MODERN WIRELESS

APRIL

THE LARGEST BRITISH WIRELESS MAGAZINE

1/-

VOL. 1. No. 3. Edited by JOHN SCOTT-TAGGART, F.Inst.P., Member I.R.E. April, 1923.

No. 3

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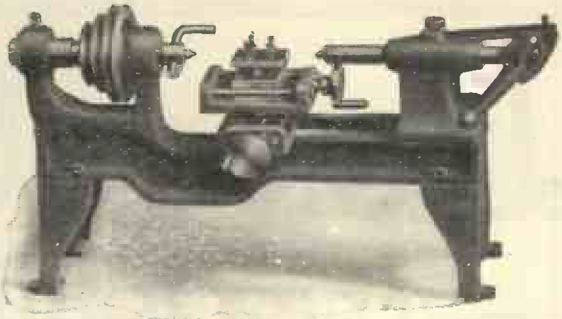

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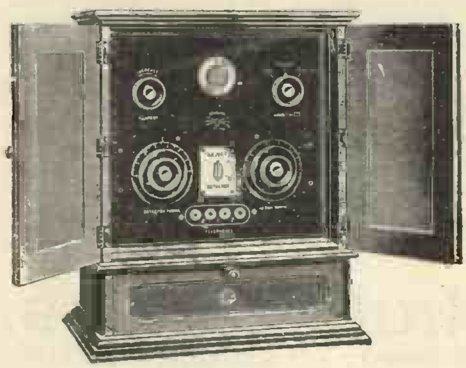

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"MODERN WIRELESS," APRIL, 1923

MODERN WIRELESS is published on or about the 26th of the month.

All correspondence relating to contributions should be addressed to Editorial Offices, Devereux Buildings, Devereux Court, Strand, W.C.2.

Contributions, illustrated whenever possible by photographs and rough pencil sketches, will be considered for publication.

PUBLISHING OFFICE: 3, Bolt Court, Fleet Street, London, E.C.4.

TELEGRAPHIC ADDRESS: "Radbooks, Estrand."

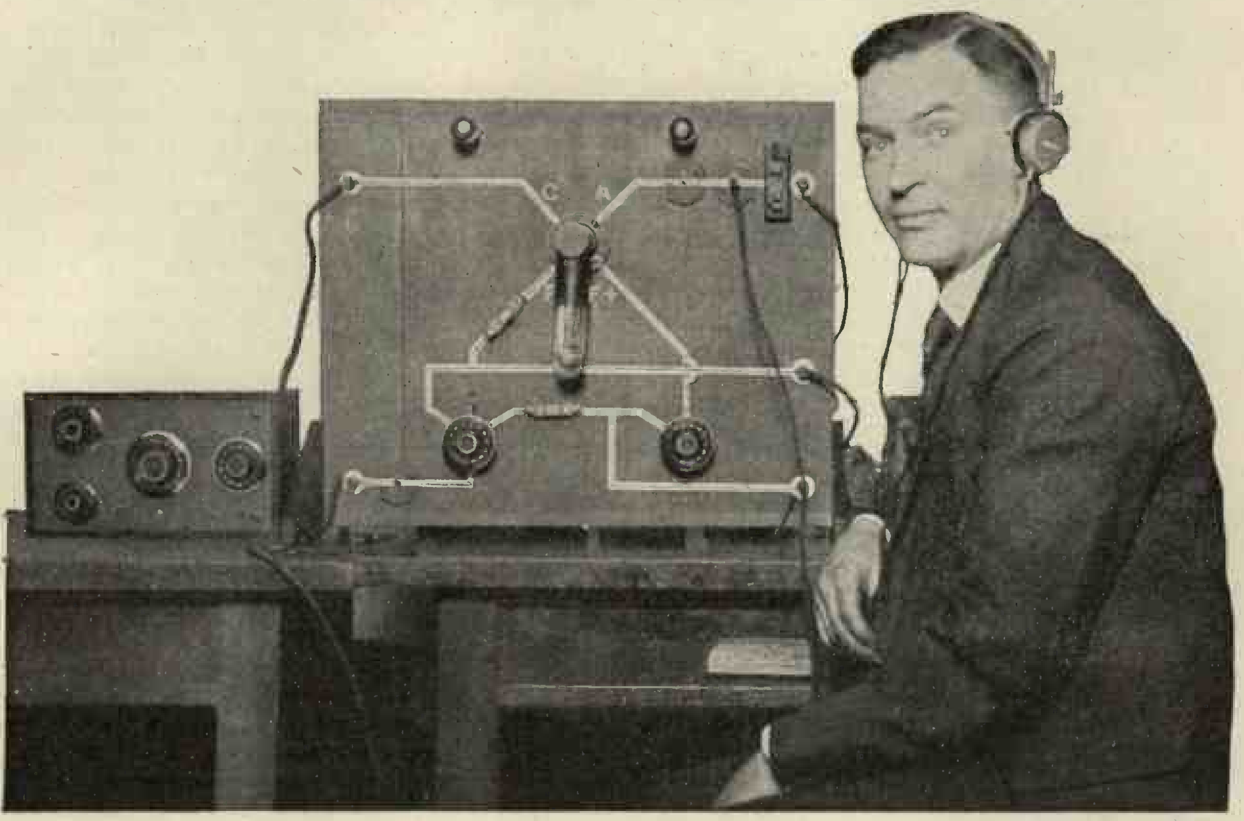
TELEPHONE NO: Central 4393.

ADVERTISEMENT OFFICES: Scheff Publicity Organisation, Ltd., 125, Pall Mall, London, S.W.1.

TELEPHONE NO.: Regent 2440.

SUBSCRIPTION RATES

15/– per annum, post free. 7/6 six months, post free. 1/3 single copy, post free.
Registered at the G.P.O. for transmission by Magazine Post to Canada and Newfoundland.



The new valve in use.

A NEW NON-INTERFERING DETECTOR VALVE

This rectifier with a liquid electrode is as sensitive as a standard valve in a reaction circuit.

MR. HAROLD P. DONLE, Chief Engineer of the Connecticut Telephone and Electric Company, U.S.A., has invented and recently made public a new type of vacuum tube which, although acting only as a rectifier, is claimed to be as sensitive as an ordinary three-electrode valve used in a reaction circuit. The new tube, which is a radical departure from the conventional triode, employs a liquid electrode of sodium which is kept warm by means of a small resistance connected in series with the filament and fixed on the glass wall of the bulb as shown in the diagram, Fig. 1.

It has been found that by using the three-element detector in the reaction circuit, sensitivity is greatly increased, but if reaction is carried more than a certain point, there is produced considerable signal distortion. Furthermore, the adjustments are very critical and such a circuit, particularly in the hands of an inexperienced operator, creates a great amount of interference for other receiving stations.

At the Institute of Radio Engineers, where the new tube was recently demonstrated, Mr. Donle said in his paper : " For several years we have conducted experiments on many different forms of detectors, and particularly upon detectors employing ionisation of metallic atoms. This was a most promising field of development, since such ionisation was found to be readily controlled and stable. As one of the results of this work we have developed the present tube, which is the logical result of experimental work which we have done along these lines. This new tube has none of the disadvantages of the regenerative and gaseous detector systems above mentioned. Its method of operation seems to involve many interesting phenomena, which are radically different from those occurring in other tubes.

"The construction of one form of this tube is illustrated diagrammatically in Fig. 1, where F is the filament, A is the anode, which may be of metallic sodium in the bottom of the tube, and H is the heater; which is a short length of resistance wire cemented to the outside of the glass directly underneath the anode. This heater maintains the anode at proper operating temperature. C is the 'collector' electrode of sheet metal bent into a 'U' and positioned above the filament with its open side toward the anode. In operation the tube may be connected to the circuit shown in Fig. 2, which is simply a two-circuit tuner with one terminal of the secondary connected to the collector electrode of the tube and the other to a contact operating on resistance connected directly across the filament battery terminals. The remainder of the circuit is as used with any simple detector."

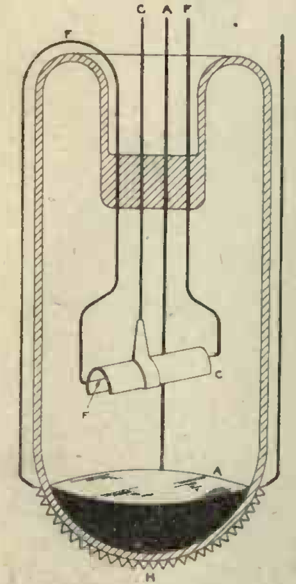


Fig. 1. Illustration of the new tube, showing internal construction. The tube itself and the resistance heating the sodium are enclosed within another glass bulb.

The adjustment of collector potential is the only one necessary for efficient operation other than the usual variation of capacity and coupling of the tuning circuit. The potential of the "B" battery is not at all critical and usually may be varied between ten and thirty volts without much effect on response.

As a detector this tube is remarkably sensitive, its adjustment is simple, and it is absolutely stable in operation. This extreme sensitivity is readily reproducible and permanent.

The response secured with this tube in a plain circuit equals in magnitude the response from a reaction circuit using maximum non-oscillating reaction. A reaction circuit under this condition of critical adjustment will give very considerable distortion, which is particularly objectionable when receiving voice or music and which can only be eliminated by a reduction of reaction and consequent reduction of signal strength.

On the other hand, the new detector creates no noticeable distortion, and, as it does not oscillate over its useful range, it cannot create any interference with other receivers. Furthermore, it is unaffected by small capacity changes, such as those produced by the operator's hand in tuning.

The response of the valve is greatly improved by very weak coupling between the circuits. This is due to its very low input impedance, which also makes the proportion of capacity and inductance of secondary circuit for maximum results quite different from those for other tubes. Although the new detector can be used successfully in an ordinary two-circuit tuner, results will fall short of the maximum unless means are available for selecting the best value of secondary inductance.

In this tube there is an electron flow from the filament to the collector, the magnitude of this current being due in part to the relatively large area of the collector and to its close proximity to the filament. It therefore receives an equivalent of large electron flow when it is at the same potential as the negative end of the filament. In order to reduce this flow an opposing potential (which may be taken from the filament battery)

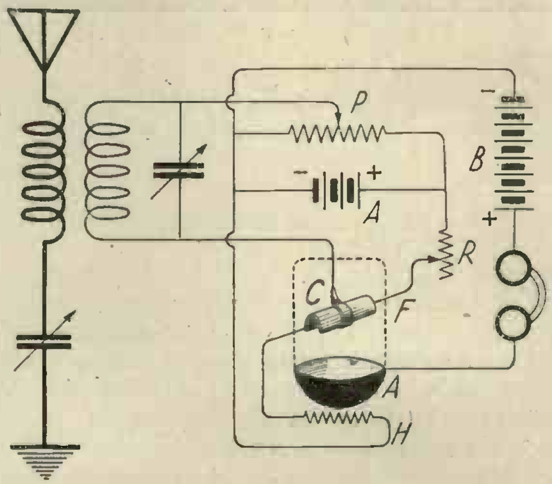


Fig. 2. Circuit of the new rectifier tube. Note the resistance in series with the filament. The current consumption is about the same as that of a standard tube.

is introduced into the circuit between collector and filament. This potential is called the neutralising potential and is used as abscissæ of curves shown in Fig. 3, which show the variation in anode and collector currents I_a and I_c with variation of neutralising potential E_n and also the collector

(*Continued on p.* 199.)

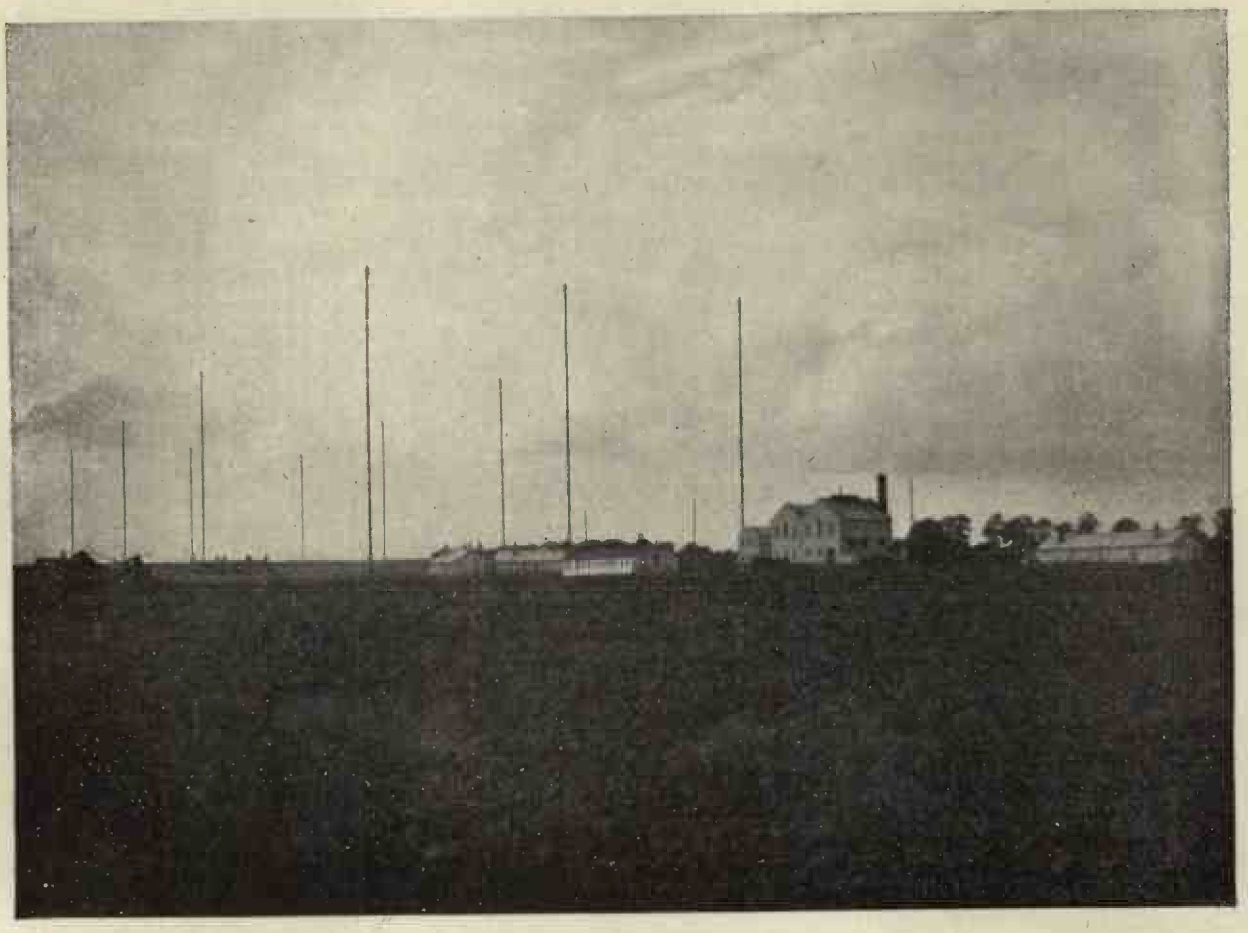


Fig. 1. "Oxford Radio," the Leafield station, call sign GBL.

WIRELESS IN THE POST OFFICE

By Lieut.-Colonel C. G. CHETWODE CRAWLEY, R.M.A., M.I.E.E., Deputy-Inspector of Wireless Telegraphy, G.P.O.

Postmaster-General the Statutory Authority

THE connection of the Post Office with wireless telegraphy dates from 1896, when Senator Marconi gave his first demonstration in this country at the request of the late Sir William Preece, who was then Engineer-in-Chief, and from that time onwards the Department has been intimately connected with all developments of wireless communication.

The Wireless Telegraphy Act of 1904 made it illegal for any person in the British Isles to install or work wireless apparatus in any place or on board any British ship except under, and in accordance with, a licence granted on behalf of the Postmaster-General, and further it stipulated that wireless could not be used in territorial waters by foreign ships otherwise than in accordance with regulations made by the Postmaster-General. The Postmaster-General thus became the Statutory Authority for wireless telegraphy and telephony in this country.

Coast Stations

In 1908 the first Post Office station for commercial work was opened at Bolt Head for communication with ships, and in the following year the other coast stations, which belonged to the Marconi Company and Lloyds, were taken over by the Department.

There are now twelve Post Office stations used for this service, *viz.*, Wick, Cullercoats, Grimsby, North Foreland, Niton, Land's End, Fishguard, Seaforth, Port Patrick, Devizes, Valentia, and Malin Head—the last two being operated, on behalf of the Post Office, by the Irish Free State Government. All of these, with the exception of Devizes, are spark stations, varying in power from 1½ to 10 kw., fitted with the 600- and 300-metre waves, and keeping watch on 600 metres, which is the wave used by ships for sending out the distress call, and, usually, also for sending traffic. The Devizes station is fitted for valve transmission for long-range working with ships which are installed with C.W. sets. Last year these stations were in communication with ships on about 150,000 occasions, resulting in a traffic of over three million words.

It will be noticed by a glance at the map that these stations are distributed round the coast so as to ensure, as far as possible, that distress signals made by ships using even very small power will not be missed. In 1921 distress calls from seventy-two ships were dealt with, and it is clearly laid down that the primary duty of these stations is to be ready at all times for this work of assisting in the safety of life at sea. All distress signals received are reported at once to all the authorities concerned, and no complaint of the action, or want of action, of a coast station in this most important matter has ever been received.

The charges for wireless telegrams to and from ships are normally at the rate of 11*d*. a word (6*d*. for the station, 4*d*. for the ship, and 1*d*. for the inland telegraph), outgoing telegrams being handed in at any telegraph office. In the case of short-distance voyages smaller charges are made. These stations also broadcast to ships, without charge, information regarding dangers to navigation, such as gales, derelicts, mines, etc. At a coast station the staff usually consists of an overseer in charge, and eight or nine operators, so that there are always two operators on duty, one on wireless watch, the other on the land line and attending to the needs of the station generally.

Fig. 2. Showing the situation of the various British Post Office wireless stations.

D.F. Stations

At the Niton Station, direction-finding apparatus is fitted experimentally, and there are D.F. stations at Berwick and Flamborough which are worked by the Admiralty on behalf of the Post Office. The naval D.F. station at Lizard also works commercially. For each bearing given by a D.F. station a charge of 5*s*. is made.

Ships' Operators

As regards the operation of ships' sets, it is laid down that only men who have obtained Certificates of Proficiency from the Post Office are allowed to carry out the duties of a wireless operator. Candidates are trained at privately-owned schools, the examination for certificates being conducted by Post Office examiners at the schools, or at the G.P.O., London. Some 12,000 candidates have obtained Certificates of Proficiency, of which about 300 were issued last year.

The Department exercises general supervision over all British ships' operators, a record being kept of the career of each individual so far as it comes under notice. Complaints against operators for breaches of signalling regulations are dealt with by the Post Office, cases concerning foreign operators being referred for action to their administrations. Last year some 1,500 cases were dealt with—about 600 British and 900 foreign.

Ship Inspection

Inspection of apparatus on board ships is also carried out by the Post Office in order to ensure that the requirements of the Merchant Shipping (Wireless Telegraphy) Act of 1919 are complied with, inspectors being stationed for this purpose at the principal ports.

Watchers

These inspectors conduct also the examinations of candidates for Certificates of Proficiency as wireless watchers. The grade of Watcher was introduced by the Merchant Shipping Act of 1919, and the only qualifications required are recognition of the distress and safety signals through interference and knowledge of how to test whether the receiving apparatus is functioning.

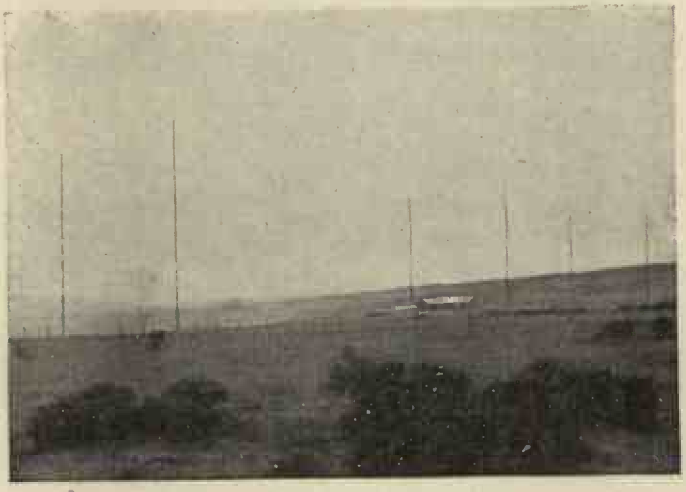


Fig. 3. "GKU," the station at Devizes.

Ships' Licences

Every ship's installation, like all other installations with the exception of those used by the Government, must be licensed by the Postmaster-General. In this country every ship of 1,600 tons gross and upwards, and every passenger-ship, must be fitted, so that the number licensed is about 3,500, the type of apparatus, call signal, waves, etc., being noted on the licence.

Aircraft Licences

Aircraft installations are also licensed and inspected by the Department, permits for operators being issued at present on the recommendation of the Air Ministry.

Point-to-Point Stations

The Post Office transmitting stations for point-to-point communications are situated at Leafield (near Oxford), Abu Zabal (near Cairo), Northolt (near London), Stonehaven (near Aberdeen), and Caister (near Great Yarmouth).

Leafield is a high-power station, fitted with 250 kw. arc transmitters, and carries out a service with a similar Post Office station at Abu Zabal in Egypt. It also transmits telegrams to distant ships, Press messages to Halifax, India, and certain ships, and broadcasts Government *communiqués*. Messages from Leafield are received by ship and shore stations, under favourable conditions, all over the globe.

In the Leafield–Abu Zabal service, the telegrams from the latter station are received at a Post Office station at Banbury, from which station also the transmitting apparatus at Leafield can be operated by distant control over land lines. Leafield can also be operated by distant control from the G.P.O. in London. At the Leafield station, therefore, there is only an engineering staff, the operation being carried out from Banbury or London by high-speed automatic apparatus, or by hand, according to circumstances. This arrangement allows of simultaneous transmission and reception, and is now in general use at all important commercial point-to-point stations.

Northolt and Stonehaven are medium-power transmitting stations, fitted with both arc and valve sets, and Caister is a low-power valve station. These stations are used for continental communications, services being conducted at present with Berlin, Rome, Amsterdam, and Buda Pest; the operation, including reception, being carried out normally at the G.P.O. The Army station at Aldershot, which works with Cologne, is also operated from the G.P.O.

For these services automatic transmission and reception is used when practicable. Creed and Wheatstone systems are normally employed, but Hughes and Siemens are also being tried. The Post Office is fortunately placed for adapting machine working to wireless, as it has available all forms of apparatus, and the accumulated experience of many years in machine working over land lines and cables.

Emergency Stations

There are five small emergency stations worked by the Post Office when required in cases of interruptions to cable communications with certain outlying islands, and provision is made for temporary portable stations being established at other places if required under similar circumstances. There are, in addition, three stations which are used for purely experimental purposes.

Amateur Wireless

As the Postmaster-General is the Statutory Authority for wireless in this country, the Department is naturally anxious to do all in its power to assist in the development of the art. Many, if not most, of the greatest discoveries in the practical application of science are due to the so-called amateur, and this indeed might be expected as the amateur worker has, *prima facie*, enthusiasm, the one indispensable attribute of the inventor. This enthusiasm of the non-professional worker is fully realised at St. Martin's-le-Grand; indeed, it could scarcely be otherwise, as enthusiasm leads to criticism—always healthy, if sometimes hasty. Criticism is the whip of progress, and in wireless, as in other matters, the Department never suffers from lack of it. The strategic, commercial, experimental, and broadcasting interests are not such as blend into one harmonious whole; they form a mixture, not a compound, and it is the duty of the Post Office to alter the prescription from time to time to suit the varying conditions.

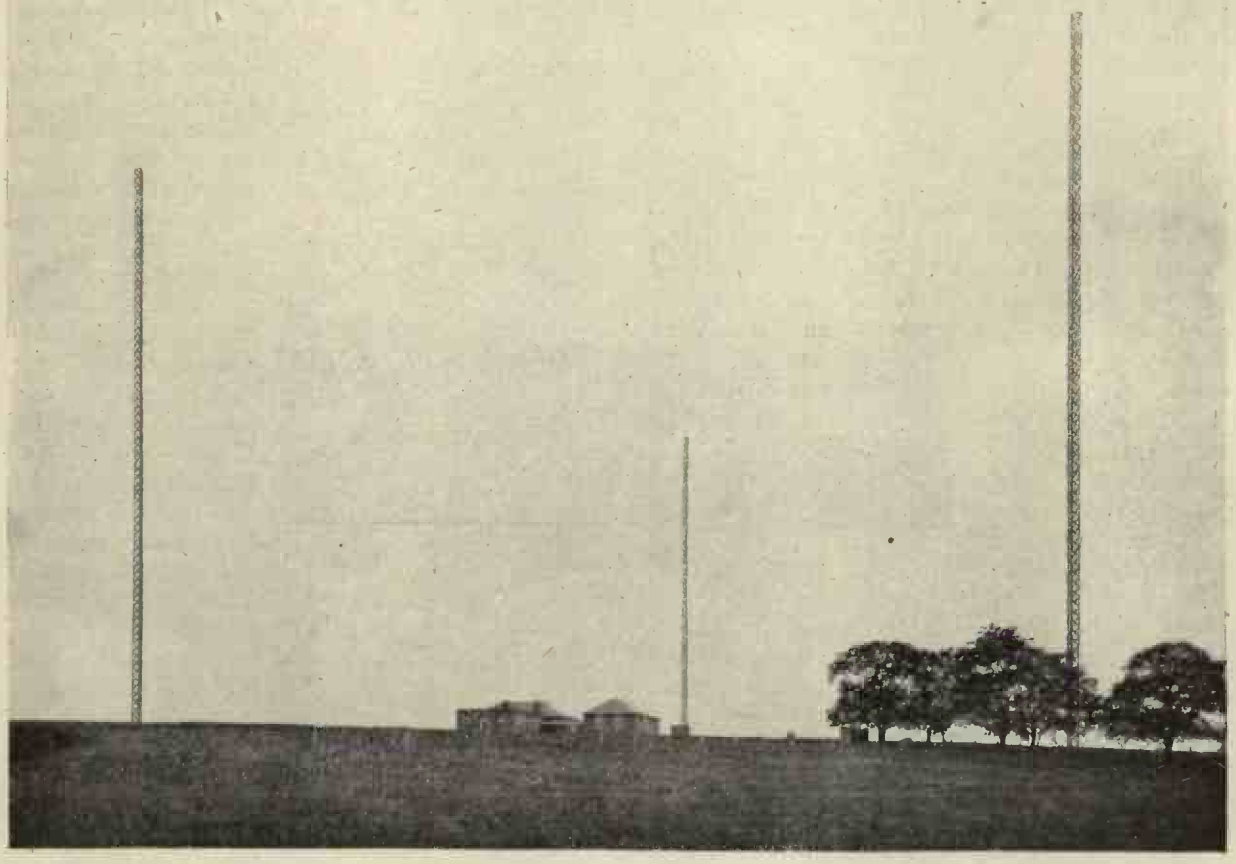


Fig. 4. The new station at Northolt, call sign GKB.

THE NEGATRON

By PAUL D. TYERS, A.M.I.R.E.

The following article relates to the negatron, a special valve which is now employed with great success on many commercial receiving stations. It is used on many liners, amongst which is the "Berengaria."

IN the February issue of MODERN WIRELESS, the writer gave a brief description of the fundamental principles underlying the operation of the dynatron, a negative resistance device which works by virtue of secondary emission. A more recently developed negative resistance device has been called the "Negatron," and is due to John Scott-Taggart.

The dynatron, it was shown, could be made to produce continuous oscillations owing to the negative resistance effect which exists under certain conditions. The expression "negative resistance" is somewhat confusing, and in order to obtain a clear conception of its meaning it is better, perhaps, to consider its effect rather than endeavour to define it. For example, when an increasing E.M.F. is applied to a circuit containing an ordinary resistance, the current increases proportionally and *vice versa*. When, however, a circuit contains a "negative resistance," the opposite effect is observed ; that is, an increase of voltage may produce a decrease of current. It can be seen from the consideration of the converse of this action that if a negative resistance effect is present it may neutralise the effect of a positive resistance. Its value in the production of continuous electrical oscillations should be apparent.

Fig. 1.

If oscillations are started in an oscillatory circuit of resonant frequency, the time during which they will persist will be dependent upon the damping of the circuit. If the damping, which is due chiefly to the ohmic resistance of the circuit, were zero, the oscillations would be maintained indefinitely. If now a negative resistance were included in the circuit, such that it balanced out the effect of the positive resistance, the oscillations would continue. The chief use of a negative resistance device for wireless purposes is in the production of oscillations, the arc, for example, being extensively used for this purpose.

The negative resistance effect is obtained in the negatron in an ingenious manner. The device illustrated in Fig. 1 consists of a filament, on either side of which is placed an anode, a control electrode being inserted between one anode and the filament. The two anodes are given a positive potential with respect to the filament, and the anode potentials and the filament emission are adjusted until a saturation effect is obtained. The total number of electrons must then be divided between the two anodes. One anode is called the main anode, and the other (next to the grid) is called the diversion anode. The grid or control electrode is connected to the main anode through a condenser

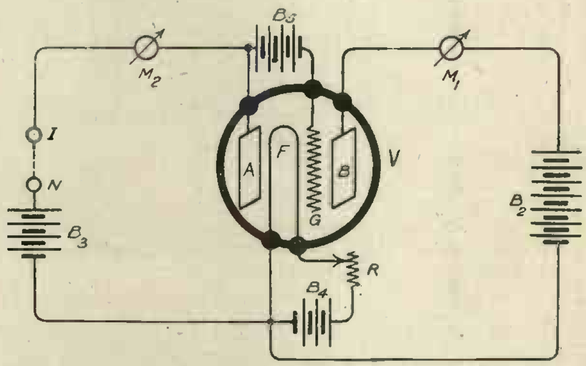


Fig. 2. *A circuit for obtaining the characteristic curve of the negatron.*

or opposing battery, so that the normal grid potential is in the neighbourhood of zero.

The operation of the negatron is briefly as follows : When the potential of the main anode is increased, the potential of the grid will be correspondingly increased ; this will cause an increase in the current to the diversion anode, and since the valve is saturated, the increase must come from the electrons flowing to the main anode Thus, increasing the main anode potential, decreases the current in that anode circuit, and hence the negative resistance effect.

The action of the negatron may be further studied by arranging the circuit shown in Fig. 2, and obtaining a characteristic curve by plotting the main anode current against the main anode voltage or change in grid voltage. Fig. 2 should be self explanatory. The divertion anode B is given a steady potential by the battery B_2, a milliameter, M_1, being included in the circuit. The main anode is given a potential by the battery B_3, which is variable, thus changing the A anode and grid potential, and another milliameter, M_2, is included in this circuit. The terminals marked I, N are, of course, short-circuited. The grid is connected to the A anode through an opposing battery, B_5, which

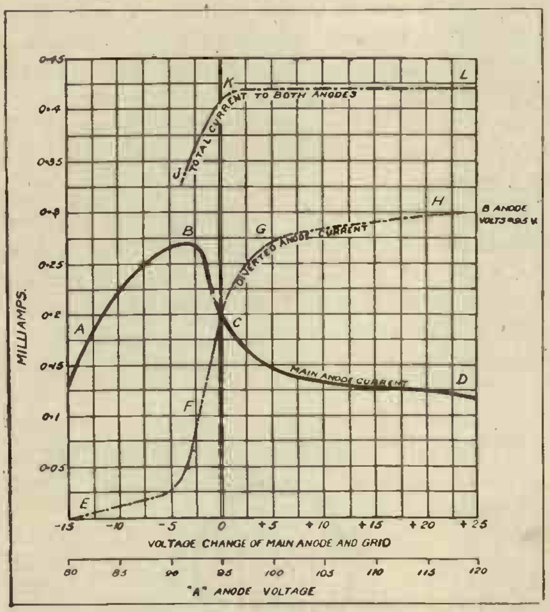


Fig. 3. Characteristic curves of the negatron, main anode and diversion anode currents being plotted against change in grid voltage.

normally gives the grid a zero or slightly negative potential. The filament is controlled by the resistance R, which is increased until the valve is saturated—that is, until all the electrons are going to the two anodes.

The total current to the two anodes is given by the sum of the two milliameter readings, and since the valve is saturated any increase in anode potentials would not normally increase the anode currents. If now B_3 is increased it will make G more positive, and cause more electrons to flow to the B anode. Since the valve is saturated the increase in current must be due to electrons leaving the main anode. Thus the increase in the diversion anode current will be indicated by the milliameter M_1, and a decrease will be indicated by the milliameter M_2. It will be obvious that the main anode current will be governed by two opposing factors. The increase of the A anode potential tends to increase the current in the A anode circuit in the normal way, and the diversion effect tends to decrease it. However, the diversion effect predominates for an obvious reason. The change in current is due to the same increase of potential on the A anode and the grid which controls the other anode circuit, and hence the effect of the potential on the grid must be greater than that on the A anode, which has no controlling action like that of a grid.

This action is borne out by the curves illustrated in Fig. 3. The top curve gives the sum of the two anode currents, and as soon as the valve is saturated it will be seen that this is constant. As the main anode and grid potentials are increased, the main anode current decreases and the diverted anode current increases. The useful part of the curve is obviously the downward slope on the main anode curve.

Some Applications of the Negatron

The main use of the negatron is in the production of continuous oscillations, and a suitable circuit is shown in Fig. 4. It is fundamentally identical with Fig. 2. The milliameters have

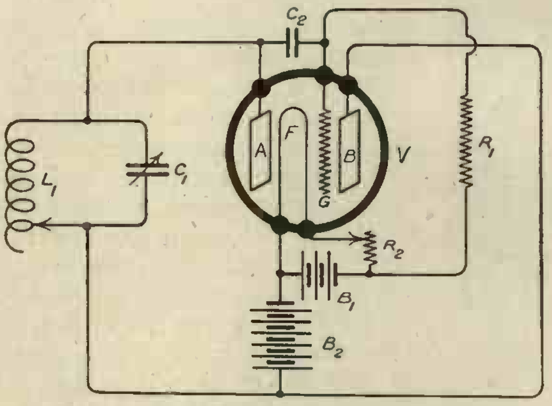


Fig. 4. The negatron employed as a generator.

been removed, the opposing battery substituted by a condenser and leak, a common anode battery supplied, and an oscillatory circuit included in the main anode circuit in the position I, N. A suitable voltage of the order of 60 volts is given to the anodes, and the filament brilliancy lowered until the valve is saturated. The negatron will oscillate over a very wide range of frequencies, which are determined by the natural frequency of the circuit L_1C_1, and hence it is extremely useful for the reception of continuous waves by the beat method. It may also be used for transmitting purposes, and a silica power tube is shown in Fig. 5. There are, of course, many other uses of the negatron, and it can be employed, for example, as an amplifier, a limiter, or a modulator for telephony circuits.

It will be obvious that the negatron will require fairly critical adjustment, and it requires careful design and manufacture, but in practice it is extremely simple to use, the chief adjustment being that of the filament brilliancy which determines the saturation of the valve by virtue of which the negative resistance effect is obtained.

Fig. 5. A silica negatron used as a generator for transmission purposes.

