substances commonly used as dielectrics. It should be noted that the strength varies not only with the temperature, but with the particular specimen being tested, its dryness, homogeneity, shape, thickness, method of applying the electro-motive force, whether gradually or suddenly, etc. A rough rule, due to Baur, is that the dielectric strength varies inversely as the cube-root of the thickness of the material.

The strengths in the table are measured at normal temperatures and atmospheric pressures. The figures should only be taken of the order of magnitude of the puncturing voltage and not as applying to any specimen of the substance in particular. The kind of substance used for a dielectric depends to a large extent upon its application. In fixed condensers, such as are used in wireless, waxed paper and thin mica form excellent dielectrics.

DIELECTRIC STRENGTHS OF COMMON SUBSTANCES

Substance	Thickness	Dielectric strength in volts per centimetre
Air	1 cm.	29,800
Ebonite	0·186 cm.	434,000
Mica	0·001 cm.	610,000
	0·01 cm.	2,000,000
Paper	0·01 cm.	400,000 to 640,000
Olive oil	4 to 8 mm.	70,000
Linseed oil	4 to 8 mm.	83,000 to 85,000
Crystal glass	0·1 cm.	285,000
	0·5 cm.	183,000

For variable condensers the usual dielectric is air, though oil is also extensively used. Paraffin paper is used in place of mica in condensers of large capacity where the question of cost becomes important. In other types of condensers ebonite and shellacked paper are both used, and in the Moscicki condenser glass serves as the dielectric.

Dielectric efficiency is the ratio of the energy output to the energy input, thereby taking account of any waste of energy that occurs during the charge or discharge of a condenser. The perfect dielectric has an efficiency of unity, *i.e.* there is no waste of energy in it. In actual practice there is no such thing as the perfect dielectric, and there is always an energy loss.

The losses are due to a number of causes. There is a loss due, for example, to leakage over the edges of the plates, and to prevent this the condenser may be immersed in oil. Another loss is due to the conduction current through the dielectric. The better the dielectric—that is, the worse conductor it is—the less is the loss due to conduction currents.

A further loss is due to the absorbing power, as it were, of the dielectric. By this is meant the ability of the condenser to retain some of its charge when it is short-circuited. It will be found that if a condenser is short-circuited, and then put aside for a short time and short-circuited again, a current will flow due to the residual charge not yielded the first time.

Other things being equal, air and oil make the best dielectrics, followed by mica. Mica condensers, however, depend so much upon the quality of the mica that their efficiency is very uncertain. Ebonite makes a good dielectric in comparatively thick sheets, but it is inefficient when thin. *See* under the names of the various dielectrics. *See* also Air Condenser; Blocking Condenser; Condenser; Insulation.

DIELECTRIC CONSTANT. Another name for inductive capacity. If e_1, e_2 are two electrical charges concentrated at two points x centimetres apart, then the force between the two charges is e_1e_2/Kx^2 dynes, where K is a constant depending only upon the medium separating the two charges. K is called the dielectric constant of the medium. It is measured by the ratio of the capacity of a condenser with the medium in question as the dielectric to the capacity of an exactly similar condenser with a vacuum as the dielectric. The dielectric constant of air at atmospheric pressure is very nearly unity, and is generally taken as such.

The dielectric constant of various materials is given below :—

Substance	Dielectric Constant.
Air	1·00058
Hydrogen	1·00026
Water	81
Castor oil	4·78
Olive oil	3·16
Turpentine	2·2
Petroleum	2·07
Glycerine	56·0
Acetone	21·85
Glass (flint)	6·6
Glass (plate)	8·4
Ebonite	2·3 to 3·2
Indiarubber (pure)	1·7 to 2·6
Indiarubber (vulcanized)	2·7 to 2·9
Mica	6 to 8
Paraffin wax	1·9 to 2·3
Porcelain	4·4 to 6·8
Shellac	2·8 to 3·7
Celluloid	18·6
Dry paper	2 to 2·5
Pitch	1·8

The dielectric constant varies with the temperature, and the constants above are measured between 15° and 20° C. The dielectric constants of liquids decrease as the temperature rises.

Substances which absorb moisture show large variation in their dielectric constants, according to the moisture present.

DIELECTRIC HYSTERESIS. In an insulator subjected to electrical pressure there may be any or all of the following losses, dielectric hysteresis, simple ohmic resistance, discharge losses and losses due to setting up of electrolytic action.

It is a very difficult matter to separate all these various losses, and in the majority of cases ordinary high-frequency resistance losses are by far the largest losses in a dielectric.

Sir Richard Threlfall has described his methods of measuring the dielectric losses in prepared samples of material.

The material to be tested is carefully dried, and turned or ground into the form of an ellipsoid. This is attached to a quartz fibre and suspended. A mirror, similar to that used on a reflecting galvanometer, is attached. The whole fibre and mirror are shielded from electrostatic action. Around the specimen, condenser plates are mounted in such a manner that they can be rotated and produce a uniform field. Threlfall found that ellipsoids of the common dielectrics were set in motion, indicating that the electric strain or polarization lags behind the electric force in phase.

The formula for the energy expended per cycle due to dielectric hysteresis is

$$W = aF^n$$

where W = the dielectric hysteresis, F = internal electric force, a is a factor depending on the material—for glass and ebonite it may be 0·03 to 0·04.

Aerial n is taken as lying between 1·5 and 1·95 for ordinary dielectrics.

Dr. Fleming shows how this loss may be expressed as a percentage of the energy stored per unit of volume.

Taking F as the uniform internal force in one unit of volume, C as the capacity per unit of volume, then

$$C = \frac{K}{4\pi}$$

hence the energy stored is

$$T = \frac{KF^2}{8\pi} \text{ per cubic unit.}$$

The energy expended in hysteresis has already been given as

$$W = aF^n$$

therefore $$\frac{W}{T} = \frac{8\pi aF^{n-2}}{K} = \beta$$

Let F = 1, then

$$\beta = \frac{8\pi a}{K}$$

For ebonite, Threlfall gives

$$K = 3·5$$
$$a = 0·029$$
$$n = 1·765$$

hence $\beta = 0·212 = 21·2\%$.

It will be seen from the above that it is by no means easy to separate out the true dielectric hysteresis from the other dielectric losses, and in the majority of practical cases it is sufficient to know what the total dielectric losses are in a particular type of insulator.

DIES AND TAPS & HOW TO USE THEM

How the Amateur Can Cut Screw Threads in Metal and Ebonite

Here are described fully and illustrated with action photographs the best varieties and the correct methods of working with these tools, which are essential in the construction of wireless apparatus. See such related articles as B.A. Screw Threads; Screws, etc. ; also Brass . Ebonite

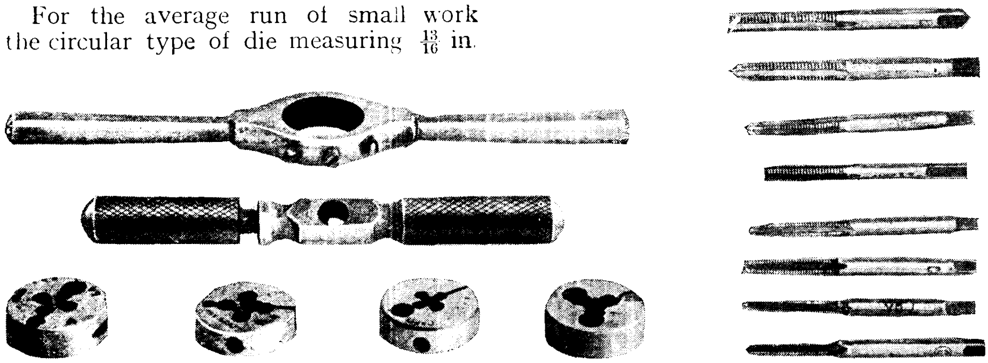
Dies and taps are metal working tools relatively small in size and generally used by hand. Their special purpose is to cut screw threads on or in metal and ebonite and similar hard materials. They are very necessary tools for all wireless experimenters, as without them most of the small work associated with wireless apparatus making could not be completed.

Dies are used to cut threads on the outside of the work, and taps to cut threads on the inside. Consequently, to ensure interchangeability it is imperative that the die and the tap for any particular type and size of screw shall be of the proper form and dimensions. To ensure the parts fitting together when they have been screwed, it is necessary for the die to be a trifle smaller in diameter than the normal size and the tap a little larger, to permit the external screwed part to enter the screwed hole.

These differences are generally allowed for by the makers, although it is usually possible to adjust the diameter of the die a trifle All commercial screws are, nowadays, manufactured to recognized limits of error, and are remarkably uniform as regards diameter and pitch of the screw threads Consequently, if the amateur purchases dies and taps of a reputable make the results will be entirely satisfactory, provided the tools be properly handled.

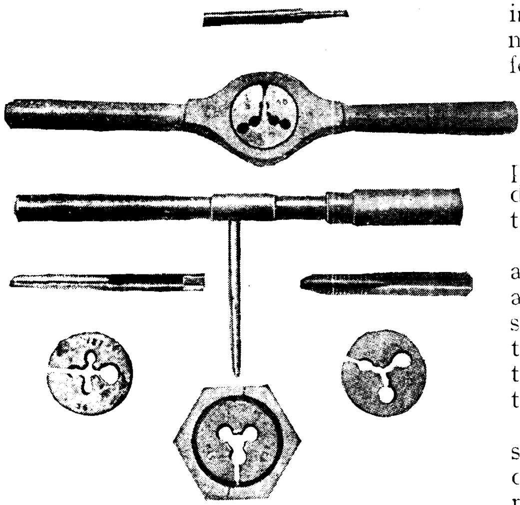
For the average run of small work the circular type of die measuring $\frac{13}{16}$ in. in diameter is most suitable, and is available singly or in sets at moderate cost. The dies are useless without a die stock or handle to hold them and wherewith to rotate them. The taps are somewhat like screws in appearance, except that they have grooves known as flutes along them. These are to form the cutting edges on the taps. The solid part, known as the shank, is generally larger in diameter than the screwed part, and terminates in a squared portion at the outer end. This is used to rotate the tap, and is held in a tap wrench or holder.

The most convenient way to acquire these tools at the outset is to obtain a small set such as that illustrated in Fig. 1, which shows a die stock, tap wrench, four dies and eight taps. The taps are of two kinds, known as tapering and plug. The former are, as the name suggests, tapered somewhat, the small entering end being reduced to a diameter equal to the bore of the hole to be tapped. This is to allow the tap to start easily, as the tapered portion permits the tap to start gradually. The hole is then opened out and completed with the plug tap, which is of uniform diameter throughout its screwed length. In some cases seconds taps are used as well, and these are practically a plug tap with a very snub end which just allows the tap to start the threads in a hole.



BRITISH ASSOCIATION (B.A.) GAUGE DIES AND TAPS

Fig. 1. Several small dies and taps are illustrated, with appropriate die stock and tap wrench. These are some of the most commonly used dies and taps in the wireless experimenter's work-room. They are particularly suited to the needs of amateurs constructing their own apparatus



ATTACHMENT OF DIE TO STOCK

Fig. 2. How the die is held in the stock and the method by which a tap is held in an adjustable tap wrench is here shown

They are mostly used on comparatively thin work where the tap can pass right through the hole. The plug tap is essential when tapping a blind hole, that is one that terminates in the metal or has a closed end.

Taper taps are used for long or deep holes, and on this class of work should be followed by a seconds tap and finished with the plug tap.

The method of holding the die is illustrated in Fig. 2, where a die is shown in place in the stock, also a tap in the tap wrench. The die shown in the hexagonal nut is a special form of holder adapted to be rotated by a spanner.

Larger screw threads are cut with more substantial tools, such as the set illustrated in Fig. 3. The dies are in this case made in two halves, and slide into grooves formed in the body of the die stock seen at the top of the illustration. Two long, detachable handles are used, and when these have been screwed into place in the die stock body, enable large diameter threads to be cut with ease up to, say, $1\frac{1}{4}$ in. diameter or thereabouts.

This class of tool is used for threads above $\frac{3}{8}$ in. diameter. The lighter patterns, as shown in Figs. 1 and 2, are used for the smaller sizes. There are numerous other types of die and stock, but those illustrated are suited to the requirements of the amateur and experimenter.

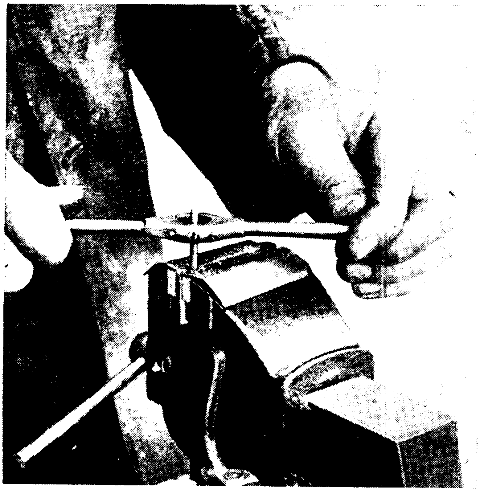
As an example of the use of the die and stock for cutting threads on the outside of a rod, consider the case of a piece of round brass rod, say, $\frac{1}{2}$ in. diameter and 4 in. long. If this is to be screwed with a $\frac{1}{4}$ in. thread, say a Whitworth, it is only necessary to place the die in the stock, and secure it with the set-screws in the side of the body. It is essential to see that the die is placed the right way up.

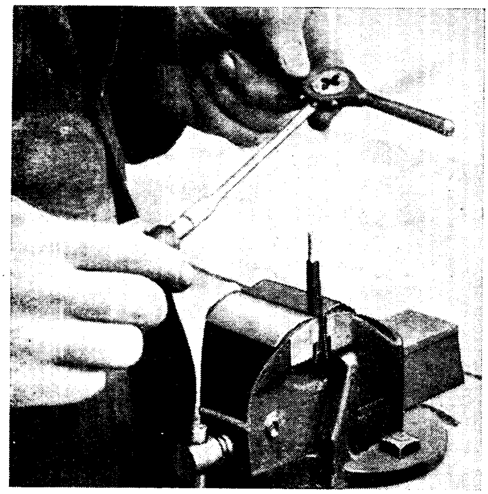
If it is examined it will be seen that the hole with the screw thread cut in it is tapered somewhat at one side and not at the other. The larger end should always be set outwards in the stock. The flange on the stock should come against the side of the die with the smaller end of the hole. This is because the pressure exerted when screwing will not tend to shift the die out of the stock, and also that the large end of the die shall commence the work, and not the small end.

The small end is the sizing end, that is to say, it is that part which brings the rod to the exact size and form. The smaller, tapered end is the starting end, and

ADJUSTABLE DIES FOR CUTTING LARGE SCREW THREADS

Fig. 3. Ranged in sizes are a set of adjustable dies with a die stock and taps and bushings suitable for constructive work. These implements are used for cutting large screw threads. The dies are made in two halves, and slide into grooves in the body of the die stock. The handle is in two sections, screwed in the projecting lugs of the stock





CORRECT METHODS FOR SCREW-THREAD CUTTING WITH DIE AND STOCK

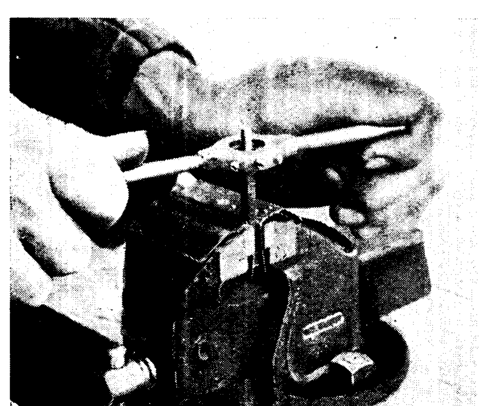
Fig. 4 (left). When cutting an external screw thread the correct way to use a die is shown in this photograph. The flange of the die stock should be uppermost, and as the stock is rotated it should be pressed downward. Fig. 5 (right). How the die is reversed and held in the die stock is here shown. It will be seen that there are three set-screws, and the operator is adjusting these screws after reversing the die

being tapered, allows the threads to start easily and gradually, as the die does not then have to reduce the rod to the full amount at one revolution.

To start an external screw thread, test the diameter of the rod and see that it is not over size. It should be exact, and if on the large side, ought to be turned to size in a lathe, or if only a trifle larger, can be corrected by polishing with emery paper. The next step is to slightly round off a point at the end of the rod. Place the die on it and, holding the tool firmly, press it downwards constantly, and at the same time rotate the stock with both hands as shown in Fig. 4, when, if the tool is sharp and properly adjusted, a clean screw thread should appear.

When cutting on brass a lubricant is not necessary, but a little oil can be used when screwing steel. In those cases where it is necessary to cut a screw thread up to a shoulder, as, for instance, when screwing a squared shaft for a condenser spindle, the work is started and the thread cut as far as possible in the manner already described. When the face of the die reaches the shoulder the die should be rotated backwards, and the die taken from the stock and turned the wrong way up, as shown in Fig. 5.

The thread is completed with the finishing side of the die, as shown in Fig. 6, which illustrates how the die can by this method cut the thread right up to the shoulder. On very high-class work a relief groove is often cut next to the shoulder to allow the die to clear, and when this is done there is no need to alter the die from its normal position in the stock. The work to be screwed should be held very firmly in the vice, together with pieces of copper or lead. These are known as clams, and should always be interposed between the work and the vice jaws to prevent scratches spoiling the work.



USING A REVERSED DIE

Fig. 6. By reversing the die in the die stock, a clean thread can be cut to the face of the shoulder on a square spindle. Spindles requiring this operation are frequently used in variable condensers

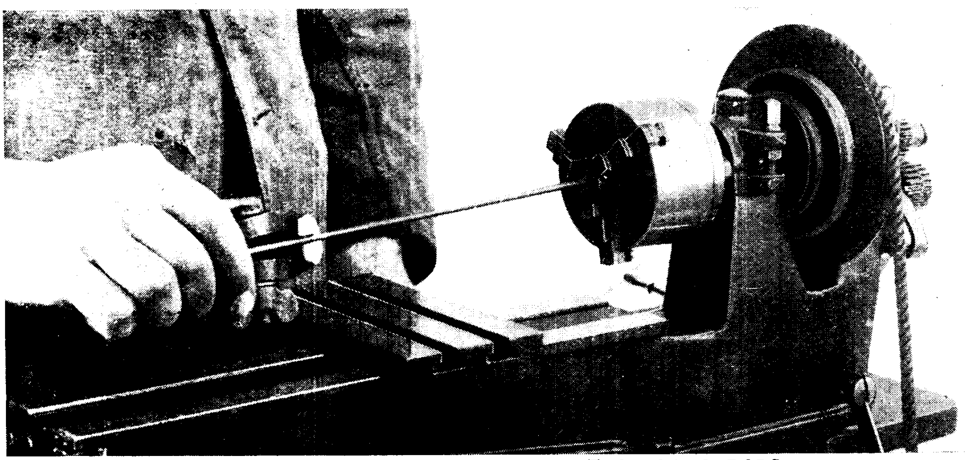
When it is desired to screw a long length of rod the die can be chucked in a lathe, as shown in Fig. 7. The rod is held in a hand vice or other convenient form of grip, the thread started by carefully rotating the lathe by hand, and the bulk of the work finished by treadling with the slowest speed engaged, or, when available, with the back gear in operation.

The larger dies, as shown in Fig. 3, are assembled in the manner illustrated in Fig. 8, by unscrewing the retaining ring with the right hand while holding the body of the stock in the left. The dies are then dropped into place the correct way up and the ring replaced. The stock is next laid on the bench and the guide bush inserted and secured loosely with the set-screw, as shown in Fig. 9. This guide is to centre the rod and help to keep it in line with the die, and so guard against stripping the thread. The next step is to place the work to be screwed in the vice and place the stock in position by inserting the end of the work into the bushing, as shown in Fig. 10.

To adjust the die it is desirable to have a piece of metal already screwed to the correct size and to tighten the adjusting screws when the die has been screwed on to this test piece.

When this is not possible the dies should be screwed up tightly to the rod and rotated backwards and forwards a few times, again tightened and rotated, and these operations repeated until a full depth thread has been cut. The screwing can then proceed to the desired length and the result tested by attempting to screw a standard-sized nut on to the thread. It will probably happen that the screwed part is over size and the nut will jam.

The dies will then have to be tightened a little and a light cut taken, again traversing the work a few turns and then reversing the direction of rotation and then on again, and so on until the whole has been screwed. This method of using the dies is preferable to attempting to cut a full thread at once, as by so doing there is risk of the threads tearing and finishing in a very ragged state.



HOW SCREW THREADS MAY BE CUT ON LONG RODS

Fig. 7. Long thin rods can be screw-threaded by the method illustrated above. Here the die is held in the chuck of a small lathe. This method is especially suitable when the lathe has a hollow mandrel. It will be noticed that the operator is holding the work by hand, gripping the rod with a hand vice

The same procedure should be followed with the smaller size used in the circular type of dies.

After the threads have been started the dies can be rotated by grasping the ends of the handles, as shown in Fig. 11. On large work of, say, $\frac{1}{2}$ in. or over considerable pressure is needed to cut the threads. All tapping operations are essentially the same, and Fig. 12 illustrates the general method. A hole is first drilled in the work to be screwed, and this hole should be smaller than the diameter of the screw. The actual size is known as the tapping size, and details of them for the most commonly used threads in the B.A. system are given in the article on B.A. Screw Threads (*q.v.*) and all others are given in any standard textbook.

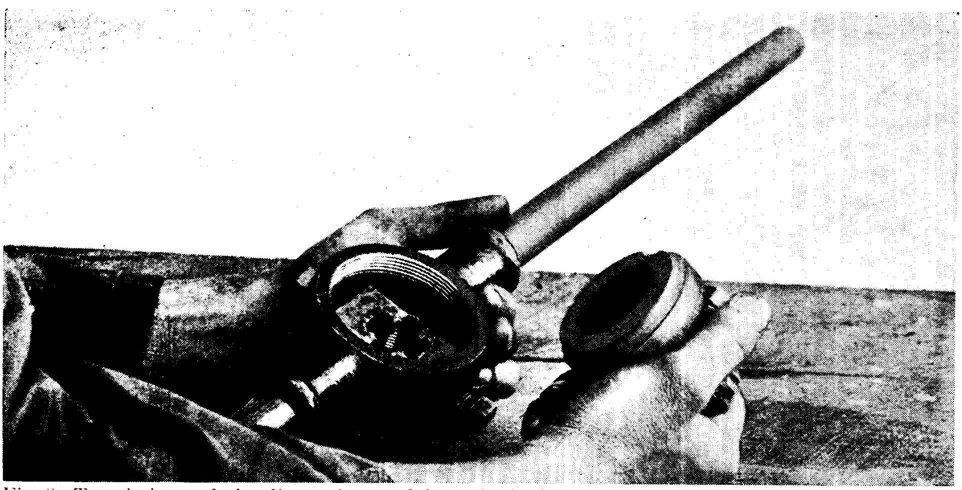


Fig. 8. Two halves of the die are inserted into the body of the stock, which is shown held in the operator's left hand. The method whereby they are retained by the screwed rims held in the operator's right hand is also apparent

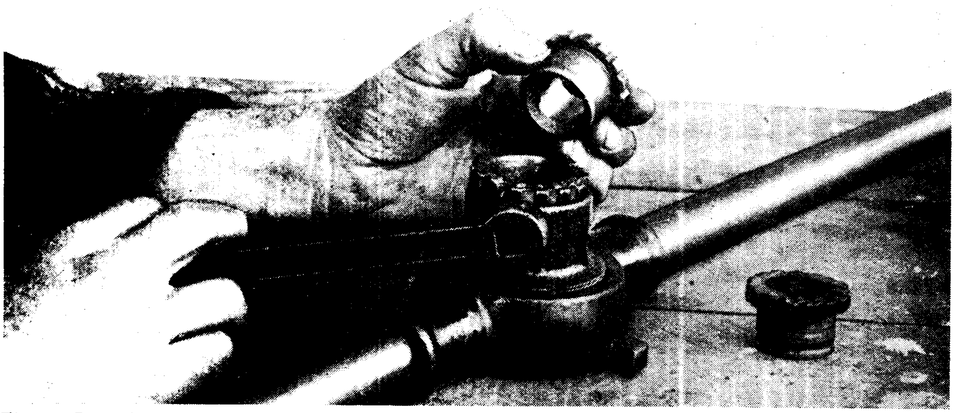


Fig. 9. In order to keep the die in line with the work, the guide bush seen in the operator's left hand is inserted and a locking nut retains it in position

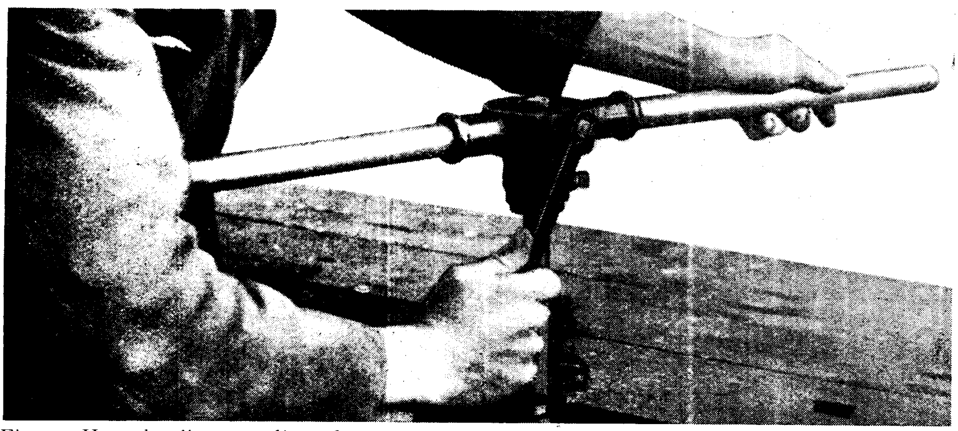
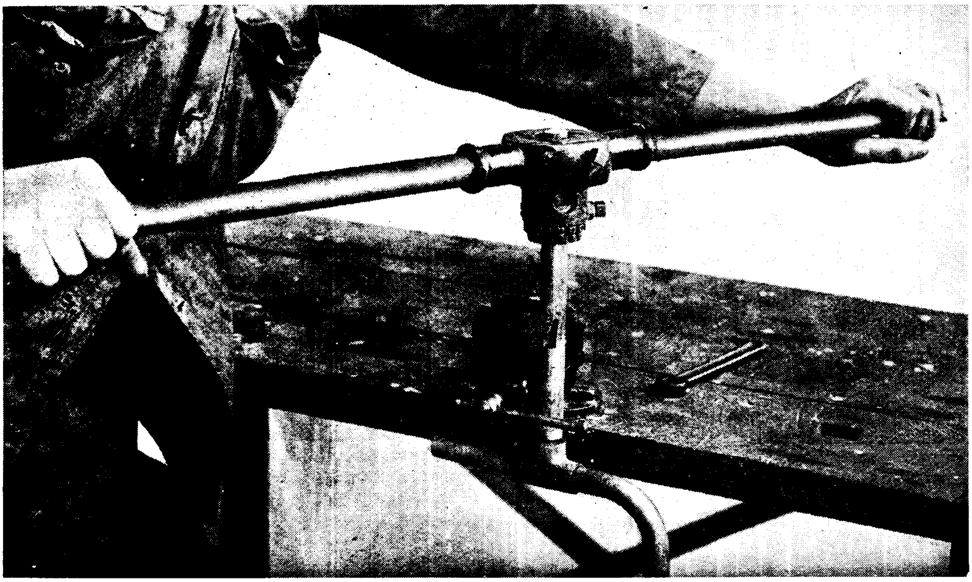


Fig. 10. How the dies are adjusted to cut to the correct diameter is shown. The use of the special box spanner which is supplied with the instrument helps to preserve the form of the head of the set-screw

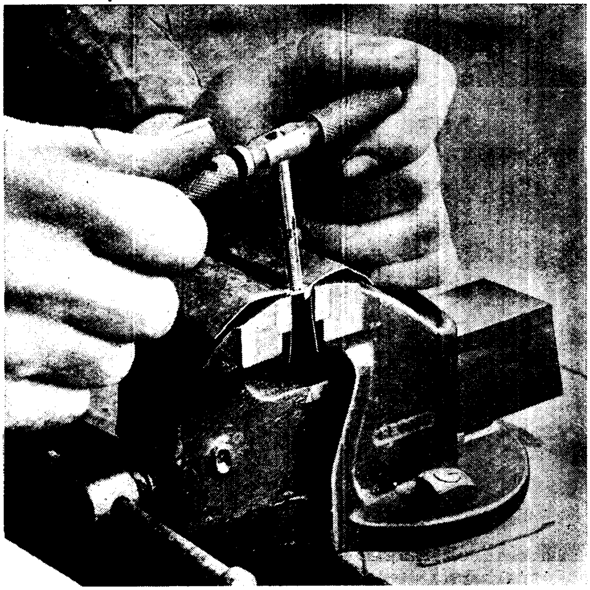
PHOTOGRAPHIC DEMONSTRATIONS OF THE USE OF A LARGE DIE AND STOCK



USING A LARGE SIZE DIE AND STOCK

Fig. 11. In constructing wireless apparatus such as the cooling system of an arc transmitter, the larger type of die stock may be called for. This illustration shows how a thread is cut in such a pipe system, the work being held in a vice and the operator gripping the extreme ends of the handles to obtain the greatest purchase

The experimenter can purchase the drills by asking for a tapping size drill for the particular size of tap to be used. The tap is then inserted in the hole and the tap wrench held and rotated as illustrated in Fig. 12, taking care to keep the tap perfectly upright and in line with the axis of the hole If this is not done the screw thread will be known as drunken—that is, not cut truly—and a screw introduced into the hole would turn with a jerky and uneven motion, or would not enter at all.



