MODERN WIRELESS

March

THE LARGEST BRITISH WIRELESS MAGAZINE

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No. 2

SPECIAL ARTICLES FOR BEGINNERS

WIRELESS MAP OF EUROPE FREE

CONSTRUCTION OF A TRANSATLANTIC RECEIVER

ARTICLES BY SIR OLIVER LODGE, D.Sc., F.R.S., & DR. F. W. ASTON, F.R.S.

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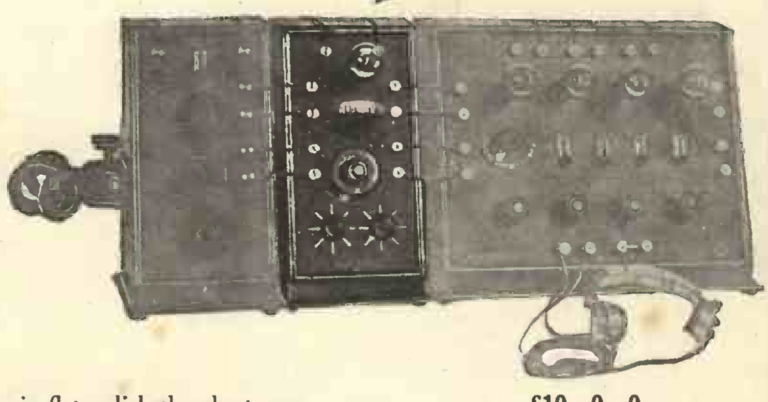

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VOL. 1 MARCH, 1923 No. 2

EDITORIAL

Our Début

MODERN WIRELESS has started well. In spite of repeated instructions and requests, only a very small proportion of those who intended to buy the first number actually placed an advance order. The result was that the first edition—namely, 20,000 copies—was miserably inadequate. Literally, every single copy was sold within a quarter of an hour of being shown on the bookstalls. Owing to orders to print further supplies, a slight delay was incurred in getting the magazine distributed throughout the country. Those who had not ordered in advance were sadly disappointed, and had to wait at least ten days before they got their copies.

We should like to apologise to those who had to wait for their copies, but as we exhorted everybody to place an advance order, and therefore enable us to estimate the correct number to print, we can hardly be blamed. If readers will give an order to their newsagent to reserve a copy of MODERN WIRELESS until the order is countermanded, they will greatly assist us.

The sales, which have now exceeded two or three times the figure which was estimated, have been very gratifying and amply prove that there was room for a high-grade production for discriminating enthusiasts.

Those Advertisements

The response which readers have made to our request to use the card at the back of the magazine and to mention MODERN WIRELESS when replying to advertisers, was very pleasing. It is really only by the good-natured support of our readers in the way of helping our advertisers that we can hope to maintain the journal at its present standard. No money, time, or trouble is being spared to provide the very best technical literature, but the hard commercial fact remains that to produce a really good class journal costs money, and this money partly comes from the advertisers. Order what you require from the advertisers in MODERN WIRELESS, and mention our name, and your courtesy will result in a better magazine in every respect.

Various Matters

We should like to acknowledge our appreciation of the confidence placed in our production by the advertisers in No. 1. From reports which we have received, they have found our journal a medium of unusual value.

* * * * * *

May I mention that we will at all times be pleased to receive suggestions for the improving of the magazine.

* * * * * *

Readers may be interested to hear that we have concluded an arrangement with the largest radio magazine in America, namely the *Radio News*, which has a circulation of about 250,000, whereby we will have the sole rights of reproduction of anything contained in their magazine. We will receive advance proofs of their articles, and readers will be kept up to date with the very latest developments on the other side of the Atlantic.

It is also with great pleasure that I am able to announce that Professor G. W. O. Howe, D.Sc., M.I.E.E., Professor of Electrical Engineering at Glasgow University, Chairman of the Wireless Section of the Institution of Electrical Engineers, and a radio scientist of international repute, has consented to act as Scientific Adviser to this journal. The privilege of conferring with Professor Howe, when it may be desirable, will be of great value in keeping to our ideal of a thoroughly sound and authoritative publication. It is our particular anxiety to maintain the accuracy and usefulness of our articles, whether or not they deal with the most elementary matters. We have seen so many misleading inaccuracies in the publications of general publishers running wireless as a side-line, that we have resolved to do our utmost to earn the respect of our more experienced readers. We believe that this is the sound policy in the long run. Readers may depend on it that the articles appearing in this journal will have passed through several technical hands before publication, adequate technical staff being actually on the premises.

NOTES

IT is rather amusing to note how the price of Mark III tuners has gone up since broadcasting started. In the days of the faithful few who scorned the idea of broadcasting, or pretended to, Mark III tuners could be bought for about £4. Their price now has suddenly increased to about £10. We now wish that we had bought one from the Disposals Board!

By the way, it would be interesting to know to what extent the advent of broadcasting has influenced those who were working in the pre-broadcasting era. Have they forsaken their work and been lured by the interesting programmes now being sent out on the 300 to 500 metre band of wavelengths? Broadcasting, of course, has seriously affected the transmitting experimenters who worked on 440 metres.

Many experimenters (incidentally we may mention here that we dislike the term "amateur") have made up a broadcast receiver which may be used when desired for the entertainment of friends, and carry out experimental work on a separate set of apparatus. This is a wise step. The experimenter who never has his set ready for broadcasting is not likely to be very popular in the family circle.

We wonder how many wireless men who say that broadcasting interferes with genuine experimental work, really mean it? Of course, it interferes with transmission tests, but for reception work it is of great value, because it provides an almost continuous signal of steady strength. Other stations, when being received, generally stop working just at the crucial stage of the experiment. However, it is fashionable to regard broadcasting with a frown!

Readers will be interested to see an article by Dr. Aston in this month's issue. Dr. Aston is one of the world's most brilliant scientists, and there are very few indeed who could claim the same knowledge of the constitution of matter as does Dr. Aston. He has achieved the highest possible distinction in chemistry, having won the Nobel prize for Chemistry for 1922. We feel greatly honoured in being allowed to publish an article from the pen of so distinguished a scientist.

We have received from the advertisers in MODERN WIRELESS a number of interesting catalogues, and we are struck with the valuable information which is obtainable from these lists. The beginner, especially, will find much to interest him. It will be found by many that it is considerably easier and often cheaper in the long run to buy component parts rather than to construct them.

It now seems quite a common thing to receive the signals of American broadcasting stations, and also signals from American amateurs. Is it simply that we have not been listening for them in the early hours of the morning?

In this issue will be found described a receiving apparatus which regularly receives American amateurs and broadcasting on an aerial which is almost completely enclosed.

The Station at Abu Zabal.

IMPERIAL WIRELESS COMMUNICATIONS

By Lieut.-Colonel C. G. CHETWODE CRAWLEY, R.M.A., M.I.E.E.

There has been a great deal of agitation in the general press regarding the desirability of immediately establishing an effective wireless chain. Lieut.-Colonel Crawley has rendered valuable services as Secretary to a Commission appointed by the Government to advise on the matter.

IT will be remembered that in 1913 an agreement was arrived at between the Postmaster-General and the Marconi Company for the erection of stations in England, Egypt, East Africa, India, South Africa, and Singapore; the Commonwealth Government to erect their own station in Australia to complete the chain. Early in 1914 a start was made with this scheme by commencing work on the English and Egyptian stations, and selecting sites for the others. The English station was to be at Leafield, near Oxford, and the Egyptian one at Abu Zabal, near Cairo.

This was the position of affairs on the outbreak of war, when the need of wireless stations throughout the Empire soon became painfully apparent, and it is now common knowledge that the absence of efficient wireless communications with our ships throughout the world cost us the loss of many valuable lives and some millions of pounds sterling. It was obvious that the proposed chain could not be in operation for a very considerable time, and the need for it strategically as a point-to-point system luckily never became vital, as our network of cables remained intact. The result was that the high-power scheme was dropped, and the Admiralty went ahead with the erection of a dozen or so stations, most of which were erected by the Marconi Company, and the remainder by the Admiralty themselves, for communication with ships, and for strategic intercommunication. The stations, which were of medium power, fitted with Marconi Spark and Naval Arc sets, were distributed throughout the Empire in such a way that large ships were very seldom out of touch with the shore, an arrangement obviously of the greatest value at all times, but especially so in time of war.

The masts at Leafield were to support the aerial of a receiving station during the war, and the Abu Zabal station was fitted up temporarily and used by the Admiralty for strategic communications.

At the outbreak of war Germany had also a chain of high-power stations in course of erection, but of the five contemplated abroad only two—Kamina, in Togoland, and Windhuk, in German South-West Africa—were ready, and neither was sufficiently powerful to send messages to Germany, though they were valuable in that they could sometimes receive from Germany up to the time of their capture and, in the early stages, retransmit to German ships.

During the war our policy of concentrating abroad on the erection of stations for ship and shore communication—a policy dictated by a world-wide Empire—was not adopted by France, Italy, or the United States of America, who all pressed on with schemes for point-to-point communication with their outlying possessions or other countries. In this country, as soon as the war was over, the congestion on our cable communications brought into prominence again the desirability of having an Imperial wireless chain, and it was decided in 1919 that, as a first step, the Post Office should complete, on modern lines, the Oxford and Cairo stations. This was done by equipping them with 250 kw. Elwell Arc installations, and the service has been in operation for the past year.

In July, 1919, the Marconi Company were awarded in the law courts £590,000 as the estimated worth of royalties which they would have received from the Government under the 1913 agreement, and in November, 1919, the Government appointed a committee, under the chairmanship of Sir Henry Norman, to consider again the problem of establishing an Imperial wireless chain.

This committee, which reported in June, 1920, recommended that valve stations should be erected in England, Egypt, India, Singapore, Hong-Kong, Australia, Kenya Colony, and South Africa, the case of Canada being postponed until representatives of the Canadian Government had been consulted. The idea was that, excluding a probable Canadian connection, there should be two chains, the first to consist of new stations in England, Egypt, India, Singapore (with a branch to Hong-Kong), and Australia; the second to consist of the existing stations at Oxford and Cairo, and new stations in Kenya and South Africa.

The committee recommended that the whole system should be State owned, the Post Office in this country, and corresponding departments overseas, arranging for the construction of the stations, their actual planning being entrusted to a small commission of experts. These recommendations were approved, and the planning commission was appointed by the Cabinet at the end of 1920. At the end of 1921 the commission reported, and gave outline specifications for the stations.

In July last, however, the Postmaster-General stated in the House of Commons that it had been decided to defer, at any rate for the present, the erection of the second station in Egypt and the stations in Kenya, Singapore, and Hong-Kong, but to proceed at once with the erection of those in England, South Africa, and India; Australia having already arranged for the erection and operation of their station by a commercial company in which the Commonwealth Government hold the majority of shares.

Since then the South African Government have signed a contract with the Marconi Company for the erection and operation of their station; the Government of India have not yet decided whether their station will be erected and operated by Government or by private enterprise; and it has been announced that the Home Government will erect a station in this country on the lines recommended by the Wireless Telegraphy Commission.

It is proposed that all these Imperial stations should be fitted with valve transmitters and be arranged for duplex working, so it is to be devoutly hoped that at last a sound scheme of wireless communication throughout the Empire is about to materialise.

SOME NEW DUAL AMPLIFICATION CIRCUITS

By JOHN SCOTT-TAGGART, F.Inst.P.

The following article describes some recent experiments with circuits using both a crystal detector and one or more valves, the object being to find out which circuits will give the best results with the minimum number of valves.

IN the last number of MODERN WIRELESS a series of circuits were given, using a crystal detector in combination with one or more valves. It must not be imagined that the crystal detector is obsolete. It will acquire even greater importance when a thoroughly reliable pattern is evolved—that is, one which will not require resetting ; claims have already in fact been made for such a detector.

The circuits given below not only use crystal detectors in combination with valves but use the valve in a dual capacity—namely, as a low-frequency amplifier and as a means of either introducing reaction into a circuit or of actually amplifying the high-frequency currents.

Improving the Single-Valve Circuit

Fig. 1 shows what is probably the best single-valve circuit of a straight-forward type permissible for the reception of broadcasting. In some cases, the valve is better used as a high-frequency amplifier, but there is little to choose between the two classes of circuits. It is proposed to improve the efficiency of this circuit by introducing reaction into the aerial circuit. As Fig. 1 stands, there is no reaction effect in the aerial

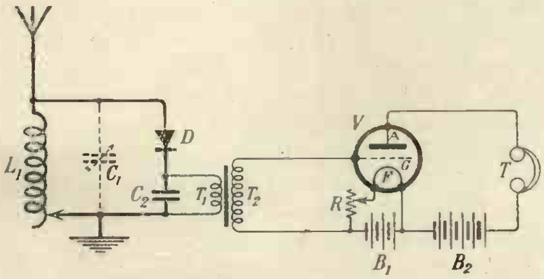


Fig. 1. An ordinary crystal circuit followed by a low-frequency amplifying valve.

circuit, which, therefore, considerably damps down the incoming signals, which for the moment we may assume are due to radio telephony. I introduce reaction into the aerial circuit by using the valve in an additional capacity. An inductance coil L_2 (Fig. 2) is now included in the grid circuit of the valve V, this coil being in series with the secondary T_2 of a step-up transformer T_1 T_2. The secondary T_2 should be shunted by a condenser C_3 having a capacity of not less than 0·001 μF. In the anode or plate circuit of the valve is included another coil L_3, which is connected in series with the telephones T, which now require to be shunted by a condenser C_4, also having a capacity of not less than 0·001 μF.

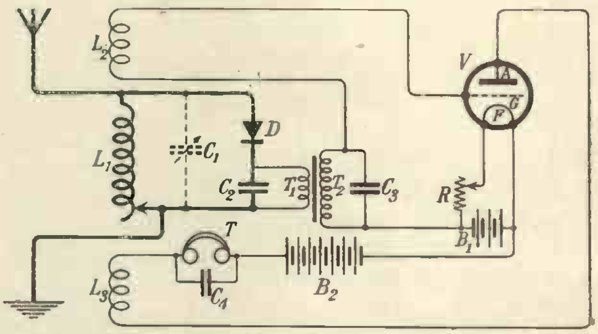


Fig. 2. The Fig. 1 circuit greatly improved by introducing reaction into the aerial circuit.

When honeycomb or similar coils are used, the aerial coil L_1 may be in the middle and the other two coils arranged one on each side, the two couplings being variable. The size of the coils L_2 and L_3 is important, and the best values must be found by experiment. The circuit is adjusted by coupling L_2 tightly to L_1 and varying the coupling between L_3 and L_1. The reverse procedure might be adopted. If both coils are tightly coupled to L_1, the valve will oscillate of its own accord and continuous wave signals may be received ; on the other hand, when spark or telephony signals are to be received, the coupling is such as to obtain the critical reaction effect which gives the loudest signals. Incidentally, this circuit is not allowed to be used for receiving broadcasting.

In order to make sure that the reaction effect is being obtained, the leads to one or other of the coils L_2 and L_3 should be reversed. As one of these coils is made to approach L_1 the signal strength should increase considerably.

Another Single-Valve Circuit

Fig. 3 shows another valve circuit in which only two coils are employed. The aerial coil L_1

may conveniently be a two-slider inductance. The lower slider is for the purpose of adjusting wavelength, and the top slider is for adjusting the degree of reaction introduced into the aerial circuit.

Fig. 3 is, in principle, very similar to Fig. 2,

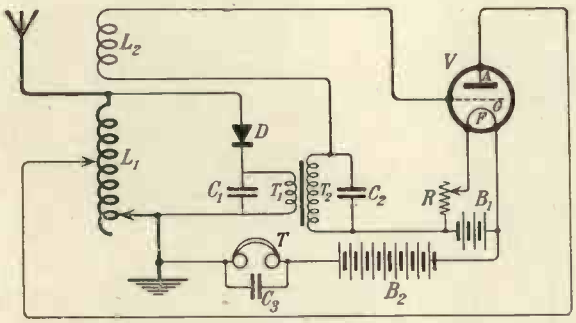


Fig. 3. A crystal circuit of the new type in which two inductances are used.

but this time the anode circuit of the valve is directly coupled to the aerial circuit, the anode current flowing through a portion of the inductance L_1 and then through the telephones T and the high-tension battery B_2, and so back to the filament. The coupling between L_2 and L_1 is adjusted to obtain the desired reaction effect. The circuit might be adapted to a circuit using an inductance tuned by means of a variable condenser, in which case a fixed tapping might be taken from a point on the inductance coil or even from the top of the coil.

Fig. 4 shows a circuit in which the crystal detector D and the primary T_1 of a step-up transformer T_1 T_2 are connected across the

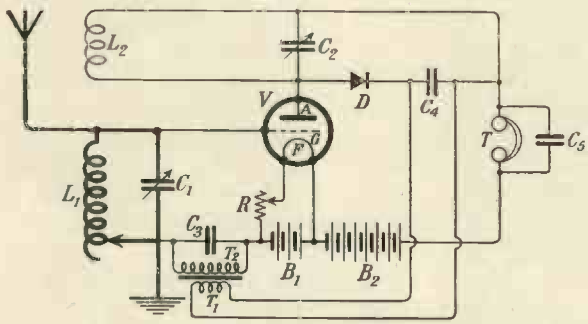


Fig. 4. A shunt amplification circuit which has not yet been fully tried out.

anode oscillatory circuit L_2 C_2 of a three-electrode valve V. The coupling between L_2 and L_1 is adjusted as before to obtain the reaction effect. The secondary T_2 of the transformer T_1 T_2 is shunted by a condenser C_3; the condensers C_3 and C_4 may both have a capacity of about 0·002 μF. The valve V is acting not only as a high-frequency reaction amplifier, but also as a low-frequency amplifier, the telephone receivers T being included in the anode circuit of the valve.

Two-Valve Circuit

It is probably when we consider a two-valve circuit, that most readers will be specially interested, as these circuits may be employed for broadcast reception as there is no reaction on the aerial circuit. Fig. 5 shows the ordinary straightforward and quite effective circuit in which the first valve acts as a high-frequency amplifier, the high-frequency oscillations in the circuit L_2 C_2 being rectified by the crystal detector D, and the low-frequency resulting current being amplified by the second valve V_2.

I have greatly improved the results obtainable

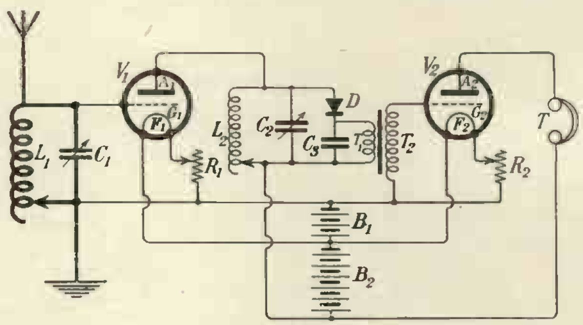


Fig. 5. A two-valve circuit of quite a usual type.

with such a circuit by introducing reaction into the oscillatory circuit L_2 C_2, which is shunted by the crystal detector. The obvious way of introducing reaction into this circuit would be to couple the inductance L_2 to the inductance L_1 in the aerial circuit. As this is forbidden when receiving broadcasting, I introduce the reaction by means of the second valve, which is acting as the low-frequency amplifier.

Fig. 6 shows a method of doing this. A fixed inductance coil L_3 is included in the grid circuit in series with the secondary T_2, which supplies the low-frequency potentials to be amplified. In the anode circuit of the valve V_2 is an inductance coil L_4 which is coupled the right way round to L_2. In the anode circuit will also be found the telephones T shunted by a by-path condenser C_5.

When the coils L_3 and L_4 are only very loosely coupled to L_2, the circuit is, in effect, the same as Fig. 5. As we approach the two coils towards the inductance L_2, the signal strength increases greatly. The fact that a reaction effect is being got out of the second valve does

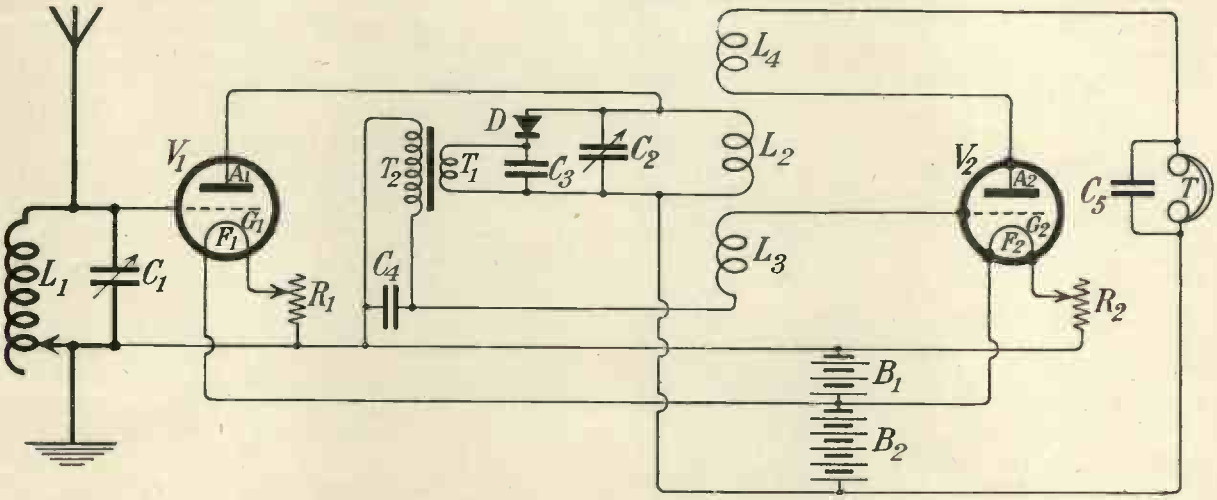


Fig. 6. The same circuit as Fig. 5 modified in a new manner, which greatly increases the signal strength.

not appear to impair its effectiveness as a low-frequency amplifier.

Another Circuit

Fig. 7 shows another circuit in which the now well-known tuned anode circuit with reaction is

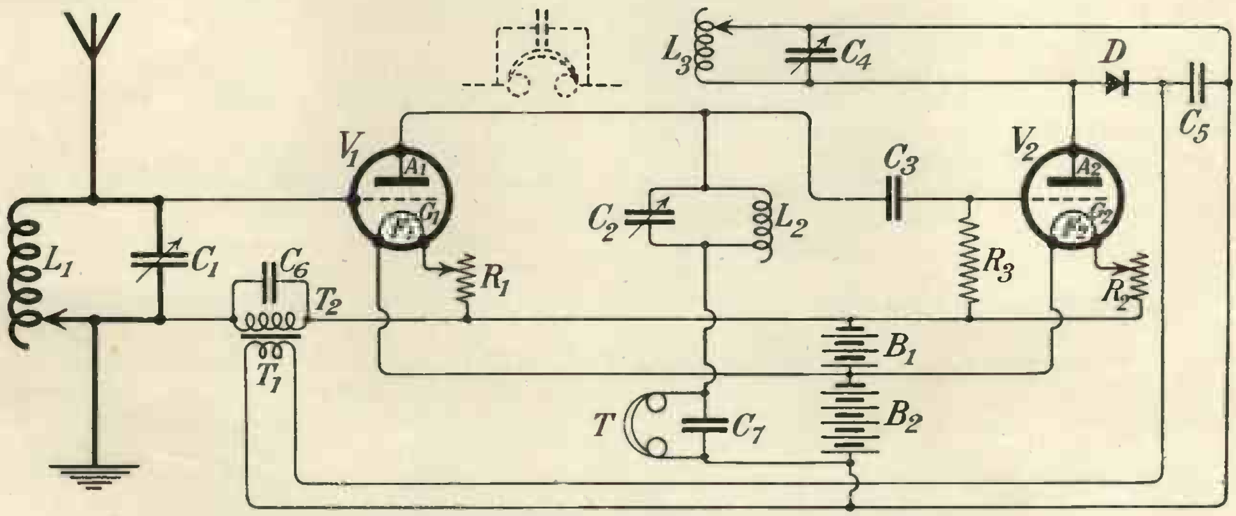


Fig. 7. A somewhat complicated circuit which involves two H.F. stages, one rectification and one stage of L.F. amplification.

employed. The circuit L_2 C_2, containing the amplified oscillations of the incoming frequency, is connected across grid and filament of the second valve in the manner shown, a condenser C_3 being connected for the purpose of preventing the high voltage of the battery B_2 being communicated to the grid of V_2. A grid leak R_3 is connected between grid and the negative side of the filament accumulator B_1. In the anode circuit of the valve V_2 is a tuned circuit L_3 C_4, which is also tuned to the incoming frequency.

Across the circuit L_3 C_4 is connected the crystal detector D and the primary T_1 of a step-up transformer T_1 T_2. The usual by-path condensers C_5 and C_6 are provided in the position shown. The telephone receivers may be connected either in the position shown between the bottom of L_2 and the positive side of B_2 or between the anode of the first valve and the junction point. The telephones and telephone condenser are shown in dotted lines. By connecting them in this position certain complications which are liable to occur may be avoided, but, on the other hand, certain disadvantages attend its use in this part of the circuit. If connected next to the high-tension battery B_2, it is important to see that the condenser C_3 is of small capacity.

This circuit is operated by tuning all the three tuned circuits to the incoming wavelength, the brightness of the two filaments not being excessive, as otherwise self-oscillation may be set up. Unless there is sufficient natural reaction between the circuits, the inductance L_3 may be gradually brought up to the inductance L_2 until the maximum signal strength is obtained, all the circuits being readjusted whenever the reaction is varied. Both valves are now acting as high-frequency amplifiers, and the first valve is, in addition, acting as a low-frequency amplifier.

Any of these circuits may be extended by the addition of an extra one or two valves in accordance with the well-known principles. A point worth noting is that when reaction is being introduced into an oscillation circuit associated with the crystal detector, as in the case of Fig. 6, it is not necessary to use the first low-frequency amplifying valve as the valve for introducing reaction. The coils L_3 and L_4 in Fig. 6 might equally well be connected in, respectively, the grid and plate circuit of any subsequent low-frequency amplifying valve provided any transformer windings or telephones in series with the coils are shunted by by-path condensers for allowing the high-frequency currents to flow readily through them. Considerable development work is still possible with these circuits and modifications of them, and experimenters will find here an interesting field of work.

A FILTER CIRCUIT

By G. P. KENDALL, B.Sc.

LIKE most other amateurs, I spent a good deal of time (and, alas! a certain amount of cash) in my early valve days seeking a satisfactory solution of the high-tension supply problem, and came to the conclusion that there wasn't one. I have since devoted myself to devising methods of minimising the defects of the dry-cell battery. A device which I have tested of late has proved so successful in reducing noises due to bad cells that I am moved to advise readers of MODERN WIRELESS to give it a trial. No great novelty is claimed for this device, since something like it is used in nearly every transmitter, and it is merely a somewhat elaborate filter circuit, whose components may be obtained very cheaply from the ex-army Fullerphones which are being broken up by most of the dealers in Disposals Board apparatus. (The total cost in my case was about half a crown.)

The chokes and condensers from the Fullerphone I have found very suitable for the purpose, but if desired, the chokes can be made by winding each with an ounce of No. 40 S.S.C. wire on a 3 in. by ½ in. iron core. The capacity values are given in the diagram, which shows the arrangement of the filter circuit.

I find this device of special benefit in low-frequency amplification, for it removes a good deal of the hissing and rustling often heard with two or three stages of magnification (sometimes unjustly put down to parasitic or microphonic effects in the valves, but very generally caused by slight imperfections in the high-tension supply). It is liable, however, to introduce distortion if the inductance of the choke L_2 is too high, or the capacity of the condenser C_3 is too

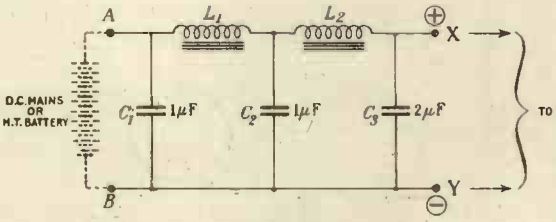


Fig. 1. The filter circuit.

low. Hence, if distortion results from the constructed unit, increase C_3, or remove some of the wire from L_2. Once this adjustment is made, no ill effects can be detected, but instead there is a very pleasing absence of crackle or rustle.

The unit is particularly useful when working off D.C. mains. The circuit is the same, but the high-tension battery shown in dotted lines is replaced by leads from the D.C. supply. A potentiometer (which must be capable of carrying, without heating up, the amperes obtained by dividing the mains' voltage by the resistance of the potentiometer) is preferably employed, so that a variation of anode voltage is obtainable.

YOUR AERIAL

By B. MITTELL, A.M.I.E.E.

WITH a little careful planning it is almost always possible to put up an aerial with very little trouble, in such a way that your receiving set will be given a fair chance to show what it can do. At the same time, it is nearly always possible to arrange the aerial so that the receiving set may be placed in the most convenient position in the house, the aerial being comparatively inconspicuous, and no damage whatever being done to the house.

Two distinct functions of the aerial must be kept clearly in mind. First of all the aerial has to pick up the wireless radiation which is sent out from the transmitting station, and of which only a small portion can possibly reach the receiving aerial. This first and most important function is best achieved by an aerial which is carried at a reasonably clear height, as free as possible from screening neighbouring objects, of which trees and metal-framed buildings are most to be avoided. Such an aerial will meet whatever wireless radiation reaches the locality, and, when the aerial is " tuned " by the receiving set, feeble electrical currents will be set up in it. It is as important to conserve these feeble currents as it is to construct an aerial at a height which will enable it to intercept the radiation.

Fig. 1. Method of fixing aerial to tree.

An important and interesting distinction is to be observed. The wireless radiation reaches the receiving aerial through the air, which is the best of electrical insulators. Good insulators do not, therefore, hinder the radiation in any way. It is when the radiation meets a conductor, such as the aerial wire, that it loses its energy through the process of forming this current. It is in identical manner that trees and metal objects act as screens, and this explains why an aerial will work satisfactorily when covered with insulating material or when arranged inside a

Fig. 2. Another aerial arrangement.

house of which the walls and roof are moderately good electrical insulators.

To conserve the current it is necessary to insulate the aerial wire with good india-rubber, or porcelain, at all supporting points throughout its course down to the receiving set, and thence to the " earth." The best guide is simplicity. Suspend the aerial wire only at its two ends and bring the down lead as directly as possible to the receiving set. From the receiving set get as short and straight a run as possible to the earth connection.

The second function of the aerial is to do a certain amount of the tuning. A very long aerial will have of itself a long wavelength, and it is important to remember that the whole length of wire enters into this, *i.e.*, aerial, down-lead, internal wiring, and the wire running to the earth connection. If this total length is too great a receiving set which has been designed for use on an average aerial will not work satisfactorily.

A Typical Aerial

We see in Figs. 1 and 2 aerials which are easily erected, and which will give good results if the ends are supported not less than 30 ft. from the ground. The length of the horizontal portion should be about 70 ft. At the tree the insulator should hang well clear of the foliage and be secured by a piece of wire fixed to a part of the tree which will not sway very much in the wind. At the other end of the aerial the insulator can be held by a piece of wire passed tightly round the chimney-stack (not the chimney-pot). A sufficient fastening for such wires is to twist them four or five times round themselves.

Length of Aerial

The Post Office regulations now allow an aerial, of which the *combined* span and length of down-lead does not exceed 100 ft., irrespective of the number of wires. For broadcasting wavelengths one such wire gives an efficient aerial. Where a longer aerial is required for experimental work application should be made to the Post Office, who usually grant permission in reasonable cases.

If the distance between the points of support of the aerial is greater than the allowable length of aerial the insulator at the far end should be so inserted as to give the proper length of aerial, and a long " tail " taken from the insulator to the point of support.

If on account of a length of indoor wiring, or if, as another example, the aerial has to be placed on the top of a very tall building : if, in short, for any reason the aerial has so great a natural wavelength that broadcasting is received only when the receiver is tuned to its extreme minimum, the wavelength of the aerial must be reduced by inserting between the aerial wire and the receiving set a " shortening condenser " having a value of, say, 0·0003 μF. This condenser should have a dielectric of air, or the best grade mica, but it need not be variable.

One Wire or Two ?

The reply to this question is usually a matter of taste. To some the business-like appearance of an aerial with two wires and " spreaders " is attractive. Others prefer the comparative invisibility of the single wire.

Where there is a sufficient distance between the aerial supports a single-wire aerial has the following advantages : It is quite as efficient for broadcast reception as a two-wire aerial, it is cheap, it is easily erected, it is light and produces an extremely small pull upon its supports.

An aerial of two wires should be used when the points between which the aerial is to be hung are so close together as to make it impossible to obtain with a single wire a length of 80 to 100 ft., including down lead.

When two wires are used they should be spaced at least 4 ft. apart to be effective, each of the same length and separately insulated. They are usually separated by means of spreaders, though this is not essential if they can be run to different supports. They need not be kept parallel, but they should preferably both be at the same height above the ground.

Spreaders

Spreaders may be purchased complete with fittings, or 5-ft. sticks of ash or bamboo may be used and a hole drilled across the diameter, close to each end, to take the " tail " from the insulator. The " tails " should be of sufficient length to be joined together 3 ft. or so from the spreader to form a " bridle."

Aerial Wire and Insulators

Use hard drawn copper wire, either stranded, such as 7/22, or plain single wire of number 14 or 16. There is little or no advantage for broadcasting wavelengths in having finer strands, or in covering them with enamel. Order plenty of aerial wire, it is useful for fixing the insulators to chimneys and trees, and for making an earth connection.

Good insulation is important, and porcelain is to be preferred, as it does not deteriorate by exposure. See that the aerial wire is kept a good clear distance from the supporting wire,

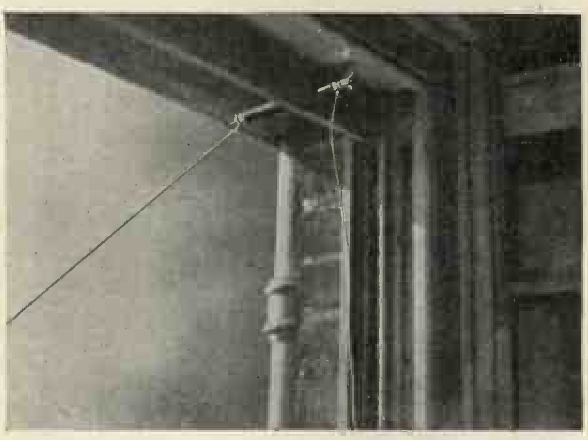


Fig. 3. *Illustrating the method of fixing the lead-in.*

or the insulator will act as a condenser, and some of the aerial current will be shunted off. There are several types of insulator which meet this condition and have adequate mechanical strength.

The Lead-in Insulator

In Fig. 3 is shown a lead-in insulator of the usual type, fixed in a way which avoids any injury to the window-frame. A strip of wood is taken and fitted to the top of the window in the run of the sash. It is held by screws or by wedges. Before being fixed into position a hole is drilled in the strip and the lead-in insulator wedged tightly in. The lead-in insulator should be placed preferably in the room in which the set is to be used, and several feet away from the wire going to the earth connection.

Lightning Arresters

The average receiving aerial adds no more risk of damage through lightning than does a telephone wire. It is, however, advisable to protect the sensitive receiving instrument from the effects of atmospheric electricity when the set is not in use. A convenient method of

Fig. 4. *A typical safety device.*

doing this is to mount upon the wall, mid-way between the lead-in insulator and the outgoing earth wire, a small switch panel carrying a vacuum lightning arrester and a switch for connecting the aerial to earth when not in use. Such an instrument is illustrated in Fig. 4. If suitable terminals are provided on this panel the aerial and earth wires may be taken thence direct to the receiver and disconnected when not in use.

Internal Wiring

When a set is to be placed anywhere other than a few feet from the lead-in insulator, the internal wiring is a knotty problem, for, as previously explained, the whole of this wiring adds to the natural wavelength of the aerial, and as the wiring to the aerial terminal of the set must run fairly close to the earth lead for some distance, this extra wiring is reducing the quality of the result.

The best and simplest plan is to take one lead straight from the lead-in insulator to the set, and the other from the set direct to the earth connection, these leads being flexibles, and not fastened to the wall. The next best plan is to run leads directly to the switch panel mentioned in the previous section.

Where the internal wiring has to be fastened to the walls use wire which has a good covering of india-rubber, avoiding the proximity of metal pipes, etc., and running the aerial lead at the top of the room with the earth lead at the bottom. If wall plugs are to be used have one for the aerial-wire connection and a separate one for the earth-wire connection.

The "Earth"

A water pipe is the most commonly used earth connection, and with the better grade of receiving set there is supplied a clip for conveniently making connection to a pipe. Preferably use insulated wire for running between the earth terminal of the set and the connection to the water pipe. Make the connection as near as possible to the point at which the main water pipe comes out of the ground. Carefully scrape or file the pipe and fix the clip tightly, so as to make, and keep, a good connection. Joints in iron pipes are commonly made with red lead, and have a high electrical resistance. When there is no alternative, as for example in some flats, connection may have to be made to the water pipes high up in the building. Under these circumstances it is often found possible to lead a well insulated wire down the outside face of the building to the water main.

Wherever possible, copper wires should be run out in any convenient fashion over the area covered by the aerial, and buried a few inches below the surface of the ground.

The Esi-fix Aerial

The Esi-fix aerial offers important advantages in a number of cases. The wire is covered with a special tough rubber, which allows the aerial to be run into positions where it has to touch buildings and trees. The aerial is easily fixed and its position is easily altered, so that it is possible to experiment with different positions until the best is found.

Where it is difficult to climb a tree a cord may be shot over the tree by means of a catapult or bow and arrow, and the Esi-fix aerial hauled on the end of the cord. When the aerial is in position the cord is fastened and acts after a fashion as a halyard.

For ranges of ten miles or so a workable aerial can be obtained by bringing the Esi-fix straight up the face of the building and disposing it from chimney to chimney.

For short ranges a good aerial may be obtained by tying an Esi-fix aerial in zigzag fashion to the rafters under the roof, or, when valve receivers are used for short distances, the aerial may be run along the ceiling of a passage, or even along the picture railing of one room.

Masts on Roofs

Aerials have sometimes to be supported by means of masts erected upon roofs. This is a task which is best left to skilled workmen, and care should be taken to see that the mast is so designed and erected that there is no possibility of its failure during a gale, as this might result in serious damage to property and person.

Where masts are wanted of only a few feet in height the problem is simpler, and a very light mast may be used.

And Finally

Make your plan before you begin.

Try to copy the simple and direct arrangement of aerial, down lead, receiving set, and earth.

When anxious to get immediate results, or uncertain as to the best plan, use an Esi-fix aerial.

THE REGULATIONS REGARDING AERIALS

Owing to the confusion which exists in the minds of many, we have approached the Post Office, and give the following interpretation of their regulations.

EVERYBODY has heard of a standard "P.M.G." aerial. The maximum size has been laid down by the Postmaster-General, but there is some confusion regarding the actual figures. Formerly the maximum aerial had a total length of 100 ft. if a single wire, as measured from the far end to the leading-in point. If more than one wire were used, the maximum total length of wire which was allowed was 140 ft. All this has now been changed, and the regulations are that you may use as many wires as you like, but the span of the aerial, together with the distance between the leading-in point and the point where the down-lead joins the aerial span, must not exceed 100 ft.

In these regulations, by "span" is meant the main portion of the aerial. In the case of an "inverted L" shaped aerial, the span would be the distance along the horizontal portion of the aerial.

As an example, if an aerial went from a bedroom window straight across a lawn to the top of a pole at the end of a garden, the lead-in being taken through the bedroom window, the length of the aerial could be 100 ft., as the distance to the leading-in point would be practically zero if the aerial were horizontal. If, however, the lead-in were taken into a downstairs room instead of into the bedroom, the distance between the span and the leading-in point would have to be taken into calculation, and if this were 30 ft. the length of the span or horizontal portion of the aerial could only be 70 ft., making a total of the permissible 100 ft.

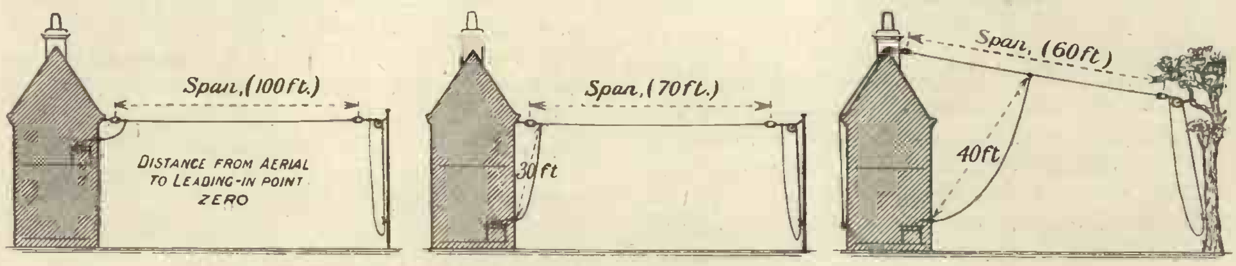


Fig. 1. *Aerial arrangements conforming to regulations.*

The accompanying illustrations give examples of aerials which conform to the new regulations. Instead of having single wires, the aerial might consist of two or more parallel wires separated by spreaders. There is no limit to the number of wires which may be used. According to usual practice, two only, separated as widely as possible, are employed. The advantages to be obtained from increasing the number of wires are not very great.