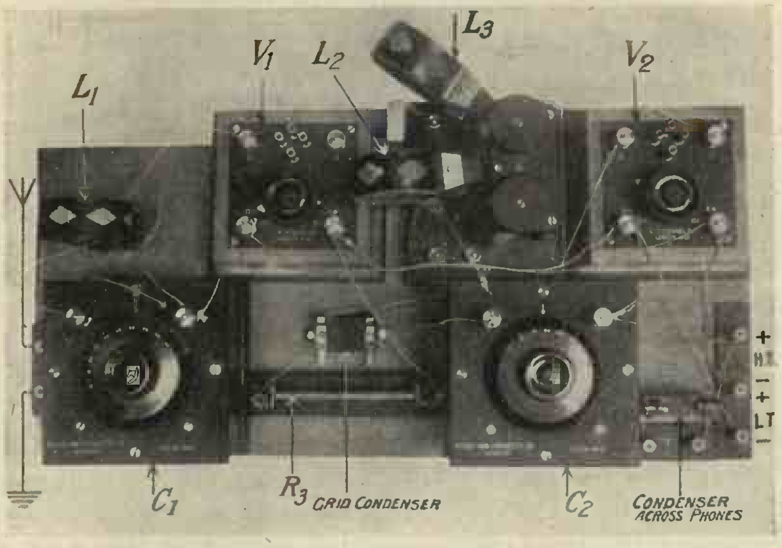


Fig. 1. Illustrating the arrangement of the two-valve receiver.

A SIMPLE TWO-VALVE GENERAL RECEIVER

The following receiver may be used for all wavelengths, but it may be particularly recommended for the reception of British broadcasting.

THE accompanying photograph shows a simple broadcast receiver made out of purchased component parts. The materials required are as follows :

2 variable condensers, preferably having a capacity of 0·001 μF., although a smaller capacity will do.

3 wave-wound coils, such as those manufactured by Messrs. Gambrell Bros.; Burndept, Ltd., or the Igranic Company, Ltd.

1 grid condenser.

1 fixed condenser having a value of about 0·002 μF.
1 6-volt accumulator, of not less than 30 ampere-hour actual capacity.
A high-tension battery which will give up to not less than 45 volts, and preferably up to 70 volts.
2 valve panels consisting merely of a valve-holder, four terminals, and a filament rheostat.
1 grid leak having a value of about 2 megohms.
2 grid-leak clips.
2 valves.
1 pair of high-resistance telephone receivers.

The price of these component parts does not amount to very much, but a very effective receiver may be built out of them, and the experimenter has the satisfaction of knowing that he can use them all for different circuits if he wishes to alter or expand his set.

The photograph shows the way the different components may be arranged on a piece of wood. They could, of course, be connected loosely on a table, but very often it is desirable to make a compact set of the kind illustrated.

The wiring of the different component parts is shown in the circuit diagram.

For the reception of broadcasting the inductance L_1 may be a No. 25 or No. 35 Igranic coil, while the coil L_2 is a No. 50 Igranic coil, and the coil L_3 is a No. 75. The advertisers in this journal who supply these plug-in coils will be pleased to inform any interested reader what values of coils should be used in the respective positions for different wavelengths. The numbers given relate to honeycomb coils, as these were the only ones at hand.

The set may be used for receiving signals of any wavelength by changing the coils.

It will be noticed that a reaction coil, L_3, is variably coupled to the coil L_2. If, on bringing L_3 close to L_2, the signal strength is not greatly increased, the leads going to the coil L_3 should be reversed. It is no good simply reversing the coil L_3, because, when using plug-in coils, a reversal of the coil also automatically involves a reversal of the leads to the coil, so that the effect obtained remains the same. Honeycomb coils will normally be in special coil-holders, and the leads to the terminals on these coil-holders should be reversed in the case of the reaction-coil terminals.

If continuous waves are to be received the coupling between the coils L_3 and L_2 should be tightened until the second valve oscillates.

When receiving telephony or spark signals, the reaction should not be made too large. The filaments of the valves should not be made too brilliant, as this tends to cause the set to oscillate.

Experiments may be carried out with the lower end of the grid circuit connected to the positive terminal of the accumulator.

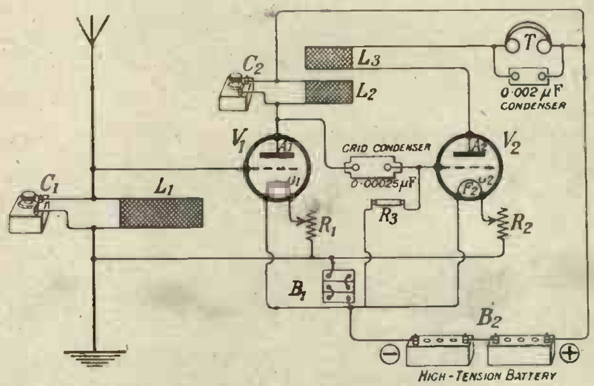


Fig. 2. Showing the wiring of the set.

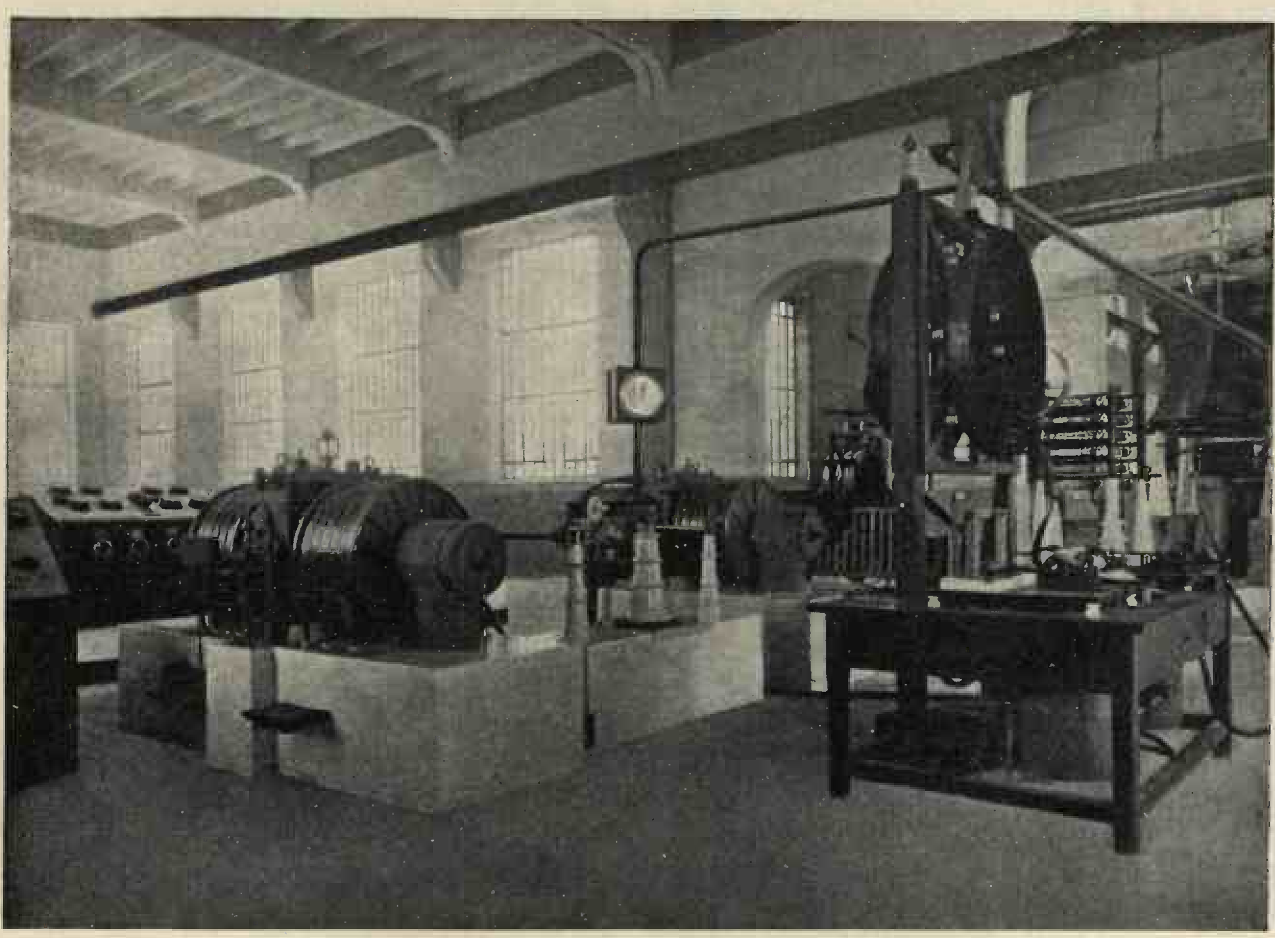


Fig. 1. Duplicate arcs installed at the Lyons station.

THE POULSEN ARC

By "*INVICTUS*"

A simple explanation of the transmitter which is most widely used for long-distance wireless transmission.

AT the present time the Arc is the most widely used type of transmitting apparatus for high-power, long-distance work. It is estimated that the Arc is now responsible for over 80 per cent. of all the energy being radiated into space for wireless purposes, leaving amateur stations out of consideration.

The Arc was the first successful transmitter of the Continuous Wave system, the overwhelming advantages of which have now rendered the Spark system obsolete. Briefly, the advantages of the Continuous Wave system are :

(1) The great sensitiveness of the receiving apparatus which can be employed.

(2) The ability of the transmitting apparatus to supply the largest high-frequency currents.

(3) The non-production of excessively high voltages even with these high-frequency currents.

(4) The extreme sharpness of "tuning" giving greater efficiency and freedom from interference by other stations.

(5) Control of the pitch of the note of the signal by the receiving operator to suit the requirements of his instruments and his ear, and to make the signal distinguishable from noises due to atmospheric strays, etc.

(6) The less absorption of continuous waves over long distances.

(7) The practicability of working at high speeds.

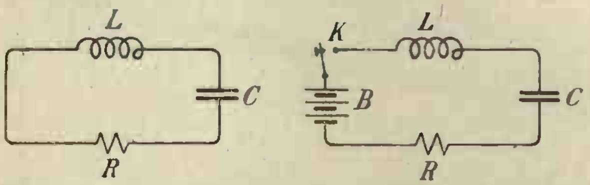
(8) The high efficiency of the plant.

A large proportion of the wireless services are now being worked by the Arc. In addition there are many others of which it is not possible to give details in the limited space of a short article. There is, for example, a new G.P.O. station at Northolt, Middlesex, whose 450-ft. masts can be seen from the Great Western Railway main line. Northolt (call sign GKB) works with Rome (call sign IDO), another Arc Station, and with a number of European countries. Leafield (GBL), near Oxford, the first station of the Imperial chain, is now equipped with Arcs and transmits a regular wireless news service to ships at sea, over distances of 5,000 miles, being read in Canada, India, South Africa, Australia, and New Zealand. Leafield's transatlantic service for news agencies is reported as being the fastest in the world. Readers will recognise on a map many of the high-power stations whose C.W. Morse they are picking up. In addition to those named, of which IDO is probably a favourite, some of the best-known stations are Eiffel Tower (FL), Lyons (YN), Cairo (SUC), and Nantes (UA) equipped by the Elwell Company, the American stations equipped by the Federal Telegraph Company, Annapolis (NSS) for example; Bordeaux (LY) in France also is using Federal Arcs, of 1,000 kw.

The development of the Poulsen Arc falls naturally into three phases, the first being the late Mr. Duddell's discovery of the "Musical Arc," from which, under certain conditions, oscillatory currents could be obtained, the next being Dr. Poulsen's modifications, by which it became possible to raise the frequency and power of these oscillations, and the third phase, following these fundamental discoveries, being the gradual development of a reliable and efficient system by accumulated experience and the application of sound engineering practice.

The Duddell Arc

To understand the working of the Arc let us consider an ordinary oscillation circuit, *i.e.*, one containing inductance and capacity, and but little resistance (Fig. 2). Let a certain D.C. voltage be applied as in Fig. 3. When the switch is closed the condenser will be charged, but the inductance will retard the growth of current, so that the charge will occupy a small but definite amount of time. When the charge produces a P.D. in the condenser nearly equal to that of the supply voltage, the charging current will tend to decrease, but the electromagnetic energy stored in the inductance will prolong the current flow, and as a result the condenser will be overcharged: its P.D. will then be greater than the supply voltage, and, after the interval during which the inductance is producing this



Figs. 2 and 3. Illustrating the application of a direct-current potential to a circuit containing inductance and capacity, but little resistance.

overcharge, will discharge back through the circuit. The inductance will behave as before, first retarding the discharge and then causing it to overshoot, recharging the condenser in the opposite sense. This cycle will be repeated, but the energy represented by succeeding oscillations will be diminished by losses and the rate of diminution will depend upon the effective resistance of the circuit. In other words, we have the well-known damped oscillatory

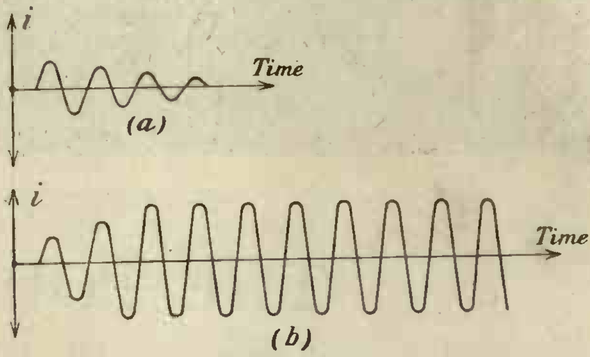


Fig. 4. The damped oscillatory discharge of a condenser.

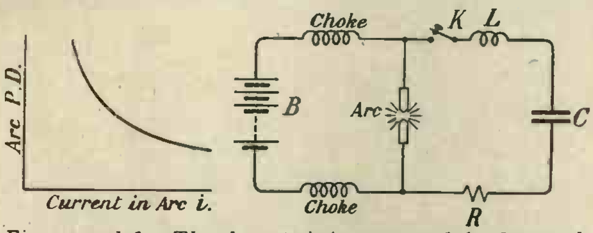
discharge of a condenser (Fig. 4), and the frequency of these oscillations is approximately

$$f = \frac{1}{2\pi\sqrt{LC}}.$$

In order to make these oscillations continuous, energy must be supplied continuously to the system to make up for that lost, and this is done by connecting the circuit across the terminals of an electric Arc which is fed from a D.C. supply through choke coils.

An electric Arc is in effect a gaseous conductor whose diameter varies so that with an increase of current the sectional area increases and the resistance falls to such an extent that the potential across the Arc is reduced. With a decrease of current the potential difference rises. This is shown graphically in Fig. 5, which represents readings observed by connecting a voltameter and an ammeter in circuit with a D.C. Arc.

Let us consider now what will happen when the oscillation circuit is connected across the



Figs. 5 and 6. The characteristic curve and fundamental circuit used with the arc.

terminals of an Arc, as in Fig. 6. Current will flow into the condenser, its growth being retarded by the inductance L as before : but, since the choke coils have a greater inductance than L, the current flowing into the condenser is mainly shunted from the Arc, there being only a small increase in the current drawn from the D.C. supply. The current in the Arc being reduced, the P.D. across the Arc will rise (Fig. 5), and this hastens the charging of the condenser. The inductance L prolongs the charge and causes the condenser to be overcharged as already explained. The condenser will then discharge through the Arc, increasing the current through the latter and therefore reducing the P.D. across the terminals. As a useful analogy to this action the escapement of a watch may be considered. The hair-spring and weighted rim represent the capacity and inductance respectively of the oscillation circuit and will oscillate in the same way as the latter if their equilibrium is disturbed. In a watch these oscillations are made continuous by steady pressure in one direction from the mainspring, which corresponds to the D.C. supply to the Arc; the Arc itself being represented by the mechanism which gives an impulse to the system once per cycle.

The natural oscillations first set up in the circuit are maintained, and their amplitude is increased until the energy lost, both in the antenna circuit and the Arc, equals that supplied. The Arc length is adjusted so that the supply current, or the antenna current, is a maximum for a given voltage. If the current is greater than required it is reduced by lowering the supply voltage.

In Duddell's " Singing Arc " the oscillations ordinarily produced were of audible frequency. In order to work on frequencies of 300,000 cycles per second, the hysteresis, or inertia from all causes, of the Arc has obviously to be very small —much smaller than that possible with an ordinary Arc between carbon electrodes. In a part of the extremely short time available for one complete cycle, the gas between the electrodes has to be de-ionized, and the difficulty of this is increased by the emission of electrons from the electrodes if they remain incandescent.

The Poulsen Arc

Dr. Poulsen's modifications of the Duddell Arc consisted of maintaining it in an atmosphere of hydrogen, between a cathode of carbon and a cold metallic anode, and in a transverse magnetic field. These all have for their object an increase in the power and frequency of the oscillations produced. The atmosphere of hydrogen cools the Arc and the electrodes on account of its very high heat conductivity and diffusion coefficient. It prevents the rapid burning away of the electrodes, and the formation upon them of oxides which, if formed, would be particularly active in the emission of electrons when incandescent.

The use of dissimilar electrodes also steepens the Arc characteristics. Heat is conducted rapidly away from the anode by making it of copper and by internal water cooling. Rotation

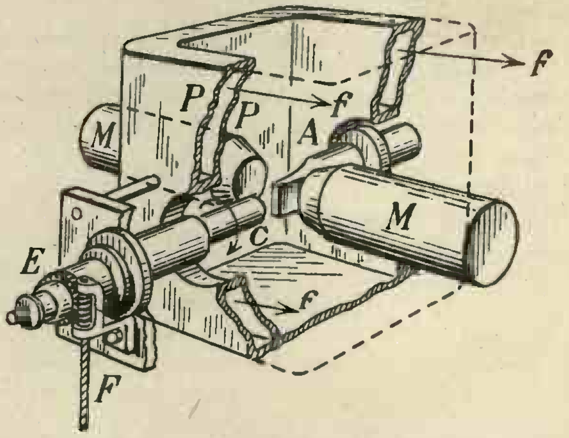


Fig. 7. A diagrammatic representation of the interior of an arc chamber.

reduces local heating of the carbon cathode. The magnetic field allows the gap between the electrodes to be quite small. Also, it blows the ions away from the electrodes with considerable velocity until the Arc is extinguished, and, if the field and other conditions are correctly adjusted, one Arc is extinguished just as another is struck between the electrodes. The essential parts of a Poulsen Arc are indicated in Fig. 7.

Arc Telephony

The invention of wireless telephony is ascribed to Dr. Poulsen, who, in producing a practical generator of continuous waves, provided the essential " carrier " by which the actual forms of speech can be communicated by wireless. Using the Arc, wireless telephony was successfully transmitted over distances of several hundred miles in 1910. It was in connection with these transmissions that the first " broadcasting " was done. At that time the problem of impressing upon the aerial current variations corresponding to speech was exceedingly difficult, and large numbers of special microphones were employed. Later on improved methods became available in the magnetic amplifier and the three-electrode valve.

When using the Arc for telephony, purity of wave is much more essential than in telegraphy. Most of the Arc stations now in use have the Arc connected, for reasons of space and economy, directly in the aerial circuit, with the result that every slight disturbance in the Arc communicates to the aerial an irregularity which would make good telephony impossible. By reverting to coupled circuits and using valve modulation, successful telephony transmission can be given.

Experimental Work with the Arc

The cost of Arc apparatus being greater than that of most laboratory equipment, there has been much less experimental work done with the Arc than with the valve. Considering that in a device so obviously suited to the production of high-frequency currents there must be scope for further improvements and invention, this is to be regretted.

Poulsen Arcs have been installed at several of the London colleges, and at East London College circuits exist for the production of any frequency from 1,000 to 100,000 periods per second.

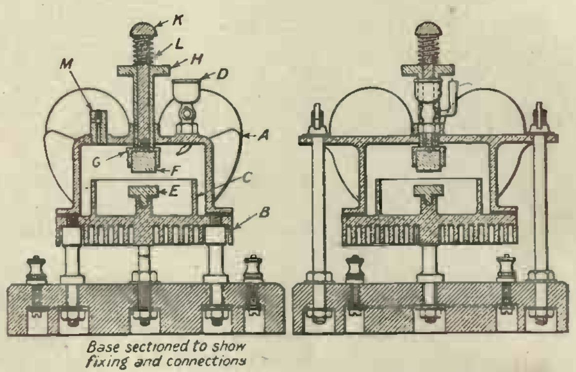


Fig. 8. A cross section through an experimental arc.

Arcs capable of handling only a few watts will operate satisfactorily on suitable circuits when constructed on the lines of Fig. 8, *i.e.*, without an impressed magnetic field. Although obviously limited in scope such Arcs are exceedingly instructive, and allow a certain amount of experimental work to be done at a small cost. The small Arc of Fig. 8 will deliver 40 watts of high-frequency energy when connected to D.C. supply mains of 100/220 volts.

A CORRECTION

WILL our readers please note that the diagram of the low-frequency amplifier in " A Transatlantic Receiving Set," by 2 WT, in No. 2 of MODERN WIRELESS (Fig. 4, p. 127), was incorrect, in that the connection from the moving contact of the Dewar switch immediately beneath the letter B to the filament resistance was omitted. This should be inserted, in order that the filament of the second valve may light up when required.

It is regretted that exigencies of space compel us to hold over until the next issue the continuations of the articles on " Directional Wireless " and " Operators and their Careers."

A HIGH-TENSION SAFETY UNIT

By L. E. PROSSER

THIS little "gadget" should appeal particularly to the experimenter whose connections frequently suffer through being hastily made, as it will make it impossible to burn out a valve through misconnecting any wires connected with the H.T. battery.

It consists essentially of a resistance of 100 ohms or more placed in series with one of the H.T. leads, so that if this be of about 50 volts not more than ½ amp. can be obtained from it; which is insufficient to harm an ordinary valve. This resistance will not impair the efficiency of the set, as all H.F. currents will pass across the blocking condenser, while the high internal ohmic resistance of the valve compared with 100 ohms renders the decrease in H.T. potential insignificant.

The resistance consists of about 7 yds. of No. 36 S.W.G. bare Eureka wire, wound for 4 in. along a wood former, 6″ by 2¾″ by ½″, as shown in Fig. 4. The spacing between the turns should be $\frac{1}{10}$ in., while the ends are secured to two small brass plates at A and B by small screws. Clearance holes for 4 B.A. screws are drilled at A, B, C, and D, going through the plates at A and B. The other side of these holes is enlarged to ½ in. diameter to a depth of ¼ in.

The blocking condenser consists of alternate sheets of waxed paper and tin-foil, as shown in Fig. 3. When finished, the condenser is stuck together by pressing with a hot iron. The base, with the two side supports as shown (Fig. 1), is made of hard wood, which, if well dried and shellacked, has good insulating properties.

A miniature tumbler switch should be screwed to this at one end and connected between the terminals C and D, with No. 22 S.W.G. insulated wire recessed into the wood. The condenser should then be fixed in position by clamping the projecting foils to terminals A and C. A nut should then be screwed on to each terminal and the resistance former placed on, after laying a piece of waxed paper over the condenser. The large diameter holes fit over the nuts, allowing the former to bed on to the condenser, and is held in place by another nut on each terminal. Contact is made between the nuts on A and B and the brass plates on the former. When finished the unit will look something like Fig. 1, and should be permanently in series with the H.T. battery.

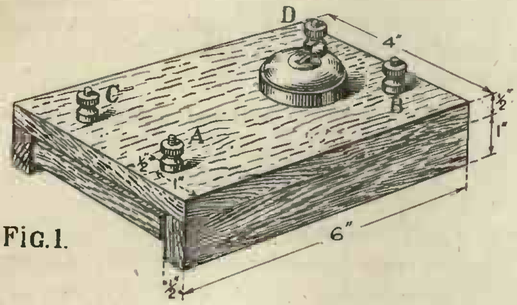
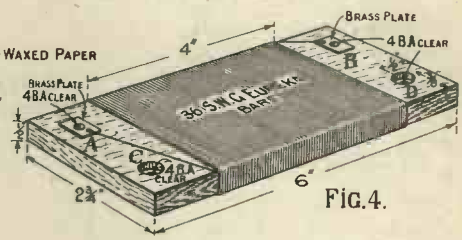
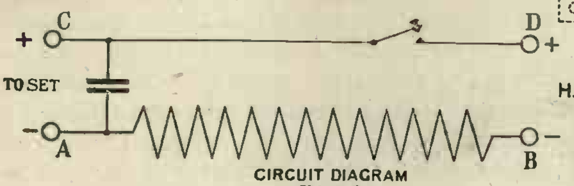


FIG.3.





CIRCUIT DIAGRAM
FIG.2.

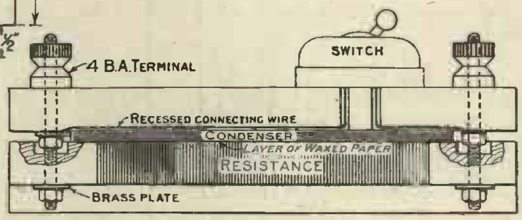


FIG. 5.

Figs. 1–5. Showing constructional details of the safety unit.

A GLASS ENCLOSED CRYSTAL DETECTOR

By C. H. LAND

THE materials used being simple, and the tools required few, the construction of this detector will appeal, I believe, to those who make their own apparatus.

The component parts are one 3-in. length of 4 B.A. screwed brass rod, one $\frac{3}{4}$-in. length

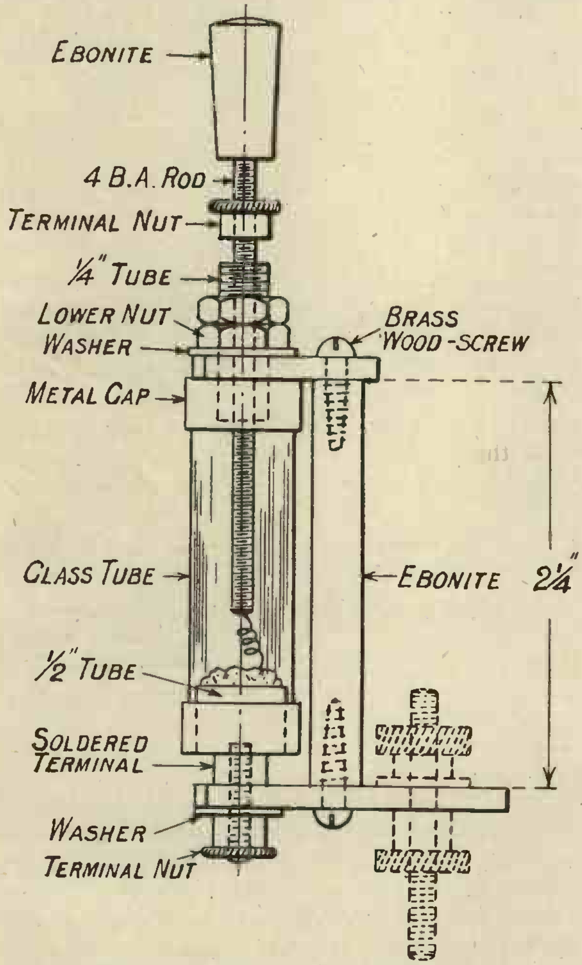


Fig. 1. General arrangement of detector.

of brass tube screwed $\frac{1}{4}$ in. outside and 4 B.A. inside, two brass nuts tapped $\frac{1}{4}$ in. for the outside of the brass tube, two 4 B.A. terminals of the screw-through type, one $\frac{3}{8}$-in. piece of $\frac{1}{2}$-in. brass tube, for crystal cup, one piece of $1\frac{3}{4}$ in. by $\frac{3}{4}$ in. by $\frac{1}{8}$ in. brass strip, and one piece 1 in. by $\frac{3}{4}$ in. by $\frac{1}{8}$ in., one $2\frac{1}{4}$-in. and one $\frac{3}{4}$-in. length of ebonite tube, one 2-in. length of glass tube, and two metal caps which will fit tightly over the ends of the glass tube.

The piece used was originally from a capsule tube, the bottom portion being nicked round the edge with a file, and broken off, the rough edge being rubbed lightly on a piece of fairly smooth sandstone to remove the roughness. The tubes are provided with nicely fitting metal caps, and as two are needed, it will be necessary to obtain two tubes, although only one will be required. Two $\frac{1}{2}$-in. round-headed brass screws and a couple of small brass washers complete the list of necessary materials.

Commence the construction by punching a hole through the centre of one of the metal caps to accommodate the bottom screw of a 4 B.A. terminal, cutting off all but about $\frac{1}{32}$ in., leaving only sufficient projecting into the interior of the cup to keep the terminal in position until secured by solder. If it is possible to secure the screw by means of riveting without damage to the cap, it is preferable, as subsequent operations are somewhat simplified. Place the $\frac{3}{8}$-in. piece of $\frac{1}{2}$-in. brass tube concentrically within the metal cap, and drop in a small piece of solder, using a non-acid flux. By gently heating the tube and cap in a clean flame the solder will melt and make a firm joint. Previous to melting the solder the terminal nut should be removed to guard against the possibility of becoming sweated to the screw. The metal cap now forms the bottom crystal cup. The cap for the top is centrally punched for the accommodation of the $\frac{3}{4}$-in. length of the $\frac{1}{4}$-in. threaded brass tube. In this case the tube may project into the interior of the cup about $\frac{1}{8}$ in. for the solder to adhere to. Any solder which may run on to the outside should be removed with a sharp knife.

Having nicely cleaned, put on a washer and the two $\frac{1}{4}$-in. brass nuts, and through the centre screw the 3-in. length of 4 B.A. threaded brass rod. If a " cat's-whisker " contact only is required, the attaching of a fine brass or copper helix may be left until the last to avoid accidental damage. Should, however, a two-crystal contact be desired, a bought cup may be screwed or soldered to the bottom end of the brass rod before screwing the shorter length of ebonite to the top. Previous to fixing the ebonite, take the top nut from the remaining terminals and screw it on to the brass rod, thus providing a binding screw to secure the contacts after final adjustment. If preferred, a cup similar to the bottom one may be made from another ⅜-in. piece of the ½-in. brass tube with a small piece of sheet brass as a cover. The main difficulty of construction in this case is to keep all accurately centred so that there shall be no

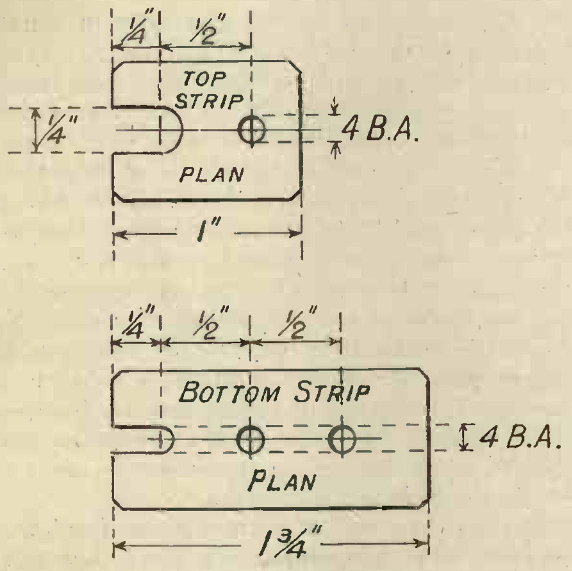


Fig. 2. Details of brass strips.

danger of breakage of the tube on rotation of the screwed rod.

The larger of the brass strips may now be drilled with three holes to allow for the free passage of a 4 B.A. screw, commencing ⅜ in. from one end and making the centre ½ in. apart. Two hacksaw cuts are taken from the end into the first hole to form a slot, thus completing the bottom plate (Fig. 2).

The small strip is drilled with two holes in a similar manner to the larger one, but allowing a ¼-in. clearance for the first hole, which, when cut into, forms a slot for the reception of the ¼-in. screwed portion of the top cup. Between the two brass strips screw the longer ebonite tube by means of the round-headed screws. If the screws are tight they should not be forced into the ebonite, but should be slightly heated, not being finally forced home until they are cold, as otherwise there is a danger of stripping the threads from the ebonite.

Having secured the bottom crystal in its cup and the top "cat's-whisker" contact or crystal, the caps are placed over the ends of the glass tube, and, sliding the whole into position between the brass strips, slip a small brass washer over the projecting terminal screw at the bottom and secure with the terminal nut. The upper cap is fixed to the strip by the lower ¼-in. nut, the upper nut securing the lead wire when connecting up.

In order to dispense with a separate base-plate the whole detector is fixed to a terminal placed in any desired position on the receiving apparatus, for which purpose the remaining hole in the bottom strip is provided. Although exact measurements are given, there is no need to adhere to them strictly, and they could be modified by the sizes of the materials on hand.

INTERVALVE TRANSFORMERS

By A. H. CURTIS, M.I.E.E.

(Continued from page 96.)

Secondary Winding

The secondary winding has now to be introduced into the design without producing any unbalancing or distorting effects on the primary winding, or iron circuit. It has a larger number of turns than the primary winding, as it is required to step up the voltage of the oscillatory current, and the necessity, therefore, arises of dealing with a winding which has an inductance many times greater than the primary winding, and whose capacity is comparatively large also, owing to the mean diameter of the layers being so much greater. The natural outcome of this is that the natural wavelength is large, and the frequency low, as near as possible within the range of audible frequencies. Unlike the primary winding, the secondary winding must have its capacity reduced to a minimum to bring the natural frequency of the coil outside the range of audible frequency, as no reduction in inductance can be made. Such an oscillatory circuit, when impressed with an oscillatory current of varying wavelength, such as obtains with audible frequencies for telephone reception, will set up an entirely separate current of definite frequency. If the resonant frequency of the current is near that of the impressed current, considerable current will be produced, strongly affecting the apparent resistance of the winding and the resonant frequency of the impressed current. It is, therefore, highly important that the natural frequency of the secondary winding shall be outside the range of audible frequencies.

The capacity of such a winding may be decreased by increasing the number of layers of wire in the coil by sectionalising the winding, or by increasing the distance between the layers, or by using an insulating medium between the layers having a low self-inductive capacity.

The electro-mechanical design of such windings needs careful study if the production of a silent transformer is the object in view. They consist of numerous turns of wire, each having a high-frequency oscillating field, working in an iron circuit, and also having a strong oscillating field, the field of the secondary winding being 90° out of phase with the field of the primary winding and iron circuit. The result under consideration is the mechanical attraction and repulsion of these two fields operating 90° out of phase with one another, at high frequency, producing a high-frequency mechanical vibration, on the turns of the coil, and this, when taking place in a strong field, must induce in the wires high-frequency oscillatory currents in phase with the primary current producing the vibrations, but 90° out of phase with the secondary current.

Such high-frequency oscillatory currents will, however small, tend to produce ripples in the current curve, distorting the transformed signal according to the strength of the vibration. From a mechanical point of view it is essential that the wires in the windings should be held firmly in spaced relation to each other by some non-resonating material, both between layers and turns, or series of turns. The two windings must also be firmly held in spaced relation with one another by a similar non-resonating material.

For a concrete example of design, the choice of the transformer recently developed by the Igranic Electric Co. will be considered. This is a shell type transformer, the iron stampings of which are formed of Stalloy iron. The iron circuit is made in two pieces, one the shape of a letter E and the other a plain yoke. The pieces are assembled together so that the yoke overlaps the ends of the legs on the shaped member, but care is taken to insulate carefully each portion from the other. No rivets are used, but the stampings are held together by two pairs of clamps, also carefully insulated from the stampings, and so arranged that they do not cross the line of any stray fields, which would set up eddy currents in them. They also act as the legs for mounting the complete transformer, forming a high insulation terminal base of low self-capacity.

The primary to secondary ratio is 1 to 5, as this has proved to be the best ratio of transformation for this purpose. The coils are wound on a low self-capacity, high insulation foundation tube by the well-known cotton interweave method, using an enamelled copper wire for the conductor. The great feature of this method of winding is that full control is obtained over the lay of each turn of wire, enabling the coil to be wound entirely free from short-circuited turns, and also over the spacing between the various layers of wire. In the latter case, the control is obtained by varying the thickness of cotton yarn woven into the coil, so that it is possible to calculate the best spacing between the layers to obtain the least self-capacity and then to put in the correct thickness of cotton to obtain the desired spacing.