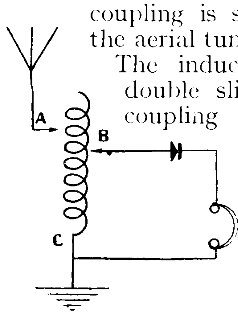
MANIPULATING A SMALL TAP

Fig. 12. Above will be seen an example of the correct way to manipulate a small tap and tap wrench. Lead clamps are used to protect the work which is being tapped

Taps and dies should never be crowded—that is, they should be coaxed into their place and gradually screwed down, reversing the direction of rotation from time to time, applying a lubricant when needed, and also wiping away any chips that might accumulate around the hole.

The object in reversing the rotation is to break up and separate the chips and avoid clogging. The greatest difficulty found by the novice in screwing with dies and taps is to keep the screwing tool in line with the hole. This is best overcome by practice, and by looking at the instrument to see that it is upright and turning the holder regularly. Any attempt to force the die or the tap will only result in stripping the thread—that is, tearing off the tops of the threads—or in jumping the threads, *i.e.* cutting them in half and making, as it were, two threads instead of one.

DIRECT COUPLING. The coupling between two or more inductances or circuits where connexion is made by metallic contact. An example of direct coupling is shown in the figure in the aerial tuning of a crystal set. The inductance consists of a double slider. Here metallic coupling exists between the aerial tuning inductance, represented by AC, and the telephone circuit, represented by BC. Technically, this may be described as two separate circuits formed by AB on one hand, and BC on the other. The advantage of this arrangement lies in greater selectivity and more pronounced sharpness of tuning.



Double-slider crystal receiver, with direct coupling between inductances AB, BC

In electrical and mechanical engineering when the main shaft of a generator or similar machine is directly attached to a motor or pump or other form of power conversion, it is said to be directly coupled. *See* Coupling.

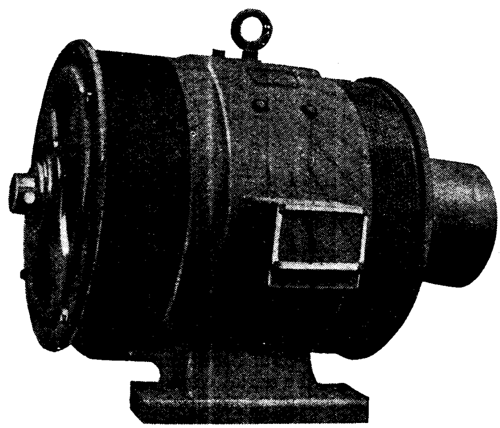
DIRECT CURRENT. Term usually applied to an electrical current flowing steadily and continuously in one direction. Commonly known as D.C. Direct current, in fact, is now held to be synonymous with continuous current, but in the standardizing rules of the A.I.E.E. (1907) a distinction was introduced between the two, "direct" being used as a general description of unidirectional currents, and "continuous" being applied more particularly to "steady or non-pulsating direct currents."

The novice in wireless can consider a direct current as one that is produced by a dry battery or accumulator, or by a direct current generator.

Direct currents are necessary for such purposes as recharging a storage battery, lighting the filament of a valve, and for the anode current flowing through the anode circuit of wireless apparatus. Other applications include the energization of relays and some forms of crystal detectors, such as carborundum. *See* Alternating Current; Current; Dynamo.

DIRECT CURRENT GENERATOR. An electrical machine designed for the production of unidirectional currents. It consists of a revolving armature usually having a series of longitudinal slots. In these slots are laid a number of wires connected at their ends with a number of commutator segments corresponding in position and number to the slots. As each particular slot passes a field magnet during the rotation of the former a definite polarity of current is created. This current travels to the section of the commutator to which it is attached, and is led off by carbon or similar brushes to the external circuit.

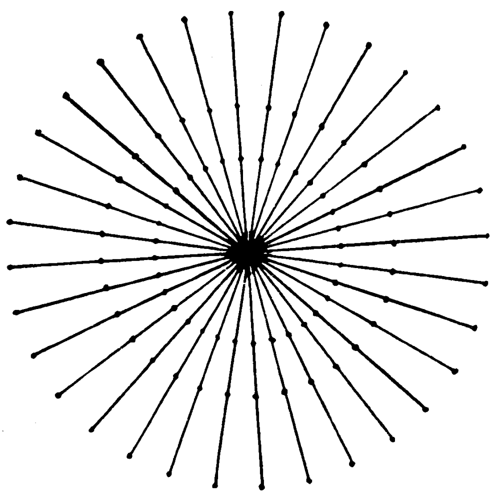
A machine of this type is shown in the photograph, illustrating a semi-enclosed or protected generator. It is protected on the commutator side by a gauze ring clearly seen in the illustration. An iron ring bolted to the top of the machine is used in lifting it about before finally bolting in position. The small box on the side of the machine houses the connexions to the mains. *See* Alternator; Dynamo; Generator.



PROTECTED DIRECT CURRENT GENERATOR
An electrical machine used in the production of direct current and known as a D.C. generator is shown above. This is of the protected or semi-enclosed type, and is made by the English Electric Company

DIRECTIONAL WIRELESS. The directional transmission of wireless signals has always been a matter of supreme interest, and is now rapidly coming to be one of paramount importance and commercial value. It is a problem beset with many difficulties, for the distance or location of a wireless transmitting station may be seriously misjudged if estimated by signal strength alone. More accurate results are achieved by employing two or more direction-finding stations, on the triangulation principle of ordinary surveying practice.

Hertz, in his original researches, demonstrated that electro-radiation could be reflected by means of mirrors, and, later, Marconi carried out various experiments, transmitting a wireless "beam" to a considerable distance by the use of copper parabolic mirrors. For long wave-lengths, however, the use of a mirror was found to

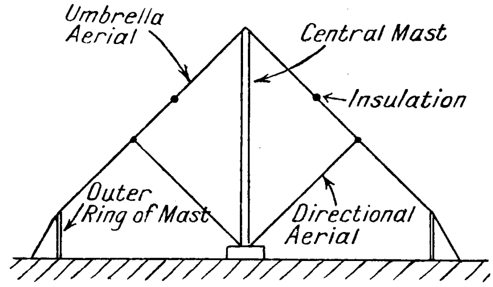


PLAN OF UMBRELLA AERIAL

Fig. 2. Where the dots occur in the radiating lines, representing the aerial wires, insulators are inserted at the inner and outer circles

be impracticable, since the size of the mirror must be comparable with the dimensions of the wave-length employed. About 1899 to 1902 screen reflectors met with some success. These consisted of vertical wires spaced about the transmitting aerial in the form of a parabolic screen, and arranged so that the transmitting aerial was at the focus. Modifications of this method are still in use, but only for wave-lengths very small in comparison with those normally used for commercial wireless signalling.

Later investigators made use of horizontal, inclined, and bent aerials, of which the most promising proved to be the inverted L type aerial. If the horizontal limb of this type of aerial is made considerably longer than the vertical portion, the radiating or receiving properties are



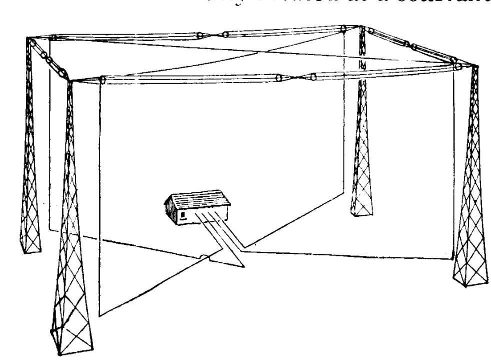
DIRECTIONAL AERIAL FOR TELEFUNKEN COMPASS

Fig. 1. Seen in section this arrangement appears like a pyramid, the sloping sides of which are the aerial wires of the umbrella aerial. The directional aerial wires are between the base of the mast and the side of the pyramid

found to be greater in a direction opposite to that in which the horizontal limb of the inverted L is pointing.

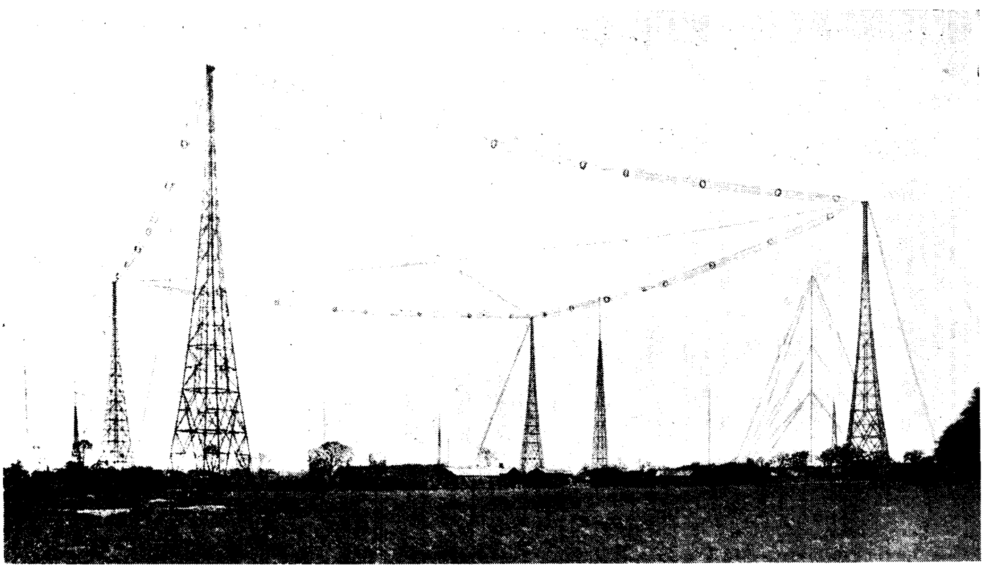
More accurate directional wireless depends upon the radiation of two or more aerials, the currents in which bear definite phase and amplitude relations to one another. S. G. Brown demonstrated that a system of two vertical aerials connected to a spark-gap and spaced half a wave-length apart was found to have maximum radiating and receiving properties in the plane of the two aerials.

A mobile wireless station may find its bearing from a fixed transmitting station with a fair degree of accuracy by the Bellini-Tosi Radiophare. The principle of operation involved is to arrange that the direction of maximum radiation from the transmitting station shall be continuously rotated at a constant



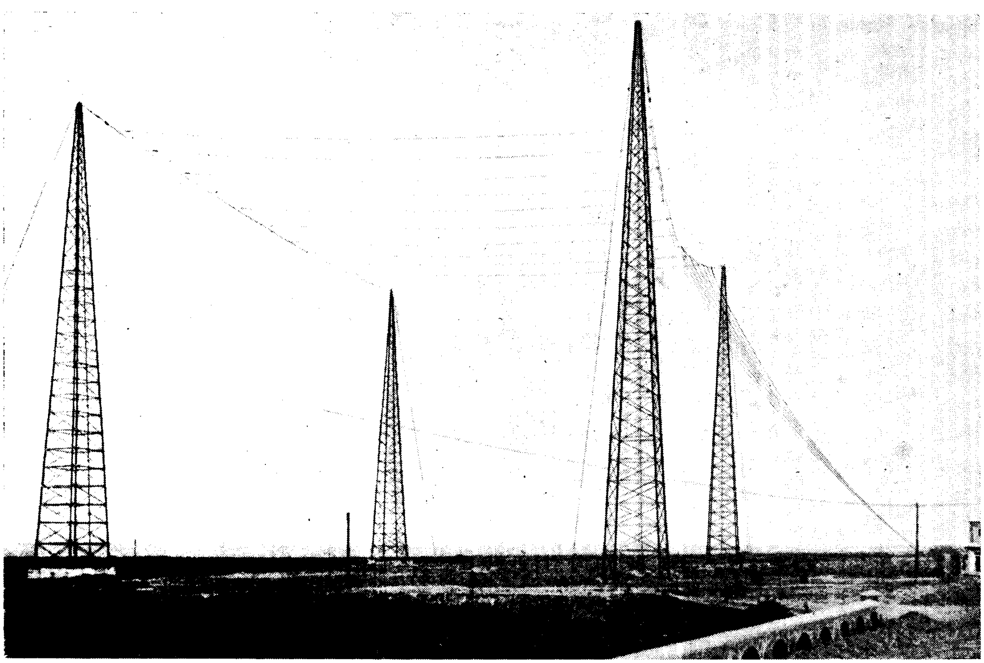
BRENTWOOD DIRECTING AERIALS

Fig. 3. Diagonal wires of the direction finder are suspended from the four corners of the cage aerial system, which, as seen in Fig. 4, forms a square. These diagonal wires are part of two loops which lead in to the receiving apparatus in the instrument hut



DIRECTIONAL AERIALS AND MASTS AT THE MARCONI STATION AT BRENTWOOD

Fig. 4. Brentwood is a well-known station belonging to the Marconi Wireless Telegraph Company. The aerial above is a combination of a horizontal loop and a diagonal cross. It is of the cage type, and the wires going diagonally across the aerial square are used for directional purposes. This is a receiving aerial. The above photograph shows clearly most of the aerial wires, but owing to their position close to the ground the diagonal leading-in wires cannot be seen. Reference should be made to the diagram in Fig. 3



MARCONI COMPANY'S DIRECTIONAL AERIAL AT CADIZ

Fig. 5. Directional operations are carried out by the Marconi Wireless Telegraph Company at their Cadiz station. The aerial is shown above. This is an adaptation of the fan type, and was designed to be directional with the wireless station at Las Palmas, Canary Islands. The lead-in wires can be distinctly seen on the right being carried away to the instrument room, partly seen in the right-hand bottom corner of the photograph

speed in a clockwise direction. At given intervals, corresponding to a known bearing, a distinctive signal is transmitted, and any ship or other mobile station suitably equipped is thus enabled to find its bearing from the transmitter by noting the signal corresponding to maximum signal intensity.

The Telefunken compass makes use of a series of directional aerials radiating from a single mast in the manner shown in Figs. 1 and 2. At prearranged intervals a time signal is transmitted on the non-directional aerial, and this is immediately followed by a series of further signals sent at intervals of one second on each of the directional aerials in turn. There are 32 of the latter, corresponding to the points of the compass, and the direction of transmission will therefore rotate once in 32 seconds, and is arranged to start and finish in the direction of due north.

Ship stations employing this system are provided with a special stop watch having the dial marked out in the form of a compass, the finger or pointer of which rotates once in every 32 seconds. When the time signal is first heard the listener starts his stop watch, and as soon as the signal has reached its maximum strength the watch is stopped. The position of the pointer on the dial will then indicate the direction of the transmission at that instant, thus giving the ship's bearing with regard to the transmitting station.

Directional wireless is possible to a limited extent by the use of the simple loop or frame aerial. When a loop aerial is rotated about its vertical axis the strength of the signal will be found to vary, being a maximum when pointing direct to the transmitting station, and at a minimum strength when at right angles to the transmitter.

The directional receiving aerial shown in Figs. 3 and 4 is at the Marconi Receiving Station, Brentwood, Essex. This aerial is a combination of a horizontal loop and a diagonal cross. The loop is in the form of a square, supported on steel lattice masts, the aerial itself being of the cage type. Besides this loop, wires are stretched diagonally across the square, forming the directional part of the aerial

By the use of an aerial of this type, not only can the direction of a signal be found upon, for instance, N and S line, but it is possible to differentiate between N and S individually. It will be noted that this is an advance upon the directional properties of the ordinary vertical loop, by the use of which it is possible to ascertain only whether the signals are coming in line with the aerial and not from in front or behind.

Fig. 5 shows the aerial and lead-in of the Marconi Telegraphy station at Cadiz. It will be seen that the aerial is an adaptation of the fan type. It was designed to be directional with another station of the same company at Las Palmas, Canary Islands, with which station Cadiz invariably communicates. *See* Aerial; Bellini-Tosi Aerial; Frame Aerial.

DIRECTION FINDERS: PRINCIPLES AND PRACTICE

An Important Modern Development in Wireless Work Fully Described and Illustrated

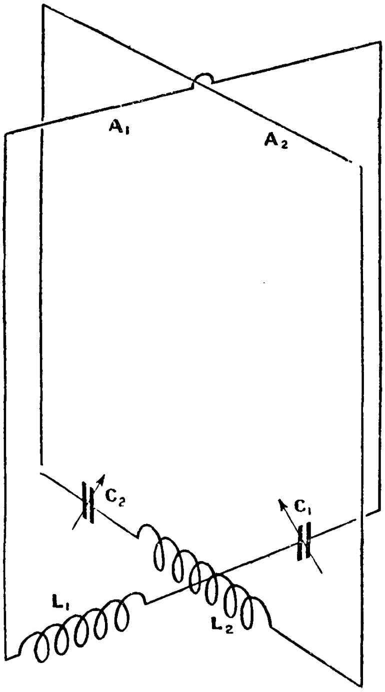
Directional transmission and reception of wireless signals is a matter of supreme importance and commercial value. Here the latest developments in modern direction-finding instruments are clearly explained, with special reference to the work of Senatore Marconi. See also Directional Wireless and such related articles as Bellini-Tosi Aerial; Goniometer; Short-Wave Transmission

Aerials so constructed as to indicate the direction from which wireless signals are coming are termed direction finders. A transmitting aerial of the coil type will produce the maximum intensity of field in its plane, and the minimum at right angles to it. In a similar manner a receiving aerial of the coil type will have the greatest current produced in its circuit when it lies in the same plane as that in which the waves are propagated, and the minimum amount of current when its plane is perpendicular to this position.

As explained under the heading Directional Wireless, if a coil aerial is made capable of rotation about its vertical axis, zero strength of signals will be received when its plane is normal to the direction from which the waves emanate.

An example of a direction finder can be instanced in the Bellini-Tosi goniometer, which is designed to obviate the necessity for actually rotating the aerial itself in order to locate the direction of transmission.

It consists of two exactly similar coil aerials set at right angles to one another



DIRECTION FINDER ON THE BELLINI-TOSI PRINCIPLE

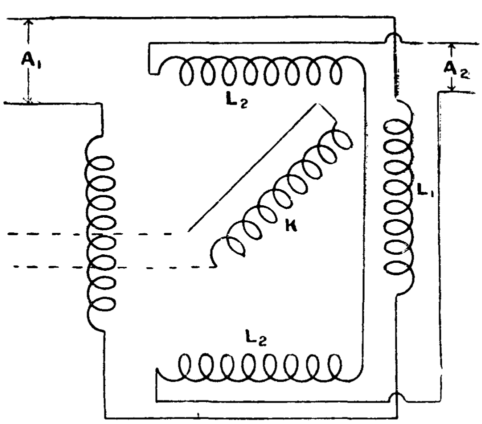
Fig. 1. Two coil aerials exactly similar are set at right angles to each other. Inductances at L1, L2, are both similar, and connected in series with the two aerials

(as shown diagrammatically in Fig. 1). Each is connected in series with similar inductance coils, L_1 and L_2, and with variable condensers C_1 and C_2, giving the usual facilities for tuning to the incoming wave-length. The coils L_1 and L_2 are constructed in a special manner, given in detail in Fig. 2, space being left in the centre of the arrangement for another coil, K, which is capable of being rotated round its axis. Coil K is connected to a tuning condenser. to which is attached the detecting circuit.

As K is rotated, the signal strength will vary, for the following reasons. If L_1 and L_2 in Fig. 3 represent the planes of the stationary coils, and K that of the movable coil, it is first assumed that the coil aerials A_1 and A_2 in Fig. 1 are so placed that the plane of A_1 is parallel to that of L_1. It is also assumed the coils L_1 and L_2, and the condensers C_1 and C_2, with their respective aerials A_1 and A_2, are so adjusted that each circuit has a natural wave-length equal to that of the incoming waves—in other words, that the circuits of the two aerials are exactly similar.

Assuming that the incoming electromagnetic waves are harmonic, it follows that harmonic electro-motive forces and currents will be induced in the respective circuits A_1 and A_2, and therefore the current in that aerial whose plane is inclined to the direction of these waves will be equal to that received by an aerial whose plane is actually parallel to the wave direction multiplied by the cosine of the angle existing between the wave direction and the aerial plane.

The signals will be practically extinguished when the normal to the plane of coil K is parallel to the direction of the waves, while maximum strength of signals will result when the normal to the plane of K is at right angles to the direction of the incoming waves. When L_1 and L_2 are parallel to A_1 and A_2 respectively, the



DETAILS OF DIRECTION-FINDER COILS

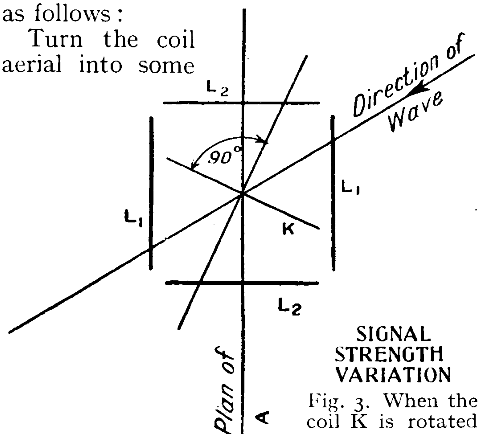
Fig. 2. Four coils are here seen spaced, with a fifth coil, K, in the centre. K is rotated on its axis, is tuned by a condenser, and is connected to the detecting circuit

result is the same as though the whole system of coils was reduced to coil K alone, used as an aerial.

By fitting the coil K with a suitably calibrated dial and rotating the coil until the weakest signal effect is produced, the direction of the incoming waves may be determined with a comparatively small percentage of error.

It is, of course, evident that the above method falls short in one essential particular, in that it does not eliminate the uncertainty as to whether signals are being received from a station at a point in front or behind the operator. This is the "180-degree error," and is provided for by the following arrangement, illustrated in Fig. 4. This figure represents the coil aerial, ABCD, also a vertical wire aerial, FG, connected to earth in series with a tuning inductance, H, and key, K. The inductance, H, is loosely coupled to the coil, N, which is inserted in series with the coil aerial. The various operations in obtaining the direction of waves received are described as follows:

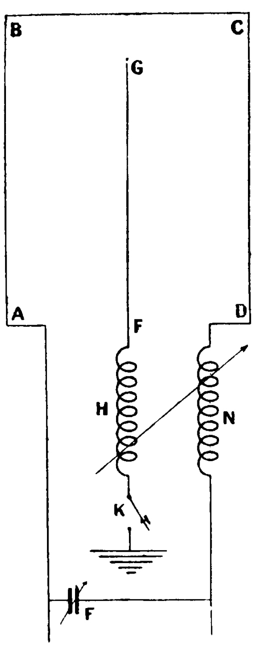
Turn the coil aerial into some



SIGNAL STRENGTH VARIATION

Fig. 3. When the coil K is rotated variations in signal strength occur for reasons described in the text

position where the signals may be easily heard, and tune the aerial circuit to the incoming wave-frequency by means of the condenser, P, key K being open at the time. Without changing the condenser adjustment then close key K and adjust the tuning inductance H until the circuit of the vertical aerial, FG, is also tuned to the same wave-frequency, which will be denoted by maximum noise in the receivers attached to the detecting circuit. The next step is to open key K and turn the aerial, ABCD, until the



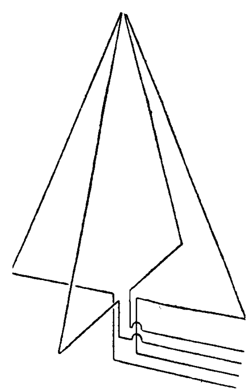
METHOD OF TUNING DIRECTION FINDER

Fig. 4. This shows diagrammatically the arrangement for avoiding the 180 degree error as described in the text

signals are either entirely extinguished or become a minimum. When in this position the normal to the plane of ABCD represents a line parallel to the direction of the waves being received.