N.B.—The regulations speak of the "combined height and length" of the aerial as not having to exceed 100 ft. Endeavouring to find out what exactly they meant by "height," and between which points the "height" is to be measured, we were given the above information.

INTERVALVE TRANSFORMERS

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

THE general inexperience in the design of intervalve transformers, and the small amount of technical information on the subject, have led the author to place before the readers of this Journal the results of his long manufacturing experience and experimental researches on such apparatus.

The design of transformers for intervalve operation on wireless telegraph and telephone receiving sets is one requiring a very careful study of all the conditions encountered when transforming audio-frequency currents from low to high voltages, to ensure the purity of the signal, or, in the case of telephony, of articulation, while, at the same time, the efficiency of transformation is kept as high as possible.

Like all power transformers, intervalve transformers consist essentially of three parts :

Primary winding,
Iron circuit,
Secondary winding.

and to produce a satisfactory transformer these three parts must be studied separately as well as in combination with one another.

Primary Winding

The primary winding of the transformer receives a current from the detecting apparatus of the receiving set, having, in the case of telephony, an oscillation varying from 200 up to 3,000 cycles per second.

In an articulatory circuit there are not only the oscillations mentioned, but also rapid changes from one frequency to another as the speech is carried on. To maintain this articulation in its pure form, it is essential that the primary circuit shall be entirely free from such conditions as will tend to vary the frequencies of the oscillating current imposed on it or prevent the rapid change of frequency. This interference is brought about by resonance in the circuit, while the former is caused by the presence of any form of natural or superimposed non-synchronous oscillatory current in the primary winding. Further, it is essential from the point of view of efficiency that the impedance of this primary winding shall be as low as possible, whereas, from a " functioning " point of view, when operating in conjunction with a thermionic valve, it is essential that the impedance of this circuit shall not be less than the impedance of the valve. Finally, the size of the coil, and the high-frequency resistance of the conductor, together with its current carrying capacity, have to be considered.

The requirements of such a winding are, from a collective consideration of all the above points, found to be :

(1) Low impedance (but not less than the impedance of the valve).
(2) Low capacity (to effect non-resonance).
(3) High inductance (to bring the natural wavelength of the winding just outside the range of audible frequencies).
(4) Low high-frequency resistance wire.
(5) Ample current carrying capacity.

Item (1) is, in itself, in the form of a compromise, while items (1) and (3) are opposed one to the other.

The natural frequency of a circuit (and in this case the winding with its natural inductance and capacity may be considered as a circuit) neglecting pure resistance, is given by

$$n = \frac{1}{2\pi} \cdot \frac{1}{\sqrt{LC}},$$

where L is the coefficient of self-induction of the circuit, and C its capacity. To bring the natural frequency outside the desired range of frequencies the product LC must, therefore, be made very small, so that the natural frequency is high.

Since the primary of a transformer having a low impedance must have a low inductance, it will follow that the number of turns and layers of turns, and the consequent capacity of the winding, will also be low ; and this, at first sight, would appear amply to meet the condition of having a frequency outside the range of audible frequencies.

But a trouble not yet enumerated now arises, owing to the production of what has come to be termed " howling " by the persistence of the very high-frequency oscillation. It may, however, be overcome by bringing the frequency of the oscillation closer to the range of audible frequency, but to do this it is necessary to increase either the inductance or the capacity. Both these methods are detrimental : the former from an impedance, and the latter from a resonance, point of view. The final solution is to connect an independent condenser of the correct value across the winding, and to keep the inductance as low as possible. By this means the impedance and the capacity of the coil itself are kept low, and, at the same time, the natural frequency of the winding, combined with the condenser, is brought closer to the range of audible frequency, thus eliminating the " howling." A further advantage of shunting the condenser across the winding is the improvement in power-factor, and, consequently, in efficiency, which is obtained.

From tabulated data on high-frequency resistances of various gauges of wire, a suitable size can be chosen to suit the range of frequencies obtaining in this coil; and, as a general rule, it has been found that No. 36 S.W.G. is the size of wire which of all the sizes made, best meets these conditions together with the current carrying requirements.

Iron Circuit

With the completion of the design of the primary winding, the iron circuit, on which it has to be wound, next claims attention.

The conditions which are impressed upon the iron circuit are, except that the effect is magnetic, identical with those in the primary winding, from which it receives high-frequency magnetic impulses, which are subject to rapid variations, and whose strength depends upon the ampere turns in the coil.

The object of producing these magnetic impulses is to couple tightly the primary to the secondary winding of the transformer, without loss of efficiency. It is essential for pure transformation that such impulses shall be absolutely in synchronism with the current oscillations producing them, and have a wave form identical with that of the current oscillations.

The presence of any form of natural or superimposed non-synchronous oscillatory magnetic impulses, or of reluctance in the iron circuit to rapid change of flux, or of an uneven rate of change of flux, will cause non-synchronous impulses and distortion of the wave form.

The ideal condition would be an iron circuit having a perfectly straight-line magnetising and demagnetising characteristic curve. Such an iron circuit is a practical impossibility owing to the hysteresis value of the iron, which even in the softest procurable Stalloy iron is appreciable at such a high impulse-frequency. Further, the degree of magnetisation of the iron is all important, as too little, or too much, iron will set up ripples in the oscillation curve which at once give distortion.

Considering the case of an iron circuit working on the flat part at the upper end of the magnetising curve, the resultant wave of induction will be flat topped, and will set up a strong harmonic oscillation of three times the fundamental frequency, which will be impressed upon the fundamental oscillation and differ from it in phase by 180°.

Such a condition will not only distort the signal being transmitted from the primary winding to the secondary winding, but will also affect the hysteresis of the iron circuit in so far that it will now have to deal with a secondary flux of treble the frequency of the fundamental flux, and 180° out of phase with it. Such out-of-phase fluxes tend to neutralise the fundamental, and are responsible for the " fringe " on the articulation. Should the iron be worked on the flat portion at the foot of the curve, similar conditions will again present themselves, although in less marked form.

When making calculations for the design of the iron circuit, the magnetic inductance of the iron should be in the neighbourhood of 3,000 lines per sq. cm., which is on the steepest portion of the magnetising curve. At this point rapid changes in the frequency of the magnetic impulses can be obtained with the minimum of distortion or loss of efficiency from hysteresis.

Another source of distortion is from eddy currents in the iron, which are eliminated to some extent by laminating the iron circuit. At these high frequencies, however, currents are induced into laminations of, say, 26 S.W.G. iron, of sufficient amplitude to cause ripples in the fundamental oscillations.

It is, therefore, of the greatest importance that when using shell-type laminations there shall not be a complete circuit of iron passing round the coil, but that the laminations to form the shell be in two portions, completely insulated from one another, and further, that the laminations should be as thin as is practicable. The actual iron should have high magnetic powers, low hysteresis value, and high resistance.

(*To be continued.*)

CHOKE-CONTROL MODULATION

The following article is a simple account of the operation of wireless telephone transmitters employing a particular method of modulating or varying the high-frequency output of a valve, this method being known as the " choke-control " system.

OF all the different kinds of modulation systems which from time to time have been proposed there is probably none which has achieved the popularity of the choke-control telephone circuit. The choke-control system has been in use by the stations at Marconi House, at the Metropolitan-Vickers works at Manchester, and at other centres. During the war our aircraft was equipped with choke-control transmitters, and in the United States the same types of transmitters have been continually in use, both in the Services and for broadcasting purposes.

General Principles

The two chief methods of modulating the high-frequency output of an oscillating valve are :

(1) The application of the microphone potentials to the grid of the valve.
(2) The application of these potentials to the plate or anode.

Choke-control circuits employ the latter method of modulation, and their operation depends on the very simple fact that if an oscillating valve circuit is set up the high-frequency current generated will depend for its strength chiefly on the voltage of the plate. It is found that if the voltage of the plate is doubled, the high-frequency current in the oscillatory circuit will also be doubled. In other words, the high-frequency current is proportional to the plate voltage. If we can make the microphone vary the plate voltage of an oscillating valve, we can vary the high-frequency output. In other words, we are able to modulate the oscillations and therefore produce modulated waves if these oscillations are produced in an aerial. Fig. 1 shows a simple transmitting circuit in which a microphone is used to apply a varying potential to the plate of an oscillating valve. It will be seen that in the plate circuit of the valve there is the usual high-tension battery B_2, but in addition there is the secondary T_2 of a step-up transformer T_1 T_2, to the primary of which is connected the microphone M and a battery B_3, usually of about 6 volts.

The circuit, apart from the microphone and microphone transformer T_1 T_2, is just an ordinary oscillating valve circuit connected directly to the aerial. To this ordinary circuit is added the microphone and microphone transformer in order that we may impress a varying voltage on the plate and thereby vary the strength of the oscillations in the aerial and the character of the waves radiated. When speaking into the microphone M the current through T_1 varies, and, as a result, varying potentials of greater value are produced across the winding T_2 and add to, or subtract themselves from, the steady voltage of the battery B_2. For example, if the value of B_2 were 200 volts and potentials of the order of 50 volts were produced across T_2, the total voltage on the anode would vary between 250 and 150.

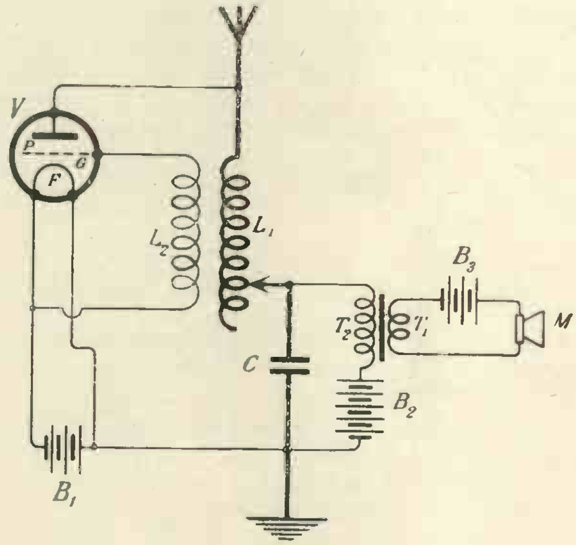


Fig. 1. A simple transmitter in which the microphone varies the potential of the plate.

The Use of Two Valves

The next step in the development of the choke-control circuit was to amplify the microphone potentials. In the simple arrangement of Fig. 1 the microphone potentials were too weak to be of any practical value. It was therefore found necessary to amplify the microphone potentials and apply the resulting energy to the anode circuit of the main oscillating valve. Fig. 2 shows the simple theoretical arrangement in which the valve V_1 acts as the main oscillator, and the valve V_2 as the amplifier of the microphone potentials. These latter are first applied to the grid G_2 of the valve V_2. They are then amplified by the ordinary action of the valve, the amplified currents passing through the transformer winding T_2 and being reproduced in the secondary T_3, which is connected in series with the usual high-tension supply B_2 of the main oscillating valve, or power valve V_1.

In the arrangement of Fig. 2, separate filament accumulators B_1 and B_4 are provided and also separate high-tension batteries B_2 and B_3. These are shown in this way in order to simplify the circuits and to enable the function of the main valve V_1 and the amplifying valve V_2 to be clearly understood. It is not, however,

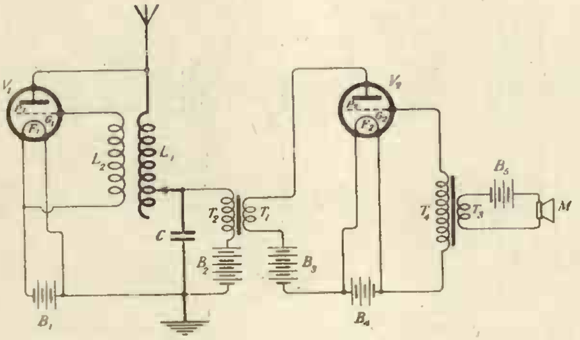


Fig. 2. A theoretical circuit in which the microphone potentials are amplified.

a practical arrangement to employ separate batteries in this way, and therefore the Fig. 2 circuit may be modified into the arrangement of Fig. 3. In this figure, the filament of the valve V_2 is heated by current drawn from the accumulator B_1, and the anode or plate circuit of V_2 is fed from the same high-tension supply B_2 which feeds the plate circuit of the oscillating valve V_1. The arrangement is really a very simple form of Fig. 1, the microphone potentials, however, being first amplified by means of the valve V_2.

It was found that the arrangement of Fig. 3 could be greatly simplified by substituting a choke-coil in place of the transformer T_1 T_2. A single choke-coil of high inductance is connected as shown in Fig. 4, in the positions previously occupied by the windings T_1 and T_2. The functioning of the circuit is identical with that of Fig. 3, but only a single coil, T_1, is now employed When speaking into the microphone M, which, incidentally, is shown working off the 6-volt accumulator B_1 instead of from a separate battery, the microphone currents are

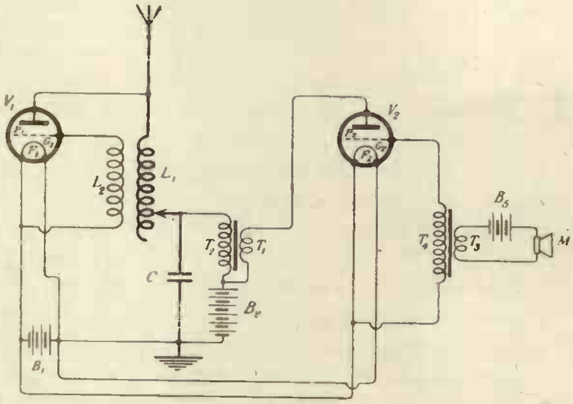


Fig. 3. A circuit similar to Fig. 2, common batteries being used.

amplified by the valve V_2, producing surges of current through T_1, producing potentials across this choke-coil. When the grid G_2 is made positive there will be an increase in the flow of electrons between F_2 and P_2, and consequently an increase in the current through the circuit F_2 P_2 T_1 B_2 F_2. This sudden increase of current will set up a potential difference across the impedance T_1, making the top end of T_1 negative with respect to the bottom end

As the choke-coil T_1 is in the plate circuit of V_1, the voltage on the plate P_1 will be altered by any variation in voltage across T_1. The choke-coil normally has only a small resistance, and when not speaking the voltage on the plate P_1

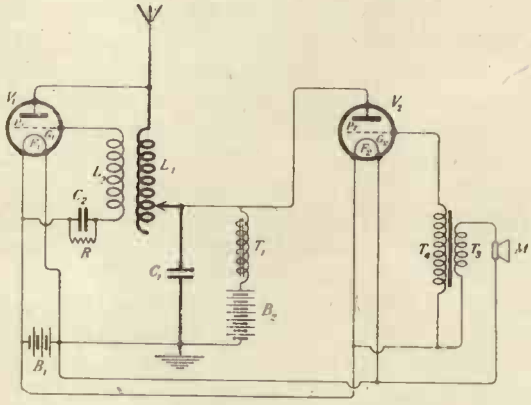


Fig. 4. A typical choke-control circuit.

is practically the same as the voltage of the supply B_2. When, however, the potential of

G_2 is becoming more positive, the plate current of V_2 increases and produces a potential difference across T_1, which opposes the potential applied by B_2 to the plate P_1. The plate voltage of V_1 will, therefore, be reduced and the current in the aerial will be reduced in proportion. When, however, the potential of the grid G_2 changes in the opposite direction the current through the valve V_2 is decreased and the change in current through T_1 sets up a potential difference across its ends which increases the total voltage applied to the plate P_1. The current in the aerial will consequently increase and the energy radiated will increase in proportion.

It will thus be seen that, when speaking into the microphone M, the voltage of the anode P_1 will be increased above the normal value, and decreased below the normal value according to the character of the speech, and, of course, the magnitude of the changes will likewise depend upon the sounds applied to the microphone. The magnitude of the voltage variations applied to the plate P_1 should be such that in the extreme cases the plate voltage should vary from nearly zero to nearly twice its normal steady value. If these limits are exceeded overmodulation occurs, with poor speech as the result. In Fig. 4 will be seen a grid condenser, C_2, and a resistance, R. This grid condenser is for the purpose of giving the grid G_1 a normal negative potential, which in nearly all cases is found necessary to make the valve generate most efficiently. Frequently a negative potential is also applied to the grid G_2, either by means of a battery or by connecting the foot of T_4, not to the filament, but to a point on the resistance R, which resistance has a drop of potential across it of such a character as to make G_2 negative.

J. S.-T.

A NEW AERIAL INSULATOR

The following is a description of a new type of insulator which has many advantages over the ordinary type.

THE most important *desideratum* of an insulator is, of course, to prevent the leakage of current across it or through it. Especially in winter-time, when rain, snow, and fog are prevalent, many an insulator, which is quite all right in dry weather, begins to leak. This leakage does not occur *through* the insulating material but along its surface. The various kinds of insulators at present on the market usually have a fairly long leakage path, such as in the case of the shell insulator. Nevertheless, the writer is not aware of any really good insulator which will keep dry. To allow an insulator to get wet and then to make the leakage path as long as possible, seems to be the wrong way of solving the problem. It would seem to be much better to keep a portion of the possible leakage path perfectly dry, so that no leakage can take place. In the case of insulators on telegraph poles, a hood or cowl of porcelain is provided, the under-surface of this hood or petticoat being kept perfectly dry. Pouring water out of a watering-can on to such an insulator would not affect its insulating properties. This cannot be said of any type of insulator used for general wireless purposes.

It will, therefore, be of interest to many readers to examine the accompanying illustration, which shows a type of insulator for which patent protection has recently been sought. It will be seen that it consists of two inverted caps of insulating material, C_1 and C_2. These are joined together by a steel rod, S. Two hooks, H_1 and H_2, are provided as shown, and to these the aerial and the supporting wire or rope are respectively

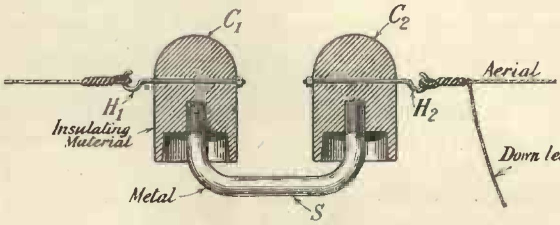


Fig. 1.

attached. When the aerial is suspended, the weight of the metal connecting-bar will keep the insulators vertical, with the result that even though the rain may be beating down on the insulator, yet the under-surface of each cup will remain perfectly dry, and any leakage would have to take place over two perfectly dry surfaces, which would be impossible.

Various modifications of this type of insulator are possible, the general principle being that the general balance of the insulator ensures that a dry " leakage surface " is maintained.

THE VALUES OF CONDENSERS, GRID LEAKS, ETC.

A few words on a subject of great importance to the experimenter.

IT is a curious fact, but the values of condensers, grid leaks, etc., always present a difficulty to the beginner. He will see a circuit and will immediately begin to wonder what the various values of the condensers are, and if they are not given he will feel disappointed.

If one knows what a condenser is for, there should be no question as to its best value. As a matter of fact, the values of condensers are not particularly important in most circuits. The most important condenser, of course, is the variable condenser for tuning purposes, and in this case its maximum capacity is the one which chiefly counts. For tuning purposes, a capacity of 0·001 μF. (μF. is, of course, the correct abbreviation for "microfarad") may be taken as a good all-round figure for general reception. With such a condenser it is possible to cover an appreciable range of wavelengths with a fixed inductance, or, if an inductance fitted with tappings is used, the tappings may be cut down to a minimum.

In the case of the ordinary type of condenser, a capacity of 0·001 μF. would be rather large when working upon low wavelengths. When such a large condenser is employed, the slightest movement of the handle causes a large variation in the capacity of the condenser, and consequently very fine tuning is not possible on short wavelengths. If, however, a very small variable condenser is connected in parallel with the main condenser, this trouble is avoided. Such a variable condenser is generally known as a "vernier" condenser.

A vernier condenser for tuning purposes is not needed if a smaller variable main condenser is used, *e.g.*, 0·0005 μF., or even smaller. When, however, you wish to receive long wavelengths, you will find that this condenser will not be sufficiently large to give you a wide variation of wavelengths with a minimum of inductance variations. It is, however, a matter of choice in each individual case. It is to be noted, however, that the loudest signals will be obtained when a fairly large inductance is used and only a small value of capacity. On the other hand, a condenser having a fairly large capacity is very useful when carrying out experimental work, as it is much easier to pick up a station. For example, if your inductance is found to be on the small side and you pick up Paris with a condenser having a capacity of 0·001 μF. full in, you would probably add more inductance and work lower down on the condenser. If, on the other hand, you had used a 0·0005 μF. condenser, you would probably not have heard the Paris signals at all, and you would have been in the dark as to the correct size of your inductance, not knowing whether it was too large or too small, or you might have doubted if your set was working.

Leaving aside condensers for tuning purposes, the next most important condenser is the grid condenser in valve circuits. The value of this condenser is not very critical, but it is generally agreed that a capacity of 0·00025 μF. gives good results. The capacity, however, may be as high as 0·0005 μF., and even greater than this.

With regard to the grid leak, this should have a value of about 1·5 or 2 megohms. The latter figure is the one generally used. The value of this leak is the same whether it is connected directly across the grid condenser or across grid and filament as in many amplifier circuits.

The next most important condenser is what is generally termed a "by-path" condenser. This condenser is connected across telephone receivers or the primary of a transformer, such as an intervalve transformer, when a high-frequency current circuit, such as a reaction coil, is connected in the anode or plate circuit of a valve. The by-path condenser should have a value of not less than 0·001 μF. Its value is not very important, but a good all-round figure is 0·002 μF.

A similar value of condenser will do as a telephone condenser in crystal circuits. Here, again, the value is not of very great importance, and will usually vary slightly with different kinds of telephone receivers. In many cases a telephone condenser makes no difference to the strength of the signals received.

The reader should recognise the different kinds of condensers at once in any circuit in which he is interested, and he may apply these values to them.

THE TRANSMISSION OF WIRELESS WAVES—II.

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

When we study the phenomenon in a true wave we find that the particles in a condensation, or greatest compression, have likewise their greatest speed. They are travelling full-speed forward, while in a rarefaction they are travelling full-speed backward. The static and the kinetic energies agree in position, just like the electric and magnetic. It is at the intermediate parts of the wave that we find them both momentarily zero. The particles are stationary at the places where the air is of average density, not in a compression or rarefaction. Hence the theory is very general, and those models which have been constructed to illustrate the propagation of waves, and to show the lag of one form of energy on the other, are erroneous. They only apply to the oscillator, not to the waves. So-called stationary waves, the result of reflexion, are essentially akin to an oscillator. True waves must advance.

The fact that the true wave only starts a quarter wavelength away from the oscillator is very instructive. It applies even in the case of light, although in that case the oscillator is of ultramicroscopic dimensions, and the frequency hundreds of millions of millions per second; so that the following-out of the process in detail might seem impossible. But it was not impossible to the great mathematician, Sir George Stokes, who in his work on fluorescence arrived at the conclusion that the quarter-wave lag or difference of phase at the start must be compensated or neutralised, so that it became obliterated in the true wave.

It is in many respects the same even with waves on the surface of water. The particles of water are moving forward on the crests, and are moving backward in the hollows. They are moving only up and down at the position of mean level. If you watch sea-waves travelling along in deep water, you will not at first notice the motion forward of the particles at the top of the crest, since straws and ripples on the surface go backward relative to the wave as it advances. But that only means that the water particles which are moving forward are not moving at anything like the speed of the wave itself. The wave is going much faster than the particles, and hence overtakes them, and slides under them. The speed of the water particles varies with the amplitude or magnitude of the disturbance. The speed of the wave does not depend on that at all, but only on the wavelength, that is, on the distance from crest to crest; whether the wave is a mere inequality of the surface, or whether it rises 20 or 30 ft. The velocity of the wave—the speed with which the crest itself advances—depends not at all on the height or intensity of the wave; but it does, in the case of a water-wave, depend on wavelength, *i.e.* on the distance separating successive crests. In fact, in deep water the velocity of wave-progress varies with the square root of wavelength, for big waves. For ripples the law is different.

All these things are complications which we do not find in the ether, nor even in the air. The speed of sound depends on the conveying material only, not on loudness, nor even on wavelength or pitch. Sir Isaac Newton realised that, for he pointed out that a band heard at a distance could not possibly sound like music unless every note, loud or soft, high or low, had one and the same rate of travel. So it is also in the case of light and wireless waves. They all travel through the ether at one identical pace, whether they be a hundred miles long, or the millionth of an inch short. Also whether they be bright like sunlight near the sun, or dim like a rushlight or a glow-worm. In this respect, therefore, ether and air waves differ from visible waves on the surface of water. But all waves agree in this, that the potential and kinetic energies—that is, the displacements and the velocities—are concurrent in phase, rising to a maximum and falling to a minimum together. This is a peculiar condition, destructive of equilibrium, and it can only be satisfied by the wave advancing through the medium at its own proper pace—a pace which in wireless waves is determined by the mutual reaction of the electric and the magnetic components, in accordance with what is called Poynting's theorem.

A receiver acts by obliterating some of the electric component, and thereby stops a portion of the wave. This it does either directly, as by a linear aerial, or inductively, as by a loop aerial. The energy of such portion of the wave as effectively encounters the aerial is abstracted and utilised for the signal, some fraction of it degenerating into heat. The rest of the wave goes on.

So to sum up. The electric and magnetic components of a wireless or electro-magnetic wave are at right angles to each other, and are equal in energy and coincident in phase, so that both reach a maximum, a minimum, or a zero together. There is no lag of one behind the other, such as occurs naturally in all our emitting or receiving instruments. And the only way in which this curious unstable condition of things can be sustained, is for them both to advance forward with the velocity of light. And that is just what they do. The oscillator is stationary, true, but then the two disturbances there, are not in phase. One is a quarter period behind the other, as one would expect : then the energy mainly pulsates, first out, then in, and is not all lost by radiation. The only part lost by radiation is that which has got a quarter wavelength away, where the one disturbance has caught up the other, and where the energy—that which is used in wireless telegraphy—is flicked off into space.

The above photograph was taken during some experiments with a Resonance Wave Coil Antenna carried out by the U.S.A. Signal Corps. Satisfactory telephony was carried out while the car was moving at 25 miles per hour.

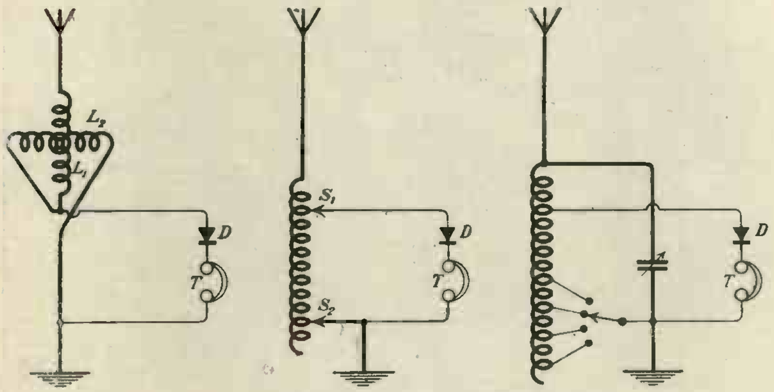
IMPROVING THE SELECTIVITY OF A WIRELESS RECEIVER

When a crystal detector is connected across a tuning inductance, the damping of the circuit is increased, thereby decreasing the selectivity of the receiver. The following article explains how this may be overcome by various connections of the detector circuit.

A DIRECT-COUPLED tuning circuit in which a detector is connected across a tuned circuit actually in the aerial circuit is very convenient, because only one tuning is necessary. A loose-coupled arrangement employing an oscillation transformer necessitates two tunings, one in the aerial circuit and the other in the closed receiving circuit. Although the direct-coupled arrangement is the simplest, yet it is not the most selective, and a considerable amount of jamming, or interference from other stations, is experienced. A great deal of this jamming may be eliminated by using two tuned circuits or, in another way, by lessening the damping or resistance of the aerial circuit.

Under ordinary circumstances we connect the detector across the whole of the used portion of the aerial inductance. By doing this we apply the maximum E.M.F. to the detector, but at the same time we introduce a considerable amount of damping due to the detector. This detector is usually of not very high resistance and any resistance at all which tends to absorb current from the aerial circuit will increase the damping of that circuit and thereby lessen its ability to accept only certain wavelengths. In the extreme case, of course, where the aerial has a very large amount of resistance, the damping is very high and practically any waves will come in, whatever their wavelength.

To obviate this disadvantage the detector, whether a valve or crystal, is connected, not across the whole of the used portion of the inductance, but across only the lower portion of it. It will usually be found that if the detector is connected across the bottom half of the used portion of the inductance, the signals obtained will not be very much weaker, and the selectivity will be considerably greater, and less jamming will be experienced. When listening in the ordinary way to British broadcasting, a considerable amount of interference from ship stations is obtained on a direct-coupled circuit, but if the arrangement described is used this may be cut out.



Figs. 1, 2 and 3, illustrating various methods of connecting detectors to decrease damping.

Fig. 1 shows the crystal detector D and telephones T connected across the bottom end of L_1 and the earth end of the inductance L_2, which is one of the coils of the variometer L_1 L_2. Fig. 2 shows a similar scheme applied to an inductance having two sliding contacts S_1, S_2. The contact S_2 varies the wavelength to which the circuit is tuned, whereas S_1 may be moved up and down so that the required amount of selectivity is obtained. Louder signals will usually be obtained if S_1 is at the top, but greater selectivity will be obtained if the contact S_1 is about half-way down. The contact S_1 might, of course, be fixed, if a second slider is not fitted to the inductance.

Fig. 3 shows a similar arrangement in which an inductance coil is fitted with a movable switch and contact studs, fine tuning being effected by a variable condenser. The detector D and telephones T are now connected across the earth and a selected point on the inductance. The above arrangements are well worth trying out if a direct-coupled circuit is to be used and if jamming is likely to be experienced.

A THREE-VALVE PANEL

By W. ISON, A.M.I.R.E.

ONE of the most useful all-round arrangements for a receiving set is that of a three-valve panel, the first valve being a high-frequency amplifier and the second a rectifier followed by one low-frequency amplifying valve. A set made on these lines and properly designed gives good strong signals on practically all wavelengths, and is all that the average amateur requires. In this article sufficient details will be given to enable the amateur of ordinary skill to construct such a set.

The photograph, Fig. 1, is a general view of the set in question as it was first made. Several alterations have since been introduced. The box in which it is mounted is that from an ex-army Mark III tuner stripped of its canvas cover and polished. Being of solid mahogany, it takes a fine finish and is just the right size. If a Mark III tuner case is not available—and they are scarce now—there are many firms advertising who make a speciality of constructing cases for amateur sets at quite reasonable costs.

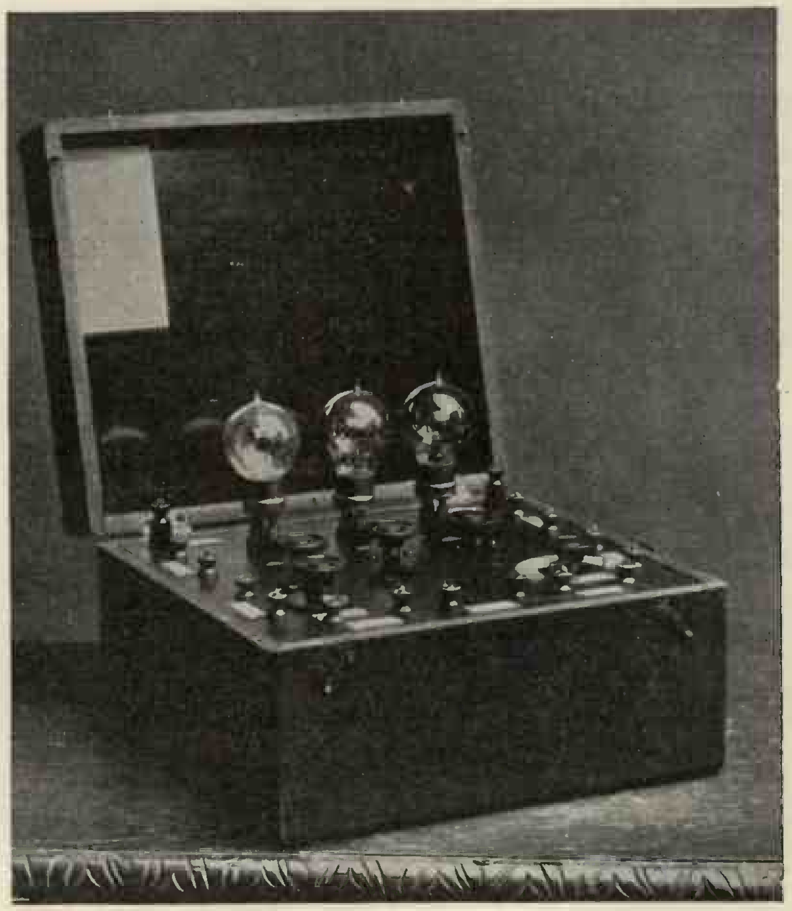


Fig. 1. A general view of the receiver, which is of very pleasing appearance.

The panel is of ebonite or radion, the new insulating material, which has a fine mahogany-like finish. It is $\frac{5}{16}$ in. thick and 13 in. by 11 in., or thereabouts, depending upon the size of the case which it should exactly fit, being supported on strips of wood fixed round the inside edge of the box, so that the ebonite is level with the rim.

In making the panel nothing but the best material should be used. The amateur will speedily find that it is false economy to use cheap stuff, and there is all too much of it being sold to-day.

The arrangement of the various parts on the ebonite will to a large extent depend upon individual taste, but Fig. 2 shows a good lay-out. The transformer used is of the tapped type. This is a transformer of a particular make, and the necessary alterations must of course be made if another type is used.

Having cut the ebonite to the required size and smoothed down the edges with a file to make a fit, decide which side of the sheet is to be the front, and then, on the reverse side, with a ruler and a sharp point, draw lines across the sheet both up and across, so that all the parts when fixed may be in alignment.

When drilling the holes from the under side great care must be taken not to drive the drill too hard, or it will chip at the hole on the front and quite spoil the appearance. When drilling, and it is judged that the drill is nearly through, use only the lightest pressure and the drill will go through quite clean.

The transformer, vernier condenser, and resistances will require to be fixed with screws and nuts. Counter-sunk ¾-in. brass of No. 4 gauge is the thing for this. The holes on the front of the panel should be carefully counter-sunk, so that the screws are flush with the ebonite. And here's a tip with regard to these screws. The terminals and other brass parts will no doubt be lacquered when bought, but the screws will not. Ebonite contains sulphur, and the screw-heads will quickly tarnish. Give them a coat of lacquer before using them, and they will keep their colour.

When all the holes are drilled and the parts tried in them, the next thing is to give the panel a nice matt finish. Lay it down flat on the bench and, using fine emery-cloth, with a good but even pressure rub down the surface, working

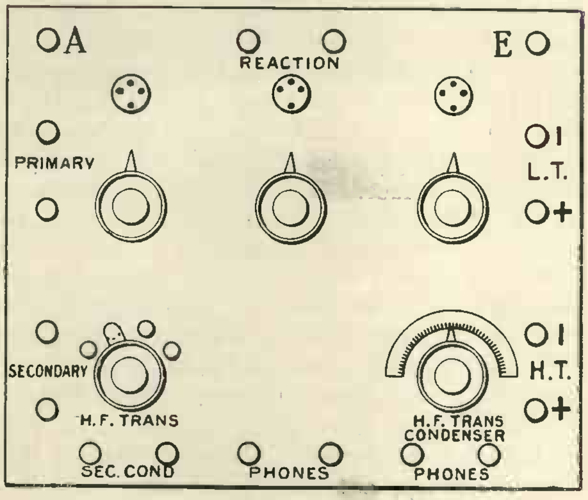


Fig. 2. The general lay-out of the receiver.

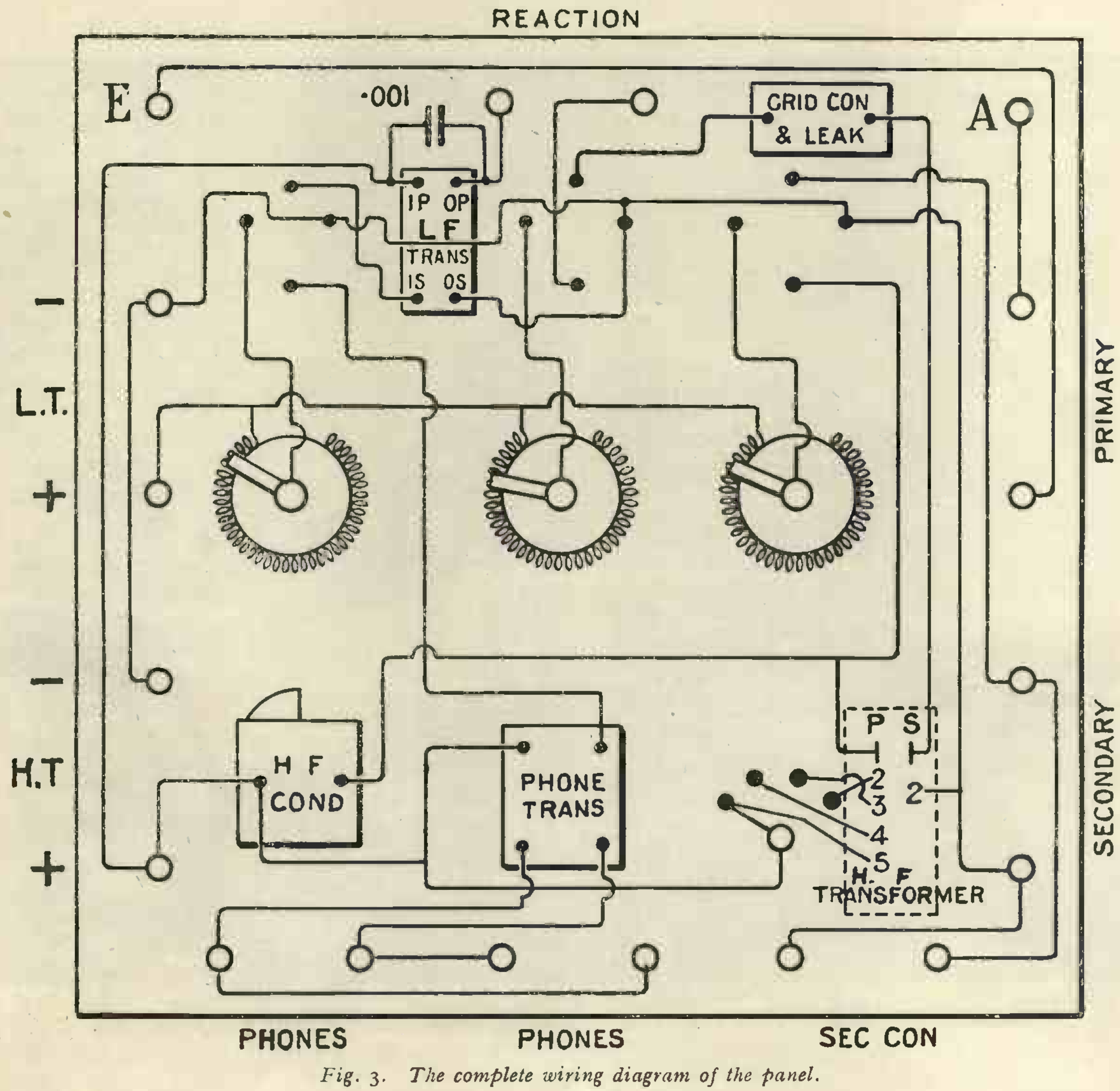


Fig. 3. The complete wiring diagram of the panel.

always in the same direction—that is, either up and down, or from left to right. When you are satisfied that you have rubbed all the polish off, wipe the dust away and then rub over the whole with an oily rag and a fine dull surface will result. Naturally, the finer the emery the finer will be the surface. If desired, this process may be repeated on the under side, but if good quality ebonite is used it should not be necessary.

Assemble all the parts on the panel, and fix them down in their positions. Terminals should have two nuts each, the first holding the terminal tight in the panel, a washer following, and then the second nut to hold the wire. If the circular type of filament resistance is used nuts will not be required, as the holes already drilled in the base can be tapped to the thread of the screw.

The wiring should now be done, using as thick a wire as reasonably handy to work with, say No. 24 or 22. All possible connections should be soldered, and the wire encased in Systoflex tubing. Keep the grid and plate circuit connections as far apart as possible, and well space the wiring. The wiring diagram is shown in Fig. 3.

If these directions are followed a most efficient set will result, and the writer has found that such a set gives most excellent results.

If it is desired to use a low-frequency amplifier later to operate a loud speaker, it is as well to leave out the telephone transformer and keep it as a separate unit, or fit a switch to cut it in and out as required.

It will be seen that terminals are provided for the secondary condenser only. A primary tuning condenser can easily be fixed outside the panel if desired. The writer does not find one necessary for general work.

Station 2 OM owned by H. S. Walker, whose transmissions are familiar to many experimenters.

METHODS OF TUNING A CIRCUIT

A SIMPLE ARTICLE FOR THE BEGINNER

THERE are several methods of tuning a circuit in which oscillations are to flow. The two principal factors which govern the wavelength of a circuit (*i.e.*, the ability of a circuit to pick up the oscillations due to waves of a specified length) are the inductance and the capacity in the circuit. All oscillation circuits possess inductance and capacity; sometimes one is fixed and the other may be varied, or *vice versa.* Sometimes both the inductance and the condenser are variable.

