Editorial

THREE years ago a band of enthusiastic wireless experimenters were anxiously making preliminary preparations for the first Transatlantic amateur wireless test. A month or two later the first tests were conducted, but although numerous entrants strained every nerve to receive signals, no success was obtained. Twelve months later a second attempt was made, this time the Americans sending one of their foremost receiver experts to this country for the purpose of listening-in. The American, Mr Paul Godley, and a number of British amateurs successfully received amateur transmissions from the other side and learned a great deal about short-wave reception in the process. Last year the tests were once more repeated and, benefiting by the experience of previous years, both British and French experimenters were astoundingly successful. During the best hours signals came in so thick and fast that it was impossible to make records of them all, so that we know for certain that any good American amateur transmitting station has now an excellent chance of getting its signals across to us when conditions are favourable.

On several occasions since the test American amateur signals have been received in the ordinary course of evening working. Owing to the difference in time between the two countries, 3 a.m. in England corresponds with 10 p.m. in the United States. It is very little use listening for American amateurs before this hour, as by agreement amongst themselves they shut down during broadcasting hours and only open up at 10 p.m.

This winter should see further great achievements, and we have no doubt that numerous cases will be recorded of the successful reception of American amateur *telephony*. One or two cases of such reception are on record, but owing to the far smaller range of telephony than telegraphy with the same power, such reception is far more difficult and taxes to the utmost the high-frequency amplification in the receiving set.

This year we have several new circuits and receivers to try on Transatlantic reception; the Neutrodyne, for example, which many amateurs have been trying during the last few months. Again, one may expect achievements with reflex circuits and super-regenerative sets.

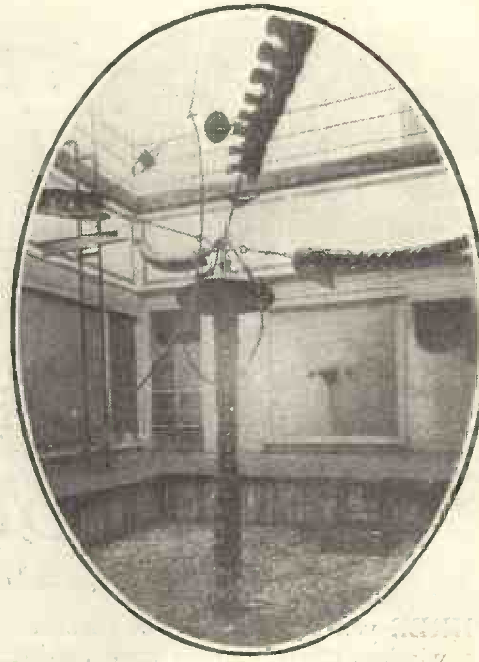
There are really two kinds of Transatlantic reception which can be attempted by the experimenter. Firstly, we can attempt the reception of Transatlantic broadcasting on wave-lengths between 360 and 400 metres or so. Secondly, there is the reception of amateur transmissions on 200 metres and below. Of these two the latter is far more difficult. This is due to the fact that satisfactory high-frequency amplification on short waves is exceedingly difficult and the difficulty rapidly increases as the wave-length is reduced.

It is in the improvement and development of high-frequency amplification on short waves that we should see the best possible technical results from these annual Transatlantic tests.

A VISIT TO THE EIFFEL TOWER WIRELESS STATION

Interesting facts about the spark, arc and valve equipment.

Of the thousands of amateurs who regularly listen-in to the Eiffel Tower concerts, probably few have ever given any thought to the large amount of machinery and apparatus which is involved in such a high-power wireless station. Many difficulties are experienced in the maintenance of a regular service of transmissions including commercial messages, concerts, and time signals, and the efficiency which has been secured is due in large measure to the well-organised staff of the station and to the foresight which has been exercised in the provision of alternative apparatus in case of breakdown.



Chains of insulators and lead-in at the Eiffel Tower station.

The Electrical Machinery

There are several different sources of electric current available for the Eiffel Tower Station. The State Railway System supplies 5,000 volt 3-phase current whilst the electric supply system of the Left Bank of the Seine provides single-phase current with a periodicity of 42. A dynamo located in the basement of the Tower is driven by a Diesel engine of 450 h.p. and provides direct current at 110 volts, this unit being entirely independent of any external electric supply system.

Compressed air reservoirs are installed in the power house and are supplied by means of a compresser driven by a synchronous motor single-phase 220 volts 42 periods. The compressed air from these cylinders is used in connection with the transmitting apparatus, as will be further described presently. The arcs are supplied from a direct current 1,200 volt generator driven by a 3-phase 5,000 volt motor.

In addition to the above there is a 3-phase 500 volt motor driving two generators; the first generator is a 1,500 volt 180 ampere machine, which may be used as an alternative in connection with the arc apparatus, whilst the second is a 110 volt 2,000 ampere machine which can, if necessary, be used as a motor, driven by the 110 volt direct current furnished by the Diesel unit and driving the 1,500 volt dynamo.

Another group of machines includes a d.c. 110 volt 2,000 ampere motor driving an a.c. generator 220 volt 24 periods, and a Bethenod alternator which can also be used as an auxiliary in the maintenance of the spark apparatus. The alternator supplies the apparatus connected with the electric supply system of the Left Bank of the Seine at 220 volts and in particular the valve set and the high-frequency alternator set, both of which are equipped for this particular supply.

Finally there is a large alternator 1,500 periodicity (known to the engineers as "Nenesse") which supplies the spark transmitter. In case of a breakdown in the 5,000 volt supply, the spark and the arc transmissions can be carried on with the Bethenod alternator and the 1,500 volt dynamo, their motors being driven by the d.c. current from the Diesel machine. The valve set and the high-frequency alternator set are supplied by the 220 volt 42 period alternator driven by the d.c. current from the Diesel generator set.