Further, the use of cotton as an insulating medium is an advantage, as it has a low self-inductive capacity, which further decreases the actual capacity of the winding. Incidentally, the building of the coils by this interweaving method binds all the wires tightly together, but they are cushioned, both between layers and between turns, by soft non-resonating material, which in turn is bound to the cotton end cheeks of the coil. Such a structure prevents vibration of the wires in the coils, or between the two windings.

To secure the winding against the incursion of moisture, the outer surface of the coil is given a covering of cotton yarn, which is sealed with paraffin wax, care being taken to ensure that this wax does not penetrate right into the coil to set up a high capacity between the layers of wire.

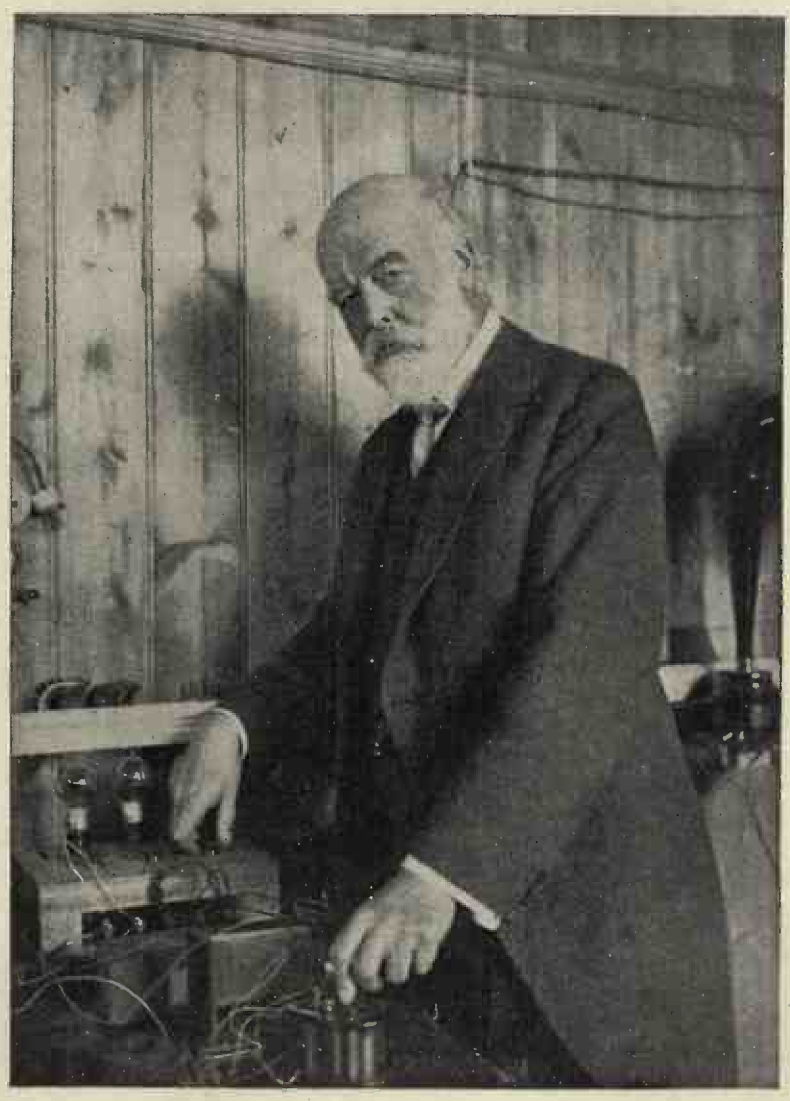
Finally, the coil is surrounded with sheets of mica and tin-foil to form the condenser, which is connected across the primary winding, and also to act as an earth shield to the coils. This fully patented scheme is used as a means for preventing howling in such transformers on the principle previously described.

From the foregoing it will at once be seen that the design of a satisfactory intervalve transformer calls for a great amount of attention to detail, both when making calculations and when producing the actual transformer.

FURTHER PECULIARITIES OF WAVE TRANSMISSION

By Sir OLIVER LODGE, D.Sc., F.R.S.

WAVES are transmitted by a combination of momentum and elastic recoil; and, in order to convey them, the medium must have the two corresponding properties—namely, something corresponding to inertia or massiveness, and something corresponding to elasticity. There is a displacement from the mean position, with a tendency to spring back, this displacement being either material or electric, according to circumstances; and there is a rushing past the mean position with a momentum which overshoots the mark, and carries the particles into a region of recoil, propelling them against the electric force, which in due course drives them back again. It is the elastic force which generates the momentum, and it is the momentum which piles-up an opposite elastic force. It is by the interaction of these two properties that oscillations are maintained, and it is by possession of these two properties that the medium is able to pick up the oscillations and transmit waves.



[E. O. Hoppe

A new portrait of Sir Oliver Lodge in his laboratory at Salisbury.

In the case of mechanical waves the momentum is straightforward mechanical momentum, due to the inertia of matter; in electric waves the momentum is magnetic momentum, and is due to the inertia of ether, just as the elastic recoil is due to the electrical rigidity or elasticity of ether—the term "rigidity" being a technical or quantitative one, not at all implying infinite rigidity.

The reaction of the two properties is easy enough to follow in the oscillator, or source of the waves, where the two are in different phases. It is rather less easy to follow in the wave itself, where they are both in the same phase. But it may help if we consider the simplest case—namely, that of sound. As the wave advances the particles are simultaneously thrown forward and nearer together, so as to make a condensation. If at the maximum condensation they came to rest, they would rebound, and the wave would go backwards. That is exactly what happens when sound encounters a wall or other obstacle and is reflected, giving rise to what are called " stationary waves," with nodes and loops in definite places. But in a progressive wave the particles are thrown forward into the condensation, and the condensation moves on by reason of the momentum of the particles, and so continually advances into new regions, spreading the disturbance at a steady advancing pace. The particles ultimately come to rest, and go back again; but when they do that the rarefaction is beginning. And so this rarefaction, or pull on the medium, travels forward likewise; though it requires a little more effort to follow the details of the advancing rarefaction, as compared with the more easily grasped details of an advancing condensation, since in a rarefaction the particles of the medium are moving in a direction opposite to that of the advancing wave —which at first seems a little confusing.

To follow out the details in the electromagnetic case is less easy, because we are less familiar with the intimate nature of electricity and magnetism. We know that magnetism is the result of an electric current (or rather that the two are different names for the same thing), and that it simulates mechanical inertia and momentum. We also know that electric displacement is another name for electric charge, and that it simulates an elastic spring-back, which is demonstrated by an electric discharge. The term " charge " is only applied to a conductor. The more general term is electric displacement, because that applies to an insulator too. But, as the process is not a mechanical one, the only way we can safely and completely follow it is by the use of the vitally important equations of Clerk-Maxwell, which contain the whole theory imbedded in their intricate and illuminated recesses.

Diffusion Waves

But now to understand the phenomenon of wave transmission more thoroughly, we ought to ask whether there is any kind of wave which does not obey those laws—which has not both momentum and elastic recoil, which does not require those properties in the medium, and which does not advance at a definite pace.

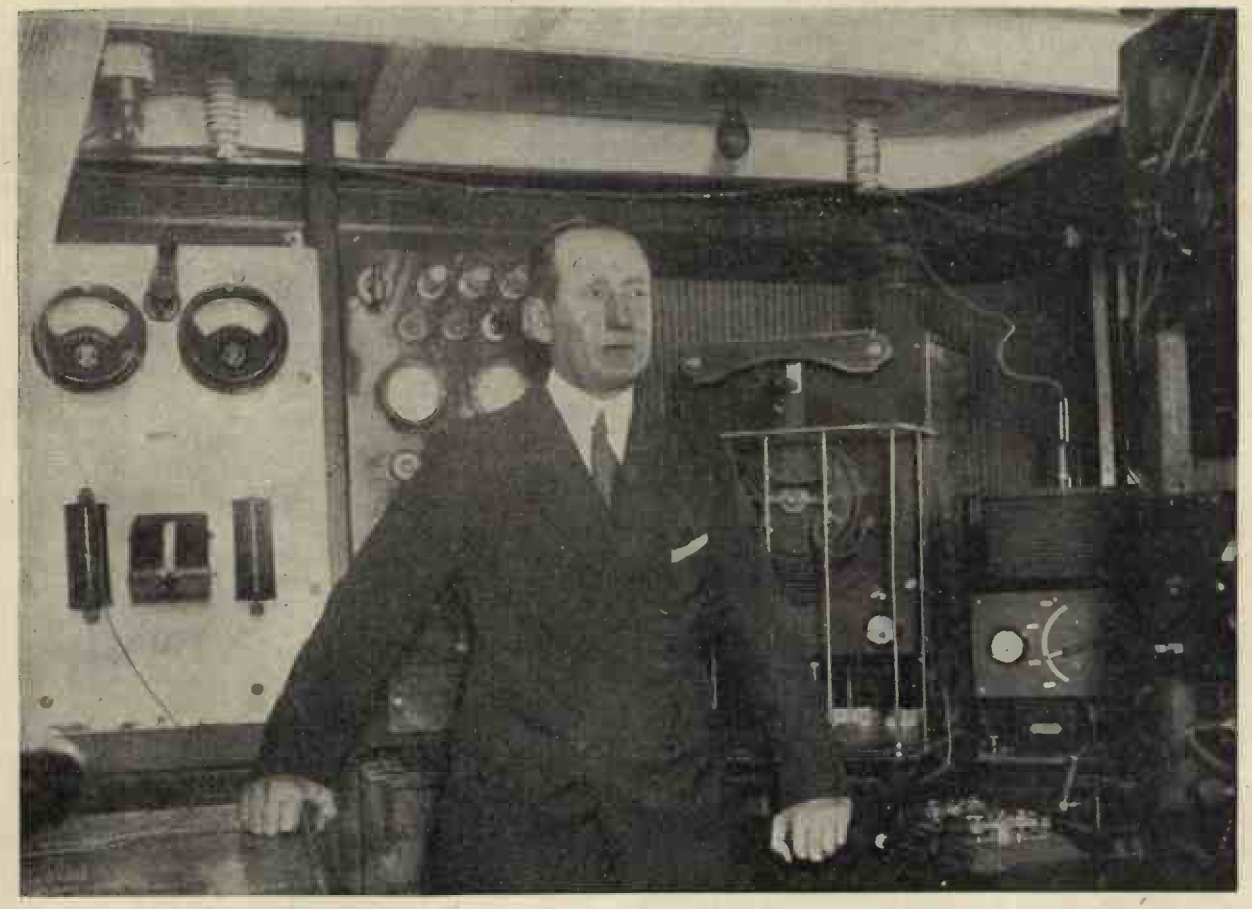
The answer is that there are such waves—if they can be called waves—waves of diffusion, transmitted from an alternating source. It may be a source of alternating temperature, for instance, like the summer and winter temperatures applied to the crust of the earth. The result is that periodic waves of temperature sink into the crust, and succeed one another at regular intervals; so that by penetrating a sufficient depth you will find a trace of last summer's heat, and by penetrating deeper you will find a trace of the preceding winter's cold, and so on; though it is true that these traces tend to smooth themselves out rapidly, and become before long difficult to recognise. But if we ask at what rate these waves travel we can give no answer, at least no clear and simple answer, as we can in the case of true waves with momentum. For the peculiarity of these heat waves is that they have no momentum. They travel according to a different law; and the time taken for any given portion of heat to reach a certain depth will depend upon how sensitive the detecting instrument can be.

We may illustrate the matter by taking a long rod of metal, packed in cotton wool or some insulating material to prevent loss of heat from the surface, and then put a thermometer at one end (which might be a sensitive thermopile), and to the other end apply heat and cold alternately; for instance, first a flame and then a douche of liquid air. The thermometer at the far end will exhibit alternations of temperature. There will be a lag, perhaps a very considerable lag, before it feels the first heat wave. The cold wave may be well on its way, and another heat wave too, before it responds: but in due time it will go up and down in response to the succession of impulses imparted to the other end. But if we ask how soon it will feel those impulses, after they started, we must realise that it is merely a question of how sensitive it is. If it will only respond to a Fahrenheit degree or two, it will be very sluggish; but if it could feel the millionth of a degree, it will be fairly quick.

This is the actual problem which had to be solved in connection with the first Atlantic cable; and Lord Kelvin solved it completely. He perceived that the electric capacity of the cable would make the laws of electric propagation correspond exactly with the laws of the flow of heat—which had been worked out by Fourier. So he gave the theory of the cable, treating it as a long conductor to one end of which positive and negative electrification was alternately supplied, a detecting instrument being at the other end. And he realised that if signalling was to be at all rapid, this detecting instrument must be of surpassing sensitiveness. He knew that there was no true velocity of propagation in a cable possessing only resistance and capacity; he knew that the waves were waves of diffusion, having no definite speed, and that the rapidity of their detection must depend on the sensitiveness of the receiving instrument. Hence his mirror galvanometer; and then his syphon recorder. He knew, further, that violent applications of electricity to a cable were unnecessary and troublesome, as well as dangerous; that they put into the conductor disturbances which would have to leak out; and that, within limits, the feebler the signals were, the better. Sharp momentary curbed signals ought to be sent; and though at the far end they arrive washed out by diffusion, yet a sufficiently sensitive instrument can detect them without more than a fraction of a second's delay, and with a reasonable amount of sharpness.

But this theory after all was not complete, was not *quite* complete. It left out of account self-induction; that is to say, it treated the electric waves as if they were really like heat waves, without momentum. As a matter of fact the heat-wave theory is only an approximation, or an analogy. Electric waves must have momentum, since every electric current has a magnetic field round it. The magnetic-inertia effect was omitted in Kelvin's theory. If thought of at all, it was thought to be insignificant, wiped out as it were by the capacity and the resistance, just as sound waves trying to pass through a haystack would have their momentum wiped out by friction, and would be stopped. Or, a better analogy, as light waves are stopped when they encounter a conducting material. The propagation of heat waves through a good conductor, the propagation of light waves through a bad conductor, and the propagation of electric oscillations through a long submarine cable, all follow the same law — the law of diffusion—the law according to which a coloured solution like sulphate of copper is conveyed along a tube of water; or a law on which a particle of salt dropped into a bucket of water is ultimately found to permeate every part, even if the water is not stirred but continues stagnant.

But whereas in the chemical case and the heat



Senator Marconi, whose early work upon the propagation and practical use of wireless waves, makes his name inseparable from a study of these matters. A photograph recently taken in the wireless cabin of his yacht.

case the absence of momentum is complete, in the electromagnetic cases it is only approximate. And when electromagnetic momentum is taken into account, the law is somewhat modified; an element of true wave makes its appearance, and there is a true velocity of propagation, though it may be only for an insignificant part of the wave. The head of the wave, however, does advance with the velocity of light, though it may be a head so small as to be undetectable.

But it may be strengthened, and the way to strengthen it is to increase the magnetic momentum, that is to say, to increase the self-induction, as might be done by coiling the wire upon itself. In that way the diffusion effect can be minimised and the wave effect strengthened, with immense gain in rapidity and clearness of signalling. The complete theory of the cable exhibits all this, and enables quantitative calculations to be made. And that complete theory the world owes to Mr. Oliver Heaviside, whose brilliant investigations were not recognised at the time by those in high telegraphic authority. He seemed to be merely complicating matters, and not introducing anything practical. So no practical improvements resulted, until ultimately Lord Kelvin himself perceived the merit of Heaviside's extended theory; and Silvanus Thompson in England, and Dr. Pupin in America, advocated the introduction of special self-inductance coils into a cable, especially one that was to be used for telephonic purposes.

Undoubtedly the construction of such electrically improved cables was a real difficulty, and the men who had to lay them naturally shied at additional complications to a problem which in its early form was difficult enough. Moreover the Kelvin instruments had enabled so much speed and certainty to be obtained in ordinary Morse signalling through a cable that there was no great stimulus to a revolutionary improvement.

But when it came to telephony the case was different. Telephonic speech was impossible if all the consonants and vowels were diffused and run together in a vague indistinguishable mass, with no genuine velocity of propagation; so that, as it were, the stronger waves arrived first, and the feebler ones never arrived at all, and the peculiarities and harmonics of a tone on which speech depends were blotted out in transit. Speech through a submarine cable a hundred miles long is impossible unless extra self-induction is introduced. Even forty miles long is difficult, and the difficulty increases with the square of the length. But if sufficient self-induction is introduced, so as once more to gain magnetic momentum, true wave propagation is restored; the signals travel with a definite speed, independent of intensity and of pitch, and arrive with their features fairly intact, weakened no doubt, but not disfigured. The deleterious effect of capacity combined with resistance remains, and there is some diffusion as well. Speech through a cable is never so easy as through a land line, or through the unconfined ether of space. But it becomes possible; and in the light of Heaviside's theory the possibility is clearly intelligible.

MULTI-LAYER COILS

By G. P. KENDALL, B.Sc., Associate Editor, MODERN WIRELESS.

An account of the theory and practice of all the most useful types of concentrated inductances.

IN beginning the consideration of the various types of multi-layer coil, I wish particularly to impress upon my readers the fact that each type is of necessity a compromise between two opposing factors. The efficiency or otherwise of any particular type depends very largely upon a satisfactory balance having been achieved between those factors, and if the amateur will realise clearly what the balance should be he will, I think, waste no more of his hard-earned cash upon inefficient coils in which it scarcely exists. (It should, perhaps, be explained at this point that the object of this series of articles is, first, to provide instructions for the winding of various types of coil, and, second, to give sufficient insight into their principles to enable a wise choice to be made if coils are purchased.)

Let us consider, then, what are the two opposing factors between which a satisfactory compromise must be achieved to produce a good multi-layer coil. They are, briefly, efficiency and compactness, and they are opposed in this sense: the whole object of the multi-layer coil is to obtain compactness—that is, we wish to coil up a large quantity of wire in a small space—yet we know that the efficiency of a tuning inductance depends, among other things, upon keeping its internal capacity as low as possible, which can only be achieved by keeping well separated from each other all turns between which there is much difference of potential. Thus, turn No. 20 must not lie side by side with turn No. 1, though turn 5 and turn 1 may do so without much harm resulting. The worst possible arrangement would be to wind a layer of, say, 100 turns upon a tube, then over this another layer, and so on until the required number of turns had been wound on. A moment's thought will show why this arrangement of turns is bad, and will enable the reader to appreciate the statement that the best possible system of winding, judged from the internal capacity point of view, is the simple single-layer type, in which there is very little difference of potential between adjacent turns. From the foregoing it will be grasped that the difference of potential between any two turns depends upon the number of turns separating them electrically in the winding. Thus, there will be a comparatively small difference of potential between, say, the first and third turns, and a comparatively large one between the first and fiftieth.

It follows, then, that a good system of multi-layer winding is one in which turns with a considerable difference of potential between them are kept well apart in the coil, and in which all turns are spaced out from their neighbours as much as is possible without making the coil too bulky. There are many such systems, and I propose in later contributions to explain some of the best of them.

The essential point to grasp is that there must be *spacing* between the turns: no coil which appears to be a solid mass of wire, with considerable depth and breadth, can possibly be really efficient, no matter how it is wound. Since in most systems of multi-layer winding the spacing is produced by some arrangement of crossing turns the actual amount of spacing-out depends in part on the thickness of wire used, and this should be noted when examining a coil. Also, when winding your own, use as thick a gauge as reasonable limits of the size of the coil will allow. This is important, not merely because it reduces the internal capacity of the coil, but because it helps to keep down its resistance, and hence the damping of any circuit in which it is connected. This matter of the gauge of wire to use is one to which the amateur would do well to pay greater heed, for much efficiency may be lost by the use of unduly fine wire.

In this connection it may be well to give some definite guidance, and I append a table giving the required information:

Wavelength.	Size of Wire.
300–1,000 metres	No. 22
1,000–5,000 ,,	No. 24 or 26
5,000–20,000 ,,	No. 30

It will be noted that for the longer waves a fairly fine wire is indicated, while a thick one is recommended for short waves. This is simply because long wave coils must contain a large number of turns, and would be of very large size if they were not wound with fine wire, whereas in the short wave coil, with its small number of turns, it is possible to secure greater efficiency by the use of thick wire.

It is not, I think, generally realised that the basic principles of the "slab" and the "pile" systems of coil-winding are essentially the same: in each we find that although turns between which there is much difference of potential are fairly well separated, there is no spacing between adjacent turns other than that provided by the insulation of the wire. Hence, while fair efficiency can be obtained in properly wound examples, these systems do not give the best possible results. Of the two, pile-winding usually produces a coil of least internal capacity, but it is not a sufficiently compact system for coils of very high inductance, and for these the slab coil is generally preferred. The latter type is extremely compact, very easy to wind (or cheap to buy, as the case may be), and, in spite of its only tolerable efficiency, it may be recommended for long-wave tuning to the beginner who wishes to put together as cheaply and easily as possible a set which will work, and which can be improved later. If the reader would prefer to adopt at the beginning a somewhat more troublesome but considerably more efficient type of coil, he is advised to wait for the next instalment of this series, in which will be described the "lattice" coil and a modification thereof which I have devised and which I find superior to any of the coils now on the market.

The Slab System

The slab coil consists of a flat disc of wire, varying in size from perhaps 2 in. to 5 in. in diameter, and from $\frac{1}{16}$ to $\frac{3}{16}$ in. in thickness, held together by paraffin wax or varnish. The process of winding is extremely simple: a wooden former or bobbin is used which is very similar to those employed for winding the sections of spark coils, and the wire is run in

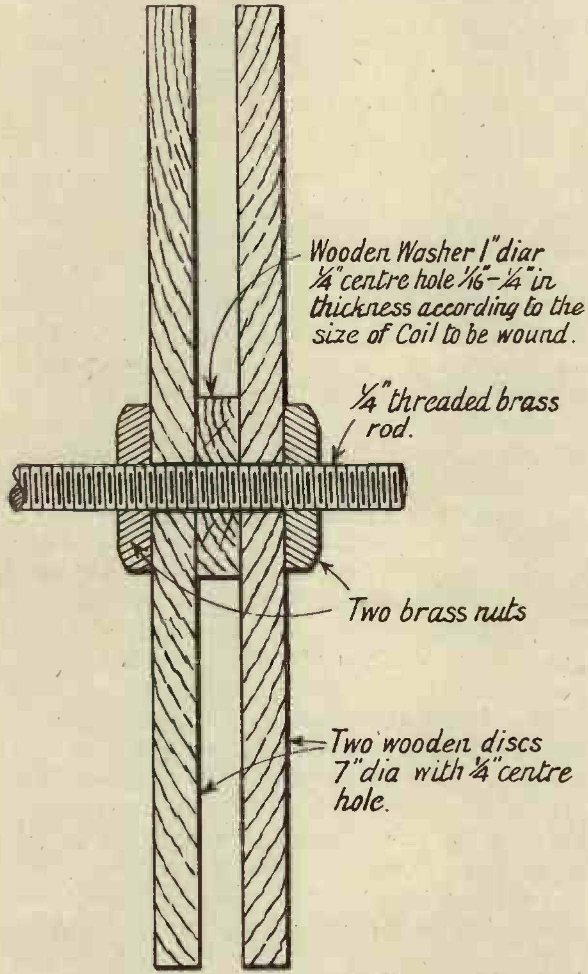


Fig. 1. Section of slab coil winder.

quite irregularly until a coil of the required size has been produced. The former is then soaked in a bath of melted wax, taken out and cooled, and the coil taken out by separating the two halves of the wooden bobbin. The necessary details for the construction of a simple former are given in Fig. 1.

To wind slab coils with the maximum of ease some means of rapidly revolving the former is required; the one illustrated is intended to be held by its central spindle in the chuck of either a lathe or a breast-drill held in a vice. By either of these methods the wire can be run in at quite a high speed, and large coils wound in a few minutes. When the required amount of wire has been wound in secure the end and soak the former in melted wax until bubbles cease to rise, then take it out, drain out the superfluous wax, and allow to cool until it is only slightly warm. Next slacken off the clamping nuts of the former, and separate the coil from the wooden discs by running a hot table-knife round between them. The coil can then be easily removed when the former is taken apart. (Do not heat the knife in the fire; dip it in boiling water.)

A series of slab coils suitable for long-wave tuning may be wound with No. 30 double cotton-covered wire with the following numbers of turns: 500, 750, 1,000, 1,250, 1,500.

The Pile System

Pile-winding differs from the slab method mainly in that it produces a cylindrical coil, and that the turns are arranged in a definite order. It bears a considerable superficial resemblance to ordinary layer-by-layer winding, the distinction being that in pile-winding the turns are wound on so as to bring together only those between which there is a small difference of potential, and to keep others separated. This is actually done by winding on all the layers at once, instead of one by one; one turn is wound upon each layer in rotation until the coil has grown to the necessary size. Thus, if a three-layer pile-wound coil is being made, the wire will be wound on in this order: first, a turn on the bottom layer, then one on the second layer, and then one on the third, after which the wire returns to the bottom layer and the process is repeated. Figs. 2 and 3 will probably convey a clearer conception of the method than any verbal description. Fig. 2 is a section of a "three-pile" winding, and Fig. 3 is a section of a three-layer winding in which the layers have been wound on separately. The numbers within the circles representing

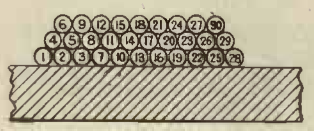


Fig. 2.

Fig. 3.

the turns of wire indicate the order in which the turns were wound on.

Pile-winding is naturally somewhat more difficult than the previous method, and a certain amount of skill has to be acquired before it can be done easily and quickly. The process is rendered considerably easier by the use of a suitable gauge of wire, since the thicker wires are too stiff for convenience and the thinner ones not stiff enough for the turns to remain where they are placed. Nos. 24 to 28 will be found to be the easiest for pile-winding.

For the first attempt a two-pile winding should be tried, since this is the easiest for a novice to tackle. The method of procedure follows: first secure the end of the wire to the tube upon which the coil is to be wound (by passing it through two holes), and then wind on two turns side by side. Next, keeping the wire tight, hitch it back and wind the third turn on top of the first two. On the completion of this turn take the wire down on to the former again and wind turn No. 4 beside turn No. 2, Turn No. 5 will then be wound on beside No. 3. No. 6 beside No. 4, and so on, adding turns alternately to the top and bottom layers until the coil is complete. Fig. 4 shows these operations in stages and should make the matter clear. When the coil is finished it may be either waxed or varnished with shellac and well baked.

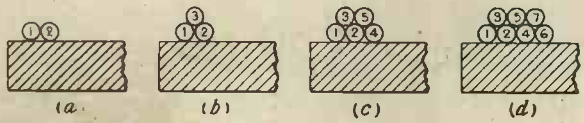


Fig. 4. Stages in two-pile winding.

To wind a three-pile coil the procedure is as indicated in Fig. 5; while the beginning of a four-pile winding is shown in Fig. 6. A greater number of layers than four, or perhaps five, is not advisable, partly on account of practical difficulties in winding and partly because the self-capacity of the coil becomes excessive if a greater depth of winding is used.

In conclusion it should be pointed out that the pile-wound coil has one point of superiority over all other multi-layer types: it is quite easy to calculate its inductance with an accuracy sufficient for rough purposes. The following

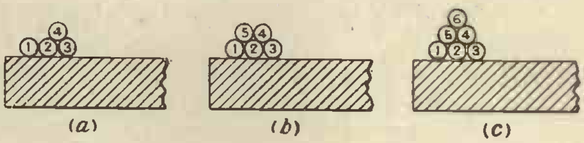


Fig. 5. Commencement of a three-pile winding.

formula will be found to give quite a good approximation:

$$L_{\text{(microhenries)}} = \frac{\pi^2 D^2 N^2 P^2 lk}{1{,}000}$$

Where D = diameter of coil in centimetres.
l = length of coil in centimetres.
N = number of turns per centimetre in any *one* of the layers.
P = number of layers or "piles" in the coil.
k = a constant whose value depends upon the ratio of the length of the coil to its diameter. Various values of k are given in the table below.

$\frac{l}{D}$	k
0·50	0·51
0·75	0·62
1·00	0·67
1·50	0·76
2·00	0·81
2·50	0·84
3·00	0·86
3·50	0·88
4·00	0·90
5	0·91
6	0·92

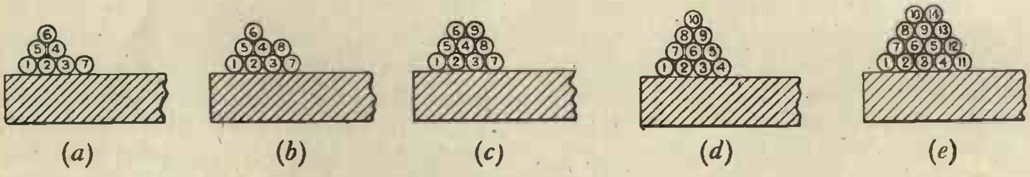


Fig. 6. Commencement of a four-pile winding.

(To be continued.)

HIGH-FREQUENCY AMPLIFICATION

An Explanation and Critical Examination of Modern Methods

By JOHN SCOTT-TAGGART, F.Inst.P., Member I.R.E.

Author of "Thermionic Tubes in Radio Telegraphy and Telephony," "Elementary Text-book on Wireless Vacuum Tubes," "Wireless Valves Simply Explained," "Practical Wireless Valve Circuits," etc.,.etc.

This article will appeal, not only to the beginner, but also to the more advanced reader, who will appreciate a criticism of the different methods of coupling valves, based on practical experience.

Introductory

THERE are two methods of increasing the strength of received wireless signals. We can either add to an ordinary receiver a low-frequency amplifier which will strengthen the actual audible signals obtained, or we may amplify or strengthen the incoming high-frequency currents before applying them to the detector. This last method, commonly known as high-frequency amplification, or radio-frequency amplification, is particularly useful for receiving feeble signals.

A detector requires a certain strength of high-frequency current to operate it effectively. The rectified current available for operating the telephone receivers or the loud-speaker is proportional to the square of the high-frequency current applied to the detector. In other words, if we double the strength of the high-frequency current, we will get four times the rectified current, and therefore four times the signal strength. Similarly, if we can multiply the strength of the high-frequency current by three, we will get nine times the rectified current available for operating the telephones. The reader will, therefore, appreciate that high-frequency amplification is of very great value. There is the additional advantage in the case of the reception of wireless speech or music, that distortion of the speech is far less likely in the case of a high-frequency amplifier than in the case of a low-frequency amplifier, which usually employs iron-core transformers, which tend to spoil the quality of the speech, particularly if more than two transformers are used ; this is due to the iron in the transformer.

Practically every reader will have some idea of how a valve acts as an amplifier. By applying varying voltages to the grid of a valve it is possible to obtain a variation of the steady current which normally flows from the filament to the anode or plate of the valve in the form of electrons and then round the anode circuit. If we apply oscillating potentials to the grid of a valve by connecting an oscillation circuit (containing an oscillatory current) across grid and filament, the varying grid potentials may be caused to set up large variations of current through a similar oscillation circuit in the anode circuit of the valve. These varying currents in the anode circuit set up large changes of potential or voltage across the oscillatory circuit in the anode circuit, and these potentials may then be applied to the grid circuit of the second valve, which valve may be used either as a detector or rectifier of the oscillations (in which case a leaky grid condenser is usually connected in the grid circuit), or as another high-frequency amplifier. It is to be noted that in the case of valve amplifiers the grid circuit is only concerned with current changes which, in turn, set up potential variations, these variations being communicated to the grid circuit of the second valve.

The problem we are now concerned with is, how to cause the large variations of anode current of the first valve to produce corresponding changes of potential applied to the grid of the second valve. If we connected a circuit in which oscillations were flowing across the grid and filament of a three-electrode valve and simply connected a high-tension battery across the anode and filament accumulator, while we would get changes of anode current exactly corresponding to the currents in the grid circuit, only larger, yet there would be no potential variations which could be applied to the grid of a second valve. To get these potential variations we have to include some piece of apparatus in the anode circuit of the first valve of such a kind that when the oscillating currents pass through it, potential variations are produced which may be applied to the grid of the second valve.

Even the beginner will know that if a direct current is passed through a resistance, a potential difference will be set up across that resistance, which potential difference or voltage will depend upon the current flowing through the resistance, *i.e.*, if the current is increased the voltage across the resistance will also increase. In the same way, if oscillating currents are passed through a resistance, varying potentials would be set up across the resistance. This immediately suggests that we might include a high resistance of, say, 50,000 ohms in between the anode of the valve and the positive terminal of the high-tension battery. The high-frequency currents flowing in the anode circuit would pass through this resistance and set up large potential variations across it, and by connecting the grid of a second valve to one end of this resistance and the filament to the other end it would be possible to couple two valves so as to get the desired effect.

If we pass a steady current through an inductance coil having negligible resistance, there will be no potential difference across the ends of the coil. If, however, we pass a varying or oscillating current through such an inductance coil, or impedance as it would be called, potential variations would be set up across the coil, the potential of one end of the coil with respect to the other end depending upon the nature of the change of current and its amount. This suggests that we might include an inductance coil in the anode circuit of the first valve and simply connect one end to the grid of the second valve and the other end to the filament of the second valve. The large variations of anode current in the first valve by passing through the inductance coil would set up oscillating potentials across its ends, and these would be communicated to the second valve, which might be acting either as a detector or as another high-frequency amplifier.

If, now, we choose to pass the anode current of the first valve through an inductance shunted by a variable condenser, we can set up oscillating currents in the oscillation circuit formed by the inductance and the condenser. If we are to get amplified currents in the anode oscillation circuit we must tune this circuit to the same frequency as that of the currents in the grid circuit of the first valve.

Putting it another way, the anode oscillatory circuit should be tuned to the same wavelength as the incoming signals. Under these conditions strong anode circuit oscillations are set up and these by flowing in the anode oscillatory circuit will set up potential variations across the oscillation circuit which may be included in the grid circuit of a second valve. Instead of doing this, however, we might couple the anode oscillatory circuit of the first valve to another oscillation circuit in the grid circuit of the second valve.

Use of Coupled Intervalve Circuits

Having explained some of the general principles of high-frequency amplification, we may consider in greater detail the exact method of utilising these principles and, to make the position clearer, diagrams have been produced which show the different methods which may be adopted.

Let it be stated at the outset that the choice of one or other of these methods of coupling valves will depend on whether reaction is to be used or not. Also, it is to be understood that there are two standards by which usefulness may be judged. One either commends a circuit for its efficiency or for its simplicity of operation. In some cases simplicity of operation is essential, and in these cases it is usual to loose a certain amount of sensitivity. These various points will be dealt with later, but there is one further point which should be raised here, and that is in connection with variable inductances.

Inductances may either be fixed inductances or they may be variable, in which latter case it is possible to vary them in stages, as, for example, by taking tappings every ten turns. On the other hand, it is also possible to obtain an inductance which is smoothly variable—that is to say, one which may be accurately adjusted. A good example of this latter type of inductance is the inductance fitted with a sliding contact. A still better example is the variometer.

A simple inductance which has no condenser across it to form an oscillation circuit is very often called an "aperiodic coil." This implies that the inductance does not possess natural selectivity, whereas an oscillation circuit, consisting of an inductance, shunted by, say, a variable condenser, does possess very distinct selective properties. One does not have to work very long with valves before realising that a simple inductance is not absolutely aperiodic. Practically every inductance has a substantial amount of what is known as self-capacity, which is due to the proximity of the different turns of wire, this proximity resulting in a condenser effect between the turns. This self-capacity combined with the inductance completes an oscillation circuit with some of the selective properties of the ordinary kind of circuit employing a separate external condenser shunted across the inductance.