With the key K still left open, turn the aerial ABCD into a new position 90° away from the one last occupied, which will result in maximum strength of signal being received. With the aerial still in this position depress key K, when the signal strength will then either increase or decrease in comparison with the observations just taken, according to the exact direction from which the waves are arriving. If the waves increase in strength upon closing K, the signal arrives from the one direction, and if they decrease in strength, they must then be arriving from the opposite direction. Previous calibration taken from a station of known position will then indicate the orientation.

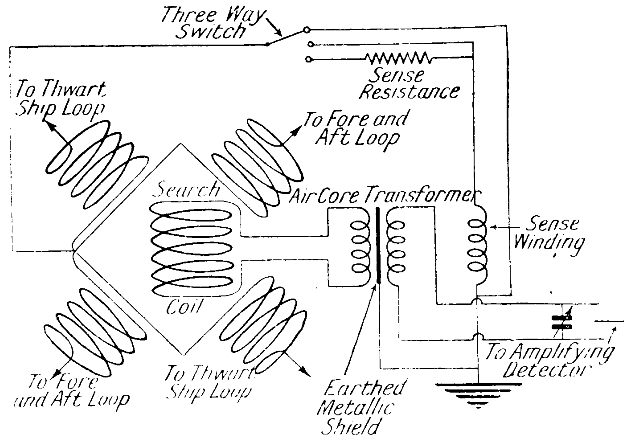
The direction finder illustrated in Fig. 8 is a standard marine instrument made by the Marconi Wireless Telegraph Co., Ltd. The aerial system used in conjunction with this set is shown diagrammatically in Fig. 5. It will be seen from this illustration that a form of double loop is used. Each loop is of triangular formation, and the loops are placed at right angles to one another. Underneath the aerial loops there are two smaller loops, which are known as the field coils (*see* Bellini-Tosi Aerial, page 230, Fig. 6). These are really part of the set itself, and are not actually placed immediately underneath or in the same plane as the aerial, but are merely shown here to indicate how they are wired to the loops.



MARCONI DIRECTION-FINDER AERIALS

Fig. 5. Two loops are employed in the Marconi direction-finding system, as illustrated in the above diagram

Reference must be made to Fig. 6 to understand this fully. Fig. 6 is a circuit diagram of the direction-finding sense and tuning arrangements in the receiver. The connexions from the loops to the respective



CIRCUIT DIAGRAM OF DIRECTION FINDER

Fig. 6. Sense and tuning arrangements are shown in the above diagram. Connexions are apparent from the loops to the respective field coils. The transformer is illustrated in Fig. 14

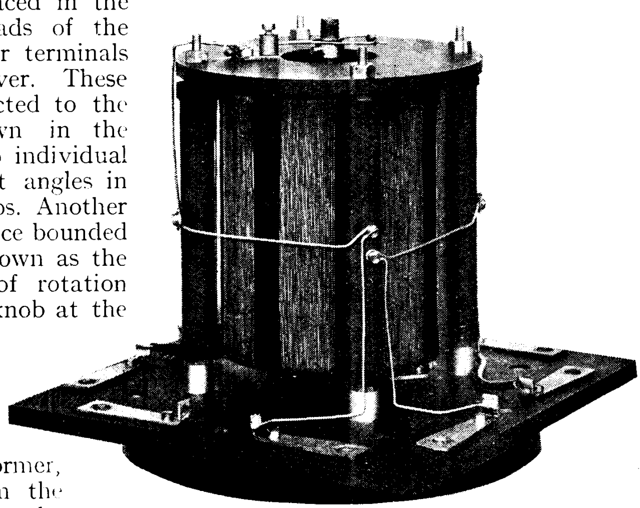
field coils will be noted from this illustration. Reverting once more to the aerials, it is usual practice to aline the loops so that one runs directly fore and aft, the other being at right angles athwartship. The top point is supported from any suitable beam by means of insulators, and the lower corners by any convenient anchorage available.

It is not essential, or even desirable, that the aerial should be placed in the wireless cabin. The four leads of the aerial are brought to the four terminals marked aerial upon the receiver. These terminals are in turn connected to the field coils, which are shown in the photograph, Fig. 7. The two individual windings are placed at right angles in the same way as the aerial loops. Another coil is arranged within the space bounded by the field coils. This is known as the search coil, and is capable of rotation about a vertical axis by the knob at the top of the spindle.

Since no metallic connexion exists between the field and search coils, the combination may be considered to be an air-cored high-frequency transformer, of which the field coils form the primary and the search coils the secondary. The search coil is itself connected to the grid and filament of the first high-frequency amplifying valve in the usual way. The valve detector-amplifier is a standard instrument, and will be described later

The taking of bearings upon any station from which signals are being received is carried out in three distinct operations. Referring to Fig. 6, it will be seen that a three-way switch is fitted, the studs being marked "D.F.," "stand-by," and "sense" respectively. For the first operation the switch is set in the stand-by position. By doing this, the mid-point of the loop aerials and field windings is connected to earth via the sense coil, which latter constitutes a second primary of the high-frequency transformer.

The incoming signals received upon the loops consist of two distinct impressions. The first has little or no effect on the search coil; it merely affects the aerials in their ordinary capacity as aerials pure and simple, and is transferred to the detector-amplifier via the sense coil and thence to the telephones. The second impression is induced into the search coil, where it travels to the same destination as the first, but viâ the primary winding of the air-core transformer. This second effect, however, is very small compared with the



MARCONI DIRECTION FINDER

Fig. 7. The diagram in Fig. 4 should be studied with this photograph, which gives a close-up view of the field and search coils. Contact to the moving search coil, which rotates within the fields, is made by a piece of wire rubbing against the spindle end, held in contact by a spiral spring

Courtesy Marconi Wireless Telegraph Co., Ltd.

first, with the result that a purely non-directional reception is produced, the object aimed at being merely to pick up a signal.

The desired station having been tuned in, the switch is placed in the D.F. position. In this position the sense winding is cut out of circuit entirely (see Fig. 6). The result of this, therefore, is to pass the currents received by the loops to the receiver itself, only via the search coil, the mid-point connexion being this time earthed. The relation of the search coil with the field coils is such that the former is only affected by the currents when it actually lies in the same plane with the direction from which the received signals are coming. It must be understood that each aerial receives most strongly those signals which come from a point in line with it.

Assuming that the transmitting station lies more closely in line with one aerial, then that aerial will be energized much more strongly than another. It will then naturally follow that the field coils will be energized most strongly when it lies in such a position that it embraces the field of whichever field coil is itself the more strongly energized. Therefore, when the search coil lies in line with one field coil the currents from the corresponding aerial will be induced in it ; in any other position the current will be weaker, until, when it lies at right angles, no current will be induced at all.

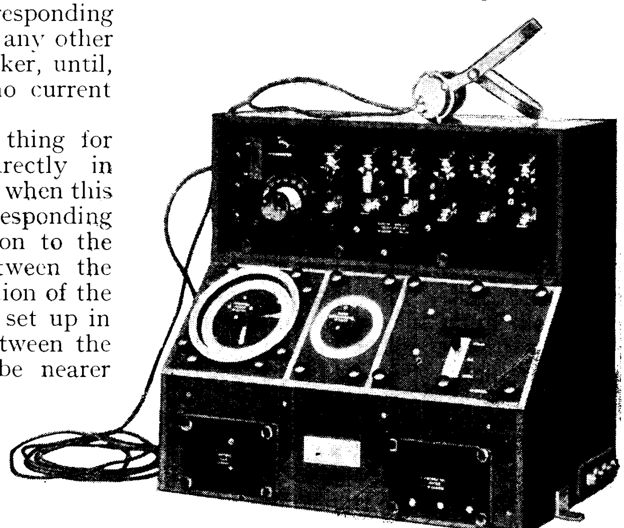
It is by no means a usual thing for one of the loops to lie directly in line with the received signal, and when this occurs the aerials and their corresponding fields are energized in proportion to the cosine of the angle formed between the plane of the aerial and the direction of the transmitting station. The field set up in such a case, then, would lie between the actual field coils, and would be nearer whichever coil was the more strongly energized. Should the oncoming signal lie in a plane midway between the coils (at 45° to them), then that would be the position of the strongest field, and it would be to that position that the search coil would have to be rotated to be energized fully.

The operator, therefore, can find out accurately the plane in which the received signals travel by rotating his search coil until those signals are at either maximum or minimum strength. As the minimum is rather more sharply defined than the maximum, the general practice is to tune it to the former.

An exterior view of the field and search coils is given in Fig. 8 on the extreme left of the sloping panel. The operating knob and the dial which surrounds it will be noted. The latter is divided into degrees in a similar manner to the compass. The pointer which indicates the position of the search coil is the longer one, shown in this instance horizontally. A second position, at right angles to the other, will be noted. This is marked "sense," and this comes into use when the three-way switch is put over into the sense position.

It has previously been explained that so far only the plane of the incoming signals has been ascertained. In the case of an E.–W. signal, for example, no indication has been given whether it actually radiates from the east or west individually. Therefore it will be seen that, rotating the search coil, two minima and two maxima may be found, each being 180° apart from one another.

In explaining the effects produced when the three-way switch was in the stand-by position, it will be remembered that two current components, one larger than the



SHIP'S DIRECTION FINDER

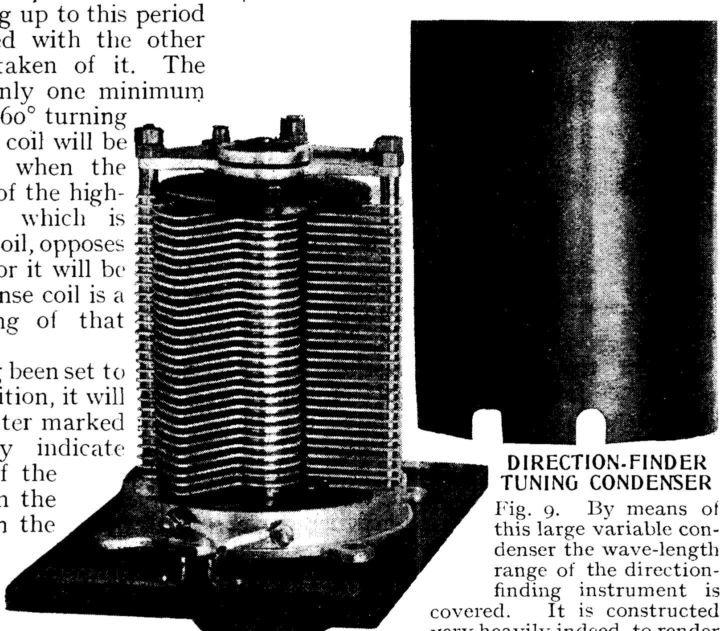
Fig. 8. On board most long-voyage vessels direction-finding apparatus is invaluable when approaching port in foggy weather. The above instrument, made by the Marconi Wireless Telegraph Company, consists of four high-frequency valves, a rectifier, and one low-frequency. The aerial is shown diagrammatically in Figs. 5 and 6

other, were produced. The changing over of this switch now to the sense position inserts a high resistance into the earth lead of the bigger component, and this will reduce this component to such a value that it can be compared with the second, the latter having up to this period been so weak compared with the other that no account was taken of it. The effect of this is that only one minimum reading in the whole 360° turning movement of the search coil will be found, and this occurs when the current in the primary of the high-frequency transformer, which is connected to the search coil, opposes that in the sense coil, for it will be remembered that the sense coil is a second primary winding of that transformer.

The search coil having been set to the single minimum position, it will be found that the pointer marked " Sense " will roughly indicate the previous position of the search coil pointer when the three-way switch was in the D.F. position. The fact that this reading may not exactly coincide with the search coil reading is immaterial, for the latter will have been noted by the operator when he was working in the D.F. position, and this second reading serves only to indicate which of the two possible readings, when in that position, was correct.

It will be seen, then, that the exact direction of the signals has been located, and since one loop is in line with the keel of the ship, the direction which the ship is travelling with respect to some land station may be established. The ship may then be guided on her course by the operator indicating to the captain the position of the ship with regard to the land station. Furthermore, if an S.O.S. message were received, the direction finder will locate the exact position of the distressed vessel and help can immediately be given in the shortest possible time by merely following the direction of the received signals.

The standard wave-length of the receiver is 400–1000 metres. The whole of this range is covered by the large variable condenser, which is shown in detail in Fig. 9.



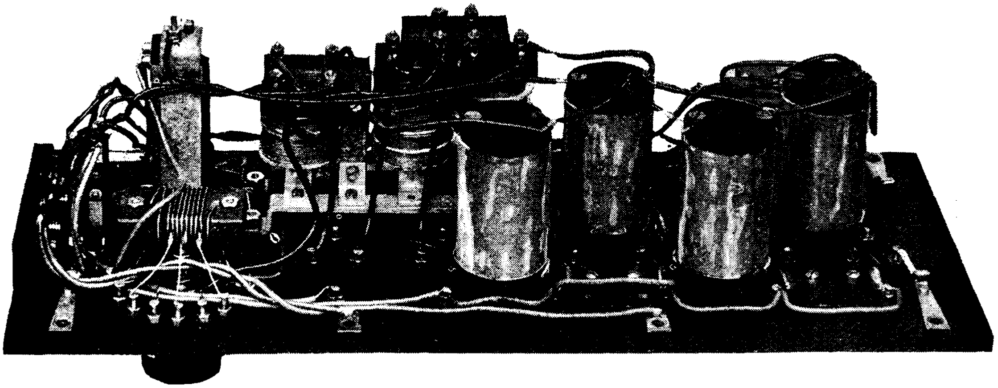
DIRECTION-FINDER TUNING CONDENSER

Fig. 9. By means of this large variable condenser the wave-length range of the direction-finding instrument is covered. It is constructed very heavily indeed, to render it immune from any changes of capacity which might, in a lightly built instrument, be due to warping plates

Courtesy Marconi Wireless Telegraph Co., Ltd.

A description of the detector-amplifier will now be given. A view of the complete instrument is shown in Fig. 8. The direction and tuning arrangements are placed in the sloping panel. The left-hand compartment is the D.F. instrument, and the dial shown near the centre is the control of the variable condenser for tuning purposes. The three-way control switch is in the centre of the right-hand panel. This is a three-way key switch, and the positions are indicated by the engraving shown on the panel.

At the rear of the cabinet is a vertical panel, to which the receiver-amplifier is attached. Contrary to general practice, the stages of amplification are arranged from left to right, instead of the more usual right to left arrangement. The first four valves are V24's, and are high-frequency amplifiers. These particular valves are very useful for high-frequency amplification on account of their low self-capacity. The advantage is due to the absence of the usual valve legs, the four connexions being made to brass caps placed at opposite sides of the glass surrounding the valve. Air-cored transformer coupling is used on each high-frequency stage Fig. 10, which is a rear



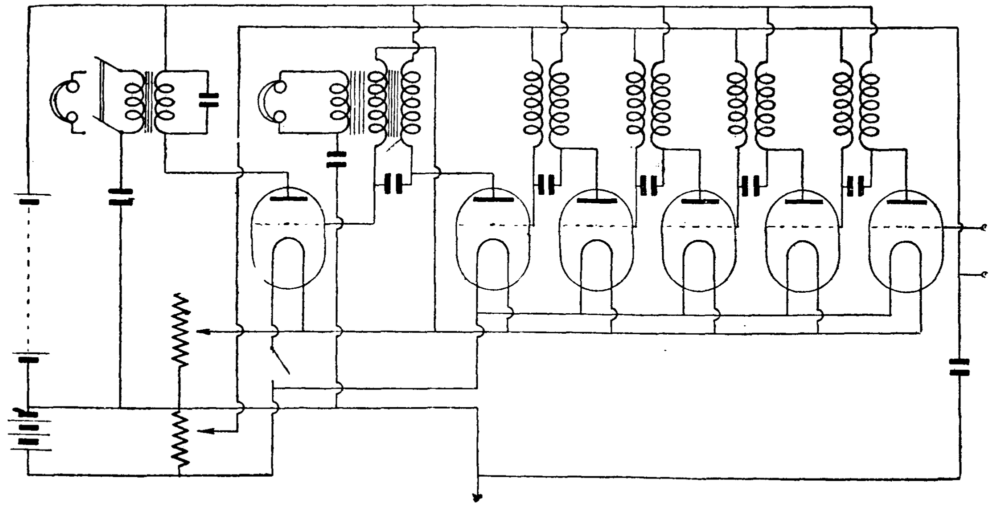
REAR VIEW OF PANEL OF MARCONI DIRECTION FINDER

Fig. 10. Laid on its face is the panel of the apparatus, showing the interior of the detector-amplifier. The cylindrical high-frequency transformers are of the standard Marconi pattern. The potentiometer is of the type in which a variable contact is made by a quick thread rubbing against the bare resistance wire upon a flat former

view of the panel in question, clearly shows the four cylindrical high-frequency transformers. As these are of the aperiodic type, no tuning is necessary.

The fifth valve, which is a Q, is the detector, and the sixth, which is another V24, is the note-magnifying valve. Common high-tension current, supplied by a 59-volt battery, is applied to the anodes of all the valves. A potential is applied to the grid circuits of the four high-frequency amplifying valves by means of a potentiometer. The latter is connected across the low-tension battery, as the circuit diagram, Fig. 11, clearly indicates. The knob controlling the potentiometer is shown at the top of the left-hand side of the vertical panel in Fig. 8.

It will be found that but little adjustment of this control is required after the instrument has first been put into use, and the points found at which best reception is obtained. Occasionally, strong signals from near-by high-powered stations which are not required may be tuned out by its means, however. This should be done in conjunction with the filament



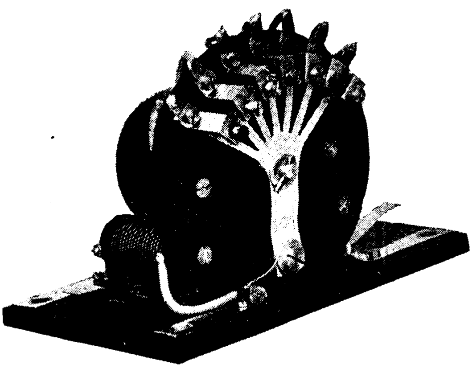
CIRCUIT DIAGRAM OF MARCONI DIRECTION FINDER

Fig. 11. Four of the valves in this arrangement are of the V24 type and are high-frequency amplifiers. The fifth valve is of the Q type. The sixth, which is a note magnifier, is a V24. It will be seen that the anodes of all the valves are supplied from one high-tension battery. The voltage of this battery is 59

resistance. This method of tuning should only be necessary when tuning by the main variable condenser proves insufficient.

A switch for putting the note magnifier in or out of circuit as required is provided. This may be seen immediately to the left of the potentiometer knob. Battery current is saved by its use, for many signals will be sufficiently loud without a note magnifier in circuit.

The transmitter on a ship is invariably situated in very close proximity to the receiver, and on this account protection for the latter is necessary to guard against any heavy currents induced which may be set up in the receiver windings. The protective device used in this instance takes the form of an earthing relay.



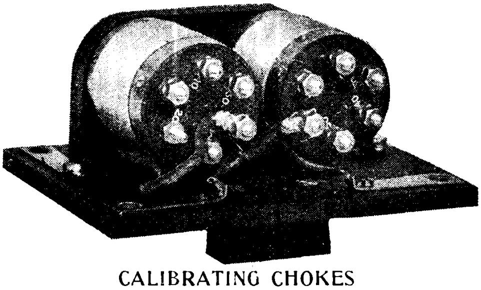
EARTHING RELAY

Fig. 12. Relay apparatus as here shown is used in the direction finder for protecting the delicate windings in the receiver from any heavy stray induced currents from a near-by transmitting set. The device is controlled by the seven-stud switch, and current for the relay comes from the L.T. battery

Courtesy Marconi Wireless Telegraph Co., Ltd

The seven-stud switch shown on the left of the vertical panel controls this device. Current for the relay is obtained from the filament battery. Ample protection for the windings is given when the relay is not energized, for in this condition the four ends of the loops and the telephone receivers are earthed and short-circuited.

Any ship on which a D.F. apparatus is fitted has, as part of its equipment, a switch which puts the D.F into use or not, as may be required. When this switch is closed the earthed connexions from the loops and telephones are automatically removed, thus rendering the D.F. instrument ready for use. A further unit of the apparatus is shown in detail



CALIBRATING CHOKES

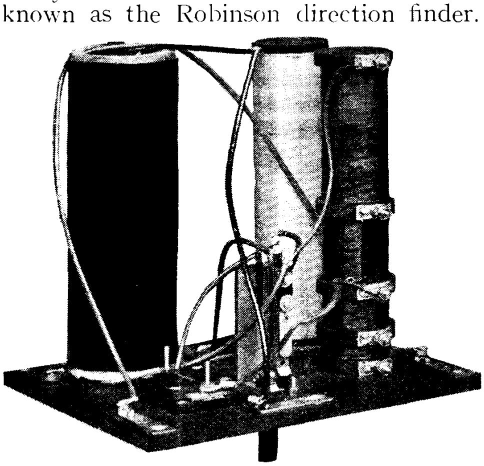
Fig. 13. Chokes as here illustrated are used to adjust the aerial characteristics so that both assume identical electrical properties. This is essential for accurate direction-finder reception

Courtesy Marconi Wireless Telegraph Co., Ltd.

in Fig. 13. This is known as the "calibrating chokes" component. The chokes consist of a pair of windings, each with five tappings, wound upon an ebonite former. Their use is to adjust the electrical constants of the loops so that they are exactly similar electrically, despite slight inherent differences due to variations in shape, proximity to walls, etc. The chokes are applied to the loops after their erection, and then adjusted accordingly.

The set has been designed to receive signals from 300 to 400 miles away, whether from ship or coast stations. This figure varies enormously according to the strength of the transmitting station, but it may be considered as an average one.

A direction finder that was used extensively in the British Air Service was that known as the Robinson direction finder.



DIRECTION-FINDER TRANSFORMER

Fig. 14. As will be seen above, and also in the diagram, Fig. 6, there are in reality two primaries in this transformer; one is the usual input primary from the tuner, and the other the "sense" coil. An earthed metallic shield is fitted to this component

It has the advantage over the usual Marconi direction finder that it does not require the large triangular aerials, and is therefore easier to instal on board ship. The finder is made by the Radio Communication Company.

In the Robinson system a large wooden framework is employed which consists of two wooden squares fixed at right angles to one another. These are 2 ft. 6 in. along each side, and are wound with thin wire so that there are two coils at right angles to each other. The whole framework is fixed upon a vertical axis and may be rotated.

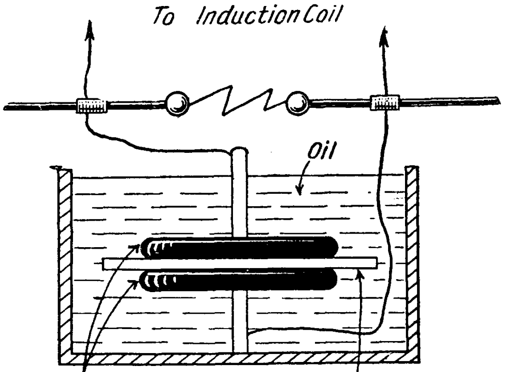
One coil is actually on a smaller framework than the other, and the larger coil picks up the signals. This it does independently of the smaller coil. The larger coil is placed to pick up as loud signals as possible. This coil, used alone, would give an error of several degrees for estimating the direction of the transmitting station, the change in audibility being small for the rotation of the aerial near the maximum receiving point.

But the second coil enables a much closer approximation to the direction to be obtained. This coil can be switched in series with the larger coil, and if it is not actually at right angles to the transmitting station it picks up some signals. The energy it picks up is either added to or subtracted from that of the larger coil, according as it is acting with or against it. By adjusting the position of the larger coil until there is no increase or decrease of strength when the other coil is switched in, the direction of the transmitting station may be determined, for it is at right angles to the plane of the smaller coil.

In the Marconi system the point of minimum strength is obtained, or that point where no signals are received. In the Robinson method, however, the point of maximum signal strength is found, and all the time signals are being received from the point which is being searched for. —*A. H. Avery and R. B. Hurton.*

See Bellini-Tosi System; Goniometer; Robinson Direction Finder; Search Coil; Short Wave.

DIRECT LOOSE COUPLING. Term applied to a metallic coupling between two circuits, when either the distance between the two circuits is considerable or when only a few turns in each of the coupled coils are common to both circuits



CONDUCTIVE DISCHARGE

Fig. 1. Between the two electrodes will be seen a plate, the dielectric strength of which is being tested. The electrodes, which are situated in a bath of oil, are each connected to an induction coil and to a spark gap

DIRECT TIGHT COUPLING. Term used in cases in which the turns of wire in two metallically connected inductances are in an appreciable ratio to one another. The term is also applied to the system of tapping off a number of turns of wire from a coil in one circuit to serve as inductance in the other circuit. It is synonymous with Direct Close Coupling.

DISCHARGE. When a conductor is subjected to a difference of potential it becomes electrified, and may be discharged in several different ways, which depend on the medium surrounding the conductor and also on the circumstances under which the discharge occurs.

The different headings under which a discharge can be classified can roughly be divided into three—*i.e.* (1) Conductive; (2) Convective; and (3) Disruptive.

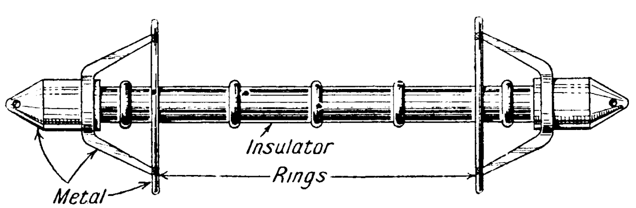
Conductive Discharge. The conductive discharge is the term applied to a discharge such as occurs in any electrical system in the form of a current flow. In its simplest form a conductive discharge occurs when a wire is connected across the positive and negative terminals of a battery, or when the terminals of an influence machine are connected together. In both the examples the current resulting from the discharge is unidirectional. When, however, a condenser is discharged, the discharge current may be an oscillatory one. If a condenser is connected to an inductance coil and a spark gap, as shown in Fig. 1, and R = resistance of the circuit (in ohms), L = inductance of the coil (in henries), and C = capacity of condenser (in farads), then the discharge current will be oscillatory if $R < \sqrt{4L/C}$, there will be no oscillations if $R > \sqrt{4L/C}$, while if $R = \sqrt{4L/C}$, the condition will be unstable.