There are in addition two small groups of high-frequency alternators which seem microscopic in comparison with those which we have just described. Until recently the station possessed only the small high-frequency alternator, the successful trials of which amateurs have already heard; the power in the aerial during the trials was 10 kw. Recently, however, a second alternator has been added and the new arrangement is in process of trial.

The current for the first was supplied by a converter consisting of 220 volt 42 period motor and 220 volt dynamo. The alternator

Above: The machine room and auxiliary spark of the spark transmitter.

Below: The Creed signalling switch and aerial loading coil.

The main spark gap showing large pipe on right supplying compressed air.

was driven by a motor of 220 volts rotating at 6,000 revolutions per minute, the frequency at this speed being 30,000 periods. The second alternator will be supplied from the same converter, but will have two driving motors instead of one.

The alternator was regulated by the Brown-Boveri system, but this has not been found satisfactory and the two machines will in future be controlled by a Thury centrifugal regulator. The control platform is adjacent to the machines which can be operated by hand rheostats.

The item which next attracts attention is an enormous coil of copper tubing; when in operation this produces such an intense field that an electric shock is experienced on touching any piece of metal in the neighbourhood. Vacuum tubes (a neon tube for example) placed anywhere near the coil were brilliantly lighted up. This coil is the one which is used in connection with the arc transmission for commercial traffic and for the work of the Central Radio Telegraphic Bureau.

The transmission is effected by an Elwell arc working in an atmosphere of coal-gas and quenched by a powerful magnetic field created by the current of the arc itself.

For several years attempts have been made to increase the output of the arc at 1,500 volts, but this has been found unsatisfactory in

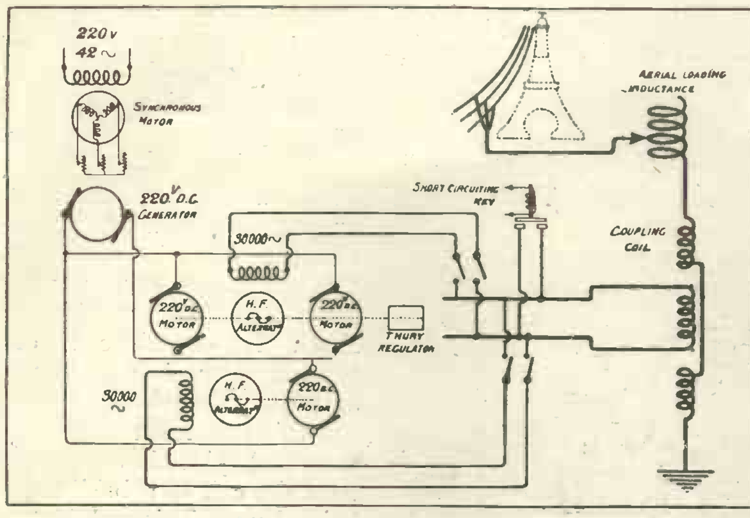
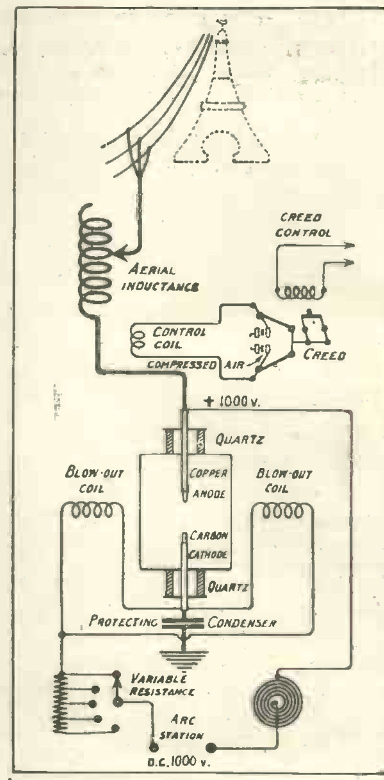


Diagram showing connections of the high-frequency alternator transmitter.

The Operating Room

The first thing to be observed in the operating room is a network of wires and coils in the midst of which is the valve set and a series of small mercury turbines mounted on a marble slab; the latter are used in the control of the spark transmission. The old spark transmitting apparatus has now disappeared to make room for the various machines associated with the valve set. A musical spark is employed, this being very suitable for reception by the simpler sets and for the transmission of time signals.

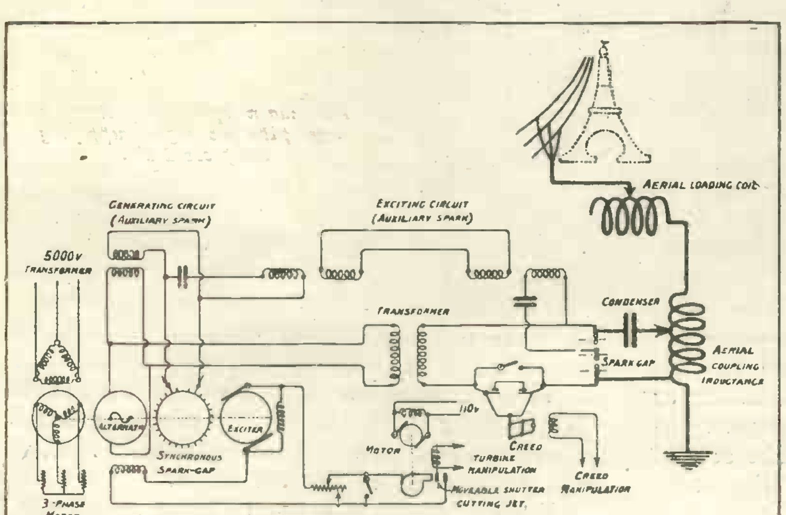
This transmission still interferes with the concerts. It is necessary, however, to send time signals on spark, for the benefit of the various French boats which cannot receive C.W.