Apart from the self-capacity of the plain inductance coil, there is always an additional condenser effect when such a plain coil is connected in the grid or anode circuit of a valve. Take, for example, the case of a coil connected in the anode circuit of a three-electrode valve. On the one side it is connected to the anode of the valve, on the other it is connected through the high-tension battery to

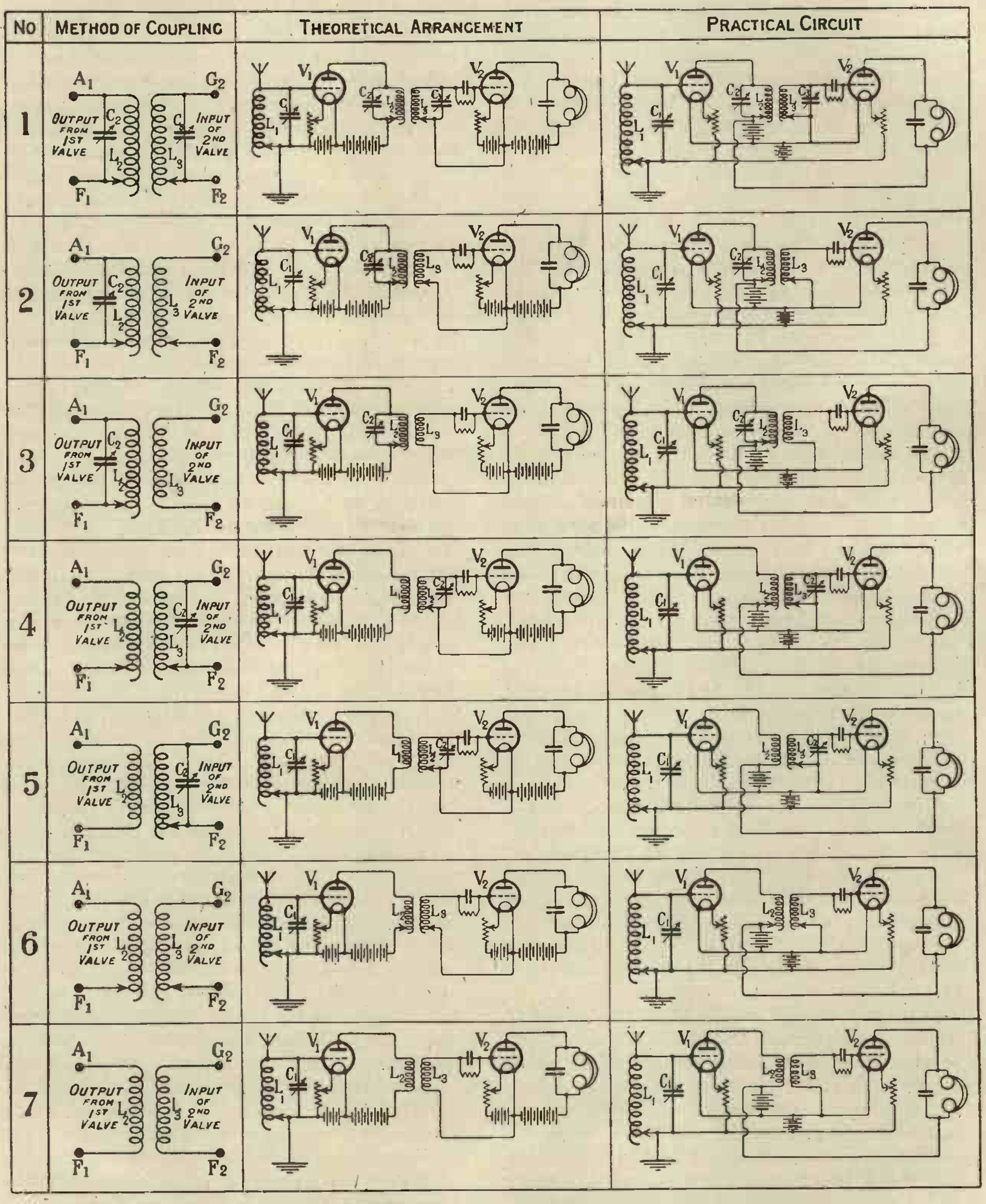


Fig. 1. Diagrams illustrating the various types of intervalve couplings and their mode of use.

the filament of the valve. The anode and filament form a very small condenser which, shunted across the inductance, produces what is really an oscillation circuit. This oscillation circuit will have what is known as a natural frequency—that is to say, it will tend to pick up currents of a given frequency more readily than currents of different frequency. If the inductance coil had no capacity whatever across it, it would not be selective to any particular frequency, and it would be possible to induce in the coil currents of widely differing frequency.

The fact that the inductance coil used in an ordinary valve circuit is not perfectly aperiodic is of great importance. It is to be realised, however, that a tuned circuit having a separate condenser is more selective.

We can look at the question from rather a different standpoint and consider that we are passing a high-frequency current through different pieces of apparatus, the high-frequency current being the high-frequency variation of a steady anode current of a three-electrode valve. The essential value of the apparatus which we are to include in the anode circuit depends upon the maximum potential variations which we can get out of it and apply to the grid of a second valve. The efficiency of the intervalve coupling is measured by the magnitude of the potential variations which are communicated to the grid of a second valve. If we use a plain inductance coil we will find that we will get potential variations set up across it whatever the frequency of the currents passed through the inductance may be, provided nevertheless that the inductance possesses at least a certain minimum value which will increase with the wavelength of the signals being amplified.

If we now replace the inductance by a tuned oscillation circuit we will find that if this circuit is tuned to a wavelength differing from that of the incoming oscillations, the potential variations across the circuit will be negligible. As we bring the tuning of the oscillation circuit closer to that of the incoming oscillations, the potential variations across the anode oscillation circuit will increase in strength and will reach a maximum when the anode oscillation circuit is exactly tuned to the incoming wavelength.

If we use two inductances coupled to each other for the purpose of coupling the anode circuit of the first valve to the grid circuit of the second valve, we have rather a different problem. A full consideration of this method of coupling valves is given later, but it may be stated here that the best effects are obtained when both coils are tuned to the same frequency, which should be that of the incoming signals.

Seven Types of Coupling

On page 188 we have seven methods of coupling valves by means of transformers consisting of two inductance coils coupled together, one coil being included in the anode circuit of the first valve, and the second coil being included in the grid circuit of the second valve, which in all cases is shown as a detector, as will be seen by the number of different systems shown. To the right of each typical method of coupling will be found a two-valve circuit of a theoretical character given for the purposes of explanation. To the right of this circuit will be found the practical method of arranging the circuit, using a single accumulator and a single high-tension battery.

It will be seen that there are cases where both circuits are tuned, other cases where the grid or anode circuit is tuned, or where neither circuit is tuned.

We will now examine each of the seven methods, and I propose to note the merits and demerits of each method, at the same time stating any peculiarities in the practical application of each system.

No. 1.—This method of coupling involves two inductance coils each tuned by means of a variable condenser. The coils may be wound over each other or otherwise coupled, and this coupling may either be fixed or variable. If high selectivity is required the coupling should be variable and should be kept very loose. This method of coupling is very useful for increasing the selectivity of a receiver. The inductance may have tappings or may be fixed, according to whether a wide range of wavelengths is to be covered or not. In the middle column will be found the theoretical circuit in which the No. 1 form of coupling is employed. Both the anode circuit of the first valve and the grid circuit of the second valve are tuned to the frequency of the incoming signals. Owing to the impracticability of having separate batteries, the circuit in the middle column may be simplified into the circuit shown in the third column.

No. 2.—This is a similar arrangement to No. 1, except that the grid circuit of the second valve is not accurately tuned. In the figure, the grid circuit of the second valve is shown as a variable inductance, but it is not accurately variable as tappings only are employed. If the inductance L_3 were provided with a slider, accurate tuning of the grid circuit could be obtained, and the arrangement would then be very similar to that of No. 1. When the grid circuit is not accurately tuned to the incoming wavelength it is better that the two inductances L_2 and L_3 should be tightly coupled, and there this case would be fixed and the arrangement would not be useful for anything but a narrow range of wavelengths. The coupling between L_2 and L_3 should be tight.

No. 4.—In this circuit the anode coil L_2 is variable in steps, whereas the grid circuit L_3C_2

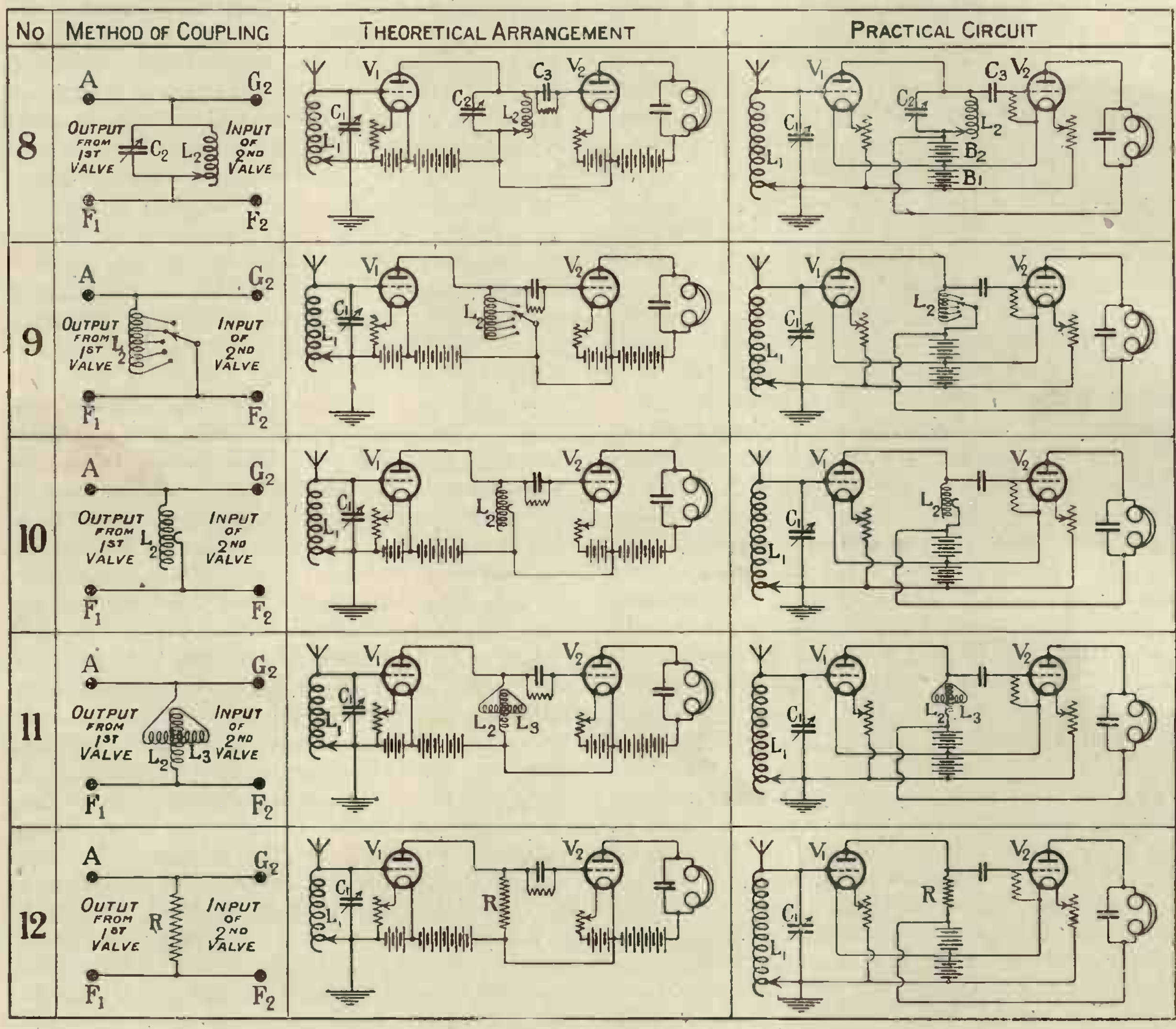


Fig. 2. Further types of H.F. couplings.

will be no particular point in having the coupling variable. In nearly all cases, the inductances will bear a fixed relationship to each other. The main tuning is accomplished by the condenser C_2, although an adjustment of the inductance L_3 will also be desirable.

No. 3.—This arrangement is similar to that of No. 2 except that the grid inductance L_3 is now fixed and all the adjustments are made by means of the inductance L_2 and condenser C_2. As before, the coupling between L_2 and L_3 in is tuned to the incoming wavelength. This circuit is certainly selective, but not to such an extent as No. 1. Its selectivity is about equal to No. 2, and there is very little difference between these two methods of coupling. The coupling between the coils L_2 and L_3 will be fixed and tight.

No. 5.—This circuit has the same degree of selectivity as No. 3, and suffers under the same disadvantage—mainly that it is only suitable for a limited range of wavelengths. Even for this range the coil L_2 has to be correctly proportioned and the coupling between L_2 and L_3 will be fixed and tight. Tuning, of course, is effected by means of the inductance L_2 and condenser C_2.

No. 6.—In this circuit, the coupling between the valves is effected by the inductances L_2 and L_3, which are both variable in steps. This class of coupling is fairly satisfactory for ordinary work, but it is not as selective or as efficient as some of the other circuits. The arrangement will be found more efficient on certain wavelengths than others, unless it is possible to arrange sliders on both the inductances L_2 and L_3, in which case very good results indeed could be obtained. This arrangement may be modified by having one inductance (it does not matter very much which) fixed and the other variable in steps.

No. 7.—This form of coupling depends upon having the two inductance coils L_2 and L_3 tightly coupled. The coupling is not variable, and the two inductances must be very carefully designed for the wavelength to be received, as otherwise the arrangement is very ineffective. For general reception this type of transformer should be avoided, as it will only respond to a certain wavelength effectively; for other wavelengths it will be most inefficient. Sometimes, to get a uniform sensitivity over a wide band of wavelengths, the coils are wound with resistance wire, but this results in a decrease of sensitivity.

We now come to a different class of coupling methods which involve the use of only a single inductance.

No. 8.—This circuit is sometimes known as a tuned anode coupled circuit or as a " rejector circuit " coupling. An inductance L_2, shunted by a variable condenser C_2, is included in the anode circuit of the first valve and the potentials across the circuit L_2C_2 are communicated to the grid circuit of the second valve. The amplified oscillations in the anode circuit of the first valve set up oscillating currents in the circuit L_2C_2, and these result in potential differences being set up across the terminals G_2, F_2. In the third column will be found the practical method of using this kind of circuit. In this circuit it is to be observed that the high-tension battery plays no part with regard to the high-frequency potentials communicated to the grid of the second valve. These potentials are derived solely from the high-frequency current in the oscillation circuit L_2C_2. In the practical circuit of the third column, the potentials which are trying to be impressed on the grid of the second valve are really those across the anode of the first valve and the filament accumulator. In between these two points we have the oscillation circuit L_2C_2 and the high-tension battery B_2. As, however, the high-tension battery has a fixed voltage which cannot be communicated to the grid of the second valve because of the grid condenser C_3, the only potentials which are communicated to the grid G_2 are the high-frequency ones across the oscillatory circuit L_2C_2. These potentials being of high frequency are readily communicated through the grid condenser to the grid of the second valve.

This method of coupling is probably the most satisfactory in all cases. There is no trouble regarding the design of a transformer and tuning is very readily effected by means of a single condenser. The writer is of opinion that the tuned anode arrangement is the best for general work and the No. 8 circuit may be confidently recommended as a type which will give excellent results with a minimum of trouble. The use of this kind of circuit with reaction on the inter-valve tuned anode circuit was first introduced by the writer in his book, " Thermionic Tubes in Radio Telegraphy and Telephony," first published in July 1921, although this part was written several years before.

The great popularity which this circuit has since achieved is ample evidence of its effectiveness. Different circuits using the same principle are described in the writer's book, " Practical Wireless Valve Circuits."

No. 9.—This arrangement consists in coupling the two valves by means of a single variable inductance, L_2, which may be tapped at every few turns, the more tappings the better. This makes an excellent form of coupling; but it is essential, if a fairly wide range of wavelengths is to be covered, that the inductance should be variable, and if only a very narrow band of wavelengths is to be covered, then the inductance should be most carefully designed. There is a certain value of the inductance at which signals commence to appear. In other words, there is no effective coupling between the valves if the inductance L_2 is too small in relation to the wavelength being received. If the inductance L_2 be increased in stages, it will be found that on a certain stud the loudest results will be obtained, and that the signal strength decreases as the inductance is increased, although there will not be a very material decrease in signal strength.

At the same time, however, it is highly probable that much more interference will be experienced when the inductance is not adjusted to that particular value which gives the loudest signals on the desired waves. A curve showing the strength of signals obtainable with this kind of an impedance coupling is given in Fig. 3. The horizontal axis of the curve shows the amount of inductance used, and the numbers may be considered as the numbers of studs equally separated. The vertical axis indicates the strength of signals obtained.

It will be seen that in the special case taken, that the loudest signals are obtained when the inductance is on stud 7, and that the signal strength falls off rapidly when the inductance is

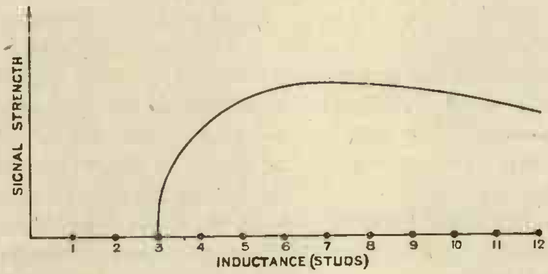


Fig. 3.

reduced towards stud 3. On studs 1, 2, and 3 nothing would be heard. If the amount of inductance is increased by moving the switch arm over studs 8, 9, 10, etc., it will be found that the signal strength diminishes, but not to the same degree as it does to the left of stud 7. It would also be found that on the studs representing larger amounts of inductance, that interference from other stations would be experienced. For example, a broadcasting station might be heard to the best advantage on stud 7, but if we increase the value of the intervalve inductance to, say, stud 12, we might begin to experience interference from ship and coast stations working on a 600-metre wavelength.

No. 10.—This circuit is similar to No. 9, except that instead of using a tapped inductance to couple the valves, an inductance coil fitted with a slider is used. The effect is much the same as that obtained with No. 9, but the results are usually much better, owing to the fact that the most sensitive point on the inductance L_1 is more accurately obtainable. The writer, in fact, prefers this type of coupling to either No. 8 or No. 9, although inductances having sliders are not absolutely satisfactory to operate, owing to the difficulty of obtaining a smooth reliable contact. Unfortunately, the selectivity of this type of coupling is not nearly as good as a tuned anode circuit having a condenser.

No. 11.—This is a similar method of coupling to No. 10, but this time the smoothly variable inductance is a variometer, L_2, L_3. The characteristics of this class of coupling are the same as those of the Nos. 9 and 10 arrangement. It is a very effective method of coupling indeed, and is even better than No. 10, to a slight extent. Variometers, however, need very careful designing. Considerable interference is likely to be experienced with this circuit.

No. 12.—This method of coupling involves the use of a non-inductive resistance, R, having a value of about 50,000 to 100,000 ohms. The high-frequency anode currents pass through the resistance R and set up potential differences across it; these potential differences being communicated to the grid of a second valve. This method of coupling is not suitable for wavelengths below 1,000 metres, owing to the fact that various unavoidable capacities reduce the effectiveness of the resistance R.

General Remarks regarding Single-circuit Coupling

Single-circuit coupling is to be recommended in all cases except those where very high selectivity is desirable, but there are one or two points which should be borne in mind. One point is that although stronger signals can usually be obtained when the tuning is performed by means of an inductance only, without the aid of a variable condenser, it is much more difficult to reproduce a circuit—that is to say, one person might get the circuit to work well, while someone else would find that the wavelength range covered by apparently the same apparatus was different. This is because the intervalve inductance is large in comparison with the self-capacity of the coil and the small shunt capacity provided by the anode and filament of the first valve, and the grid and filament of the second valve.

The total capacity across the inductance is exceedingly small, with the result that any slight variation in this capacity, as by changing the valves, will cause large variations in the natural wavelength of the intervalve circuit; for we cannot assume that the inductance is a purely aperiodic one without any natural oscillation period of its own. Actually, the fact that the inductance has to be adjusted to a certain point to get the maximum transference of energy from one valve to the next, is a clear indication that we are really providing a tuned anode circuit in which the capacity is provided by the self-capacity of the coil and the electrodes of the two valves. This capacity is very small, but nevertheless it is sufficient to change the intervalve circuit into something very much like an oscillation circuit.

When a variometer is used between the valves there may always be trouble between different sets owing to the differences in the small capacities across the variometer. When, however, a coil, fitted with a slider, is provided it is always possible to make up for any slight differences in capacities shunted across the intervalve inductance.

The Effects of Introducing Reaction

When using a tuned anode circuit, or coupling two valves, it frequently happens that a certain amount of reaction takes place between the intervalve circuit and the grid circuit of the first valve. This reaction is inherent in the circuit, and is due to the coupling between the intervalve circuit and the grid circuit by means of the small natural capacity between the grid and anode of the first valve. In some cases, when the high-tension battery has a high value and the filament is bright, self-oscillation of the first valve may occur owing to this natural reaction effect in the first valve. In most cases this reaction effect is not very marked, and reaction is obtained by coupling a coil included in the anode circuit of the second valve to the intermediary intervalve circuit. When a loose-coupled tuner is connected to the aerial the tendency to self-oscillation is very much greater.

It is a curious fact that very few experimenters seem to realise that when reaction is introduced into a circuit the selectivity of that circuit is very greatly increased, and, consequently, the tuning has to be very much sharper. It is, therefore, almost useless to introduce reaction into a circuit which cannot be sharply tuned, such as a circuit consisting of a single inductance coil tapped, say, at every 10 turns. A certain beneficial effect may be obtained by introducing a small amount of reaction on to such a circuit, but to get the full effect it is absolutely essential that the intervalve circuit, whatever its nature, should be very accurately tunable ; the greater the reaction the more selective does the intervalve circuit become, and the more important is it to be able to tune that circuit accurately. That is why vernier condensers are often employed in a tuned anode circuit for the simple purpose of ensuring greater accuracy when reaction is employed. When reaction is not used very accurate tuning of the intervalve circuits is not essential, and, in fact, sufficient tuning can very often be obtained without a variable condenser, simply by taking suitable tappings and selecting the right stud. If, however, we are going to introduce reaction on the intervalve circuits, our methods must be changed, and if we have been previously using an inductance tapped, say, every 10 turns, we must now ensure that we can tune the intervalve circuit more accurately, *e.g.*, by using a variable condenser across the inductance.

It quite often happens that when reaction is introduced into a circuit which is not accurately tuned, or accurately tunable, a weakening instead of a strengthening effect is obtained. This is for the following reason : If the intervalve circuit is really naturally tuned to a wavelength of 400 metres, a signal having a wavelength of 369 metres will be quite effectively transferred from the anode circuit of the first valve to the grid circuit of the next. If, however, we introduce reaction into the intervalve circuit, this latter circuit will become highly selective at 400 metres, and will refuse to pass on any signals which are not of that wavelength, with the result that the strength of the 369-metre signals is decreased.

Readers who are accustomed to experiment with these sort of circuits will, no doubt, have often found that introducing reaction into a tuned intervalve circuit very often produces no increase in the signal strength until the intervalve circuit is retuned.

These remarks are simply intended to show that, if reaction is to be introduced into an intervalve circuit, then that method of coupling must provide for accurate tuning, whereas when reaction is not to be used, the tuning may be much rougher.

Single- and Double-Coil Couplings Compared

In general, the writer would recommend single-coil intervalve couplings in preference to double-coil couplings. The only time that he would prefer to employ an oscillation transformer would be when it was desired to obtain great selectivity, in which case both windings should be tunable.

A not unimportant advantage, however, of the double-coil type of transformer is that when the second valve is used as an amplifier and not as a detector, a grid condenser and leak is not necessary.

THE WINDING OF CYLINDRICAL INDUCTANCES

Some tips for overcoming a beginner's difficulty.

By L. VIZARD

TO most beginners the winding of inductance coils is looked upon with a certain amount of dread as being a tedious job, and this short article describes a method which, in the writer's opinion, is simple and efficient. The type of coil is confined to the cylindrical form only — this type being by far the most efficient when the wavelength to be received is not long, and space is no object.

This article describes the winding of coils up to 6 or 7 in. in length, and about 3½ to 4 in. in diameter. Wire is usually sold on reels, but if bought any other way should be wound on to some suitable bobbin, with a hole through the centre. Slip the reel over a rod, and place the rod in a vice, or other suitable support, so that the reel easily turns round when the wire is reeled off. If possible the reel should fit the rod a little tightly, so that the wire is kept taut while winding.

Start winding the coil from the right hand, first securing the ends of the wire by means of two holes drilled through the former on which the wire is being wound. Take hold of the former with the left hand so that the palm of the hand is towards the hole through the centre. This hand is for rotating the former, and the direction is towards the body. The right hand is used solely to steady the former and guide the wire in the following manner, as illustrated in Fig. 1.

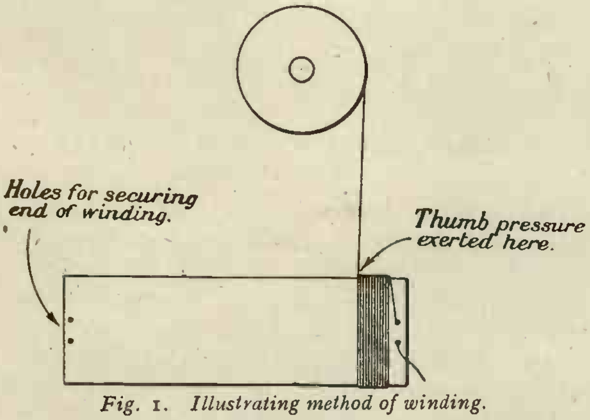


Fig. 1. Illustrating method of winding.

Place the right hand round the former, with the back towards the body, and the thumb pressing down upon the wire which is being reeled off, thus keeping it in position next to the preceding turn as the former is rotated. Pressure is exerted with the thumb downwards and also towards the last completed turn of wire.

By examining Fig. 1 it will be seen that the former is inclined at an angle to the wire. This further ensures the wire falling into place by

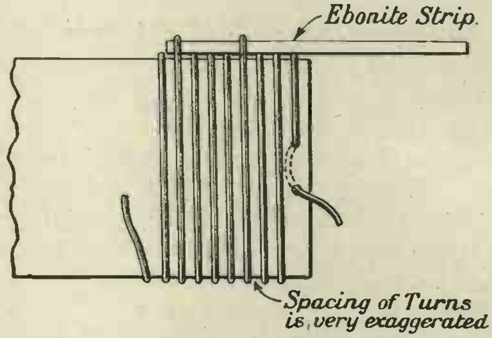


Fig. 2. Manner of making tappings.

the side of the last turn. The first turn that is wound on should be carefully watched to see that it is perfectly level with the edge of the former, otherwise the winding is apt to slip loose later on. It is obvious that no skill is required to wind coils in this manner.

The next point in coil-winding is the tappings, and the writer considers that the following is the most satisfactory method. Procure a piece of ebonite about $\frac{1}{16}$ in. thick, $\frac{3}{8}$ in. wide, and the length of the coil it is intended to wind, or, alternatively, two pieces, say each half the length of the coil. Suppose a tapping is required at the tenth turn. Wind on nine turns, then place the piece of ebonite on them so that the end projects well over (say ¼ in.) and wind the tenth turn over the piece of ebonite. The eleventh turn must not go over this piece, but must be pushed underneath it and close up to the tenth turn, and the same with the twelfth turn. The piece of ebonite can then be pulled back level with the twelfth turn and winding can go on undisturbed until the next tapping is reached, when the same procedure is adopted, and so on. Fig. 2 will perhaps make this quite clear.

When the coil is completed the wire that passes over the ebonite strip can be scraped clean and a good soldered joint made with the wire that leads to the selector switch.

The best wire to use is probably "double cotton covered," as the thickness of the covering allows for quite a good spacing between turns.

"IF"

A few remarks on what I should do, and some of the things I should avoid, if I were starting wireless again.

By Captain R. L. ROPER

SOME people become interested in wireless through the agency of a friend or some other person who is experienced and more or less competent to guide them in their search after knowledge and instructive recreation. Others may not be so lucky; others, again, may grow interested as a result of the purchase and operation of a concert receiving set, and wish to blossom forth from the "broadcaster's" stage to real experimental work. To such as these, I cannot help thinking my own experience may be of some value. Being of an inquisitive nature, and having a mechanical training not used or catered for in my daily occupation, wireless offered me a constructive hobby in a new and interesting form.

If I had bought one book and stuck to it and faithfully observed the author's instructions, I should probably have been successful in some degree with my first effort. But this I did not do; many and various publications did I read, ranging from instructions for making a crystal set from articles commonly found in lumber sheds, etc., to the most elaborate technical treatise on seven-valve amplifiers. Unfortunately, the volumes were not accumulated in progressive order, but rather as they happened to come to my notice on bookstall or booksellers' shelf. The chaotic condition of mind may be imagined when I say that they were all read, but only semi-digested, as they came into my possession. As a consequence the first detector, representing hours of work, was a hopeless mixture of all I had read about crystal receivers. I had got dozens of crystals, which mostly got mixed in the wrong boxes, and the bench was a jumble of wires, batteries, water rheostats, and aerial tuning inductances two feet long with three sliding contacts; also there was a soldering-iron permanently on a gas ring for crystal changing. And yet I knew so little about it that my earth wire was fixed to a plate standing in the water of an earthenware syphon drain, carefully insulated, that is, except when the drain overflowed, which it did not.

In any case, I was sitting for hours fiddling with the set, using low resistance "disposal" phones, diaphragms covered in rust, with, as I discovered later, a broken cord to one earpiece.

However, all the blame for lack of signals was laid at the door of the crystal, and I asked the P.M.G. for permission to use valves. About now things took a turn for the better.

In reading up about valves to decide what was to be incorporated into the valve panel I was proposing to make, I found out a bit about earths, and it struck me that if the house side of a big cistern of water was not all that was desirable in the earth line, a few pints of water down a drain could not be of much use. This was duly remedied, and that night I got my first signal, one of the two ever obtained, as it was a powerful Admiralty station about five miles away, who later made me shut off whenever he started up. It was not much use as an effort, but the following morning, when retailed for general information, it had magnified from a hoarse scratch almost to the proportions I was later to receive it in.

At this time, too, I joined the local Society, and I consider this was the most important thing I ever did in the wireless line. During the period covered by the above, I had obtained a wireless magazine, but must admit that very little of the subject matter was understood by me, and, judging by the queries submitted, there were numerous others situated as myself. But I saw an announcement to the effect that there was a flourishing society in the City, and that they were open to accept new members. I decided to join; the actual value of the subscription was soon recovered from certain dealers in gear, who had an arrangement with the Society, while the information and advice which I obtained was worth very much more; the first result was a visit by one of the experienced members with a portable set to test my aerial.

It was upon this occasion that I obtained my second signal on the crystal, most of my impediments were removed from the "set"; the inductance was deprived of two of its slides, a telephone transformer was substituted for the large bundle of wire, insulating tape and iron wire which I proudly imagined would make my 120-ohm phones give loud signals, and with two sets of phones we heard a coastal station eighty miles away. I might have got more signals from that crystal set, but its doom was settled within the next few minutes. My newly-found precentor proceeded to test the aerial, and I was listening to what appeared to me to be most of the C.W. stations in the world, with a few spark stations thrown in, and was somewhat taken aback when informed that these were only a few, on or about the same wavelength, and we were just making up our minds which one to listen to.

We finally decided on a good loud one, and found it to be an American station; by this time I had quite made up my mind that this was what my war-time habits forced me to call "the stuff to give 'em," and by the time my magician left me I had found out enough about valve sets to pick from my "library" a volume which contained detailed instructions for the construction of a tuner and valve panel suitable for my requirements.

By my next appearance at the Society, I was almost ready to operate; my high-resistance phones had been delivered meanwhile, and by the following week could report results. The single layer inductance had to go and was replaced by honeycomb coils. One mid-day, casually switching on the filament and trying my new coils, I heard speech in German, followed by music; without intention I had found LP on 2,500 metres. In the evening, with the same setting, I heard FL, but somewhat faintly. For several days I heard no more; I was fully occupied on a second valve panel for the addition of a stage of H.F. amplification with reactance capacity coupling.

For a time I was content. During this period liberal quantities of Bangay, Coursey, Scott-Taggart and others had been taken in daily doses, and thenceforward my trouble ceased to be in the same category as heretofore.

Therefore, I say that if I were starting again, in view of my past experiences, I certainly should not proceed on anything like the same lines as I did. Had I got to the valve stage without the guidance and advice which I received at the Society, I know what I should have been; a general nuisance, which is putting it mildly. Consequently, my course would be guided by the following general rules:

(1) Join a Wireless Society; not necessarily the nearest or the cheapest; if there were a choice, one with apparatus and facilities for serious work and a good syllabus of lectures.

(2) Allow the Secretary to guide my reading according to my stated requirements, not being above tackling the elementary principles, nor too modest about my ultimate aims.

(3) Before either purchasing or constructing any apparatus, discuss it with others, making sure it was really what I required and the most efficient of its kind.

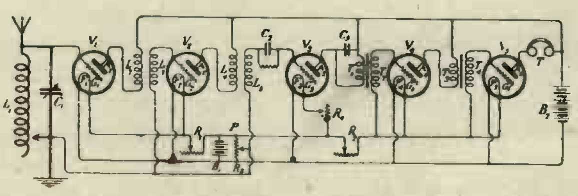
(4) Let all the accumulation be in such form that it is easily added to, preferably on the unit system.

(5) Except for a special duty, have all apparatus and components capable of rearrangement.

Rules 1 and 2 are of great importance and the remainder a natural corollary.

A CORRECTION

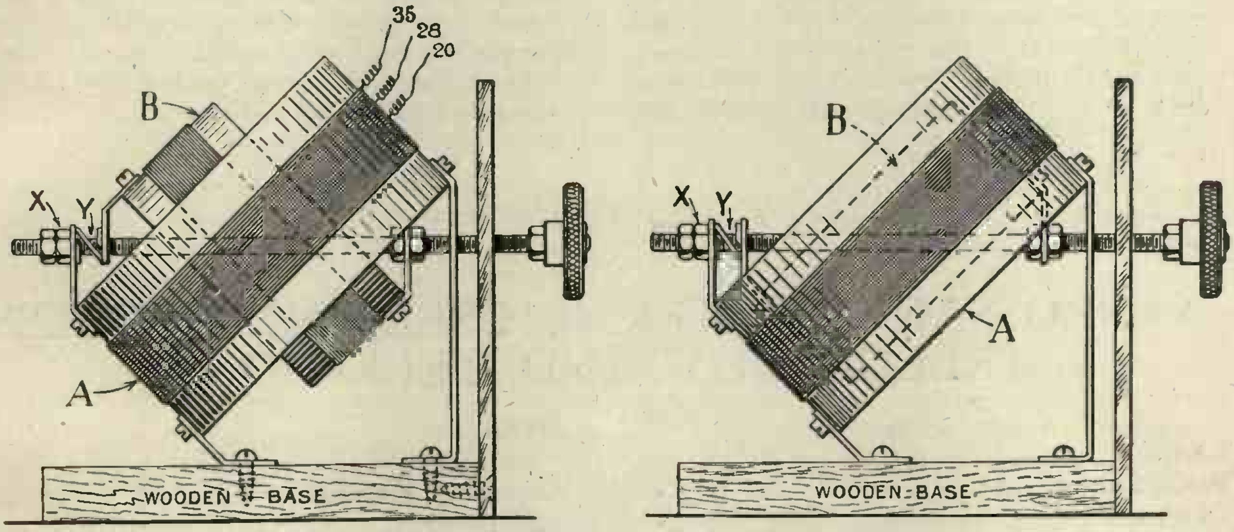
A FEW copies of "Practical Wireless Valve Circuits" have been allowed to pass through our Sales Department in error. Will any readers who may possess such copies note that circuit ST. 51 should be as below, and not as given in the one or two copies in question.