Convective Discharge. A convective discharge occurs between two conductors when their potential difference is sufficiently great to electrify particles of a surrounding medium. The particles are repelled from the charged conductor, and convey some of the charge to the oppositely charged conductor.

This type of discharge may occur in either liquids or gases (including air) at low pressure. The pressure and nature of the gas in the container determines the voltage required to produce the discharge and its characteristics. There are many instances of the practical use of the latter type. Among these may be cited the Cooper-Hewitt mercury vapour lamp for lighting purposes, mercury rectifiers for transforming alternating current into direct current, and the many examples of variously shaped tubes and bulbs filled with gases at low pressure now used for advertisement purposes.

Although the rectifying and three-electrode valves used for wireless telegraphy and the X-ray bulb used for radiographic work have very high vacua, the principle of the discharge is the same as for the gas-filled tubes previously referred to.

The convective discharge in the rectifying and three-electrode valves is caused by a heated filament in conjunction with a positive charge on a plate or cylinder placed at some distance from the filament. The filament, when incandescent, emits negatively charged electrons which are attracted to a positively charged plate, thus causing a current to flow through the valve. In the X-ray bulb the electron flow is caused by the use of two oppositely charged plates.



STRAIN INSULATOR WITH CORONA RINGS

Fig. 2. Transmitting systems employ this means of limiting energy losses due to leakage along the strain insulators. The rings form a special guard

Disruptive Discharge. When two conductors are subjected to a difference of potential, a state of strain will be set up in the medium round the conductors. The strain will be greatest along a line joining the conductors, and the tension along the lines of electric force increases as the square of the intensity of the electric field. If the potential difference between the two conductors is made sufficiently great the resistance of the surrounding medium will suddenly break down, and a spark will occur.

Instead of an actual spark occurring between the two charged conductors, a glow in the form of a " brush " can often be seen, a hissing sound accompanying the discharge.

The disruptive discharge is often used for testing the dielectric strength of insulating materials used in electrical machines and apparatus. The material to be tested is mounted between two small flat plates immersed in oil and connected to the opposite terminals of an induction coil capable of giving a pressure of several thousand volts. Across the coil are also mounted two metal spheres so arranged that the gap between them is adjustable, and the gap is increased until the material under test is punctured. From tables of sparking distances under the given test conditions the dielectric strength of the material is obtained. Fig. 1 shows a method of testing the dielectric strength of plates by this method.

Although this method of testing the dielectric strength of an insulator is very useful, the conditions under which the test is carried out must be carefully noted, as many factors, such as pressure, temperature, size, and condition of electrodes affect the spark length. The method is therefore used more for comparative measurements than for absolute determinations.

The Corona Effect. When parallel conductors, such as are used for the overhead transmission of electrical energy at extra high potentials, are subjected to an increasing difference of potential, a point is reached where a considerable amount of energy is lost in the form of a discharge between the two conductors. If the potential difference is still further increased, the energy loss rapidly rises, and the conductors exhibit a discharge in the form of a luminous ring of bluish colour. This ring is known as the "corona." If the difference of potential is still further increased the diameter of the corona will increase.

The voltage at which the corona starts is affected not only by the factors already mentioned which affect spark distances, but by the diameter of the conductors and their distance apart. The wave-form of the supply will also to some extent affect the voltage necessary to produce the corona, a pointed wave-form producing the corona at a lower R.M.S. voltage than a flat-topped wave.

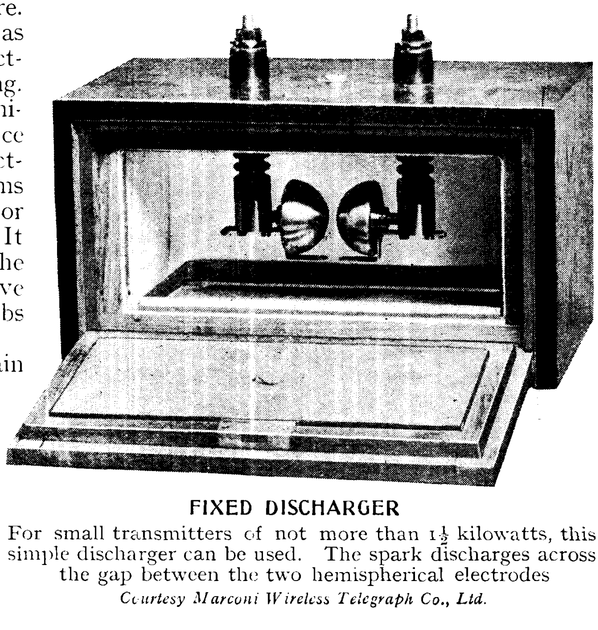
The aerials used at a large wireless telegraph transmitting station often have to withstand exceedingly high voltages, and in order to limit the energy losses due to leakage along the strain insulators a special guard, in the form of a ring, is mounted round each end of the insulator. The ring then considerably reduces the potential gradient along the insulator. A sketch of a strain insulator with two corona rings is shown in Fig. 2. *See* Critical Resistance; Disruptive Discharge.

DISCHARGER. Term commonly used for that piece of apparatus in the primary oscillating circuit in which the spark or arc takes place. There are many forms of discharger. A simple discharger for small transmitters of not more than 1½ kilowatt power, as used by the Marconi Company, is shown in the figure. The type of discharger is known as a fixed discharger, since the electrodes are fixed during discharging. The gap itself consists of two hemispheres arranged a short distance apart from each other. These electrodes are mounted upon metal arms fitted with screw adjustment for varying the width of the gap. It will be seen that the leads to the electrodes are carried in massive ribbed ebonite insulators. The ribs ensure minimum surface leakage.

Immediately below the main hemispherical electrodes are two needle points arranged at a slightly greater distance from each other than the main electrodes. These subsidiary electrodes are known as the guard points. It occasionally happens that a sudden rise of pressure occurs in the transmitting set, due to resonance effects, and should this be so, the condensers are protected from breakdown by the auxiliary gap.

In another form of discharger, due to Fleming, balls are set in motion by mechanical means, and move round in a heavy iron chamber in which nitrogen or carbonic acid is compressed. The balls, between which the discharge takes place, move slowly round, and a continual fresh surface is presented for sparking. The balls are hollow, water being made to circulate through them to keep them cool. The object of placing the balls in a heavy iron reservoir containing compressed nitrogen is to ensure a noiseless discharge.

The Lodge-Chambers discharger consists of two sets of grooved copper disks, like pulleys, separated by ebonite washers and mounted on parallel ebonite shafts. The disks are so attached to a support that one set is fixed in position, while the other can be moved by a screw parallel to the first set. The disks on each shaft are so arranged that an electric discharge jumps backwards and forwards from one set of disks to the other. The whole spark gap is, in effect, split up into a large number of short gaps. The disks are continuously rotated in opposite directions by a small electric motor. This form of discharger produces a highly damped or quenched discharge. *See* Disk Discharger; Quenched Spark Gap; Rotary Spark Disk.



FIXED DISCHARGER

For small transmitters of not more than 1½ kilowatts, this simple discharger can be used. The spark discharges across the gap between the two hemispherical electrodes

Courtesy Marconi Wireless Telegraph Co., Ltd.

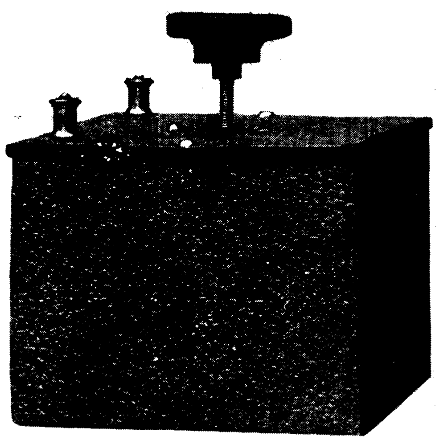
DISK CONDENSER. The name applied to any type of variable condenser in which the plates can be moved between one another without touching, and about a common centre or axis. The dielectric may be air, mica, or other appropriate material. In the general use of the expression are included all the various patterns of moving plate condensers which are rotatable about a central spindle, such as the variable air condensers, where the plates are made more or less semicircular in form, and one set of moving plates is brought into close relationship with a set of fixed plates so that the capacity may be varied from approximately zero to the maximum when all the plates are fully engaged.

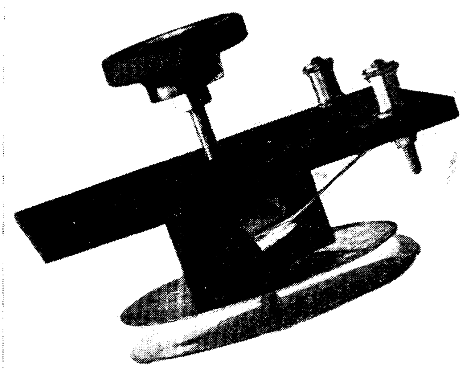
The term, however, is often restricted to those types of condenser where a few plates only are employed and more or less circular in form, or those of rectangular pattern, where the plate or plates can be moved away or towards one another by a central screw or control handle, so varying the capacity by varying the thickness of the dielectric, *i.e.* mica and air.

There are two common types of simple mica dielectric disk condensers which can be made up with very little trouble, and, where a fairly small capacity is only required, are remarkably efficient. If substantially made, they may be used with satisfaction in place of the usual air dielectric vane condenser in any circuit likely to be used by the amateur making his own receiving station. It will be realized, however, that although at its maximum capacity the mica, to a very large extent, is the principal agent in securing this capacity, as the plates are separated air also begins to have an effect. Consequently, a very small movement of the knob will have considerable effect when the plates are very close together; but when they are separated, there will be a very rapidly decreasing capacity. Against this, however, we have the advantage of more nearly approaching zero than is the case when the diameters of the semicircular vanes in an air condenser are in fairly close relation to the opposing plates.

The first type of mica dielectric condenser which is here illustrated (Fig. 1) is enclosed in a casing. The components are shown in Fig. 2, and it will be seen that the bottom or moving plate is attached to a length of 2 B.A. rod by a nut and solder. As the knob is revolved through a stationary nut fastened between the panel and block (of hardwood or fibre), the lower plate rises until the mica prevents the respective plates from making a metallic contact, and the maximum capacity is secured.

The diameter of the brass plates in the condenser illustrated is 3 in., the length of the rod is $2\frac{1}{2}$ in. and the block $1\frac{1}{2}$ in. square and 1 in. thick. It will be noted in Fig. 3 that the connexion to the lower plate is by means of the 2 B.A. nut, and





HOME-MADE VARIABLE DISK CONDENSER WITH MICA DIELECTRIC

Fig. 1. Contained in this condenser is a moving plate and rod, which revolve in unison.
Fig. 2. Fixed to the moving lower plate is the spindle. The connexion to the lower plate is held in position between block and panel

thence by a piece of strip-brass to which the nut is soldered, the connexion to the terminal being made at the free end. The connexion to the upper plate is simply soldered to the underside of this plate. Care should be taken in cutting a fairly large hole in the centre of the top plate, say $\frac{1}{2}$ in. in diameter, in order that it may be well free of the spindle passing through the centre. The size of the panel is 4 in. square. The mica may be fastened to the lower plate with shellac if desired. This particular condenser is found to be satisfactory in tuning the aerial circuit with a commercial set of coils, though the wave-length covered with an individual coil is not quite so great as with a standard ·001 variable condenser.

The second type, which may be used with considerable satisfaction in tuning the anode coil or secondary of a loose coupler, is also illustrated in Fig. 4. In this case the knob and rod do not rise as the capacity of the condenser is varied.

The rod, which is 3 in. long, is recessed at the lower end, as in Fig. 5, and is allowed to revolve between two pieces of brass, suitably filed and fastened to the bottom of the box. The moving nut is fastened with solder to a brass arm, Fig. 6, at the other end of which is a brass head. This arm is of such length that the head rests in one corner of the box and thus the arm cannot revolve. The knob being turned, the nut will rise or fall, and with it the lower plate. The lower plate is $2\frac{1}{2}$ in. in diameter, with a hole $\frac{1}{2}$ in. in diameter in the centre. Below is fastened a small

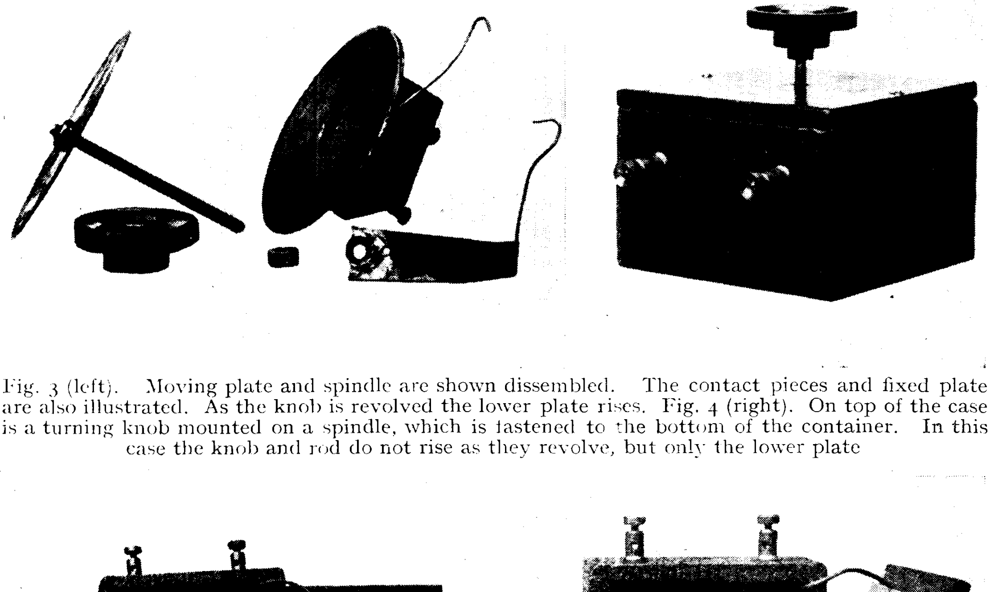


Fig. 3 (left). Moving plate and spindle are shown dissembled. The contact pieces and fixed plate are also illustrated. As the knob is revolved the lower plate rises. Fig. 4 (right). On top of the case is a turning knob mounted on a spindle, which is fastened to the bottom of the container. In this case the knob and rod do not rise as they revolve, but only the lower plate

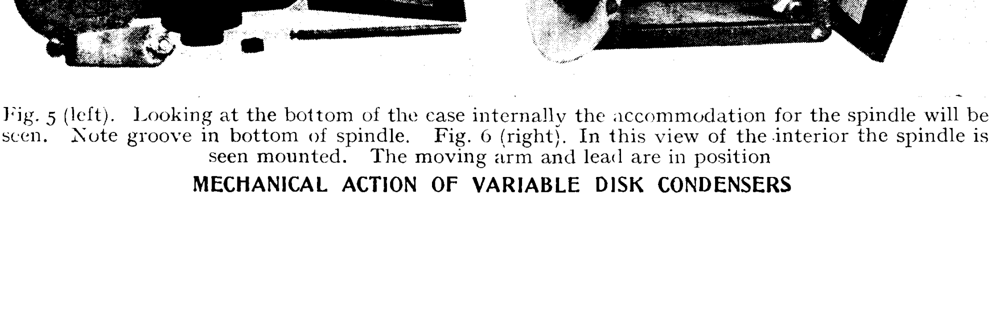


Fig. 5 (left). Looking at the bottom of the case internally the accommodation for the spindle will be seen. Note groove in bottom of spindle. Fig. 6 (right). In this view of the interior the spindle is seen mounted. The moving arm and lead are in position

MECHANICAL ACTION OF VARIABLE DISK CONDENSERS block of wood, through which is drilled a hole of sufficient size to easily clear the rod.

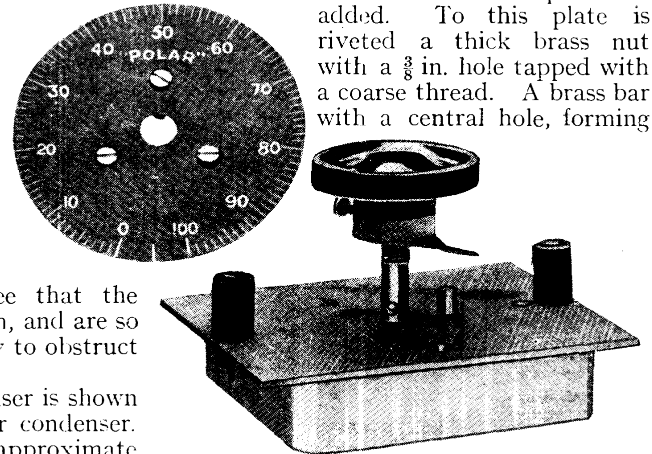
The plate and block being slipped over the rod, will naturally rise and fall as the spindle is turned. The top plate is $2\frac{1}{2}$ in. square, and is attached to the panel with small insulating pieces. It will be noted that this condenser can only be used in a normal standing position, and is unsuitable for mounting on a vertical panel, as the working depends upon the weight and freedom of the lower plate enabling it to rest upon the plate below it. In wiring up the terminals, care should be taken to see that the flexible leads have ample room, and are so arranged that they are unlikely to obstruct the working.

A novel type of disk condenser is shown in Fig. 7, illustrating a Polar condenser. This is a variable condenser of approximate capacity of ·001 mfd. It has the advantage of occupying very little space.

A flat plate of stout-gauge brass forms the major part of the device. In electrical contact with it is a copper sheet having a central hole. A hole in the centre of the plate forms one bearing for the central spindle.

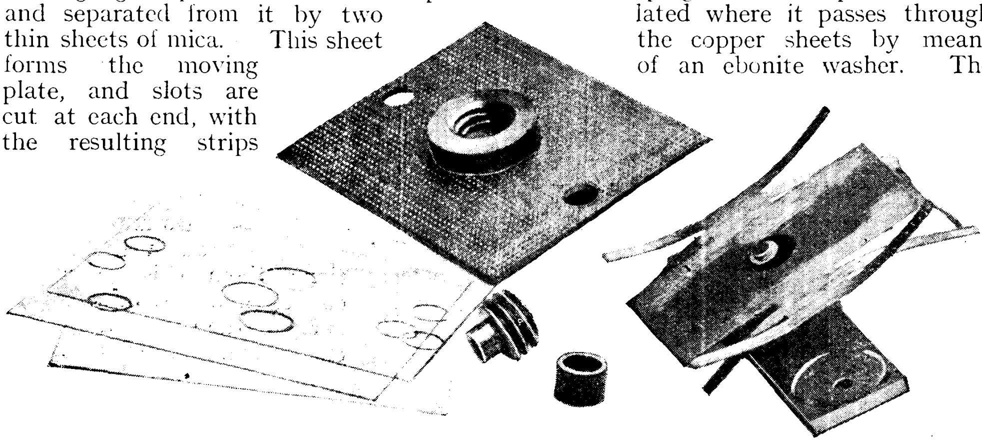
Three projections are riveted to the plate; two on opposite sides of the central hole, form pillars holding the back plate and keeping the mica insulating sheets in position. A sheet of copper of stout gauge is placed over the first piece and separated from it by two thin sheets of mica. This sheet forms the moving plate, and slots are cut at each end, with the resulting strips bent over to form springs to enable the sheet to remain midway between the two other plates forming the other electrode, Fig. 8.

Two more mica sheets follow, after which a stout brass plate sliding up and down on the two pillars is added. To this plate is riveted a thick brass nut with a $\frac{3}{8}$ in. hole tapped with a coarse thread. A brass bar with a central hole, forming the second bearing for the spindle, is rigidly mounted to the ends of the pillars. A small piece of ebonite is riveted to this plate and connexion taken from the central plate to an angle piece mounted on the ebonite. The spindle is of steel, screwed on one end to take a knob and pointer, and on the other end to hold a quick thread screw, rigidly fixed to the spindle with a clamping nut. The spindle is insulated where it passes through the copper sheets by means of an ebonite washer. The



COMPLETE DISK CONDENSER

Fig. 7. Complete with dial and knob is a "Polar" disk condenser. The ebonite distance pieces hold the condenser clear of the panel



COMPONENTS OF A POLAR DISK CONDENSER

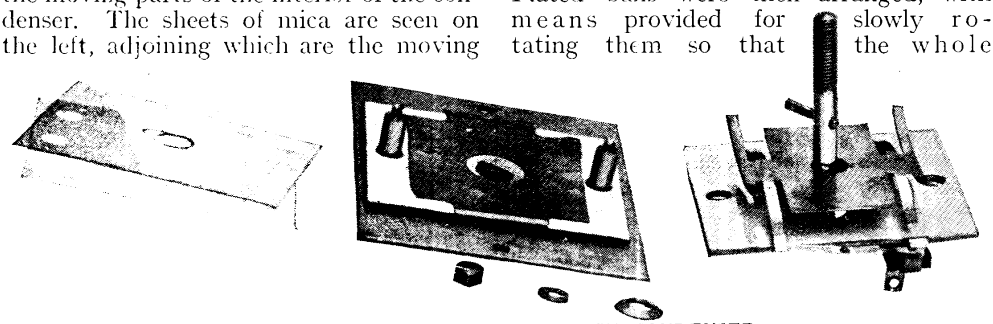
Fig. 8. Parts of the "Polar" disk condenser are laid out to show the spring strips of the moving plate to keep it midway between the outer electrodes. Three mica sheets are shown on the left

extent of rotation is limited by a projection on the spindle which comes into contact with a piece of brass riveted to the front of the condenser.

The condenser is attached to the panel or instrument by means of two 1 in. screws; two washers of ebonite are slipped over these screws to keep the condenser away from the panel. A dial divided into 100 divisions is held in position by three countersunk screws and nuts.

In Fig. 8 is shown (with the exception of the back bearing plate, which is rigid) the moving parts of the interior of the condenser. The sheets of mica are seen on the left, adjoining which are the moving plate with screwed portion attached, the insulating collar, and the quick thread screw for attachment to the spindle. To the right is shown the middle electrode, with the back bearing plate partly showing beneath it. The pillars are shown on the mainplate in Fig. 9, with the first plate resting on a piece of paper. To the right is another view of the moving plate with spindle in position.

Fig. 10 shows a side view of the condenser with the back cover removed. The moving plate is tightly screwed against the fixed one, giving a maximum capacity. When the spindle is turned to the left, the distance between the plates is increased, causing a corresponding decrease in capacity. *See* Air Condenser; Capacity; Condenser; Dielectric.



METHOD OF OPERATION OF A DISK CONDENSER

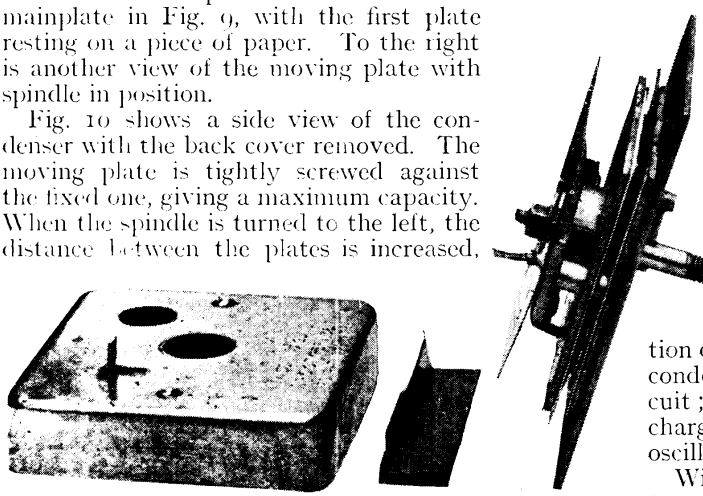
Fig. 9. Another view of the parts of a "Polar" disk condenser, illustrating the method of moving the plates. The pillars in the centre portion are those on which the moving plates slide in and out. Corresponding holes are seen in the moving plate at the right of the photograph

DISK DISCHARGER. The earliest form of discharger consisted of two round balls, between which a spark passed. The spark generally passed between two more or less fixed spots on these balls, with the result that that point became worn, rough, and oxidized, so that the spark became irregular.

When freshly polished or plated balls were used good sparks were obtained. Plated balls were then arranged, with means provided for slowly rotating them so that the whole surface should be uniformly used. As the power used for transmitting stations was gradually increased, difficulty with arcing, as distinct from sparking, began to be felt, and fresh methods had to be adopted to overcome this defect.

In Fig. 1 a simple spark circuit is shown. A is the alternator; T a transformer stepping up the alternator voltage to the order of 10,000 volts; I_1 and I_2 are protector chokes to prevent high-frequency current getting back into the transformer windings and breaking down the insulation of them; C is the primary condenser of the oscillating circuit; S the spark gap or discharger, and J the "jigger" or oscillation transformer.

With such a circuit the transformer charges up the condenser, C, in the usual way during each half-cycle of the alternator, and when the

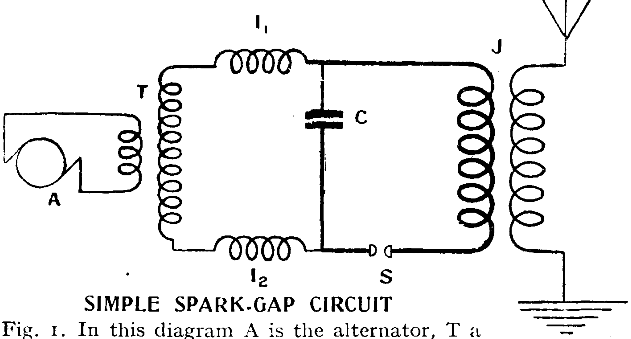


DETAILS OF DISK CONDENSER

Fig. 10. On the left is the back cover of the condenser, which is shown edgewise. The order in which the various components are assembled can be clearly seen

condenser voltage has reached a certain value a spark at S will take place. The current in the circuit C J S will oscillate and a train of sparks will pass across the spark gap at S.

In the meanwhile the alternator is still feeding current into the condenser C. The



SIMPLE SPARK-GAP CIRCUIT

Fig. 1. In this diagram A is the alternator, T a step-up transformer, C oscillatory circuit primary condenser, S the spark gap or discharger

discharge at S will therefore not be a pure condenser discharge, but will be spoiled to some extent by arcing, which spoils the quality of the spark.

It was found that if the current passing in the spark at S was sufficient to melt the metal of the spark balls, the gas given off by the molten metal assisted this arcing, and that when the gap electrodes were kept cold, arcing was considerably reduced, and many methods have been introduced to keep the electrodes cool. Oil and water-cooled electrodes are chiefly used.