The arc transmitter circuit.

practice and the attempts have now been abandoned. An identical auxiliary arc is placed side by side with the first one. At the time of our visit this was in course of being cleaned, and the engineers, black with carbon dust, looked more like engine-drivers than radio engineers. Wireless initiates one into a variety of trades! Far from complaining, however, they merely remarked that it was "all in the cause of wireless."

Transmission is carried out in the usual way by changing the wave-length, for which purpose the coil coupled to the aerial coil is short circuited, the short circuit being made by a Creed relay operated by compressed air and controlled by electromagnetic relays. Compressed air is also used for extinguishing the spark between the contacts of the Creed relay.



The spark transmitting arrangements.

The installation is of the usual type; alternating current is fed into the primary of a transformer, the secondary being connected to condensers which, with the spark gap of the primary coil of the Oudin transformer, form the primary oscillatory circuit.

This transmission system is supplied, as already mentioned, by an alternator of 1,500 periodicity or by the Bethenod alternator. The latter works on resonance, and it is necessary to use the appropriate transformer with each alternator.

The operation depends upon the regulation of the circuits so that the spark only occurs when the exciting current reaches a certain value or alternatively upon the opening of the high-tension condenser circuit. The first is accomplished by the cutting of a mercury jet in the mercury turbine, carbon contacts being actuated by an electromagnet. The second system, due to M. Laut, permits of great rapidity in the manipulation and is the most reliable. With Creed relays of the same type as those used for the arcs it works very satisfactorily.

The layout of the apparatus is obviously very extensive, but this does not present any difficulty owing to the employment of compressed air operation. The contacts, like the arcs, are quenched by means of jets of compressed air.

The spark gap employed in the ordinary service has three electrodes which are capable of rotation about parallel axes, the central one only having a uniform movement. The two lateral ones, owing to the difficulty of connecting them to the other parts of the oscillatory circuit, do not turn completely round, but are capable of partial rotation and are connected by flexible strips of plaited copper wire. The subsidiary spark gap is of the automatic eccentric cone type. Both spark-gaps are quenched by compressed air jets.

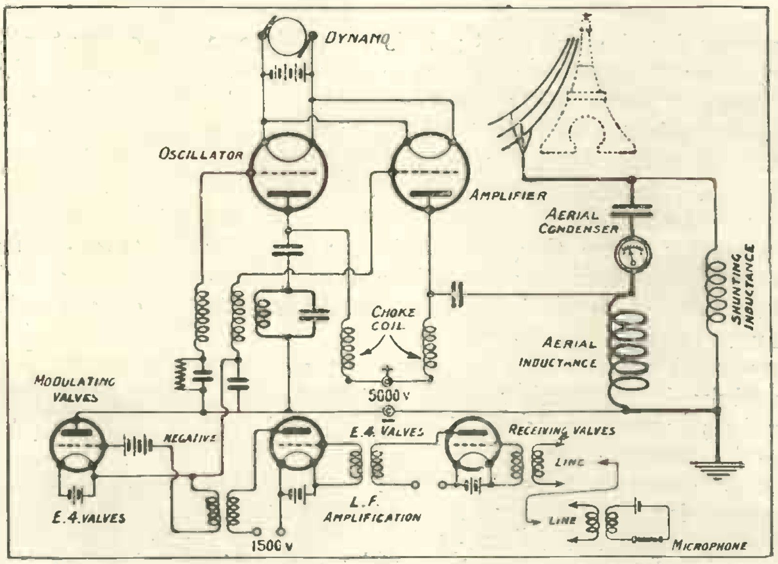
The purity of the note of the spark has been obtained by the aid of the auxiliary spark, which has a higher frequency than that of the principal spark and acts as a means of adjustment.

This system requires that the speed of the alternator shall be kept constant; unfortunately the 3-phase 5,000 volt supply often varies by as much as 300 volts, with corresponding variations in the speed of the alternator.

The start up of the transmission is quite impressive. The engineer who has charge of the synchronising ("l'homme synchrone" as he is called) is endeavouring to secure the proper adjustment of the auxiliary spark; in the high-tension room the rotary spark gap is coming into operation, and amid a roar like thunder the transmission begins.

The Valve Apparatus

The problem of the production of the necessary high voltage for the valve apparatus has been solved by the use of a synchronous converter, and the excellent concerts from