In the case of most broadcast receivers, a direct aerial arrangement is employed, the aerial circuit consisting of the condenser formed by the aerial and the earth and a special variable inductance connected between the aerial and the earth. Connected between the aerial and the earth is usually a crystal detector in series with a pair of telephone receivers, the latter being included on the earth side of the circuit.

Fig. 1 shows the simplest way of tuning an aerial circuit. An inductance coil L has a sliding contact S moving along a bared strip of the coil. Contact with any turn of the coil is obtainable. It is to be noted that only the portion of the inductance L between the slider S and the aerial is actually in use. The portion of the inductance below S may be practically ignored. This portion, however, sometimes has the effect of weakening the signals, and this may frequently be avoided by connecting the bottom end of the coil L to the sliding contact, as shown in Fig. 2.

Fig. 3 shows a very common form of circuit. The aerial inductance is now shown variable in fairly large steps, tappings being taken from the inductance coil L to a number of contact studs. A movable switch arm enables, say, 20, 40, 60, or 80 turns of wire to be included in the aerial circuit. The switch arm is connected to earth, and it is also frequently connected to the end of the coil L. As accurate tuning is impossible by means of taking tappings in this way, a variable condenser usually having a value of 0·0005 to 0·001 μF, is employed, and is connected across aerial and earth.

A modification of the Fig. 3 method of varying the inductance L is shown in Fig. 4. The switch arm now takes the form of a metal sector which makes contact with the studs. The advantage of the arrangement is that not only can the required number of turns be included in the aerial circuit, but the unused turns are all shorted in sections, and therefore produce very little effect on the incoming signals. This

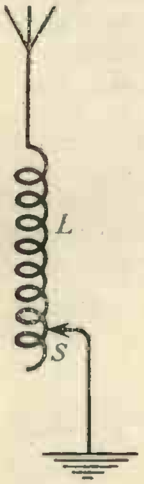


FIG. 1.

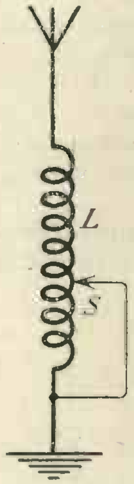


FIG. 2.

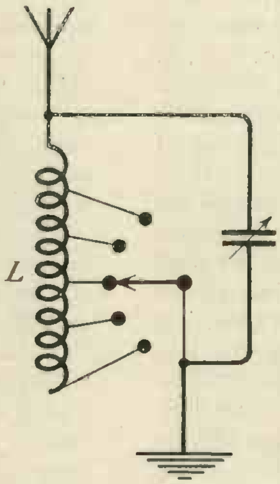


FIG. 3.

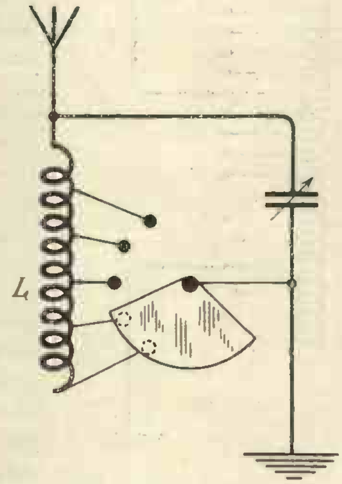


FIG. 4.

Some typical switching devices.

special form of switch arm is not frequently seen, and is in the nature of a luxury, as it is rather difficult to make effectively.

Fig. 5 shows another method of varying an inductance, the inductance in the diagram being shown connected in the aerial circuit for the purpose of tuning. This time two switch arms are employed, one being used to obtain a rough adjustment of the inductance by taking tappings at, say, every ten turns. Thus, by moving the second switch arm over the studs A, B, C, zero, 10, 20, 30, etc., turns may be included in the aerial circuit. In the Fig. 3 arrangement, fine adjustment was obtained by using a variable condenser. Such a condenser, however, almost invariably causes a slight decrease in signal strength, and in the Fig. 5 arrangement this is avoided by having a separate switch arm which passes over ten studs marked 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, each stud going to a consecutive turn at the beginning of the inductance. With the second switch on the stud A, and the other switch arm on the stud 0, there is no inductance in the aerial circuit. If now we move the fine switch to the stud 1 there will be one turn on the inductance in series with the aerial. By moving it over the studs it is possible to obtain any number of turns up to 9. To obtain ten turns, we return it to stud 0 and move the other switch arm on to the stud B. If eleven turns are now required we move the fine switch on to stud 1. By adjustment, it is possible to obtain any number of turns from 10 to 19. If 20 turns are required the switch is moved on to the stud C and by suitably adjusting the other it is possible to obtain any number of turns between 20 and 29. It will be seen that any number of turns may be connected in the aerial circuit, which is therefore capable of being accurately tuned.

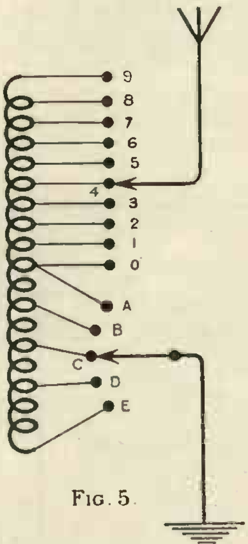


FIG. 5

Two switch arms to give fine and coarse tuning.

It is, of course, possible to tune a circuit simply by means of a variable condenser using a fixed inductance. This is quite a good method and honeycomb or other similar inductance coils of fixed value may be employed. With a fixed coil it is not possible to tune efficiently over a wide range of wavelengths, and it is therefore merely only suitable when a short range of wavelengths has to be covered, *e.g.*, 350 to 600 metres. It is usual if a wide range of wavelengths has to be covered to have a number of fixed coils of different inductance and to interchange these coils. Fig. 6 shows the arrangement.

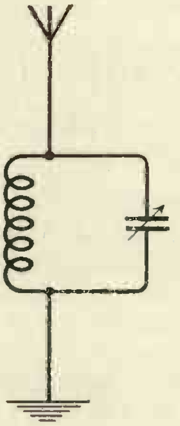


FIG. 6.

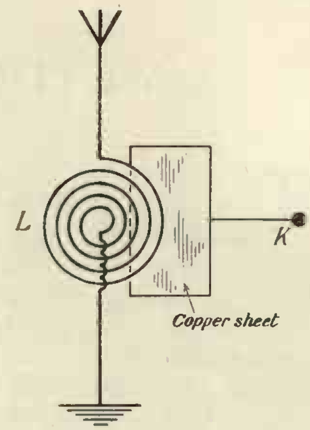


FIG. 7

Tuning by a condenser and a movable copper sheet.

Fig. 7 shows a rather interesting but inefficient method of tuning a fixed coil. A copper sheet is made to slide over the pancake coil L. A knob K may be used for sliding the copper sheet over the pancake coil L and so obtain a variation of inductance L. The arrangement, of course, may be applied to any sort of receiver. We now come to what is known as variometer tuning.

FIG. 8.

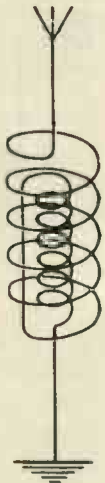


FIG. 9.

The principle of the variometer.

A variometer in its simplest form consists of two inductance coils connected in series, the relative position of the two coils being variable. When current is flowing through the coils a magnetic field is produced around each, and if the coils are so placed that the magnetic field of one helps that of the other the inductance is increased, but if the reverse is the case the inductance is reduced.

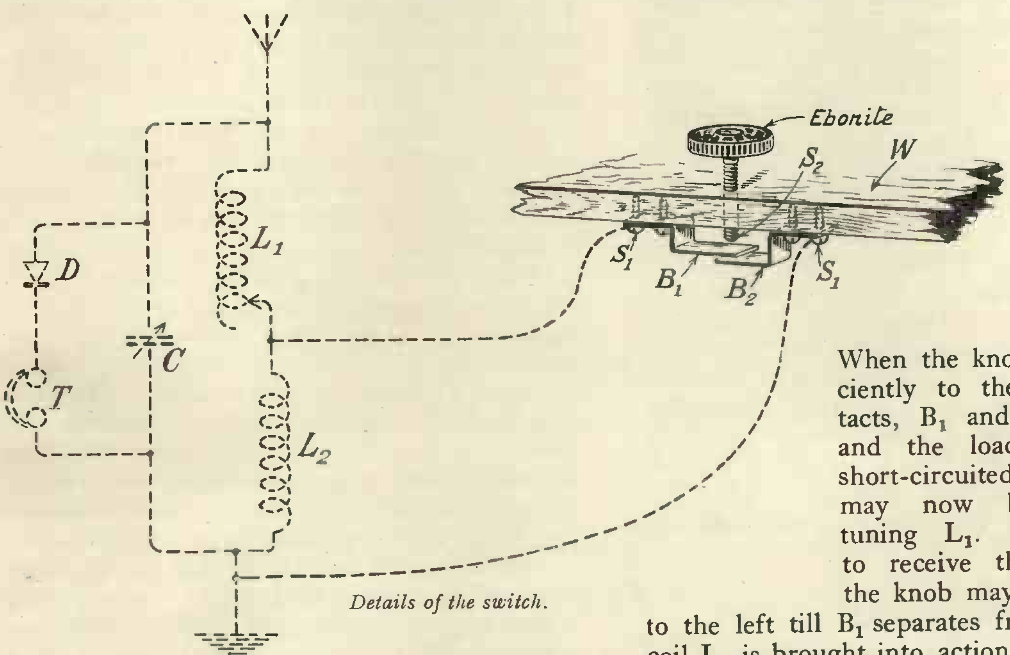
Fig. 8 shows the coils connected in series, and Fig. 9 shows the lower coil slipped into the upper coil, which may be of slightly larger diameter. By moving the lower coil L_2 upwards the total inductance in the aerial circuit is increased. If, however, we reverse the inductance coil L_2 so that the earth end of it enters the coil L_1, we find that by moving the coil L_2 upwards the total inductance is considerably less than the normal total inductance of the ordinary Fig. 8 arrangement. By altering the position of the coil L_2 and by reversing it, it is possible to obtain any value of inductance from a low value to a comparatively high one.

Variometers are extremely useful and might be used to a greater extent than they are at present. Instead of having two cylindrical coils and reversing one of them to vary the inductance, it is usual to have the two coils cylindrical and of short length, the inner coil being connected in series with the outer coil and rotating 180 degrees within the other coil. By means of a knob it is simplicity itself to reverse the inside coil and thereby gain a very wide range of tuning.

A VERY SIMPLE SHORTING SWITCH

IT is frequently desirable when making up a receiver capable of being used over a fairly wide range of wavelengths to be able to short-circuit a loading coil. The accompanying figure shows an extremely simple shorting arrangement which may be fixed on to a wooden cover of a box containing the coils, etc. In the figure, the letter W represents the wooden panel of the set. A screw S_2, fitted with an ebonite knob, is screwed into the wood W, and will move up or down, according to the way the knob is turned. Two strips of springy brass, B_1 and B_2, are mounted on the under side of the wooden board W by means of a couple of screws as shown.

The knob is turned round until the spring B_1 is just clear of the strip B_2. To these strips B_1 and B_2 are connected the leads which may come from a loading coil L_2, for example, included in, say, the aerial circuit of a crystal receiver. The inductance L_1 might be a sliding inductance suitable for receiving broadcasting, and the loading coil L_2 might be brought into action for the purpose of receiving F.L. (Eiffel Tower, Paris). When the knob is turned sufficiently to the right the contacts, B_1 and B_2, are closed, and the loading coil L_2 is short-circuited. Short waves may now be received by tuning L_1. If it is desired to receive the longer waves, the knob may be turned round to the left till B_1 separates from B_2, when the coil L_2 is brought into action. This extremely simple switch may be applied to a great variety of purposes, such as switching on or off the filament current of a valve. The screw with an ebonite knob may be purchased for a few pence from any wireless dealer.



Details of the switch.

WIRELESS OPERATORS AND THEIR CAREERS—II.

By "*TRAFFIC MANAGER*"

UNDER existing regulations it is impossible for any person to sign on the articles of a British steamer as a wireless operator without first qualifying for the Postmaster-General's Certificate of Proficiency in Wireless Telegraphy. It is, therefore, essential that those who aspire to appointment on the operating staff of any wireless or shipping company must first go through a course of training at one of the recognised colleges in order to obtain this certificate. Before proceeding to deal with matters pertaining to those now undergoing training or actually employed as operators, it is desirable to issue a few words of warning to would-be operators.

A few years ago, when hundreds of ships were being fitted with wireless sets each month, there was a very heavy demand for operators. This resulted in the opening of a large number of colleges throughout the country, which were able to obtain employment for all the men they could train. The position is now changed, for owing to the severe and prolonged shipping slump, and the introduction of new legislation, many operators have been thrown out of employment, and the vacancies for men without previous sea experience considerably reduced. This has resulted in the closing down of many colleges and the establishment of long waiting lists on the books of employers.

It may be assumed that the only method of obtaining employment at the present time is to qualify at a college working under the auspices of a company employing operators, where the entrants are regulated to the number that can actually be absorbed. Those who contemplate going through a course with a view to obtaining wireless employment would, therefore, be well advised to see that their training is to be conducted under the supervision of the company that will ultimately employ them.

The Student

It should be the aim of every student at a wireless college to prove himself both capable and useful during his first voyage at sea. There is an enormous difference between school work and practical ship work, no matter how nearly practical conditions may be simulated, so that unless a student has entered whole-heartedly into the spirit of his training, he is very little use when faced with the responsibility of a sea watch.

It is well known that although the Postmaster-General's examination ensures that a student knows the regulations governing the working of stations, and is qualified to operate and maintain his apparatus, there are many other things in which he must become proficient before he will be accepted by a wireless company. The school curriculum is usually divided under the following six headings :

(1) Telegraphy Transmission and Reception.
(2) P.M.G. Handbook.
(3) Wireless Theory.
(4) Practical Wireless.
(5) Traffic Accounting and Ship's Book-keeping.
(6) Wireless Company's Regulations.

Of these six sections, the first four only are dealt with in the Postmaster-General's examination; the fifth and sixth sections are, however, equally important, for without a thorough grounding in these two subjects, an operator is liable to create a very bad impression during his first few months of service. A few words of advice in connection with each item may possibly be of assistance ; they will not be dealt with at length here as they will form subjects for detailed discussion later on.

Operators are essentially telegraphists. A man who cannot send readable Morse and copy correctly at average speeds is a hopeless person, particularly on board a passenger-ship where there is a traffic to be handled. The first essential in telegraphy, both in sending and receiving, is accuracy, not speed. Students frequently make the fatal mistake of trying to improve their speed at a time when they should be wholly concerned with the proper formation of characters. Speed should not be practised; it comes naturally. If a learner finds himself able to send steadily at eight words a minute over a period of five minutes, without a single error, he should adopt that speed for all his practice for the succeeding week. At the end of that period he will find that he is able to send accurately at a speed of ten words a minute although he has never practised at that speed. He may find it possible to work the key at twelve words a minute with a few mistakes, but he will ruin his style if he practises at a speed that he cannot comfortably maintain with perfect accuracy.

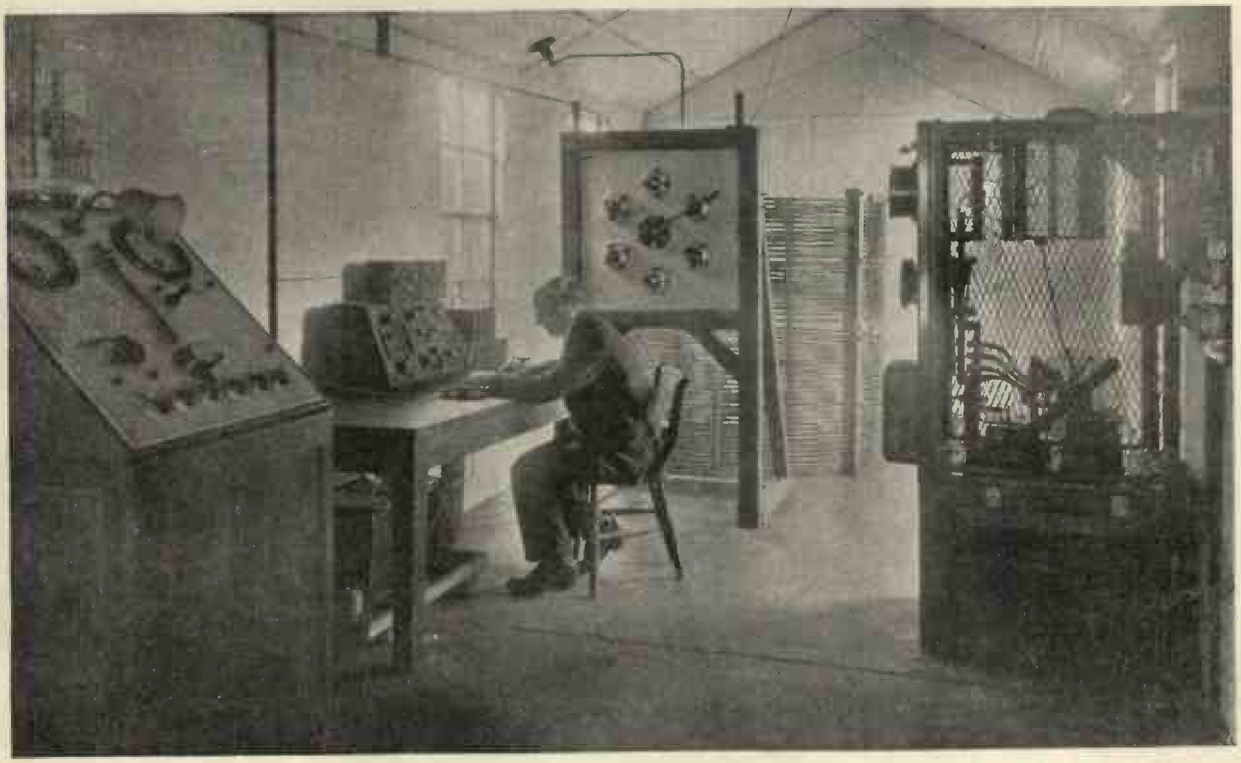
Receiving practice should also be conducted at a comfortable speed, although this is not so important. Some learners progress more rapidly when practising at a speed slightly beyond them. Most receiving practice should be done in code, particularly at speeds below twenty words per minute, otherwise the student unconsciously develops the fatal habit of guessing. When studying the Postmaster-General's handbook it is always advisable to procure a copy of the International Convention Report from which the rules and regulations contained in this handbook are extracted. Studious perusal of the full text permits a better perspective of procedure. It is unnecessary to learn the wording of the text parrot fashion, but it is essential that the procedure and its reason is thoroughly understood.

The theoretical and practical wireless studies are of very great importance, and should be followed with the keenest diligence. Students, when commencing their course, should provide themselves with good strong notebooks having interleaved graph sheets. Copious notes and diagrams should be entered at all lectures, as these are extremely useful for home studies and are of great assistance when faced with difficulties after appointment to the service.

When a student completes his course he is expected to be capable of doing all the clerical work incidental to a ship station. He should know the correct method of ascertaining the rates on messages routed through any Coast Station to all parts of the world ; how to count them ; how to abstract them ; how to make up the daily and voyage returns ; he should be familiar with conversion of currencies, and should know exactly how to do all the necessary book-keeping.

A good deal of time should be devoted to this subject, particularly in regard to the compilation, checking and balancing of abstracts. A neatly written set of abstracts covering a representative collection of messages should be made out and retained for reference at a later date ; these should be checked and passed by an instructor, as it is important that they contain no errors. Care should be taken to develop neat and correct methods of writing up the station log, entering preamble and service instructions on messages, and bunching traffic and records for handing over at the end of voyages.

[Our next article under this heading will deal with the work of a junior operator at sea, and the responsibilities he imposes upon his senior.]



A Wireless operator at work at a land station.

LOUD-SPEAKING TELEPHONES

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

This is the first of a series of articles relating to various types of loud-speaking telephones, and explains the action of the electro-dynamic variety.

THE loud speaker is the natural development of the telephone, the main use, of course, being the production of a large volume of sound. The simplest type of loud speaker is naturally an ordinary telephone receiver, to which is attached some form of horn. The efficiency of this arrangement is obviously limited, owing to the small size of the telephone.

The two factors controlling the strength of the sound are the size of the horn and the size of the diaphragm. The sound is produced by the movement of the diaphragm, and this is dependent upon its size and the amplitude of

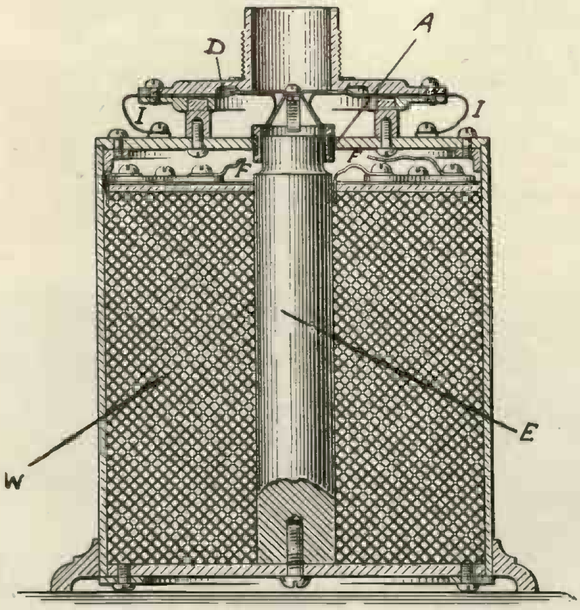


Fig. 1. Illustrating the internal construction of the Magnavox.

the vibration. Hence it is clear that if a large volume of sound is desired the diaphragm must be of fairly large proportions, and it must be strongly energised. This implies that the input current must be great enough to produce the necessary energisation of the diaphragm. Further, the diaphragm must be capable of setting into motion an air column of considerable size, which in practice is obtained by the use of a horn.

It will be seen by the foregoing remarks that electrical, mechanical, and acoustic properties must be duly taken into account in the design of a loud speaker. The problem, therefore, is somewhat complicated, and many forms of loud-speaking telephones have been developed from time to time. It is not proposed to consider the actual design of any specific instrument, but rather to give an account of the types in general use at the present time. The acoustic properties of the trumpet are outside the scope of the present article, and it is desired to limit the consideration to the mechanical and electrical construction of the various instruments.

In the ordinary type of telephone receiver a thin flat diaphragm of specially alloyed iron is rigidly supported above the pole pieces of a permanent magnet, around which are coils of insulated wire. The coils of wire are connected to the supply circuit and an electro-magnetic field is then produced by the current flowing through the circuit. This field will tend either to help or to oppose that due to the permanent magnets. In practice a telephone or loud speaker through which a steady current is passing should always be so connected that the electro-magnetic field helps that due to the permanent magnet. For this reason the correct polarity is usually indicated. Any variation in the current through the magnet coils will cause a corresponding variation in the total magnetic field, and hence the pull on the diaphragm, which is of iron, will vary in time with the variations of the field. Thus the note emitted by the diaphragm is of the same frequency as that of the initial current variations. Although this is the general principle of the operation of a magnetic telephone or loud speaker, there are other factors which somewhat modify the action and determine the quality of the emitted speech.

It has been pointed out that the volume of sound emitted is dependent upon the amplitude of the vibration of the diaphragm. In the ordinary form of telephone the sensitiveness is dependent upon the distance between the pole pieces and the diaphragm. Thus, if the diaphragm is strongly deflected, it is liable to batter against the magnet poles, and hence the effectiveness is limited by the amount of deflection allowable. This difficulty, however, has been overcome in a variety of ways. A notable example of this is in the electro-dynamic variety, of which there are a number of forms.

Here, again, the operation is dependent upon the force between two magnetic fields, the permanent magnet being replaced by a large electromagnet. This is energised by means of an

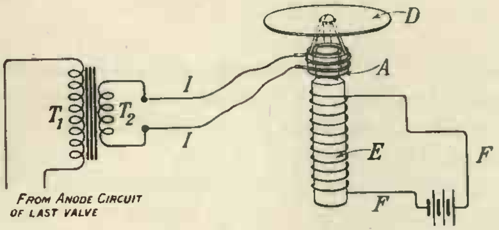


Fig. 2. The principle of the electro-dynamic loud speaker.

accumulator, a very powerful field being produced. If another coil, through which a current is passing, is placed within the vicinity of the field due to the electro-magnet, it will experience a force of attraction or repulsion according to the direction of the current passing through it. If the current through the coil varies in direction or strength, a corresponding variation will occur in the force between it and the electromagnet. Thus, if the coil is free to move, any variation of current through it will be accompanied by a movement. Further, if the coil be attached to a light diaphragm, the diaphragm will vibrate in sympathy with the current variations in the coil.

The foregoing principle is adopted in one form of electro-dynamic loud speaker which is well known to many experimenters as the Magnavox. An idea of the internal arrangement can be inferred from Fig. 1. The input is connected through a step-down transformer, the secondary of which is in circuit with the movable coil, being connected by the wires I. In order that a large movement of the coil may be obtained, a large current should pass through it, and for this reason the resistance is only of the order of 8 ohms. A coil of this description could not be inserted directly in the anode circuit of a valve, and consequently a suitable step-down transformer is employed, so that the coil may receive as large a current as possible. The basic circuit which is employed is shown in Fig. 2. The moving coil A is fixed to the centre of the diaphragm D, and it is so arranged that the coil is perfectly free to move around the end of the pole piece E. It will be seen, therefore, that the diaphragm can fully respond to the strongest impulses. The winding, W, of the electromagnet is energised by a 6-volt accumulator.

It can be shown quite easily that the coil will respond but very feebly to weak currents, and hence an amplifier is always used in conjunction with the loud speaker. Any form of amplifier may be used, but it is desirable that it should be specially designed for the purpose. A suitable amplifier, for example, is made for use with the Magnavox, and an illustration of this is shown in Fig. 3. An amplifier of this description is designed to handle comparatively heavy currents. The valves used are of somewhat similar character to a hard receiving valve, but they are made to work with about 200 to 300 volts on the anode, thus ensuring a large anode current. Small transmitting valves are frequently used for the purpose.

Fig. 3. A typical power amplifier.
[*By courtesy of The Sterling Telephone Co., Ltd.*

The particular amplifier shown is provided with three switches, which enable one, two, or three valves to be used at will. In this direction it should be noted that only sufficient valves to give clear strong signals should be used. There is nothing to be gained by producing deafening signals at the expense of filament current and general wear on the apparatus.

THE USE OF CHEMICAL RECTIFIERS FOR CHARGING ACCUMULATORS

By E. H. ROBINSON

THE provision of a reliable source of low-tension supply of filament current is one of the most worrying problems that face the radio experimenter who uses valves. There is no need to describe the feeling of annoyance which one experiences when one's filament becomes dim and the signals suddenly fall off, indicating that it is again time to heave several pounds of lead round to the nearest charging depôt and pay a shilling or two for a sixpenny-worth of energy. When, as is frequent, electric

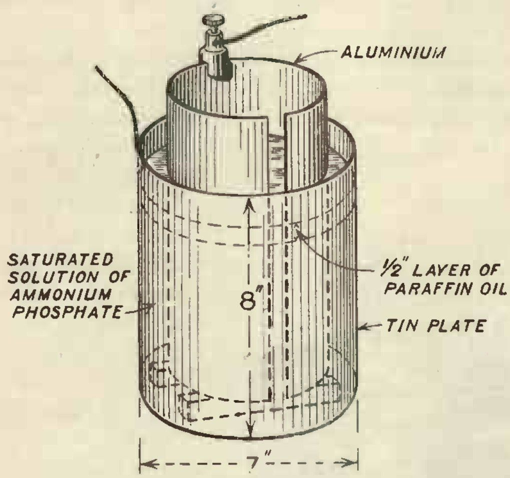


Fig. 1. A simple, but efficient, form of rectifier.

lighting or power supply is available it is quite possible to charge accumulators at moderate expense if the right methods are used. As alternating current is more common than direct current, the problem of charging accumulators off the mains usually resolves itself into the efficient rectification of alternating current. For this purpose electrolytic and mechanical rectifiers are available. The latter are very efficient if carefully constructed, but the following remarks are confined to the use of electrolytic rectifiers, as these require no skill to construct and are cheap to install.

As is well known, the action of this type of rectifier depends on the fact that a cell containing an electrode of aluminium and one of some other metal, such as lead, immersed in a solution of certain salts will allow current to pass freely from the lead to the aluminium, but practically no current in the reverse direction, provided that the reverse E.M.F. does not exceed a certain value (about 70 volts). The rectification takes place at the aluminium electrode, which is really the business part of the rectifier; the other electrode may be of any conductor which is unaffected by the electrolytes. Lead, iron, carbon, or tin may be used.

The electrolytic rectifier has been the victim of much abuse and misrepresentation by those who have tried it without knowing the conditions which are necessary to obtain efficient work. If the points enumerated below are carefully attended to, however, the results obtained will assume a much more satisfactory aspect.

First, the supply current should be transformed down to a voltage not much in excess of twice the voltage of the cells to be charged. Thus, if two 6-volt accumulators are to be charged in series, the transformer used should give 20 to 30 volts alternating E.M.F. across its secondary terminals. Allowance should always be made for the resistance losses in the rectifier, although these may be made small by correct proportioning of the electrodes, etc., of the rectifier itself. It is hopeless to try to make an electrolytic aluminium rectifier of the ordinary type work off 100 volts or more, as it will not rectify properly voltages exceeding 60 to 80. If higher alternating E.M.F. than these are applied the current simply " walks through " in both directions and the electrolyte becomes hot.

The electrolyte used is extremely important, and it is in the choice of this that many people go wrong. Amongst the solutes one reads about as being suitable are sodium bicarbonate, borax, and ammonium phosphate. The writer has tried all three substances, both pure and commercial, and finds that pure ammonium phosphate is the only one which gives satisfaction. Borax and sodium bicarbonate give very poor results; not only is their rectifying action poor, but, owing to the sparing solubility of these substances, only weak solutions can be prepared, which have a comparatively low conductivity. Some samples of commercial ammonium phosphate give fairly good results, but the commercial product is apt to contain considerable quantities of free acid and other impurities which cause corrosion of the aluminium electrode and the formation of a copious "sludge." This precipitate is usually white or grey, and being in a practically colloidal state cannot readily be removed by filtration.

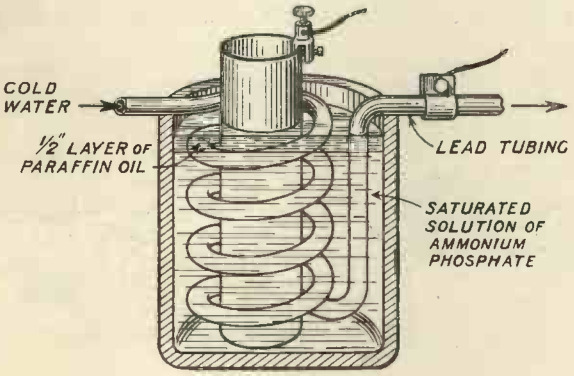


Fig. 2. A method of keeping a rectifier cool.

If, however, it is desired to use commercial phosphate, the saturated solution of it should be tested with a piece of blue litmus paper, which will turn pink if any free acid is present. In this case ammonia should be added until the solution is just permanently alkaline—that is, until the well-stirred solution turns a piece of pink litmus paper blue; in order to avoid undue dilution by this treatment it is best to use the strongest ammonia solution (specific gravity, 0·880). It is much better to buy pure ammonium phosphate in the first place from a reliable chemical dealer. This will be found to be just alkaline. The price is usually more than double that of the commercial variety, but it pays in the end. The solution should be saturated, or nearly so, one pint of water requiring half a pound or more of the solid ammonium phosphate. If care is taken to avoid overheating, the solution should remain fairly clear, and the aluminium should remain unattacked for a few months.

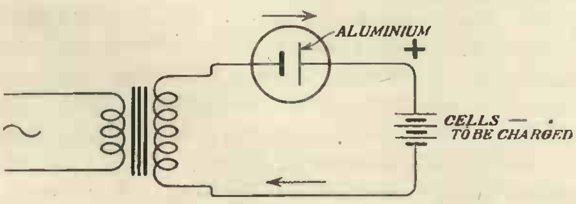


Fig. 3. Circuit for half-cycle rectification.

The next important point is to prevent the solution in the rectifier from becoming hot. If it is allowed to boil up, the rectifying action is reduced, the aluminium is corroded, and sludge tends to form. Wasteful heating may be avoided to a large extent by correct choice of voltage and solution as set forth above. By making the rectifier cell large with a large bulk of solution and large electrodes heating effects are reduced. Instead of using a cell made of glass or earthenware, an iron vessel may be used, which, being a better conductor of heat, assists in dissipating any heat formed in the solution; incidentally, the iron cell itself may be used as one electrode of the rectifier, the aluminium electrode being supported in the cell by some means which does not allow it to touch the sides or bottom of the cell. The writer finds large tin-plate canisters are very suitable. It is well to solder up the seams, if this is not already done, in order to ensure the cell being perfectly water-tight. For handling currents of two or three amperes the tin may be 7 in. in diameter and 8 in. high, containing an aluminium plate bent into a cylinder 5 in. in diameter and 9 in. high.

The arrangement is shown in Fig. 1. It should be remembered that the resistance of the system, and consequently the heat wastage, may be materially reduced by making the area of the electrodes large and reducing the distance between them. Further cooling may be obtained, if necessary, by immersing the whole cell in water contained in an external reservoir.

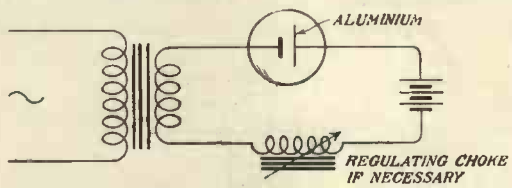


Fig. 4. Illustrating the use of a choke to control the charging current.

A very good method of keeping the cell cool is shown in Fig. 2. The anode consists of a helix of lead tubing, through which a steady stream of tap-water flows. The connection to the water main should be made by rubber tubing, as electrical complications may possibly result if the lead anode becomes earthed. As the cooling is very effective, the bulk of electrolyte and size of the aluminium electrode need not be large in order to avoid undue rise in temperature.

The aluminium should be kept clean. The incrustation of oxide that is apt to form on the surface of the aluminium is detrimental to its rectifying action, and may be removed by allowing the aluminium to stand for some time in dilute sulphuric acid or a solution of caustic soda. Before being replaced in the rectifier the aluminium should be thoroughly rinsed in running water. It is a good plan to float a layer of paraffin oil about half an inch deep on top of the ammonium phosphate solution. This reduces evaporation and, to some extent, prevents the salt in solution from creeping up the electrodes.

The simplest circuit to use is shown in Fig. 3. This only makes use of one-half of the cycle of the alternating supply, the other half being suppressed. If the secondary E.M.F. of the transformer is correctly chosen, it will be unnecessary to use any regulating resistance in the charging circuit. If, however, the transformer delivers too much current into the charging circuit it should be reduced by inserting a choke-coil as in Fig. 4. A suitably designed choke wound with thick wire on a laminated iron core will reduce alternating or pulsating currents without entailing the wastage of power as heat which is experienced when regulating resistances are used. The choke has the additional advantage that it offers a much larger impedance to any alternating component

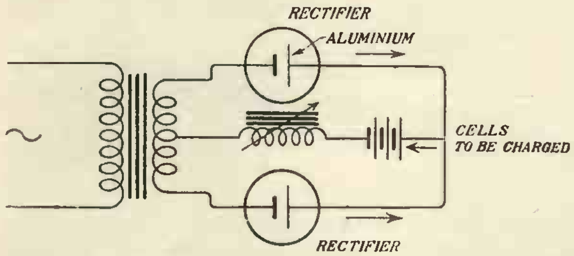


Fig. 5. Full cycle rectification, using two cells and split-winding transformer.

which finds its way through the rectifier than to the pulses of rectified D.C.

Figs. 5 and 6 show circuits for using both halves of the cycle in the charging circuit, but in the writer's opinion there is nothing to gain by the extra complications involved. In one case a split-winding transformer is required, and in the other four rectifier cells are necessary. It is erroneous to suppose that there is any wastage in the method used in Fig. 3 on account of only one-half of the cycle being suppressed. The suppressed half simply remains unused and is not registered at the supply meter as having been consumed. It is therefore best, for small charging installations at any rate, to use only half-cycle rectification and concentrate on making

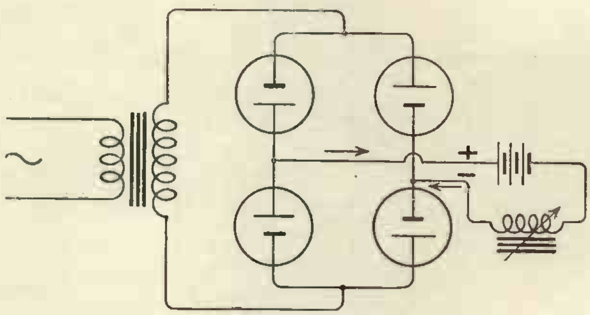


Fig. 6. Full cycle rectification, using four cells.

one large and well-cooled rectifier cell instead of four indifferent ones.

With regard to the use of tins as containing cells and anodes, it might be mentioned that they are corroded and eaten through by prolonged use with impure ammonium phosphate, but will resist pure phosphate indefinitely.

In conclusion an interesting and important property of the electrolytic rectifier might be mentioned. During the suppressed half-cycle an infinitesimally thin insulating film of oxide forms on the surface of the aluminium plate, with the result that the rectifier acts as a condenser of enormous capacity—perhaps several microfarads. This perhaps accounts for the peculiar things that happen sometimes when a choke is inserted in the rectifier circuit. For instance, it was found that when a rectifier was connected in series with a choke and accumulator across the step-down transformer more current flowed through the circuit than when the rectifier alone was connected across the transformer. One would not expect this *a priori*, as the accumulator introduces extra resistance and the choke introduces extra impedance into the circuit. The writer is inclined to attribute this to resonance phenomena brought into play by the condenser effect in the rectifier. We should be glad to hear from any reader who can throw definite light on the subject.

THE ATOMS OF MATTER: THEIR SIZE AND CONSTRUCTION

By F. W. ASTON, M.A., D.Sc., F.R.S., Fellow of Trinity College, Cambridge.

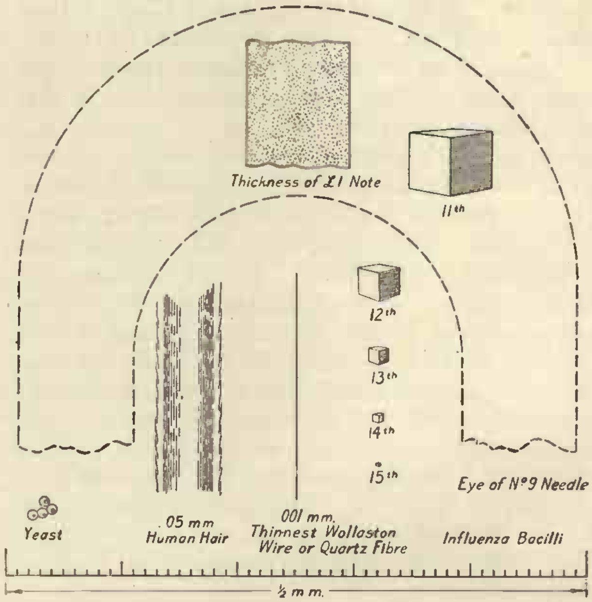
The following remarkable article has been specially prepared for MODERN WIRELESS by Dr. Aston, the winner of the 1922 Nobel Prize for Chemistry (the highest honour obtainable in this subject). The subject of atoms and matter is of great interest and importance to all serious wireless experimenters owing to its close relationship to electronic emission.

THAT matter is discontinuous and consists of discrete particles, is now an accepted fact, but it is by no means obvious to the senses. The surfaces of clean liquids, even under the most powerful microscope, appear perfectly smooth, coherent and continuous. The merest trace of a soluble dye will colour millions of times its volume of water. It is not surprising, therefore, that in the past there have arisen schools who believe that matter is quite continuous and infinitely divisible.

The upholders of this view said that if you took a piece of material, lead, for instance, and went on cutting it into smaller and smaller fragments with a sufficiently sharp knife, you could go on indefinitely. The opposing school argued that at some stage in the operations either the act of section would become impossible, or the result would be lead no longer. Bacon, Descartes, Gassendi, Boyle, and Hooke were all partial to the latter theory, and Newton, in 1675, tried to explain Boyle's Law on the assumption that gases were made up of mutually repulsive particles.

The accuracy of modern knowledge is such that we can carry out, indirectly at least, the experiment suggested by the old philosophers right up to the stage when the second school is proved correct, and the ultimate atom of lead reached. For convenience, we will start with a standard decimetre cube of lead, weighing 11·37 kilograms, and the operation of section will consist of three cuts at right angles to each other, dividing the original cube into eight similar bodies, each of half the linear dimensions and one-eighth the weight. Thus the first cube will have 5 cm. sides and weigh 1·42 kilograms, the second will weigh 178 grs., the fourth 2·78 grs., and so on. Diminution in the series is very rapid, and the result of the ninth operation is a quantity of lead just weighable on the ordinary chemical balance. The results of further operations are compared with suitable objects and a scale of length in Figs. 1, 2, and 3. The last operation possible, without breaking up the lead atom, is the twenty-eighth. The twenty-sixth is illustrated in Fig. 3. It contains 64 atoms, whose size, distance apart and general arrangement can be represented with considerable accuracy, thanks to the exact knowledge derived from research on X-rays and specific heats. On the same scale are represented the largest atom, cæsium, and the smallest atom, carbon,

Fig. 1.