A NEW TYPE OF REACTION COUPLING

By S. K. LEWER

IT is now known that the P.M.G. will allow amateurs to couple the reaction coil back to the anode coil in the plate circuit of a high-frequency amplifier, and therefore the design of an efficient coupler, where the critical point of reaction can be found easily, will be needed by many enthusiastic amateurs.



Figs. 1 and 2. Showing the general arrangement of the coupling device.

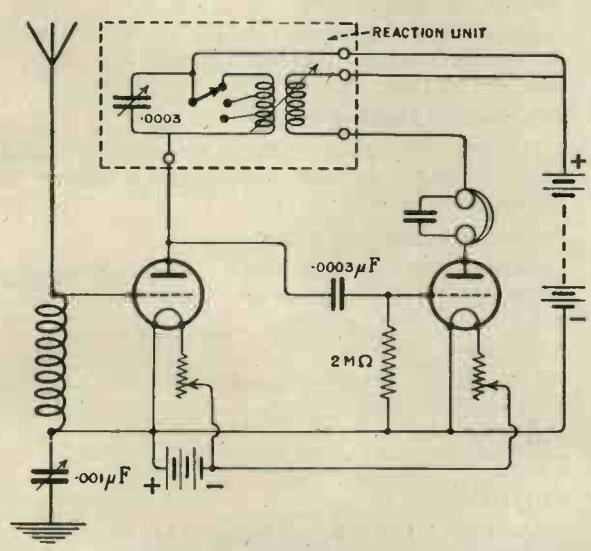


Fig. 3. Showing the connection of the coupling device.

In this type of coupler the reaction coil moves through 180° for the same variation in coupling as one gets with 90° in the ordinary type of rotating coil or ball reaction. By this one can see that the critical point of reaction for telephony is more easily obtained. Figs. 1 and 2 show the minimum and maximum coupling respectively. Of course, the necessary fine adjustment could be performed with a small variable condenser across the reaction coil, but that increases the cost and would take up considerable space on the panel.

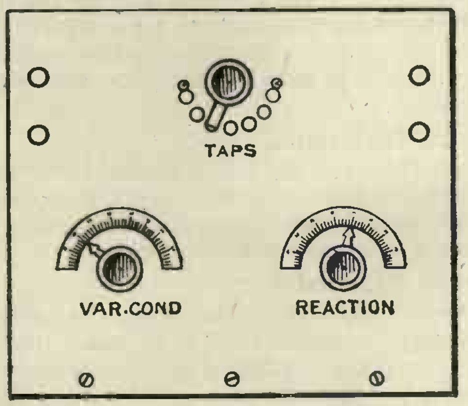


Fig. 4. A lay-out for a suitable panel.

The average amateur could build this coupler for nothing, because the necessary wire, cardboard, etc., will be found already in his possession; but even when buying the materials, the cost is less than 2*s.* 6*d.* The fixed coil A is wound on a tube 4 in. in diameter and 2 in long; 35 turns of No. 24 d.c.c. should give well over 400 metres when a 0·0003 μF. variable condenser is connected in parallel. Tappings should be taken from the 20th, 28th and 35th turns to a three-stud switch. The minimum wavelength will then be well below 300 metres. The reaction coil B consists of about 1 in. of winding on a former 3 in. in diameter and 2 in. long, of any gauge between No. 26 S.W.G. and No. 36 S.W.G. The coils instead of being mounted vertically or horizontally are tilted at an angle of 45°. The bearings and supports may be of $\frac{1}{32}$ in. brass strip, preferably $\frac{1}{2}$ in. wide. Holes are pierced in the cardboard formers (ebonite may be used if cost does not matter), and the bearings secured by small nuts and bolts. The rotating spindle may be 6 in. of No. 2 B.A. brass studding, and the reaction coil secured to it by gripping with two nuts. Two nuts locked at X and a spring washer at Y will enable the coil to rotate steadily. Fig. 3 is a circuit diagram using this coupler, and Fig. 4 is a suggested design for a complete reaction unit.

The telephone condenser, it should be added, may have a capacity of about 0·002 μF.

A GLOSSARY OF TERMS USED IN WIRELESS TELEGRAPHY AND TELEPHONY

A

A.C.
See Current.

Acceptor
A circuit consisting of inductance and capacity in series, which has the property of offering low resistance to currents of the frequency to which it is tuned. *Compare* Rejector.

Accumulator
See Battery, Secondary.

Aerial
The elevated wire or wires used for the transfer of energy from transmitting set to space or from space to receiver. The term is now extended to wires which are not elevated above the apparatus (*see below*).

Aerial, Directional
Any aerial the shape of which causes a variation of signal strength according to the direction from which signals are coming. The frame aerial especially possesses this property.

Aerial, External
The normal type. Well-known varieties are "L" or "inverted L," "T," and "umbrella," whose shapes are indicated by their names.

Aerial, Indoor
A small aerial of usual type erected within the house; to be distinguished from the frame aerial.

Aerial, Frame
A coil of wire of 1 to 50 turns wound on a large frame (say 2 to 10 ft. across), the two ends being used as aerial and earth.

Aether
See Ether.

Alternating Current
See Current.

Alternator
See Generator.

Ammeter
An instrument for measuring currents.

Ammeter, Hot Wire
Depends on change of length of a wire when heated by current passing through it. May be used for all frequencies.

Ammeter, Moving-coil
Depends on magnetic effect of current. Indicates direction as well as amount. Useless for alternating currents.

Ammeter, Moving-iron
Depends on magnetic effect. Does not indicate direction. May be used for low-frequency A.C., but not high frequencies.

Ammeter, Thermo
Depends on rise of temperature of wire. May be used for all frequencies.

Ampere
Unit of current.

Amplifier
An apparatus for causing weak currents to control a local power supply, thus producing larger currents. Distinguished from a relay by the fact that in an amplifier the local currents produced should be exactly proportional to the currents controlling them.

(*Continued on page* 207.)

A NEW NON-INTERFERING DETECTOR VALVE

(*Continued from page* 162.)

current when the anode circuit is open I'_c. The curve labelled $I_c - I'_c$ is the difference between the collector current with the anode circuit completed and opened. This last curve is interesting in that it apparently takes into consideration

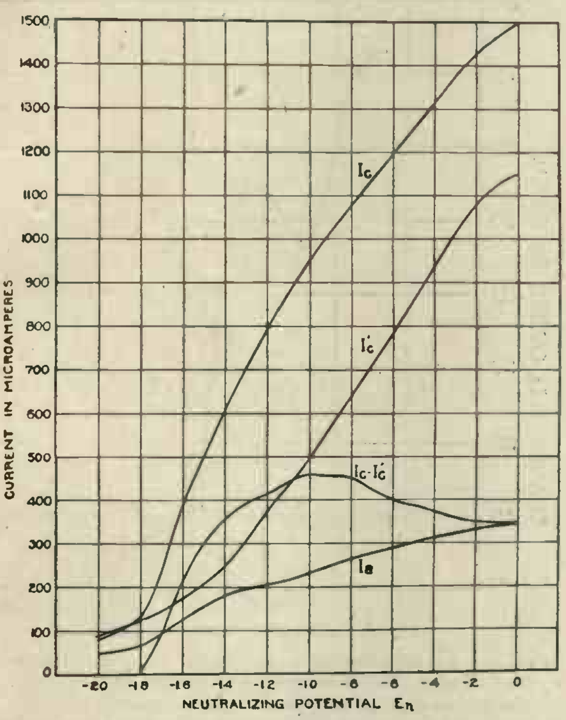


Fig. 3. *Variation in anode and collector currents* I_a *and* I_c *with variation of neutralising potential* E_n.

various phenomena concerned in the operation, and its slope is practically a direct index of the merit of the tube as a detector.

The abrupt bend in the collector current at $E_n = -1{\cdot}8$ is a point at which maximum detection would be expected to take place according to the usual conception of detection as being due to rectification over a section of the characteristic slope where the rate of change is large. One would also gather from this curve that the effect of a signal impressed would be to increase the average value of the collector and anode currents. Although some detection takes place on this part of the curve, in magnitude it is incomparable to that secured over the sensitive portion of the slope. The point of maximum sensitivity for these curves is at $E_n = -1{\cdot}4$ volts, which is at a relatively flat portion of the collector current curve and considerably above the lower bend. Furthermore, a signal impressed on the collector circuit always gives a decrease in collector current regardless of whether the characteristic curve at the sensitive point is concave or convex, many examples of both types having been observed. It should also be noted that the point of maximum sensitivity occurs somewhat above the middle of the $I_c - I'_c$ curve. Another point of interest in connection with these curves is the values at operating potentials of collector and anode currents, the collector current usually being two to four times that of the anode. Special attention should be given also to the large changes of current produced by small changes of neutralising potential.

Fig. 4 shows the change in collector current for impressed signals of different wavelengths. The ordinates of this curve show in microamperes the actual decrease in collector current caused by a signal of variable frequency, but of constant amplitude. This curve shows that the response for the particular tube on which this data was taken becomes small above the wavelength of 1,000 meters, and that below this wavelength detection increases rapidly. This might seem to indicate a limited wavelength band of operation for this type of tube, but the entire shape and position of this curve depends upon the relative potentials of the tube electrodes and upon their proportions and relative positions. It is possible radically to change this curve by a simple variation of the neutralising potential. It is also possible by a proper selection of values

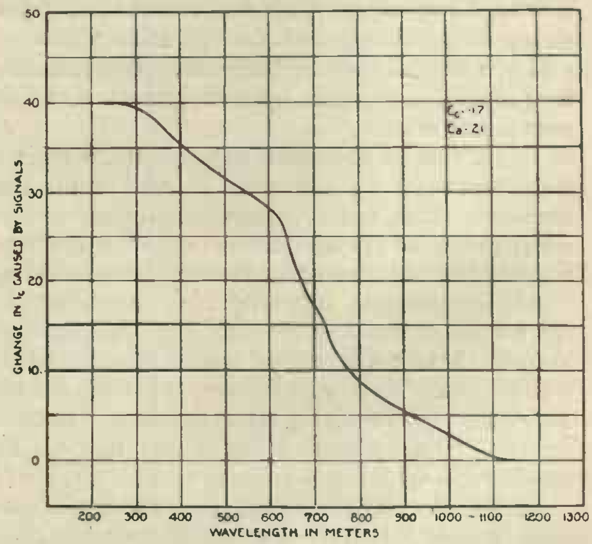


Fig. 4. *Curve showing the change in collector current for impressed signals at various wavelengths.*

to secure a serrated form of this curve of which Fig. 5 is a typical example.

The possibilities indicated by this curve in the elimination of interference are obvious.

When the alternating potential of a signal is applied to the collector circuit, the pulsation is impeded to a greater or less extent depending upon the amplitude and frequency of this potential. Furthermore, since the pulsation causes a build-up of average collector current, the effect of a signal in this circuit is invariably to reduce the average value of this current.

Since slow changes in the collector circuit current are reflected in the anode circuit, a decrease of the average value of the collector current will result in a like decrease in the anode current, but this occurs without any appreciable amplification. By experiment on large numbers of tubes the ratio of change of power in collector circuit to resulting power change in anode circuit was found to be approximately unity.

This lack of amplification accompanying the detection effects makes it feasible to operate the tube with an indicating device, such as a telephone receiver, placed directly in the collector circuit instead of in the anode circuit as shown in Fig. 2. This is of interest, although results are not quite as good as with the normal circuit (Fig. 2), due to the fact that in the low impedance circuit the high resistance of the receivers interferes with proper functioning. The anode circuit impedance is well suited to the standard telephones and transformers on the market.

With the telephones in the collector circuit the device might seem to be more or less the equivalent of a two-element tube, but the contrary is true, however, for with this connection, if the anode circuit is opened, no operation whatever will be secured, thus demonstrating that satisfactory operation depends upon the presence of this new anode circuit.

The action of this tube depends upon ionisation produced by electrons emitted from the filament. It is, however, not the purpose of this short article to go into detail beyond a description of some of the most interesting characteristics.

At first thought it would seem necessary to allow a considerable time after lighting the tube filament before the anode would become sufficiently hot. That is, however, not the case on account of the following most interesting phenomenon. When the filament is first lighted the anode receives a small amount of heat by direct radiation from the filament and there will be, even at this relatively low temperature, a considerable emission of particles from this anode. This emission will, however, decay with time, and in a period of possibly one hour it will have reached a small fraction of its initial value. However, with the external heater connected in series with the filament, as described above, when the filament is lighted the anode will commence to receive heat from this heater. Its effect in raising the anode temperature will be necessarily slow on account of the interposition of the glass wall of the tube, but the temperature of the anode is increased by this heater at a rate approximately correct to compensate for the decay of the initial

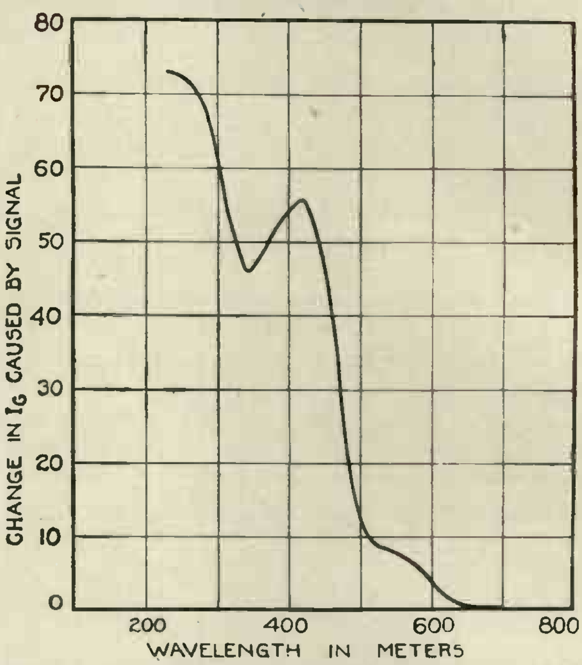


Fig. 5. By adjustment, it is possible to secure a curve o this shape. The possibilities indicated by this curve in the elimination of interference are obvious.

emission, and thus the emission of particles from the anode will become fairly constant within a few seconds after the tube is first lighted. The result of this combination of affairs is that when the tube is lighted it is almost immediately in operative condition, although in some cases a slight readjustment of neutralising potential is later necessary to maintain a maximum sensitivity.

Ionisation controlled in this way is extremely stable, and these tubes may be maintained in their most sensitive adjustment for long periods of time. This is an impossibility with a gaseous detector. Also, with this type of ionisation, it is possible to manufacture in quantity tubes with little if any variation of sensitivity. The tubes will remain substantially constant in sensitiveness throughout their lives.

It is felt that the unique characteristics of this device and its inherent advantages over prior detectors should offer a new avenue of approach to the problem of detection. By replacing, without loss of sensitiveness, many of the reactions now in use, the new tube should further help to eliminate much of the present disagreeable interference.

CONSTRUCTIONAL NOTES

An Efficient but easily made Intervalve Transformer

EVERYONE has a use at some time or other for a low-frequency transformer. The average experimenter does not, however, feel justified in spending perhaps something over a guinea on one; and furthermore, may not be prepared to spend the same amount whenever he wants to add another stage of amplification.

The following brief description of a suitable iron core transformer, which can be carried into several stages if necessary, will be of assistance to those who wish to employ several L.F. stages in as economical a manner as possible. The transformer detailed here has the further advantage that it can be readily made with very few tools, although the winding of the primary and secondary coils may prove a little tedious. An exact knowledge of the number of turns, whilst desirable, is not absolutely essential if the winding is laid on evenly, as the ratio of turns can be gauged by the depth of the respective coils.

The first essential is a bundle of iron core wires 6 in. long and ½ in. in diameter. These must be perfectly straight, and to make them adhere while the coils are being wound they may be immersed in hot paraffin wax, after having been bound with thread.

When cool they will form a rigid core rod. This must be wrapped for 2½ in. of its length at the centre with one layer of empire cloth. Two discs of stout cardboard, impregnated with hot glue so as to render them solid, must be cut out with an over-all diameter of 2 in. and a centre hole of such a nature that they will fit tightly over the centre core and wedge themselves firmly against each end of the empire-cloth wrapping. A coating of shellac varnish over the discs and centre of the core will assist in securing the whole.

A pinhole having been made through one of the discs close to the core, one end of a bobbin of No. 38 S.W.G. s.s.c. wire is passed through it and the core is wound to a depth of one-third the total diameter of the disc available for winding space.

This may be done by mounting the core in some form of holder and rotating the whole until the required depth of winding is obtained.

One layer of empire cloth is wrapped over this winding, the end having been passed through another pinhole in the same disc as the first one, and care must be taken to ensure the insulation overlapping the ends of the winding thoroughly.

A pinhole having been made in the other disc just above the empire cloth, the No. 38 S.W.G. wire is again passed through, and the remaining two-thirds space filled up flush with the top of the discs. A single layer of paper or empire cloth again will protect the outer layers from damage, and this may be bound on with thread or secured by a little Chatterton compound.

The four wires, which should be at least 6 in. long, are then encased in rubber tubing, such as cycle valve tubing, which should be sealed to the end discs close to each pinhole by a spot of Chatterton compound to prevent damage to the fine wire from the iron core.

The core wires projecting at each end of the transformer should now be all bent inwards until they meet over the outside of the secondary winding; care must be taken to bring out the rubber-covered leads from the transformer and to mark them as follows: First pinhole, P_1; second, P_2; third pinhole, S_1; fourth (or end of coil), S_2. The core wires must now be bound down firmly on the outside of the secondary winding by wrappings of fine copper wire, and a touch of solder may be given to the joint to secure the binding.

This transformer is easily mounted by screwing down under a hoop of brass, and may be used with high plate voltages safely.

A. L. M. D.

An Aerial Gadget

ONE of the details of aerial erection over which difficulty is sometimes experienced is the matter of making fast the wire to the insulator at the end of the horizontal span from which the down-lead is taken. A common method of doing this is to take the wire round the insulator, and then twist it several times round itself before taking it down to the leading-in insulator. This method is by no means ideal, since it is liable to cause considerable

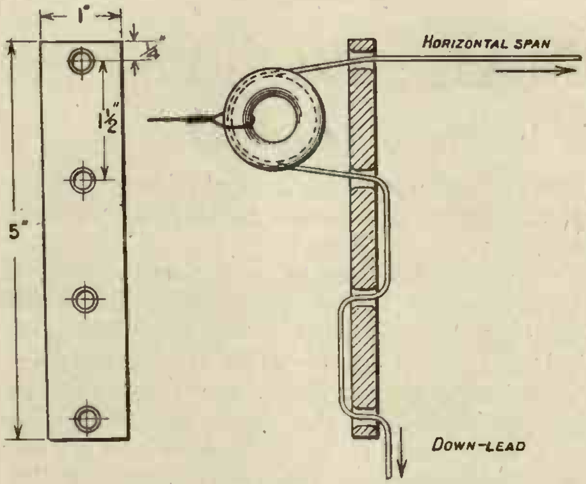


Fig. 1. Showing dimensions of the ebonite strip and its mode of attachment.

damage to the stranded and enamelled type of wire, resulting in untwisting and disarrangement of the strands and cracking-off of the enamel. The gadget illustrated in Fig. 1 will be found to overcome the difficulty quite successfully. It is cut from ⅜-in. sheet ebonite to approximately the dimensions indicated, and four ¼-in. holes are drilled in the positions shown. (It is desirable to take the sharp edges off the holes by means of a rose-head drill or a large twist drill, giving them the shape shown in section in Fig. 1.) The method of attaching the gadget should be made plain by the section (Fig. 1).

When a fairly stiff aerial wire, such as 7/22*s*, 7/24*s*, or single No. 16 or 14 is used, this device is capable of withstanding heavy strains, much heavier, indeed, than anything which the aerial is likely to put upon it, and it has the advantage of enabling one to adjust the exact length of the horizontal span by slipping the wire through it, which is sometimes a convenience in erecting multiple-wire aerials.

G. P. K.

A Lamp Resistance for Accumulator Charging

WHEN charging accumulators from the mains, a system of resistance-mats is sometimes used to cut down the current to a suitable value. This method strikes me as unwieldy and troublesome to rig up, besides leading to insulation weakness with so much exposed metal. I would suggest that a better method is to charge through a lamp resistance. In that case a number of lamps are coupled up in parallel and placed across the mains, the accumulators being connected in series with the circuit. Each lamp acts as a path for a certain amount of current, the aggregate of which passes through the cells, thus the amount of charging current can be varied according to the number of lamps in the circuit. Carbon filament lamps are generally used, as these have a lower resistance than metal filament lamps, a 32 c.p. carbon lamp on a 230–250-volt circuit allowing approximately a ½-ampere to pass, and twice that on a 110-volt circuit. If then 3 amps. charging current is required, it will be necessary to provide six or seven lamps on a 250-volt circuit. Old lamps that are still intact but too blackened for use will do excellently. The simplest way to rig up the bank of lamps is to mount seven back-plate lamp-holders on a 3-ft. piece of 2-in. lighting casing, spacing them about 4 to 5 in. apart. At one end fix two terminals for the battery connections T_1 and T_2 (Fig. 2). A length of 14/36*s* lighting flex, sufficient to reach to the nearest ceiling rose, is then connected, one end to terminal T_1, the other end to the terminal of the first holder. Wire is now looped from this same terminal into the next holder, on to the next, and so to the last; whilst another piece of flex starts at T_2 and loops into the remaining terminals of the holders, terminating at the end holder (Fig. 2). The casing can be

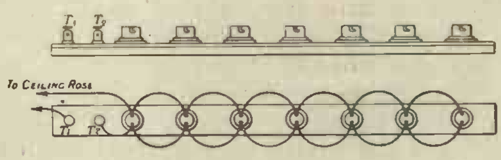


Fig. 2. Construction and wiring of the lamp resistance.

fixed to the wall, the lamps inserted, and the polarity of the terminals T_1 and T_2 tested with pole-finding paper and marked + and −, the positive of the accumulator being connected to the positive terminal on the casing and the negative of the accumulator to the other.

Charging will now proceed, the charging current being cut down as required by taking out the necessary number of lamps, deducting half an ampere approximately for each lamp removed.

W. L.

GUIDANCE FOR THE FIRST STEPS OF THE BEGINNER

Below will be found a very much condensed account of the principles of wireless and broadcasting, together with some sound advice for the absolute beginner. For a fuller account reference should be made to "Wireless for All" (6d.) *and "Simplified Wireless"* (1s.), *which may be obtained from the publishers of this journal.*

IT is not intended in this limited space to attempt to tell the beginner all that he needs to know before setting out upon his wireless way, but rather to show him where he may obtain the information and help which he will need; being unable to give him a complete map of his route, we must content ourselves with telling him where to look for sign-posts.

One of the first things to be noted by anyone beginning to take an interest in wireless matters is that non-professional wireless enthusiasts are divided into two classes: there are those who are only interested in broadcasting and the reception of music, lectures, concerts, news items, and entertainment generally, distributed by the various stations of the British Broadcasting Company each night, and also by certain continental stations (Paris, The Hague, Berlin, etc.). Then there is a second class whose chief interest is in the technicalities of the subject of wireless. This latter class is interested, not only in broadcasting, but in the thousands of other kinds of messages and signals which are being sent by wireless, such as messages from high-power transatlantic stations, from ships and aeroplanes, and so on. They are interested, too, in intercommunication work between amateur stations, and of course take much joy in the construction of apparatus, experimenting with new ideas, and so forth. The members of this second class are commonly referred to as "experimenters," while the former class are often described as "broadcasters," which is obviously incorrect, but must serve until someone coins a better word.

To whichever class you intend to belong you must know something about the subject, or you will miss half its pleasure, and, moreover, run the risk of being frequently held up by trifling difficulties in the use of your apparatus. The best way of acquiring the needful knowledge is to buy, in the first place, the two very simple and helpful little books mentioned in the subheading of this page. Then you should try to get in touch with someone who has already installed a wireless receiver in your neighbourhood, since in this way you will have the great advantage of being able to profit by someone else's mistakes. If possible, get acquainted with a member of the local wireless society, and preferably join the society yourself. The fees are small, no technical qualifications are necessary, and you will become thereby a member of the corporate body of wireless men, and as such will be able to play your part in the future development of the science.

Having got some general ideas on the subject you may then ask your friend's advice as to purchasing a wireless receiver. If you are only interested in broadcasting you might, if you preferred, go straight to a wireless dealer of standing and ask his advice, telling him your needs and the amount you desire to pay for your set. If you desire to take up wireless experimenting, or to make your own wireless receiver, you should most certainly get in touch with another wireless experimenter. Your first real step will be to apply for an experimental licence from the General Post Office, London. This licence will cost you 10*s*., and the method of procedure to obtain it is described in the February number of MODERN WIRELESS.

While waiting for your licence you cannot do better than make up one of the sets described in "Simplified Wireless," or MODERN WIRELESS. You had better begin on the crystal receiver before attempting anything more ambitious. The golden rule for experimenters is to join a wireless society. The golden rule for the would-be broadcast receiver is to talk to an experimenter who already has a set installed. We hope that our advice will not be considered interested if we advise you to take in a good wireless periodical, and to buy good authoritative books on wireless.

Having made, or bought, your set, the next thing to do is to fix up your wireless aerial, and this will only call for a little common sense and a little time in reading the aerial section, of the two little books mentioned above.

It may, perhaps, be helpful to give at this point a superficial idea of the general *modus operandi* of wireless and broadcasting, as a preliminary to a more exact study.

A wireless transmitting station consists of special apparatus, which sets up electric currents in a length of wire slung up at as great a height as possible—usually between two masts. The currents in this *aerial*, as it is called, set up invisible wireless waves, which travel in all directions. The distance these waves travel depends upon the power of the transmitting station. The waves may be received by the receiving station, which consists of very much simpler apparatus, and an aerial wire slung up, usually, between the house and a tree, or between two poles, or, in fact, in any other way. The receiving aerial for broadcasting and experimental work is usually about 100 ft. long. When the receiving station is being operated, the wireless waves from the transmitting station are caught by the aerial wire, producing electrical currents which operate the receiving gear and cause buzzing noises, speech or music, according to the nature of the transmissions from the transmitting station. These noises come from telephone receivers, or what is known as a loud-speaker, which is somewhat similar to a gramophone horn. The telephone receivers are somewhat similar to the telephone receiver ear-piece on the ordinary telephone. Any number of wireless receiving stations within a certain range of the transmitting station may be able to pick up the messages from that transmitting station, since the wireless waves radiated from the transmitting aerial spread out in all directions, just as do the sound waves from, say, the explosion of a gun; just as in the case of sound waves, the wireless waves become more and more attenuated the further they travel, until finally they become imperceptible to even the most sensitive apparatus.

It may be asked whether, as so many wireless transmitting stations are working in the world, there is not a jumble. The reason why there is not a jumble is that the transmitting stations send out different kinds of waves, and at your receiver you pick out the particular kind that you want to receive.

So long as the waves differ from each other by a certain amount, you can adjust your apparatus so that you only hear the desired signals, but if, as sometimes happens, two or more stations happen to be sending on the same or nearly the same "wavelength," as it is called, they will all be heard together, and you get the state of affairs known as "jamming."

Wireless waves are somewhat similar to the ripples produced on the surface of a pond when a stone is thrown into it. These ripples travel outwards in all directions, as do wireless waves. The wireless waves, however, are invisible. When one person speaks to another, the speech is communicated by waves in the air—sound waves. When a wireless station transmits, somewhat similar waves are set up, but they are not heard by an ordinary person in the ordinary way, they require a special receiving apparatus to make them audible.

Different transmitting stations send out their messages with different kinds of waves. These waves differ from each other in their length; the length of a wave is the distance from the crest of one wave to the crest of the next wave. The receiving apparatus may be tuned, that is to say, adjusted, so as to pick up only the waves of a certain station. When different strings on a piano are struck different notes are sent out. Perhaps one note will be high and another low. The difference between these notes is that the sound waves, in the case of one note, differ from the sound waves produced in the case of the other note, the difference being in their wavelength. The human ear can distinguish between the one and the other.

In the same way, a transmitting station may be arranged to send its signals on one "note" or on another. The wireless receiver is also able to distinguish between the different wireless waves, and it is possible so to adjust the apparatus that only the desired waves will be received, the others not being made audible at all. By giving different stations different wavelengths to work on, it is possible to be able to pick up at a receiving station waves from hundreds of different wireless stations.

It may perhaps be of interest to give a little general information bearing upon the matters which are of importance to, and sometimes perplex, the novice.

Most ordinary wireless business messages are sent in the Morse code, which consists of short and long buzzes, known as dots and dashes. These are arranged in a special manner to represent different letters of the alphabet. The serious experimenter should preferably learn the Morse alphabet, while the broadcast receiver will not need to learn the Morse code at all, but if he hears buzzing noises in his receiver these will probably be due to his hearing messages being sent in Morse code. The ordinary music and speech comes through just as if one were in the same room as the artist.

A NEW DOUBLE-REACTION CIRCUIT

Judging from the correspondence we have received, the description of a new class of circuit designed by John Scott-Taggart, F.Inst.P., and described in No. 1 of MODERN WIRELESS, has aroused considerable interest, and the following description of another type of circuit using this principle will, no doubt, be of interest.

THE effects of double reaction are frequently masked or interfered with by natural reaction effects which are produced by the capacity coupling in a valve. Owing to the condenser action between the grid and anode of a three-electrode valve acting as a high-frequency amplifier, there will nearly always be an appreciable reaction effect, which at times may be sufficient for self-oscillation to be set up.

A particular example of this is in the tuned-anode-with-reaction type of circuit which was first described in my book "Thermionic Tubes in Radio Telegraphy and Telephony," and which has since that date become so extremely popular. In this circuit there is a tuned oscillation circuit in the anode circuit of the first valve, reaction being produced in this circuit by a coil which is coupled to it, and which is included in the anode circuit of the second valve. If we tightened the coupling between the two coils so as to increase the reaction effect, the strength of the oscillations in the tuned anode circuit would increase and there would be an increase in the ever-present small reaction effect between the tuned anode circuit and the grid circuit of the first valve. It therefore often happens that this unintentional reaction effect may be highly beneficial as introducing reaction into the aerial circuit. The unfortunate fact about this reaction effect is that it is not possible with the ordinary circuit to get the *maximum* reaction effect on the tuned anode circuit *and* on the aerial circuit; the reaction effect obtained is usually less on the aerial circuit, with the result that the maximum strength of signals is not obtainable.

In the original article on the double-reaction type of circuit which appeared in No. 1 of this journal, it was proposed that a reaction effect should be obtained from the anode circuit of either the first or second valve. A disadvantage of obtaining the double-reaction effect in this way is that it is still impossible to regulate the reaction in the aerial circuit without also causing some change in the reaction on the tuned anode circuit and *vice versa*. The result is that there is always trouble likely to arise owing to either the first or second valve oscillating when it should not.

To obviate these effects, the reaction in the aerial circuit is now obtained from quite a different source than the first or second valves; whereas the reaction on the tuned anode circuit continues to be obtained by coupling an inductance coil included in the anode circuit of the second valve to the tuned anode circuit. The actual method adopted is to obtain the reaction effect from a valve which is being used as a low-frequency amplifier.

The accompanying Fig. 1 shows a four-valve circuit which has given very good results, and in which a reaction effect, which may be adjusted right up to the critical value, is obtained in the aerial circuit; a similar reaction effect, which may be adjusted to the critical value, being obtained in the tuned anode circuit L_2C_2.

It will be seen that the first valve V_1 acts as a high-frequency amplifier, the coupling between the first and second valves being accomplished by the tuned anode circuit L_2C_2. The second valve V_2 acts as a detector, and in its anode circuit is an inductance coil, L_3, which is coupled to L_2 in such a direction as to produce a reaction effect in the circuit L_2C_2 for the purpose of increasing the strength of signals. The primary T_1 of a step-up transformer, T_1T_2, is also included in the anode circuit of the valve V_2, a condenser, C_4, having a capacity of about 0·002 μF., being used in the usual way as a by-path condenser. The secondary T_2 of the step-up transformer is included in the grid circuit of the third valve V_3, a by-path condenser, C_5, similar to C_4, being shunted across the winding T_2. The grid circuit of the third valve, however, also contains, next to the grid, an inductance coil, L_4, which is coupled to the aerial inductance L_1. The fourth valve V_4 also acts, like the third valve, as a low-frequency amplifier, an intervalve transformer, T_3T_4, being used to couple the valves V_3 and V_4. It is, however, to be noticed that in series with the primary T_3 and included in the anode circuit of the valve V_3, next to the anode, is an inductance coil, L_5, which is coupled to the aerial inductance L_1.

The three coils L_4, L_1, and L_5 might conveniently be three honeycomb or similar coils mounted on a stand, the two coils L_4 and L_5 being movable.

The operation of the circuit is briefly as follows. The coils L_4 and L_5 are moved away from L_1, the coil L_3 is still kept away from the coil L_2. The aerial circuit is tuned by the condenser C_1, and the tuned anode circuit L_2C_2 is tuned by the condenser C_2 until the loudest signals are obtained. The coil L_3 is now made to approach the coil L_2 to obtain a reaction effect, which should increase the strength of signals. If a decrease of signal strength is noticed the connection to the coil L_3 should be reversed and the process repeated. Having adjusted the coupling so that practically the maximum reaction effect is obtained in the circuit L_2C_2, without the second valve oscillating, the coils L_4 and L_5 are gradually made to approach the aerial inductance. An increase in signal strength should at once be noted, a slight retuning of C_1 being necessary. If a reduction of signal strength is obtained it will either be because the coils L_4 and L_5 are not of the correct size, or because the connections to one of the coils should be reversed.

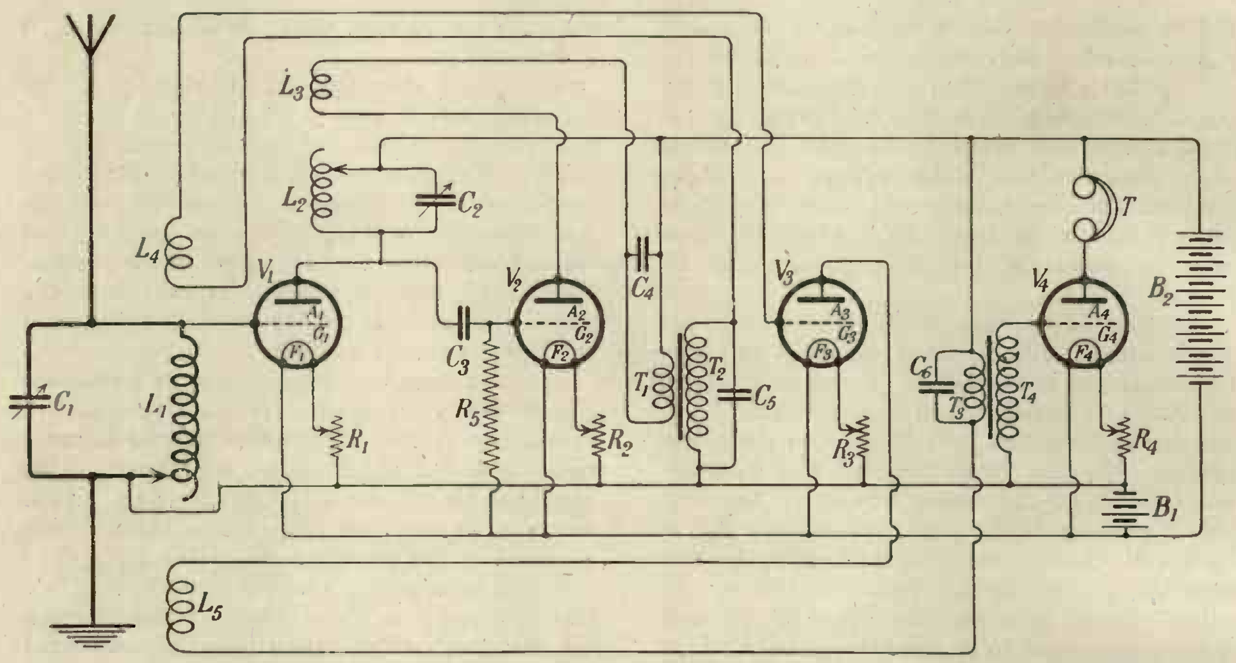


Fig. 1. The new circuit, which enables reaction effects to be produced in both aerial and anode circuits independently.