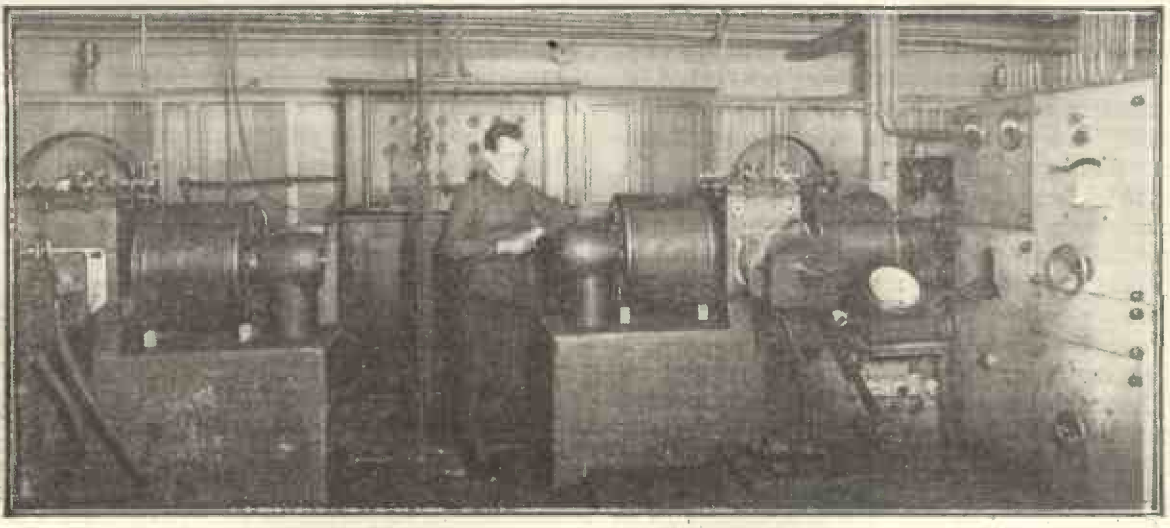


Circuit of valve transmitter.

1922 onwards have been operated in this way on a mechanically converted current at 42 periodicity. Great hopes are entertained of the results of introducing the 5,000 volt 10 kw. machine.

The 5 kw. valve after various delays is at last a reality, and if amateurs do not get very powerful reception, they must console themselves with the reflection that in a short time further amplification will be available and in the near future the station will be able to transmit telephony on 8 kw.

The old 25 h.p. synchronous motor which served to ventilate the gap of the spark apparatus has now been employed for supplying



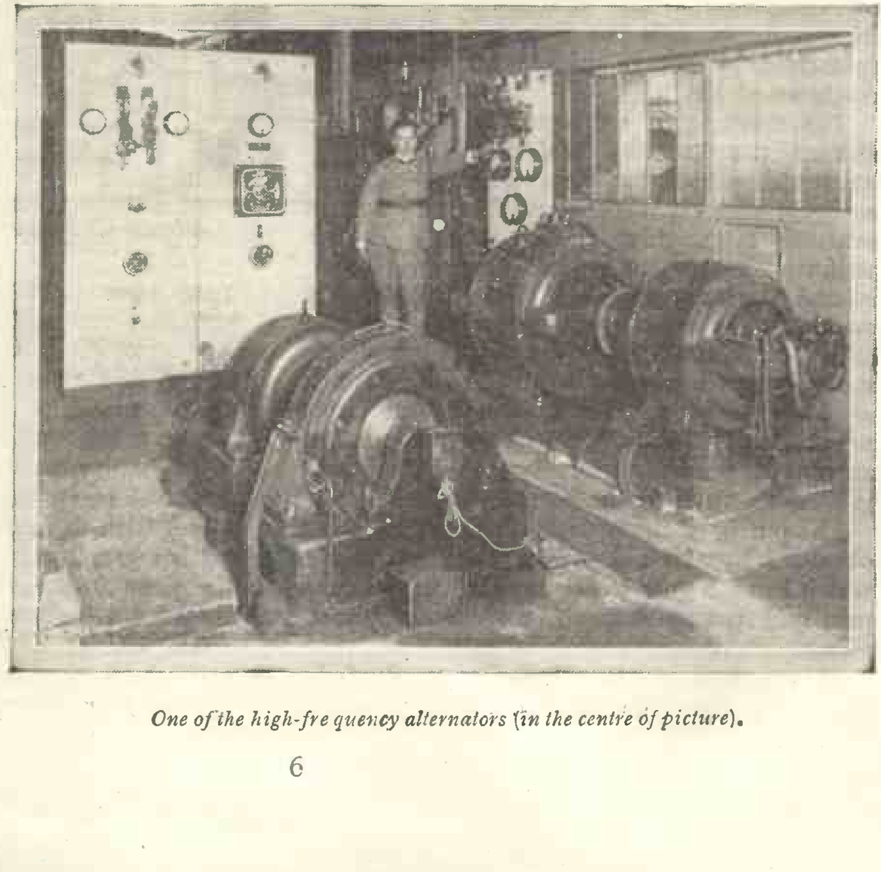
The two Elwell arcs.

energy for the valve set; it is coupled to a 5,000-volt generator and also to a low-tension generator for heating the filaments.

The valves which were originally used have now been discarded for the following reasons. In order to utilise the whole of the emission it was desirable to employ 5,000 volts from the generator, since the current from the latter was limited to 2 amperes. The valves, however, were designed for 3,000 volts and did not function properly at 5,000. Furthermore an unduly large number of valves were necessary and consequently very large currents were required for the heating of the filaments. Two machines had to be employed in parallel and a special machine was ordered for the purpose. Now, however, special valves have been adopted working on 5,000 volts and with 20 volts applied to the filaments.

Layout of the Apparatus

The apparatus includes a microphone mounted in the usual way, the current from which goes by telephone line to the station at the North Pilier. The telephone current passes into the primary of a transformer which operates the grids of two receiving valves mounted in parallel and forming a speech amplifier. In the anode circuit of these valves is a transformer which operates the grids of two E 4 valves in parallel, the anode potential being 700 volts. A further transformer controls the grids of a number of E 4 valves depending upon the number of transmitting valves, and arranged on the



One of the high-frequency alternators (in the centre of picture).

Beauvois system. The variable resistance thus constituted is shunted across the transmitting valves. These valves give 1.5 to 2.5 kw. in the aerial with an efficiency of 75 per cent.

The anode voltage of the E 4 valves is developed by a dynamo of 1,500 volts, 900 watts driven by a 110-volt motor. Trials are in progress with a view to ascertaining the most efficient arrangement of valves, and amateurs will be interested to listen-in to the trials.