Cubes 11–15 compared with familiar objects to scale.

together with molecules of oxygen and nitrogen, at their average distance apart in the air, and the helical arrangement of silicon and oxygen atoms in quartz crystals discovered by X-ray analysis. The following table shows at what stages certain analytical methods break down. The great superiority of the microscope is a noteworthy point.

Just as any vivid notion of the size of the cubes passes out of our power at about the twelfth—the limiting size of a dark object visible to the unaided eye—so when one considers the figures expressing the number of atoms in any ordinary mass of material, the mind is staggered by their immensity. Thus if we slice the original decimetre cube into square plates one atom thick the area of these plates will total one and one-quarter square miles. If we cut these plates into strings of atoms spaced apart as they are in the solid, these decimetre strings put end-to-end will reach 6·3 million million miles, the distance light will travel in a year, a quarter of the distance to the nearest fixed star. If the atoms are spaced but one millimetre apart the string will be three and a half million times longer yet, spanning the whole Universe.

Cube.	Side in Cms.	Mass in Grms.	Limiting Analytical Methods.
9	·0195	$8 \cdot 5 \times 10^{-5}$	Ordinary Chemical Balance.
14	$6 \cdot 1 \times 10^{-4}$	$2 \cdot 58 \times 10^{-9}$	Quartz Micro-balance.
15	$3 \cdot 05 \times 10^{-4}$	$3 \cdot 22 \times 10^{-10}$	Spectrum Analysis (Na lines).
18	$3 \cdot 8 \times 10^{-5}$	$6 \cdot 25 \times 10^{-13}$	Ordinary Microscope.
24	$6 \cdot 0 \times 10^{-7}$	$2 \cdot 38 \times 10^{-18}$	Ultra Microscope.
28	$3 \cdot 7 \times 10^{-8}$	$5 \cdot 15 \times 10^{-22}$	
Atom	$3 \cdot 0 \times 10^{-8}$	$3 \cdot 44 \times 10^{-22}$	Radioactivity.

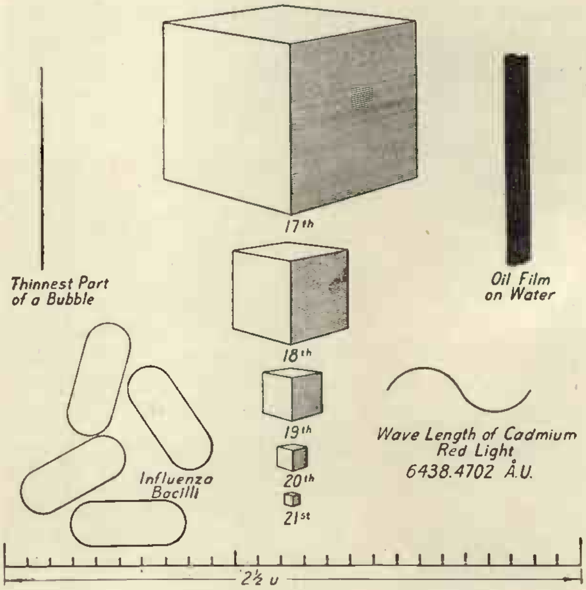
Table indicating the limit of analytical methods.

Again, if an ordinary evacuated electric-light bulb were pierced with an aperture such that one million molecules of the air entered per second, the pressure in the bulb would not rise to that of the air outside for a hundred million years. Perhaps the most striking illustration is as follows: Take a tumbler full of water and —supposing it possible—label all the molecules in it. Throw the water into the sea, or, indeed, anywhere you please, and after a period of time so great that all the water on the earth—in seas, lakes, rivers and clouds—has had time to become *perfectly mixed*, fill your tumbler again at the nearest tap. How many of the labelled molecules are to be expected in it? The answer is, roughly, 2,000; for although the number of tumblerfuls of water on the earth is 5×10^{21}, the number of molecules of water in a single tumbler is 10^{25}.

From the above statement it would, at first sight, appear absurd to hope to obtain effects from single atoms, yet this can now be done in several ways, and indeed it is largely due to the results of such experiment that the figures can be stated with so much confidence. Detection of an individual is only feasible in the case of an atom moving with an enormous velocity when, although its mass is so minute, its energy is quite appreciable. The charged helium atom shot out by radioactive substances in the form of an alpha ray possesses so much energy that the splash of light caused by its impact against a fluorescent screen can be visibly detected, the ionization caused by its passage through a suitable gas can be measured on a sensitive electrometer, and in the beautiful experiments of C. T. R. Wilson, its path in air can be both seen and photographed by means of the condensation of water drops upon the atomic wreckage it leaves behind it.

In the first complete Atomic Theory put forward by Dalton in 1803 one of the postulates states that: "Atoms of the same element are similar to one another and equal in weight." Of course, if we take this as a definition of the word "Element" it becomes a truism; but, on the other hand, what Dalton probably meant by an element, and what we understand by the word to-day, is a substance such as hydrogen, chlorine,

FIG. 2.



Cubes 17–21 compared with minute objects.

or lead, which has unique chemical properties and cannot be resolved into more elementary constituents by any known chemical process.

For many of the well-known elements Dalton's postulate still appears to be strictly true, but for others, probably the majority, it needs some modification.

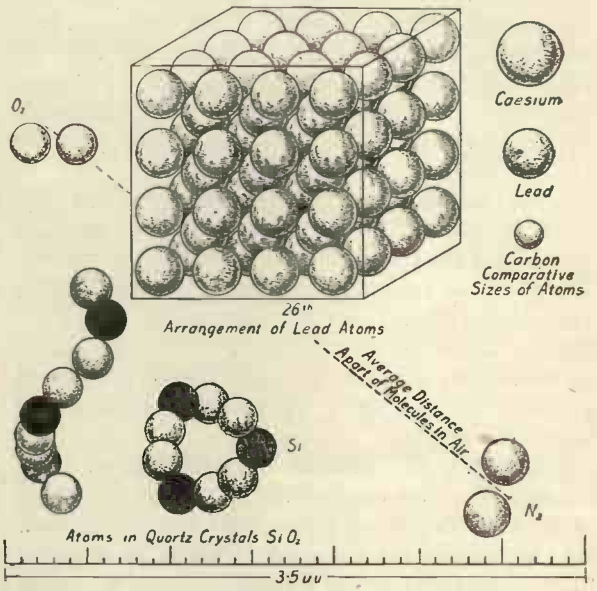
Throughout the history of science philosophers have been in favour of the idea that all matter is composed of the same primordial substance, and that the atoms of the elements are simply stable aggregations of atoms of this substance. Shortly after Dalton's theory had been put forward, Prout suggested that the atoms of the elements were composed of atoms of a substance he called "protyle" which he endeavoured to identify with hydrogen.

If Dalton and Prout were both right the combining weights of the elements should all be expressible as whole numbers, hydrogen being unity. Experimental evidence showed this to be impossible in many cases. Chemists, therefore, wisely preferred Dalton's theory, which was in accord with definite though fractional atomic weights, to Prout's which would necessitate the elements of fractional atomic weight being heterogeneous mixtures of atoms of different weight.

The idea that atoms of the same element are all identical in weight could not be challenged by ordinary chemical methods, for the atoms are by definition chemically identical and numerical ratios were only to be obtained in such methods by the use of quantities of the element containing countless myriads of atoms. At the same time it is rather surprising, when we consider the complete absence of positive evidence in its support, that no theoretical doubts were publicly expressed until late in the nineteenth century, first by Schutzenberger and then by Crookes, and that these doubts have been regarded, even up to the last few years, as speculative in the highest degree. In order to dismiss the idea that the atoms of such a familiar element as chlorine might not all be of the same weight, one had only to mention diffusion experiments and the constancy of chemical equivalents. It is only within the last few years that the lamentable weakness of such arguments has been exposed, and it has been realised that the experimental separation of atoms differing from each other by as much as 10 per cent. in weight, is really an excessively difficult operation.

There are two ways by which the identity of the weights of the atoms forming an element can be tested. The one is by the direct comparison of the weights of individual atoms, the other is by obtaining samples of the element from different sources or by different processes,

FIG. 3.



Cube 26, indicating atoms with reference scale.

which, although perfectly pure, do not give the same chemical atomic weight. It was by the second and less direct of these methods that it was first shown by the experiments of Soddy and others on the atomic weight of lead from different radioactive sources, that substances could exist which, though chemically identical, had different atomic weights. These substances Soddy called "Isotopes" as they occupy the same place in the periodic table of the elements.

The first experimental comparison of the weights of individual atoms was made by Sir J. J. Thomson in his analysis of positive rays by the "parabola" method. Subjected to this test most of the lighter elements appeared to follow Dalton's rule, but the results with the rare gas neon suggested the possibility of the atoms of this element being of two different weights, roughly 20 and 22 respectively. In other words the parabolas of neon indicated that it might be a mixture of isotopes, but the accuracy of measurement by this method was not sufficient to settle the point with certainty.

The requisite accuracy has been obtained by an instrument for the analysis of positive rays called the "mass-spectrograph." By this device, by which the weights of atoms can be compared to an accuracy of one tenth per cent., it has been demonstrated not only that neon (20·2) is a mixture of atoms of weights exactly 20 and 22, but also that chlorine (35·46) is a mixture of isotopic atoms of weight 35 and 37. Furthermore, about half the elements investigated turn out to be mixtures ; some of the heavier ones consist of six or more different constituents. Most important of all is the fact that every element investigated, with the exception of hydrogen, consists of atoms whose weights are expressible as whole numbers on the oxygen scale used by chemists.

This remarkable generalisation, called the "whole number rule," has removed the last obstacle in the way of the unitary theory of matter. We have no hesitation in affirming that Nature uses the same standard bricks in the construction of the atoms of all elements, and that these standard bricks are the primordial atoms of positive and negative electricity, protons and electrons.

These are the natural unit charges of electricity, equal but of opposite sign. Of the shape of these particles we know next to nothing, but the wonderful advances of modern physics, in particular those of radioactivity, enable us to speak of their weights and dimensions with some assurance. The weight of the proton is very nearly the weight of a hydrogen atom, the electron is nearly two thousand times lighter, so that the atomic weight of an element (not consisting of isotopes) will be roughly equal to the number of protons in its atoms. The dimensions of the electron are about one hundred thousand times less than those of the atoms as illustrated above, and the proton is probably nearly two thousand times smaller still.

We now know of what atoms are constructed, and may go on to consider the evidence as to how their constituent parts are arranged. In the foregoing diagrams the atoms are represented as spheres, and in respect to the small forces and velocities which occur in the collisions between the atoms of gases at ordinary temperatures they do behave very exactly as smooth elastic spheres. But, unfortunately, the idea of a sphere carries the suggestion of a portion of space *full* of something ; that is the atom as a sort of spherical bag packed full of electric charges. Nothing could be further from the actuality, for, from the figures already given, it can be seen at once that even in the heaviest atom known the constituent charges fail to fill even one million millionth part of its whole volume. To convey any direct idea of these numerical relations by diagrams is practically hopeless, and were we to construct a scale model of the atom as big as the dome of St. Paul's we should have some difficulty in seeing the electrons, which would be little larger than pins heads, while the protons would escape notice altogether as dust particles invisible to the unaided eye. Experimental evidence leaves us no escape from the astounding conclusion that the atom of matter, as a structure, is empty, empty as the solar system, and what we measure as its spherical boundary really only represents the limiting orbits of its outermost electrons.

The hypothesis which has led to the greatest advances in our knowledge of the inner construction of atoms is Rutherford's theory of the "nucleus atom" put forward in 1911. This is now supported by so many results of direct experiment that it is now universally accepted, and must be substantially correct. It postulates that all of the positive and about half of the negative electricity, that is practically the entire weight, of the atom is concentrated at its centre, forming a very small body called the nucleus. In other words all the protons and about half the electrons in the atom are packed together forming a sort of sun round which revolve the remaining electrons as planets. The number of protons in excess of electrons in the nucleus will clearly be its net positive charge, and since this will not depend on the gross numbers of protons and electrons, but only on their difference, we can have elements whose atoms have nuclei of different weights but the same net charge. These are isotopes, but the chemical properties of an atom are determined by the charge of its nucleus.

The nucleus is extremely small compared with the whole atom. Thus if in the atom of helium, atomic weight 4, atomic number 2, we take the nucleus, consisting of 4 protons and 2 electrons, as represented by a rather large pea, its planetary electrons may be represented on the same scale as two rather smaller peas revolving round it at a distance of a *quarter of a mile*. The dislodgment of one of its planetary electrons from an atom requires comparatively little energy, and is the well-known process called ionisation. This change is only a temporary one, as the atom takes the first opportunity of attracting it or any other stray electron back into its orbit and becoming neutral again. It is by a sort of continual exchange of such loose electrons that electricity is conducted along metallic wires. Disruption of the nucleus, on the other hand, needs enormous energy, but once performed must give rise to the atom of a new element. This process of transmutation has been achieved by Sir Ernest Rutherford in the case of some of the lighter elements by bombarding their atoms with alpha rays, which are charged helium nuclei expelled at enormous speeds from radioactive atoms during their natural process of disintegration. From the tiny dimensions of the nucleus compared with those of the atom it is obvious that the chance of getting a direct hit on the nucleus is only one in many millions, but the experiment shows that when this does take place protons are dislodged from the atoms of the element struck, and that therefore transmutation has been actually carried out.

The quantity of matter so transmuted is indeed almost inconceivably small, but it is the first step towards what may well be the greatest achievement of the human race, the release and control of the so-called "atomic energy." We now know with certainty that four neutral hydrogen atoms weigh appreciably more than one neutral helium atom, though they contain identically the same units, 4 protons and 4 electrons. The change of weight is probably due to the closer "packing" in the helium nucleus, but whatever the explanation may be transmutation of hydrogen into helium must inevitably destroy matter, and therefore liberate energy. The quantity of energy can be calculated and is prodigious beyond the dreams of scientific fiction. If we could transmute the hydrogen contained in one pint of water, the energy so liberated would be sufficient to propel the *Mauretania* across the Atlantic and back at full speed. With such vast stores of energy at our disposal, there would be literally no limit to the material achievements of the human race.

The possibility that the process of transmutation might be beyond control, and result in the detonation of all the water on the earth at once, is an interesting one, since in that case the earth and its inhabitants would be dissipated into space as a new star, but the probability of such a catastrophe is too remote to be considered seriously. A recent newspaper article pointed out the danger of scientific discovery, and actually suggested that any results of research which might lead to the liberation of atomic energy should be suppressed. So, doubtless, the more elderly and apelike of our prehistoric ancestors grumbled at the innovation of cooked food, and gravely pointed out the terrible dangers of the newly invented agency of fire; but it can hardly be maintained to-day that subsequent history has justified their caution.

A READILY MADE VARIABLE INDUCTANCE

NEVER having possessed very much mechanical ability, the writer has always tried to make his experimental apparatus out of the simplest of materials, and in such a way as to avoid much additional work in the making of apparatus. Naturally, the first thing that I had to make was a variable inductance, and as I did not care very much for the single slider type, evolved the design shown in the accompanying diagram (Fig. 1). The variable inductance is shown inserted in the usual place in a simple crystal receiving circuit.

In the figure seven tappings are shown, but it will be obvious that any suitable number may be used and the range of wavelength required will largely determine the number of tappings taken from the inductance coil, which is shown in the diagram. The inductance consists of a tube usually about 3½ in. or 4 in. in diameter, wound with, say, No. 26 S.W.G. double cotton-covered wire. One end of the coil is connected permanently to a terminal T_1, and the other end is similarly connected to a terminal T_8. Along the coil are taken tappings at every so many turns. The tappings may conveniently be in the form of twisted loops, the ends of which are bared and secured by solder, or otherwise, to terminals T_2, T_3, T_4, T_5, T_6, and T_7, screwed into the lid of the box B. These terminals are of the wood screw type, having a horizontal hole through the brass portion. When using these terminals in the ordinary way a wire would be passed through the hole and secured by turning round the head of the screw. In the present case, however, it is not proposed to employ the terminals in this manner. They are arranged so that a knitting needle, W, or other stout wire, may pass through all the holes in the terminals in the manner shown. At the end of the knitting needle is a wooden knob, K, which, however, may conveniently be made of ebonite, or even simply sealing wax.

When the knitting needle W is passed through all the terminals T_2, T_3, T_4, T_5, T_6, and T_7,

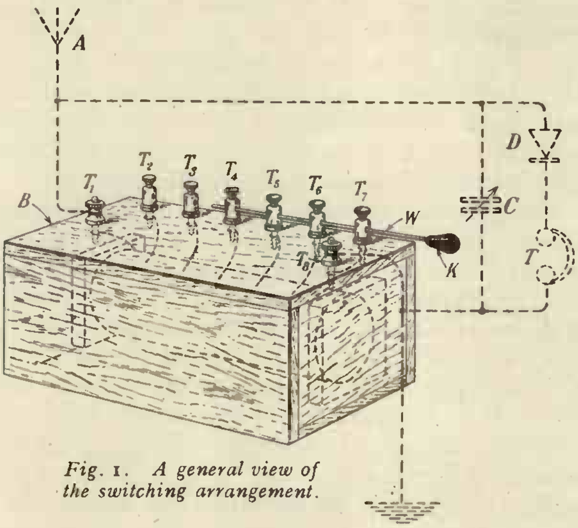


Fig. 1. A general view of the switching arrangement.

only that portion of the inductance between the terminals T_1 and T_2 will be used. All the rest of the coil will be short-circuited, and short-circuited in the best possible manner, as each particular section will be shorted. Losses are thereby reduced to a minimum. If now we pull out the knob K, so that the knitting needle only passes through the terminals T_3, T_4, T_5, T_6, and T_7, more inductance will be added to the circuit, which will now include the turns between the terminals T_1 and T_3. All the rest of the coil will be shorted in sections.

If we pull out the needle so that it occupies the actual position shown in the accompanying diagram, the amount of inductance will be further increased, and will consist of the turns of wire between T_1 and T_4. Any amount of inductance may be obtained in this manner. and if the wire W is pulled out of all the terminals except the last, the whole of the inductance will be connected in circuit. It is to be noted that the terminal T_7 is also connected to the terminal T_8. Fig. 2 shows a plan of the box, illustrating the method of taking tappings from the coil.

The variable inductance thus constructed does not lend itself to rapid searching for a certain wavelength, as it is desirable to screw down the

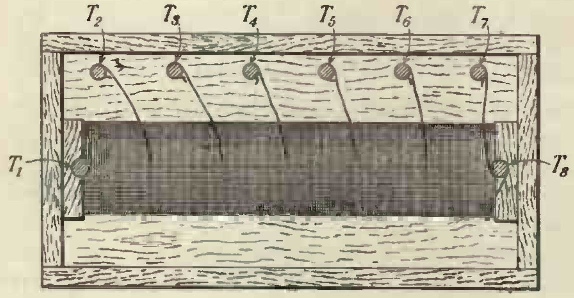


Fig. 2. View of box with lid removed.

terminal screws on to the knitting needle or stout wire W in each case. The inductance, however, may be thoroughly recommended as a very simple form of apparatus for use in cases where a very rapid change in wavelength is not desired. The inductance may be used, of course, in any kind of circuit, although, in the diagram, it is shown employed in a simple crystal receiver circuit. G. N. K.

A VARIABLE GRID LEAK

By A. DRAKE.

ONE of the most important parts, and usually the most neglected by the amateur, is the grid leak, since most of the working diagrams of to-day simply dismiss the leak with " A value of two meghoms."

Each valve requires its own value of leak resistance, and any particular valve, irrespective of type, requires different values of resistance dependent upon its operating characteristics and its use as a Detector, Amplifier or Oscillator. As a striking example of this in the recent Transatlantic tests a large number of successful entrants used leaks of their own manufacture, pencil marks on ebonite, slate pencil, etc.

Below I give the details of a variable leak that I have had in use for a considerable time, and has become almost indispensable. The following materials are quite inexpensive, and the instrument can be made up by almost any keen amateur :

1 piece of ebonite, 4 by 4 by ¼ in.
1 switch arm.
11 contact studs and 2 stops.
2 terminals.
A little Indian ink and a piece of cartridge paper.

The switch arm and studs may be purchased from any of the well-known dealers, or they may be made if so desired. Having obtained the switch arm and studs, proceed to drill the ebonite to suit the radius, taking care to get the studs fairly close together, otherwise the switch arm, especially if it is of the laminated type, will lodge between the studs. A little care in this direction will be amply repaid later. Take the cartridge paper and cut approximately to size as shown by the dotted line in Fig. 1. Carefully drill this so that it will fit over the contact studs at the back of the ebonite. Having completed this operation, obtain some Indian ink, that used by artists already mixed being preferable, although the dry, dissolved in methylated spirit, answers the purpose just as well. The kind having been decided upon, mix a little graphite (scrapings from a soft lead pencil were used by the writer) with the ink until it is made up to the consistency of cream.

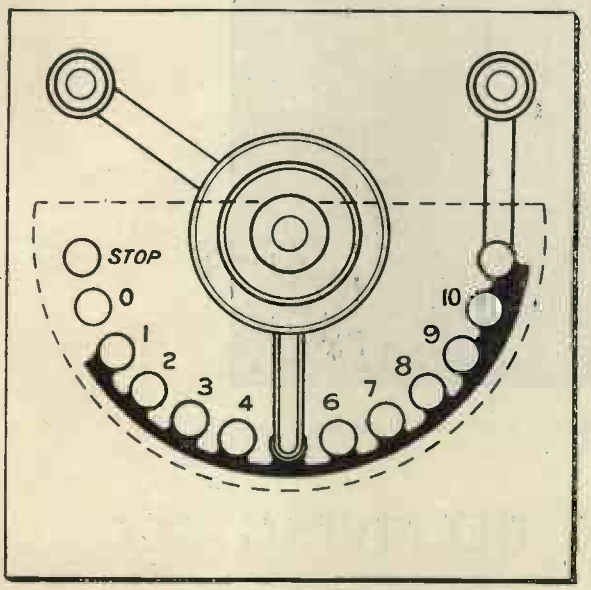


Fig. 1. The general arrangement of the variable leak.

With a fine brush carefully mark over the cartridge paper as illustrated in the shaded portion of Fig. 2, care being taken to get it well under the spaces where the back nuts will cover it; at the same time it is necessary that one stud does not run into the other, as that stud would be shorted and thus render it useless. Only a very thin layer is required, as the cartridge paper absorbs the mixture and tends to spread it. When the mixture has been applied it should be placed on one side to dry. The terminals are then fitted, a thin brass strip being connected to each. One is taken to the switch arm and the other to the last stud. An extra blob of ink should be applied to the last stud and the connecting strip to ensure proper contact. This should not be done, however, until the cartridge paper has been assembled in its proper place. Place the prepared cartridge paper over the studs and make the connections already mentioned, screw on the back nuts, and the variable grid leak is complete and ready to be fitted into some type of case to suit maker's taste.

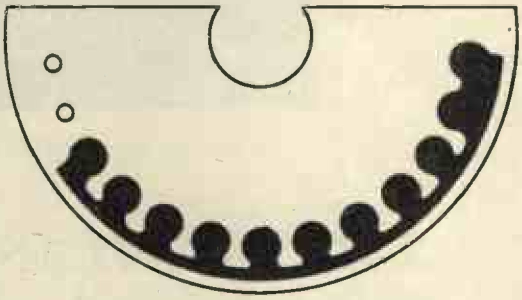
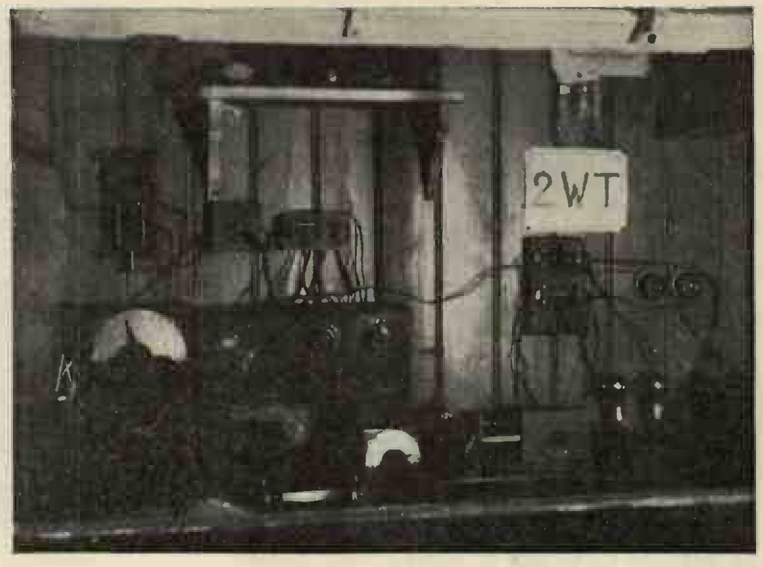


Fig. 2. Showing details of the Indian ink and cartridge paper.

In operation place the switch arm on the central stud, bring filament up to proper brilliancy, and you will note that by moving the arm either to right or left an increase of signal strength is obtained. In some cases, with proper adjustments in conjunction with the filament rheostat, a jamming station can be entirely cut out.



2 WT, the station at which the apparatus described below is installed.

A TRANSATLANTIC RECEIVING SET

By H. CHADWICK (2 WT)

This practical article gives full instructions for making a sensitive receiver on which the writer regularly receives American amateurs and also many of the world's high-power stations. The writer's station has been visited by a member of our technical staff, and there is no doubt that highly successful results are obtained.

THIS description of my receiving gear will, no doubt, be of interest to radio experimenters in general, and perhaps of assistance to anyone who is unable to decide upon the constructional details, number of valves, and such other little items which vary so considerably in every enthusiast's ideas of perfection.

The circuit itself is of normal type, but in assembling the component parts, a departure is made from the now common method of building everything on to one panel, which results in all parts being practically inaccessible. The receiver has been built up from the simplest crystal set, and is, as yet, by no means completed, but results so far obtained justify the method of construction. The main points considered in the design are universal range, as regards tuning and number of valves, ready interchange of parts with all wiring easily accessible when necessary for alteration of circuit, and where possible switches to effect quickly the foregoing changes. Efficiency and reliability naturally must always be in the foreground.

A total of five valves will eventually be used, four only being in circuit at present, and an examination of Fig. 1 will show that the first is a high-frequency amplifier followed by a detector, and two note-magnifying valves. Valve switching devices are omitted from this diagram for the sake of simplicity.

The Tuning Units

Three separate tuners are used to cover the whole range of wavelengths, two only being shown, the well-known Mark III tuner doing yeoman service between 100 and 600 metres.

For the benefit of anyone not possessing this valuable tuner, I will give details. Both the aerial and closed circuit coils are wound on ebonite formers 4 in. long by $3\frac{1}{2}$ in. diameter with about sixty-five turns of Litzendraht. This is equivalent to about 18 S.W.G. d.c.c. copper wire, which should be quite satisfactory if used, and, of course, cardboard tubes could be employed. Coupling is obtained by mounting the coils on a common axis and is varied by rotating the secondary coil, the position of minimum coupling being obtained when the secondary is at right angles to the A.T.I. (aerial tuning inductance). The same effect may be produced by winding the secondary on a smaller former with finer gauge wire, and sliding it in and out of the A.T.I.

The A.T.I. is tapped out every 3⅓ turns to a 19-point switch and the secondary to a 5-point switch. I have added a third coil for use as a reaction coil. It measures 3 in. long by 2½ in. diameter, wound with No. 26 S.W.G. d.c.c. copper wire and slides inside the A.T.I. This is tapped out to a 3-stud switch and the whole tuner, less condensers, is remounted into a polished mahogany cabinet.

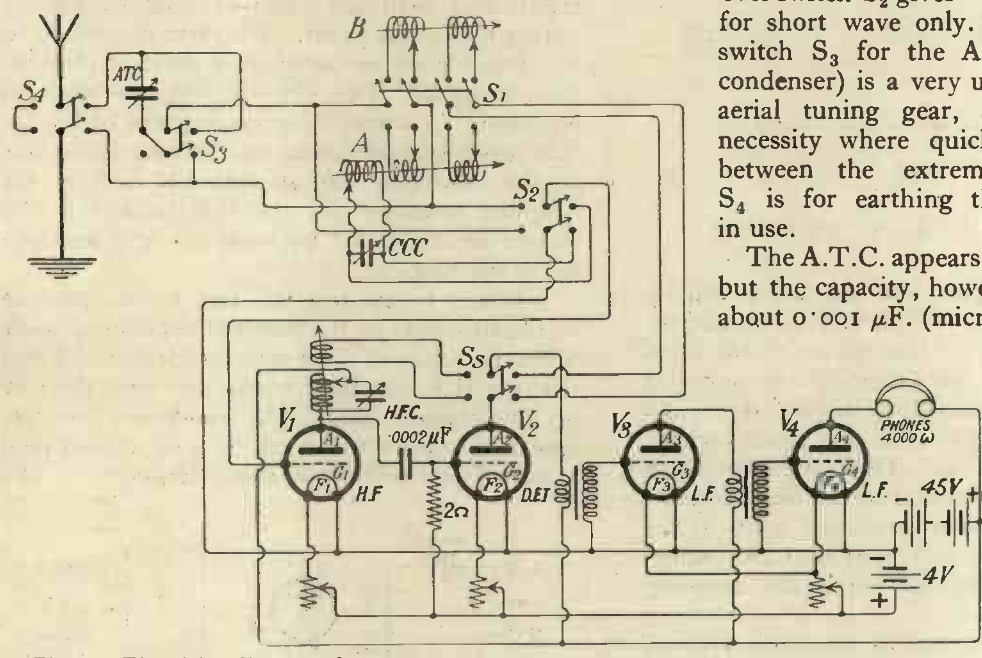


Fig. 1. The wiring diagram of the complete circuit, showing the switching of the tuning circuits.

The second tuner covers a range of 600 to 4,500 metres, and is again of the solenoid type. Two coils only are used in this case, namely the aerial inductance and reaction coil. The A.T.I. is wound, single layer, with 26 S.W.G. d.c.c. copper on a cardboard former 9½ in. long by 5 in. diameter, tapped to an 11-stud switch. The reaction coil is 5 in. long by 3 in. diameter, wound also with 26 S.W.G. d.c.c. wire with four tappings. This coil is arranged to slide on two brass rods into the A.T.I.

As I am a firm believer in the single layer solenoid type of tuning coil, and as I possessed a hollow wooden tube 10 in. by 7 in. diameter, a relic of my crystal experiments, I attempted to reach long waves by winding it with 30 S.W.G. and added a reaction coil. Unfortunately, my calculation of its inductance was too optimistic, for I found, on trial, that my efforts were futile. A very cumbersome and unwieldy tuner was the result which only gives a wavelength of about 8,000 metres. It is, therefore, seldom used and will be replaced as soon as possible with tapped multilayer coils capable of tuning to the longest wavelength in use.

Change over from one tuner to the other is effected by means of a 4-pole 2-way switch, S_1 (Fig. 1). A is the Mark III tuner and B the medium-wave tuner. The long-wave tuner, when completed, will be placed in circuit by means of an arrangement of plugs. A 2-pole change-over switch S_2 gives "tune," or "standby" for short wave only. The series parallel switch S_3 for the A.T.C. (aerial tuning condenser) is a very useful addition to the aerial tuning gear, and is, in fact, a necessity where quick change is desired between the extremes of wavelength. S_4 is for earthing the aerial when not in use.

The A.T.C. appears to be of gigantic size, but the capacity, however, is only normal, about 0·001 μF. (microfarad). The plates are semi-circular 2½ in. radius, with 9 fixed and 8 moving vanes with an air spacing of $\frac{1}{16}$ in. The closed circuit condenser C.C.C. (Fig. 1) has 29 plates 1⅜th radius with a spacing of $\frac{1}{16}$th in., and has a capacity of about 0.0005 μF.

The H.F. Amplifier Unit

As an experiment to enable me to decide which type of high frequency amplification to install permanently, I made a separate single-valve amplifier, using reactance capacity coupling, or, as it is popularly called, "tuned anode" coupling. The component parts are all mounted openly on a wood panel 11 in. by 6 in. and, in fact, wood is responsible for the whole insulation of the amplifier, with the exception of the valve-holder.

Fig. 2 shows the wiring of this panel, which is placed before the detector and wired to it. Separate filament control is used, as shown. The coil L, which was wound specially for the Transatlantic Tests, is wound single layer on a former 4 in. by 1¾ in. with 22 S.W.G. copper d.c.c. wire and tapped to a 7-stud switch. The condenser across it is temporarily borrowed from the closed circuit of the tuner, plain aerial reception being adopted until another condenser is made. With the arrangement in use the amplifier operates from about 100 to 400 metres. The

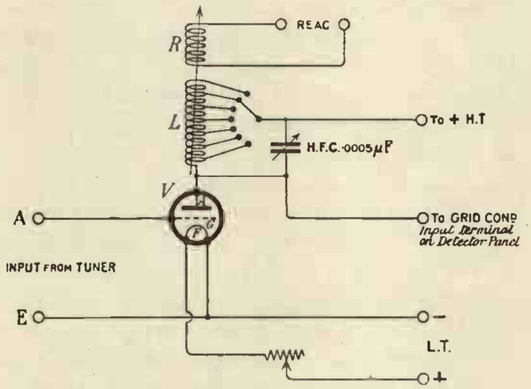


Fig. 2. Details of the high-frequency amplifier.

reaction coil R couples into the anode coil by sliding, and is wound with 30 S.W.G. on a $2\frac{1}{2}$ in. by $1\frac{1}{2}$ in. former. No tappings are required on this coil as I find that sufficient variation of coupling can be obtained by sliding alone, the coils coming clear away from the anode inductance for loose coupling. This type of reaction is alternative to the reaction on the aerial inductance, and does not cause radiation when in the oscillatory condition, reception of C.W. being, however, possible by tightening the coupling until the valve oscillates.

The indiscriminate use of even this type of reaction when receiving continuous wave signals is not to be recommended, and a separate heterodyne will shortly be constructed, the use of which should minimise all possible chance of radiation. The coupling condenser and leak, which assist in transferring the high frequency energy from the amplifier to the detector are mounted on the detector panel, and are described below.

The above values of the coils are for a short range of wavelengths only, *viz.*, 100 to 400 metres. If the unit of Fig. 2 is for use over a wavelength range of 100 to 1,000 metres, the coil L in Fig. 2 is a cardboard tube measuring 4 in. long by 2 in. diameter wound with 30 S.W.G. d.c.c. wire and fitted with nine evenly distributed tappings. The tuning condenser marked HFC in Fig. 2 may have any convenient value not less than 0·0002 μF. capacity. The reaction coil R for this wider range of wavelengths may be a cardboard tube 3 in. long by $1\frac{1}{2}$ in. diameter wound with 30 S.W.G. d.c.c. wire; no tappings on it are provided, but the coupling between it and L should be variable.

The Detector Unit

Now, a perusal of valve circuits will reveal the fact that, in nearly all cases, the valve detector circuit is standard, and common to all, the circuits for high or low frequency amplification being added to the detector. I therefore built the detector panel as a separate unit, and can thus experiment with any form of amplification by wiring up to this panel. All parts pertaining to the detector are mounted on a sheet of ebonite, 7 in. by $4\frac{1}{2}$ in. This ebonite might be replaced by wood. A wiring diagram is given in Fig. 3. The usual grid condenser and leak are fitted, but as the condenser has also to be used as the coupling condenser for the H.F. valve, the leak should be connected between the grid and one leg of the filament.

Whether to connect the leak to the positive or negative side of the filament depends entirely upon the values of condenser and leak, but I find that the H.F. amplifier works best with the leak on the positive side. The condenser has five sheets of copper foil 2 in. by $\frac{3}{8}$ in. overlapping 1 and $\frac{1}{4}$ in. with thin mica dielectric. The

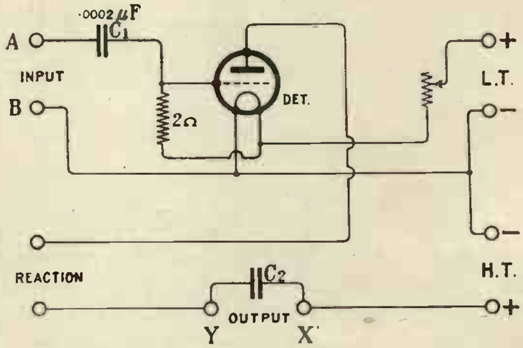


Fig. 3. The detector unit.

leak is the usual blacklead line, between terminals on fibre, enclosed with a fibre top piece, and the joint varnished to ensure constancy of resistance in a variable but usually damp climate.

The condenser C_2 across the output terminals XY of Fig. 3, is important, and has a fairly large capacity. It consists of a total of about twenty sheets of tinfoil, 1 in. wide. The two sets of about ten plates each overlap about $1\frac{1}{2}$ in. Very thin mica is used for the dielectric.

The L.F. Amplifier Unit

The two-valve low frequency magnifier is arranged on an ebonite panel (9 in. by $6\frac{1}{2}$ in.). The size of this panel is, of course, determined by the size of transformers, filament rheostat, and switching arrangements. In this case bought intervalve transformers are used, and a " Dewar " lever switch is fitted for controlling the number of valves.

Fig. 4 gives the method of wiring the switch, which allows the use of detector only, or the addition of one or two L.F. valves by the movement of a very small lever. This switch is, in effect, equivalent to two double-pole change-over switches, and in spite of its very small size is very robust and reliable. The first set of contacts A change over with the first movement of the lever, the second movement then changing the B contacts over. It will be seen from the diagram that high resistance 'phones are used, and a 'phone transformer is therefore unnecessary, though of course it would be an easy matter to incorporate one in the amplifier if desired.

Six terminals are fitted in pairs for input, output, and low-tension battery. High-tension for the plate circuit, as will be seen, is fed from the output terminals of the detector panel, and consequently separate H.T. is not used for the amplifier.

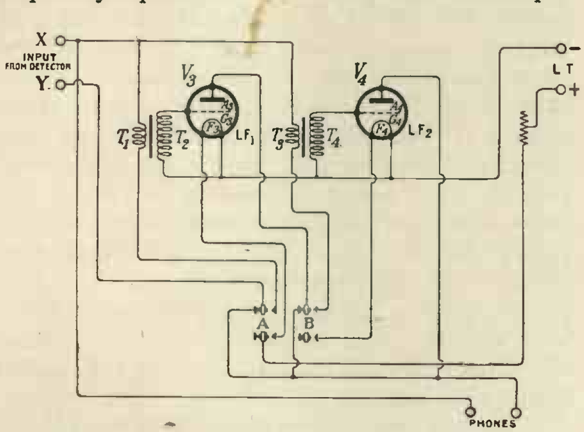


Fig. 4. Details of the low-frequency amplifier.

In this respect it is requisite that a little caution be observed when wiring the amplifier up to the detector. The input terminals marked X and Y must be connected to their respective terminals marked X and Y on the detector panel, that is, connect X on to X, and connect Y to Y. To connect them the other way round would render the amplifier inoperative. The filament rheostat is wound on a slate cylinder, a sliding contact moving along it controlled by means of a very quick threaded rod similar to the Archimedean drill. A rotary filament rheostat would be preferable.

A Modified 2-Valve H.F. Amplifying Unit

High frequency amplification is undoubtedly a subject about which a great deal may be written, but to put my own experience into a few words, I find that, at least so far as one stage of amplification goes, there is very little to choose between the reactance capacity and tuned " plug-in " transformer types of coupling. The former, in my opinion, has preference, simply because it is actually a modification of the latter, and is probably easier to fix up and operate if required over a wavelength range of, say, 100 to 1,000 metres. I accordingly built an experimental panel employing reactance capacity coupling, and having obtained good and consistent results, I propose to incorporate this principle into a two-stage amplifier, the design of which I will describe.

The wiring diagram (Fig. 5) shows the method of connecting the proposed amplifier. In keeping with the rest of the receiver, provision will be made for the switching of valves, and also for the use of resistance capacity coupling for wavelengths over 1,000 metres. The input terminals AE (Fig. 5) are connected to the tuner, and may be changed over to the second valve or detector valve input, by means of the Dewar switch AB, at the same time breaking the filament circuit of the valve which is cut out. The plate circuit coils L_1 and L_2, in order to cover a range of 100 to 1,000 metres, are wound with 30 S.W.G. d.c.c. wire, in cardboard tubes 4 in. by 2 in. diameter, with 9 tappings in progressive stages. For convenience in tuning both circuits, both coils are identical with the tappings taken off at exactly the same place on each coil. Two 11-stud switches are required, the tenth studs placing in circuit anode resistances of the order of 30,000 ohms, and the last studs placing the switch on to terminals X_1 and X_2 for the addition of external coupling coils or resistances for experimental purposes. This arrangement is clearly shown in Fig. 5.

The tuning condensers C_1 and C_2 have a capacity of about $0{\cdot}0002\ \mu F.$, made up of six fixed and five moving vanes of the standard size, which may be purchased quite cheaply, with standard spacing washers. The actual capacity is not important. When using resistance coupling these condensers act as a shunt and will lower the efficiency. They should, therefore, be set to zero, or preferably switched out of circuit if anything like efficiency is required for resistance capacity working.