The effect of the two coils L_4 and L_5 is to introduce reaction to the aerial circuit, the valve which produces this reaction being the third valve, V_3, which, from a high-frequency point of view, is entirely separate and distinct from the valves V_1 and V_2. The method of using a valve in this capacity was fully explained in No. 1 of MODERN WIRELESS.

J. S.-T.

Obituary

IT is with the greatest regret that we have to announce the death, on the 17th of February, of Mr. T. W. Stratford Andrews, Chairman of the Radio Press, Limited.

His death is a great loss, not only to all who came into personal contact with him, but to the wireless and telegraph industry generally.

CORRESPONDENCE

Re Double Reaction

To the Editor of MODERN WIRELESS

SIR,—With reference to the article on double reaction in the February number of MODERN WIRELESS, a very good practical method of utilising the arrangement shown in Fig. 1 of that article is to use a 3-coil holder connected as shown in the accompanying diagram.

It will be seen that the centre (fixed) coil is the

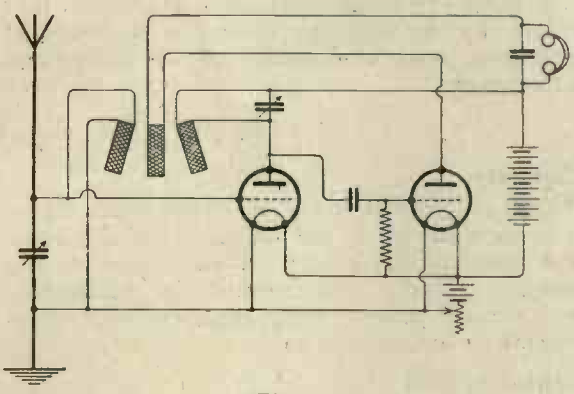


Fig. 1.

reaction coil, the two movable coils being the aerial and anode tuning coils respectively.

This arrangement has several advantages. It is very flexible, and can be used in several ways without changing the connections.

When both the outer coils are at right angles to the centre coil there is no reaction effect. By moving one or other of the outside coils closer to the centre coil reaction can be introduced into either the aerial or anode circuit as desired. If both the movable coils are brought closer to the fixed coil the double reaction effect is obtained.

This method dispenses with one of the reaction coils shown in the original diagram.

S.S. Hatasu. J. F. JOHNSTON.

To the Editor of MODERN WIRELESS

SIR,—I received and read with much pleasure No. 1 of MODERN WIRELESS, especially the description of your new invention: double reaction.

I thought that there were many possibilities in this very interesting invention, and I tried it on a new set of 2 H.F. and 1 L.F. valves.

I have pleasure in communicating the results:

(1) The selectivity is much better.
(2) Signals are much stronger than with single reaction.
(3) My set gained what we call in French a splendid *souplesse*.

As a point of comparison I may state that one of my friends is working with 4 H.F. valves on a splendid outdoor aerial and with single reaction; I work on an indoor aerial, half the length of the other, and I receive the concerts of Radiola (Paris) 50 per cent. better than my friend.

(Prof.) M. DAISOMONT.

The Seminary,
Roulers, Belgium.

A GLOSSARY OF TERMS USED IN WIRELESS TELEGRAPHY AND TELEPHONY

(*Continued from page* 198.)

Amplifier, H.F. (High Frequency)

Use indicated by its name. Almost always employs valves. Also known as Radio Frequency Amplifier.

Amplifier, L.F. (Low Frequency)

Use indicated by name. Usually used to denote a valve amplifier, but the term really includes microphone relays, etc.

Anode

Strictly, the point at which a positive current enters any piece of electrical apparatus. In valve practice a metal plate within the valve, the electron flow to which constitutes the output current. Term also used in X-ray and electrolytic practice.

Anode, Tuned

A form of reactance intervalve coupling (*see* Coupling) comprising the use in the anode circuit of an inductance tuned by a variable condenser across it. Very efficient. The word "circuit" is understood, although strictly neither the anode nor the anode circuit as a whole is tuned.

Antenna

See Aerial.

Aperiodic Circuit

A circuit which, owing to high resistance or other causes, either has no natural frequency or is so highly damped that free oscillations cannot occur in it.

Arc

When a circuit, carrying current, is broken a flame is seen at the break. This flame is largely used as a source of light, and also, under proper conditions, as a source of oscillations.

Atmospheric

In wireless work a current produced in the aerial by natural discharges of atmospheric electricity. Also known as " x's," " statics," or " strays."

Autodyne

See Heterodyne.

Auto-jigger

See Transformer.

B

Balanced Crystal

A method of eliminating jamming and atmospherics requiring two detectors in opposition, one being maintained in its most sensitive condition, the other not.

Battery

A chemical source of electric energy.

Battery, Filament

Sometimes called " A " battery in America. The supply (usually an accumulator) of energy by which the filament is raised to a temperature high enough to ensure a sufficient electron emission.

Battery, High Tension

Called " B " battery in America. The source of current in the anode circuit of a valve. Forms the supply for the valve output. Usually of small dry cells. Other sources of H.T. current are used, such as dynamos, etc., especially for transmission.

Battery, Primary

In this case the energy is derived from a non-reversible chemical change in the materials. When the change is complete the battery is useless and is scrapped.

Battery, Secondary

Also called storage battery or accumulator. A battery in which the change in materials is reversible. When the battery has been " discharged " it can be brought back to its original condition by forcing through it a current in the opposite direction to that which it gives itself.

Beat

When two alternating currents of slightly different frequencies are impressed on the same circuit, the resultant current has the peculiarity of waxing and waning. The period between two maxima is known as a " beat," and the number of beats per second is the beat frequency. It equals the difference between the two applied frequencies. Important in the reception of continuous waves. *See also* Heterodyne.

Bornite

A native sulphide of iron and copper ($2Cu_2S,Cu_2,S_2 2FeS$), used as a detector in combination with zincite. Potentiometer not necessary, but sometimes an improvement. Fairly firm contact. Appearance: metallic, crystalline, blue lustre.

Buzzer

A make-and-break mechanism similar to that of an electric bell. Important as a means of setting up weak local oscillations for testing and adjustment.

C

Capacity

That property of an electric circuit which allows it to store energy on the application of a voltage, and give up this energy on the release of the voltage. Usually concentrated in condensers, which may possess large capacity with small inductance and conductance.

Capacity, Self

The capacity to earth, etc., of all or any of the various objects comprising a set of wireless apparatus. Especially important in the case of inductance coils and (for short waves) in valves.

Carborundum

A compound of carbon and silicon (SC), made in the electric furnace, and used in wireless as a detector in contact with a metal plate. Potentiometer necessary. Heavy contact. Appearance: grey, green or purple (grey is best); somewhat like coke.

Cathode

See Kathode.

Chalcopyrite

A native sulphide of iron and copper (Cu_2S,Fe_2S_3) used as a detector in combination with zincite. Potentiometer not needed. Appearance: irregular lumps, brassy lustre. Often contains white crystals; these are useless.

Characteristic

In valve work generally connotes a curve or table showing the relation between grid voltage and anode current. In arc or crystal work, a curve showing the relation between applied voltage and resulting current.

(*To be continued.*)

TIMES OF REGULAR TRANSMISSIONS

This list, though short, includes only those stations actually heard in England.

TIME (G.M.T.)	CALL-SIGN.	NAME OF STATION.	WAVELENGTH.
Mid-night	GBL	Leafield	8,750 C.W.
0005–0205	FL	Paris	7,000
0100	POZ	Nauen	12,000 C.W.
0100	ICI	Guglielmo Marconi (Coltano)	5,250 C.W.
0120	GBL	Leafield	8,750 C.W.
0200	GKB	Northolt	6,850 C.W.
0200	GFA	Air Ministry	4,100 C.W.
0230	UA	Nantes	9,000 C.W.
0300	HB	Budapest	4,250
0315	FUA	Bizerta	5,150 C.W.
0330	FL	Paris	6.500 C.W.
0400	UA	Nantes	9,000 C.W.
0430	FL	Paris	7,400 C.W.
0550	ICI	Guglielmo Marconi (Coltano)	5,250 C.W.
0600	GFA	Air Ministry	4,100 C.W.
0600	IDO	Rome	11,000 C.W.
0635	LP	Berlin (Königswusterhausen)	5,250 C.W.
0650	LP	Berlin (Königswusterhausen)	5,250 C.W.
0700	POZ	Nauen	— —
0700	FL	Paris	3,200 C.W.
0715	FL	Paris	6,500 C.W.
0730	UA	Nantes	9,000 C.W.
0735	GFA	Air Ministry	1,681 C.W.
9740	SAJ	Karlsborg	4,300 C.W.
0750	BUC	Bucharest	7,500 C.W.
0800	EAA	Aranjuez	6,700 C.W.
0800	GFA	Air Ministry	4,100 C.W.
0835	GFA	Air Ministry	1,680 C.W.
0840	LP	Berlin (Königswusterhausen)	5,250 C.W.
0845	CNM	—	5,000 C.W.
0850	GFA	Air Ministry	4,100 C.W.
0850	LP	Berlin (Königswusterhausen)	5,250 C.W.
0855	STB	Soesterburg	1,680 C.W.
0904	YN	Lyons	15,000 C.W.
0915	GFA	Air Ministry	4,100 C.W.
0923–0930	FL	Paris	2,600 Spark.
0925	FL	Paris	2,600 Spark.
0928	ZM	Le Bourget	1,680 C.W.
0930	IDO	Rome	11,000 C.W.
0935	GFA	Air Ministry	1,680 C.W.
0958–1015	FL	Paris	2,600 Spark.
1000	FL	Paris	2,600 Spark.
1003	FL	Paris	3,200 C.W.
1028	ZM	Le Bourget	1,680 C.W.
1035	FL	Paris	2,600 Spark.
1035	GFA	Air Ministry	1,680 C.W.
1036–1049	FL	Paris	2,600 Spark.
1044	FL	Paris	2,600 Spark.
1050	ZM	Le Bourget	1,680 C.W.
1115	PCH	Scheveningen	1,800 Spark.
1128	ZM	Le Bourget	1,680 C.W.
1130	FL	Paris	2,600 Spark.
1135	GFA	Air Ministry	1,680 C.W.
1130–1205	FL	Paris	7,000 C.W.
1130–1300	FL	Paris	7,000 C.W.
1150	ZM	Le Bourget	1,680 C.W.
1155	POZ	Nauen	3,100 Spark.
1200	GBL	Leafield	8,500 C.W.
1200	ICI	Guglielmo Marconi (Coltano)	5,900 C.W.
1228	ZM	Le Bourget	1,680 C.W.
1230	UA	Nantes	3,400 Spark.
1235	GFA	Air Ministry	1,680 C.W.
1300	LY	Bordeaux	23,500 C.W.
1300–1415	FL	Paris	7,000 C.W.
1306	AN	Nimes	1,680 C.W.
1328	ZM	Le Bourget	1,680 C.W.
1335	GFA	Air Ministry	1,680 C.W.
1400	GFA	Air Ministry	4,100 C.W.
1400	GNF	North Foreland	600 Spark.
1415	UA	Nantes	9,500 C.W.

TIME (G.M.T.)	CALL-SIGN.	NAME OF STATION.	WAVELENGTH
1425	OPO	Brussels	1,680 C.W.
1428	ZM	Le Bourget	1,680 C.W.
1430	YN	Lyons	15,000 C.W.
1435	GFA	Air Ministry	1,680 C.W.
1435	FL	Paris	6,500 C.W.
1500	FL	Paris	7,300 C.W.
1500–1600	FL	Paris	7,000 C.W.
1505	STB	Soesterburg	1,680 C.W.
1525	OPO	Brussels	1,680 C.W.
1528	ZM	Le Bourget	1,680 C.W.
1535	GFA	Air Ministry	1,680 C.W.
1625	OPO	Brussels	1,680 C.W.
1628	ZM	Le Bourget	1,680 C.W.
1635	GFA	Air Ministry	1,680 C.W.
1715–1800	FL	Paris	7,000 C.W.
1800	POZ	Nauen	6,500 C.W.
1800	FL	Paris	6,800 C.W.
1830	POZ	Nauen	9,000 C.W.
1830	STB	Soesterburg	1,680 C.W.
1900	OUI	Hanover	9,500 C.W.
1900	GFA	Air Ministry	4,100 C.W.
1900–1930	FL	Paris	7,000 C.W.
1945	CNM	—	5,000 C.W.
1955	LY	Bordeaux	23,500 C.W.
2000	GBL	Leafield	8,750 C.W.
2000	SAJ	Karlsborg	2,500 Spark.
2000	EGC	Madrid	1,600 Spark.
2015	LY	Bordeaux	23,500 C.W.
2015–2200	FL	Paris	7,000 C.W.
2030	EGC	Madrid	2,000 Spark.
2045	IDO	Rome	11,000 C.W.
2130	LY	Bordeaux	23,500 C.W.
2200	FL	Paris	2,600 Spark.
2230	UA	Nantes	9,500 C.W.
2235	FL	Paris	2,600 Spark.
2236–2249	FL	Paris	2,600 Spark.
2244	FL	Paris	2,600 Spark.
2300	IDO	Rome	11,000 C.W.
2315	PCH	Scheveningen	1,800 Spark.
2330	POZ	Nauen	12,600 C.W.

Operating almost continuously :

FL	Paris	8,000 C.W.
GB	Glace Bay	7,850 C.W.
GBL	Leafield	8,750 C.W.
GKU	Devizes	2,100 C.W.
GLA	Ongar	2,900 C.W.
GLB	Ongar	3,800 C.W.
GLO	Ongar	4,350 C.W.
GSW	Stonehaven	5,600 C.W.
LCM	Stavanger	12,000 C.W.
IDO	Rome	11,000 C.W.
MUU	Carnarvon	14,000 C.W.
OUI	Hanover	14,500 C.W.
POZ	Nauen	12,600 C.W.
UFT	Saint Assises	15,000 C.W.
WGG	Tuckerton	16,100 C.W.
WII	New Brunswick	13,600 C.W.
WQK	Long Island	16,460 C.W.
WQL	Long Island	19,200 C.W.
WSO	Marion	11,500 C.W.
YN	Lyons	15,000 C.W.
LY	Bordeaux	23,500 C.W.

British Coast Stations Working Continuously on 600 Metres :

GCA Tobermory, GCB Lochboisdale, GCC Cullercoats, GCS Caister, GKR Wick, GLD Land's End, GLV Seaforth, GNF North Foreland, GNI Niton, GPQ Parkeston Quay, GRL Fishguard, GXO Crookhaven.

Continental Coast Stations Continuously Heard on 600 Metres :

FFB Boulogne, OST Ostend, PCH Scheveningen.

AN INDUCTIVELY-COUPLED CRYSTAL RECEIVER OF GREAT UTILITY

By ALAN L. M. DOUGLAS

THERE appear to be many experimenters at the present time who consider that the additional trouble incurred by the construction of an inductively-coupled tuner is not at all outweighed by the greater advantages accruing from its use.

This is an entirely erroneous idea, and it is only necessary to examine the better class of commercial receiving gear to realise that the leading designers of the day share the opinions of the author in regard to this matter.

Briefly speaking, greater — much greater — selectivity, sharper tuning, and increase in signal strength are the more important results from the use of an inductively-coupled tuner.

The receiver about to be described has a range of from 200 to 3,000 metres, and is one of great use for receiving medium-power spark and tonic train transmissions, as well as for British broadcasting, Paris time signals, and with a valve amplifier Continental telephony of all classes.

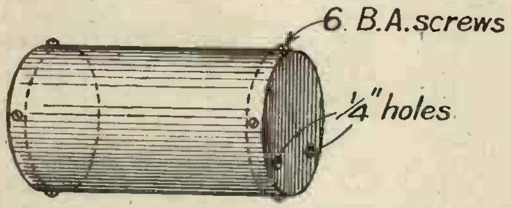


Fig. 1. Tube for secondary winding.

The first essential is the tuner itself. By a simple method of construction we are enabled to overcome most of the difficulties of mounting the two coils, and may now examine what materials we need to lay in.

In the first place, ebonite tubes should be used. Do not grudge the expense of these, as their perfect insulating properties and symmetry of outline more than compensate for the additional expense. " Isolo " tubes, a fibrous composition, will be found equally suitable, and may be a little cheaper. One tube, 6 in. in diameter and 10 in. long, will be required, and another, 5½ in. in diameter and 10 in. long, will also be needed. The first is for the aerial or primary coil, the second for the detector or secondary coil.

The 6-in. tube should be wound full of No. 24 S.W.G. enamelled copper wire, save for half an inch at each end. This may have a strip bared along the top of about 3/16 in. in width, to allow a sliding contact to press upon the wire and select the number of turns in use. The baring process is easily accomplished by rubbing gently along the surface of the coil with a piece of fine emery-cloth attached to a board about 1 in. in breadth. Care should be taken not to rub too hard, lest some of the actual wire be rubbed away, and all dust should be blown carefully off the coil afterwards.

This coil should be laid aside for a moment while we tackle the secondary coil—that is the 5½-in. diameter tube. It will be necessary to obtain two turned discs of ebonite of such a diameter as to be a close fit inside the ends of this tube. They may be attached to the tube by means of small screws, as in Fig. 1, and should have two holes drilled in them to take ¼-in. round brass rods. The tube and disc assembly should be a good sliding fit on these rods.

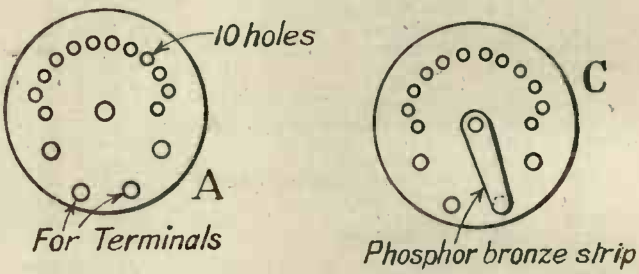


Fig. 2. Arrangement of secondary switch.

Looking at Fig. 2, we will see that one of these discs must be drilled with ten holes for contact studs, one for a switch-arm, two for stops for the switch-arm, and two for terminals. Fig. 5 gives the arrangement of these parts. The tube must now be marked off for drilling as in Fig. 3, from which it will be seen that there are ten tapping-points at progressive intervals from the left. This coil should be wound with No. 28 S.W.G. enamelled wire, and as each hole is reached the wire must be looped through it in such a way that the loops come out to one end of the tube, plus about 1 in.

This is for attachment to the contact studs. The mounting of the switch-arm and its assembly, together with the terminals, will be readily grasped from Fig. 5, which shows these parts fitted. Connection to the studs is made by looping a small portion of the wire which has been scraped clean behind each contact stud and screwing with a nut and washer.

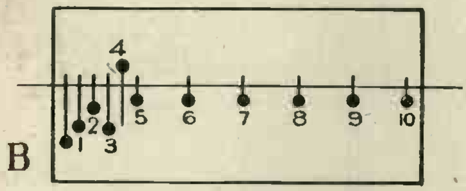


Fig 3. *Tapping points on secondary.*

We have now to consider the assembly of the whole instrument. A suitable base-board must be procured, which should be large enough to hold the entire tuner and the remainder of the apparatus. A suitable size is 24 in. long by 10 in. broad by 1 in. thick. At one corner, as indicated by Fig. 6 (which shows a plan of the base), must be drilled a clearance hole for a 2 B.A. screwed rod. A $\frac{3}{16}$ in. hole will be found correct.

This hole is marked A. A similar hole is to be drilled at B, and yet a third at C.

The larger tube must have $\frac{3}{16}$ in. holes drilled through it at X, Y, X_1, Y_1, and a 10-in. slider-bar and slider must now be procured. Any of the standard forms on the market may be

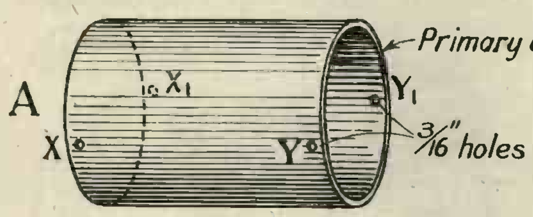


Fig. 4. *Details of primary tube.*

used for this purpose, and $\frac{3}{16}$ in. holes are to be drilled in this to correspond with the holes X Y in the primary tube.

Two strips of ebonite, Fig. 7A, should now be prepared. These should be 1 in. by 1 in. by 4 in., but may be made of wood if desired. They are to be drilled as indicated. The purpose of these is to support the rods for the secondary coil, which will be 24 in. long by $\frac{1}{4}$ in. in diameter, screwed for 2 in. at each end.

One piece of 2 B.A. screwed rod may be used to attach the primary coil, secondary support rod, and slider-bar to each other and to the base as shown, and another short piece must be prepared to hold the slider-bar the correct distance above the coil at Y.

The adjustment of the slider so that the proper tension is put upon the wire over the bared strip (which lies, of course, between the holes X and Y) is readily carried out by means of the nuts on the 2 B.A. rod. Care must be taken where the rod at Y is concerned not to let sufficient of it project into the centre of the

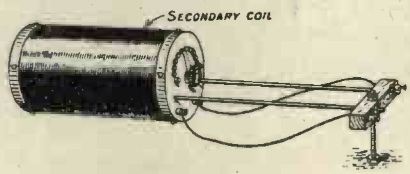


Fig. 5. *Assembly of secondary coil.*

coil to foul the secondary when it slides within.

The same arrangement is adopted to raise the coil above the base at the hole Y_1.

The guide-bar for the secondary coil rods may now be clamped exactly in the centre of the aerial coils by nuts above and below it (Fig. 9), and a rod erected through the hole will serve to hold the other support for the secondary firmly in place (Fig. 7B). These two must, of course, be in the same plane.

The $\frac{1}{4}$-in. rods should now be pushed through the secondary coil, and the ends passed through the front and rear supports and locked by the $\frac{1}{4}$-in. nuts. This will make the whole structure rigid and the position of the secondary with regard to the primary can be adjusted at will by screwing the rods up or down. This is a useful feature, and one which should commend

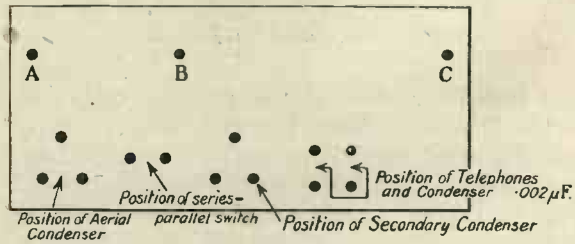


Fig. 6. *Plan of the base-board.*

itself to the builder who has not extensive workshop facilities.

Connection from the secondary coil should be made to two terminals mounted in the outside end support by means of flexible cable. This will be clear from Fig. 5. Having completed the construction of the tuner, the rest of the receiver will now have attention.

A condenser of 0·001 μF. capacity, and another of 0·0005 μF., will be required to tune the aerial

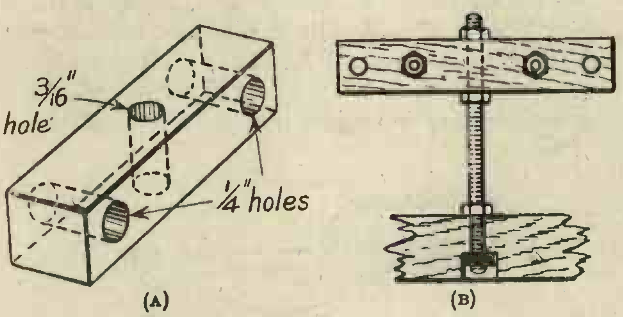


Fig. 7. Supports for the secondary.

and secondary circuits. A double-pole change-over switch, to function as a series-parallel switch, a crystal detector, and a small fixed condenser of 0·002 μF. capacity will complete the list of essential details.

The variable condensers should be purchased ready made, but instructions are given in so many books as to their construction that it is not thought necessary to go into these details here. They should be screwed down to the

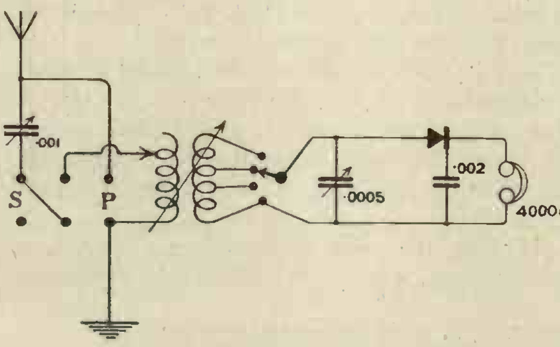


Fig. 8. The circuit of the receiver.

base-board in front of the primary coil, with the double-pole switch between them.

This latter should be one of the porcelain-base type switches, which may be readily obtained from accessory dealers, and its function is to put the condenser of 0·001 μF. capacity either into series with the aerial and primary coil for receiving short wavelengths, or in parallel for the longer wavelengths. A diagram of the circuit, and the arrangement of this switch in it, is given in Fig. 8.

Excellent detectors may now be bought for a very few shillings, and will be found to possess the necessary adjustments for the crystal, usually somewhat better made than would justify the making of such a detector by the experimenter. For those, however, who wish to construct their own instrument, detailed instructions

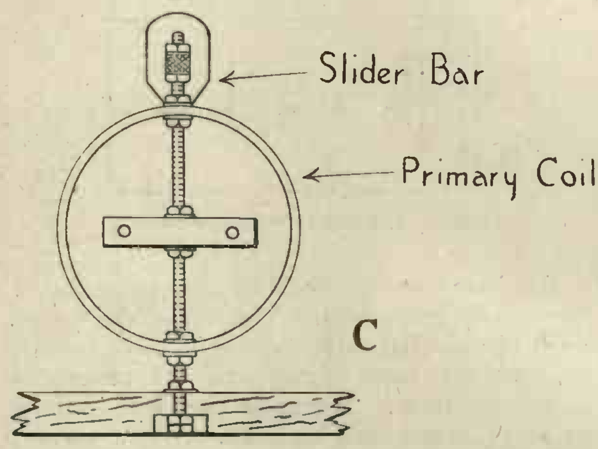


Fig. 9. Showing the position of the supports for the secondary within the primary.

will be found in the first number of MODERN WIRELESS, on page 56. A crystal of one of the specially treated substances known as "Permanite," "Radiocite," "Hertzite," etc., will be found to be extremely satisfactory.

The condenser of 0·002 μF. capacity, which is to be connected across the telephone terminals, may be readily bought as a complete article

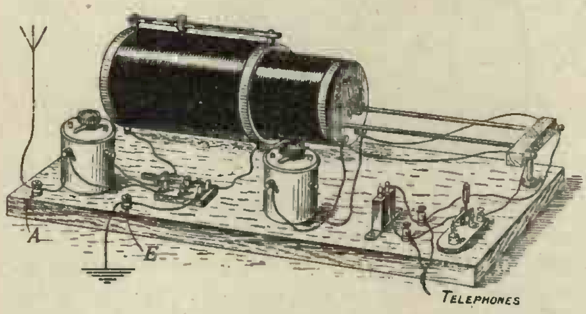


Fig. 10. Showing the appearance of the complete receiver.

suitable for mounting on the base-board, but for those who desire to make one for themselves the following dimensions will give this capacity: 15 foils, with a 2 by 1 cm. overlap, interleaved with mica of 0·005 in. thickness.

These should be firmly clamped between two brass plates or heavy pieces of ebonite, so as to bear with equal pressure on all points of the condenser.

Such a crystal receiver is well worth some trouble expended upon it, and will be found to provide wonderfully selective tuning for British broadcasting and ship work, for which purpose the aerial condenser should be in series. Other stations may be tuned in with the switch in the parallel position, and of course the Paris time signals may be tuned in anywhere in the British Isles by the use of this instrument.

The tuner will also prove of great use should the crystal enthusiast subsequently decide to embark on valve work, the great selectivity afforded being even more valuable here than with the crystal detector.

RECENT ADDITIONS TO OUR LIST OF EXPERIMENTAL CALL-SIGNS

Continued from page 155 of our last issue. To be appended to our "WIRELESS DIRECTORY," thus forming a complete and reliable list of commercial and amateur call-signs.

CALL.	NAME OF OWNER.	ADDRESS.
2 AB	Capt. H. de A. Donisthorpe	London.
2 AV	D. H. W. Swiney	Southend.
2 HR	F. O. Read & Co.	13/4, Gt. Queen Street, W.C.
2 PP	J. S. Knight	Clark's Hill Nursery, Prestwich.
2 PV	G. M. Clarke	Waverley Road, Kenilworth.
2 RQ	E. C. N. Strong	119, Church Lane, Handsworth Wood, Birmingham.
2 RR	W. V. Waddoup	56, Wellington Road, Handsworth Wood, Birmingham.
2 RY	S. Hanley	Forbury, Kintbury, Berks.
2 SA	Sir Hanbury Brown	Crawley Down, Sussex.
2 SS	Mr. Evans	Bradford Technical College.
2 SU	M. Eskdale	330, Manchester Road, Bradford.
2 UC	E. J. Winstone	West Kensington.
2 VU	J. W. Hobley	Mill Road, Wellingborough.
2 WJ	R. L. Royle	"Southwold," Alderman's Hill, Palmer's Green, N.13.
2 WY	A. W. Gamage, Ltd.	Holborn, London.
2 YX	F. E. B. Jones	Hill Crest, Wylde Green, Birmingham.
2 ZB	Clacton Electric Co.	Clacton-on-Sea.
2 ZG	W. J. Badman	9, Orchard Street, Weston-super-Mare.
2 ZS	F. J. Dinsdale	14, Highfield View, Stoneycroft, Liverpool.
5 AQ	D. Donet	10, Rovington Gardens, Putney, S.W.15.
5 AS	F. A. Bourne	10, Linley Road, Tottenham.
5 AY	T. F. Crowther	29, North Drive, St. Annes-on-Sea.
5 BG	J. B. Kaye	Close Hill, Huddersfield.
5 CA	N. L. Yates-Fish	19, Mansfield Road, Reading.
5 CC	Bath Electro-plating Works	Foxcombe Road, Bath.
5 DC	W. T. Aked	"Kasanli," Devonshire Road, St. Annes-on-Sea.
5 DD	Capt. M. H. Barnes	"Akabo," Ainsdale, Southport.
5 FL	T. W. Pevensey	Lewisham, S.E.
5 FM	Rev. Stone	Hon. Sec. Camberwell and District Wireless Club.
5 FS	W. A. Andrews	1, Balmoral Mansions, St. Andrew's Park, Bristol.
5 FW	S. I. Holt	St. Albans Road, St. Annes-on-Sea.
5 FZ	Lincoln Wireless Society	Lincoln.
5 GF	H. Stopher	14, Johnston Terrace, Cricklewood, N.W.12.
5 GJ	J. Bevis	Radex Villa, Linford Estate, near Stanford-le-hope, Essex.
5 GX	P. D. Tyers	30, Mildred Avenue, Watford.
5 GY	G. H. Horwood	Buckland, 557, Lordship Lane, S.E.22.
5 HD	H. St. John Ward	Blenheim Chambers, 1, Crowtree Road, Sunderland.
5 HY	B. Honri	Cromwell Hall, East Finchley N.2.
5 IC	F. C. Harney	Sunset Avenue, Woodford Green, Essex.
5 IG	J. E. Sheldrick	"The Brambles," Third Avenue, Denville, Havant, Hants.
5 JD	F. Bulmer	4, Carlton Terrace, Scarborough.
5 JG	R. F. Longley	Kilworth, 81, Langdale Road, Thornton Heath.
5 JM	W. Woods	8, Brighton Street, Barrow-in-Furness.
5 JX	M. G. Scroggie	37, Clung Gardens, Edinburgh.
5 KA	G. C. Beddington	"Stagsden," West Cliff Road, Bournemouth.
5 KO	F. W. Higgs	45, Howard Road, Westbury Park, Bristol.
5 KW	René Hodges	Holly Mount, Westdale Lane, Mapperley, Nottingham.
5 KX	W. Ward	Agent for 5 KW. portable.
5 LJ	E. Jackson	37, Manley Road, Whalley Range, Manchester.
5 LO	J. W. Clough	142, Revidge Road, Blackburn.
5 LP	J. H. A. Whitehouse	Brighton, Cheshire.
5 LZ	A. G. S. Quinn	61, Carnarvon Road, Stratford, E.15.
5 MC	W. Woodhams	24, Marlborough Place, Brighton.
5 MD	R. W. Hardistz	5, Ethelbert Road, Canterbury.
5 MU	C. W. Titherington	Dorset Motor and Coach Works, Dorchester, Dorset.
5 ND	J. H. Taylor	Macaulay Street, Huddersfield.
5 NH	A. C. Hulme	39, Poplar Avenue, Edgbaston, Birmingham.
5 NT	C. H. Friskarz	23, Tennyson Street, Lincoln.
5 NW	E. J. Allen	8, Westfield Place, Dundee.
5 OL	J. F. Cullen	68, Queen's Drive, West Derby, Liverpool.
5 PH	C. F. Metcalfe	Flacten Works, Halifax.
5 PS	J. E. Catt	"Melrose," Alexandra Road, Farnborough, Hants.
5 PU	T. Allison	33, Wilton Grove, Merton Park, S.W.
5 QV	F. L. Stollery	"Fairmead," Vista Road, Clacton-on-Sea.
5 RF	L. F. Hunter	18, Tansfield Road, Sydenham, S.E.26.
5 SC	British Broadcasting Co.	Glasgow Station.
5 SF	J. K. Wilkie	"Avondale," Knowsley Road, Cressington Park, Liverpool.
5 TA	V. I. N. Williams	"Mersk," Lees Road, Bramhall, Cheshire.
5 TF	P. A. Gooding	16, Cambridge Road, Hammersmith, W.
5 WA	British Broadcasting Co.	Cardiff Station.
5 ZH	Cromwell Engineering Co.	127, Fulham Road, S.W.

CIRCULATION OF No. 2.

This is to certify that we have printed 120,000 copies of No. 2 of Modern Wireless.

SPOTTISWOODE, BALLANTYNE & CO., LTD.