The High-Tension Room

The high-tension room is at once recognisable by the strong smell of ozone. In this room are located some large transformers, the spark-gap and also a small experimental valve set. The latter operates a comparatively short aerial extended from one of the lower parts of the Tower. The signals transmitted from this aerial, in spite of the proximity of the large arc-operated aerial, are heard quite well throughout the whole of France, using a power of only a few hundred watts.

When higher-power transmitting valves are used to enable the power to be raised to some tens of kilowatts, telephony from the Eiffel Tower Station, which has already reached as far as New York, should be heard over the entire world.

REGULAR PROGRAMMES FROM BRITISH AND FRENCH BROADCASTING STATIONS

(*Times in Greenwich Mean Time.*)

GREAT BRITAIN.

Station.	Call Sign.	Wave-length.	*Times.*
Cardiff ...	5 WA	353	3.30 to 4.30 p.m. (except London) and 5.0 p.m. to 10.30 p.m. London (day transmission) 11.30 a.m. to 12.30 p.m. *Sundays.* 8.30 to 10.30 p.m. London also 3.0 p.m. to 5.0 p.m.
London ...	2 LO	369	
Manchester ...	2 ZY	385	
Newcastle ...	5 NO	400	
Glasgow ...	5 SC	415	
Birmingham	5 IT	425	

Silent Periods.

Cardiff ...	8.0 to 8.30 p.m.
London ...	7.15 to 7.45 p.m.
Manchester ...	7.45 to 8.15 p.m.
Newcastle ...	9.0 to 9.30 p.m.
Glasgow ...	9.0 to 9.30 p.m.
Birmingham	8.0 to 8.45 p.m.

FRANCE.

PARIS, EIFFEL TOWER. (FL, 2,600 metres.)

Weekdays (daily).

6.40 a.m. Meteorological forecast.
11.15 a.m. Meteor. forecast and time giving.
2.30 p.m. Financial bulletin.
5.10 p.m. Concert.
6.20 p.m. Meteor. forecast.
10 15 p.m. Meteor. forecast.

Sundays.

5.10 p.m. Concert.
6.20 p.m. Meteor. forecast.

Other concerts specially announced from time to time.

PARIS, RADIOLA. (1780 metres.)

Weekdays (daily).

11.30 a m. Information (Cotton Exchange, Havre, Liverpool, Alexandria).
11.40 a.m. Concert.
4.0 p.m. Commercial information.
4.10 p.m. Financial information.
4.20 p.m. Concert.
7.45 p.m. News.
8.0 p.m. till 9.0 p.m. Concert.
Thursday, 8.45 p.m. till 9.30 p.m. Dancing concert.

Sundays.

1.0 p.m. till 2.0 p.m. Concert.
7.45 p.m. News.
8.0 p.m. till 8.45 p.m. Concert.
8.45 p.m. till 9.30 p.m. Dancing concert.

PARIS. SCHOOL OF POST AND TELEGRAPHS. (450 metres.)

Tuesday and Thursday.

7.30 p.m. Concert.

And very frequent radiophone transmissions of plays (comic operas).

LYONS. YN, 3,100 metres.

9.45 a.m. Concert (gramophone).
2.35 p.m. Financial news.

THE "OLD FOLKS'" RECEIVER

A Loud-Speaker Set with Single Control

By PERCY W. HARRIS, Assistant Editor.

Many readers have asked for an ultra-simple loud-speaker set with "one-handle" control. This receiver complies with their requirements and in addition is very sharply tuned to avoid interference.

BROADCASTING, whatever else it has done, has already proved a priceless boon to the old folks at home. These people, fully as appreciative of music as the younger generation, are often confined to their homes through infirmity or illness, and if we can provide them with a good reliable wireless receiving set, requiring the minimum of attention, we shall undoubtedly gain their gratitude.

Let us consider in detail for a few moments the kind of set which would prove most suitable in the circumstances. Firstly, we must have clarity and distinctness, with a volume rather greater than would otherwise be required, for elderly people frequently suffer from deafness. Secondly, we must have the simplest possible control, which means, in effect, that the turning of a single dial must be all required to bring in the station. Thirdly, the set must be as robust as possible, with no projections which might catch dust or easily be broken. Fourthly, it must be very economical of current from an accumulator, as it will be a troublesome matter to get the accumulator re-charged very often.

Now, in the present state of the art, to attain such simplicity we must needs sacrifice sensitiveness in the reception of distant broadcasting. If we are content to receive one station only and that the nearest, we can in most cases dispense with high-frequency amplification (which almost inevitably necessitates skilled handling to get the best results) and simply use a detector followed by two stages of note magnification. The simplest form of detector is, of course, the crystal, but no one who is used to handling crystals will disagree with me when I say they are not the best detectors for people who are not quite so delicate of touch as they used to be. A valve detector is far easier to handle, and even if used without reaction (as we must do if we wish to avoid re-radiation) will give better results than the best crystal. A detector valve, then, followed by two stages of note magnification, will give sufficient volume for a loud speaker anywhere up to 10 or 15 miles from the broadcasting station, and as many thousands of potential listeners-in are situated within this distance, we may reasonably expect that the set to be described will meet the wants of many.