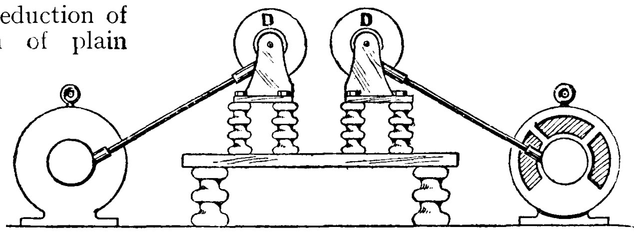
The next step towards the reduction of arcing was the introduction of plain wheels or disks at S.

These two disks were made of copper and well insulated from earth, being driven slowly round, through long insulating driving shafts, by an electric motor, Fig. 2, the drive at each end of the insulating shafts being by worm gearing so that the disks only rotated about once a minute.

In Fig. 2, D and D represent the disks which replaced the simple spark gap. Current was led into these disks by means of brass wire brushes pressing on the side of the disks, and connected to the oscillating circuit. The disks themselves were mounted in heavy bearings standing on insulators, which are clearly shown in the diagram.

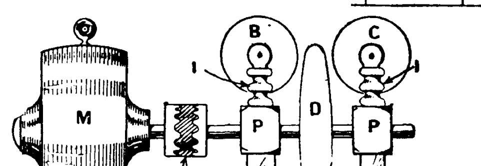
This type of disk was a considerable improvement on the simple spark gap, as, due to the fact that the actual sparking surfaces were always relatively cold, the spark was cleaner in character and more free from arcing.

At this time alternating current of low frequency was in use, and the note given out by such a discharger was low and rough. Higher frequency alternators gave higher and better notes, but the spark note was not clear or really free from arcing until it was obtained by the use of the synchronous disk discharger. In 1908 Senatore Marconi described at the Royal Institution one type of his high-speed disk discharger, which led up to the present synchronous dischargers



REDUCTION OF ARCING

Fig. 2. Instead of the spark gap at S in Fig. 1, two wheels or disks, seen in this diagram at D D, are introduced. Brass wire bushes conduct the current to these disks

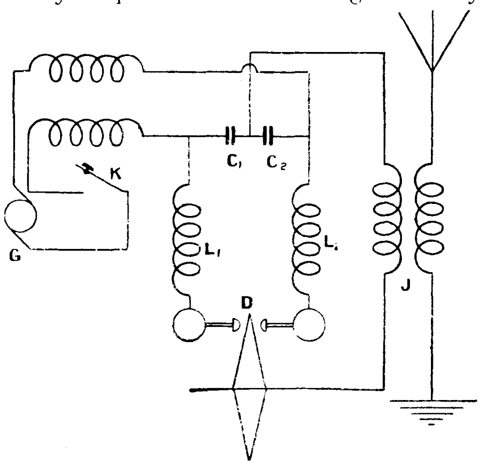


SYNCHRONOUS DISCHARGER

Fig. 3. In order to obtain a spark note free from arcing the synchronous disk discharger above was introduced. This consists of a central disk, D, driven at a peripheral speed of over 100 metres per second

This disk, Fig. 3, consisted of a central disk, D, driven at the very high peripheral speed of over 100 metres per second by means of the electric motor, M, which was well insulated by the insulating coupling, K, from the disk shaft. Mounted by means of insulators, I and I, on two bearings P, P, were two insulated side disks, B and C, which were also driven by means of gearing from the same motor, so that they slowly revolved. The sparks passed between the two side disks, B and C, and the high-speed disk D. With this type of disk a circuit, as Fig. 4, was used, consisting of two condensers, C_1 C_2, of equal value, and two inductances, L_1 and L_2. This circuit is often referred to as a split condenser circuit.

The energy was supplied to the oscillating circuit from the generator G, which was either an alternator working through a transformer or, later, a high-tension direct current generator. The aerial was inductively coupled to the oscillating circuit by



HIGH-SPEED DISK DISCHARGER

Fig. 4. Between the two disks of the discharger on either side of D is a third high-speed disk in a split condenser circuit

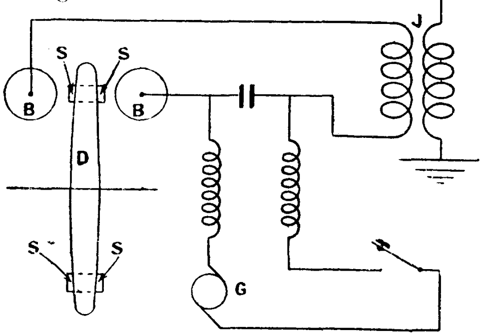
means of the oscillation transformer or "jigger," J, as it was called.

The very high speed of the disk, with its consequent cooling, reduced arcing, and the set gave a nearly pure musical spark. The next step was to drill the main disk, D, and place copper studs in it, so that these studs formed a bridge between the two side disks, B and C.

The side disks were then adjusted so that the studs in passing actually just made contact with them, thus insuring the complete discharge of the condenser through a path of minimum resistance.

Air pressure was found to play an important part in the rapid extinction of the arc, and finally two air jets were added, one on each side of the main disk, and blowing on the spot where the sparks took place. The circuit was then simplified till the final form became as shown in Fig. 5, where D is the high-speed disk with studs, S, whilst B and B are the side disks. The condenser is shown joined to the two inductances, while J is the oscillation transformer, and G the direct current generator.

In all the arrangements of disk discharger described up to the present the charge and discharge of the condenser has been to some extent left to chance, except when a direct current generator is used for charging the condenser, as in Fig. 5. It is, however, possible to obtain a pure spark note when using alternating current to supply the condenser. This is the case with the synchronous disk discharger, which consists of an arrangement similar to Fig. 5, except that an alternator is used to replace the generator and that the alternator is rigidly fixed to the disk shaft, as shown in Fig. 6.



SIMPLIFIED DISK DISCHARGER

Fig. 5. After experiments an arrangement as above was arrived at, in which the condenser is charged from a direct current generator

Here A = the alternator, which should have a frequency of some 300 cycles;
M = a motor driving the alternator and the disk D;
I = an insulating coupling between the alternator and the disk;
D = a disk made of steel, having copper studs, S, inserted in it;
B B = copper side disks;
C = the main primary condenser;
J = the oscillation transformer or jigger;
E E = protector chokes;
T = a static transformer;
L = a low-frequency adjustable inductance;
G G = two guard lamps.

The disk D must have slots in it corresponding in pitch to the pole pitch of the alternator.

Assuming that a frequency of 300 is required and that the alternator has 12 poles, then it will have to be driven at 3,000 r.p.m. for this frequency, which is a suitable speed for a well-designed disk. In a synchronous disk there must be one train of sparks for each half-cycle of the alternator. The alternator in question will produce 6 complete or 12 half-cycles per revolution; there must therefore be 12 studs in the disk.

B and B are the copper side disks, having a thickness equal to the thickness of the studs S. The whole disk, D, must be insulated from the ground, and the disks B, B must be well insulated from one another and from the ground. C is the main primary condenser, depending in capacity on the wave-length which it is desired to radiate. The capacity of C will also be fixed to some extent by the inductance of the transformer T and alternator A.

The values of C*j* will determine the wave-length. If λ = wave-length in centimetres, then $\lambda = 2\pi\sqrt{LC}$, all in centimetres; in this case L is the inductance of the coil *j*.

If C is measured in microfarads, and L is measured in microhenries, and the wave-length is required in metres, then this is obtained from

$$\lambda = 1885\sqrt{LC}$$

Therefore, either C or *j* may be changed in order to increase or decrease the wave-length. But there is one best value of C which suits the constants of the transformer circuit. This is the value of capacity which gives resonance.

Resonance is the condition which gives a maximum voltage on the condenser C, and may be obtained by varying the inductance L in the primary of the transformer, or by altering C.

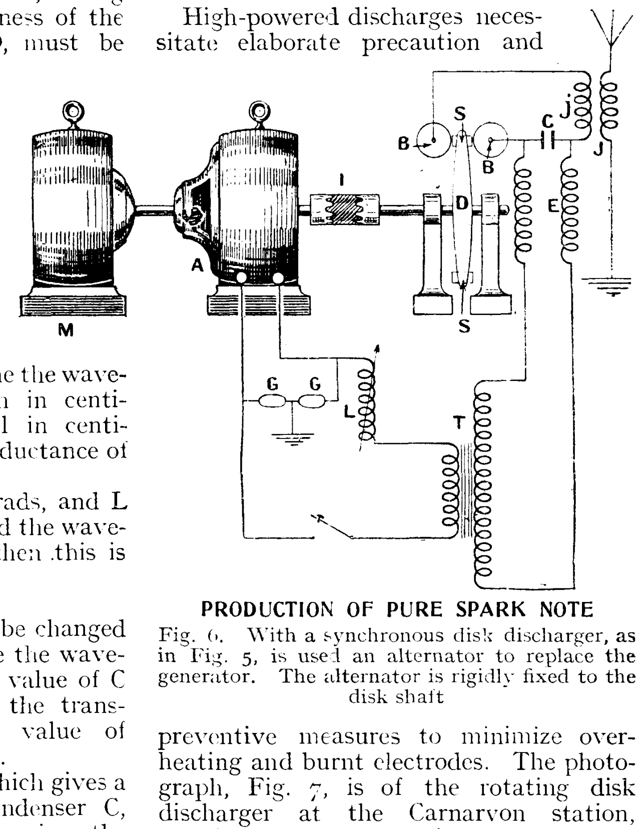
The two coils, E, are shown as air-cored protecting chokes, and are included to prevent harmful surges reaching the secondary of the transformer, T, and breaking down the insulation of the end turns, whilst G, G, two lamps, preferably having straight filaments, act as protectors to the alternator.

In tuning up the disk discharger circuit, resonance is first obtained by adjusting L or C. In the diagram, L is shown as variable and C as fixed, though the condenser may be variable. The wave-length of *j*CB is then measured, and adjusted to the correct amount by changes of inductance made to *j*.

The aerial and its inductance are then tuned to the same wave-length and coupled to *j*.

The disk must then be turned on its shaft, relative to the alternator poles, until the spark becomes clear. This adjustment is made on the coupling between the alternator and disk at I.

High-powered discharges necessitate elaborate precaution and



PRODUCTION OF PURE SPARK NOTE

Fig. 6. With a synchronous disk discharger, as in Fig. 5, is used an alternator to replace the generator. The alternator is rigidly fixed to the disk shaft

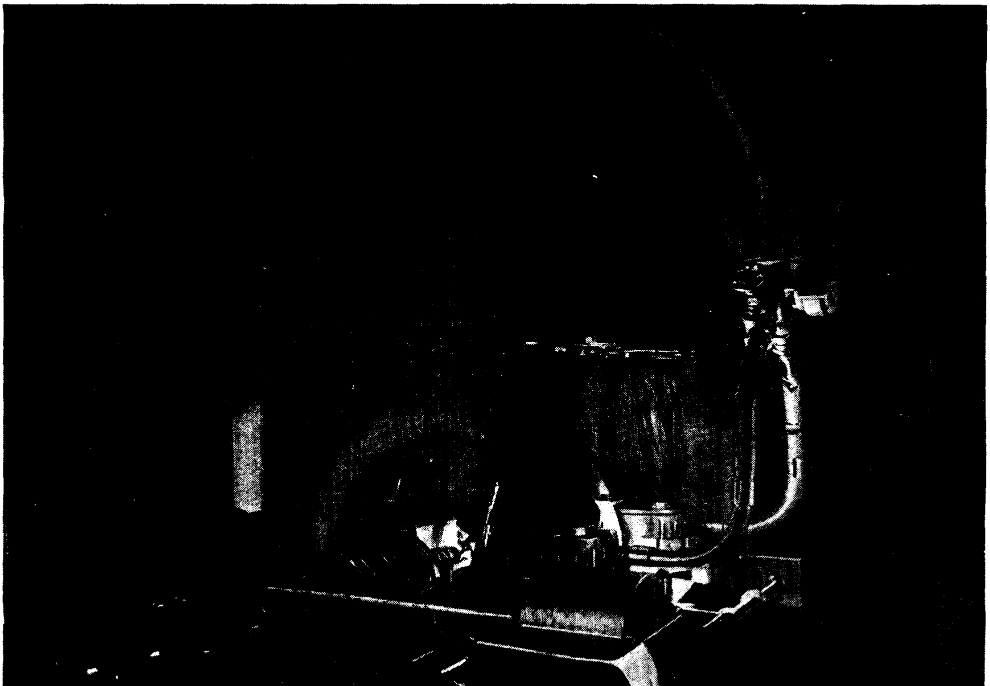
preventive measures to minimize overheating and burnt electrodes. The photograph, Fig. 7, is of the rotating disk discharger at the Carnarvon station, showing the heavy machinery necessary to fulfil the above functions.

The transmitter leads are shown coming down vertically from the roof in two large tubes, the last two feet or so being left open, exposing the stranded cable. Immediately below these cables are the horizontal circular metal cases containing the smaller rotating disks. Situated between the latter, and at right angles to them, is the large disk, the edge of which may be seen protruding from its casing. The size of this disk can be seen by the casing inside which it rotates, and which extends right from the front of the machine to the back wall of the room. The main driving shaft may be seen at the back.

The pipe, which divides into two with a control valve, and is situated just in front of the cable conduits, contains compressed air at high pressure. This air stream is projected through two nozzles on to the sparking points of the arc disks. It is interesting to note that this photograph was taken entirely by the light from the discharge.

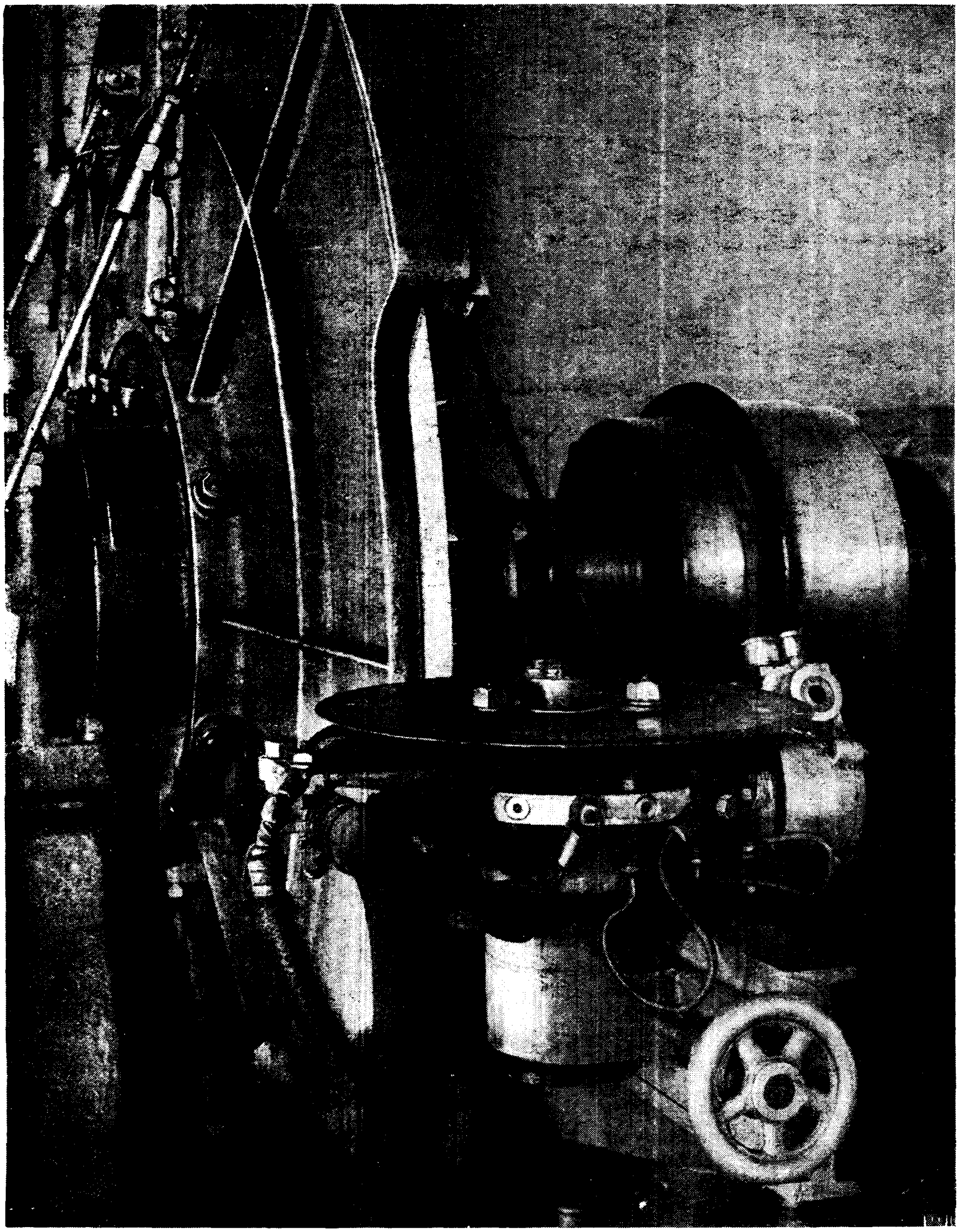
A close-up view of the rotary disks in a typical high-powered discharger is shown in the photograph, Fig. 8. The main disk, upon the horizontal axis, may be seen with its edge just protruding from its casing. It will be noted that the edge of this disk is saw-cut at regular intervals around its periphery. The casing is stiffened by means of tie-rods, each fitted with a tensioning device. This arrangement is necessary, since the high speed at which the disk is driven vibrates the casing and would soon throw it out of truth without tension tie-rods. The shaft coupling which couples the motor shaft to the disk shaft may be seen on the right of the photograph.

The horizontal disk is shown in the foreground. This consists of a very thin



TRANSATLANTIC SPARK DISK DISCHARGER AT CARNARVON STATION, M U U

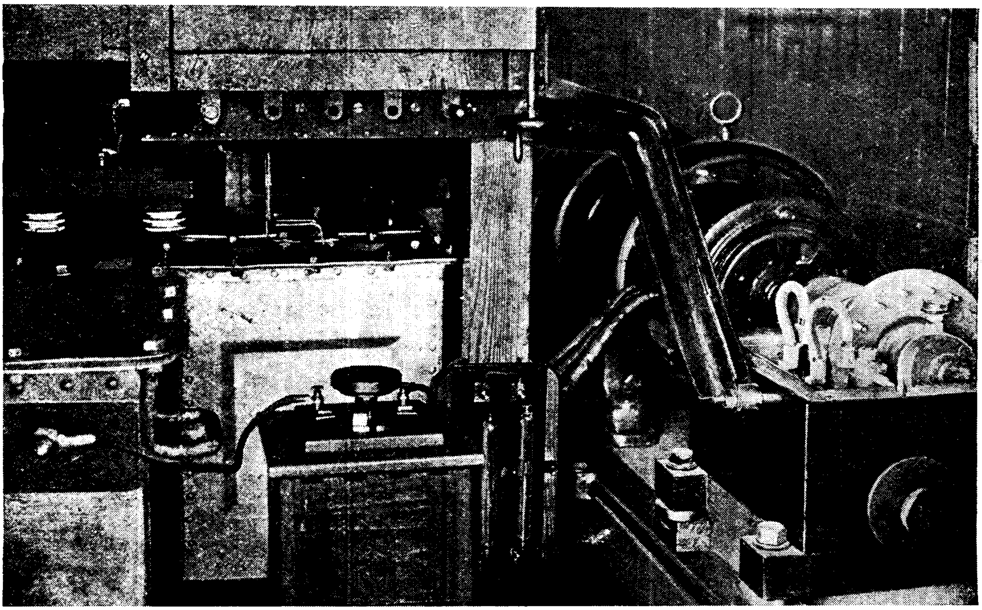
Fig. 7. Carnarvon Station, M U U, is owned and operated by the Marconi Company. The above photograph shows the disk discharger installed at that station, and was taken entirely by the light of the disk discharge. The transmitter leads are shown coming down vertically from the roof in the two large tubes, with a control valve, seen where the tubes join



TRIGGER DISK OF 300 KW. CONTINUOUS WAVE TRANSMITTING SET

Fig. 8. Rotating disks seen in a near view. These form part of the high-power discharger at the Marconi Wireless Telegraph Company's station at Carnarvon. The main vertical disk can be seen with the edge just coming through the casing to pass the horizontal disk; it will be noticed that the edge is saw-cut at regular intervals around its periphery

metal plate mounted upon a vertical spindle, and driven by gearing enclosed in the cast metal cover. The hand wheel shown is for adjusting the distance between the rims of the two disks. Immediately to the left of the small disk in the photograph may be seen the pipe which carries compressed air from the blower to the nozzle which projects the air stream upon the discharge.



MARCONI 5 KW. SPARK TRANSMITTER

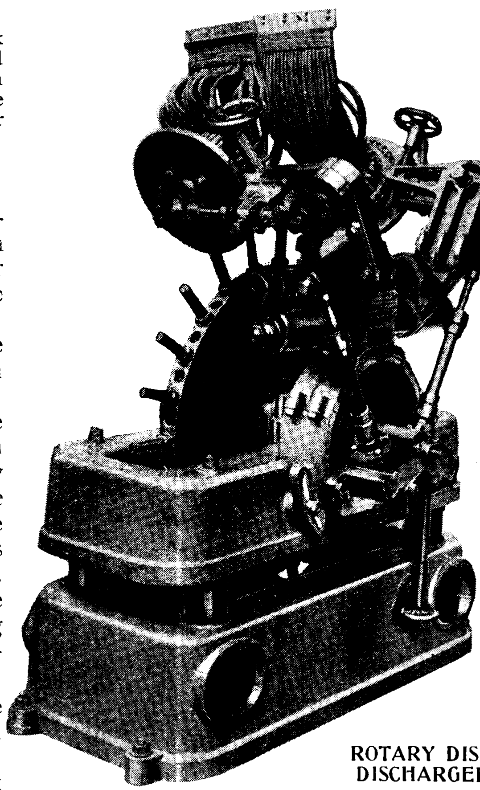
Fig. 9. On the right will be seen the disk discharger. High-tension current is supplied by the transformer on the extreme left, through the large transmission-type condensers at the back. Behind the disk discharger is the motor by which it is driven

Courtesy Marconi's Wireless Telegraph Co., Ltd.

Current from the transmitter is conveyed to the disk shafts by friction contacts. The leads to those contacts for both disks may be clearly seen in the illustration.

A low-powered disk discharger, suitable for power inputs up to 5 kw., is shown in Fig. 9. The high-tension current is supplied from the transformer shown on the extreme left of the background. From this it flows to the condensers, which may also be seen. The discharger, and the motor which drives it, may be seen on the right of the picture. The disk itself is partially enclosed in a box-like structure. The main disk is of the studded type, the studs of which may be seen projecting from its side at right angles to the direction of motion.

Another form of disk discharger, the large disk of which is of the studded type, appears in Fig. 10. It will be seen that owing to the high speed at which the disk is rotated the base casing is necessarily of very massive design. The smaller disks are seen mounted above the main disk. They are driven by a system of



ROTARY DISK DISCHARGER

Fig. 10. In this rotary disk discharger a disk of the studded type is employed. On account of the high speed of the disk it will be noted that the structure is necessarily massive

Courtesy Marconi's Wireless Telegraph Co., Ltd.

bevel gears and shafting from the main shaft. The primary drive of these gears is enclosed in an inverted V-shaped cover.

In a discharger of this type the current from the transmitter is conveyed to one of the small disks. From this the spark jumps to the large disk, which latter conducts it to the point where it jumps to the second small disk. Hence no connexions are necessary to the large disk. A number of friction plates are fitted to the small disks, the main conductors being divided, a separate smaller conductor being fitted to each contact. These divided leads are shown at the top of the discharger. It is clear that a very large number of contacts are necessary. *See* Colin-Jeance Arc ; Transmission.

DISPLACEMENT CURRENT. Variation of electric stress in a dielectric. It is equivalent in its magnetic effect to an electric current. It is a current, in practice, which flows momentarily in a dielectric or insulating material when an electro-motive force is impressed across that material, or when an electro-motive force impressed on that material is changed in intensity.

When an electro-motive force is impressed across an insulator, a charging or capacity current flows momentarily in the direction of the electro-motive force. This displacement current only flows when the applied electro-motive force is increasing or decreasing. So long as the impressed electro-motive force is continued without variation in intensity across the insulator, the dielectric will remain in a state of strain. *See* Current.

DISPLACEMENT MOMENT. Term used for one of the intrinsic constants of a vibration galvanometer. *See* Damping Moment.

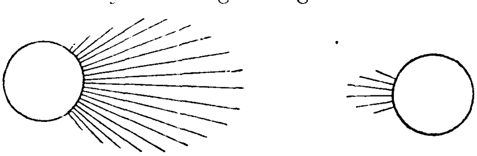
DISRUPTIVE DISCHARGE. When the difference of potential between two conductors is sufficiently great, or the potential gradient in the medium between them is sufficiently increased by decreasing the distance between the conductors, a discharge will occur in the intervening space. This discharge may take the form either of a single or forked line, in which case it is termed a "spark" discharge, or of a brush-like formation diverging from one of the conductors, in which case it is termed a "brush" discharge.

Whether the discharge is a spark or a brush is determined by the quantity of electricity discharged. If the quantity is large and the distance between the conductors is small, then the discharge will be a straight intense spark. This type of discharge is well illustrated when a condenser is discharged across two spheres placed a short distance apart, or when a large induction coil is discharging across a small gap. If the thickness of the dielectric filling the space is increased, then the spark becomes split up as shown in Fig. 1. When the quantity of electricity is small, the brush discharge is obtained, and takes the form illustrated in Fig. 2. The brush discharge can be seen as a luminous glow at the conductor, and is

SPARK DISCHARGE

Fig. 1. Two sides of a spark gap are represented by circles. The discharge assumes a forked lightning appearance

accompanied by a sharp hissing sound. A brush discharge can sometimes be seen at sharp points connected to extra high-tension generators, and, as a precaution against this, it is usual, in practice, to eliminate sharp points or corners by sufficiently rounding all edges.



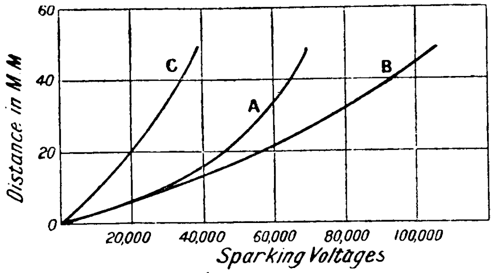
BRUSH DISCHARGE

Fig. 2. Brush discharge takes place when the quantity of electricity is small. A large discharge would cause a straight intense spark

The difference of potential required to cause a spark between two conductors is determined not only by the distance between them, but by the shape, size, and nature of the conductors, the nature of the dielectric, its pressure and temperature.