(*Signed*) R. Affleck, *General Manager.*

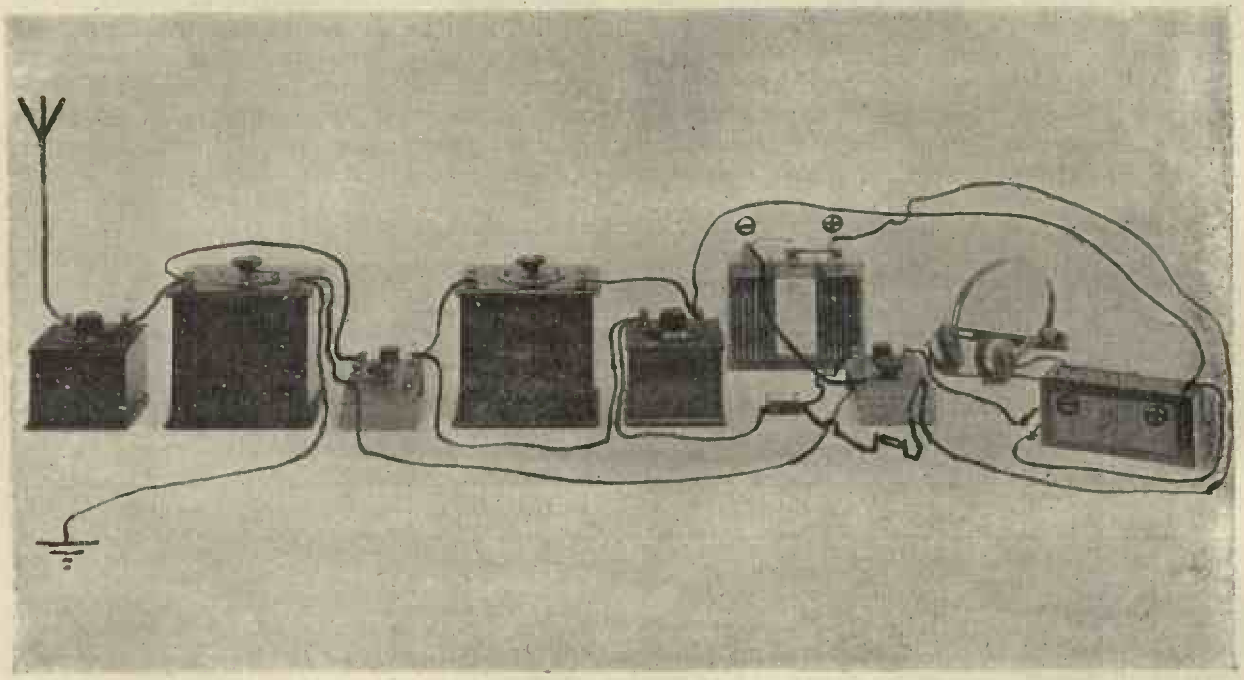


Fig. 1. The two-valve set.

THE CONSTRUCTION OF A TWO-, THREE- OR FOUR-VALVE RECEIVER COVERING A WAVELENGTH RANGE OF 200 TO 5,000 METRES

The following description relates to a receiver for British broadcasting, The Hague, Paris, and numerous other stations.

THE average listener-in sooner or later desires to hear signals from stations other than merely the British broadcasting centres. The concerts from The Hague and the concerts and weather reports from the Eiffel Tower, Paris, always have a fascination, and, moreover, the time signals sent out by Paris are particularly useful. The reader who desires to obtain signals from all these stations will be able to do so by carrying out the simple directions given below.

The apparatus may be arranged as a two-valve set, a three-valve receiver, or a four-valve set. It is proposed first to describe the arrangement of the apparatus to form a two-valve receiver. The three- and four-valve sets are made simply by adding one or two more simple units, the original apparatus need not be varied in any way.

Fig. 1 shows a photograph of the different units used in the two-valve set. A key to the arrangement of the apparatus will be found in Fig. 2. It will be seen that the apparatus used consists of the following :

Two variable condensers having a capacity of either 0·005 μF. or, preferably, 0·001 μF.

Two variable inductance units of different sizes.

Two simple valve panels of the same type.

One grid condenser.

One grid leak.

One 6-volt accumulator.

One high-tension battery.

One pair of telephone receivers of high resistance.

Fig 2 shows the general appearance of these different items, and also shows how to connect them up. Fig. 3 shows the circuital arrangement of the apparatus. It will be seen that the aerial circuit is tuned by means of a variable condenser, C_1, and a variable inductance, L_1, the latter being variable by means of a switch moving over 12 studs, which are connected to 12 tappings from the inductance coil L_1. One end of the coil L_1 is connected to the grid G_1 of the valve V_1. In the anode circuit of the valve V_1 is another variable inductance, L_2, different from the first

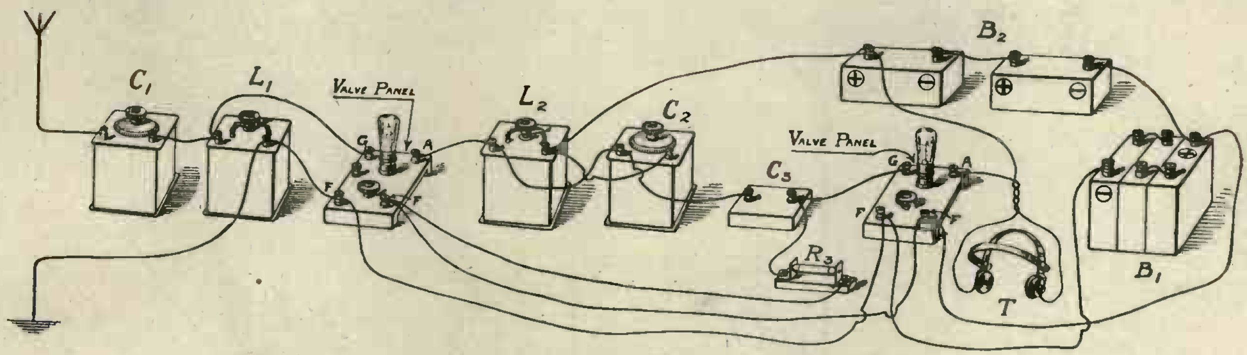


Fig. 2. Connections of the two-valve set.

in that it is larger and has 15 tappings. In parallel with this is a variable condenser, C_2. The aerial circuit and the tuned anode circuit L_2C_2 are tuned to the wavelength of the incoming signals. The condenser C_3 has a capacity of about 0·0005 or 0·00025 μF., preferably the latter. This condenser may be bought for about

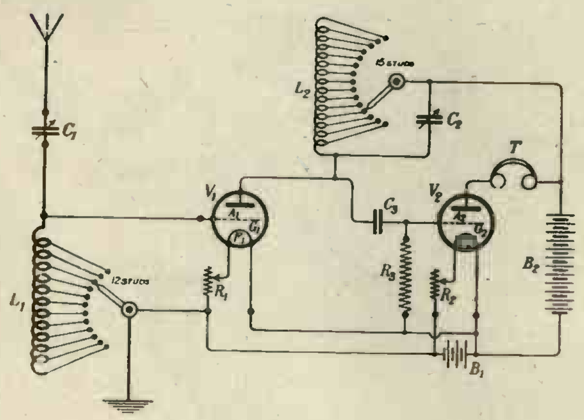


Fig. 3. Circuit of the two-valve receiver.

2*s.* 6*d.*, but instructions are given for making such condenser.

R_3 is a grid leak connected between the grid G_2 of the second valve and the positive side of the filament accumulator B_1. This leak has a resistance of about 2 megohms, and may be made according to instructions which have been given in MODERN WIRELESS, or may be bought. Grid leaks are now so cheap that most readers will prefer to buy them.

In the anode circuit of the second valve we have the telephones T. No further comment is needed on this arrangement of apparatus, and we will now proceed to describe the construction of one or two of the component parts. It is not proposed to describe the construction of the variable condensers as such descriptions have often been given, and in any case most experimenters prefer to buy their own condensers.

The First Inductance (L_1)

This inductance is mounted as a separate unit in a special box, measuring about 6½ in. by 5 in. by 6½ in. This box is made out of wood about ⅜ in. thick. These boxes may be purchased ready made for two or three shillings, or they may be made at home. The tops and bottoms of the boxes may protrude over the edge of the vertical walls for the sake of appearance.

Fig. 4 shows the outward appearance of the completed inductance unit. It will be seen that there are two terminals, T_1 and T_2, to which connection is made. A rotary switch, S_1, has an arm passing over 12 equally placed brass studs. A screw is placed at each end of the semi-circle to prevent the switch-arm from slipping off the last stud. The switch-arm should preferably be purchased, and this and all the other parts mentioned in this article may be purchased from advertisers in this journal who state that they are prepared to supply such parts.

The spacing and size of the studs is of importance if a smooth adjustment is to be obtained. Using studs of normal size, ⅜ of an inch may be allowed for each one. That is, the studs are to be placed with a distance of ⅜ in. between the centre of one and the centre of the next. A switch-arm with a radius of 1½ in. will suit the size of the box-lid, which is 7 in. by 5½ in., and it should be of the type illustrated in Fig. 4.

The inductance coil itself is shown in Fig. 5. This is a cardboard tube measuring 4½ in. in dia-

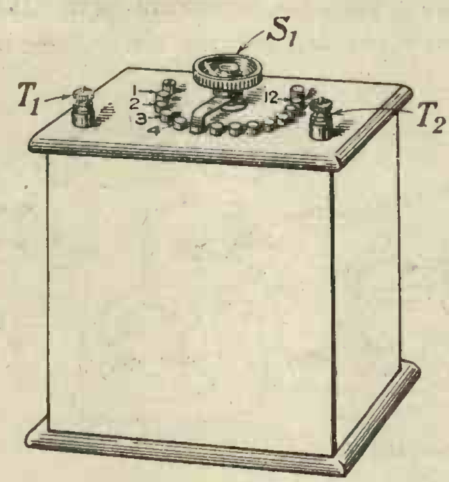


Fig. 4. *Showing the appearance of the finished inductance unit.*

meter and 4½ in. long. It is wound for practically the whole of its length with No. 26 single silk-covered copper wire. The total number of turns is 120, and 12 equal tappings are taken from the

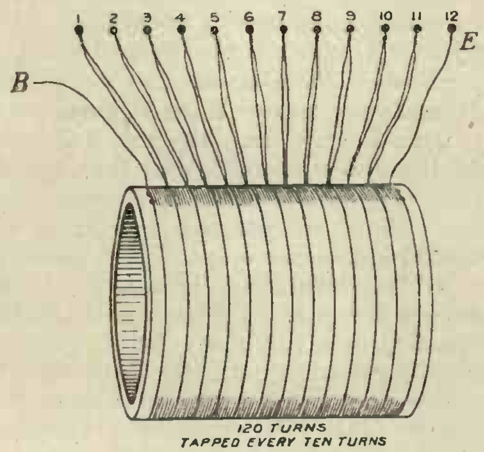


Fig. 5. *Illustrating the method of winding the inductance coil with* 12 *tappings.*

coil. One end of the coil is taken to the terminal T_1 shown in Fig. 4, and the first tapping is taken at the tenth turn and goes to the stud marked "1." The other end of the coil goes to the stud marked "12." Tappings are taken by means of "looping" the wire, giving it a twist near the tube, and then continuing. Each loop should be about 7 or 8 in. long. The ends of these loops are bared with a knife and soldered to their respective studs. Having fixed all the loops to the underneath ends of the studs, the coil is fitted into the box container.

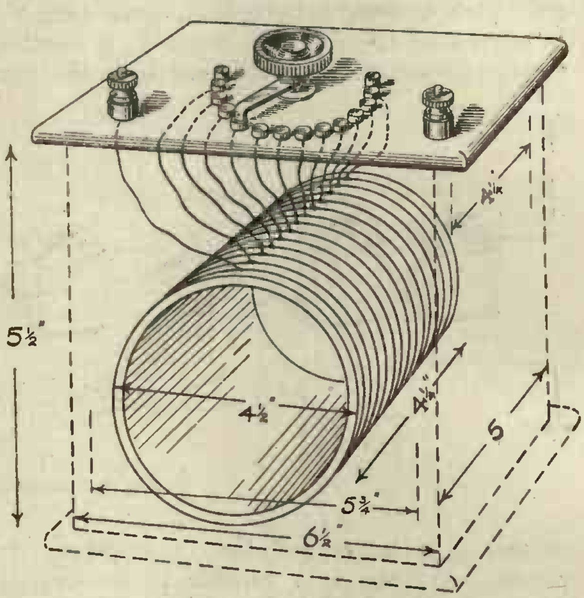


Fig. 6. *The coil in position.*

Fig. 6 shows the arrangement of the loops, with the inductance loosely in position inside the box container. There is no need to fix

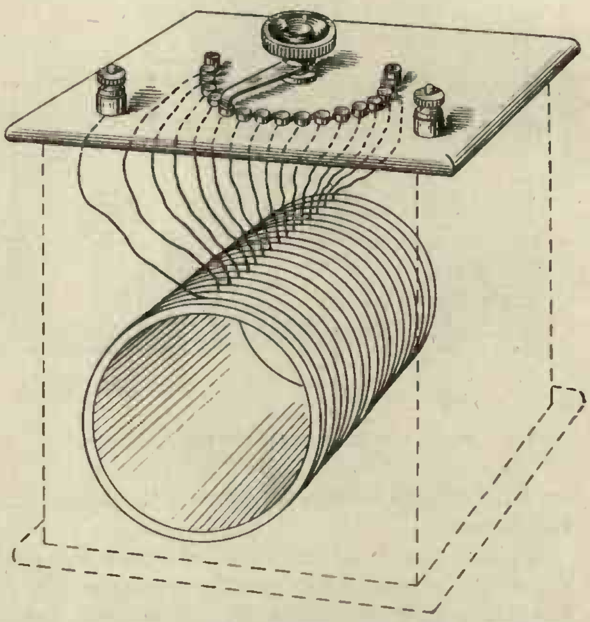


Fig. 7. *The second inductance, showing the* 15 *tappings.*

the inductance inside the container in any way. The length of the inductance coil is such that it should just fit into the box container; hence there is no need to secure it in any way as the coil will rest comfortably at the bottom of the box. If it is desired to move the inductance coil about, it is advisable to fix the cardboard tube into the box by means of a small wedge.

The second inductance (L_2) is made in exactly the same way as the first, and the boxes are the same size. The only difference is that this time the cardboard tube is wound with No. 36 double cotton-covered copper wire, and there are 15 tappings taken.

Fig. 7 shows the second inductance box. It will be seen that there are 15 contact studs and that the 15 tappings are taken at equal distances along the coil, which is wound for practically the whole of its length with No. 36 gauge wire. The total number of turns is 250 and the 15 tappings are taken at equal distances.

The Grid Condenser

The grid condenser will usually be bought, but it may be made as shown in Figs. 8 and 9. All that is needed is a wooden base-board, a photographic ¼-plate which has had the film removed

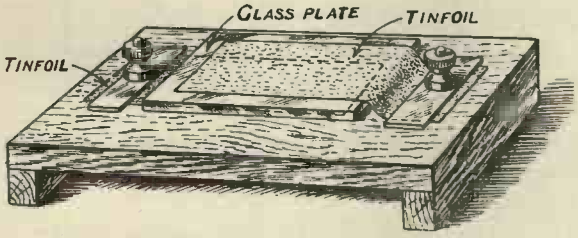


Fig. 8. Illustrating a home-made grid condenser.

by washing in boiling water, and two sheets of tin-foil. The sheets of tin-foil are cut to a size of 2⅝ in. by 4¾ in. One is seccotined to the wooden board and the ¼-plate is then placed over it.

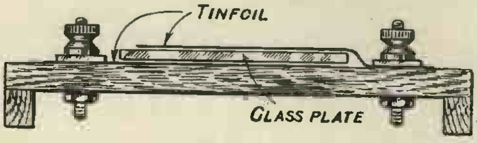


Fig. 9. Side view of the grid condenser.

The other sheet of tin-foil is now gummed to the under-surface of the ¼-plate and the overlapping edge is taken out from the other side. The two overlapping edges are now connected to two terminals, one at each end of the condenser, and gripped by a strip of brass, pressing down on the tin-foil to make contact with it.

The general method of construction of this type of condenser has already been described in the booklet, "Simplified Wireless."

The Grid Leak

A holder for the grid leak is shown in Fig. 10, although a grid leak, either variable or fixed, may be made by the reader himself. Descrip-

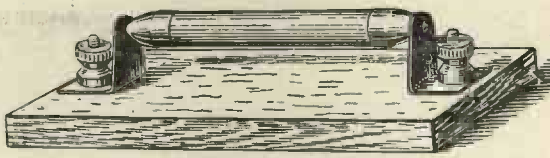


Fig. 10. The holder for the grid leak.

tions of suitable grid leaks have already been described in Nos. 1 and 2 of MODERN WIRELESS.

The Valve Panel

Fig. 11 shows a valve panel of suitable design. It simply consists of an ebonite valve-holder, V_1, which is fastened to a wooden base-board, W, mounted on two small ledges to keep it off the level of the terminals, and to allow for the wiring,

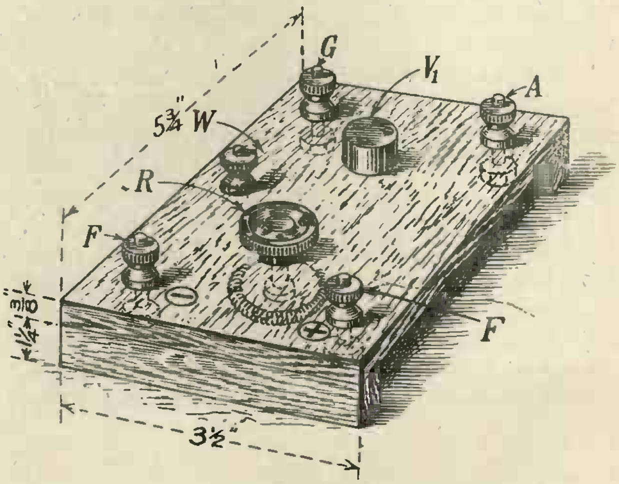


Fig. 11. Illustrating a suitable valve panel.

etc., underneath. Four terminals, G, A, and the two terminals F, are provided, and are preferably of the Army 4 B.A. type. A rotary rheostat, R, which should be bought, is mounted on the base-board, and the connections to the different parts are made as shown.

Fig. 12 shows what is a clearer wiring diagram of the panel. It would be preferable to mount such a valve-holder on an ebonite base, but quite satisfactory results may be obtained by using a wooden board.

Arrangement of the Completed Apparatus

Having described the individual components, it simply remains to refer to Fig. 2, which shows how the different parts are connected together. The high-tension battery should have a value of from 45 to 70 volts, preferably the latter value. The accumulator should be a 6-volt one, and should have an actual capacity of not less than 30 ampere hours.

Operation of the Set

When receiving broadcasting, the switch on the first inductance L_1 should be on one or other of the first four studs, and the variable condenser should be varied until signals are heard.

As regards the tuned anode circuit, different studs and different values of the condenser C_2 should also be tried with different adjustments of the aerial circuit. Probably the best way of adjusting the set is to try varying the aerial circuit while the tuned anode circuit is at a given adjustment. If signals are not picked up try another stud or another value of condenser on the intermediate oscillation circuit, and again try different adjustments of the aerial circuit.

If it is desired to receive longer waves, such as the 2,600-metre waves from the Eiffel Tower, Paris, the condenser in the aerial circuit should be shunted across the inductance L_1 instead of in series with it.

The arrangement of the apparatus shown in Fig. 2 would now be modified. The aerial wire would now go to one terminal of the inductance box without the current having to pass through the condenser. One terminal of the condenser is now connected to the aerial terminal and the other terminal of the condenser is connected to the earth terminal. The effect of increasing the capacity of the condenser will now be to increase the wavelength to which the set is tuned, and it is possible in this way to adjust the set to wavelengths somewhere between 4,000 and 5,000 metres, whereas when the aerial condenser is in

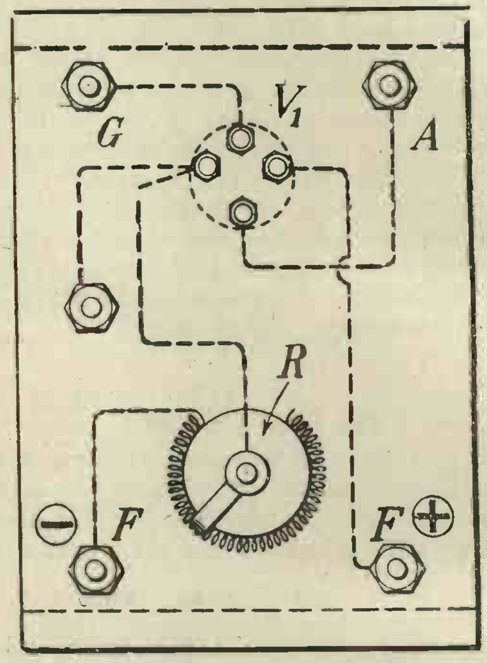


Fig. 12. Wiring of valve panel, seen from above.

series with the aerial inductance L_1 it is possible to go down to a very low wavelength.

Modifications necessary to Change the Set into a Three-valve Receiver

A description will be given in our next number of the additions required to connect the set into a three- or four-valve receiver. All the apparatus required for the two-valve set will be employed in the larger one, however.

AN ANNOUNCEMENT

Commencing with our next issue each number of MODERN WIRELESS will have a fresh cover-design. The familiar orange and black top and bottom panels, however, will be retained.

THE BROADCASTING COMPANY AND THE EXPERIMENTER

THE British Broadcasting Company has now been formed and is in working order, their temporary offices being at Magnet House, Kingsway. This Company is composed of *bona fide* wireless manufacturers, who have combined together to provide the concerts and other entertainments which are now broadcasted from the various stations in different parts of the country. In providing suitable broadcast programmes an expenditure of £50 per night per station would appear reasonable, but this amounts to a sum of £150,000 per annum for eight stations, and in order that a high standard of programme may be maintained the Company is naturally anxious to secure this revenue. The general public who desire to buy sets for receiving broadcasting are compelled to buy a set marked with the letters "B.B.C.," which stand for "British Broadcasting Company." In the case of every set so marked the manufacturer has to pay to the British Broadcasting Company a certain sum, which helps to provide the entertainment. The broadcasting licence, which is obtainable at any Post Office for 10*s*., also helps the Broadcasting Company, as 5*s*. of every wireless licence issued goes to the British Broadcasting Company, the other 5*s*. going to the General Post Office.

Mr. A. R. Burrows, the programme director of the B.B.C.

What the Broadcasting Company now complain of is that experimenters who make their own sets or assemble component parts frequently listen-in to and enjoy entertainment provided by the British Broadcasting Company without contributing to the revenue of that Company by buying their apparatus. They regard the 5*s*. of the licence fee as a totally inadequate sum, and are desirous of having the experimenter's licence fee increased.

In this connection it is to be feared that there is a danger of the standard of qualifications being increased, in order to limit the number of experimental licences issued, and to exclude the man who wants to make his set simply for the sake of receiving broadcasting. Recently a committee of the Radio Society of Great Britain attended a conference with the Post Office officials, and recommended that the licence fee should be increased somewhat, provided experimental licences were freely given.

We ourselves will do all in our power to prevent a limitation of the number of experimental licences. The experimenter is the salt of the earth, and anything which prevents his legitimate work is inimical to the best interests of wireless progress. Experimental licences must be freely given, and it is both impracticable and unreasonable to lay down a standard of technical qualifications. It is only by having an experimental licence and working on their own that beginners can hope to learn about wireless. If they were only to be given experimental licences when they had technical qualifications, they would never obtain a start. The Post Office officials have been very reasonable, but there is no doubt that considerable sympathy is felt in many quarters for the natural desire of the British Broadcasting Company to obtain some financial support from the man who makes his own set. The Broadcasting Company has now plainly stated—if at rather a late date—that it desires the full support of the experimentalist movement. They will, no doubt, now give us *detailed* information regarding the financial aspects of the case so that we can examine more closely their suggestions for a fair settlement of what is plainly a difficult, and certainly an unprecedented, problem.

Meanwhile, readers may rest assured that this journal intends to oppose, as I myself have always previously opposed, any restrictions which will make it more difficult for beginners to construct and experiment with their own sets.

QUESTIONS AND ANSWERS

We invite readers to write to us when any technical difficulties in connection with wireless are encountered. All letters must be addressed to : The Editor, " Modern Wireless," Devereux Court, Strand, W.C. 2, and envelopes are to be marked " Query " on the top left-hand corner. Not more than three questions are to be asked in each letter, which should be typewritten or clearly written in ink upon one side of the paper only, and must be accompanied by a " query " coupon, cut from the current issue. Sketches or diagrams should be supplied whenever possible and should be clearly drawn in ink upon a separate sheet and be attached to the letter. Will readers please note that we cannot under any circumstances answer queries by post.

C. L. (Thornton Heath) asks whether it is possible to supply the filament current of valves from wet batteries.

It is not possible, or, at any rate, not convenient, to work the filaments of ordinary valves from wet primary batteries. There are, however, certain valves upon the market known as low-temperature emitters which require so small a filament current that they can quite well be supplied from ordinary dry cells of a fairly large size.

G. F. S. (Rotherham) refers to the licensing of home-made apparatus.

It is very difficult at the present time to advise you on this matter because we understand that the whole question of licences for the use of home-made broadcast receivers is under review by the Post Office authorities. At present it is not possible to use a home-made set under the broadcast licence, but we understand that there is some prospect of a new type of licence being created to enable this to be done.

J. N. C. (Muswell Hill) refers to the article on " Dual Amplification," on p. 87 of MODERN WIRELESS (No. 2), and asks for certain information.

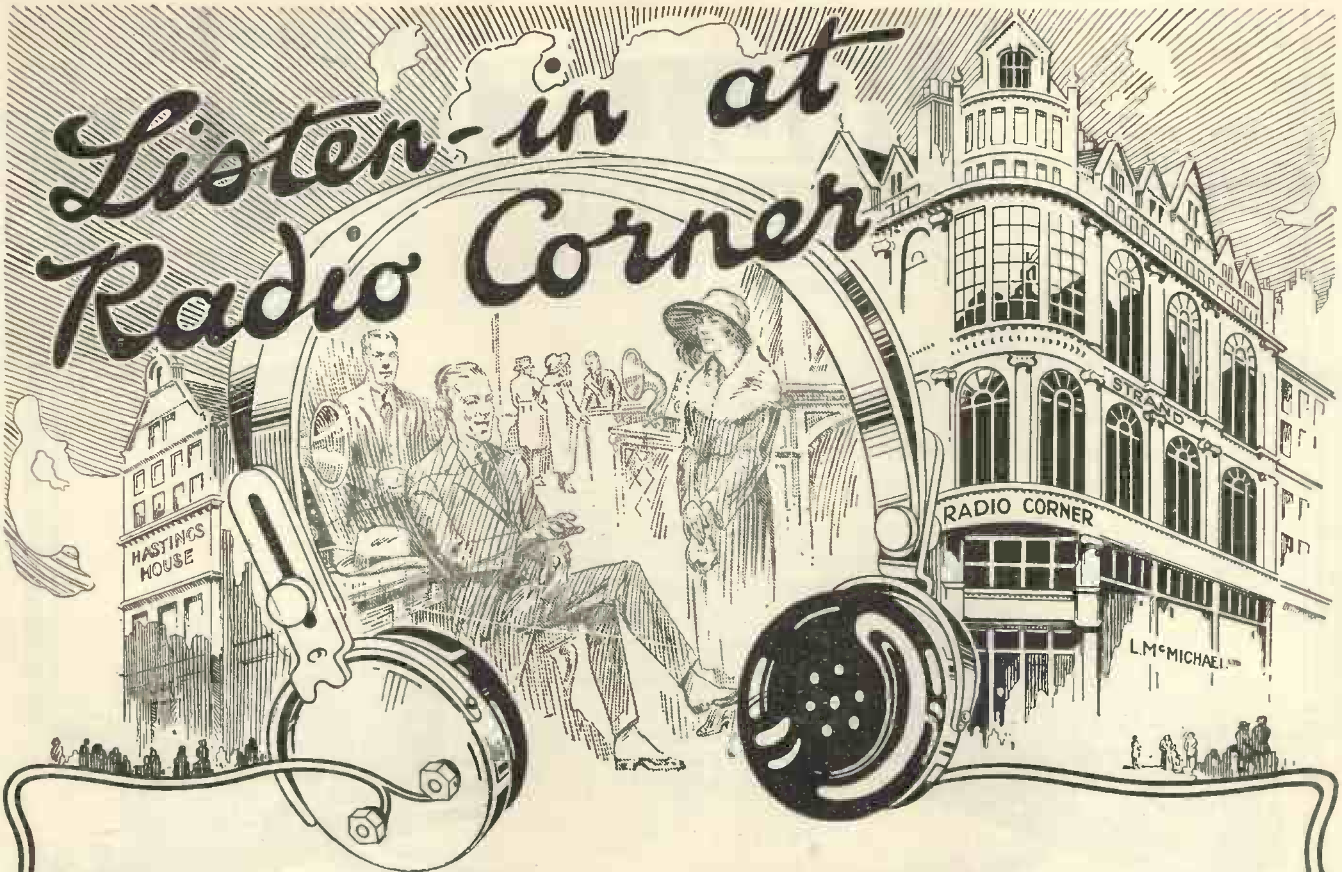
The following are suitable values for most of the components required to construct the circuit shown in Fig. 7. We should warn you that these circuits are not, as a rule, very easy to work and a certain amount of adjustment of the various constants is generally necessary. The coils L_1, L_2, and L_3, should be suitable plug-in coils, such as honeycomb coils, of a size requisite to give the wavelength which you desire to receive. The condenser C_1 should have a capacity of about ·001 μF., and should be connected in series with the aerial for short-wave reception. Condenser C_2 may have a capacity of about ·0003 μF., and condenser C_4 a capacity of the same value. The condensers C_5, C_6, and C_7, should have a fixed capacity of about ·002 μF., while the condenser C_3 should be of about ·0003 μF. capacity. The detector D in the figure should be of a type which does not require a potentiometer, such as a hertzite crystal. The remainder of the components used in this set should have normal values.

H. J. C. (Epsom) refers to the article on " Choke-control and Choke-control Modulation," on p. 97 of MODERN WIRELESS (No. 2), and asks for the necessary constants of the circuit in Fig. 4.

The values which you require are as follows : Coil L_1 may be a coil wound with, say, No. 18 double cotton-covered wire upon a tube 3 in. in diameter by 4 in. long, with tappings taken from every ten turns. The coil L_2 should be wound with No. 28 double cotton-covered wire, with about the same total number of turns, with perhaps five tappings taken from it, and so arranged by being wound upon a smaller tube that it can slide into coil L_1 so as to vary the coupling. The condenser C_1 should have a capacity of about ·001 μF. The condenser C_2 should preferably be variable with a maximum capacity of about ·0005 μF., and the resistance R should have a value of about 10,000 ohms. We should not advise you to wind the choke or the transformer for yourself, since it is difficult to do so satisfactorily, and it is generally better to obtain these components from a maker. The voltage of the battery B_2 will depend upon the type of valve you use, but in any case should not be less than about 200 volts. The range of the set will depend upon many things. For example, the size of the valve used—that is, its rated power ; the voltage of the battery B_2, the quality of the aerial and the skill of the manipulator. It should be quite useful up to distances of twenty miles when batteries are used for its supply.

C. H. W. (Moreton) asks for sizes of basket coils.

As you do not say what wavelengths you desire to receive, it is rather difficult to advise you what size to make your coils. The best way to arrange for tuning over a range of wavelengths of, say, 300 to 600 metres with basket coils is to wind a series of these coils and mount them on some sort of plug-in arrangement so that they will be interchangeable in the circuit. Suitable numbers of turns for such a series are as follows : 30, 45, 60, 75, 100, 125, 150 turns. This series should be sufficient to tune over a considerable wavelength range when using various different types of circuits.



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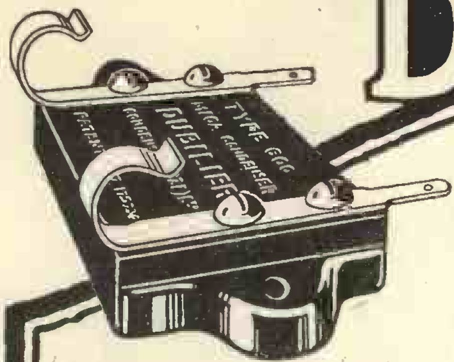

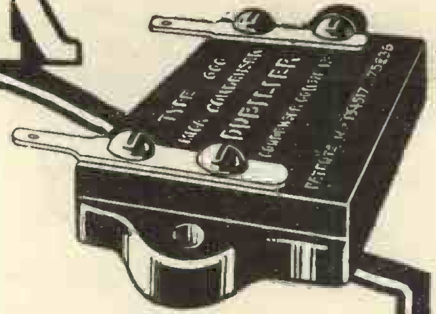

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For close mounting in wireless receivers, space occupies 2⅜ in. × ⅜ in.

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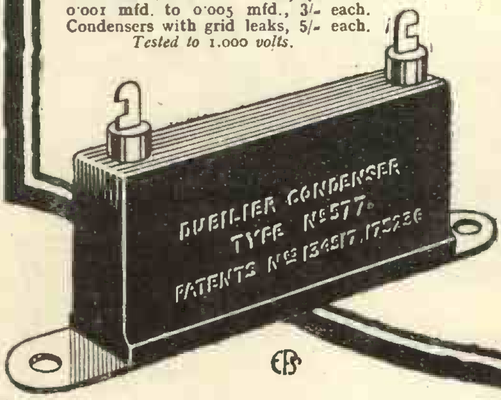

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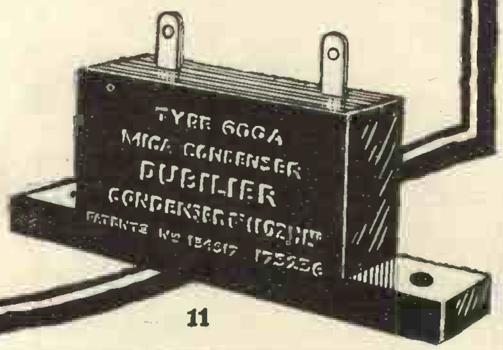

11

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Telephone: Willesden 3055 (3 lines). *Telegrams: "Milliamp, 'Phone, London."*

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"A G.R.C. Radiophone in every home."

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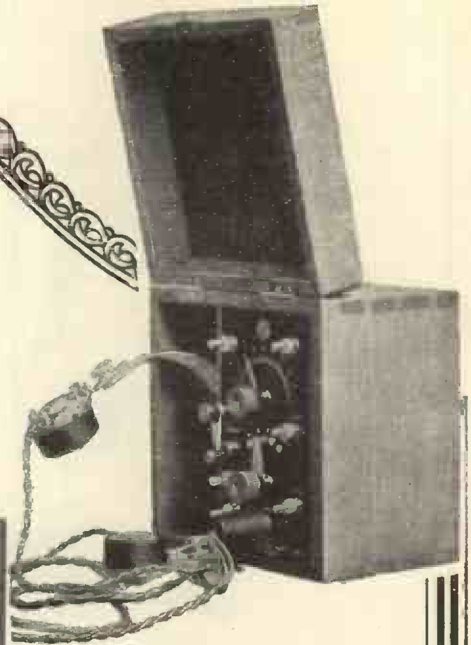

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ARISTOPHONE RECEIVER 55

A high-grade, self-contained 2-valve receiver for British Broadcasting.
Can be supplied fitted with Long-wave Selective Reaction Tuner for receiving, in addition, Paris and The Hague.
Other models in 3 and 4 valves.

ARISTOPHONE RECEIVER 11A

A complete high-grade crystal receiver of the Panel Series. Brown's type "A" adjustable supersensitive Head Telephones are supplied as a standard feature and are contained in the case.
Exceptionally fine results can be obtained with this instrument.

A complete range of cabinets in all periods, embodying the highest grade 4-valve receivers and the finest cabinet work.

Write for particulars of the complete range of Elwell Wireless, Dept. M.W.