It is a very simple matter to design a three-valve set consisting of a detector followed by two magni-

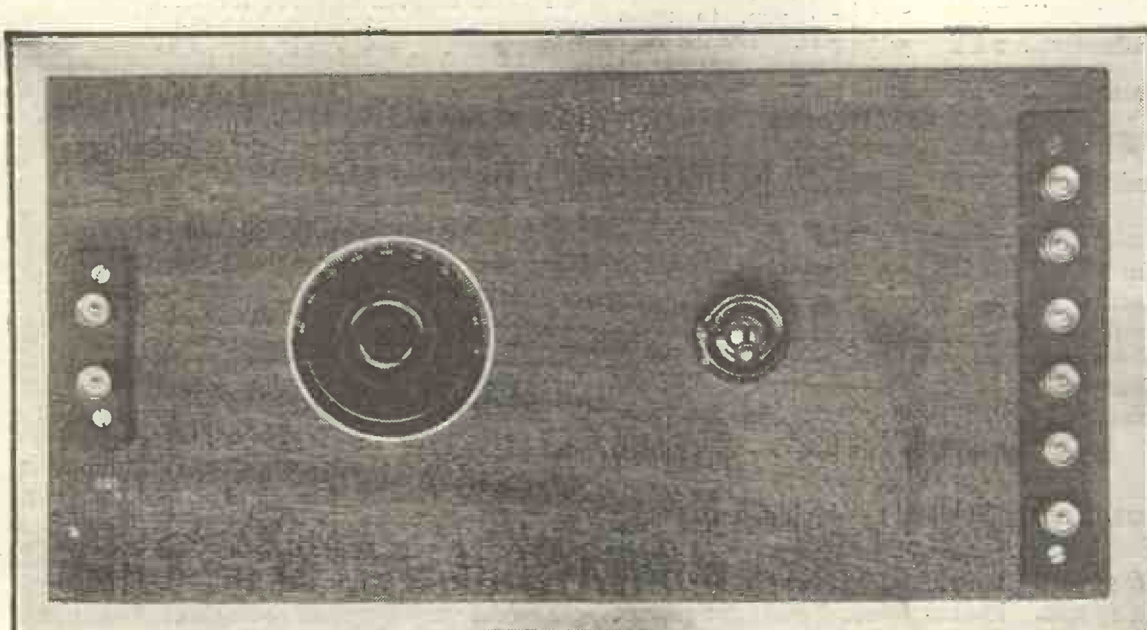


Fig. 1.—One dial to turn and a tumbler switch to turn on all filaments. What could be simpler? The terminals on the left are for aerial and earth, while those on the right (reading from the top) are: L.T. positive, L.T. negative, H.T. positive, H.T. negative and telephones.

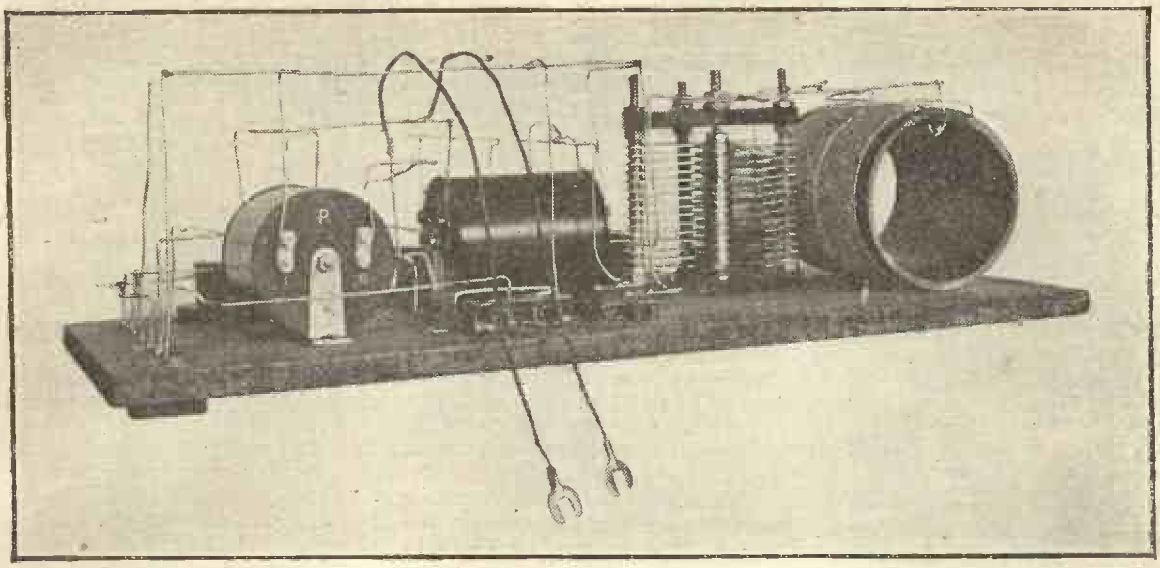


Fig. 2.—The back of the panel carries all the component parts. The only ebonite needed is the two terminal strips.

fying valves, and I should not think it worth while describing the present set if it were not for one or two novel features I have introduced into it, and which, I think, will appeal to many readers of MODERN WIRELESS. First of all, I am using a method of tuning which is practically unknown in this country and indeed very little used as yet in the United States, where, I believe, it originated. I have already described in *Wireless Weekly* a crystal set utilising this principle and I am giving in this article detailed instructions for the construction of a simple valve set on the same lines.

Briefly, the principle consists of having an untuned aerial circuit and a tuned closed circuit coupled to the aerial circuit with a fixed coupling so proportioned as to give the effect of a loose coupler, but with the simplicity of the ordinary direct coupled instrument with its single dial control of tuning. The circuit diagram on page 11 shows the instrument in its simplest form. The aerial coil used for coupling purposes consists merely of 8 turns of No. 22 double cotton covered wire and the inductance of the closed circuit, which is tuned by a variable condenser of .0005 μF capacity, consists of 80 turns of the same gauge wire wound on a 3-in. former. Examination of the photographs and diagram will show that the aerial coil is wound directly on top of the closed-circuit inductance and these few turns in the aerial are all that is required to pass the energy from the open to the closed circuit. An aerial with so few turns in series with it seems to work practically as if it were aperiodic, that is to say, having no particular tune of its own.