The reaction coil R is 3 in. long by 1½ in. diameter, with a winding of 30 S.W.G. d.c.c. copper wire, and is coupled into the plate circuit coil of the second valve by sliding right inside. It is also allowed to come clear away for loose coupling. The grid condenser C_3 and leak R have values identical with those on the detector panel.

As regards mounting the components of this amplifier, I think all that need be mentioned is that the coils L_1 and L_2 should be placed as far apart as possible and mutually at right angles, adjustment of the reaction coupling being obtained by rotating a knob connected to the coil by means of a rack and pinion or similar device.

This amplifier has worked very well in the experimental stage, has been thoroughly reliable, and, of course, will not suffer any loss of efficiency when panelled and mounted in a cabinet. Refinements will naturally suggest themselves, such as a change-over system to tuned transformer coupling, but this cannot be accomplished without overcomplicating the already numerous switching arrangements.

The switch S_5 in Fig. 1 allows the use of single-valve reaction on any other wavelength than that on which broadcasting takes place.

The Results Obtained

No doubt the erection of a good aerial is a very serious problem to many amateurs, as it was in my case. However, having made the easiest and most convenient job with the facilities I had available, I find that I can obtain some very fair results, which proves that this method of receiver construction is by no means detrimental to the efficiency of the completed outfit. The aerial used is a 50 ft. twin of 18 S.W.G. bare copper wire, with spreaders only 3 ft. long, and height 20 ft. The houses surrounding the aerial are much higher, and as the aerial is only about 12 ft. away from the side of the house at the farthest point, it may be considered as a very inefficient arrangement.

As regards results, I think anyone will now admit that the old 1,000 metre wave was decidedly inefficient for amateur transmission. I will therefore quote two examples of reception on this wavelength. I have heard telephony from 2 KD at twenty-five miles when he stated his radiation as 0·22 ampere, and Morse from 2 KF (nearly 200 miles) when his radiation was 0·45 ampere, using detector valve only. All the usual Continental and U.S.A. stations are readable on one valve, and I have heard telephony from 8 GS (France) using two valves H.F. and detector, the wavelength being about 200 metres. During the recent Transatlantic tests over forty American amateurs were recorded, and several others missed through jamming, harmonics and atmospheric disturbances, which always seem to become particularly fierce when least wanted. This was using two, and occasionally three, valves H.F., detector, and L.F. added when required. I could hear 2 FP, 0 XM, 8 AQO, and one or two others with the 'phones on the table, and, needless to say, was very much surprised myself.

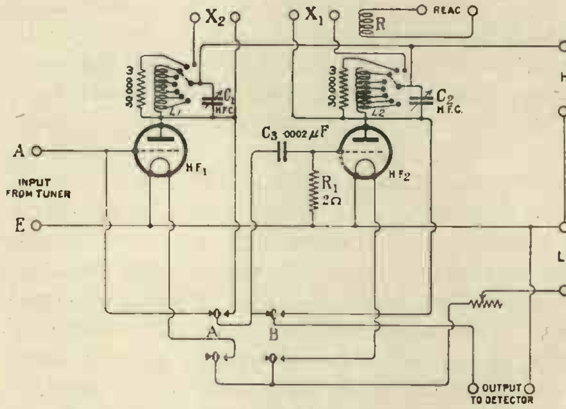


Fig. 5. The two-valve high-frequency amplifier.

"DIRECTIONAL WIRELESS"

By J. ROBINSON, M.B.E., Ph.D., M.Sc., F.Inst.P.

(*Continued from page 52 MODERN WIRELESS.*)

FIG. 1 shows this diagrammatically, W indicating the direction of travel, E and H showing the directions of the electric and magnetic forces. Usually these three directions are well-defined and so that W, the direction of travel, is along the surface of the earth; E, the

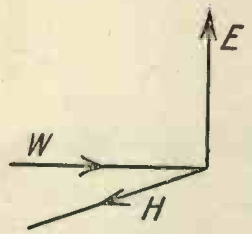


Fig. 1. Direction of travel, electric and magnetic forces.

electric force, is vertical; and H, the magnetic force, is horizontal. It can readily be seen why the electric force is usually vertical, as transmitting stations have vertical aerials, and the reason for transmission is that the electric potentials of the transmitter travel up and down this vertical part. Hence, at the start of the waves, we have the electric force vertical. The direction of travel is known to be usually along the surface of the earth, and thus the magnetic force, which must be perpendicular to both the electric force and the direction of travel, is horizontal. An easy method of visualising these three directions is by stretching out the thumb, first and second fingers of either hand, all three being at right angles to each other as shown in Fig. 2. The thumb represents the direction of propagation, the first finger the magnetic force, and the second finger the electric force.

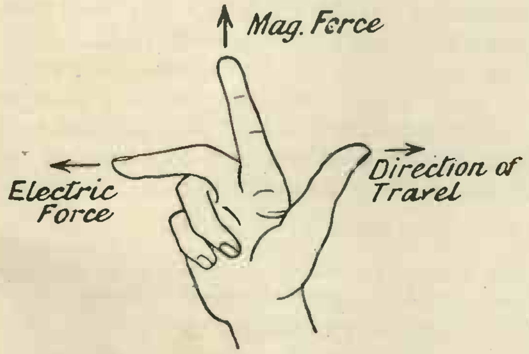


Fig. 2. An analogy with the hand.

The magnetic force and the electric force both vary rapidly, oscillating at the frequency of the waves. If the wavelength of the waves is 1,000 metres the frequency of the oscillation is at the rate of 300,000 per second. If we consider a loop placed so that the waves fall on it, it is readily seen how an electromotive force is produced. The well-known laws of electromagnetic induction come to our aid. Whenever there is relative motion between a loop and a magnetic field, an electromotive force is produced in the loop. This can be done, as in the case of the dynamo, by rotating a loop between the poles of a magnet. In the case of wireless waves no rotation or movement of the loop is necessary, for the magnetic field is already in motion,

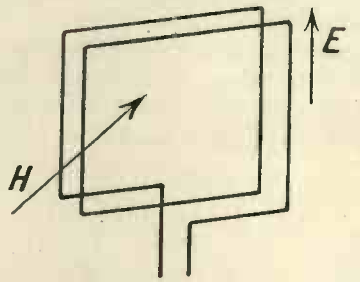


Fig. 3. Electric and magnetic forces in relation to a loop.

oscillating at a very high frequency, in this case of 1,000-metre waves at 300,000 times per second. There is the essential condition as expressed by the laws of induction that it is the magnetic force which cuts through the loop which is effective. Hence the electromotive force is produced in the loop in every position of the loop except when the direction of the magnetic force is parallel to the plane of the loop. The maximum effect is obtained when the magnetic force is perpendicular to the plane of the loop. Referring to Figs. 1 and 3, it is seen that this is the case when the plane of the loop is vertical and pointing to the transmitting station. The minimum or zero effect is obtained when the loop is turned so as to have its plane perpendicular to the direction of travel, for in this case its plane is parallel to the magnetic force and thus there is no cutting through the loop.

If we thus arrange a loop of a suitable number of turns to be capable of rotation about a vertical axis, and arrange suitable receiving apparatus, we find that as it is rotated the intensity of the signals varies from a maximum to a minimum.

Referring to Fig. 4, which is a view looking vertically down on a loop A B, where W represents the direction of travel of the waves, and H the direction of the magnetic force, three positions of the loop are shown :

Position (1) with the loop A B with its plane making an angle θ with the magnetic force H.

Position (2) with the loop A_1 B_1 perpendicular to the magnetic force and thus in the direction of the waves.

Position (3) with the loop A_2 B_2 parallel to the magnetic force and thus perpendicular to the direction of the waves.

In position (2) the loop A_1 B_1 has the whole effect of the cutting of the magnetic lines of force. In the case (1) there is only a portion of the cutting of the lines of force, and the effect is equal to that due to H sin θ. The electromotive force obtained as the loop is rotated is thus proportional to the sine of the angle between the plane of the loop and the magnetic force. This electromotive force is, of course, alternating at a very great frequency, and in order to detect it the use of rectifiers is employed, which with amplification and the use of telephones, converts the alternating electromotive force into an

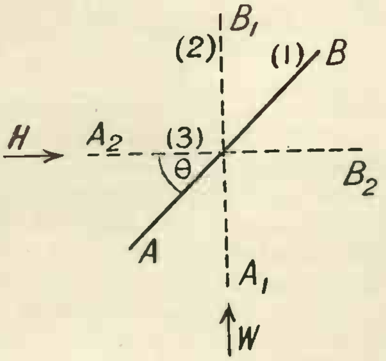


Fig. 4. A plan view of the loop.

intensity of sound. Thus we find that as the loop is rotated there is a maximum of sound in the position A_1 B_1 and also when the loop is completely reversed to the position B_1 A_1, and a minimum of sound in the positions A_2 B_2 or B_2 A_2. Fig. 5 shows the intensity of sound plotted for various angles of the loop with regard to the direction of the waves. The two maxima and the two minima in one complete rotation of 360° are shown.

2. Signal Strength with a Simple Loop

Having shown how the signal strength with a simple loop varies as the loop is rotated, it is useful to consider the conditions which determine how best the signals can be observed. The first point to consider is the actual magnitude of the signal strength, and we are at once faced with the fact that signals received on loops are very much weaker than on open aerials for wavelengths in common use. In fact, signals

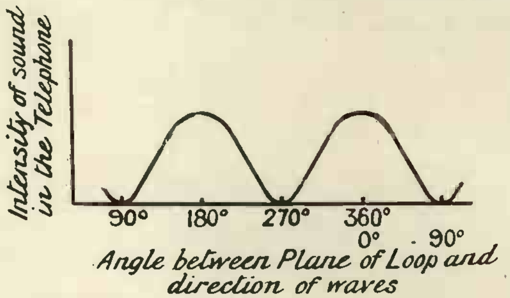


Fig. 5. Indicating signal intensity in relation to angle of loop. Actually, the curve peaks are flatter.

are so weak with loops that before the advent of thermionic valve amplifiers, when crystals were the best detectors known, loops could only be used for the very strongest transmitting stations, and even then only when quite near to them. The reason for this can be readily understood. We will consider the effect produced in a square loop of height h_1 and length d, and that in an open aerial of the same height h (Fig 6). Consider first the effect produced in the plain aerial h. Calling the laws of electromagnetic induction to our mind again, we know that if a straight conductor of height h is moved at a speed v in a magnetic field of strength H, there is an electromotive force E produced in it

$$\text{where } E = h\,v\,H.$$

In this case the straight conductor or aerial h is fixed and the magnetic force is moving.

Now considering the loop, there is an electromotive force $E = h\,v\,H$ produced in one vertical arm h_1 and an identical electromotive force produced in the other vertical arm h_2. From the method of connection these two electromotive forces oppose each other, and we would at first expect to get no resultant electromotive force at all. However, these electromotive forces do not entirely balance out, owing to the fact that the two arms h_1 and h_2 are not usually cut by the same strength of magnetic force at the same time, and thus the maximum electromotive force in h_1 lags behind that of h_2. The amount of lag is given by the distance between h_1 and h_2 as compared with the wavelength. If the distance *d* is one quarter of a wavelength it is obvious that when the electromotive force in h_1 is a maximum the electromotive force in h_2 is a minimum. It is, however, not practicable to have the distance d_1, *i.e.*, the width of a loop, equal to a quarter of a wavelength for waves in common use, and we have to be content with the distance *d* being a very small percentage of a quarter of a wavelength. Thus the electromotive force in h_1 lags very little behind that of h_2, and they thus very nearly balance out, leaving only a very small electromotive force.

It is thus seen that for loops of a practicable

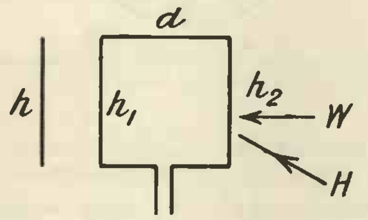


Fig. 6. Illustrating the effect upon loop in relation to dimensions.

size the electromotive force produced is very much smaller than that produced in an open aerial of the same height, and that its magnitude varies with the width of the loop. In order to increase the electromotive force it is advisable to use more than one turn, and then the resultant effect is proportional to the number of turns. In fact, again referring to the laws of electromagnetic induction, the electromotive force is proportional to the number of turns and to the area of each turn, assuming the waves are not too short nor the loop too large. The total area of the turns is thus an important factor of a loop, and it is customary to refer to this as the "area turns."

Unfortunately one cannot go on increasing the area turns indefinitely by increasing the number of turns, but this point will be referred to in more detail later.

An example of the relative electromotive forces produced in an open aerial and a loop is as follows: Consider an open aerial 90 ft. high and a loop of 10 turns 3 ft. high and 3 ft. wide. On a wavelength of 1,000 metres the open earial has 300 times the electromotive force of the loop. When the wavelength is 2,000 metres the ratio is 600, and when 500 metres the ratio is 150. Thus the shorter the wavelength the better is the loop.

3. Method of Receiving Signals with a Simple Loop

Having seen that the electromotive force obtained in a loop is small compared with that of an open aerial it is essential to pay careful attention to the method of reception. It is, of course, essential to tune the loop to the incoming waves, which is done usually by using a variable condenser, C, and joining the ends of the loop to it (Fig. 7). As with open aerials rectification is necessary, but amplification is also necessary. It is advisable to use a high-frequency amplifier which amplifies the oscillations before rectification. The Marconi Type 55 amplifier is suitable, as also is the amplifier Type R.A. 20 of the Radio Communication Co. Attention should be given in choosing an amplifier to the range of wavelengths to be worked on, and to choose the amplifier suitable for that range.

The loop may be joined direct to the first valve of the amplifier, as shown in Fig. 7. In this case leads are taken from the terminals of the tuning condenser to the grid and filament terminals of the first valve of the amplifier. By this method of connection it is quite easy to search for transmitting stations, provided the amplifier is not too selective. If the amplifier is sensitive over a wide range of wavelengths all that is required to hear a transmitting station is to tune the aerial circuit by the condenser C,

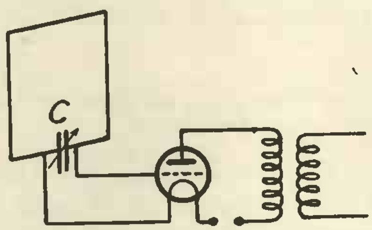


Fig. 7. Connection of loop to receiver.

rotating the loop slowly so as to guarantee not being on the minimum bearing of the transmitting station.

There are occasions on which it is advisable not to join the amplifier direct to the aerial loop but to use coupled circuits. Certain circumstances making this necessary will be referred to later. However, for most purposes it is quite sufficient to use the direct coupling shown in Fig. 7. It might be thought that questions of selectivity would make it very advisable to use coupled circuits universally. This is not so, for by suitable choice of wire for the aerial loop it can be made quite reasonably selective. When using open aerials it is almost always necessary to use coupled circuits, in order to attain reasonable freedom from interference; the reason for this being the large damping in open aerials. With loops damping can be kept down to reasonable limits, so that satisfactory working can be obtained by direct connection to the amplifier.

When a coupled circuit is required it is very advisable to divide the primary coil A_1 A_2 of the transformer, which is inserted in the loop circuit, into two equal portions, and to insert the tuning condenser between the two equal parts A_1 A_2 (Fig. 8). This splitting of the primary coil of the transformer into two equal parts is for the purpose of symmetry, the importance of which will be described later. The secondary coil D of the transformer may be placed in circuit with

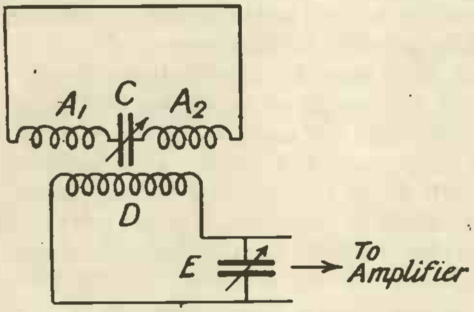


Fig. 8. An alternative method of connection.

another tuning condenser E, the amplifier being joined to the terminals of this condenser.

4. How to Use a Simple Loop to Obtain Bearings

We have seen that as a loop is rotated about a vertical axis, the strength of signals varies, being a maximum when the loop is pointing to the transmitting station, and a minimum when at right angles to this direction. Hence all that is required is to find the position of the loop for maximum or for minimum signal strength. An attempt to fix the maximum will soon show that it is not easy to do so with any accuracy, for the loop can be moved for 10° or 20° of arc in the neighbourhood of the maximum with very little change of signal strength. Reference to Fig. 5 will show that the maximum is flat. This curve is not a sine curve, and in fact cannot be, for the two halves are not on opposite sides of the zero line. However, the amplitude of the oscillating electromotive force in a loop varies with the angle according to a sine law, but after rectification and amplification this ideal form is departed from. At the maximum the curve does not differ much from a sine curve, and it is well-known that the maximum of such a curve is flat.

Considering the minimum we find that the rate of change of intensity is much greater than at the maximum, and it is possible to determine the position of the minimum with much greater accuracy. This is usually effected by swinging

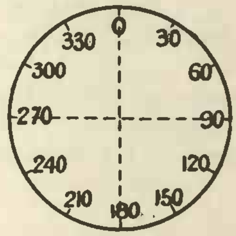


Fig. 9. The direction is calculated from the position of the loop measured in degrees.

the loop through the minimum and noting the positions of the circular scale where the signal just becomes audible on both sides of the minimum. The mean of these two readings gives the position of the minimum. If the loop has already been aligned so that when the reading on the circular scale is 0° or 360°, the loop is pointing true north, the reading of the scale for the minimum of a transmitting station gives the bearing of that station when 90° is added or

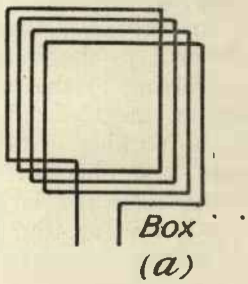


Fig. 10A. A box frame aerial.

subtracted, that is the angle that the line joining the transmitting station to the loop makes with the geographical meridan or the true north and south line. For instance, when the pointer of the loop is at 0° or 180°, the loop is pointing true north or south. Suppose that the two readings on both sides of the minimum are 90° and 120°. The mean of these readings is

$$\frac{90 + 120}{2} = 105°$$

which is the reading of the minimum. The loop will need to be turned through 90° to point to the station, so that the bearing is 105° + 90° = 195°, or 105° – 90° = 15°.

It is noted that one of two directions has been obtained, but these are opposite directions. A simple loop thus merely determines the line towards the transmitting station, and cannot distinguish which side should be taken.

5. Details and Examples of Simple Loops

We have seen that in order to get the best signal strength the area turns should be as large as possible. The size of the loop, however, must be kept reasonably small, so that it can be rotated easily and quickly. A very usual size is 3 to 4 ft. square, although much smaller loops are used, and also much larger ones.

The framework for the loop may be square, rectangular, or hexagonal. Other shapes are occasionally used—for example, octagonal or even circular—but these forms are exceptional. The framework may be such as to allow the turns to be laid side by side as in Fig. 10A. This form

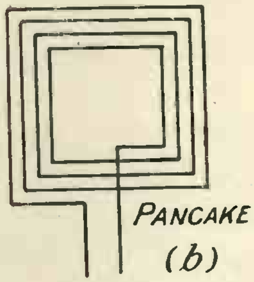


Fig. 10B. *A pancake frame aerial.*

of loop is called the box type. Again, the winding may be made so that the turns are all in the same plane, the turns thus being of different dimensions as in Fig. 10B. This form is called the pancake type.

ABOUT REACTION

A few words to the Beginner.

There will, no doubt, be some beginners who have heard the London Broadcasting Station, or one of the other stations, tell its audience that trouble is being caused in certain districts by amateurs allowing their valves to oscillate.

MANY valve circuits employ what is known as "reaction," which is a very useful phenomenon in its right place, but is liable to cause a lot of trouble when wrongly employed. Reaction is a method of strengthening wireless signals in a special manner, and it may only be used in certain parts of a wireless circuit, owing to the fact that unless it is very carefully adjusted, the valve receiver is changed into a miniature transmitting station which sends out feeble wireless waves which interfere with other receiving stations, producing whistling noises and similar disturbances which very often completely spoil the entertainment of another listener-in.

The Postmaster-General strictly forbids the use of reaction on the aerial circuit or closed receiving circuit of a wireless receiver when employed for receiving broadcasting. Reaction, however, may be used on intervalve circuits, but even then it should be used with intelligence, and experimenters and those who have not attained to that rank should get wise to the trouble caused not only to other experimenters, but to themselves, by lack of skill in adjusting their apparatus.

THE IDEAL HOME EXHIBITION

This year's Ideal Home Exhibition is peculiar in that a special section is being devoted exclusively to wireless. The Exhibition will be open from March 1 to 24 inclusive, and the wireless section will include Exhibitions by more than thirty well-known firms.

We hope that every reader of MODERN WIRELESS will find time to spend a few hours amongst what we are sure will be a very fine collection of apparatus, and also not forget to call at the Radio Press Stand No. 5 (Wireless Section).

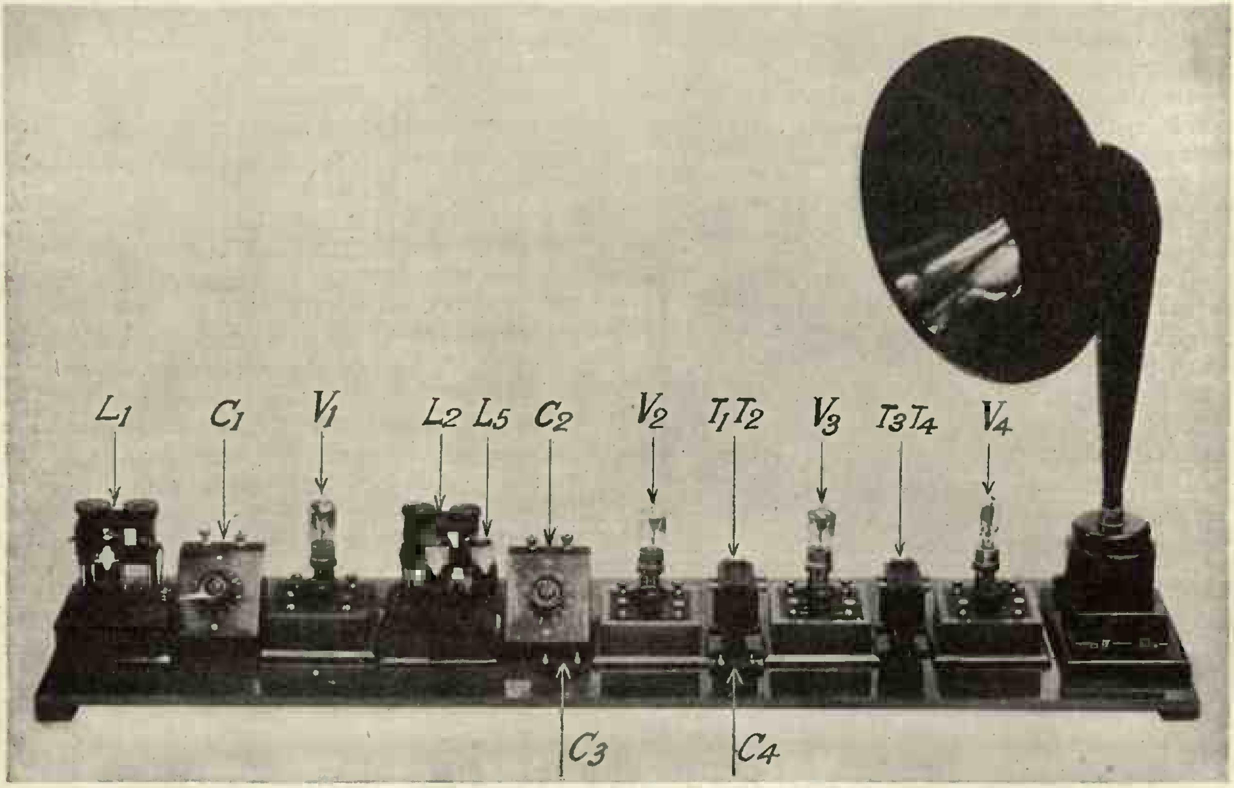


Fig. 1. The universal receiver as arranged for the reception of broadcasting.

A UNIVERSAL RECEIVER FOR ALL WAVELENGTHS

This article describes how to arrange a number of component parts, which may be purchased separately, so as to obtain a very effective receiver of continuous waves, damped waves, or wireless telephone signals. With appropriate coils, the apparatus makes an exceedingly useful broadcast receiver of very high sensitivity.

THE apparatus described below is being used for general reception purposes regularly, and some particulars will, therefore, no doubt, be of interest to many readers.

It has always seemed to the writer that a great deal more interest could be derived out of radio by purchasing a number of component parts than by constructing a complete cabinet or panel set. In the latter case the facilities for trying out new circuits are a minimum, whereas if the experimenter would only buy a few valve panels, a few coil-holders, and several similar sorts of component parts, which may be purchased for a reasonable sum, he could carry out an infinite number of experiments, and his apparatus could always be kept up to date. If a new circuit is to be tried out, it simply means a slight amount of time in rewiring. There are too many listeners-in who, apparently, have no greater ambition than to listen-in night after night to broadcasting. The really progressive experimentalist will want to have a number of parts which he can rewire in numerous different ways to get different effects. However, even those who have no ambition to carry out much experimental work will find the following set an excellent one for general reception.

The photograph shows the different units which might be purchased from any of the advertisers in this journal. The apparatus actually required will depend on whether continuous-wave wireless signals are to be received or not.

If only spark signals and wireless telephony are to be received, there is no need for the parts which go to make a local oscillator. The only apparatus required will be two variable condensers having a capacity of either 0·0005 μF. or 0·001 μF. (microfarad); one, or preferably two, complete sets of plug-in coils; four valve panels containing filament rheostats, but no grid condensers or leaks; one grid condenser having a capacity of about 0·00025 μF.; one grid leak having a value of about 2 megohms; two intervalve low-frequency transformers; four valves; one 6-volt accumulator (of not less than 30 ampere hour actual capacity); one pair of high-resistance telephone receivers.

In addition to the above list, we will require another set of coils, an additional valve and an additional valve panel, if continuous waves are to be received.

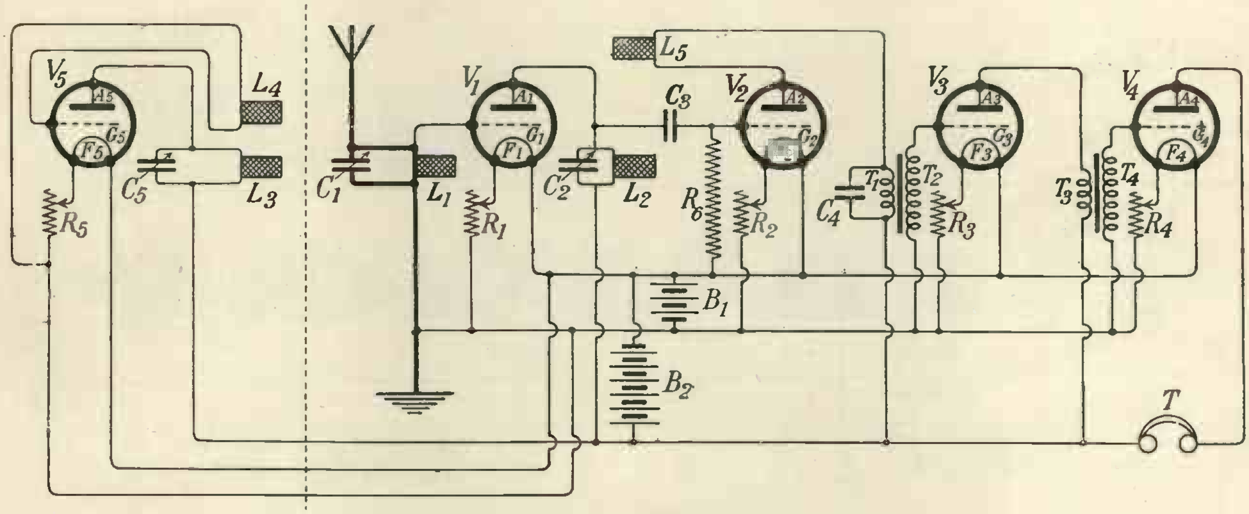


Fig. 2. The circuit used on the universal receiver.

The Apparatus for Spark or Telephony Reception

Fig. 2 shows the circuit which is employed and which may be recommended with every confidence as probably the best all-round circuit using four valves. With this apparatus it is possible to hear broadcasting 100 yards from a loud-speaker using a high-tension battery of only 60 volts, the receiving station being about 15 miles from the broadcasting station, and the aerial being of the standard Post Office type.

The variable condensers C_1 and C_2 should have, preferably, a maximum capacity of either 0·0005 μF. or 0·001 μF. One is quite safe using these sizes of condenser. The latter size is particularly useful for all-round work, but has the disadvantage that when receiving short waves it is rather difficult to tune in very accurately unless an additional vernier condenser is used in parallel with the main one. Very frequently, therefore, if the reader acquires a complete set of coils from the manufacturer, he can with confidence use the size of condenser which such manufacturer recommends for use with his coils. For example, one manufacturer recommends the use of a 0·00035 μF. condenser. More coils, however, are required if a small variable condenser is used.

The coils used should be of the plug-in type, and there are two or three types on the market. If you refer to this article, the manufacturers of these coils will tell you which ones to employ in the different positions to get a given wavelength. For example, when using the Igranic Honeycomb Coils for the reception of 2 LO, the inductance coil L_1 was No. 35, although in some cases No. 25 would be required. Unless one knows exactly what the aerial is like, it is not always possible to tell to within one number which coil to use. In the case of the intervalve coil L_2, however, this can always be stated. For broadcast reception a No. 50 coil was found suitable. The reaction coil L_5 was No. 75.

Generally speaking, the aerial coil will be the smallest, then will follow the next size in the intervalve position, and a size larger may be used for a reaction coil. By interchanging these different coils it is possible to cover any particular desired range of wavelengths.

The grid condenser C_3 and the grid leak R_6 should be bought, as also should the condenser C_4, which latter should have a capacity of somewhere about 0·002 μF. The intervalve transformers T_1 T_2 and T_3 T_4 may also be bought for a reasonable price from advertisers in this journal.

Wiring of the Circuit

The wiring of the circuit is shown in Fig. 3. With different types of valve panels and coil-holders the positions of the terminals will vary, but even a novice should be able to connect up the apparatus either from the circuit of Fig. 2, or from Fig. 3. In Fig. 3, a loud-speaker is shown connected up. Instead of a loud-speaker, telephone receivers may be connected across the terminals marked "input terminals." It is no use simply reversing the coil itself. As the reaction is increased by moving the coil L_5 nearer to L_2, the condenser C_2, and also C_1, should be readjusted until the loudest signals are obtained. If L_5 is brought too close to L_2 the second valve will oscillate of its own accord, and howling noises and other disturbances will render the reception of speech inefficient. When this is noted, the coil L_5 should immediately be withdrawn and the reaction again carefully adjusted, without causing self-oscillation.

Receiving Continuous Waves

When receiving continuous waves, it is desirable to use a fifth valve, V_5 (Fig. 2), which has its

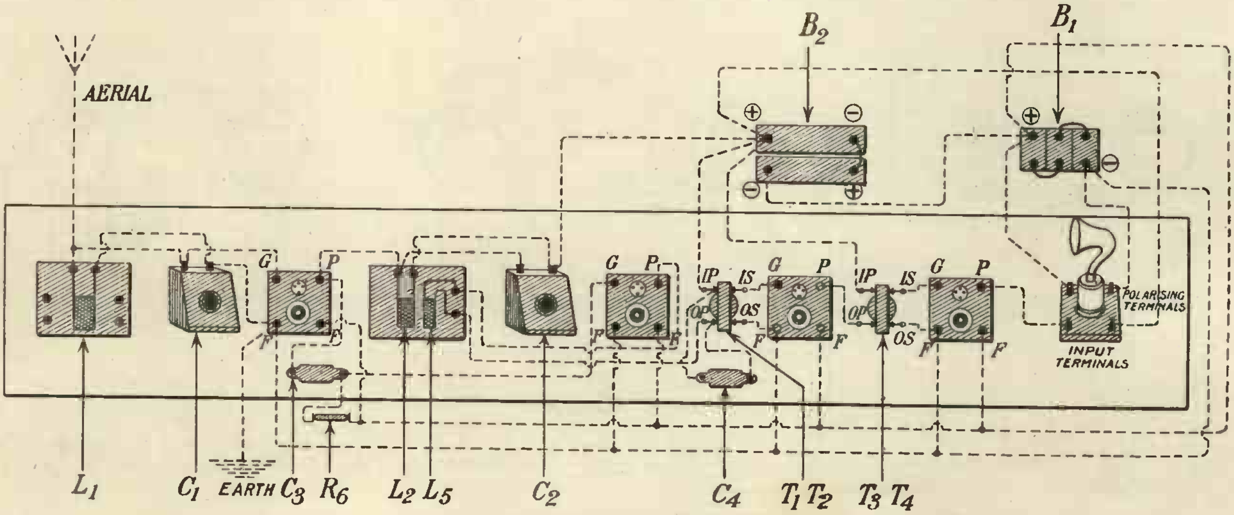


Fig. 3. The wiring of the universal receiver for the reception of broadcasting.

If the loud-speaker is of a type requiring a "polarising" current from a 6-volt accumulator, the connections shown are made between the polarising terminals and the filament accumulator.

Operation of the Apparatus

The operation of the apparatus is simplicity itself. All the filament rheostats should be adjusted to give the filaments an average brilliancy. The coil L_5 may be at first loosely coupled to L_2, and signals tuned in by adjusting the condensers C_1 and C_2 more or less together. Once the signal is heard and the condensers have been accurately adjusted, coil L_5 should be brought up closer to L_2. As this is done, the signals should increase in strength. If they do not, the leads to the coil L_5 should be reversed.

filament worked off the same accumulator as the other four, its anode circuit being likewise fed from the same high-tension battery B_2. In the anode circuit of the valve V_5 is a plug-in coil, L_3, shunted by variable condenser C_5, which should preferably have a maximum capacity of 0·001 μF. In the grid circuit is another coil, L_4, which will usually be about the same size as the coil L_3 or, if anything, slightly larger. This coil may be kept close to L_3, and a variable coupling is not essential.

When connected up, the valve V_5 oscillates, and the continuous oscillations will be naturally induced into the receiver, and so enable continuous waves to be received by the heterodyne system. If it is not possible to receive continuous waves, it is probably due to the connections to the coil L_4 being the wrong way round. They should be reversed and reception tried again.

Conclusion

Those who are only interested in broadcast reception need only pay attention to the part of the apparatus to the right of the vertical dotted line in Fig. 2. If extra selectivity is desired, instead of connecting the aerial and earth to the circuit L_1 C_1, they may be connected to a similar inductance and condenser, the inductance coil being coupled to L_1 very loosely. If this form of loose coupling is employed, the inductance coil L_1, connected in the grid circuit of the first valve, would have to be a No. 50 Igranic coil, or equivalent suitable coil for broadcasting wavelengths. The coil L_1 would then be the same size as coil L_2.

Those who do not desire to have this initial loose-coupling could really dispense with the first coil-holder, connection being simply made to the plugs on the inductance coil. This, however, is not so neat, and in many cases the additional coil-holder will be required for different circuits, such as the double reaction circuit explained in last month's issue of MODERN WIRELESS.

The effectiveness of the apparatus described may be vouched for, and we will supply any further particulars which may be required.

J. S.-T.

A TWO-VALVE NOTE AMPLIFIER

The following is a description of an excellent two-valve low-frequency amplifier which may be constructed with bought components for about £2 10s.

THOSE who have already made a crystal receiving set, or who have a single-valve receiver, will, no doubt, be interested in the following description of a two-valve amplifier

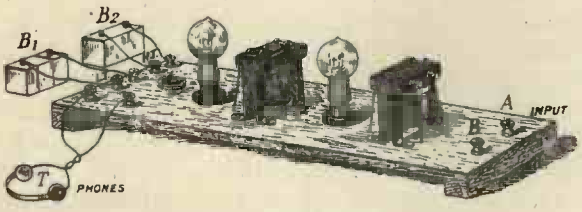


Fig. 1. A general view of the amplifier.

for magnifying the rectified signals of such a simple set.

A two-valve low-frequency amplifier, or note magnifier, lends itself particularly to construction out of purchased component parts. These component parts are two intervalve transformers, one rotary filament rheostat, two valve-holders, and six terminals.

The actual type of intervalve transformer will vary with the manufacturer, but the illustration in Fig. 1 will give a general idea how the amplifier is arranged. The terminals A B are the input terminals of the amplifier, and are connected to the two terminals or leads to which the telephone receivers would, in the ordinary course of events, be connected. The two terminals H T are connected to the high-tension battery B_2 of about 45 volts. The terminals L T are connected to the filament accumulator, which would have a value of 6 volts. The terminals T are connected to the telephone receivers, which should be of high resistance.

The two valve-holders may be purchased for a

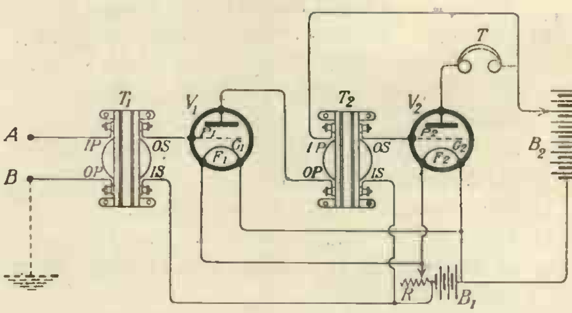


Fig. 2. Showing connections of the amplifier.

reasonable sum and screwed down to the main base-board.

The connections to the amplifier are shown in Fig. 2. It will be seen that the terminals A and

[*Continued on page* 152.

THE CONSIDERATIONS GOVERNING THE CHOICE OF A RECEIVING CIRCUIT

By JOHN SCOTT-TAGGART, F.Inst.P.

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.

What sort of a circuit should one use? This article explains how the answer will depend upon circumstances.

WHEN a student or experimenter realises how many thousands of circuits may be arranged with a number of three-electrode valves, it is little wonder that he frequently asks for guidance as to which of these multitudinous circuits he is to use.

The advice he will get will probably vary a great deal. The question when put to the average experimenter of experience will usually be met evasively. The number of those who have experimented with practically every circuit is very small, and the beginner is therefore handicapped at the start by hearing excellent accounts of different kinds of circuits which really in no way resemble each other.

Some Preliminary Questions to be Considered

I am, perhaps, a little ambitious myself in putting forward some suggestions regarding the choice of circuits. If I were asked what is the best class of valve circuit using one, two, three, four, five, or six valves, I would probably first reply by asking the following questions :

(1) Do you desire to receive signals which are initially weak, such as transatlantic signals, or signals which are initially loud, such as those from the Eiffel Tower, Paris ?
(2) What is the main object of the reception ? Is it to produce very loud signals, or will it do if clearly readable signals are obtained ?
(3) Is it necessary for the receiver to be absolutely reliable ?
(4) How many valves are to be used ?
(5) Is a loud-speaker to be employed ?
(6) Is it desired to lessen interference from other stations ?
(7) Is it desired to eliminate atmospherics ?
(8) Does a certain amount of distortion matter ?
(9) What are the experimenter's resources ?
(10) Is the set to be made up of bought component parts, or made entirely by the experimenter ?
(11) Is the set to be rapidly tuneable or not ?
(12) Are standard circuits to be employed or not ?
(13) Is the circuit to work on a narrow band of wavelengths or not ?
(14) Are continuous waves to be received ?

Let us examine these questions carefully and see what effect the answers have on the most suitable design of a circuit. Are the signals to be received initially weak or strong ? If the answer is " weak," then I recommend the use of one or more stages of high-frequency amplification, as otherwise the signals will not effectively operate a detector. If the initial signals are strong there is no particular point in amplifying at high-frequency, unless exceedingly loud results are required, and then efficient amplification cannot be obtained alone by low-frequency stages ; high-frequency stages have to be introduced in order to get the loudest effects. This really brings us on to question (2) : Are very loud signals desired ?

Assuming that very loud signals are not desired, but that the incoming signals are strong, then a rectifier followed by one or more low-frequency amplifying valves is all that is required. A crystal detector followed by a two-valve note magnifier will do excellently for receiving broadcasting or other strong signals over a short range, and, moreover, the use of two or more valves will enable a loud-speaker to be effectively operated. A three-electrode valve may be used as a simple detector, followed by a low-frequency amplifier, or the first valve may have reaction introduced to strengthen the incoming signals. This, of course, cannot be done on broadcast wavelengths during the broadcasting hours. The question of whether very loud signals are desired is an important one, as it chiefly governs the number of valves to be used.

If the final signals are to be very loud and the incoming signals are very weak, it will be obvious that several stages of high-frequency amplification followed by several stages of low-frequency amplification, after rectification, will be required.

If, on the other hand, the incoming signals are strong and sufficient final strength is obtainable by the use of two or, at the most, three valves amplifying at low frequency, then high-frequency amplification may be eliminated altogether. I cannot advise more than three stages of low-frequency amplification. Trouble is usually experienced when more than three valves are used, owing to self-oscillation at audible frequencies. Personally, I think two stages of note amplification should not be exceeded under ordinary conditions.