The difference of potential required to cause a spark across various distances between spheres is shown in Fig. 3. Curve A shows the voltage required between 2 cm. diameter spheres, and curve B shows the voltage required between 5 cm. diameter spheres.

Fig. 3, curve C, also shows the voltages for various distances required to cause a spark between needle points, and it will be seen that they are much lower than those required between spheres.



POTENTIAL DIFFERENCE TO CAUSE A SPARK

Fig. 3. Difference of potential is shown in the above curve in the necessary charge to cause a spark between the conductors

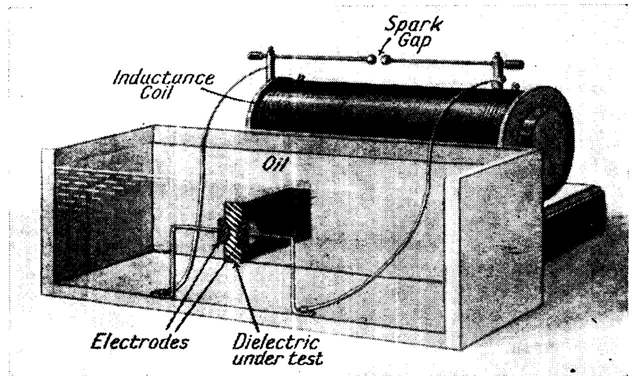
The pressure has a very important effect upon the voltage required for a given dielectric length, and the curves are the results obtained with air dielectric at normal pressure. If the pressure of the dielectric is increased, then a greater voltage is required to cause a spark between a given distance. If the pressure is reduced, but not excessively, the discharge loses the spark form and becomes a glow, as evidenced by the X-ray bulb. When the pressure is exceedingly low, such as obtains in a modern three-electrode valve used for wireless telegraph transmitters, then no visible discharge occurs, but under certain conditions an electron flow is set up.

The disruptive discharge is used for testing the dielectric strength of insulating materials. The sample to be tested is generally placed between two disk-shaped electrodes of standard diameter and thickness, or between standard diameter spheres, and immersed in oil (to eliminate brush discharges).

The electrodes are connected to a large induction coil, across the terminals of which are also connected two spheres so mounted that the distance between them is adjustable. The spark gap between the movable spheres is increased until the insulation resistance of the sample under test breaks down. The breakdown voltage is then obtained from the appropriate curve, drawn from the data compiled from a series of tests after the manner of the curves shown in Fig. 3. The diagrammatic illustration in Fig. 4 shows the form of spherical electrodes adopted by the National Physical Laboratory for dielectric strength tests.

The method is of great utility for comparative tests, but owing to the number of factors which influence the breakdown voltage (as previously mentioned), it is difficult to utilize it for absolute measurements. It is, therefore, very necessary that the conditions under which the tests were conducted should be noted.

A very important practical application of the disruptive discharge is the use of the condenser in the spark system of wireless telegraphy. In this system a charged condenser—usually of large capacity—is caused to discharge across a spark gap. A manipulating or transmitting key causes the condenser to discharge across the gap, the length of time of the discharge being controlled in accordance with the long and short dashes of the Morse code. *See* Critical Resistance; Discharge; Disk Discharger.



DISRUPTIVE DISCHARGE

Fig. 4. Electrodes as illustrated in this diagram are adopted by the National Physical Laboratory for testing dielectric strength

DISRUPTIVE VOLTAGE. Voltage required to break down the dielectric between any two electrodes. *See* Dielectric; Insulation.

DISSONANCE. The interaction of two oscillations which differ in frequency, as opposed to Resonance (*q.v.*). When an alternating current is superimposed upon another alternating current of unrelated frequency, the result is a series of " beat " vibrations, the frequency of which is equal to the difference between the frequencies of the two currents. This dissonance is made use of in the reception of continuous waves by the heterodyne method. *See* Continuous Waves; Heterodyne.

DISTANCE OF RECEPTION. The average range of a receiving set, consistent with perfect audibility, constitutes its distance of reception. Only more or less approximate figures can be given for the working range of a set, as so many factors enter into each individual receiving station, each factor having a deciding effect on the range or distance of reception.

An aerial 50 feet up from the ground and free from the screening influence of trees or other bodies would be considered a very good aerial, and would probably have a range about 25 per cent better than an aerial similarly situated but only 25 feet up. This latter aerial, however, would be found superior to another 40 feet up if screened by trees, for example.

The presence of a number of telephone or telegraph wires in the vicinity of an aerial has a very bad effect on good reception. An efficient earth also plays an important part, and the direction of the aerial with respect to the transmitting station also influences the question.

Under average conditions the range of a crystal set is about 15 miles. Cases are not uncommon, however, where a crystal set has ranged 40 miles, or more.

A valve rectifier using a standard circuit is efficient up to 25 miles, and with the addition of one stage of high-frequency amplification the range is extended to 75 miles. A crystal set with similar amplification should give a radius of good reception up to 45 miles.

In multi-valve sets the distance of reception may be greatly increased. A crystal rectifier with one stage of high and one of low frequency averages a range of 135 miles, and a similar set with a valve detector in the place of the crystal approximates 225 miles. A crystal set that should cover the whole range of British broadcasting from any part of the country, allowing for moderate conditions, would require one stage of high-frequency followed by two stages of low-frequency amplification. The range of such a set would be about 405 miles. By using a valve detector in place of the crystal, the range is increased to about 520 miles.

DISTORTION PROBLEMS IN RADIO RECEPTION

Causes of Distortion of Speech and Transmitted Waves Made Clear

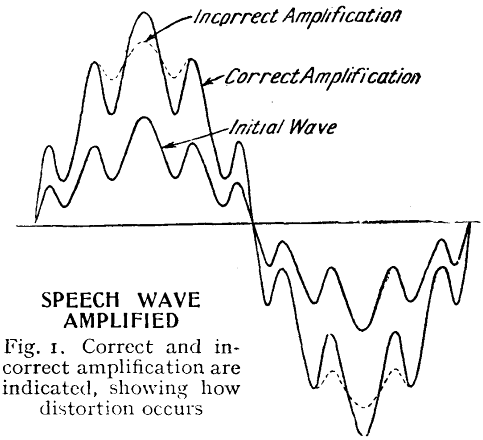
Here are discussed and explained the reasons for distortion of two kinds—that of speech occurring in receiving sets, and that of electro-magnetic waves in course of transmission. See, further, such headings as Heaviside Layer; Oscillation; Reaction; and particular articles, as Amplification ; Loud Speaker, etc.

When a vibration is propagated through space the wave form is subjected to a number of influences which under certain circumstances will seriously alter its form. So long as the wave form is preserved ; the ultimate effect of the vibration will be a faithful reproduction of the initial vibration. If, however, the wave is subjected to any influence that alters its form, then the ultimate effect will not be a faithful reproduction of the initial vibration, and the wave form is said to be distorted.

Distortion of wave vibrations is an everyday effect, but in ordinary life it is generally of no consequence, and only under certain circumstances is it necessary to adopt precautions to eliminate distortion. As evidence of this, light waves can be reflected and refracted—within limits—without suffering undue distortion. With the camera, however, elaborate precautions are taken so to design the lens that a picture is not distorted by refraction through the lens. When, however, we are dealing with the propagation of speech vibrations, the wave form must retain all its complex vibrations in order that the speech shall be clearly understood. In ordinary conversation distortion does not occur, but when the speech vibrations are transformed into the electric currents required for line and radio-telephony, there are present many influences which attempt to destroy the wave form and so cause distortion.

The transformation of speech waves into electric currents is one that, although fundamentally very simple, has necessitated an immense amount of research work both by telephone and radio engineers.

The ordinary telephone transmitter diaphragm is the first cause of distortion when sound vibrations are converted into electric currents for either line or radio-telephony. This cause of distortion is because of the inertia of the diaphragm, and is due to the great difficulty of making the diaphragm respond proportionately to the higher notes and to the lower notes. Hence the telephone diaphragm smoothes out the harmonics and destroys clear speech. If the diaphragm is made very thin and its inertia is very small, then it will generally be resonant to a particular frequency, usually within the range of audible frequencies, thus causing a greater effect at this frequency than is required.

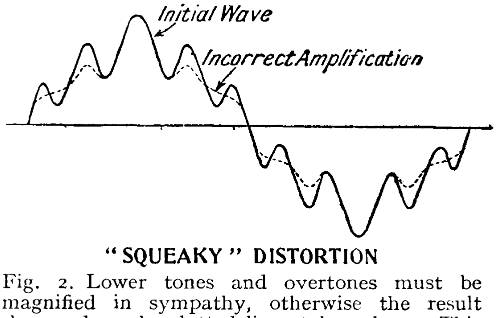


SPEECH WAVE AMPLIFIED

Fig. 1. Correct and incorrect amplification are indicated, showing how distortion occurs

Another cause of distortion, suggested by Preece, is due to inductance. If an inductance is included in an electrical circuit, to the terminals of which is applied an alternating electro-motive force of varying frequencies, the current in the circuit is inversely proportional to the frequency. Hence when the circuit includes an inductance, each and every change of frequency impressed on it by the sound wave is opposed by the effect of the inductance, with the result that the inductance does not readily allow the passage of the higher frequency currents.

Since every electrical circuit possesses inductance, means must be adopted to neutralize this effect. A condenser included in the circuit has an effect opposite to the inductance, and allows the passage of the higher frequency currents more readily than those of lower frequency. By adjusting, therefore, either the inductance or the capacity of the circuit to the correct value, the effects of each can be balanced out and this, in effect, is the tuning in of the signals.



"SQUEAKY" DISTORTION

Fig. 2. Lower tones and overtones must be magnified in sympathy, otherwise the result shown above by dotted lines takes place. This gives rise to squeaky speech

If the inductance of any circuit in which are present oscillations of audible frequency preponderates, then the speech will become "drummy" owing to the exaggeration of the lower tones. If, on the other hand, the capacity preponderates, then the speech will become "squeaky" owing to the exaggeration of the harmonics.

The use of iron-cored transformers is also a cause of distortion. The inductance of an iron core is not a constant quantity, and the nearer to the "saturation" portion of the magnetization curve the greater is this change. Precautions must be taken, therefore, that the transformer is working on a portion of the magnetization curve where the flux is at all times proportional to the magnetizing current.

It has already been pointed out that if the speech vibrations are not reproduced identically of the same form after every transformation in the various processes between transmission and reception, distortion will occur. The energy of speech waves has, in order to be transmitted by means of radio-telephony, to be magnified many times at the transmitter, and often at the receiving end, and one of the causes of distortion of the wave is the greater magnification of some portions of the wave than of other portions. This is termed "non-linear" amplification.

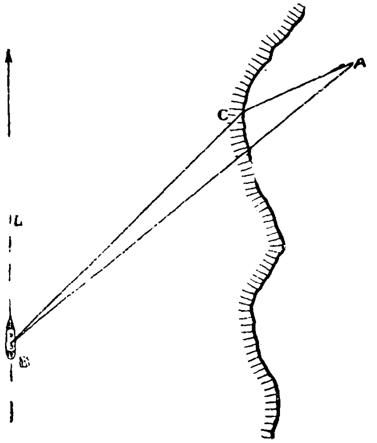
Let the curve shown in Fig. 1 represent a speech wave. Then if this curve is faithfully magnified all the vertical heights would be proportionately increased. This would increase the loudness of the sound without altering its frequency. If, however, the vertical heights of the lower tones are correctly magnified, while those of the overtones are magnified a smaller amount, the result would be as shown by the dotted line in Fig. 1. The result of this magnification would be that speech would be distorted and it would be termed "drummy."

On the other hand, if the lower tones are magnified to a greater extent than the overtones, then the resultant speech would again be distorted and the speech would be "squeaky." This type of distortion is shown in Fig. 2. Where the dotted line and thick line coincide, the magnification is correct, but when this is not so, the dotted line shows the portion incorrectly magnified.

It is also possible to have a combination of these two defects, in which case the speech would be blurred or muffled.

These effects have to be carefully guarded against, both in line telephony and in the transmitters, as well as in the amplifying detectors used in wireless telephony. It is, generally speaking, in the amplifying detectors, especially when note or low-frequency magnification is used, that most distortion is likely to occur.

Distortion of Electro-magnetic Waves. Electro-magnetic waves of the length normally used in wireless telegraphy may



ELECTRO-MAGNETIC DISTORTION BY WATER

Fig. 3. How the sea refracts the path of a wireless wave is illustrated. This form of distortion has to be considered in direction finding

suffer distortion due (*a*) to refraction of the wave, and (*b*) to a series of phenomena called "night effects."

(*a*) *Refraction.* An electro-magnetic wave with such a frequency as is used in wireless telegraphy is affected by the medium over which it travels, and is refracted in exactly the same way as a beam of light when it passes into or out of a medium of greater or lesser density. A light wave is refracted because on entering a medium of greater or lesser density the absorption of the medium causes a change in velocity. The same effect occurs in a wave used for wireless telegraphy—the two waves are, in fact, the same, and both are propagated in the ether.

Thus a wave emitted by a transmitting station situated on land would not necessarily travel in a straight line to a ship at sea. Using the light wave as an analogy, the passage of the wave from land to water affects the velocity of the waves and results in refraction.

Fig. 3 illustrates a transmitting station on land communicating with a ship station. Let AB be a straight line between the land station and the ship. When the wave reaches a medium of different density, *i.e.* the sea, it is refracted and the path of the wave is represented by ACB. If now the ship is fitted with direction-finding apparatus and the bearing on the shore station is taken, the angle DBC will be obtained, whereas the correct angle is DBA. The actual bearing obtained is, therefore, incorrect by the angle CBA, and this error may become large.

It should be noted, for example, that the deviation from the correct bearing will become greater as the angle between the path of the wave and the shore becomes more acute.

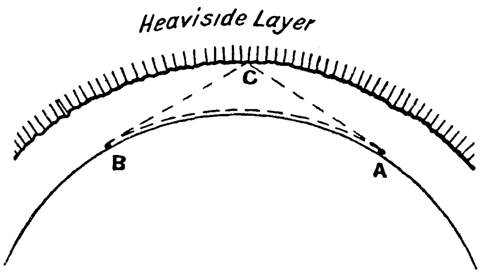
(*b*) *Night Effects.* At night time there are a number of effects which sometimes influence the accuracy of bearings when obtained by means of wireless direction finders. These effects are generally termed "night effects," because, as the name implies, they are present only during the dark hours.

In direction-finding work by wireless methods, the bearing of any transmitting station is found by means of an instrument called a radiogoniometer, or search coil unit, and by means of special connexions of the receiving apparatus the radiogoniometer indicates the direction or bearing of a transmitting station when signals of minimum intensity are obtained (*see* Bellini-Tosi Aerial.) Under normal working conditions this minimum should be sharp; extending only over a degree or two. The night effects may cause the minimum to become indefinite, although the bearing may be incorrect, the minimum to be sharp but the bearing inaccurate, or a combination of both effects. Also if two bearings are taken on two different stations it is sometimes impossible to obtain a correct intersection. Further, rapid variations may occur in the signal strength and make accurate determination difficult.

Fully to explain the cause of night effects would require a mathematical treatise, but it may briefly be stated that the cause is due to a polarization of the electro-magnetic wave and the vertical angle of incidence of the wave at the receiving aerial.

The magnetic force of an electro-magnetic wave can be resolved into two components, a vertical component and an horizontal, and depending on the angle of incidence of the wave on the receiving aerial, so will these two components affect the frame aerial of the direction-finding apparatus with a more or less adverse effect on the sharpness of the minimum reading.

Electro-magnetic waves from a transmitting station may be received direct from the transmitter, and also after reflection from what is known as the "Heaviside Layer." Fig. 4 shows the path of a direct and a reflected wave, and



DIRECT AND REFLECTED WAVES

Fig. 4. Changing phase relationships of the direct and reflected waves cause distortion, and the bearing of a transmitter is accordingly given inaccurately

as a result of the changing phase relationship of the direct and reflected waves, the bearing of the transmitter is rendered inaccurate.

The distortion of electro-magnetic waves is a subject on which much investigation is still proceeding, but gradually the causes are being discovered and steps taken to eliminate the inaccurate results sometimes obtained when direction-finding is carried out at night. *See* Direction Finding; Goniometer; Heaviside Layer.

DISTRESS CALL. The distress call is . . . - - - . . . or S.O.S. It should be answered by any station or ship that hears it, unless there is added the call of any particular station, when that station alone replies. Any ship or station hearing the distress call stops all other transmission or reception until the call is answered. *See* S.O.S.

DISTRIBUTED CAPACITY. Inherent capacity or condenser effect in a coil of wire or other form of electrical apparatus. In such cases the current as it flows through the conductor sets up a local magnetic field about it, and also an electrostatic field with lines of force parallel to the conductor. Consequently adjacent conditions become in effect a form of miniature condenser. The insulation of the wire has a bearing on the effects produced, as the specific inductive resistance of various insulators varies. Air is a very good dielectric, and to reduce the distributed capacity the wires are arranged in such a way that they are separated by an air gap, and the induced magnetic and electrostatic fields between adjacent turns of the wire are reduced to a minimum value.

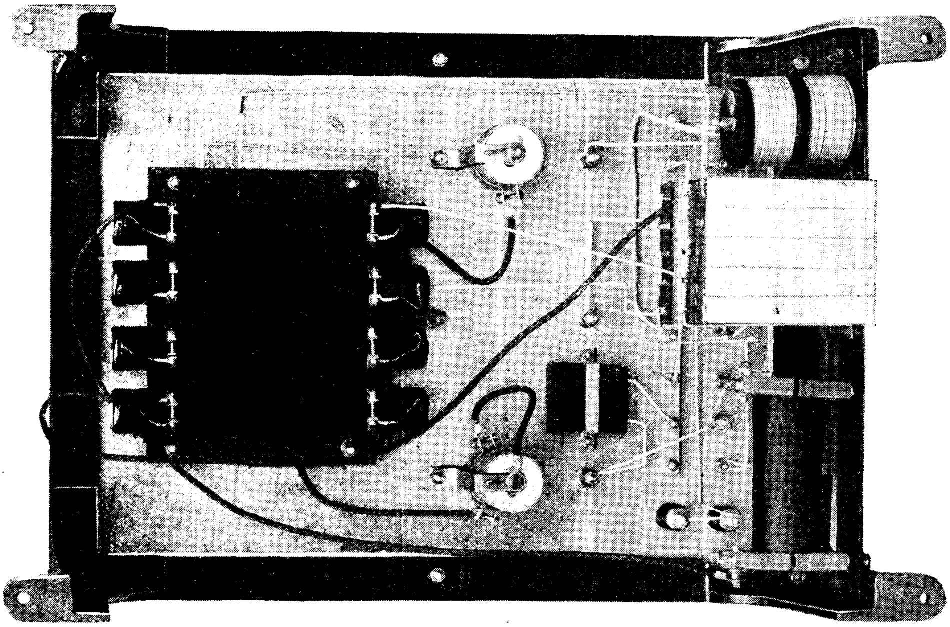
This is attained in various ways according to the purpose and mode of construction of the coil. One example is to wind the wire in a criss-cross way, so that the induction of one turn of the wire is largely destroyed by the induction of the next or adjacent turn.

In another system the windings are so spaced that an air gap is maintained between each and every turn of wire, and of sufficient amount to destroy the effect or reduce it to a minimum.

The distributed capacity effect is mostly felt in the case of a long coil, and is most pronounced at the ends. In practice the multilayer coils wound on one of the numerous duo-lateral systems gives the minimum effect. *See* Capacity; Coil; Dielectric; Honeycomb Coil; Inductance.

DISTRIBUTION BOARD. A distribution board is a link between any number of isolated units and the main source of electrical supply. The illustration shows a typical distribution board for wireless purposes. It is the rear view of the board used in conjunction with the Marconi Duplex wireless telephone set to connect the power supply to the receiving and transmitting apparatus. All the apparatus necessary to enable directly generated current to be used for wireless work is assembled on the board, consisting chiefly of condensers and chokes. The ordinary apparatus associated with the generation of electricity for any purpose, such as fuses, and circuit breakers, is also fitted.

The front of the board has two rows of terminals, each one labelled, so that their connexion to the various instruments,



BACK OF X.A. POWER DISTRIBUTION UNIT

Isolated units are connected up by a distribution board. This is a back view of such a board as used with the Marconi duplex wireless telephone set, and gives a clear idea of the wiring and components, including condensers and chokes

Courtesy Marconi Wireless Telegraph Co., L d.

valves, etc., is a matter of the utmost simplicity. The board is erected with a wire-mesh cage surrounding it, in order to protect the user from danger of shock, and the board from mechanical injury through accidents arising from falling objects.

DOLEZALEK ALTERNATOR. A special type of high-frequency alternator made in several sizes and types, including those for the audio-frequencies of 200 to 10,000 alternations per second. A simple machine of this type has a toothed and laminated ring or disk, rotated near to the poles of an electro-magnet which is magnetized by a winding carrying a direct current. Near to the ends of the poles other secondary windings are provided, and these have an alternating voltage induced in them by the variations of magnetic flux resulting from the passage of the toothed disk. The machine is run by a direct current motor, and in some cases the speed is steadied and controlled by the provision of a small direct current dynamo coupled to the opposite end of the main shaft. *See* Alternator.

DONITZ WAVEMETER. A closed-circuit wavemeter, comprising essentially a circular inductance coil of known value in series with a variable air condenser. Part of the circuit is inductively connected to a second circuit, which includes an air thermometer with a fine wire platinum coil sealed in the bulb.

To measure the frequency or wave-length of the oscillations in a circuit a loop is formed in it, and this is brought near to the coil on the wavemeter. The condenser is adjusted until the air thermometer shows a maximum, when it is taken that the oscillations in the circuit and in the wavemeter are the same.

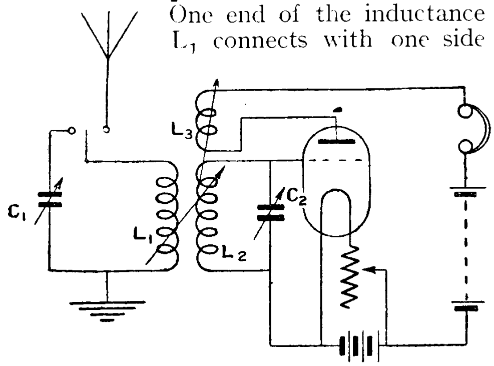
As the value of the inductance and capacity in the wavemeter are known, the values for the external circuit are then known. To increase the wave-length range the inductance coils can be altered and others of different value substituted.

DOUBLE CLICK. A method of measuring the effective capacity of an aerial or a variable condenser, or of determining the inductive value of a coil when a calibrated condenser is available

In the figure is an oscillating circuit comprising an inductance, L_2, to which is variably coupled a reaction coil, L_3. A tuning condenser is connected across L_2 to vary the tuning of the grid circuit.

The remainder of the oscillator circuit follows standard practice.

In order to test the capacity of an aerial a circuit is arranged as shown on the left of the figure, and consists of an inductance coil, L_1, variably coupled to the inductance, L_2, in the oscillator circuit. One end of the inductance L_1 connects with one side



DOUBLE-CLICK CAPACITY TEST

Aerial capacity can be ascertained by the method employed in the above circuit. Tuning the two clicks is accomplished by the two condensers, which must be calibrated

of a calibrated variable condenser, C_1, and to earth. The opposite end of the inductance is joined to the moving arm of a two-way switch.

To these switch studs are connected respectively the other end of the calibrated condenser and the aerial. The inductance L_1 is chosen to give the desired wave-length on which the capacity of the aerial is to be ascertained.

To operate the apparatus the switch arm is connected to the aerial and the condenser C_2, and the coupling between L_1 and L_2 varied until a click is heard in the headphones. The click will be heard again on turning back the condenser, and the coupling is varied until the clicks nearly coincide. This indicates that the two circuits are in resonance. Midway between the two clicks may be taken as the point of true resonance.

The switch is now changed over to the other stud, thus disconnecting the aerial and including the calibrated condenser. The tuning of the oscillator circuit is not changed. The condenser C_1 is now slowly rotated until the clicks are again heard in the telephones. The midway point between the two clicks is the aerial capacity at the wave-length chosen. On long wave-lengths the aerial capacity is nearly constant.

The value of any required inductances and capacities may be ascertained by the double-click method in a similar way to the foregoing by the use of a calibrated wave-meter. *See* Wave-meter.

DOUBLE COTTON COVERED WIRE. Abbreviated as D.C.C., this expression refers to a particular type of insulated copper wire extensively used in wireless work. As generally used by the experimenter it is supplied on a wooden spool or bobbin, and in quantities measured by weight.

The insulation is composed of two separate and distinct layers of cotton. The first, or that next to the wire, is often laid more or less in the direction of the length of the wire. The outer or second covering is wound around the first, efficiently insulating the wire. Such wire is chiefly used for winding inductance coils and the like. Obtainable in different coloured cotton coverings, it is easy to distinguish the various parts of a circuit. The grid circuit, for example, could be wired with red and the plate with blue or white.

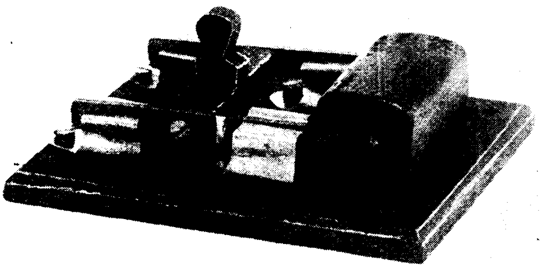
Double cotton covered wire is obtainable in a range of sizes known by gauge numbers, these having reference to the diameter of the wire. British-made wire is generally sold in accordance with the I.S.W.G. sizes, and in comparing the various tables of values and turns per inch, and so forth, these gauge sizes ought not to be confused with the wire sold by other nationalities who use a series of similar gauge numbers but of different sizes to the I.S.W.G.

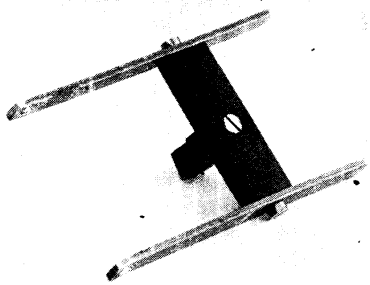
DOUBLE-FLUID CELL. A primary cell using two electrolytes. The most common forms of double-fluid cells are the Fuller, Daniell, Grove, and the Bunsen.

In the majority of these cells the electrolytes are separated by means of a porous pot. An exception to this is seen in the gravity Daniell cell, in which, owing to their different specific gravities, one fluid rests on top of the other.