If slightly better signal strength, with less sharp tuning, is desired the number of turns of aerial may be increased up to about fifteen or sixteen.

The wave-length range of the present set is from 250 metres to 700 metres, which is quite good considering only a .0005 microfarad condenser is used.

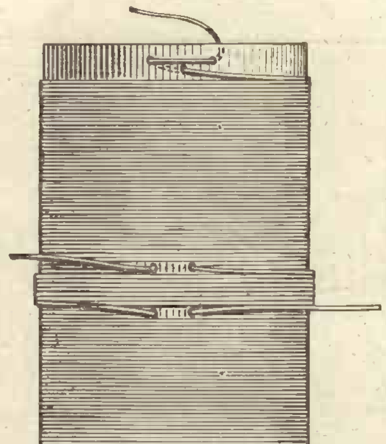


Fig. 3.—The coil, showing method of winding.

In previous sets I have endeavoured to reduce the expenditure on ebonite to a minimum, and I believe in the present set I have gone farther in this direction than in any previous article. The whole of the apparatus is mounted on a single wooden panel measuring 16 in. × 8 in. The only ebonite needed is two strips measuring 1 in. wide, 3 in. and 7 in. long respectively. The former on which the coil is wound is of waxed cardboard of the kind purchasable from any wireless dealer. The panel is set upright on the front of a cabinet and the front carries the knob and dial of the tuning condenser and a single tumbler switch for switching the whole set on and off. These are the only parts which show on the front and are the only portions which it is needed to manipulate to tune in to the station required. No filament resistance is used, as the set is designed to work with a 4-volt accumulator for ordinary valves or a 2-volt accumulator for dull-emitters. If desired, a filament resistance can be inserted where shown on the circuit diagram enabling a 6-volt battery to be used.

A characteristic of the method of aerial coupling described above is that whatever wave-length to which the closed circuit is tuned,

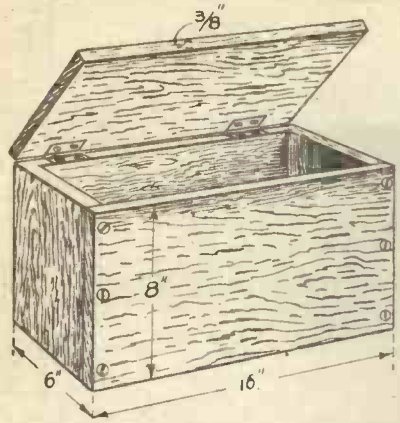


Fig. 4 How to make the cabinet. The front panel carries the component parts.

the calibration is not affected in any way by changes in the aerial. This means in practice that we can calibrate the set on our own aerial and make a note that, say, London can be tuned in on, perhaps, 43 deg. on the scale. When this set is taken away and connected to quite a different aerial 2 LO will still be found at the same position of the tuning condenser. This point will, I am sure, be appreciated by many readers who wish to send the set to their "people" in the country.

As no filament resistance is used and we cannot get the desirable negative bias on the grids of the note magnifying valves by the usual expedient of connecting the I.S terminals to the battery side of the filament resistances, it has been found desirable to connect the leads from the I.S. side of the transformers to the negative terminal of a 2 cell flashlight battery, the positive of which is connected to the negative filament lead. This battery is placed within the box and connected with flexible leads, so that these can be disconnected when it is desired to change the battery. A Mansbridge condenser of .3 μF is shunted across the high-tension battery and the whole of the wiring is carried out by means of tinned copper wire, which looks neat, is efficient and obviates the use of systoflex or other insulating tubing.

The valves themselves, it will be seen, are hidden away inside the box, where they are not likely to come to any harm. The valve sockets are of the flanged type and the projecting pins on the under side have been cut off practically flush with the flange. A slight depression is cut out of the panel underneath each of these sockets and wires are soldered to the pins before the sockets are screwed in place.

The components required for making this set are as follows :—

Cardboard tube, 4½ in. long by 3 in. in diameter.

A quantity of No. 22 d.c.c. wire.

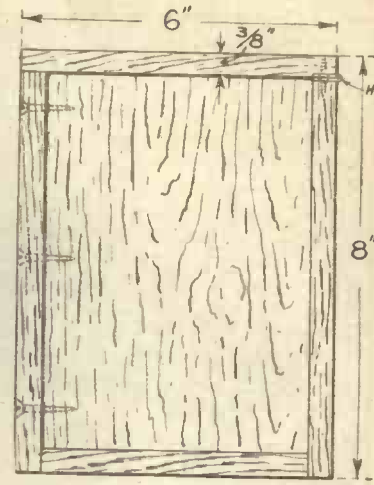


Fig. 5, Side view of cabinet.

8 terminals.

1 tumbler switch (of the kind used for mounting on the dashboards of motor-cars, for switching headlights on and off).

1 grid condenser (.0003 μF) and leak with clips (2 megohms). The Dubilier or other types in which the leak are clipped to the condenser is quite suitable.

2 intervalve transformers.

3 valve sockets of the flange type.

1 .002 fixed condenser.

1 variable condenser, .0005 μF capacity.