Is it necessary for the receiver to be absolutely reliable ? If the answer is " No," then a crystal detector may be employed with advantage as the rectifier. If absolute reliability is required, then it is necessary to employ a valve as the detector.

How many valves are to be used ? This, one would imagine, would be a perfectly straightforward question, but many experimenters prefer to say that they want to receive Annapolis, The Hague, Paris, Rome, or some other station, and then proceed to inquire how many valves are necessary. My own recommendation is that not less than three valves should be employed for general reception, and not less than five if the reception is to be over long distances, such as have to be spanned when receiving American stations. In the case of the amateur who is limited as regards means, or who desires to try simpler circuits as a start, one or two valves may be employed.

Is a loud-speaker to be employed ? If a loud-speaker is to be used, then a two-stage low-frequency amplifier is an almost unavoidable necessity, especially when using a Magnavox, or similar loud-speaker, which only operates off fairly heavy currents. Loud-speakers are very rarely worked off a circuit comprising a few stages of high-frequency amplification and a detector.

Is it desired to lessen interference from other stations ? If the answer is " No, not particularly," then the circuit recommended will be a relatively simple one. Direct aerial coupling may be employed as distinct from an oscillation transformer, having two separate windings. If, however, other stations are to be cut out, then an initial oscillation transformer is to be recommended, together with tuned intervalve transformers between the high-frequency amplifying valves. Both plate and grid circuits should be tuned to the desired wavelength, and the coupling kept very weak. Reaction from the last high-frequency valve to the first of the series will improve the selectivity of all the tuned circuits.

Is it desired to eliminate atmospherics ? The answer to this question will almost invariably be " No." The elimination of atmospherics is the greatest problem in wireless to-day, and only very few would care to adopt special precautions for lessening atmospherics.

Does a certain amount of distortion matter ? If spark or C.W. signals are to be received the answer is " No." If speech is to be received the answer will probably be " Yes." In the latter case, it is most emphatically desirable to keep to high-frequency amplification as much as possible. The more iron in the circuit the greater the distortion. Only intervalve iron-core transformers of thoroughly sound design should be employed. The steady grid potentials of the low-frequency amplifying valves should preferably be adjustable and should be negative, care being taken, however, that the representative point on the characteristic curve does not travel off the steep straight portion. Reaction invariably introduces a certain amount of distortion, although it is not very noticeable, except when signals are amplified to a great extent. Reaction becomes troublesome as regards distortion if carried to excess. The moral is not to use too much reaction.

Distortion is also caused by the inherent tendency of low-frequency amplifiers to oscillate, and distortion is therefore prevented by lessening the tendency of the amplifier to oscillate.

What are the experimenter's resources ? If the experimenter's purse is well filled, considerations of this sort need not be a source of worry. On the other hand, the financial question is, in many cases, a distinctly serious one. This will govern the number of valves in use, and will also usually limit the number of variable condensers available. High-frequency amplification is very much cheaper than low-frequency amplification, unless the low-frequency transformers are made by the experimenter himself. This class of experimenter will generally prefer to use variometers for tuning purposes, rather than variable condensers, and he will cut down low-frequency amplification to a minimum, making up signal strength by high-frequency amplification.

Is the set to be made up of bought component parts, or made entirely by the experimenter ? Personally, I recommend the purchase of component parts, the connecting up of them being left to the experimentalist. If the amateur makes his own set, then let him make his own component parts rather than make any special complete set.

Is the set to be rapidly tuneable or not? This is another vital question to be answered before advice can be given. Some experimenters like to have a set with which it is possible to search the whole band of existing wavelengths from, say, 150 metres to 25,000 metres. Such a set, of course, is useful for entertaining friends and impressing them with the wonders of wireless. Some desire to be able to say "This is an experimenter in Glasgow," "That is the Post Office station at Seaforth," "We are now receiving The Hague," "Another turn of the switch and we are now receiving the Eiffel Tower, Paris," "By another slight adjustment, we can receive Carnarvon, and on this stud the station at Bordeaux may be heard."

This in my opinion, is not wireless *experimenting*, but such a set can be extremely useful as a sort of stand-by to see what stations are working. The trouble with such a set, however, is usually that several stations may be heard on any given adjustment. On long wavelengths, for example, the interfering continuous wave signals often cause a mere jumble of differently

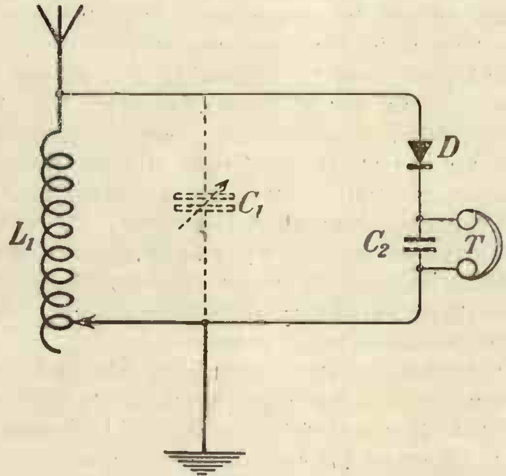


Fig. 1. This is the simplest form of crystal detector receiving circuit. L_1 is a variable inductance and may or may not be shunted by the variable condenser C_1. If L_1 is only tapped every few turns a variable condenser C_1 will be necessary, but if L_1 is a variometer, or if it is provided with a slider, or if it is possible to obtain any number of individual turns included in the aerial circuit, no tuning condenser is necessary. The telephones T are preferably shunted by condenser C_2 of about 0·001 μF., but good signals may be obtained without the use of this telephone condenser.

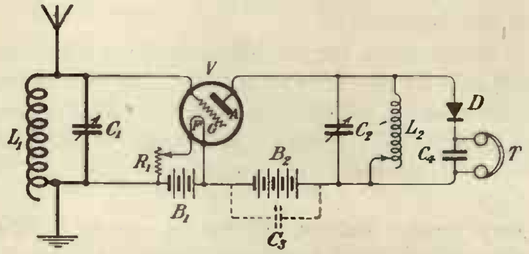


Fig. 3. This is a simple circuit in which the valves act as an amplifier of the incoming oscillations. The magnified oscillations are rectified by the crystal detector D. The condenser C_2 is sometimes omitted, but it is best left in. This circuit tends to oscillate of its own accord. This may be prevented by detuning the circuit L_2 C_2.

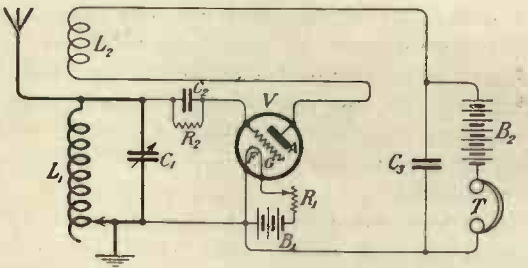


Fig. 4. The best single-valve circuit for general reception. The coupling between L_2 and L_1 is variable. This circuit may not be employed for the reception of British broadcasting on account of its tendency to oscillate. The condenser C_3 should be employed and should have a capacity of not less than 0·001 μF. Its actual capacity is not very important. If this condenser is not employed the reaction is liable to vary and the coupling between L_2 and L_1 needs to be tighter.

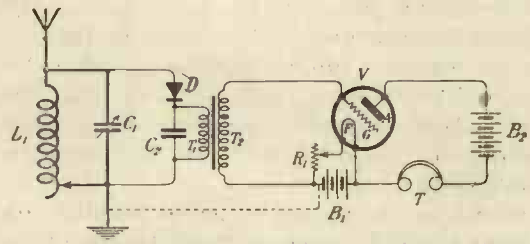


Fig. 2. This is the best single-valve circuit for receiving signals which are quite strong when only the crystal detector circuit is employed. An increase in strength of about 5 times is obtainable by the addition of the valve in this way. The initial tuning arrangements may, of course, be varied in many ways.

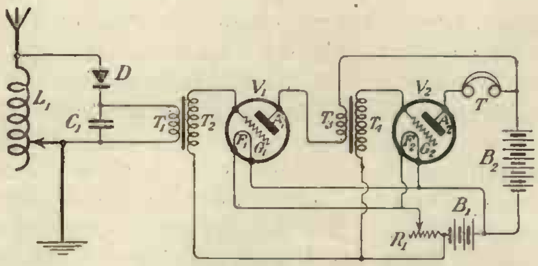


Fig. 5. This shows the application of the ST. 26 amplifier to a crystal detector circuit. This circuit may be thoroughly recommended when signals are fairly strong. The negative side of B_1 is sometimes earthed.

pitched notes. This class of circuit used to be favoured to a much greater extent than it is at present. A saner view, however, is now being taken of experimental wireless; and those engaged in this work, while still anxious to have a set applicable to all ranges of wavelengths, do not forget that selectivity and efficient reception are factors of primary importance. Interchangeable coils have become far more popular, and may be strongly recommended, although effective variable intervalve high-frequency transformers of good design may be purchased or made.

For general reception there is nothing to beat the simple reaction detector followed by one, two or three low-frequency amplifying valves, the reaction being variable. There is simply one main adjustment, but the selectivity is appalling. Greatly improved results may be obtained by having a separate aerial circuit, which, however, immediately introduces a new variable. This, however, is nearly always an advantage. If the experimenter is going to specialise in a given band of wavelengths, say the band on which the transatlantic stations work, he cannot do better than use tuned intervalve transformers, tuned by means of

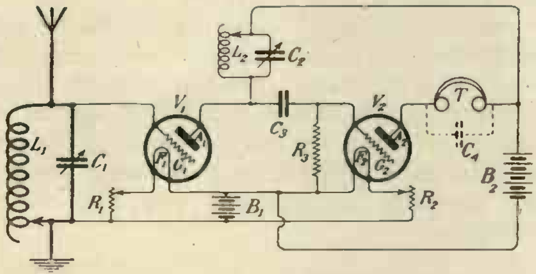


Fig. 6. *This is an excellent circuit for reception of broadcasting and for general reception. The circuit L_2 C_2 is tuned to the incoming wavelength. The condenser C_4 is very desirable. Its value should preferably not be less than* 0·0005 *μF. The condenser C_3 has a capacity of about* 0·0005 *μF., and R_3 is a grid leak having a resistance of about 2 megohms. Some values of high-tension voltage and filament current cause this circuit to oscillate of its own accord. This tendency may be lessened by connecting the bottom of the aerial circuit to a selected positive terminal of the* 6-*volt accumulator. By coupling L_2 to L_1, the first valve will oscillate and continuous waves may be received.*

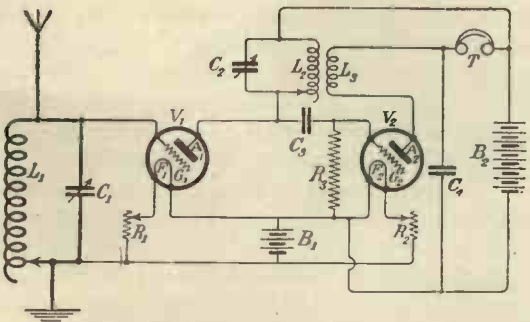


Fig. 7. *This arrangement is probably the very best circuit for the reception of British broadcasting. The circuit is similar to No. ST.* 32, *but reaction has been arranged on the circuit L_2 C_2, by connecting a coil L_3 in the plate circuit of the second valve and coupling this coil to L_2. Great care must be taken to prevent self-oscillation of the* first *valve (see notes on circuit No. ST.* 32). *If this circuit is to receive continuous waves, the second valve should be made to oscillate by tightening the coupling between L_3 and L_2; we then have a circuit which produces no radiation from the aerial.*

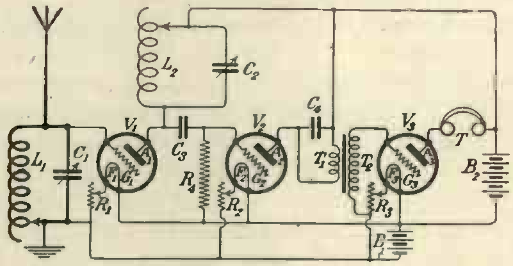


Fig. 8. *This circuit belongs to the same class and is to be preferred to circuit ST.* 41. *The circuit L_2 C_2 is tuned to the incoming wavelength. Coupling between L_2 and L_1 may be used to obtain reaction, but not when receiving British broadcasting. A circuit which may be recommended with every confidence.*

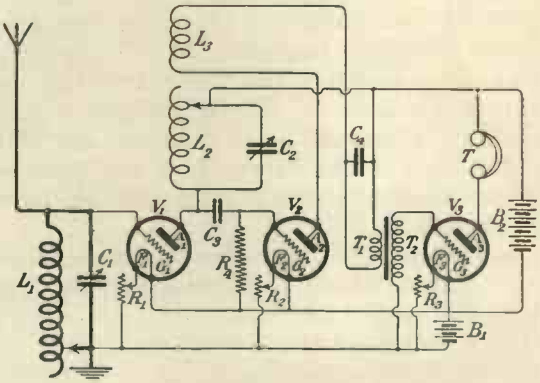


Fig. 9. *This is probably the best way of connecting up three valves for the reception of British broadcasting. Reaction is produced in the grid circuit of the second valve.*

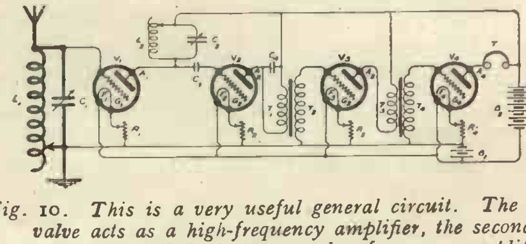


Fig. 10. *This is a very useful general circuit. The first valve acts as a high-frequency amplifier, the second as a detector, and the last two as low-frequency amplifiers. The telephones may be replaced by a loud-speaker.*

condensers across each winding, the coupling, however, being kept very loose. The trouble here, of course, is that about a dozen adjustments will be necessary. The circuits are expensive to construct, but the results obtained are always worth the trouble.

Then there is the question of the local oscillator for heterodyne reception. I am, myself, strongly in favour of employing a separate local oscillator for all continuous wave reception, reaction being employed whenever possible. An exception might be made in the case of very low wavelengths, when a self-heterodyne circuit is generally as convenient as anything else, and does not require an additional valve.

Are standard circuits to be employed or not ? The reply to this will largely govern the actions of an experimenter of an inquiring turn of mind. The inquiring experimenter will want to try all kinds of freak circuits which he has read about, or possibly has thought out himself. Work of this kind is of the greatest importance, and every experimenter should realise that he has the opportunity of inventing something new. My advice to the beginner, however, is to keep off freak or unusual circuits. Most of these, it will be found, are freakish methods of obtaining reaction or doing in a complicated way what may be done in a straightforward manner. Many, no doubt, will have found that by touching certain parts of their circuit, or by connecting a condenser here, or a resistance there, louder signals may be obtained. This, in ninety-nine cases out of a hundred, will be because a certain amount of reaction is introduced, and if this reaction is put into the circuit in one of the well-known standard ways equally good results may be obtained.

Is the circuit to work on a narrow band of wavelengths or not ? This matter has already been discussed fairly fully above, but there are one or two points of special importance. If a narrow band of wavelengths is to be covered, then fixed inductances with variable condensers may be employed throughout, and the experimenter may easily make these inductances himself. My advice to the experimenter whose experience is limited is to use a fairly large variable condenser, not less than $0{\cdot}001\ \mu$F., unless a number of tappings are employed, in which case a capacity of $0{\cdot}0005\ \mu$F. may be used. The advantage of a large variable condenser is that you can find your station rapidly in nearly all cases, even if your inductance is not altogether the right size. If you are working with a variable condenser of small capacity and cannot find the station desired, much time may be wasted, whereas if a large condenser is used the station is sure to be easily found, unless the size of the inductance is altogether wrong.

If the station is picked up with a condenser at 170°, it is obvious that a larger inductance should be employed. It is, of course, well known that to get the highest E.M.F. across a circuit the capacity across the inductance should be kept as small as possible,

Are continuous waves to be received ? If the answer is "No," there is no need to arrange an oscillating valve for producing local oscillations. When continuous waves are to be received, I invariably prefer to employ a local oscillator, which means that the design of the receiver is not in any way affected, as the local oscillator is a separate unit—worked, however, off the same accumulator and high-tension battery.

Conclusion

If every beginner will answer these questions he will find what he requires, and will be able to employ a circuit which suits his convenience. If he is only interested in broadcasting, he must, of course, take precautions to see that there is no reaction on the aerial or closed receiving circuit, although there may be reaction on the intervalve circuit. There will, of course, be a great temptation for many to want all the advantages which may be obtained. Sooner or later, however, a definite decision must be made to sacrifice one advantage for another. My personal recommendation is to arrange a number of component parts and units which may be connected up in innumerable ways according to the class of experimental work to be done. A made-up set, however, is always useful as a stand-by.

If I were starting as an amateur, I would first build a crystal receiver. Then later, I would add a high-frequency valve unit. The next stage would be a second valve used as a low-frequency amplifier. Then I would add another valve acting as a low-frequency amplifier. Having now three valves to play about with, I would indulge in an orgy of experimenting with different circuits for which I would, by this time, be qualified.

Fig. 1. Front view of completed set ready for connecting up to aerial and earth.

A COMPACT BROADCAST RECEIVING SET

By E. REDPATH, Associate Editor, MODERN WIRELESS

WITHOUT discussing in any way the theoretical pros and cons of the numerous types of crystal receiving sets designed for the reception of broadcasting, the writer purposes giving in the present article full constructional details to enable any reader to make for himself a thoroughly serviceable, compact, and easily operated set, capable of continuous adjustment over a range of wavelengths from 250 to about 750 metres.

It is considered an advantage to be able to include the 600-metre wavelength used by all ship and shore stations, as signals from such stations may usually be utilised as a preliminary test of the apparatus, besides affording, for those who desire practice in the Morse code, or merely in the absence of broadcast music, etc., a plentiful supply of signals.

The photograph (Fig. 1) shows the general external appearance of the completed set with high-resistance telephone receivers connected to the right-hand terminals. Of the remaining terminals, the lower one is to be connected to the aerial and the upper one to earth (*e.g.*, to the nearest main water pipe).

There are no other external connections whatever, and as soon as the position of the point of contact and the mechanical pressure between the two crystals in the detector are properly adjusted, " tuning in signals " is merely a matter of *slowly* turning the ebonite knob so as to swing the pointer over the 180° graduated scale.

As the complete range of wavelengths mentioned above is covered by this 180° movement, the necessity of moving the pointer *slowly* will, no doubt, be readily appreciated. The tuning, except in the case of signals (speech, etc.) from a near-by and fairly powerful transmitting station, is, in fact, rather critical. If preferred, a somewhat larger gauge of wire may be used in winding the inductances, which will have the effect of rendering the tuning less critical, at the same time, however, restricting the *range* of wavelengths receivable. This point will be alluded to again presently.

The second photograph (Fig. 2) shows the internal arrangement of the set. The tuning is performd entirely by means of a variometer consisting of a turned wooden ball carrying a winding (in two portions, but connected together in series), which rotates through 180° inside a fixed concave winding (also in two portions), and in so doing varies the *mutual inductance* between the rotating and fixed windings and, accordingly, the total effective inductance of the complete variometer, the entire winding of which is continuous.

This is the true variometer principle, a fact which is here mentioned on account of the carelessness rather prevalent in alluding to almost any type of " coupler " in which a rotating section of tube or other former is used, as a *variometer*. In the case of a " coupler " (whether used as an oscillation transformer, reaction coupling, or other similar arrangement), the two windings each form part of distinct and separate circuits, whereas in a true variometer the two windings are connected in series, and form only one circuit.

As the variometer affords a means of obtaining a smooth and continuous variation of wavelength over the complete range of the set, no variable condenser is necessary, and the only condenser in the set is the fixed condenser connected across the telephones.

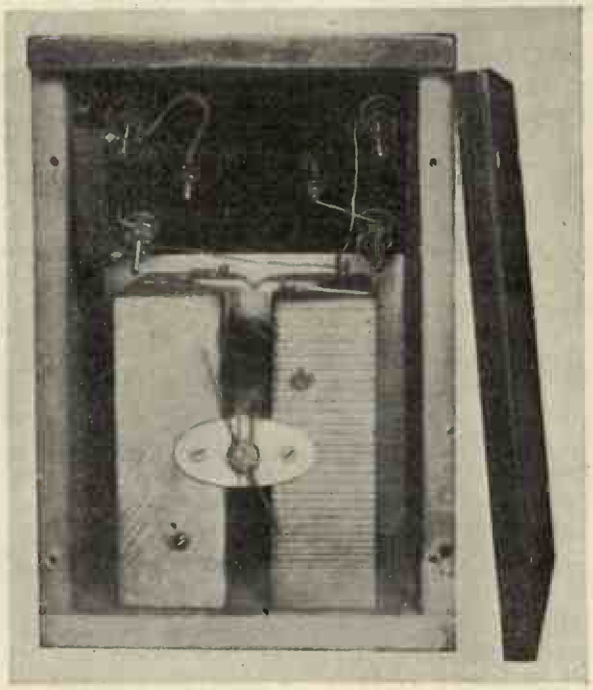


Fig. 2. Back of the set removed to show internal arrangements.

In the photograph (Fig. 2), the variometer will be seen in the centre, and the telephone condenser, secured to the side of the containing box, on the left near the top.

Specification of Materials

In order to avoid the accidental omission of some small but important detail, and with a view to enabling any reader who undertakes the construction of the set to proceed with the assembly of his materials in a businesslike manner, the following specification is given :

Item No. 1. The Containing Box, of canary or yellow pine, $\frac{3}{8}$ in. thick. Back, one piece 6 in. by $4\frac{3}{4}$ in. ; front, one piece 4 in. by $4\frac{3}{4}$ in. ; base, one piece $4\frac{3}{8}$ in. by $4\frac{3}{4}$ in. ; sides, two pieces, each 6 in. by 4 in. ; top, one piece $2\frac{5}{8}$ in. by $4\frac{3}{4}$ in ; with ebonite panel, $4\frac{3}{4}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{4}$ in. thick, and four brass terminals, No. 4 B.A., each with two back nuts.

Item No. 2. The Tuning Variometer, consisting of : rotor, 1 hard-wood block (beech), $2\frac{3}{4}$ in. cube ; stator, 2 hard-wood blocks (beech), each $3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $1\frac{1}{4}$ in. ; spindle, 1 length screwed brass rod, 3 in. by No. 2 B.A., and 1 length screwed brass rod, 2 in. by No. 2 B.A. ; bearings, 2 pieces sheet brass, each $1\frac{1}{4}$ in. by $\frac{3}{4}$ in. by $\frac{1}{16}$ in. thick ; contacts, about 12 in. of brass spring wire, No. 24 or No. 26 S.W.G. and 2 No. 2 B.A. brass washers ; windings, about 2 ounces of No. 24 S.W.G. d.c.c. copper wire. (Alternatively, No. 22 S.W.G. d.c.c. wire may be used, in which case the range of wavelengths will be from 230 to 550 metres approximately) ; ebonite knob, tapped No. 2 B.A. ; brass pointer, ivorine scale, or alternatively an engraved ebonite dial and a suitable fixed pointer.

In addition to the above-mentioned materials, a " winding jig " is required during the construction of the variometer, as will be explained shortly. To make this " jig " another wooden block, 3 in. by 3 in. by $3\frac{1}{2}$ in., and a thin, circular brass disc, $1\frac{1}{2}$ in. in diameter, are required.

Item No. 3. The Telephone Condenser. This may either be purchased ready-made or constructed from the following materials : 2 pieces, soft brass, each 1 in. by $\frac{1}{2}$ in. by $\frac{1}{32}$ in. or nearest ; tin- or copper-foil, 6 pieces, each $1\frac{1}{4}$ in. by $\frac{3}{4}$ in ; mica, approximately $\frac{1}{300}$ of an inch thick and of the best quality, 7 pieces, each $1\frac{1}{4}$ in. by 1 in. If purchased, a capacity of 0·001 μF. should be specified, and the type manufactured by the Dubilier Company is very suitable and compact.

Item No. 4. The Crystal Detector. This item also may be purchased readily and quite cheaply. The detector fitted to the set shown in the photograph Fig. 1 is of the " Perikon " type taken from an old Mark III tuner. Sets of parts to make up complete detectors are also available nowadays, though if any reader prefers to make the item himself, there is no necessity to adhere to the type illustrated, and constructional details will be found in the previous issue of the magazine.

Construction

The construction of the containing box is made as simple as possible, the various pieces being secured together with glue and " panel pins," with the exception of the back which is to be fastened in place by means of four countersunk-headed brass screws $\frac{3}{4}$ in. long.

The ebonite panel, bevelled at the upper and lower edges to fit against the top and front respectively of the box, is also to be secured by means of four similar but smaller screws ($\frac{5}{8}$ in. long), having first been drilled, polished, and fitted with four terminals and the crystal detector.

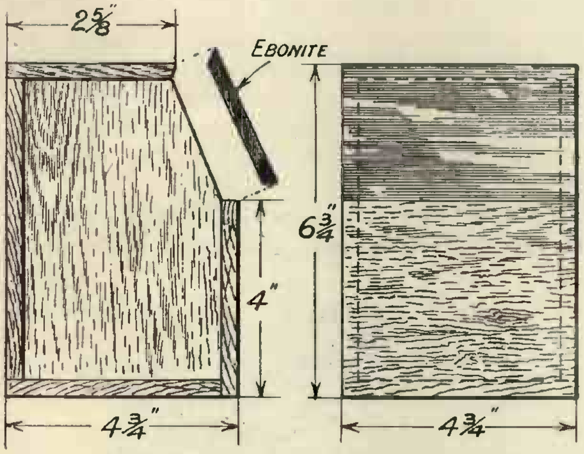


Fig. 3. *Constructional details of the containing box and ebonite panel.*

The shape and details of construction of the box itself will readily be understood on reference to Fig. 3. It will no doubt be desired to stain and polish (or varnish) the completed box. Either mahogany or walnut stain gives a good appearance, and this work should be done at this stage, the ebonite panel being temporarily removed for this purpose.

The next item to receive attention is the

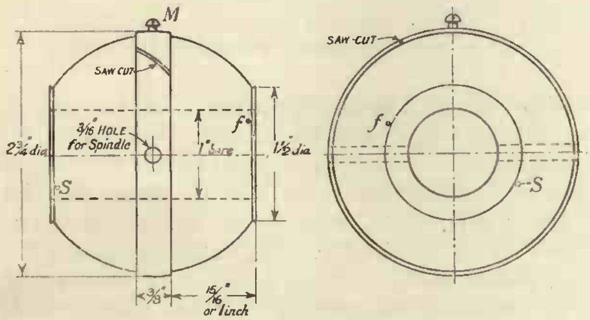


Fig. 4. (a) *The variometer rotor.*

variometer. The four wooden blocks are first to be turned and bored as shown in Fig. 4, in which (a) represents the rotor, (b) one of the two halves of the stator, and (c) the "winding jig," already referred to. It is probable that the average constructor will be unable to execute this part of the work himself. There should not be much difficulty, however, in getting it done by some local wood-turner, and to facilitate matters the drawings (a, b, and c, Fig. 4) should be carefully redrawn *full size.*

It is important that the two $\frac{3}{16}$-in. holes for the rotor spindles are exactly opposite one another, otherwise the rotor will not run true when mounted in place, and the rotor and stator windings may catch. This should be pointed out to the turner when handing him the drawings.

The actual winding operations require care, and the method of procedure is as follows:

First drill the two small holes (say $\frac{1}{16}$ in. diameter) shown at (*s*) and (*f*) in Fig. 4 (a), and insert a temporary securing screw as shown at (*m*) in the same Fig., then, having threaded a few inches of the d.c.c. copper wire through the hole (*s*) from the outside and secured it by wedging a small splinter of wood into the hole and touching with shellac varnish, commence winding, taking care that the turns of wire are laid closely and evenly, whilst a fair, steady pressure is maintained upon the wire. Avoid

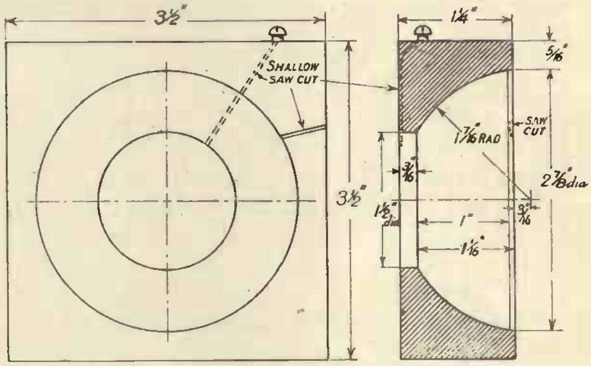


Fig. 4. (b) *One half of the stator.*

undue pressure, however, especially at the commencement of the winding, or the turns may all be displaced.

When the half-winding is completed, secure the finishing end of the wire by twisting round the small screw at (*m*) and cut the wire.

Turn the former right round, and repeat the winding process exactly with the second half, securing the ends of the wire as before. If these instructions have been carefully followed, the *direction* of winding will be the same right from the hole (*s*), *the start*, to the hole (*f*), *the finish.*

With a hack-saw blade, make an oblique cut across the uncovered centre portion of the rotor, adjacent to the temporary screw (*m*), of sufficient depth and in such a direction that the bared ends of the wire, removed from the screw and cut to correct length, will lie snugly in the saw-cut, in which position they are to be carefully soldered together.

The two lengths of screwed brass may now be screwed *tightly* into the $\frac{3}{16}$ in. holes in the rotor until about $\frac{1}{4}$ in. of each projects inside, to which the starting and finishing ends of the rotor-winding respectively are to be soldered. It is advisable to smear the threads of each spindle with shellac varnish when screwing into place, to ensure that they will not work loose later. The spindles themselves will require cutting to correct lengths, but this should not be done until the complete variometer is assembled.

The rotor, complete with winding, should now be given a good coat of shellac varnish and laid upon one side to dry.

The two rotor bearing plates are next to be trimmed up, levelled and drilled as shown in Fig. 5. The centre hole will require to be made a neat working fit on the rotor spindles, whilst the four corner holes should be drilled to suit whatever size of small brass screws are available.

The variometer stator should be dealt with next. In this case the wire cannot be wound

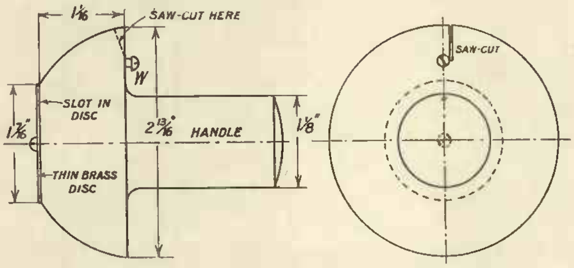


Fig 4. (c) *Jig on which stator coils are wound.*

upon the concave inner surface where it is ultimately to be secured, but must be wound upon a special "jig" (illustrated in Fig. 4, c), to the central flat portion of which the brass disc is to be attached so as to form a ridge to hold the turns of wire in place during the winding operation. This disc must be capable of passing *through* the centre hole of each half-stator. The reason for this will be apparent later.

Take the "winding jig," and, when fixing the brass disc in place, secure the end of the d.c.c. copper wire beneath the head of the screw, leaving about 3 in. of wire to spare and at the same time filing a small slot in the edge of the disc so that the wire may pass through on to the curved surface of the "jig." Proceed with the winding exactly as in the case of the half-rotor windings, the finishing end being taken through a saw-cut in the wood and secured to a small screw, W, Fig. 4 (c). The winding should not quite cover the curved surface of the "jig," but the last turn should lie about $\frac{1}{8}$ in. below the outer edge.

It is now necessary to transfer the completed half-stator winding from the "jig" to the inner surface of one of the half-stators and secure it there. Prepare some especially thick shellac varnish and liberally coat the outer surface of the winding with same, taking care that the varnish does not run over on to the "jig" itself. Treat the inner surface of the half-stator (which is to receive the winding) in a similar manner, and wait until both lots of varnish are properly "tacky."

In this matter it is better to wait too long rather than to attempt the transfer too soon.

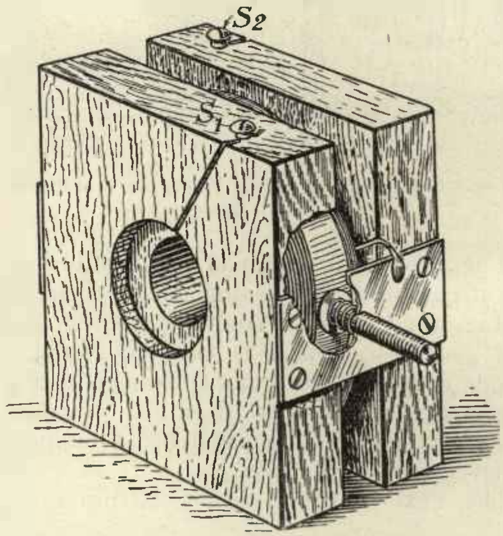


Fig. 4. (d) *The assembled variometer with bearing plate cut away to show contact spring upon the spindle.*

When satisfied with the condition of the varnish, place the "jig" and winding in place inside the half-stator; press firmly into place; remove the screw holding the brass disc in place, also the disc itself, which must pass *through the centre hole* of the half-stator, and, having waited a few moments whilst a firm pressure is maintained, thus pressing the winding well into place, release the *finishing* end of the winding from the securing screw and cautiously remove the "jig," giving it a start by means of a slight rotary movement if any difficulty is experienced.

As soon as the "jig" is out of the way, give the inner side of the stator winding a good coat of shellac varnish and place on one side to set. Repeat the operation completely, and in a precisely similar manner with the second half-stator. The initial winding upon the "jig" will require to be in the same direction in both cases, as the second half-stator will eventually be turned round so as to face the first.

When the varnish is all properly dry, the complete variometer (rotor and two half-stators) may be assembled. Upon each of the brass spindles slip a No. 2 B.A. brass washer. These washers should preferably be a fairly tight fit, and they will then remain in place close up to the rotor whilst they are *soldered* to the spindles.

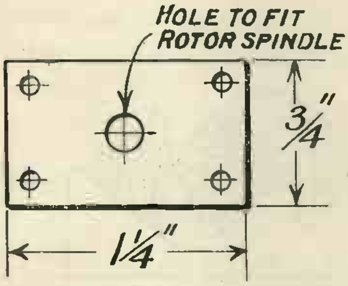


Fig. 5. One of the two brass bearing plates.

Make two spiral springs from the length of brass wire, by winding in the threads of the spindles. When released the wire will spring out and the inner diameter should about clear the spindle itself. The initial length (*i.e.*, when not compressed) of each spring should be about ¾ in. so that, when the rotor is in place and the two bearing-plates with spindles passing through them are screwed in position, the springs will make good contact between the spindles (to the inner end of which the respective ends of the rotor winding are soldered) and the bearing-plates (to which the finishing end of respective half-stator windings are now to be soldered). The starting ends of the stator windings are to be soldered to screws S_1 S_2, Fig. 4 (d), which shows the assembled variometer.

The circuit through the variometer will therefore be as follows: Commencing at screw (S_1), through one half-stator winding to rear bearing; thence *via* the spindles, through the rotor winding to the front bearing, and from there through the second half-stator winding to the screw (S_2).

It will be noted that the two bearing-plates act also as distance pieces for the two half-stators. In fact they hold the complete variometer together until eventually assisted by the four securing screws through the bottom of the containing box. Great care must be exercised in assembling the variometer, and particularly when fixing these bearing-plates, otherwise the rotor and stator windings will catch when the former is rotated.

Place the assembled variometer in position inside the containing box and mark exactly the position to be occupied by the *longer* spindle which is to project through the front of the box to carry the ebonite knob and brass pointer. Drill the necessary hole, and then mark and drill the bottom of the box for four countersunk-headed brass screws, which, inserted from below, secure the variometer in place. Take care to place these screws where the wood in the half-stators is sufficiently thick to take them, otherwise the points of the screws may displace, short-circuit, or even break the winding.

Having fitted the ebonite knob, pointer and scale, it remains to provide simple "stops" (either to be engaged by the pointer or by a rod or stiff wire at the back of the stator as shown in the photograph, Fig. 2) to limit the turning movement of the rotor to the desired 180°, and to ensure that, with the pointer set at 90°,

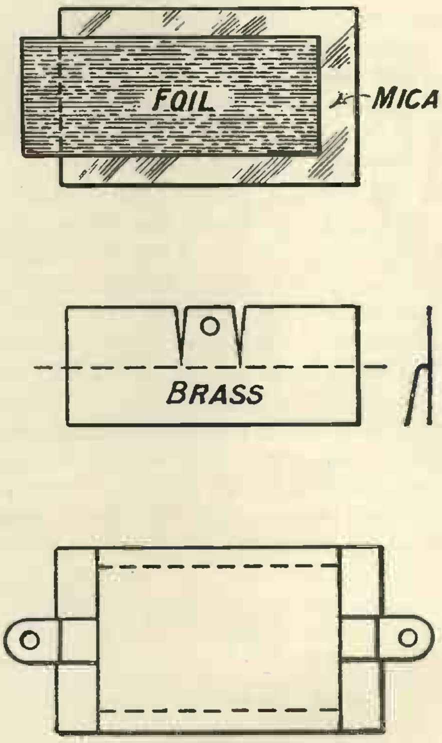


Fig. 6. (a), (b), *and* (c) *Details of construction of the telephone condenser.*

the rotor and stator windings are *at right angles to each other*. Should it be found, when the set is tested, that turning the pointer clockwise decreases instead of increases the wavelength, it will be necessary to reverse either the two stator connections to the bearing plates or, alternatively, the connections at the inner ends of the rotor spindles.

The telephone condenser is to consist of alternate pieces of tin-foil or copper-foil and mica, the foils being arranged so that a clear $\frac{1}{8}$ in. of mica is left around three sides of each, whilst the foil projects for about $\frac{1}{8}$ in. upon the fourth side—*i.e.*, three foils projecting upon one side and three upon the other.

Assembly of the condenser is facilitated by the use of quite a small amount of shellac varnish. The assembled condenser with alternate sets of projecting foils bent back upon the upper surface of mica, is to be secured by means of the two pieces of soft brass which are to be formed into clips and compressed over the foils and mica at opposite ends. The complete assembly is shown in Fig. 6 (a), (b), and (c).

For all internal connections of the set, which are to be made in accordance with the circuit diagram Fig. 7, tinned copper wire, No. 24 S.W.G., and insulating sleeving are recommended.

As beginners may perhaps experience a little difficulty in making the necessary connections correctly from the circuit diagram Fig. 7, the following description of the wiring will, in such cases, prove of assistance.

With the set before one, but turned round and with the back of the box removed (as in the photograph, Fig. 2). The lower right-hand terminal (aerial) is to be connected to the right-hand end of the stator winding and direct to the crystal detector. The upper right-hand terminal (earth) is to be connected to the remaining end of the variometer winding (at screw S_1 in Fig. 4, d), and to the lower left-hand (telephone) terminal. The remaining telephone terminal is to be connected direct to the unoccupied side of the crystal detector, and the fixed condenser should be connected directly across the telephone terminals.

As already mentioned, it is not intended to deal here with the actual construction of a crystal detector, as particulars are given elsewhere in this and in the previous issue of this magazine.

The set just described and illustrated in the photographs has given very satisfactory results,

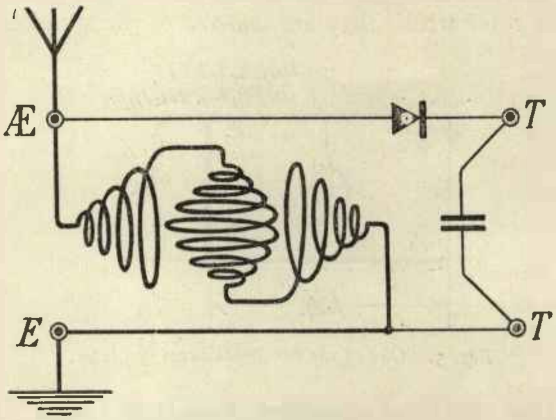


Fig. 7. Illustrating the method of wiring up the set.

both in the reception of Morse signals and of "broadcasting." For commercial reasons, the design of the set has been registered at H.M. Patent Office, but there is no objection to readers making sets for their own use. Rather than state that "signals have been received over such-and-such a distance," the writer prefers to leave it to readers of MODERN WIRELESS to ascertain, by actually making and testing the set, the limits of its performance, and will be pleased to learn of any results obtained which, by reason of distance and / or comparatively poor receiving aerial, appear worthy of note. All letters are to be addressed c/o The Editor, MODERN WIRELESS.