Polarization is one of the difficulties encountered in all primary cells, but as a general rule double-fluid cells suffer less in this respect. In the Daniell cell one of the fluids, copper sulphate, acts as a depolarizer, and in the Grove cell nitric acid acts as a depolarizer. *See* Daniell Cell ; Gravity Cell ; Grove Cell.

DOUBLE-HUMPED WAVE. An irregular wave radiated when an open circuit is oscillating to two frequencies, usually as the result of coupling the





DOUBLE-POLE SWITCH AND ITS CONTACT ARMS

Fig. 1 (left). Construction of a simple double-pole switch, as seen in this photograph, is easily carried out by the amateur. Details of the method of construction are given in the following figures. Fig. 2 (right). Two contact arms are spaced by an ebonite bar with an added handle, also of ebonite

primary and secondary of an oscillation transformer too tightly. The effect is shown graphically by a double hump resonance curve, the two peaks or humps in which denote the irregularity referred to. *See* Wave.

DOUBLE MAGNIFICATION CIRCUIT. An expression synonymous with dual amplification circuits, wherein a valve is constrained to perform the duties usually undertaken by two valves. *See* Dual Amplification.

DOUBLE-POLE SWITCH. A mechanical device for interrupting both poles of the source of supply of electrical currents simultaneously by the movement of one handle or switch arm.

The construction of a small double-pole switch, shown in Fig. 1, suitable for the control of low-tension current, can readily be undertaken by the experimenter from simple material. The base may consist of a piece of ebonite about $\frac{1}{4}$ in. thick, 3 in. long, and $1\frac{3}{4}$ in. wide, or other size as may be most convenient. To one end of this base is attached a substantial block of ebonite, fixed by means of two small screws passed through from the underside of the base.

Four screw holes should be drilled through the corners of the base for fastening purposes. The switch arms are simply two short, straight pieces of strip brass or copper, about $\frac{1}{4}$ in. wide and $\frac{1}{16}$ in. thick. These are pivoted one on each side of the ebonite block, and kept in position by screws which pass through the brass strip and screw into blind holes in the ebonite block. It is important that these screws should not touch, and also that they should not collide with the fixing screws.

Another ebonite block should be prepared to fit between the two contact arms, and secured to them with small brass screws, which also must be well separated, as shown in Fig. 2. A small ebonite knob may then be fixed to the upper surface of this second block, which acts as a handle for raising and lowering the contact levers.

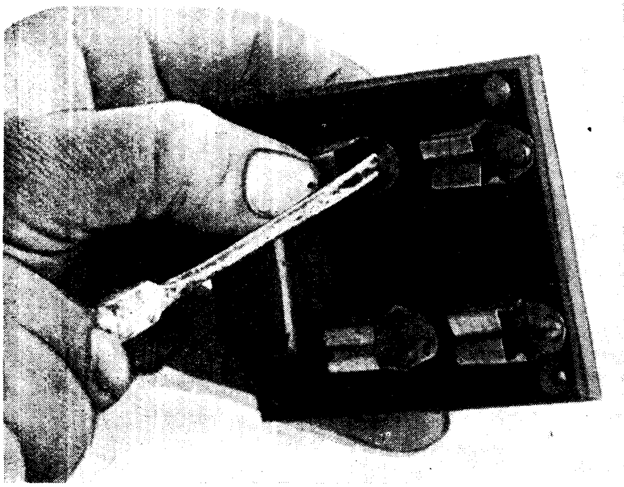
The contacts themselves are made by cutting four pieces of copper to a T shape, punching a hole through one leg, and bending the others to the shape shown in the illustration, Fig. 3. These should be closed up so that the two sides of the contact jaws just touch. They are then secured to the base by four small brass screws, as in Fig. 4, and are arranged two contacts on each arm, the ebonite cross bar and handle going between these contacts.

CONTACTS OF DOUBLE-POLE SWITCH

Fig. 3. One of the copper contacts is seen on the right in the flat state, and another on the left is bent to shape. This component is very simple to prepare

Connexion should be made by taking one wire to one of the contacts and another wire from the second contact on the same side of the base. One of these wires is then connected to, say, the positive side of the low-tension battery and the other wire taken to the receiving set, or wherever the current is to be delivered. The two contacts on the opposite side of the base are similarly wired and connected to the negative side of the battery. Consequently, when the levers are pressed down into contact, both sides of the battery are connected, whereas when the lever is lifted, both circuits are broken.

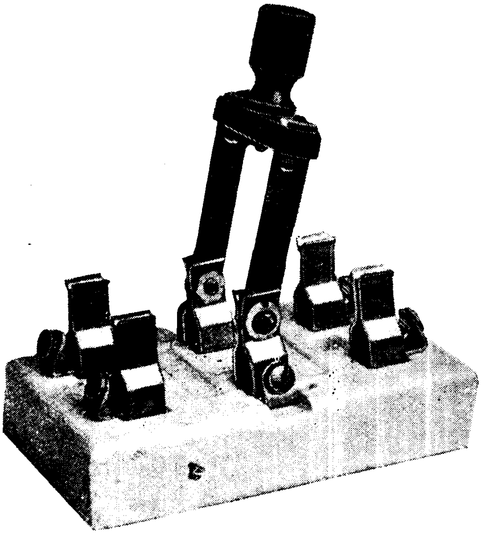
An example of a commercial type of switch is shown in Fig. 5. The switch has a china base and substantial copper contacts. The two switch arms are connected by an ebonite crossbar having a knob at the outer end. Connexions are made by the small screws at the base of the contacts, and in the case of permanent connexions the wires could profitably be soldered to them in addition to ensure a perfect electrical connexion.



SECURING THE CONTACTS

Fig. 4. Contacts as shown in Fig. 3 are secured to the base with screws. The spring grips must be in line, so that the switch arms fit either pair without bending them out of shape

Other patterns of double-pole switches are made, but in all of them the essential point is that both the positive and the negative sides of a circuit are severed or connected simultaneously by the movement of a switch arm or handle. On large work, as, for example, in a powerful transmitting station, the switches are of considerable size and incorporate various features, such as a quick break device and other means for the safety of the switch and the adequate control of the circuits.



DOUBLE-POLE DOUBLE-THROW SWITCH

Fig. 5. Switches of this kind are inexpensive to buy. The above is a commercially made switch with a china base for insulation purposes, and is provided with two sets of contacts

Double-pole switches should always be used for the initial control of the current from a powerful source of supply.

DOUBLE - RANGE AMMETER. A double-range ammeter is an ammeter capable of giving two independent ranges of readings, both from the one movement and pointer. Any type of instrument is suitable for the purpose of giving two ranges. The double-range instrument has two scales arranged concentrically upon the one dial or scale plate, and instead of the usual two terminals, three are fitted; one being common to both ranges, the other two being the alternative positions enabling either range to be used at will.

An ammeter must always be placed in series in a circuit, and therefore the whole of the current in that circuit would pass through the meter windings were not measures taken to avoid it. It will be appreciated that for the meter windings to carry a current of anything over a fraction of an ampere would be very bad for the instrument. This applies particularly to those of the moving coil type. If the whole load in a circuit were to pass through the windings, they would either have to be made very heavy and bulky, or else they would heat up and burn out very quickly.

For this reason all ammeters have a shunt connected across the winding, and use of this device is made in the double-range instrument. These shunts are really very low resistances designed to carry the maximum load the instrument is ever likely to carry. They are usually made of strips of stalloy held in slots cut in massive copper blocks. Each strip is separated from its neighbour by an air space, in order that any heat developed may be freely dissipated.

Instruments reading only up to a few amperes have the shunt contained inside the case, but those designed for heavy work have the shunt fitted externally to the adjoining switchboard, and connected in parallel with the instrument by large copper leads, as short as possible.

It will be realized that as the resistance of the shunt compared with the coil is very low, the bulk of the current passes through the former. Therefore by substituting one shunt for another of different ohmic value, it is possible to make the meter read as many different values as there are shunts, for any given needle deflection.

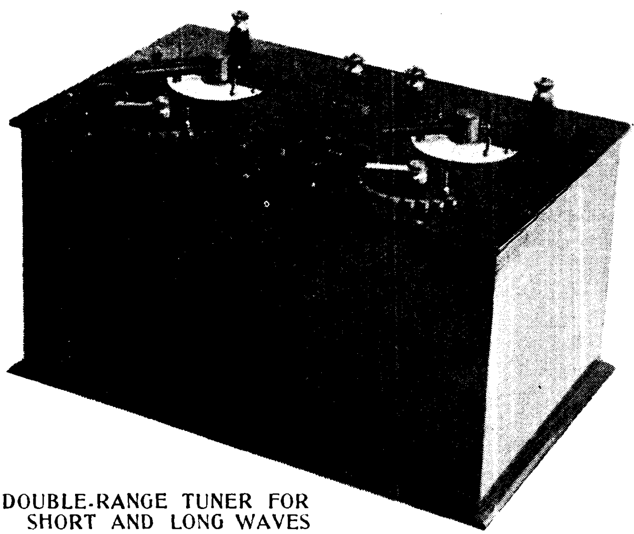
In the case of moving coil instruments it is only necessary to have one actual series of divisions, for the needle deflection is directly proportional to the current value, and therefore two different numbers against each numbered division is all that is necessary. Moving iron or hot-wire instruments, however, must necessarily have two entirely separate scales, each individually calibrated, for the scaling of these instruments is not at all even.

DOUBLE-RANGE TUNER. A variable inductance having two distinct inductances, one usually designed for short wave-lengths and the other for longer wave-lengths. The most common form of double-range tuner is an inductance with two sets of tappings. One provides coarse tuning and the other fine tuning between any two studs of the coarser tuning.

Another type of double-range tuner employs a plug and socket arrangement, allowing an extra inductance to be plugged in to reach a higher wave-length than that to which the inductance can be normally tuned. This inductance is called a "loading coil."

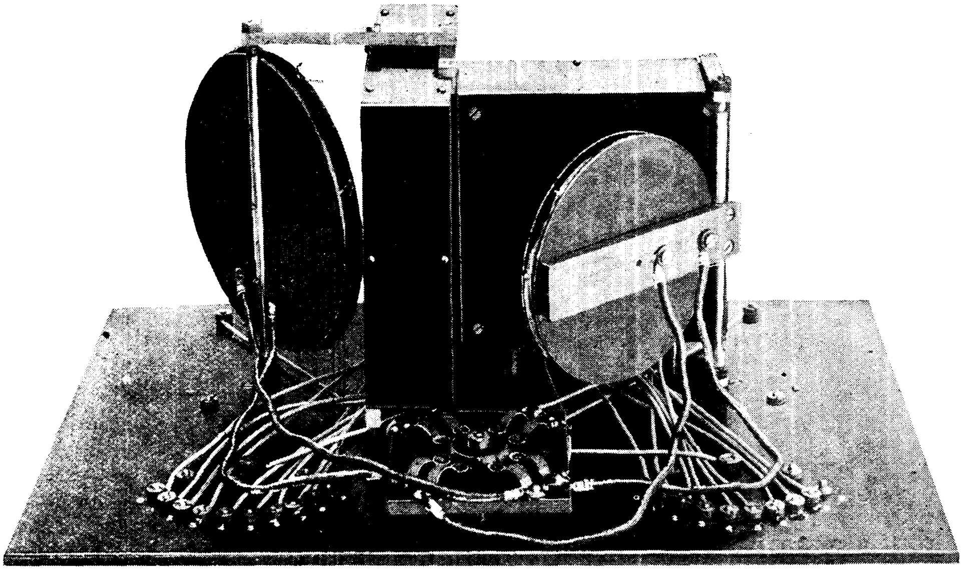
One form of double-range tuning coil is made in which two variometer formers rotate in a stator consisting of an ebonite tube. The tube is wound with two separate inductances, which are brought out to tags. The variometer connexions are similarly terminated in tag ends. This combination permits of many different combinations of wiring. It is, in fact, a double vario-coupler in which one stator inductance is wound for a higher wave-length than the other.

A useful example of a double-range tuner is shown in Figs. 1 and 2. Fig. 1 shows the exterior of the tuner. A ten-stud switch on the left of the panel controls a bank of short basket coils, conveniently housed in an ebonite box. On the right is a similar switch for long wave-lengths. The former will tune from 250 metres to 3,000 metres, and the latter up to 30,000 metres. Between these studs is a switch



DOUBLE-RANGE TUNER FOR SHORT AND LONG WAVES

Fig. 1. On the panel of the tuner seen above are two large terminals at the back for aerial and earth connexions. Between them are the terminals for reaction. Two tuning switches are seen, one is for short wave-lengths, the other for long wave-lengths. This is a very convenient form of double-range tuning inductance



INTERIOR OF DOUBLE-RANGE TUNER

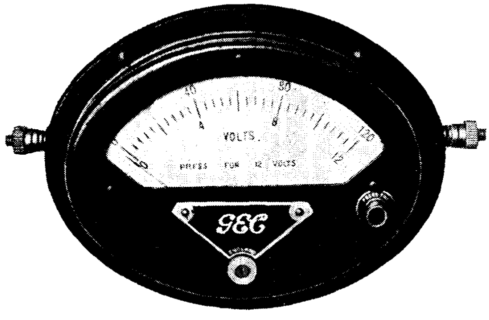
Fig. 2. Two banks of basket coils are shown set at right angles to each other. In the front are seen the contact studs of the switches and between them is the back of the change-over switch. Control knobs for these three switches may be seen in Fig. 1. The coils may be used either for inductance and reaction or for variometer effect

enabling either to be used. Immediately behind each switch is an arm operating a variably coupled coil, which may be connected either as a reaction coil or to give a variometer effect on the inductances. These features are seen in the illustration of the back of the tuner in Fig. 2. It will be noticed that the two banks of basket coils are set at right angles to each other to avoid interaction. The switch is seen in front of the coils, with the back of the stud switches on either side.

DOUBLE-RANGE VOLTMETER. A double-range voltmeter is a voltmeter capable of giving two independent ranges of readings, both from one movement and one pointer. Either the moving coil or moving iron type of instrument may be used for the purpose. In place of the usual single scale, two are fitted, arranged concentrically upon the one dial or scale-plate. In order to obtain the second range, either a third terminal or the usual two used in conjunction with a push button are fitted. Should three terminals be fitted, one is common to both ranges, the other two being connected independently, one to each range.

Voltmeters must necessarily be connected across the mains, the P.D. of which is to be measured, and therefore must be high-resistance instruments. They are also usually connected permanently in the circuit.

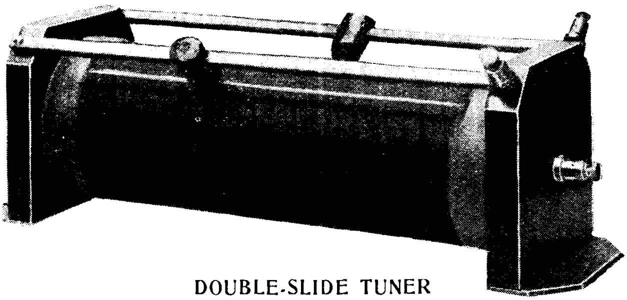
It is general practice to connect a high resistance of constant value in series with the instrument coil, the meter being calibrated with the resistance in circuit. These resistances must be of absolutely constant value despite temperature changes, and for this reason are usually made of constantin or manganin wire.



DOUBLE-RANGE VOLTMETER

Fig. 1. This type of voltmeter is capable of giving two independent ranges of readings by one movement and one pointer. A push button shown on the right below the dial enables readings from 0 to 12 volts to be taken

Courtesy General Electric Company, Ltd.



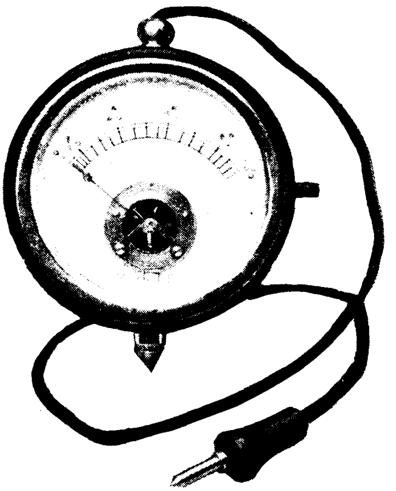
DOUBLE-SLIDE TUNER

Fig. 1. Tuning coils with two sliders are commonly used in simple circuits. The model shown above is easily made and simple to adjust. It is more selective that the single-slide tuner

Courtesy Economic Electric Company

In a double-range instrument two separate resistances are used, one for each range, the instrument being calibrated separately to each resistance.

It should be noted that any voltmeter of the moving coil type can be made to read any desired range above that for which it was designed by a very simple method. In order to do this, it is necessary to ascertain the resistance of the instrument by a Wheatstone bridge or other method. If then, for instance, it is desired to make it read double the number of volts for which it was scaled, a resistance of equal value to itself must be placed in series with it. As with this class of instrument the needle deflection is absolutely directly proportional to the applied volts, and as its resistance is now doubled,



DOUBLE-RANGE POCKET VOLTMETER

Fig. 2. Similar to the simple pocket type of voltmeter is this double-range voltmeter. By pressing the pin on the right, voltages from 0 to 10 may be read. When the pin is released up to 100 volts can be registered

it will be seen that the deflection per volt will now be one half of that normally obtained. This property of the moving coil instrument will be found most useful in the laboratory.

DOUBLE-SLIDE TUNER. An adjustable inductance coil having two separate sliding contacts. A standard pattern is illustrated, and shows the general arrangement of the parts. The coil is wound of insulating wire on a tubular former, supported at the ends by vertical cheeks. The lower parts of the cheeks are fitted with projecting feet with which to fasten the set to the baseboard or elsewhere.

The upper part is fitted with two parallel square brass bars, and on them slide the insulated contact plungers. These make contact with exposed contact paths on the winding, and the inner end of the plungers bear on the underside of the bars. Terminals are provided for the various connexions to enable the tuner to be placed in a circuit.

This type of tuning coil can be used for almost any circuit, and is frequently employed in crystal sets; it is rather more selective than a single-slide tuner. With this class of tuner one of the sliders could tune the aerial circuit and the other be employed to tune a closed circuit embodying the crystal detector and the telephones. Another way in which this tuner could be used is to provide tuning of the aerial circuit and also a reaction coupling, the latter governed by the second slider. This is applicable to a single valve set, with or without audio-frequency amplification. *See* Coil.

DOUBLE-THROW SWITCH. A mechanical device whereby a current of electricity, reaching the switch by one terminal, can be handed on from one or other of two separate contact points from which the current is taken to any desired point on the apparatus. It consists in essence of a pivoted lever mounted on a central support, so that it can be turned over and its outer end can make contact with either of the contacts, which are arranged at opposite ends of the base plate.

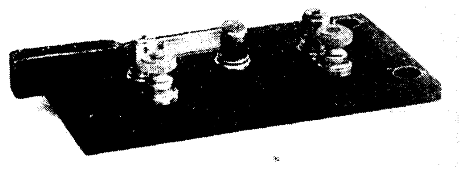


Fig. 1. Mounted on an ebonite box is a complete and simple double-throw switch as made by many amateur experimenters

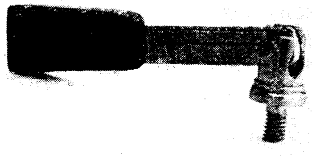


Fig. 2. Pivoted on a central post is a flat contact arm with an ebonite handle. A telephone terminal can be converted into a post

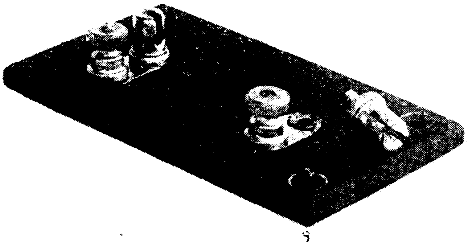


Fig. 3. Contacts are here shown in place with one slotted terminal detached. Terminals and slotted terminals are connected by flat copper strips

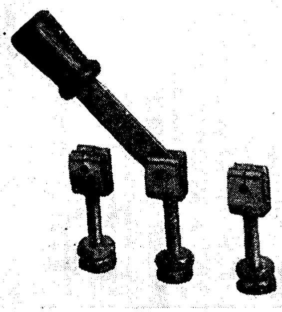


Fig. 4. Components of a commercially made double-throw switch are shown dismounted. These may be mounted direct on to the panel without a separate base

HOW TO MAKE A DOUBLE-THROW SWITCH

Double-throw switches are made with two sets of such levers and contacts, and are then known as double-throw double-pole switches.

A simple double-throw switch can be made up in a very short time on a small ebonite base measuring about 4 in. in length and $1\frac{1}{4}$ in. in breadth, or any other size that may be most convenient. The contacts are made from telephone terminals, by removing the set screw on the top and cutting a slot down them to the cross-wise hole which is always drilled in this kind of terminal.

Three terminals should be prepared in the same way, and they should be mounted on the baseboard by drilling three holes in line with each other, uniformly separated, and towards the back part of the baseboard. The terminals may be secured to the base by tapping the ebonite and screwing the terminals firmly into position, cleaning off the underside flush and smooth. If the threads are a good fit, no other fastening will be necessary.

The centre terminal should be drilled through at right angles to the slot, and through this may be placed a small brass pin to act as a pivot for the lever. This can be made from a short piece of brass strip about $\frac{1}{4}$ in. wide and $\frac{1}{16}$ in. thick, pivoted at one end to the centre-piece, as in Fig. 2, and provided with a small ebonite handle at the other.

All three terminals should be adjusted so that the lever, when turned from one side to the other, makes equally good connexion at either end of its travel. Connexions should be made direct to the contact terminal by soldering the contacts to them, preferably by using copper contact strips, which should connect the contact terminals to separate terminals with small milled-headed nuts, or of any other desired pattern, along the lines shown in the illustration, Fig. 3, one terminal being removed to show the strip connexions.

There are numerous examples of the commercially made articles on the market, but one pattern only is illustrated, as it is suited to the needs of those who prefer to mount the switch on the face of the panel. As illustrated in Fig. 4, the components are shown as they are sold, and all that has to be done to mount them is to drill three holes at the correct distances apart and insert the screwed part of the shanks through them Adjust the contacts and the arm until they are all in line, and tighten the nuts beneath the panel. The second nut can be used to secure the conductors. *See* Knife Switch.

DOWNHAUL. Name given to a rope used to control and haul down an aerial, and also to any rope used to pull an object down from a mast or similar structure. *See* Aerial.

DOWN LEAD. Name given to the wire leading from an aerial to the instruments. In many cases the down lead is a continuation of the aerial, a few turns being twisted round the aerial to prevent the wire from being pulled through the insulator. In the case of a twin or multi-wire aerial the down lead, or lead-in wire, as it is alternatively called, is connected to a wire joining every strand of the aerial.

In constructing an aerial, particular care must be taken both in the design and erection of down leads. The down lead should be kept as far away as possible from trees, walls, or any other objects, which will be found to have a bad effect if too near the down lead. Metals especially are to be avoided, as they have a decided capacity effect on the aerial.

Where the down lead enters the house care must be taken to secure perfect insulation and provision made to prevent leakages due to the presence of water. The down lead should be kept fairly rigid, as it will give a varying wave-length if allowed to swing about in the wind, owing to a varying capacity with adjacent bodies. There is no need to insulate a down lead, unless it touches a wall or other substance at any point in its length. If this cannot be avoided the down lead may consist of heavily-rubbered magneto wire during this portion. It is of great importance to make all joints electrically perfect, and this can only be assured for any degree of permanency by well soldering. *See* Aerial; Bradfield; Insulator, Lead-in.

D.P. ACCUMULATOR. A commercial accumulator of the lead-plate type, made by the D.P. Battery Co., Ltd. The positive plates are of the Planté pattern.

This consists of a plate having as large a surface area as possible, in which the active material is produced from the metallic lead of the plate itself. The positive plates are of ribbed design, strengthened by horizontal binding members. This method of construction permits of free circulation of the electrolyte throughout the plates and gives a tough adherent skin when the plates have been formed. In the design of plates of the Planté type, such as are used in the D.P. accumulator every care is taken to provide maximum surface of lead consistent with mechanical strength. In the forming process this metallic surface is electro-chemically changed to peroxide of lead. Many makers have their own methods of plate forming, exact details of which are not available, but these methods mainly quicken the process of formation, which consists of repeatedly charging and discharging the plates. Dummy negatives are used in this process, and the charging is carried out in an alternate positive and negative direction.

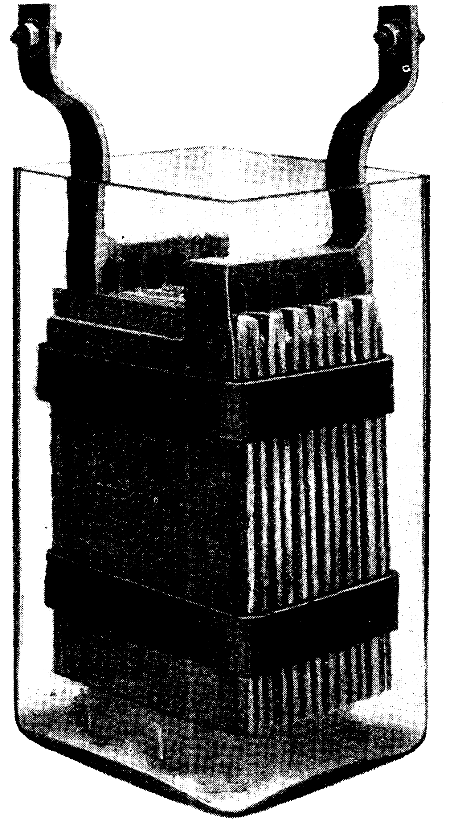


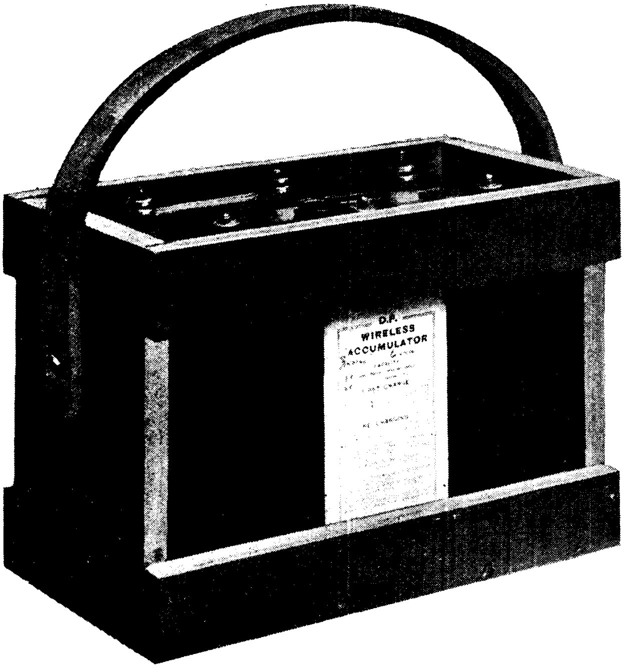
PLATE SEPARATORS FOR PREVENTING DEPOSIT

Fig. 1. Patent separators are fitted to the above cell, which is of the house-lighting type. By means of this addition deposit is prevented from forming, as lead peroxide is arrested in its effort to escape from the positive plate surface

Courtesy D.P. Battery Co., Ltd.