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Telephone: Regent 1007. Telegrams Elradioeng Westcent London

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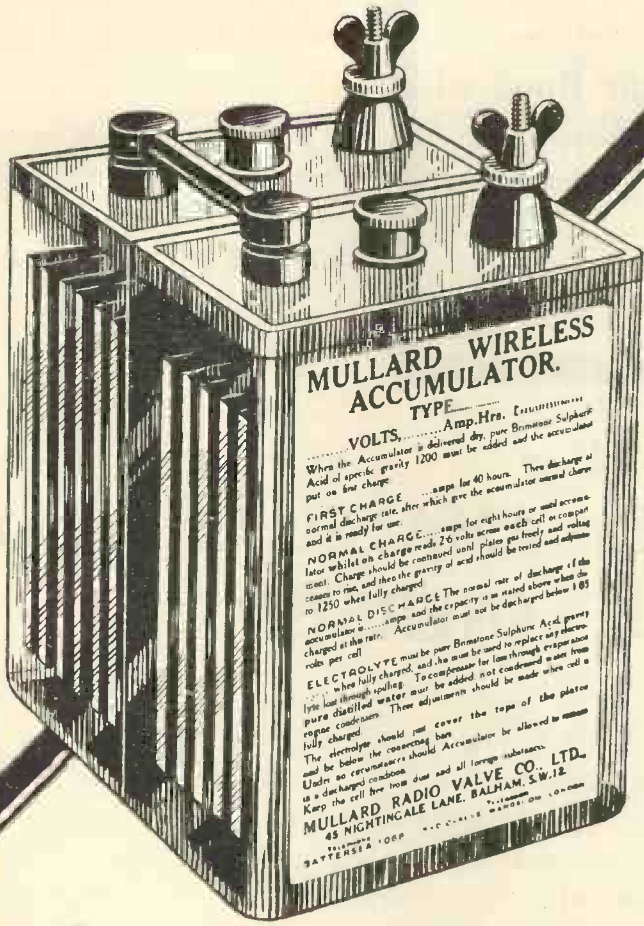

The same high standard of reliability and efficiency of the "ORA" Valve will be found in

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37

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TYPE	VOLTS	CAPACITY CONTINUOUS RATING AMPS. HRS.	PRICE £ s. d.
M.1	4	10	1 0 10
M.2	4	20	1 8 10
M.3	4	30	1 14 10
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2M2	6	20	2 1 2
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Delivery ex-Stock.

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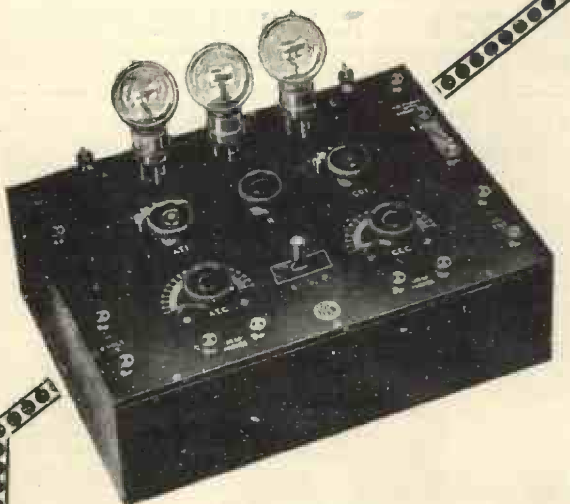

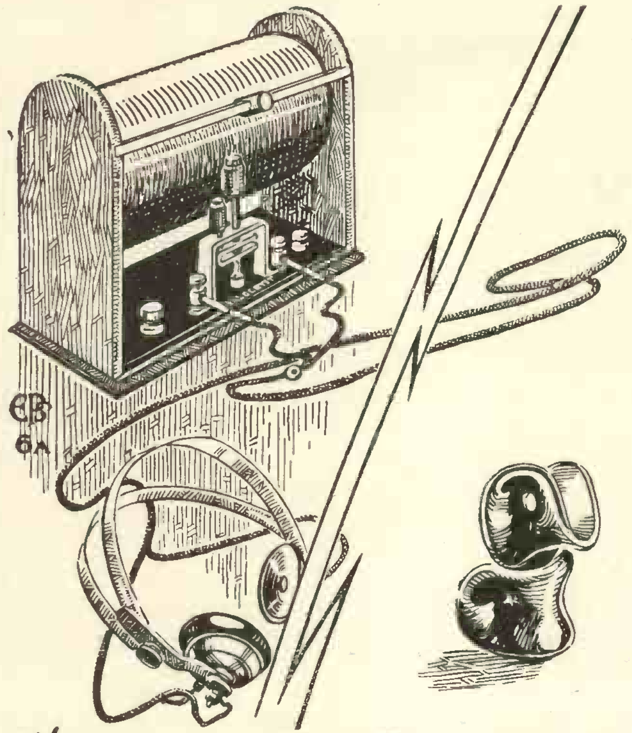

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This is an excellent crystal receiving set, which gives very good results on all wavelengths from 300 to 1,500 metres, and is suitable for receiving broadcasting from ships and long-distance stations.

The adjustments are simple and easily made, and the silicon crystal detector well maintains its sensitive state.

No batteries are required. The set is sent out complete and includes 100-ft. coil of 7/22 stranded copper aerial wire, 2 shell insulators and one pair 4,000 ohms double headphones.

Every set is tested and guaranteed to receive broadcasting up to 15 to 20 miles, and Morse signals from much greater distance.

The "FELLOCRYST" is British Made throughout, and Approved by the B.B.C. and Postmaster-General.

PRICE Complete £3 : 15 : 6
Inclusive of all taxes. Postage 1/6 extra.

Extra 4,000 ohms double headphones ... 21/6
Inclusive of all taxes. Postage 1/-

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For they are jolly good Fellows

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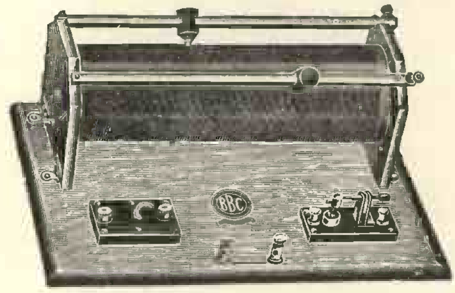
APPROXIMATE RANGE, 30 MILES.



Double Slider Tuner, handsomely mounted on polished base. Tested and guaranteed, complete with 100 ft. aerial wire, 2 insulators and lead-in terminal, 1 pair B.B.C. Headphones, and B.B.C. royalty **£4.**

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Broadcast Receivers
are undoubtedly the best obtainable by reason of comparative tests

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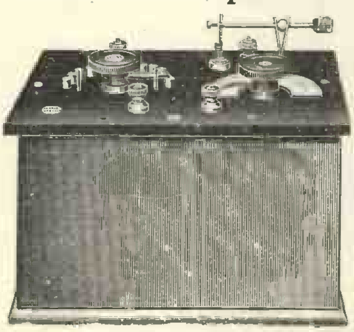

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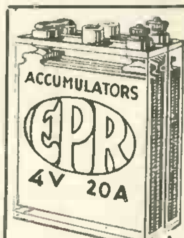
Manufacturer of Distinctive Radio Apparatus.
BRAINTREE, ESSEX



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Accumulators charged on the premises day and night.

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No.	Voltage.	Ignition Cap. Amps.	Act. A.H. Cap.	Price.
1000	4	17	8	9/11
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Specialities:
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Complete in plush-lined case, very reliable, 6/11
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Genuine 7/22 bare copper stranded, 100 ft. **2/6**

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Ebonite with brass ends, 6 in., **10d.**; 9 in., **1/-**; 12 in. **1/2**

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Large **3d.** doz., small, doz. **2d.**
Cheaper for quantities

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Very Special. Positive stops at Zero, full resistance **3/6**

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Best bushed knob with 4-leaf laminator switch **1/3**
(Also another pattern at **1/6**)

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7 in set **5/-**

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Highly finished ... ... doz. **5d.**

Nuts 2 BA and 4 BA, 3 doz. ... **8d.**

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W.O., Telephone, P.O., and other designs, with nut and washer, 2 for ... ... **3½d.**

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Glass covered, dust proof, extra quality **4/6**
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Mica condensers in ebonite with terminals, all capacities **1/3**

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Valve Sockets ... per doz. **1/-**

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TRADE SUPPLIED. CALLERS ONLY. NO POST ORDERS.

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TESTIMONIAL

LONDON HOSPITAL.
7th March, 1923. Whitechapel Road, E.1.

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Yours faithfully,
Frank Clifford.

If you require a really Reliable Headphone
TRY

"ERICSSON"

(CONTINENTAL)

per **23/6** pair

Stamped B.B.C.

SELLING HUNDREDS DAILY

Double Phones, complete with Headbands and Cords. Very comfortable to Wear.

I USE THEM MYSELF.

"BRUNET"

(GENUINE)

Owing to the extreme difficulty in obtaining Genuine Brunet Phones at the moment, same are only offered subject to manufacturer's delivery.

25/- pair

Right Opposite DALY'S Gallery Door.

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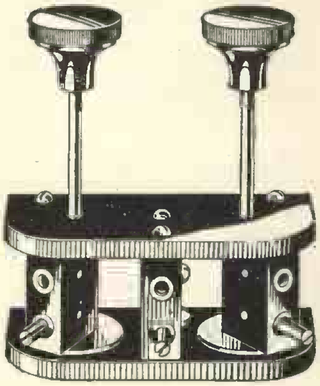
OPEN : 9 a.m. - - CLOSE : 6.30 p.m.
OPEN : Saturdays, 9 a.m. CLOSE : 4 p.m.

"POLAR"

Sets Service Signals

"POLAR" CAM-VERNIER COIL HOLDERS.

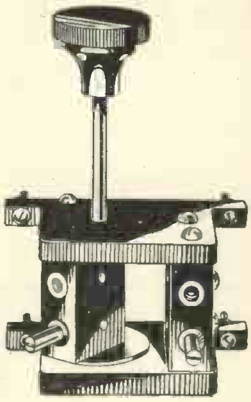


AN ADVANCED DESIGN FOR THE EXPERIMENTER.

This new coil holder has been designed to render fine adjustments easy. In addition to the usual quick movement, the movable coils have a slow fine-tuning movement through an angle of about 10 degs. in all positions. Hence, extremely precise adjustments are rapidly obtainable after the coils have been brought roughly into position by the usual quick movement. It will be realised that fine settings can thus be secured with precision without groping in the usual tedious manner for the best position of the coil.

We are convinced this is a matter of real importance to the wireless experimenter, rendering the setting of his coils convenient, certain and accurate.

"Polar" Cam-Vernier Coil Holders are made throughout in dull ebonite for mounting on panels or on the sides of instruments. It will be seen they are of very neat and compact design, the slow movement not involving any bulky mechanism; they are constructed to take standard coil plugs.



PRICES:

3-Coil Holder, 20/9, post free.
2-Coil Holder, 13/9, post free.

Make your reactance adjustment with precision and thus avoid complaints from your neighbours.

Fine adjustment is the key to better signals.
"Polar" Cam-Vernier Coil Holders eliminate tedious fumbling.

THE

RADIO COMMUNICATION CO., LTD.,

OSWALDESTRE HOUSE, NORFOLK STREET, LONDON, W.C. 2.

BRANCHES:

NEWCASTLE: 17 SANDHILL. SOUTHAMPTON: 19 QUEEN'S TERRACE. CARDIFF: ATLAS CHAMBERS, JAMES STREET. LIVERPOOL: 67 DALE STREET. GLASGOW: 116 HOPE STREET.
WARRINGTON: 37 BRIDGE STREET ABERDEEN: 9 HADDEN STREET.

The BURNDEPT Ultra III

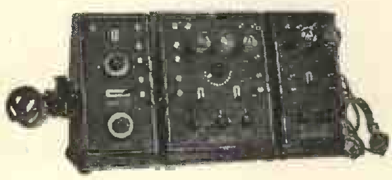
THE Burndept Ultra III is a 3-valve receiver, embodying several unique features, which make it superior to many 5-valve receivers at present on the market. It comprises one Radio Frequency Amplifying Valve, one Detector, and one Low Frequency or Note Magnifier Valve. The filament current of each valve is controlled separately by means of rheostats of our own design and manufacture.

All valves do not have to be alight at the same time. It is possible by means of Burndept Anticapacity Switches, to employ any of the following combination of valves to give the required intensity.

Detector only; Detector and one stage of Radio Frequency Amplification; Detector and one stage Frequency Audio or Note Magnification; one stage Radio Frequency Amplification, Detector and one stage Audio Frequency or Note Magnification.

In the Burndept Ultra III, all the usual radio frequency intervalve transformer difficulties have been overcome, and the design allows of regular and steady H.F. amplification on a standard P.M.G. aerial on all wavelengths from 150 to 24,000 metres. The radio frequency amplifier is set to the necessary wavelength by merely turning a switch arm, which rotates over twelve studs. This feature ensures reaction being absolutely under control.

The Burndept Ultra III should be used in conjunction with a Burndept Tuner, when it will receive the high-power concerts anywhere in the United Kingdom; also Paris, and Dutch concerts, and American, North African, and European Telegraphy; under favourable conditions American Broadcast can be heard clearly.



PRICES

No. 103. In flat case without valves, **£25 0 0**

No. 103s. In sloping cabinet without valves, **£26 5 0**

Complete station as illustrated, comprising—

No. 123s. Burndept Tuner, Mark III, in sloping cabinet	**£9 10 0**
No. 103s. Ultra III Receiver in sloping cabinet, less valves	**£26 5 0**
No, 114 Burndept Note Magnifier, in sloping cabinet, with valves	**£14 0 0**
	£49 15 0

BURNDEPT

WIRELESS APPARATUS

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AERIAL & EASTNOR WORKS, BLACKHEATH, S.E. 3.

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A Set you will be proud to have in your home.

THE purity and volume of the tone obtained from the *BROADCAST MAJOR* is a revelation to those who have only listened-in on Crystal Sets. When buying your first Receiving Set be sure to get one with a generous reserve of tone sufficient to carry you through on nights when transmissions are poor. For this you need two Valves. If you suffer from traffic disturbances, too, you'll appreciate the extra volume from such a Receiver as the *BROADCAST MAJOR*. No need to drop the Head-phones in disgust when a heavy lorry rumbles by.

If you live within 25/30 miles from London, Manchester, Birmingham, Newcastle, Cardiff, or Glasgow, you will find the *BROADCAST MAJOR* an ideal Set. You may be asked to pay very much more, but you will certainly not get better value.

Remember that every Instrument is tested on our own Aerial before being passed for issue, and is sold on the express understanding that it must give you complete satisfaction after a *seven days' trial in your own home*, or money willingly refunded in full.

Its handsome, polished Oak Cabinet, with plated piano-type hinges and all connections at rear, is a worthy addition to any room. Get one now. You'll be investing in a Receiving Set which will prove a never-ending source of enjoyment.

The Equipment Supplied Without Extra Charge.

ACCUMULATOR, 6 volt, 40 amps. Best British Manufacture.

H.T. BATTERY, 60 volt, specially made to our specification.

HEAD-PHONES, One pair of Western Electric 4,000 ohms, highly efficient.

AERIAL WIRE, 150 feet of enamelled copper.

INSULATORS. Two are supplied—sufficient for a single-wire Aerial.

NOTE.—When this Set is required for use with Broadcast Licence a royalty of 35/- must be paid at time of purchasing. The royalty of 25/- due to Marconi Co. is being paid by us.

COMPLETE

£9-9-0

Valves 15/- each extra.

Broadcast Instrument Folder, post free.
Radio Components Catalogue, 32 pages, fully illustrated, 3d.

The PETO-SCOTT Co., Ltd., FEATHERSTONE HOUSE, 64 High Holborn, W.C.1

Type A I. Cap. ·0005.

Type A II. Cap. ·0005.

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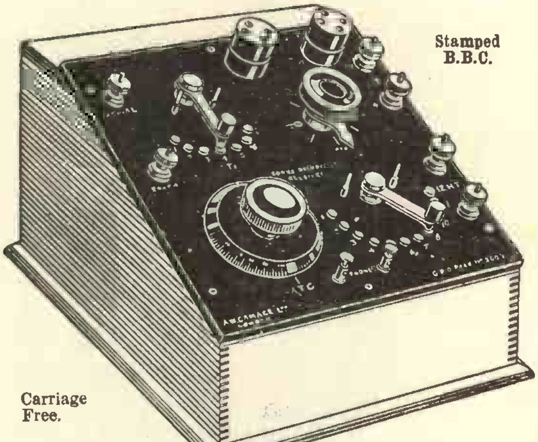
You can only save a few shillings by buying "cheap" apparatus of uncertain origin, but you can save endless trouble by buying all your needs from Gamages. Here every single purchase can be relied upon. Experiments and research in the Gamage Broadcasting Station maintains their lead in design. Behind all is the Gamage reputation for Quality and Value—second to none in the World.

WRITE NOW FOR NEW WIRELESS CATALOGUE—POST FREE.



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Carriage Free.

"SONUS" TWO-VALVE BROADCAST RECEIVER (Improved Model)

Consisting of one High Frequency and Detecting Valve. Telephony from Broadcasting Stations up to 60 miles distant can be satisfactorily received on telephones and Low Frequency Amplifying Valves can be added, to increase the volume of music for purposes of operating a loud speaker or several pairs of 'phones. The number of Low Frequency Valves required depends upon the distance from the Transmitting Station. Music and speech are exceptionally clear on this Broadcast Receiver. The Set has been designed to work on the average aerial, and has a wave range of 300 to 3,000 metres, which enables the owner to receive the well-known Time Signals from Paris. The range of reception of Spark Signals is approximately 150 to 2,000 miles. This set is in accordance with the requirements of Postmaster-General, and has been passed by him.

Price, complete as shown, **£21**

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Single Valve AMPLIFIERS for increasing volume of sound	42/-
Improved SONUS Type, Model A.1 ..	50/-
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FILAMENT RESISTANCE	3/-
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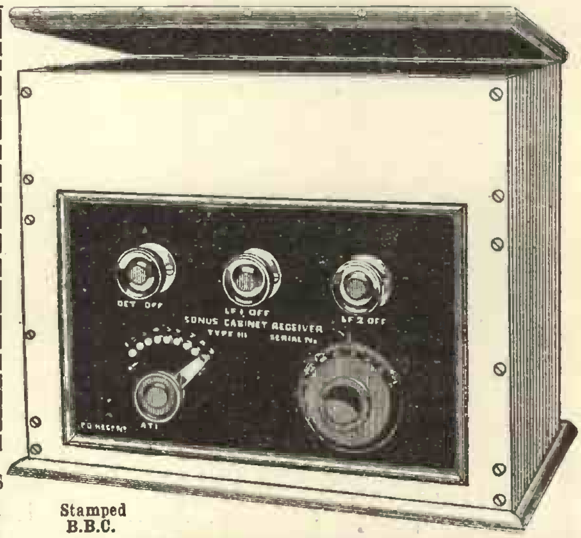

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"GAMAGE" MULTI-VALVE CABINET RECEIVERS

These sets are the results of very carefully organised experiments in Broadcast Reception which has enabled us to offer the public a reliable Receiver, covering a wave range of 300—3,000 metres, with a minimum number of controls consistent with good operating. Simplicity is one of the outstanding features, together with unique design. All valves are enclosed so that no glare to the eyes is experienced and breakage is impossible. All connections are made at the back of the set and the high tension battery is enclosed. The Cabinet is made of 7/16 in. solid Walnut and workmanship throughout is perfection.

Made in the following sizes:

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6-Valve Set, range 300 to 350 miles Valves 15/- each extra.	£42 7 6
Complete Set of Accessories, including 'phones, extra per set.	£7 0 0

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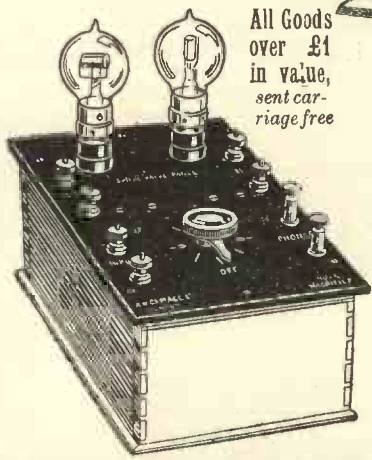

"SONUS" TWO-VALVE AMPLIFIER

for use with Crystal or Valve Sets for magnifying music and speech, and for operating a loud speaker. Beautifully made of best material and workmanship throughout. Price **6 Gns.**

Valves extra. B.B.C. Royalty, £1 extra.

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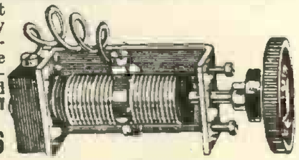
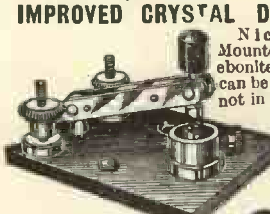


Perfect movement and absolutely silent. Very efficient and will take two valves satisfactorily. Fitted with On-and-Off switch.

PRICE Post Free **5/6**

IMPROVED CRYSTAL DETECTOR



Nickel-plated. Mounted on polished ebonite. Crystal cup can be reversed when not in use, thus protecting crystal from Just. Price, with crystal **6/6** Post 4d.

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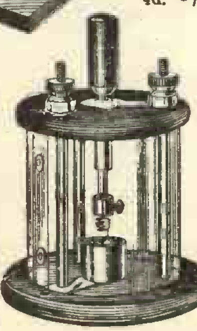
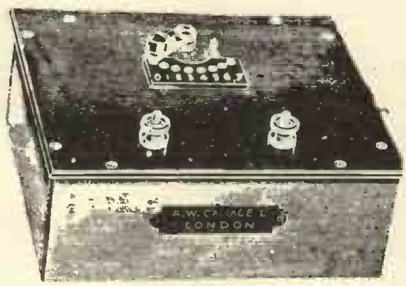


A beautifully made piece of apparatus. Very efficient in use. Transparent cover protects the "Permanite" Crystal from dust. Price, complete with crystal **7/-** Post 4d.



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Improved design with base board and green baize bottom. Finished in polished mahogany with ebonite top. Designed to give total output of 105 volts varied in seven steps of 15 volts. Price, container only, **19/9**

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High Tension Batteries, 2/2½ per unit of 15 volts.

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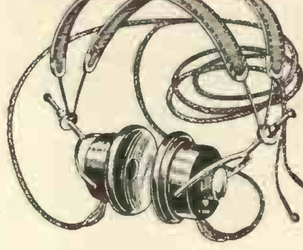
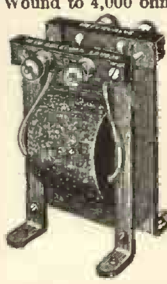
Wound to 4,000 ohms, 30s. Post Free.





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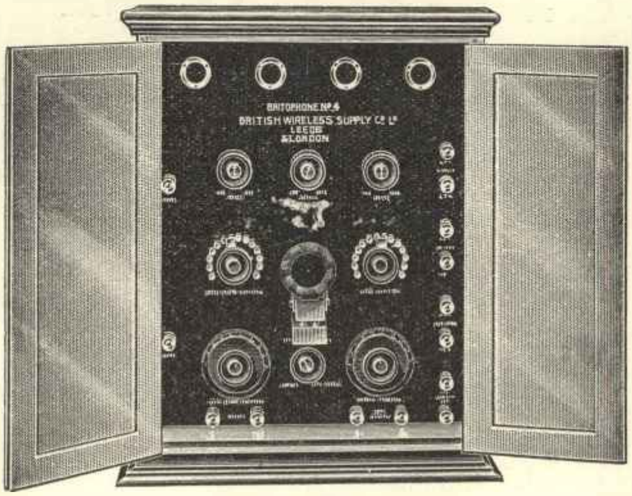

P.O. Regd. No. 0181.

BRITPHONE NO. 4

Cabinet Measurements, 20½" × 16½" × 9½". *Range covers* 200 *to* 25,000 *metres wavelength.* An excellent four-valve Broadcast Receiver in polished mahogany cabinet, with folding panelled doors fully in keeping with the general appearance of the instrument. The receiving panel is of Radio Mahoganite.

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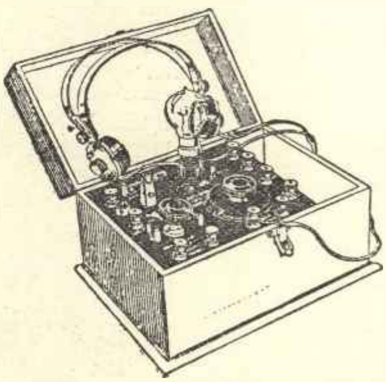
PRICE complete with all accessories, including four Valves and Coils up to 4,000 metres - - - - **40 GNS.**



BRITPHONE No. 2

The "BRITPHONE" No. 2 can be used simply as a Crystal Receiver, or as a combination of crystal and valve. The addition of the valve is obtained by a special switching device. This Set gives extremely clear reception of Music, Speech, and Morse Code. It is contained in Solid Mahogany case of excellent workmanship and finish. Eminently suitable for Broadcast Concerts.

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By the addition of other "plug-in" coils, the range can be increased up to 25,000 metres.

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All "Britphone" Apparatus is approved by the Postmaster-General, and is manufactured under Marconi licence.

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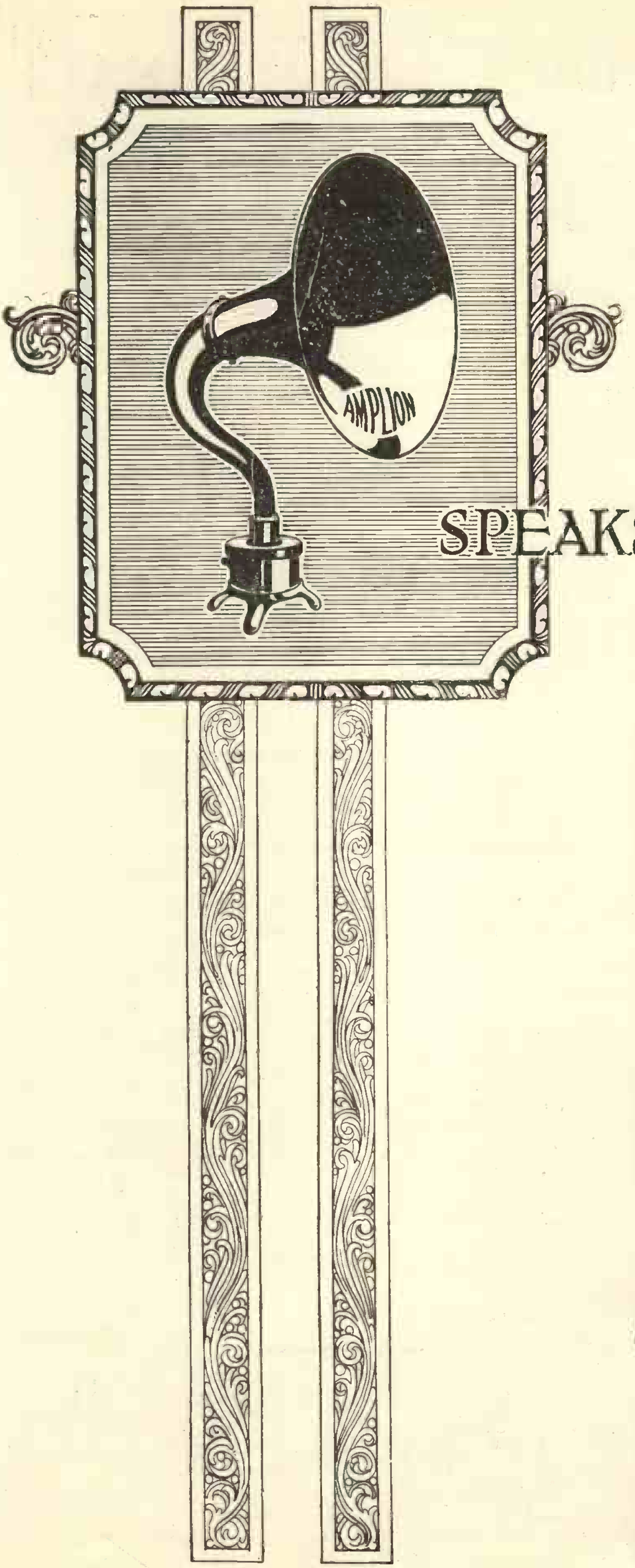

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AMPLION RECEIVERS are designed and produced by the world's original and largest manufacturers of Loud-speaking Telephones.

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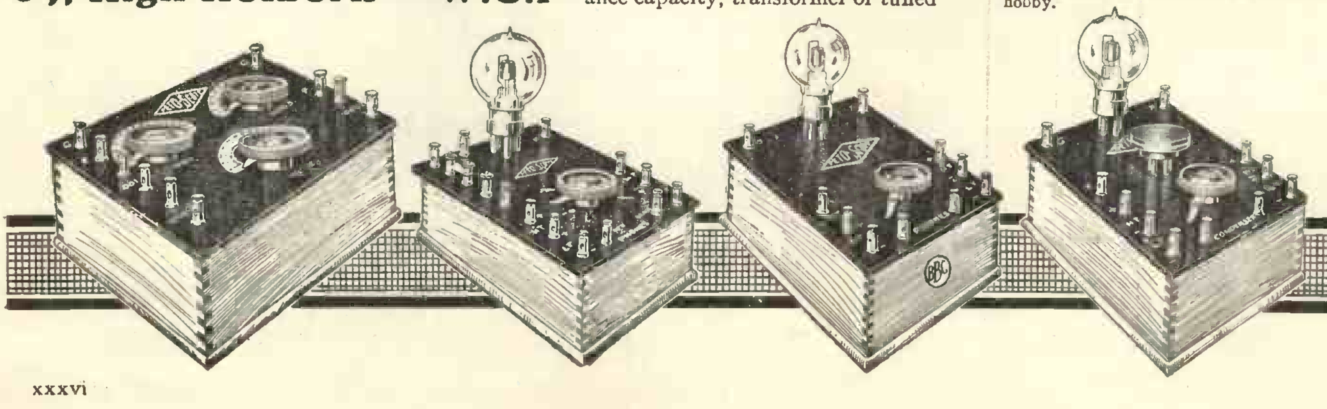

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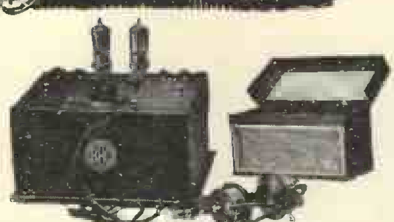

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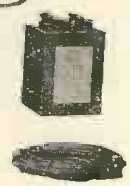

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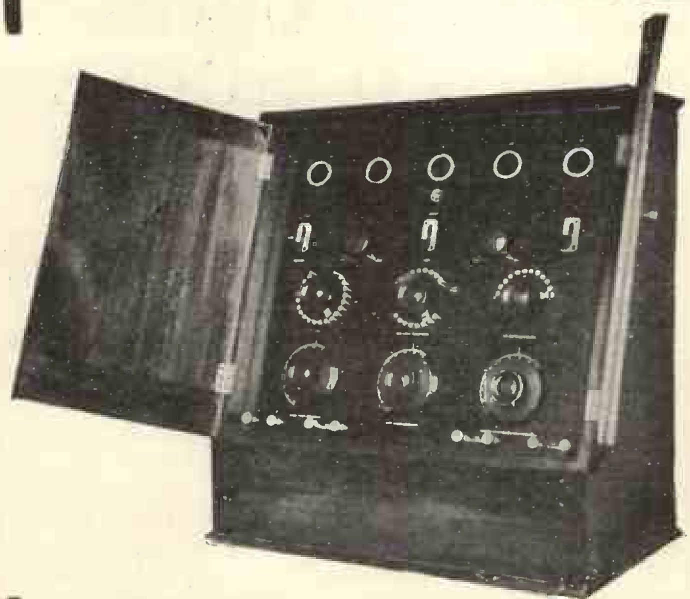

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5-VALVE RECEIVER

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(2 H.F. — Rectifier — 2 L.F.)

The wavelength ranges from 100 to 30,000 metres.

This Set embodies all the latest developments in wireless receivers.

This Set is capable of receiving all British Broadcast Stations, Continental and American Telephony.

This Set also contains high-frequency tuned anode valves and variable reaction enabling C.W. Morse Signals to be received.

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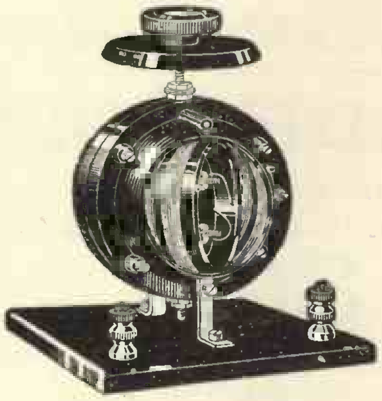

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Fully mounted as indicated, connections made and carried to double terminals.

(*Overall size 5½" high by 3" wide.*)

Giving an Inductance Ratio of 9 to 1

The Inductance range given is from 55 microhenries minimum to 530 maximum approximately. Thus with a standard P.O. **aerial of 100 feet having approximately ·0003 mfd. capacity the wave length range is 245 metres to 755 metres.** Any such proportional range of wave length may be obtained by tuning with fixed condensers in parallel. For example: using ·0006 fixed condenser, wave length range is 350-1050 metres; or, with ·005 fixed condenser, wave length range is 1000-3150 metres. The Rotor is of the Ball type, and as the Internally wound Stator lies closely round the Rotor, **the unusually large Inductance Ratio of 9 to 1 is obtained.** The instrument is as strong and durable as good craftsmanship can make it, and its handsome ebonite finish throughout renders it very attractive. It is suitable for use in Crystal Sets, Tuners, Amplifier Circuits, etc., and is recommended for use with capacity reaction in H.F. Amplification. Any information on these matters will be given gladly to intending purchasers.

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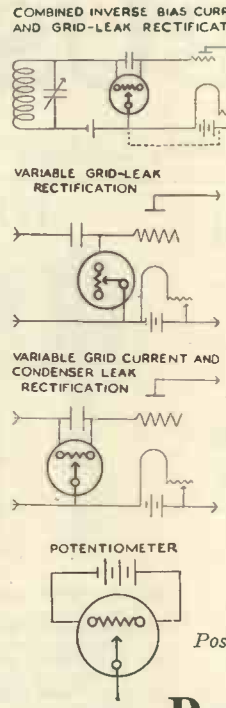

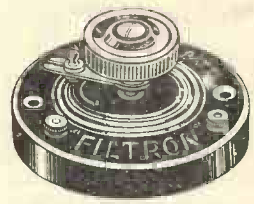

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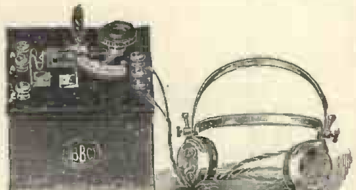

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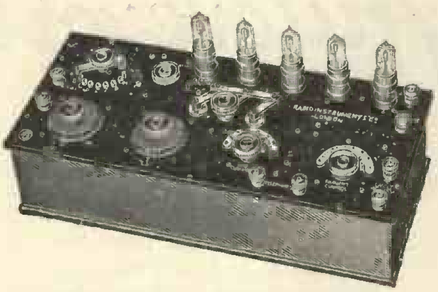

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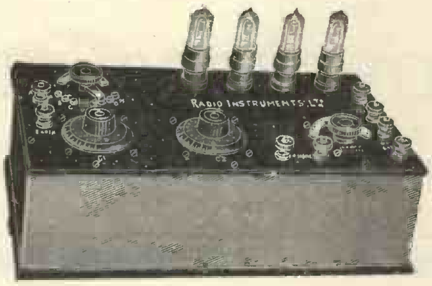

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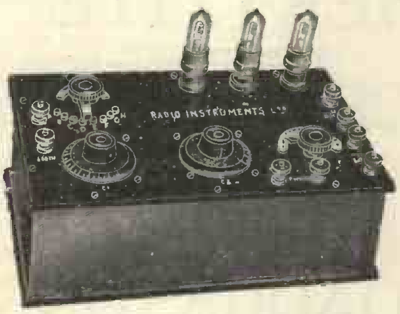

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