NOTE.—*With a view to stimulating interest amongst our readers in the matter of the construction and manipulation of comparatively simple apparatus capable of yielding really good results, we have decided to give prizes of £5, £2, and £1 to the three readers, who, in the course of the next three months, obtain the best results in the reception of "broadcasting" by means of apparatus substantially as described in the foregoing article by Mr. E. Redpath, and which the reader has actually constructed or himself.*

The only conditions applying to this offer are as follows :

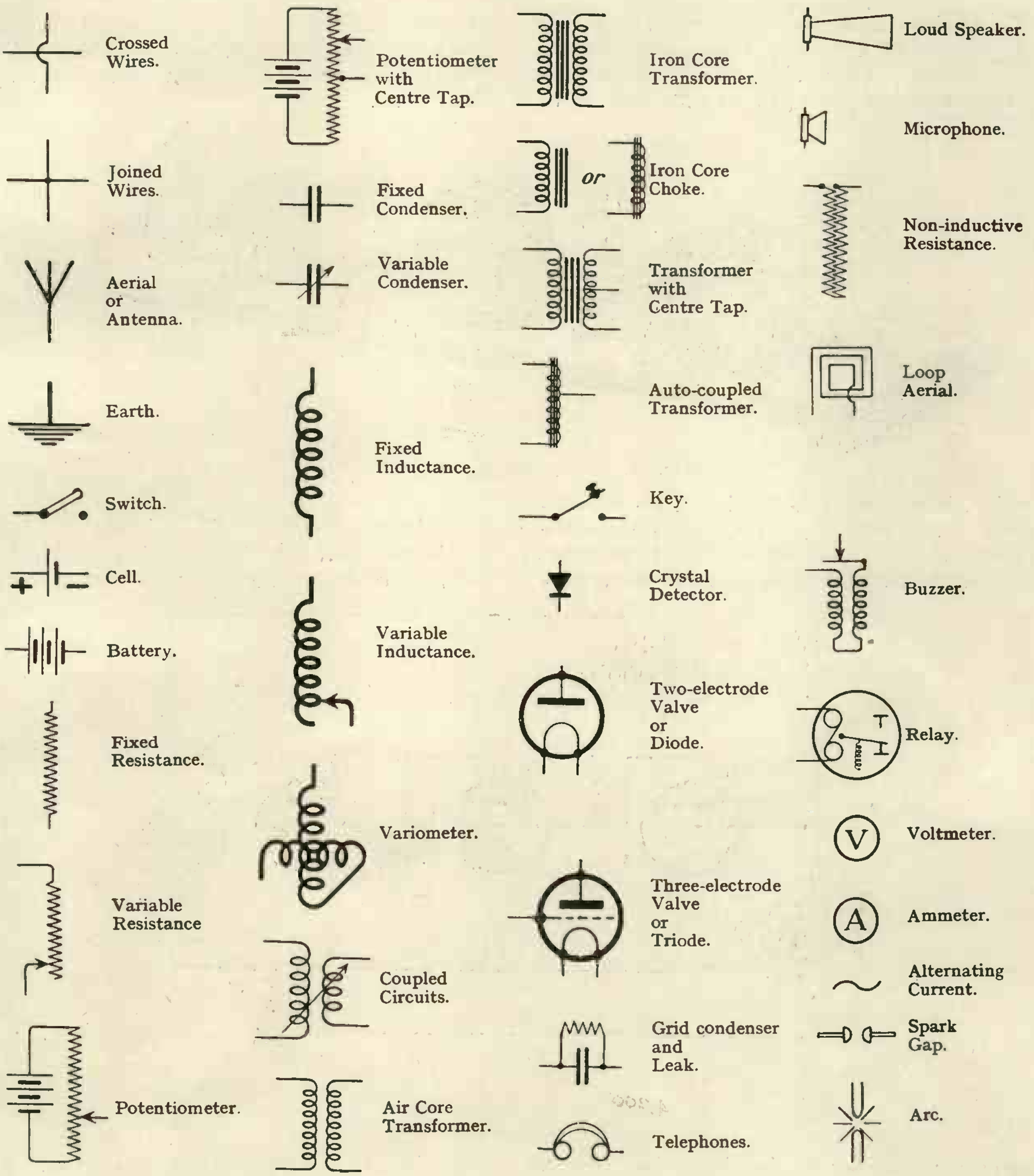
1. *The reception claimed must be repeated in the presence of our representative.*
2. *The closing date for the receipt of reports shall be April* 30*th*, 1923.
3. *The Editor's decision shall be final.*

A WIRELESS EXHIBITION

Messrs. Bertram Day & Company, Limited, who organised the Exhibition at the Horticultural Hall, Westminster, in October last, are arranging for a similar one to be held under the auspices of the Manchester Wireless Society.

It will be known as the Manchester All British Wireless Exhibition, and will be held at the Burlington Hall, Manchester, from March 17 to 24. There will be daily demonstrations. We advise every reader in the district to visit this Exhibition.

CONVENTIONAL SIGNS
USED IN WIRELESS DIAGRAMS



A THREE- OR FOUR-VALVE BROADCAST RECEIVER

This receiver will enable broadcasting to be heard perfectly on a loud-speaker up to about forty miles. This is a conservative estimate. The reader is advised to build the four-valve set in preference to the three-valve arrangement.

LAST month's issue of MODERN WIRELESS described a simple two-valve broadcast receiver. Continuing from that article, we are explaining how, by an extension of the design, it is possible to build a three- or four-valve set. Those who have already made the two-valve set are advised to extend the range of their receiver by making a two-valve low-frequency amplifier as described elsewhere in this issue.

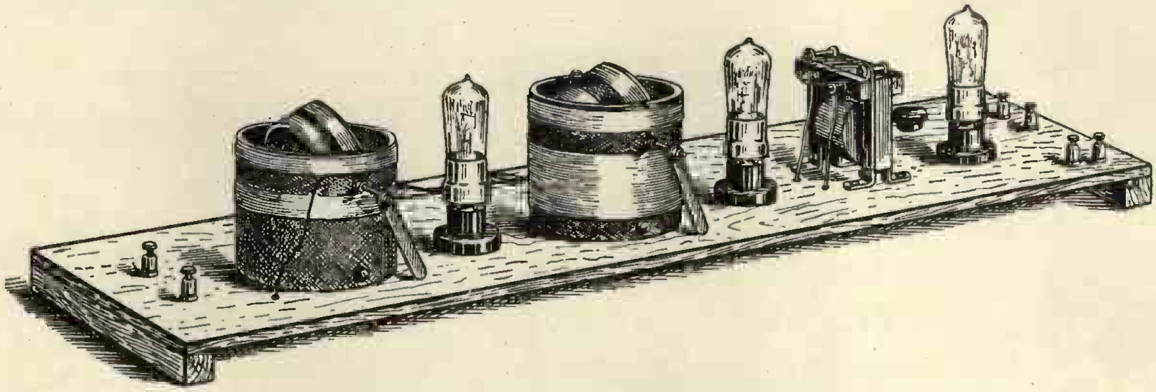


Fig. 14. The lay-out of the three-valve set.

Those who wish to set out from the beginning should read up the constructional details given in the last issue, and for the supplementary information consult the following description.

A Three-Valve Set

The two-valve set will not satisfy everybody, particularly those who are anxious to produce loud signals for operating a loud-speaker. A third valve may now be added, and the whole set now presents the appearance of Fig. 14.

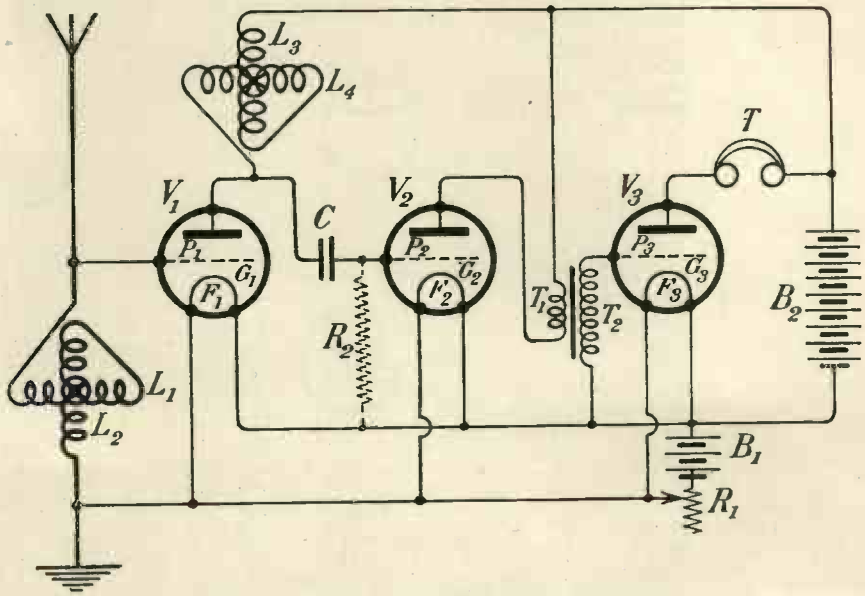


Fig. 15. The circuit used for the three-valve set.

It will be seen that Fig. 14 is a similar set to that previously described, but the base-board now measures 2 ft. 6 in., and two more items have been added, one being a step-up intervalve transformer, which should preferably be purchased, and the other a valve-holder. The intervalve transformer has four terminals, two of them usually being marked P, or I.P., and O.P., and two terminals S, or I.S., and O.S. The terminals marked P are the ends of the primary winding, while the terminals marked S are the ends of the secondary winding.

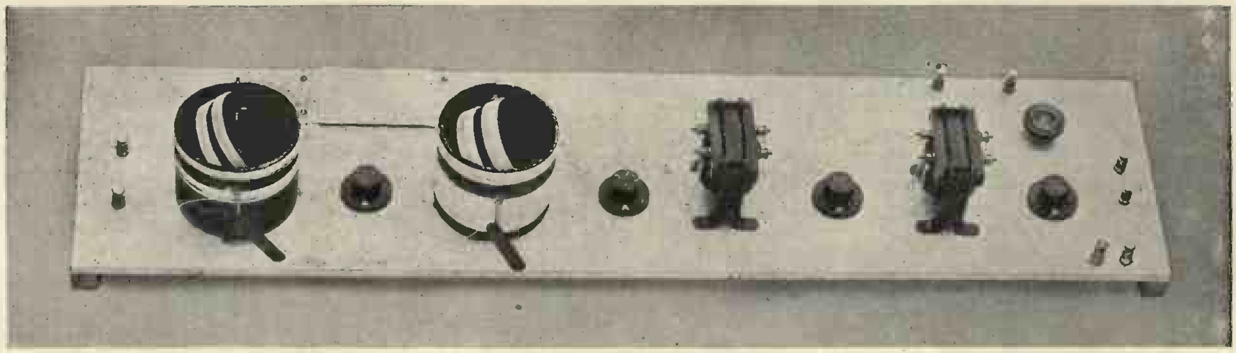


Fig. 16. An illustration of the four-valve receiver.

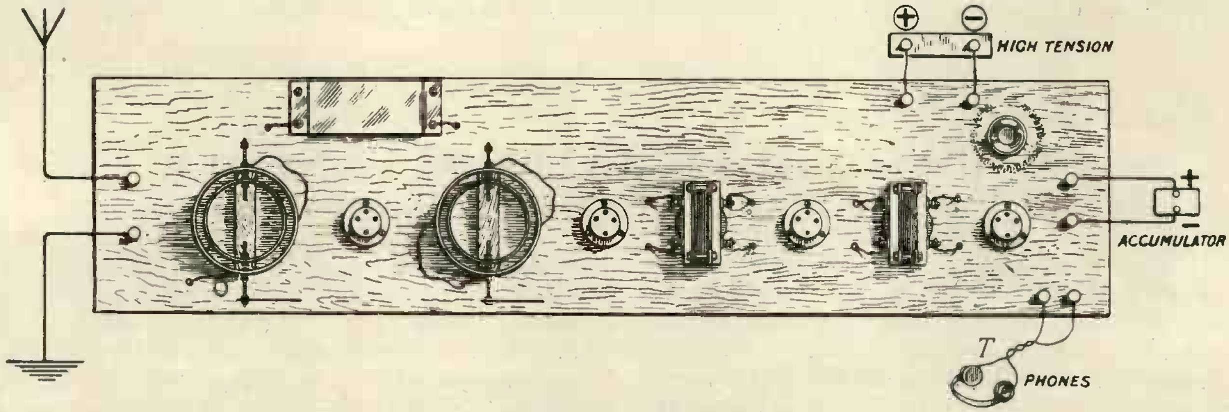


Fig. 17. A plan view of the four-valve receiver.

The Filament Rheostat

The filament rheostat is a variable resistance which is used for varying the filament current of the valve. The additional wiring necessary is as follows: The three valve-holders are now connected in parallel, that is to say, the left- and right-hand filament pins of the new holder are connected to the corresponding pins on the second holder. The plate pin of the second valve-holder, instead of being taken to one of the telephone terminals, is now taken to one of the terminals P of the intervalve transformer.

The other primary terminal of this transformer is connected to the positive H.T. terminal. One of the secondary terminals of the transformer is connected to the grid pin of the third valve-holder, the other secondary terminal being connected to the negative terminal of the 6-volt accumulator. The plate pin of the third valve-holder is connected to one of the telephone terminals, the other of which is connected to the positive H.T. terminal. The actual new circuit diagram is reproduced in Fig. 15.

A Four-Valve Receiver

A four-valve receiver giving excellent results on broadcasting over long ranges, or when a loud-speaker is employed, is illustrated in Figs. 16 and 17. It will be noticed that an additional valve-socket and another intervalve transformer have been added, thereby increasing the amplification of signals. The actual circuit diagram now used is shown in Fig. 18, and from it anyone will readily be able to construct the complete set. The base-board now measures 1 ft. 3 in. by ⅜ in., and the relative dimensions of the set are given in the plan view of Fig. 17.

In general, a point to notice is that if the grid condenser is mounted directly on the wood signals would not be quite as good as if a properly constructed or a purchased grid condenser were employed. The general leakage through the wood makes a special grid leak unnecessary, but if a properly constructed or purchased grid condenser is employed, then a grid leak will also be desirable. It should be connected between the grid and the positive side of the filament accumulator. J.S.-T.

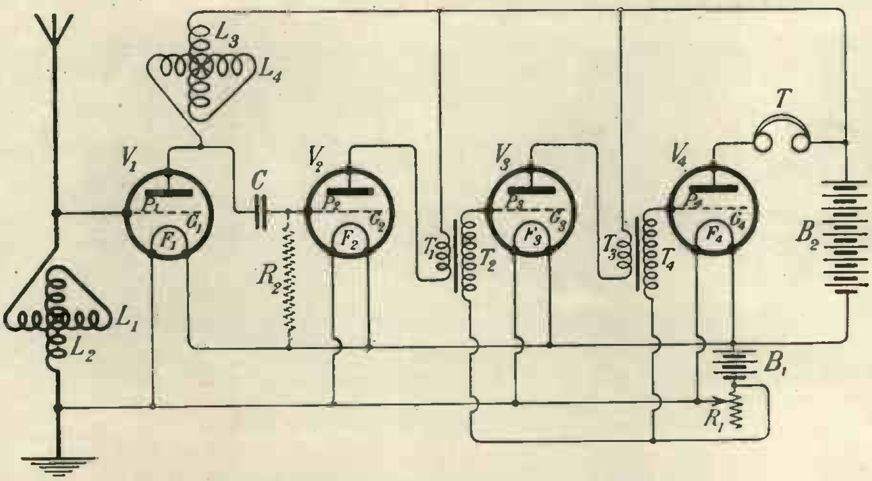


Fig. 18. The circuit used on the four-valve set.

A TWO-VALVE NOTE MAGNIFIER

(*Continued from page* 137.)

B go to the terminals I P and O P of the primary winding of the transformer T_1. One terminal OS of the secondary of this transformer is connected to the grid of the first valve, while the second terminals IS is connected to the negative terminal of the filament accumulator B_1. The plate P_1 of the first valve is connected to one of the terminals OP of the primary of the second intervalve transformer T_2; while the other primary terminal IP is connected to a point on the variable high-tension battery B_2. A secondary terminal OS is connected to the grid G_2 of the second valve, while the other secondary terminal IS is connected to the negative terminal of the accumulator B_1. The plate circuit of the second valve contains the telephones T as shown. The filament rheostat R is connected in the position shown in the diagram.

The detailed wiring of the amplifier is shown in Fig. 3. The point to notice in connection with this amplifier is that it may be applied to an existing valve set. If this valve receiver employs only a single valve, then care must be taken to see that in that receiver the high-tension battery normally comes next to the filament. If the telephone receivers were next to the filament accumulator, the other side of the telephones being connected to the negative side of the high-tension battery, then it would not be possible to use the same accumulator and the same high-tension battery. The same batteries, however, may be employed if the telephones and high-tension battery are interchanged.

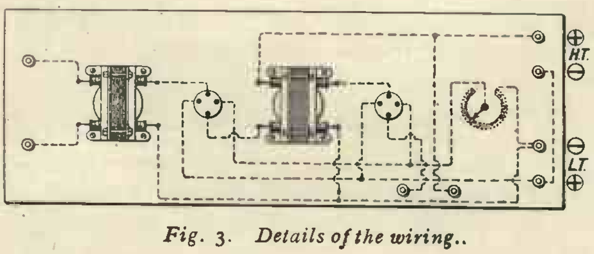


Fig. 3. Details of the wiring..

PATENTS OF THE MONTH

Any of these patents specifications may be obtained (1s. each, post paid) by writing to the Patent Office, 25 Southampton Buildings, London, W.C. 2.

183,104. Schneider, F. A detector having an electrode gap which is bridged over by a sphere of some detecting substance, the electrodes being capable of rotation about their centres so that the sphere held between them may be rolled about until its most sensitive points are presented to the electrode surfaces. (July 13, 1921.)

188,483. Walker, H. S. A system for modulation in radio-telephony in which a control valve, to the grid of which microphonic potentials are applied, is shunted across the grid coil and grid leak of the main power valve. (October 4, 1921.)

188,707. British Thomson-Houston Co., Ltd. A four-electrode valve having two grids between the filament and anode, working by virtue of secondary emission from one of the grids in a similar manner to the dynatron. Signals to be amplified are applied between the other grid and the filament, unusually large amplification being stated to be possible. (June 18, 1921.)

188,709. Brown, S. G. Microphones for the electrical transmission or reproduction of sounds. Two or more aperiodic differential microphones may be mounted on a common shaft connected to a diaphragm, the microphonic elements being surrounded by massive metallic casing in such a way as to facilitate the dissipation of heat formed. (July 9, 1921.)

188,763. De Forest, L. A novel construction for loud-speakers or microphones, in which the instrument takes the form of a conical shade on a vertical stand, the whole serving also as a table-lamp if desired. The conical shade, which acts as the vibrating diaphragm, is made of parchment, rubberised fabric, or other suitable material, and is clamped at its periphery to a ring rigidly connected by radial members to the stand—the apex being attached to a vertical rod passing into the stand, where it is actuated by telephone magnets. (August 16, 1921.)

188,823. General Electric Co., Ltd., and Eden, C. G. Improved holders for thermionic valves, whereby valves may be inserted and removed with facility, one spring contact sufficing to secure the valve safely in position and to maintain pressure at the other contacts. The valve is provided at one end with a moulded insulating base, with three of the contacts distributed around it, the fourth contact taking the form of a point and socket at the other end of the valve. One of the holder contacts takes the form of a flat spring. (August 30, 1921.)

189,266. Grenfell, G. P.; Robinson, J.; Gill, T. H., and Erskine Murray, J. Directional transmitting systems in which all oscillatory circuits are maintained in rigid relation to each other and rotated as a whole, thus avoiding the previous discrepancies due to stationary portions of the oscillatory system. (September 7, 1921.)

189,270. General Electric Co., Ltd., and Barlett, A. C. A method of maintaining an electrically heated wire, such as a valve filament, at a constant temperature in spite of changes in the diameter of the wire, which consists in placing a constant resistance in series with the said wire, the value of the resistance being one-third of that of the heated wire, and at the same time maintaining a constant potential difference between the ends of the circuit which comprises the heated wire and the constant resistance in series. (September 9, 1921.)

189,339. Welch, A. P. A valve-holder having fillets or barriers on the top or under-side, or both, arranged between the contacts to provide a long leakage path between contacts at unequal potentials. A clip may be provided for the purpose of making electrical connection between the valve cap and one of the contact sockets. (November 16, 1921.)

189,645. Turner, L. B. Limiting device for reducing the effects of atmospherics in which the aerial circuit is connected to grid circuit of a valve arranged as an H.F. amplifier, a specially low plate voltage being used. Balancing devices are provided to minimise the effect of the input circuits on output circuits due to stray fields. (December 1, 1921.)

189,693. Turner, L. B. The use of a single aerial for exciting the grids of a plurality of thermionic valves, each of which valves excites one of a corresponding plurality of receiving circuits, each of which circuits may be adjusted without affecting the currents in the aerial. (February 8, 1922.)

168,882. American Radio and Research Corporation, and Smith, C. S. A condenser having a gaseous dielectric under reduced pressure, characterised by the fact that the distance between the electrodes is small and comparable with the mean free path of electrons in the gas. Special means are provided to prevent ionisation at the edges of the electrodes. (August 30, 1920.)

RECENT ADDITIONS TO OUR LIST OF EXPERIMENTAL CALL-SIGNS

These additions (continued from page 65 of last issue), should be added to our "WIRELESS DIRECTORY," thus forming a complete and relaible list of commercial and amateur call-signs.

CALL.	NAME OF OWNER.	ADDRESS.
2 SI	L. C. Holton	112, Conway Road, N. 14.
2 SM	R. J. Bates	Abbeygate Street, Bury St. Edmunds.
2 SO	T. Geeson	Alder Cottage, Peel Street, Macclesfield.
2 SQ	A. J. Spears	25, Rawlings Road, Birmingham.
2 SY	H. Stevens	25, Oaklands Road, Wolverhampton.
2 SZ	W. H. Brown	Mill Hill School, N.W. 7.
2 TC	H. W. Sellers	Caresbrook, Langley Avenue, Bingley, Yorks.
2 TF	Edinburgh and District Radio Society..	Edinburgh.
2 TM	L. H. Mansell	Woodfield, Madersfield, Malvern.
2 TP	C. W. Andrews	26, Melody Road, Wandsworth, S.W.
2 TQ	T. C. Macnamara	31, Rolls Court Avenue, Herne Hill.
2 TR	F. C. Sparrow	8, North Drive, Swinton, Manchester.
2 UD	E. W. Smith	77, Grove Lane, Camberwell.
2 UI	A. R. Ogston	41, Broomfield Avenue, Palmer's Green.
2 UK	Coleridge Day Continuation School	Kings Norton, Birmingham.
2 UN	Y.M.C.A. (Boys' Department) ..	Cardiff.
2 UY	W. Fenn	Holly Cottage, Polesworth, Tamworth.
2 UZ	C. V. Stead	29, Spolebrook View, Chapeltown, Leeds.
2 VJ	B. J. Axten	78, Ealing Road, Wembley.
2 VK	Burndept Ltd.	Blackheath.
2 VS	L. E. Owen	156, Beaulah Hill, Norwood, S.E. 19.
2 VT	W. K. Hill	Norwood.
2 VV	Installations Ltd.	Southampton.
2 WA	J. Pigott	Manor Farm, Wolvercote, Oxford.
2 WI	C. J. Munday	Tiverton, Devon.
2 WL	F. J. Cripwell	Lonkhill, Thorpe Tamworth.
2 WP	Western Electric Co.	Witton, Birmingham.
2 WS	H. Squelch (Junr.)	35, Crown Lane, Bromley.
2 WT	H. Chadwick	9, Raimond Street, Bolton.
2 WU	Capt. C. H. Bailey	Monkswood, Usk, Mon.
2 WX	G. H. Gardner	
2 XA	Rev. C. H. Townson	Wilts Farm School, Warminster.
2 XC	H. Johnson	Avondale, Chestnut Walk, Worcester.
2 XD	H. R. Gladwell	London Road, Abridge, Essex.
2 XL	Capt. E. Davis	22, Lavender Hill, S.W. 11.
2 XM, 2 XN	Downside School	Stratton on the Foss, Bath.
2 XP	J. F. Payne	22, Shakespeare Crescent, Manor Park, E.
2 XR	J. F. Haines	36, Zetland Street, Poplar, E. 14.
2 XU	A. H. A. Kilbourn	Bath Street, Abingdon.
2 XW	H. A. Woodyer	118, Buckingham Road, Heath Moor.
2 XX	D. F. Young	23, Holcombe Road, Ilford.

CALL.	NAME OF OWNER.	ADDRESS.
2 YG	L. G. Boomer	42nd Camberwell Troop Scouts.
2 YI	W. J. Hewitt	83, Reddings Road, Moseley, Birmingham.
2 YK	T. M. Ovenden	12A, Elgin Court, Elgin Avenue, Hampstead.
2 YM	R. W. Piper	62, Chiltern View Road, Uxbridge.
2 YN	A. W. Thompson	32, St. Nicholas Street, Scarborough.
2 YU	G. W. Hale and R. Lyle	36, Dagnal Park, South Norwood.
2 YV	G. M. Whitehouse	Allport House, Cannock.
2 YY	O. H. Patterson	26, Allerton Road, Stoke Newington.
2 ZD	A. Woodcock	Montague Road, Handsworth, Birmingham.
2 ZL	H. W. Gee	44, Gordon Street, Gainsborough, Lincs.
2 ZM	T. H. Isted	Terling, Witham, Essex.
2 ZP	G. H. Forwood	West Chart, Limpfield, Surrey.
2 ZQ	H. Nunn	49, Leigh Road, Highbury.
2 ZT	C. M. Benham	"Benhilton," New Maldon.
2 ZU	T. Heckles	30, Thackeray Street, Liverpool.
2 ZV	F. T. Smith	Rutlands, Felstead.
2 ZY	Metropolitan-Vickers Electric Co., Ltd.	Trafford Park, Manchester.

5 AA	"Leicester Mercury"	Leicester
5 AF	J. A. D. Devey	232, Great Brickkiln Street, Wolverhampton.
5 AG	A. E. Gregory	77, Khedive Road, E. 7.
5 AI	A. H. Sheffield	139, Wallwood Road, Leytonstone, E. 11.
5 AK	H. G. Mansell	Cleeve View, Harvington, near Evesham.
5 AN	W. J. Joughin	21, Troughton Road, Charlton, S.E. 7.
5 AO	H. H. Elson	142, Birchfield Road, Birmingham.
5 AV	R. W. Harvey	25, Shakespeare Avenue, Portswood, Southampton.
5 AW	F. Hough (Southport), Ltd... ..	60, Sussex Road, Southport.
5 BI	G. E. Beale	Bournemouth.
5 BK	W. G. H. Brown	52, Winstonian Road, Cheltenham.
5 BM	J. T. Quick	164, Portland Road, Edgbaston.
5 BV	H. N. Ryan	88, Home Park Road, Wimbledon Park.
5 BW	A. de Villers	79, St. George's Road, S.E.
5 CD	G. Ward Booth	Albany House, Clarkson Avenue, Wesbook.
5 CF	F. G. S. Wise	7, Vernon Road, Hornsey, N. 8.
5 CJ	J. Balderston	6, Clough Terrace, Barnoldswick, *via* Colne.
5 CK	L. H. Pearson	Thorncliffe Road, Nottingham.
5 CS	G. R. Garratt	35, Abbey Road, St. John's Wood, N.W. 8.
5 CV	R. J. Harrison	Seaton, Walton-on-Thames.
5 CW	A. H. S. Colebrooke	Sharborne Street, Birmingham.
5 CX	A. Higson	161, Cotton Tree Lane, Colne, Lancs.
5 DA	G. Gore	24, Brucegate, Berwick.
5 DB	C. H. P. Nutter	243A, Selhurst Road, S.E. 25.
5 DI	C. J. Matthews	450, Cranbrook Road, Ilford.
5 DM	A. N. J. Ley	Grove House, Albert Grove, Nottingham.
5 DN	L. R. K. Halcomb	106, Millhouses Lane, Sheffield.
5 DP	F. L. Stollery, Sea Scouts H.Q. ..	"Fairmead," Vista Road, Clacton-on-Sea.
5 DV	D. Whittaker	56, Park Road, St. Anne's-on-Sea.
5 FH	L. H. Lee	155, Rosefield Rd., Smethwick, Birmingham.
5 FM	R. Stone	3D, Bushey Hill Road, Camberwell.

(*To be continued.*)

THE WORLD'S LAND STATIONS

THEIR CALLS AND WAVELENGTHS

(*Continued from Page* 59 *in last issue*.)

NOTE.—The experimenter or operator who desires to know what stations he may expect on a certain receiver or adjustment will find the following list of great value. The stations are arranged in order of wavelengths. Spark stations are in ordinary type and continuous wave stations in italics.

METRES.	
3,000	HB Buda-Pesth, VAS Vaslui, IQZ Pola.
	XOC Wuchang, XQL Kalgan.
	BYB Cleethorpes.
	RT Rotterdam (Higher limit).
	Certain German Shore Stations (Higher limit).
3,100	OHD Deutsch Altenburg.
3,200	FL Paris, FF Sofia.
	LP Berlin, FL Paris.
3,300	SAJ Karlsborg.
	BYD Aberdeen, VPT Malta Is.
3,375	PKF Balikpapan, PKG Tarakan.
3,500	HCG Guayaquil, HCQ Quito, OHD Deutsch Altenburg.
	OXE Lyngby, PKX Malabang (Higher limit proposed for Navy and Army).
3,600	CCU Llanquihue, CCW Punta Arenas.
3,700	*LP Berlin.*
3,750	EGC Madrid.
3,800	EAA Aranjuez, SAJ Karlsborg.
	MZX Chelmsford (3,800).
3,900	POZ Nauen.
4,000	POZ Nauen, OHD Deutsch Altenburg (4,100).
	JJC Funabashi.
	PRG Prague (4,100), *BZK Bathurst, BZJ Port Nolloth, BZI Durban.*
	OHL Laerberg (Vienna) (Lower limit), LCH Christiania (4,100).
	PKX Malabang (Lower Insular limit proposed.)
4,200	SAJ Karlsborg.
	BZL Demerera, BZM S. John's, VAL Barrington Passage.
	BYD Cleethorpes, BYZ Rinella, BZR Somerset Is.
	BZQ Christiania (Ja.).
	OHD Deutsch Altenburg (4,250), *OXE Lyngby, SAJ Karlsborg.*

METRES.	
4,300	BZO Ascension.
4,500	BZN Falkland Is.
	BYB Cleethorpes.
4,600	*GSW Stonehaven.*
4,700	*BZI Durban, BZJ Port Nolloth, BZG Mauritius, BZH Seychelles.*
	POZ Nauen.
4,800	*BYF Pembroke, BWW North Front, BZK Bathurst.*
	NPG S. Francisco, PSO Posen.
5,000	JJC Funabashi, MSK Moscow, GSW Stonehaven.
	BZE Martara, BXW Seletar, BXY Stonecutters, BZO Ascension.
	OXE Lyngby, HJG Bogota, BZK Bathurst, BZJ Port Nolloth.
	NPO Cavite.
5,200	*BYB Cleethorpes.*
5,250	*NAU S. Juan, BYB Cleethorpes.*
5,300	NBA Ballao.
	BZF Aden, BZE Matara, BZH Seychelles.
5,450	*LCH Christiania.*
5,500	*OHD Deutsch Altenburg, OSM Osmanie.*
5,670	*OHD Deutsch Altenburg.*
6,000	MFT Clifden.
	SAA Karlskrona (Higher limit for reception only).
	IQZ Pola, PKX Malabang (Higher Insular limit proposed).
	OJA Helsingfors, BYC Horsea.
	MFT Clifden.
6,300	*BWW North Front.*
6,500	*HFB Bagnitza, OHL Vienna, FL Paris.*
6,700	*EAA Aranjuez, PCG Kootwijk-Sambeek* (6,650) *(Lower limit proposed).*
	MSK Moscow.
7,000	*HFB Bagnitza, NBA Balboa, FL Paris.*

(*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	Eiffel Tower	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	Eiffel Tower	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	Eiffel Tower	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	Eiffel Tower	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.
1130	FL	Eiffel Tower	2,600 Spark.
1135	GFA	Air Ministry	1,680 C.W.
1130–1205	FL	Eiffel Tower	7,000 C.W.
1130–1300	FL	Eiffel Tower	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	Eiffel Tower	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.
1425	OPQ	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	Eiffel Tower	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.

TIME (G.M.T.)	CALL-SIGN.	NAME OF STATION.	WAVELENGTH.
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	Eiffel Tower	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.
1945	CNM	—	5,000 C.W.
1900–1930	FL	Eiffel Tower	7,000 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	Eiffel Tower	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	Eiffel Tower	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.

TIME (G.M.T.)	CALL-SIGN.	NAME OF STATION.	WAVELENGTH.
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	4,600 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 Assizes	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.

100,000 Copies of No. 1 !

A net sales certificate will be issued in due course, but the following printers' certificates are of interest.

27.1.23.

This is to state that we have printed 20,000 copies of MODERN WIRELESS (No. 1) for Radio Press Limited.

For CHELTENHAM PRESS LIMITED,
(*Signed*) R. MATTHIAS,
Manager.

9.2.23.

This is to certify that we have completed reprints of No. 1 of MODERN WIRELESS to the extent of 80,000 copies.

For SPOTTISWOODE, BALLANTYNE & CO. LTD.
(*Signed*) R. AFFLECK,
General Manager.

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" in 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.

Queries will not be answered by post.

J. A. W. (Llanfrothan) refers to the two-valve broadcast receiving set as described on pages 14 to 18 of our previous issue, and asks whether that set, with one additional note-magnifying valve, will enable him to receive 2 LO on a loud-speaker.

Probably, but to ensure success you are advised to add two L.F. valves as described in a supplementary article appearing in this present issue. By the way, you are not now restricted to 100 ft. of wire in your aerial (see page 94). (1)

H. R. M. (Hanwell, W. 7).—See reply to J. A. W. (Llanfrothan) above. With a view to receiving waves up to 3,000 metres, you might try an additional inductance consisting of a former 4 in. in diameter by 8 in. long closely wound for 7 in. of its length with No. 26 S.W.G. enamelled copper wire fitted with a slider, in series with the winding of each variometer. Rough tuning can be done by means of the slider and fine tuning with the variometers. The H.T. and L.T. voltages specified will be quite in order. (2)

R. J. T. (London, N.W. 6).—Please see the two replies above. (3)

J. W. (London, S.W. 1) is experiencing difficulties in connection with the windings of the variometers in the two-valve receiving set described in our previous issue.

If, when testing the winding of the second variometer with a pocket flash lamp and battery, the lamp glows brightly, it certainly indicates that you have a short circuit somewhere. The dull red glow obtained when testing the stator coils indicates that they are in order, so that the trouble must be in the rotor itself. With regard to the "direction" of winding, it is usually found convenient to connect the rotor so that a clockwise movement effects an increase in wavelength. With regard to the reception of longer wavelengths, please see replies above.

Many thanks for your appreciative remarks. (4)

T. E. (Dungannon, co. Tyrone).—The range of every receiving set depends upon several factors, of which the following are very important.

1. The power of the transmitting station.
2. The height and length of the receiving aerial.
3. The general efficiency of the aerial-earth system.
4. The efficiency of the receiving apparatus itself.

As the only information you give refers to the last-named item, we are unable to give a definite and useful opinion. Adding low-frequency amplifying valves will increase the loudness of the received piece, etc., rather than the range. You should be able to receive from some of the British Broadcasting Stations using only the two valves.

Thanks for your good wishes. (5)

C. B. (Guildersome, nr. Leeds) inquires regarding a method of transmitting Morse signals with the apparatus described in the article entitled "A Simple Telephone Transmitter" in our last issue.

It is only necessary to omit the microphone with its attached coil and insert a transmitting key between the reaction coil and the filament lighting battery. If a 100-volt dry-cell battery is employed as a source of H.T. supply, it should be connected as shown in the diagram, but the positive side of the battery should be connected to the earth end of the inductance coil L_1. (6)

A COMMON INQUIRY *re* OUR LAST MONTH'S TWO-VALVE SET.

Several readers have stated that they find the inner variometer tube too big to rotate inside the outer tube. This is because their outer tubes are too thick. This trouble may be overcome by scraping out the inside of the outer tube with a pen-knife until there is sufficient clearance.

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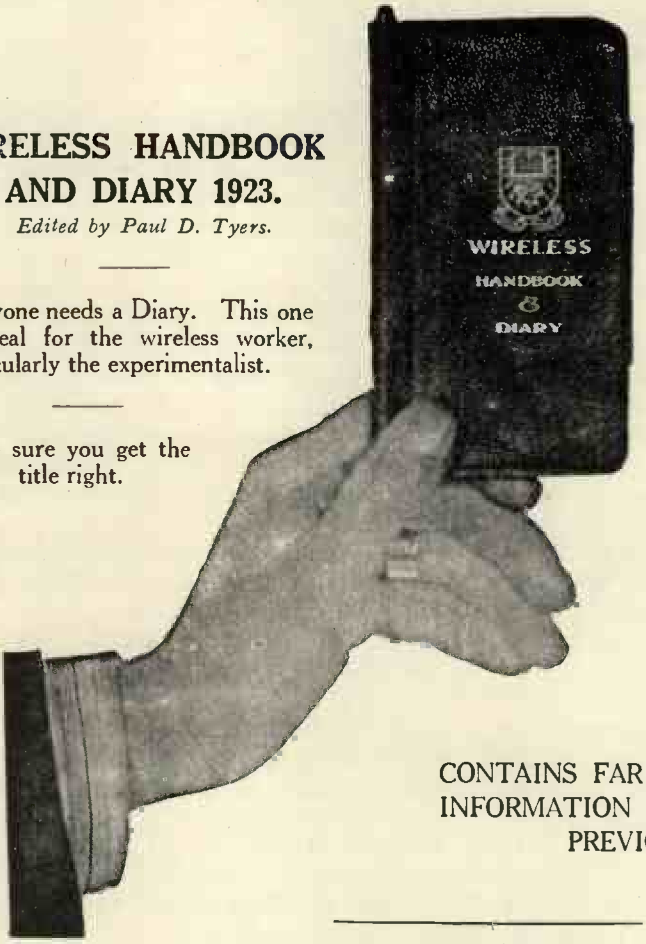

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As regards the quality of the production, we have only to mention the name of Charles Letts. As regards the authoritative and useful character of the wireless information it is only necessary to remind you that it has been prepared by the technical staff of Radio Press Ltd.