The D.P. negative plates are built up on the Faure principle. In this method spongy lead is pressed into a lead framework or grid. This substance has the great advantage of slightly expanding when on charge, and this property ensures perfect contact to the grid, in addition to preventing any tendency to fall out. Negative plates made on the Faure principle have very largely superseded Planté negative plates.

In the D.P. construction the negative plate is encased in a perforated shield, which effectively prevents disintegration of the plate.



WIRELESS D.P. ACCUMULATOR

Fig. 2. Six-volt portable batteries, as the one illustrated, are used for filament lighting and general experimental work. Terminals are provided on each cell, so that when low voltages are required one or more cells can be cut out, and each cell can be used separately

Courtesy D.P. Battery Co.

A D.P. cell embodying a new feature is shown in Fig. 1. This consists of a patented plate separator composed of a special kind of felt made from spun glass wool. This material is in thin sheets of uniform density and thickness. In appearance it is similar to a porous pasteboard, and is stiff enough to be easily handled. Owing to its soft and elastic texture, it effectually prevents the escape of peroxide from the surface of the positive plate. The separator is prevented from actually touching the surface of the negative plate by the presence of a thin sheet of porous wood. A battery having this type of elastic separator is to be recommended where the battery is likely to be subject to vibration.

Both sets of plates, in types where portability is not desired, are fitted with projecting lugs, enabling the plates to hang on the edges of the containing vessel. Glass tube separators are used between the plates. A set of three cells embodying these features will be found very useful to the experimenter for wireless work, especially if facilities are available for charging.

A battery of smaller capacity but of the same voltage as the foregoing is seen in Fig. 2. This has a discharge rate of 33 actual ampere-hours and a potential difference of 6 volts. A substantial carrying crate and handle make it readily portable. *See* Accumulator; Battery; Dry Cell; Exide Cell.

DRAIN CIRCUIT. A particular type of circuit employed to minimize interference from signals on some particular wavelength. As an example a receiving circuit may be tuned to receive signals on some particular wave-length, say, of the order of 400 metres, or those commonly used for broadcasting. From a low potential point on the aerial circuit a second circuit is tapped and tuned to become an acceptor circuit for the interfering wavelength. The 400 metre wavelength signals will set all the circuits in oscillation that are tuned to it, but only a small amount of the energy will be expended on the acceptor circuit for the interfering wave-length.

On the other hand the interfering wave will expend the bulk of its energy that remains after it has reached the tapping point in setting up oscillations in the second circuit, and as this is earthed the interfering waves are drained away and there should be little or no interference in the telephones from it.

This type of circuit is useful for dealing with a local and persistent interference from some particular station. A similar closed circuit using a variable inductance and a variable condenser is used for the purpose. *See* Interference; Intermediate Circuit; Wave Trap.

DRAWING INSTRUMENTS & HOW TO USE THEM

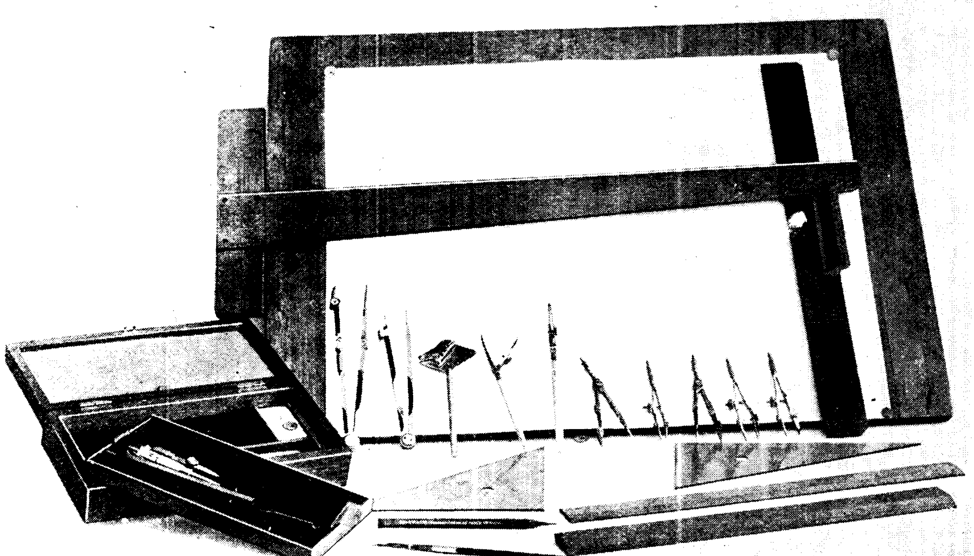
What the Amateur Needs for Wireless Designs and Working Drawings

This is one of the many useful complementary sections in our Encyclopedia which render it a vade mecum, complete in itself, for wireless experimenters and amateurs. Here are described the simple sets of instruments necessary in preparing designs and drawings of wireless apparatus and the correct methods for their use

Employed for the making of mechanical drawings, drawing instruments may be grouped under three headings. First, those which form a guide and support for the paper, as, for example, the drawing board; secondly, the various articles used for drawing the lines, including in this category those for drawing straight lines, as a ruler, and those for drawing curves, or compasses; and thirdly, the measuring instruments for determining the limits and proportions of the different parts.

A group of typical instruments is illustrated in Fig. 1, which also shows, at the left, a convenient case for containing the objects, clamped drawing board whereon to mount the paper, a T-square, set squares, ruler, scales, and several typical instruments. For amateur purposes in connexion with the design of wireless apparatus and the preparation of the necessary working drawings, it will only be necessary to have a fairly limited selection, and these might include a pair of 6-in. compasses, a pair of dividers, one or two ruling pens for drawing ink lines, a set of strong bows, and a half set of small-size compasses about 3½ in. in length. A good quality mahogany fluted T-square with ebonite edge, one 45° and one 60° set square, preferably of the celluloid type, a 12 in. boxwood ruler, some drawing pins, fixed Indian ink, and india-rubber, together with some pencils of assorted degrees of hardness, ranging from B for rough sketches to HH for the fine work, will also be needed.

The ruling pens are made in slightly different ways according to the various makers' practice. They consist essentially of an ivory, bone, or metal handle, at the end of which are arranged two oval-shaped steel blades or nibs. In the simplest forms these are made solid and can only be



INSTRUMENTS USED FOR DRAWING WIRELESS DIAGRAMS

Fig. 1. Mechanical drawings and diagrams of wireless apparatus should be made with great precision, and instruments as illustrated above are necessary for making neat and accurate drawings from which apparatus is to be constructed or wired. A set such as the above is usually contained in a case, seen on left

adjusted by means of a small set-screw. On some patterns one of the blades is fixed and the other is jointed or hinged, so that it can be folded back to allow the cleaning of the inside of the blades. In use, the two blades are adjusted until the tips nearly touch each other. The point is then charged with Indian ink by dipping a small brush into the bottle of Indian ink and transferring the ink with it to the space between the blades. Any ink that might run over to the outside of the blades must be very carefully wiped off with a piece of soft cloth, such as an old handkerchief wrapped around the first finger. The blades should be separated at intervals and the inside edges thoroughly cleaned from the dried Indian ink, or they will clog up and give thick, uneven lines.

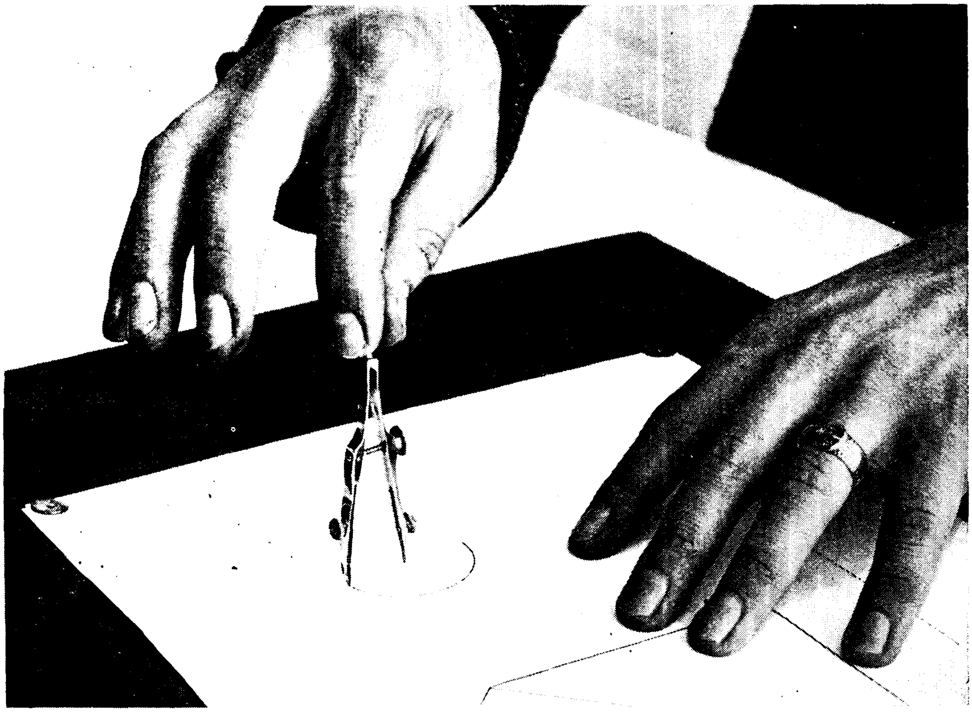
The next step is to hold the ruler firmly on the drawing paper, which should be fixed to the drawing board with drawing pins. The pen is then grasped between the thumb and first and second fingers of the right hand and held in a slightly slanting position, and drawn along with the point in contact with the paper, guiding its course with the aid of the ruler in the manner clearly illustrated in Fig. 2.

Spring bows of the pattern illustrated in Fig. 3 can be obtained made throughout in rustless steel, and these are exceedingly convenient in use, as they never tarnish or rust and are always clean to handle. Other patterns are made in electrum or nickel silver and brass. The latter are objectionable, as they are somewhat dirty in use, tending to soil the figures on the paper. However they are made, the spring bows or small compasses are used in the same way, as illustrated in Fig. 3, by adjusting the distance between the needle point or sharp-pointed end on one of the legs and the point of the pen or pencil, as the case may be, which forms a part of the other leg. Adjustment is effected by turning a milled-headed nut which presses the legs together against the springiness of the metal which tends to force them apart.

To draw a circle with them the pencil is sharpened to a fine point, or the pen charged with ink, as already described.

DRAWING A DIAGRAM WITH A DRAWING PEN

Fig. 2. Drawing pens are frequently used in the making of diagrams. The pen seen in use above is being employed with Indian ink. The pen should be held in a slightly slanting position, as illustrated, in order that the ink may run evenly



SPRING BOW COMPASSES IN USE WITH INDIAN INK

Fig. 3. Circles and curves which have to be inserted in a drawing made in ink are made by using a spring bow. The best types are made from rustless steel with needle points. The compasses are held lightly at the top, as shown in the above photograph, by the thumb and first finger

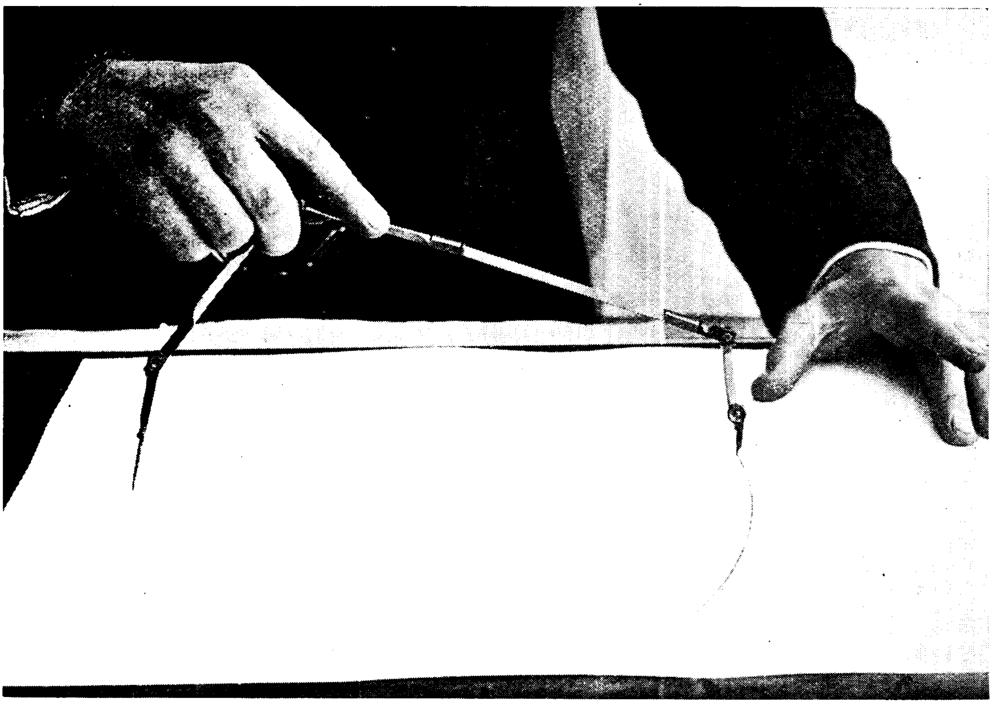
The instrument is then held perfectly upright and the needle point placed exactly on the centre from which the circle is to be scribed. This spot should be defined on the paper by two short lines at right angles to each other. The compasses are rotated between the finger and thumb of the right hand by rolling the finger across the ball of the thumb, thereby rotating the instrument. It is necessary to preserve a firm pressure on the paper and rotate the instrument in an upright position. The amateur will find, at first, considerable difficulty in keeping the compasses vertical and the pressure even. But it is only by doing so that a perfectly clean, regular line may be obtained, especially with ink.

Spring bows are always made either with a pen point—that is, for drawing lines with ink—or with a small pencil for drawing pencil lines.

A third pattern is that known as dividers, in which both legs are provided with very fine points. In all drawing instruments the needle point should be preferred, as those illustrated in Figs. 3 and 4.

When a large-diameter circle is to be drawn, say, about 18 in. or so, it is customary to use a lengthening bar, and this fits into one of the legs of the large compasses, which are made with a joint for this purpose. The joint may be secured in various ways, as with a set-screw, or may be self-locking. It is provided to enable the pencil point to be changed over to pen point or for dividers, and to take the lengthening bar as necessary. The instrument is manipulated in the same manner, but in this case the circle is scribed by means of movement of the wrist, and not by movement of the finger and thumb. The method to be adopted is clearly shown in Fig. 4, which shows 6 in. compasses with lengthening bar in use, describing an arc of a circle.

On most drawings of wireless apparatus it is customary to draw dotted lines to indicate the centre line of some part of the apparatus, and for this purpose an automatic dotting pen, such as that illustrated in Fig. 5, may be employed. This comprises a handle and framework whereon is mounted a ruling point and guide ruler and



HOW TO USE COMPASSES LENGTHENING BAR FOR LARGE CIRCLES

Fig. 4. When it is desired to draw a circle of comparatively large radius, compasses may be used as shown here. A lengthening bar is used which fits into one of the legs of the compasses, and a joint at the end of the bar enables the pencil-holder section to be kept perpendicular to the plane of the paper

an interchangeable cogged wheel. When the instrument has been adjusted it is manipulated, as shown in Fig. 5, by running it along the edge of the ruler. The cogged wheel moves a small lever which raises or lowers the point as it is traversed over the paper, and thus makes the desired interrupted dotted line. By changing the wheel various arrangements, such as long and short dashes, or a dash and a dot, can be drawn with the same instrument.

The dividers, illustrated in Fig. 6, are usually made with one fixed leg and one adjustable leg, and in some patterns have a fine adjustment screw, when it is then possible to move the points of the dividers by a very small amount, as little as $\frac{1}{1000}$ in. in good instruments. Dividers can be used for setting out centres for circles and other important parts in the drawing which have to be accurate. The dividers are the draughtsman's most accurate measuring instrument, and to set out several uniform dimensions the dividers should be adjusted to a good quality steel rule and the dimensions transferred to the drawing in the manner illustrated in Fig. 6. The points of the dividers are lightly pressed on to the paper just sufficient to make a tiny pinprick in it, and this point is subsequently indicated by drawing a cross upon it with a fine, hard pencil.

When it is desired to reproduce a drawing of a wireless set to some other size, such, for example, as enlarging a drawing reproduced in this Encyclopedia, a convenient and practical instrument is known as the proportional compasses, a good example of which is illustrated in Fig. 7. This comprises essentially two flat slotted legs, which are united by means of sliding blocks secured together by means of a screw and nut which pass through them. This nut serves to hold both parts of the compasses together, and also acts as a pivot about which the legs rotate. The edge of the slot is calibrated, and by setting the sliding block in accordance with the calibration it is possible to cause the legs of the compasses to open by different amounts.

There are in this case two working ends of the compasses and, as shown in the

Fig. 5. Dotted lines in a finished drawing are essentially required to be neatly made. Unaided, considerable skill and patience would be required of the draughtsman, but with the automatic dotting pen much time is saved and the dots are evenly spaced

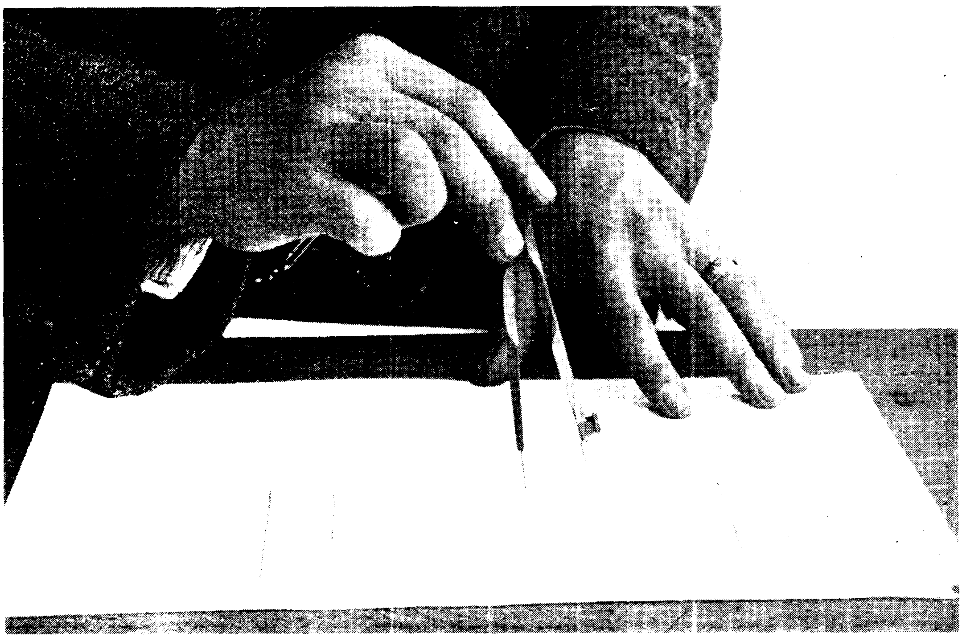
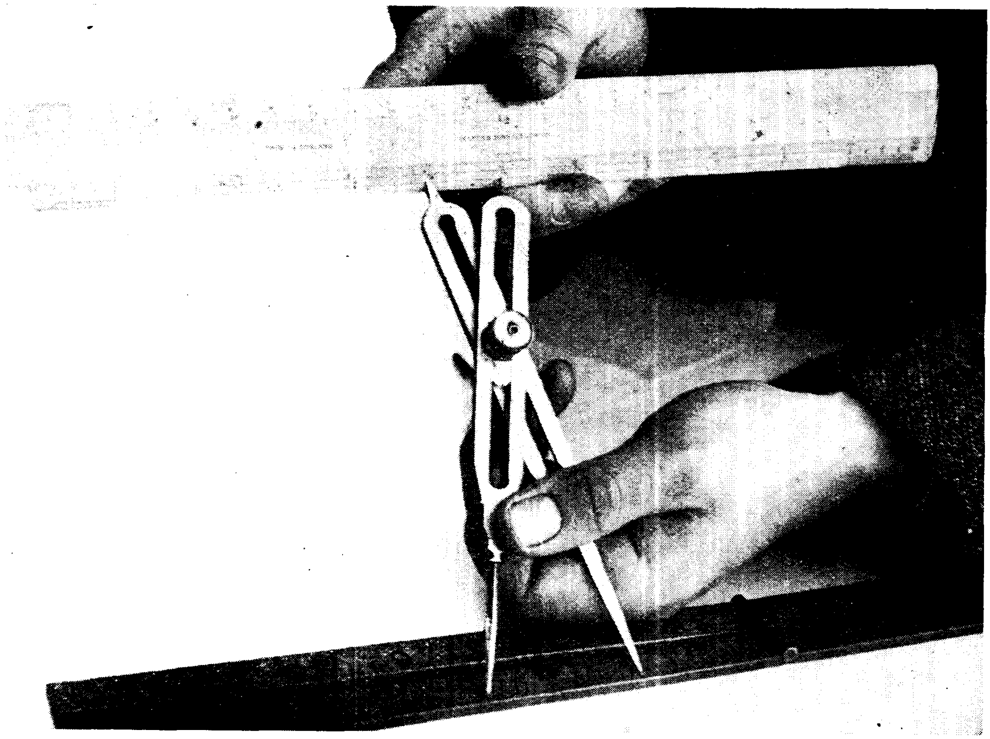


Fig. 6. Dividers make it possible to space out divisions of equal dimension with the greatest speed and accuracy. In preparing wireless diagrams this is often required, especially when components are to be included at equal distances from each other. Pairs of terminals can be plotted in a working drawing by using dividers to mark out the corresponding equal distances; another use is marking calibrations on the actual work before engraving

HOW TO USE THE DOTTING PEN AND DIVIDERS



PROPORTIONAL COMPASSES FOR ENLARGING DIAGRAMS

Fig. 7. Constructional drawings and diagrams, such as are found in other articles in this Encyclopedia, provided they are drawn to scale, can be enlarged to the actual size of the components or panel lay-out designs which they represent by using the instrument in the above photograph. The compasses are double-ended; the small ends being placed on the original, the opposite ends give proportional enlargement, or the large ends being placed on the original, the small ends give proportional reduction

illustration, an amount of 2 in. on the 2-ft. rule is shown on the scale as 1 in., the compasses in this case being set to reproduce a drawing from half the original size or to double the original size. To double the size of the drawing the short end of the legs are applied to the original and adjusted to any one of the dimensions, and the long end of the legs then applied to the paper on which the enlarged drawing is to be reproduced. Any other enlargements are produced in the same way by setting the sliding block at the appropriate position.

The care and attention that should be given to all drawing instruments includes storage of the smaller instruments in a suitable case, so that they are kept clean and free from dust and dirt. They should be cleaned with a cloth from time to time as necessary, and very occasionally the joints may receive a spot of typewriter oil, after which the outside of the instrument should be wiped perfectly clean and dry. The nibs of the ruling pen should be kept scrupulously clean, and after long use may require resetting by sharpening them or smoothing them off on a piece of fine-grade hone such as is used by barbers in setting razors.

The T-square should be hung up in a vertical position and its edges preserved from damage, as if it be bruised the indentations will be reproduced on the drawings. The set squares are most conveniently stored by hanging them on a nail. Their edges should also receive the same consideration as those of the T-square. The board, when not in use, should be kept in a baize bag, or otherwise protected from dust and dirt, and should be kept in a dry place. Drawing paper should be stored flat and away from dust and dirt.—*E. W. Hobbs.*

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CORRECTION

We regret that in Part 4 of our WIRELESS ENCYCLOPEDIA, *under the heading* Call Signs, *on page 352, the call sign 5 D T is wrongly ascribed. This station is in no way connected with the firm of Hutchinson & Co. (F. Pinkerton), of* 101 *Dartmouth Road, Forest Hill, S.E. 23. For the benefit of both transmitting and receiving amateurs it may be stated that 5 D T station is situated in Forest Hill, London, S.E. 23.*

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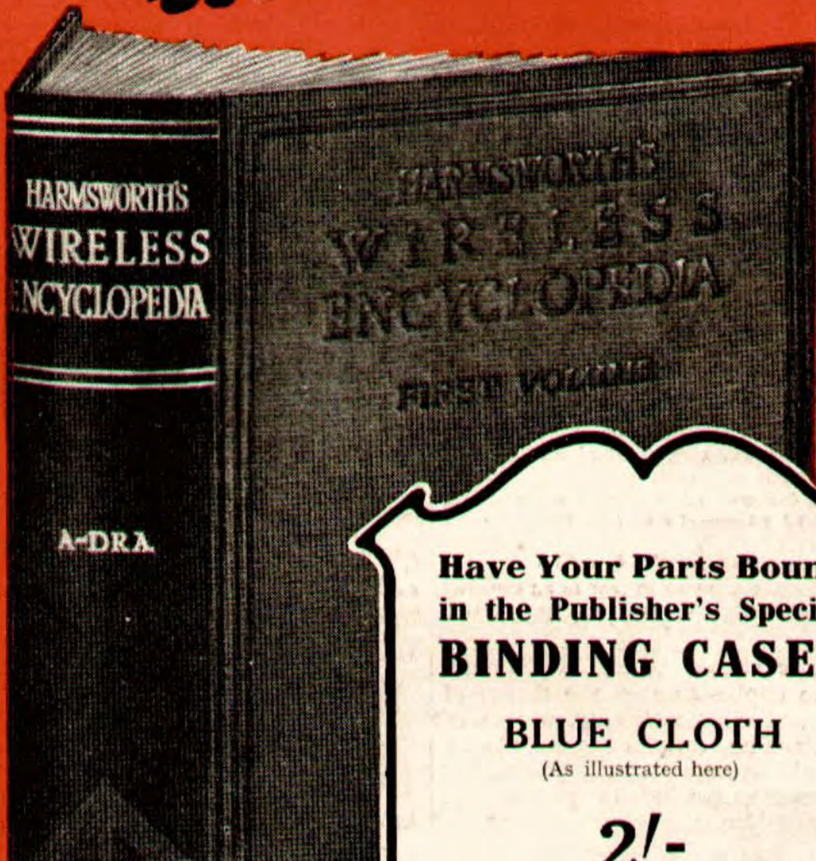

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