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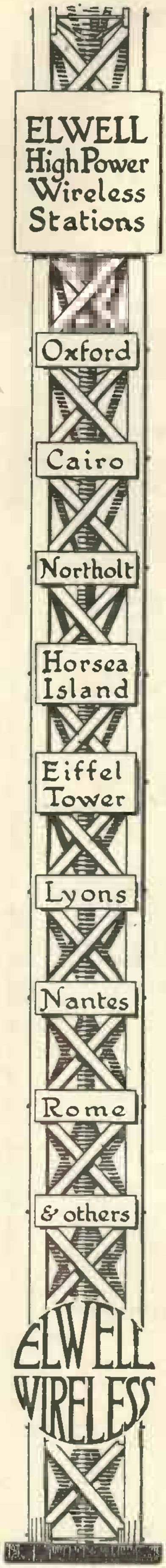

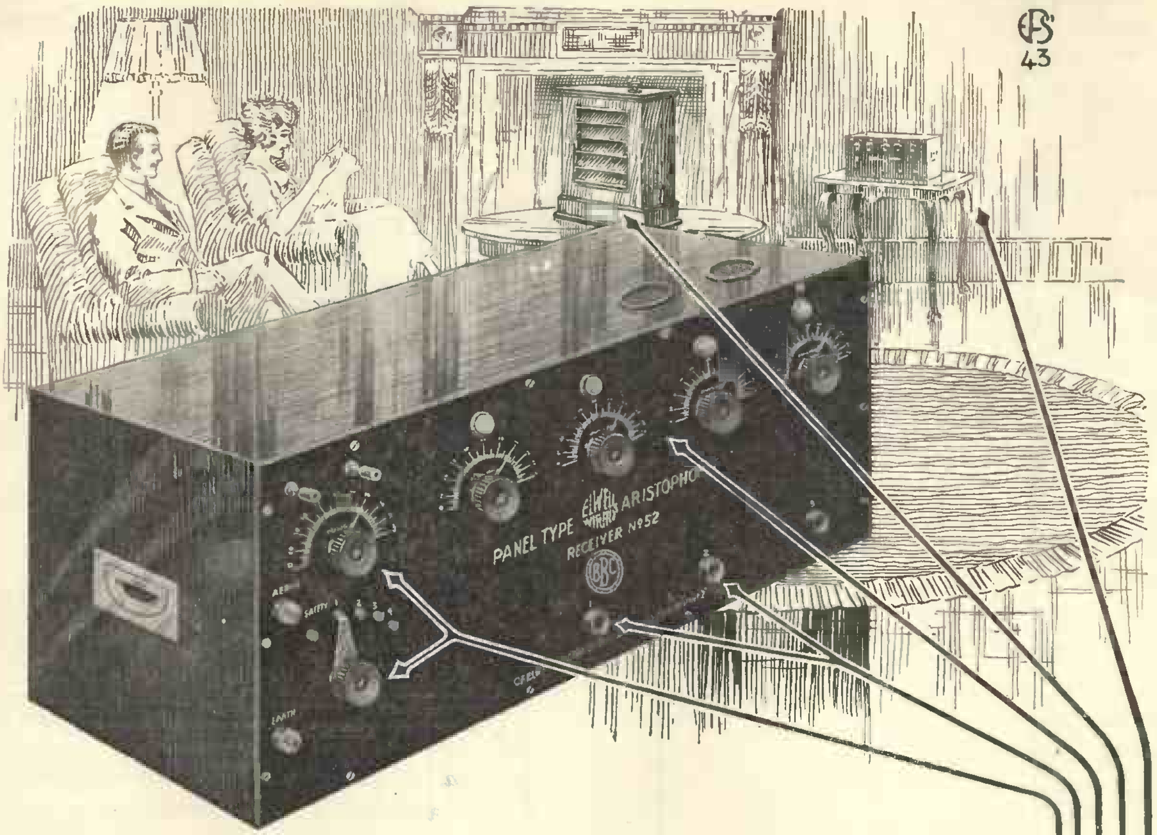

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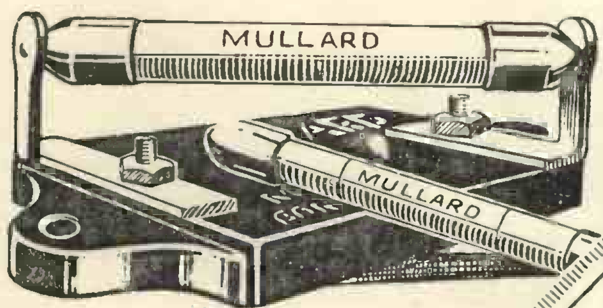

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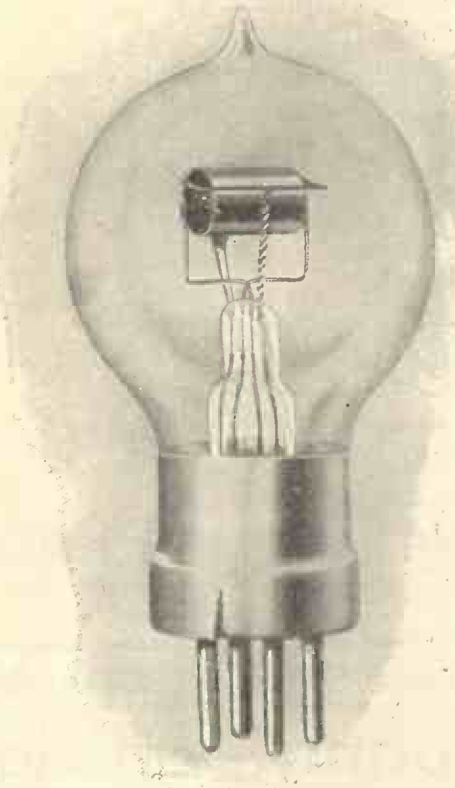

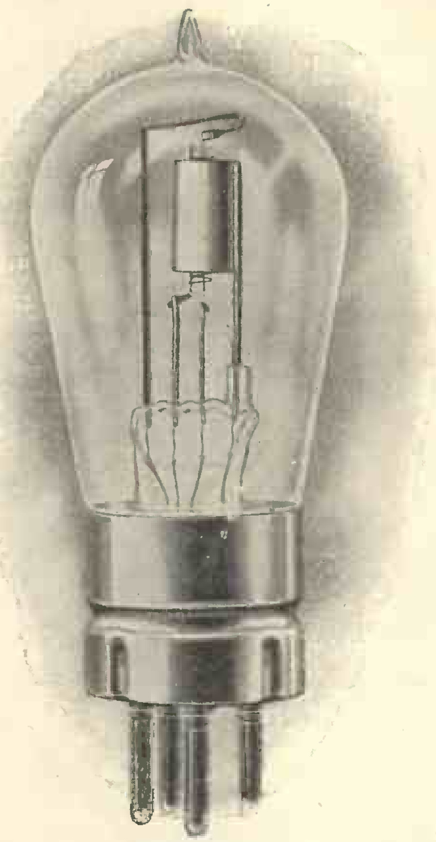

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READING RADIO RESEARCH SOCY.
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SLOUGH AND DISTRICT RADIO SOCIETY.
Hon. Sec.: Ravensham House, Dolphin Road, Slough.

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HULLO

Do YOU Know Us? If not, why not?

COMPLETE SETS *of* PARTS *for* MAKING VARIABLE CONDENSERS

EVERYTHING READY to ASSEMBLE and CONSISTS of the FOLLOWING:

Accurate Aluminium Fixed and Moving Vanes, Large and Small Spacer Washers, Centre Square Spindle (Screwed Ends, 2 B.A.), 3 Side Rods, 13 Nuts and 13 Brass Washers (2 B.A.), Pointer-scale 0-180, Terminals, 3 bushes, Spring Coil Washers, Best Quality Knob with 2 B.A. Nut in Centre.

ALL HIGHEST QUALITY GOODS

REVISED PRICES, WITHOUT EBONITE

Approximate Capacity in Microfarads	*No. of Plates*	*Price*
.0015	85	9/-
.001	57	6/6
.00075	43	5/6
.0005	29	4/6
.0003	19	3/-
.0002	13	2/3
.0001	7	2/-
Vernier	3	1/9

Postage and Packing: 1 set, 1/- ; 2 sets, 1/3; 3 sets, 1/6

If more than 3 sets kindly include ample for packing and carriage, as the value given does not permit of my paying same.

DRILLED EBONITE ENDS - - 1/- pair

Come along and see us. We keep just what you want. If you think goods are not as represented, cash returned.

HEADPHONES

America's Best

"FEDERAL"

4,400 ohm phones
Magnificent Value

Post **27/6** free

Not **cheap,** but the Goods!
LIMITED SUPPLY

I Usually Stock

"BRUNET"

AT

25/-

but cannot always guarantee delivery. Post 1/-.

WESTERN ELECTRIC

Phones 4,000 ohms
Stamped B.B.C.
Passed P.M.G.

Per **32/-** Pair
Post 1/-.

Right Opposite
DALY'S
Gallery Door

M. RAYMOND

27, LISLE STREET, W.C.2

'Phone : . . . . . . GERRARD 4637

To avoid mistakes, this address is close to Charing X Road and Leicester Square Tube

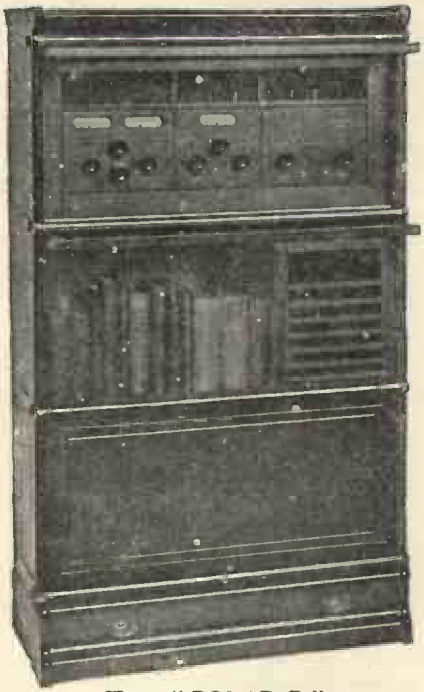
SECTIONAL BOOKCASE

CABINET RECEIVING SETS

This handsome and compact piece of furniture is an ornament for any room, and can be supplied to match existing sectional bookcases. Standard finishes are in oak and in mahogany.

It contains the famous "POLAR" Radiophone Combination Receiving Set, Type RA 33, 34, and 35, complete with "POLAR" Loud-Speaker, H.T. and L.T. Batteries (in bottom compartment), Headphones, and all connections.

This is a seven-valve receiving set with three stages H.F. Amplification which can be switched in or out of circuit at the whim of the user and constitutes the most powerful provision available for the magnification of weak signals.



Type "POLAR B"

RESULTS OBTAINABLE (as described by some of the users):

NEWCASTLE, 30/12/22

"*The 7-Valve Radiophone Set* was duly fitted for Messrs. .... yesterday and tests carried out last night.

"I beg to report that excellent results were obtained to our great satisfaction: Very strong reception was got from Marconi House and local telephony from a Newcastle Station 5 BA. Good signals were received from Writtle, Birmingham and Manchester. Signals throughout from all stations were very clear and distinct without the slightest distortion. *Everyone listening remarked on the perfect tuning and lack of interference from Commercial Stations.* **Cullercoats could hardly be heard although using 5 k.w. a few miles away. He was not strong enough to interfere with the weakest telephony."**

The above results refer entirely to the loud-speaker, the telephones being used for tuning in.

GLASGOW, 12/12/22

"I am pleased to say, that the R.A. *33, 34 and 35 Combination*, **supplied through Messrs. .... to Mr. .... has been installed and was tested by myself personally, last night. Reception through 2-L.O., which was too strong for the Head Telephones, was comfortable over a large-sized room through the medium of a Gramophone Adaptor, and a Hornless H.M.V. Machine. Manchester was particularly clear, and Mr. .... has expressed his** *surprise and appreciation of the excellent results achieved, which were far beyond his expectations.*

"I myself, am particularly pleased with the results, as this is the first set which has been actually tested in this district, and considerable doubt had been expressed locally, as to its capability of receiving London through *this heavily screened area.*"

Chosen for Good.

PRICE . . In Oak **£82 15 0**

In Mahogany .. **£85 15 0**

THE

RADIO COMMUNICATION CO., LTD.,

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

BRANCHES:

NEWCASTLE:	SOUTHAMPTON:	CARDIFF:	LIVERPOOL:	GLASGOW:
17 SANDHILL.	19 QUEEN'S TERRACE.	ATLAS CHAMBERS, JAMES STREET.	67 DALE STREET.	116 HOPE STREET.

WARRINGTON: 37 BRIDGE STREET.

(E.P.S. 39.)

"POLAR"

CHOSEN FOR GOOD

CONCENTRATED EFFICIENCY.

—The Condenser condensed

The new " Polar " Variable Condenser embodies *maximum efficiency* with *minimum dimensions* at *minimum cost.*

Made in three ranges :—

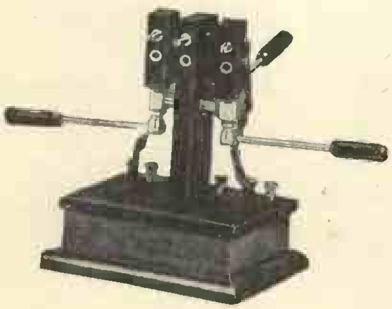
·0001 to **·001** mfd.
·00005 to **·0005** mfd.
·00005 to **·0003** mfd.

All types are of the same dimensions, **3″** × **3½″** × **1″**, and sold at the same price :—

14/9 for panel mounting. Post free.

20/9 mounted in polished wood case. Post free.

"POLAR" THREE-COIL TUNING STAND



Of sound design, good workmanship and fine finish.

The centre coil is rigid while the outer ones can be rotated independently about their axes of support, or swung both together in planes parallel to that of the fixed coil. The former movement is controlled by two independent handles, one at each side, the latter by a single handle at the rear. The length of the handles is such as to prevent the hands of the operator from adding temporarily to the capacity while making the adjustments.

The coil holders are of ebonite arranged for standard coil plugs. They are carried on solid brass swivels. The whole is mounted on an ebonite panel supported by a polished wood base. All brass parts are highly lacquered, and the complete instrument is finished in a first-class manner.

Price 31/- Post free

THE

RADIO COMMUNICATION CO., LTD.,

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

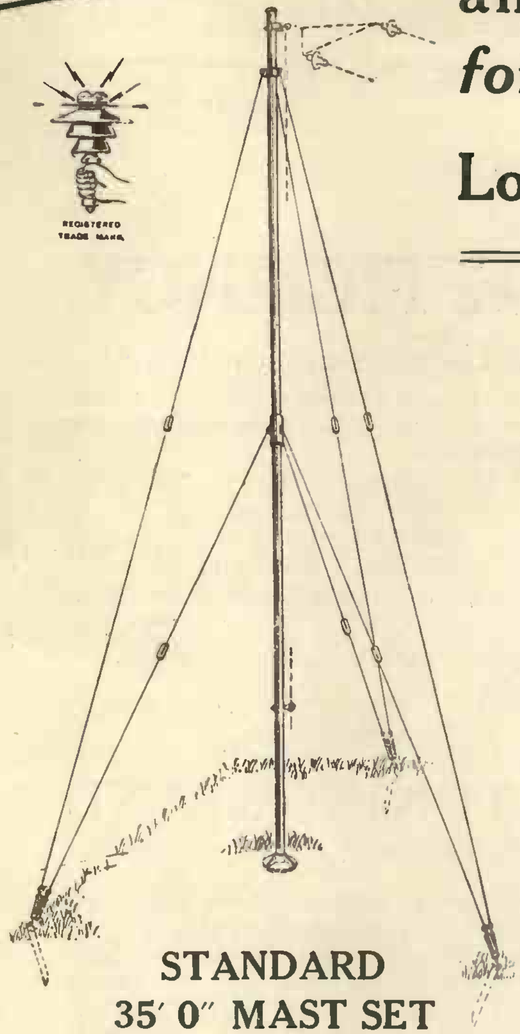
BRANCHES :

NEWCASTLE : 7 SANDHILL. SOUTHAMPTON : 19 QUEEN'S TERRACE. CARDIFF : ATLAS CHAMBERS, JAMES STREET. LIVERPOOL : 67 DALE STREET. GLASGOW : 116 HOPE STREET. WARRINGTON : 37 BRIDGE STREET.

44

BULLERS'

Tubular Steel Mast Sets and Wireless Insulators *for* Broadcasting Reception *and* Low Power Transmission



REGISTERED TRADE MARK

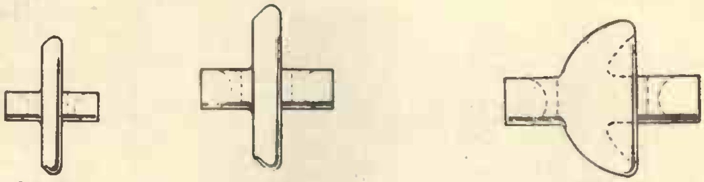
STANDARD 35′ 0″ MAST SET

Each set consists of :—

One top tube, one bottom tube with shoe and joint socket. Six double swivels for adjusting the stay wires. One 3-way stay clip. Three stay pegs of angle iron, 2′ long, pointed at one end and provided with a hole in each flange for independent adjustment of stays. 180′ of No. 12 flexible steel wire rope. Six guy insulators, Patt. EA.8760. One aerial halyard pulley and eye bolt for securing halyard. The whole of the metalwork is galvanised except the stay pegs which are oiled.

TOTAL WEIGHT OF TUBES AND SOCKET, 59 LBS.

INSULATORS



EA 9340 EA 9341 EA 9342

Type.	Diam.	Weight.	Tests.	Retail Price.
EA9340 –	3¼″	6 oz.	40,000 volts 500 lbs.	1/4 each
EA9341 –	4″	11 oz.	52,000 volts 600 lbs.	2/-each
EA9342 –	3 11/16″	18 oz.	52,000 volts 800 lbs.	2/6 each

Advantages over other Types.

1. Very low capacity.
2. Instant shedding of rain.
3. Highest insulation possible.
4. Negligible weight.
5. Great tensile strength.
6. Easy to attach to aerial or halyard.

THESE MASTS are light, strong and the general arrangement is based on sound engineering practice. The design is as economical as is possible, consistent with necessary strength and weathering capabilities; sufficient stay wire is provided to enable the erector to vary the staying points within a reasonable margin.

These Masts can conveniently be erected on a base of 20′ diameter. 40′ Masts can be supplied at slight extra cost.

RETAIL £3 - 15 - 0 PRICE

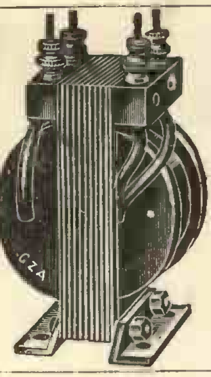
PER SET COMPLETE DELIVERED GT. BRITAIN.

SPECIAL TERMS TO THE TRADE.

BULLERS LTD., 6, Laurence Pountney Hill, LONDON——E.C.4.

Phone— *City* 985/6

AUCKLAND'S

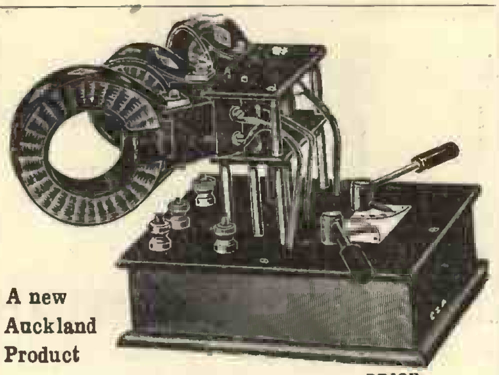


Intervalve Transformers

Most efficient cores being built up of Stalloy and in correct proportion. The bobbin is Layer Wound, each Layer being spaced. Designed to give maximum amplification.

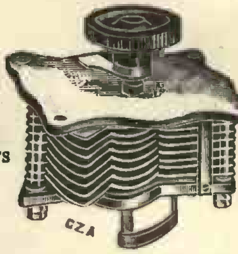
Price **20/-** each

Delivery — stock.



A new Auckland Product

3 Coil Holder with Remote Control, keeping Capacity effects from body. Finish as a first-class instrument. PRICE **22/6** EACH



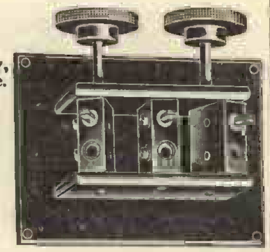
Auckland Condensers

·0002	MFD.	15/-	·0005	MFD.	18/-
·0003	,,	16/-	·001	,,	24/-

Coil Holder

Three way, Panel Type.

PRICE **12/6**

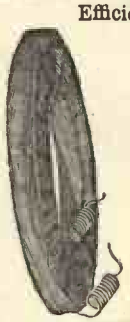


Auckland (Igranic) Duolateral Coils

Made under De Forest Patents.

Prices from 5/- Mounted.

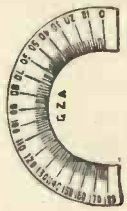
Efficient and Compact Inductances



Wound on a Uni Wave Principle to minimise self-capacity. Being only ½ in. wide and covering a range of 150–30,000 metres, these coils are eminently suited for loading coils, anode coupling, etc., etc.

Per set of 8 coils.

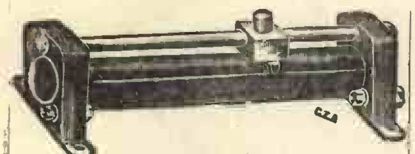
PRICE **12/6**



Ivorine Scales

A Component that is always useful. 6d. each.

Bevelled Dials with knob and bush. 3/- each.



Potentiometers

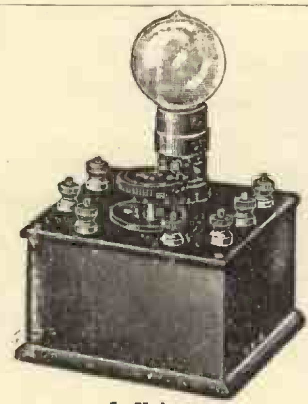
Most useful for Grid Potential Crystal adjustment, etc., etc.

Solid Construction. Enamelled Tubes. 200 w.

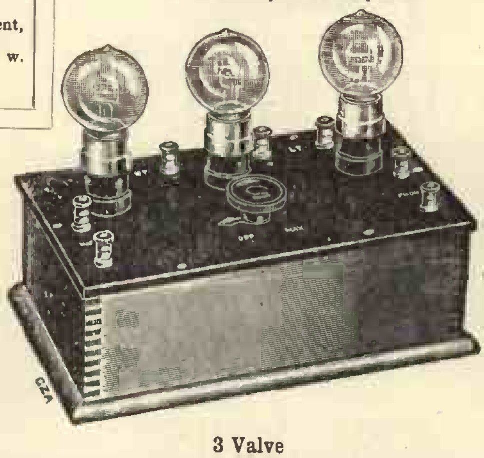
PRICE **8/6**

NOTE MAGNIFIERS

Are a Necessity for Loud-Speakers.

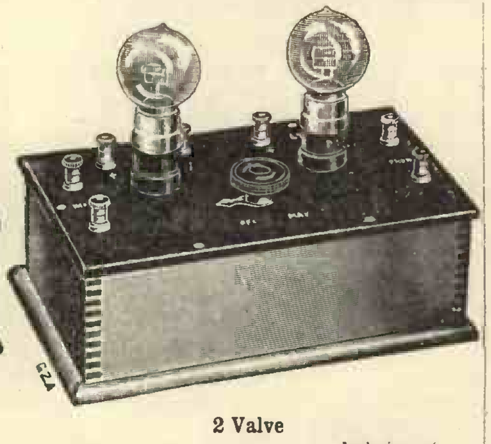


1 Valve



3 Valve

These Amplifiers are made up with our own Intervalve Trans, as shown above, fitted with Fil Resistance, and all necessary terminals, suitably engraved; 2 and 3 valve are fitted with Transformers for 120 w. output.



2 Valve

PRICES.	Inclusive of all Royalties.
1 Valve (less valve)	£3 5 0
2 ,, ,,	5 12 0
3 ,, ,,	7 10 0

Each tested before dispatch.

G. Z. AUCKLAND & SON,

London Offices : 395 ST. JOHN STREET, E.C.1.

Factories—ISLINGTON, N. WIRELESS INSTRUMENT MAKERS. Phone 3173 CLERKENWELL.

We know you'll keep it —— Because

The RADIONETTE offers the highest efficiency with a specification and equipment second to none, and therefore we will send it to you for a—

SEVEN DAYS' FREE TRIAL IN YOUR OWN HOME.

If you are not satisfied, return it, and we will refund you your money.

£3-10-0

IT IS RESULTS THAT MATTER—

The Radionette GUARANTEES MAXIMUM RESULTS IRRESPECTIVE OF PRICE AT MINIMUM COST AND INCLUDES A PAIR OF SIEMENS 4,000 OHM HEADPHONES, TWO CRYSTOR AERIAL INSULATORS, and 100 ft. COPPER AERIAL WIRE.

YOU "LISTEN-IN" AT ONCE! NO EXTRAS.

PRICE **£3 : 10 : 0** inclusive of B.B.C. DUTY.

STOCKED by all leading Wireless Stores **EVERYWHERE**

SOLE DISTRIBUTING AGENTS:

WIRELESS AGENCIES, Ltd.

64, Mortimer St., London, W. 1.

'Phone: MUSEUM 2672. 'Grams: Adragonax, Westo, London.

WIRELESS AGENCIES, LIMITED,
64, Mortimer Street, London, W. 1.

Dear Sirs,

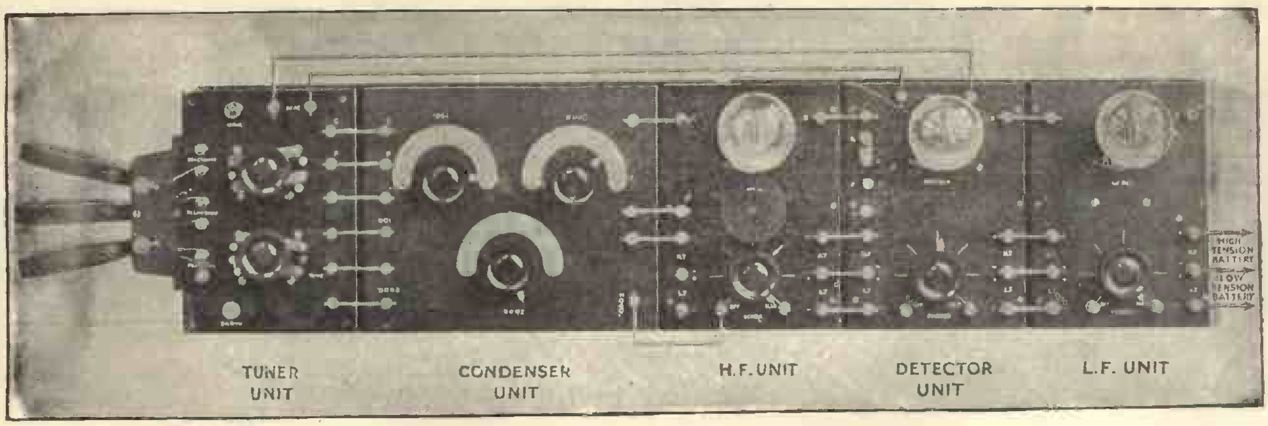
Please send me your Radionette Outfit No. 1, for which I enclose the sum of £3 10s. on conditions that you refund me this sum (less carriage, 3s.), if I return the Outfit to you undamaged within seven days of receipt.

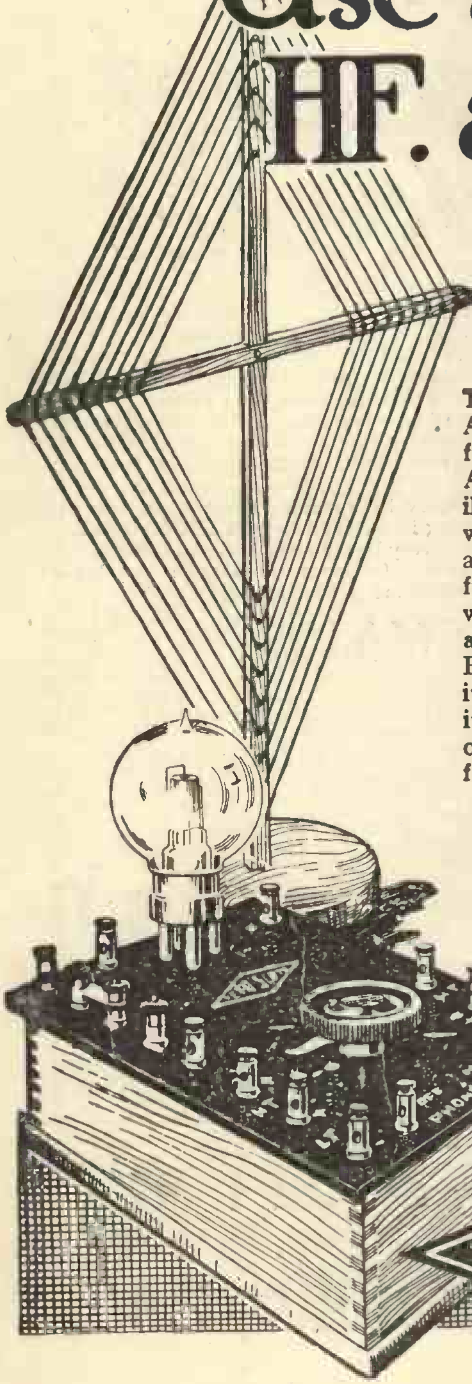
Yours faithfully,

Name

Address

(Please write clearly.)


HIGH TENSION BATTERY
LOW TENSION BATTERY
TUNER UNIT
CONDENSER UNIT
H.F. UNIT
DETECTOR UNIT
L.F. UNIT




THE PETO-SCOTT CO.
PETO SCOTT

The Cottage
Greenford Green
South Harrow

Telephone: Harrow

January 6th 1923

Messrs The Peto-Scott Co.
64 High Holborn WC1.

Dear Sirs

No doubt you will be pleased to hear my personal experiences with the "Broadcast Major" which I obtained from you a few days ago on behalf of a friend

Having had considerable experience in the design of Radio Instruments -- my present Set being the fourth I have constructed -- I was certainly rather sceptical as to the results likely to be obtained with such a simple tuning arrangement as incorporated in the "Broadcast Major".

After a thorough trial, however, during which I received the London Broadcasting Station with perfect clearness and at excellent strength on as many as five pairs of head-phones at once, I wish to offer you my hearty congratulations

You have certainly been able to manufacture an excellent two-Valve Set at a very moderate figure.

I need hardly state that my friend, on whose behalf I purchased the instrument, is equally pleased with it, and is nightly receiving the excellent Conc from 2LO at his home some 20 miles from Lond

ess.

Wishing you

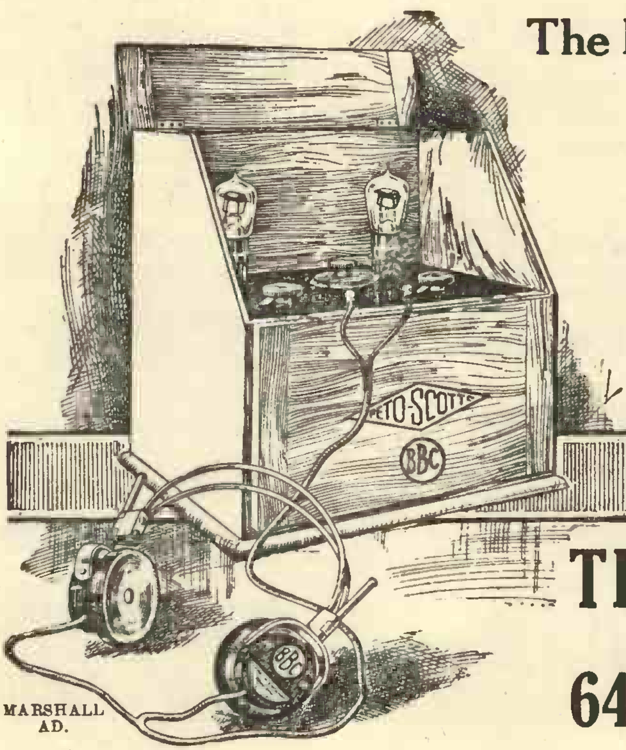
An Excellent 2 Valve Set

5 pairs of phones at once

¶ Absolutely complete—nothing more to buy

BEFORE introducing this Set, we have put it to exhaustive tests, and are now satisfied that for simplicity of operation, clearness, purity, and volume of tone, it is absolutely without a rival. If you are situated within 25 to 30 miles from any of the four Broadcasting stations—London, Birmingham, Manchester, and Newcastle—you cannot purchase a better Instrument, although you may be asked to pay very much more.

Remember every Instrument is tested on our own Aerial before being issued, and bears a certificate to that effect. Further, every Instrument carries our full guarantee of complete satisfaction after a seven days' trial in your own home or money willingly refunded.



The BROADCAST MAJOR

(Passed by P.M.G.)

Cabinet made from solid mahogany, hand polished throughout and fitted with hinged top and drop-down front

The tuning is controlled by one rotating dial and is very selective on all wavelengths between 350-550 metres—the Concert Wavelengths. Two filament rheostats are provided for regulating the filaments of the two valves. The L.F. Transformer is the MAX-AMP—our own design and manufacture. Included with the Set is an accumulator (6 volt 40 amp. hours), an H.T. Battery (60 volts), both of best British manufacture, and a pair of Western Electric Head-Phones. A complete Aerial outfit, including 150 feet of Aerial wire, together with necessary insulators, is supplied with the Set without extra charge. With the exception of the Valves, which owing to risk of breakage should be purchased locally, nothing more is required.

£9-9-0

Valves 15/- each extra

¶ **When this Set is required for use with Broadcast Licence a B.B.C. royalty of 35s. must be paid at time of purchasing. The royalty of 25s. due to the Marconi Co. is being paid by us.**

THE PETO-SCOTT CO.,

Featherstone House,

64, HIGH HOLBORN, W.C.1.

MARSHALL AD.

IT'S RELIABILITY YOU WANT——GET IT AT

GAMAGES of HOLBORN

Valve or Crystal, Complete Set or Smallest Accessory, you cannot go wrong at GAMAGES. Stocks are so complete, prices for warranted apparatus so keen, and the firm's desire to help the Amateur so genuine, that it would seem almost folly to go elsewhere.

New Season's Prices! Wireless Sundries.

Single Valve Amplifiers for increasing the volume of sound	42/-
Improved " Sonus " type, Model A.1.	50/-
Single Valve High Frequency Amplifier for increasing the range	70/-
Intervalve Transformers (Low frequency), maximum efficiency ..	25/-
" Ora " Valves	15/-
" Ediswan " Valves	15/-
" Marconi Osram " Valves	17/6
Valve holders	1/6
Filament Resistances	3/-
Fixed Condensers, ·002, ·0003, ·0004, best quality	3/-
Contact Studs, doz.	1/6
On - Off Switches, high class	3/9
Earthing Switches on porcelain	4/6

GAMAGES CRYSTAL RECEIVING SET

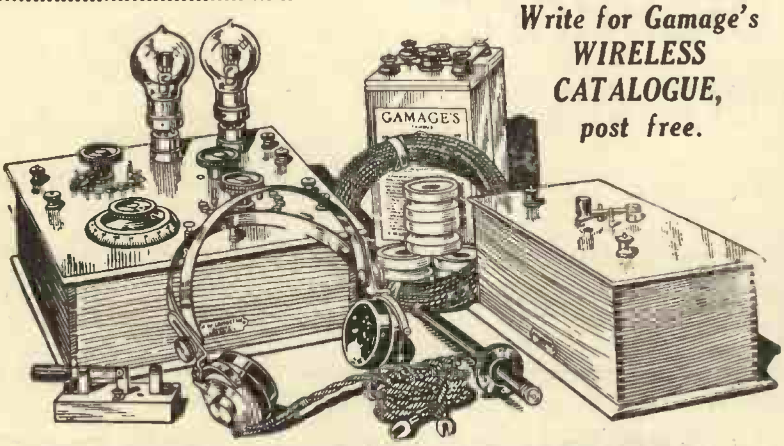
Fully licensed by Postmaster-General. Regd. No. 226. Tuning coil wound with best quality wire, and tapped in four places. This, when used in conjunction with the Variable Condenser, which is of the best possible workmanship, gives a good variation of tuning. The crystal detector, designed to prevent dust from deteriorating the sensitivity of the crystal, contains our famous " Permanite " Crystal, which has given such excellent results. The task of finding a sensitive spot on the crystal is minimised by means of a buzzer. Will receive Telephony for 30 miles, and signals from Spark stations using a wavelength of 300–500 metres for 150 to 200 miles. Complete in polished mahogany cabinet, with instruments mounted on polished Ebonite; 'Phones, Aerial Wire, and Insulators ready for use. Price **£4 19s. 6d.**

Substantial Reductions in Prices of Sundries.

"Permanite" Crystal, per piece, ...	1/6
Silicon Crystal, per piece	1/-
Zincite Crystal, per piece	2/6
Bornite Crystal, per piece	1/-
Copper Pyrites	1/-
Woods' Metal 1/- and	2/-
Ebonite Panels, cut to size .... per lb.	5/-
Shellac Varnish, per tin .... 1/- and	1/6
High Class Dust proof Crystal Detectors, complete with crystal	7/-
Aluminium Pulleys, 2 in.	1/4
Aerial Insulators, reel type	3d.
Ditto, barrel type ..	6d.
Ditto, shell type ...	1/-
Ditto, superior types	1/9 and 1/6

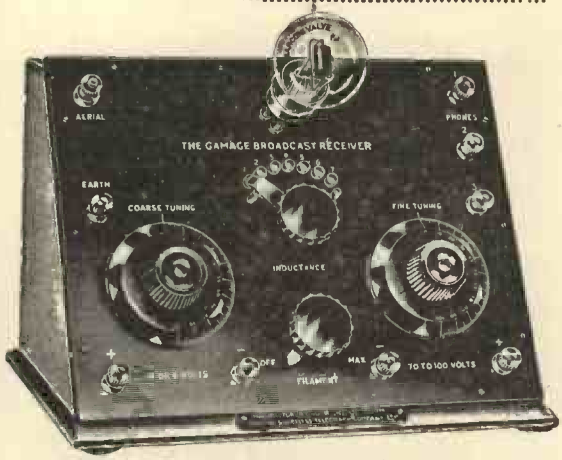
For further details, etc., see our WIRELESS LIST, free on request.

Write for Gamage's WIRELESS CATALOGUE, post free.



The "SONUS" Two-Valve BROADCAST RECEIVER

Consisting of one High Frequency and Detecting Valve. Telephony from Broadcasting Stations up to 100 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.**



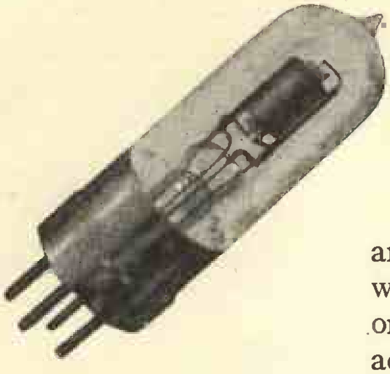
THE GAMAGE Single-Valve BROADCAST RECEIVING SET

A most efficient and compact set, comprising tuning unit and valve detector. Wavelength 300–500 metres, but any wavelength may be obtained by the addition of ordinary Honeycomb coil. Note the position of the Marconi " R " Valve—the filament being held vertical, cannot touch grid when sagging takes place. The tuning coil entirely eliminates self-induction and self-capacity effects.

TELEPHONY can be received up to 40 miles, and spark signals over a considerable distance. The complete set, licensed and passed by the P.M.G. and the Marconi Company, comprising the " Broadcaster " H.T. Battery, L.T. Battery, Phones, Aerial Wire, Insulators, Switch, and Lead-in Tube. Price complete **£22:10s.**

Be sure to visit our Stand No. 26 IDEAL HOME EXHIBITION at OLYMPIA, March 1st to 24th, 1923, (New Hall Gallery)
and inspect the very latest in Wireless Broadcast Receiving Sets that incorporate all the new improvements.

A. W. GAMAGE, LTD., HOLBORN, LONDON, E.C.1



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VALVES

are manufactured by a firm who have been associated with the development and production of the Thermionic Valve almost since its inception, and who, in addition, can bring to bear over forty years of experience in lamp making.

The type AR Valve has been specially designed for amateur use, as it is extremely strong and efficient, silent in working and economical in current consumption. Its high sensitivity makes it equally suitable for the serious experimenter as well as for the Broadcast receptionist.

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FOR H.T. and L.T.

All Ediswan Accumulators and Dry Cells are manufactured with that care in the selection of the materials and the quality of the workmanship which is the hall mark of all Ediswan Products.

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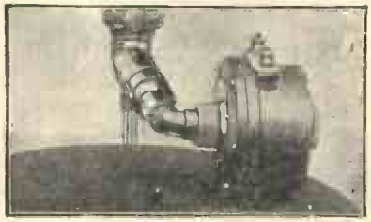
It speaks for itself in a loud, clear and perfectly natural tone

With the highest amplification of all Wireless reception, and particularly of Vocal and Instrumental music, the clarity and tonal purity of the AMPLION is unapproached in any other form of Loud Speaker

The adjustment is simplicity itself, and " volume " may be regulated to a nicety.



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The World's Standard

LOUD - SOUNDING RECEIVER with adaptor for connection with tone arm of a gramophone. Illustration above shows it fitted.

are supplied in a series of 10 models, suited to every service—the Home, Laboratory and Concert Hall—and the prices range from fifty shillings to fifteen guineas.

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Ask for Folder " B."

TABLE TYPE, 14" bell mouth with independent receiver, from £5 2s. 6d.

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The WESTON

Model 280 VOLT-AMMETER

Triple Range. 150/15/3 volts. 15/1·5/0·15 amps.

This Precision Instrument is especially suitable for Wireless Research Work, *i.e.*
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"Castaphone" apparatus is not designed to compete with cheap sets which must be unsatisfactory in use; they represent a standard in design and workmanship, giving results that cannot be bettered.

Write for full particulars, gratis. Illustrated List of Broadcast and General Apparatus, post free, 4d.

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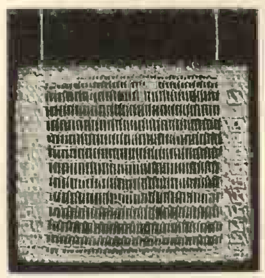
Manufacturer of Distinctive Wireless Apparatus,
BRAINTREE, ESSEX.

ASBESTOS RESISTANCE MATS

For

ACCUMULATOR CHARGING

Price : 2/6 each post extra.



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CHARGE YOUR ACCUMULATORS AT HOME by inserting one or more of our Resistance Mats in your lighting circuit.

See illustrated descriptive article, page 31, February issue of MODERN WIRELESS.

For ratings of mats required for any particular case, write us stating :

Voltage of supply (direct current).

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BURLINGTON HALL
BURLINGTON ST., MANCHESTER.

17th—24th MARCH
(Saturday to Saturday inclusive)

Organised at the request of the *Manchester Wireless Traders Association*. The Convention will be held under the auspices of the *Manchester Wireless Society*.

Applications for Stands are now being dealt with in strict rotation by the organisers.

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with its adjustable receivers which fit closely to the ears without disarranging the hair.

Earcaps instantly removable if two persons wish to listen-in on one pair. Cases are of polished aluminium; leather-covered headbands, best Tungsten steel magnets wound to 4,000 ohms; four feet of twin flexible cord with ends, giving free movement to the listener-in. FULLY TESTED AND GUARANTEED.

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Send at once for our

COMPLETE CRYSTAL SET

Carriage 47/6 paid.

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Price: 2,000 ohms, £6 2 6 each.
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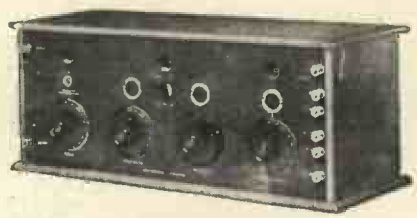
ASHLEY 3-VALVE RECEIVING SET



Embodies REACTION and unlimited wavelength, the most efficient combination, comprising two high-frequency amplifying valves and one detector valve. Simplified and easily manipulated controls. High-grade finish and readily accessible interior. Includes a set of interchangeable aerial tuning and H.F. Transformer Coils. Will receive on all wavelengths up to 3,000 metres. Price £27. (Valves, Batteries, and Phones extra.)

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Ready March 1st.

Get a copy of this and build your own Set.

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Not only are full details given for building these Instruments at little cost, but chapters are also devoted to the construction and erection of Aerials, the elementary theory of Wireless and the operation of Receiving Sets.

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