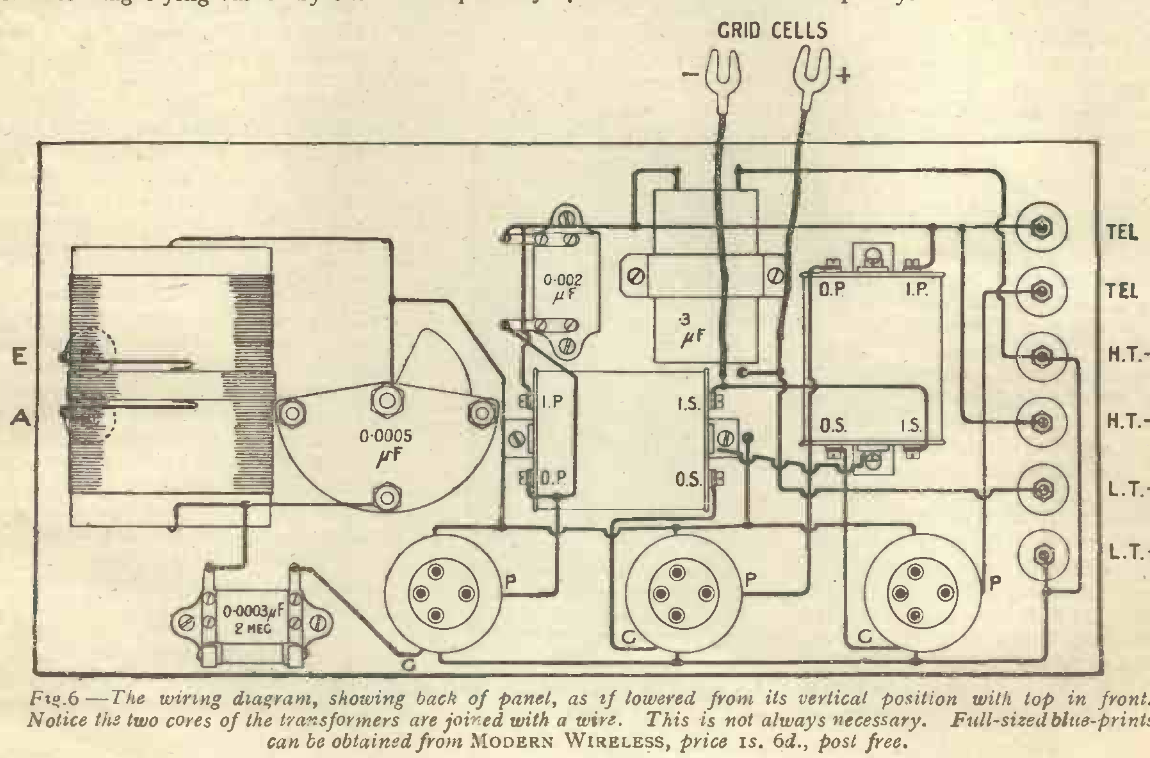


Fig. 6.—The wiring diagram, showing back of panel, as if lowered from its vertical position with top in front. Notice the two cores of the transformers are joined with a wire. This is not always necessary. Full-sized blue-prints can be obtained from MODERN WIRELESS, *price 1s. 6d., post free.*

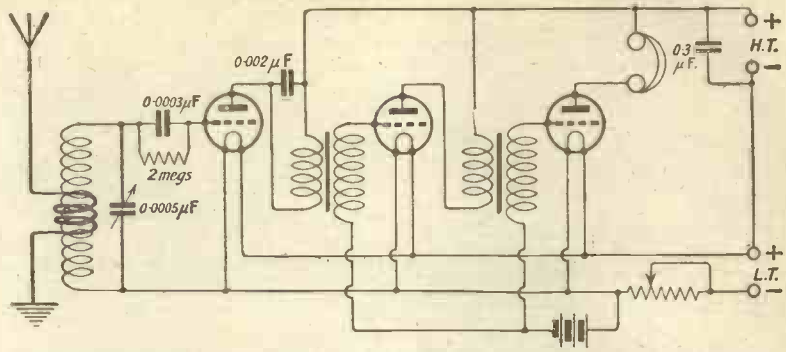


Fig. 7—Theoretical diagram. In this a filament resistance is inserted to show where it may be placed if desired, but with a 4-volt battery for "bright emitters" and a 2-volt for dull emitters it is not needed.

1 wooden box with hinged lid.
2 ebonite strips 1 in. wide and ½ in. thick. One strip to be 7 in. long and the other 3 in. long.

The front of the box should be detachable, as it forms the panel on which the parts are mounted.

The first step should be to make the cabinet or purchase it ready made. Three-eighth inch planed mahogany is very suitable for this box, and I have used this wood myself. If you are making the box, yourself you should first of all cut the front panel and smooth its surface with sand or emery paper, making quite sure that the edges are square. When this is done drill a hole for the condenser spindle and holes for the leads of the tumbler switch. Next take a ½ in. bit in a brace and drill 6 holes at one end and two at the other at positions marked, so that there may be a clearance round the shanks and nuts of the terminals, which will be mounted on the ebonite strips. These are practically the only holes which will need to be cut through the panel, and it is advisable to make them before we go on to the finishing of the woodwork, which can be carried out with stain and varnish. Next lay the panel face downwards and mount the various components in place in the manner shown, using wood screws of the correct size and of a length sufficient to afford a good hold, but not long enough to go right through the panel to the front. You will not be able to use wood screws for the variable condeuser and in this case the best method will be to bore two holes in the panel and secure the condenser by passing two long 4 B.A. metal screws through the holes into the top plate of the condenser, securing them by nuts. The coil is secured by boring two holes in the ends of the former and passing wood screws through them into the panel itself. Alternatively, metal screws can be passed through the panel from the front and the coil secured by lock nuts.

Before mounting the three valve sockets, it will be necessary to saw off the projecting pins flush with the underside and tin them with your soldering iron. You should then solder 3 or 4 in. lengths of wire to each of the pins and bend them so that they pass along the slots. These wires can be cut to the correct length during wiring-up. Now turn the sockets over and screw them into position with wood screws through the three holes on each.

The rest of the constructional work will be quite evident from inspection of the photographs and diagrams. It is well worth while to spend some time in bending the wires neatly, as this will add considerably to the appearance of the set.

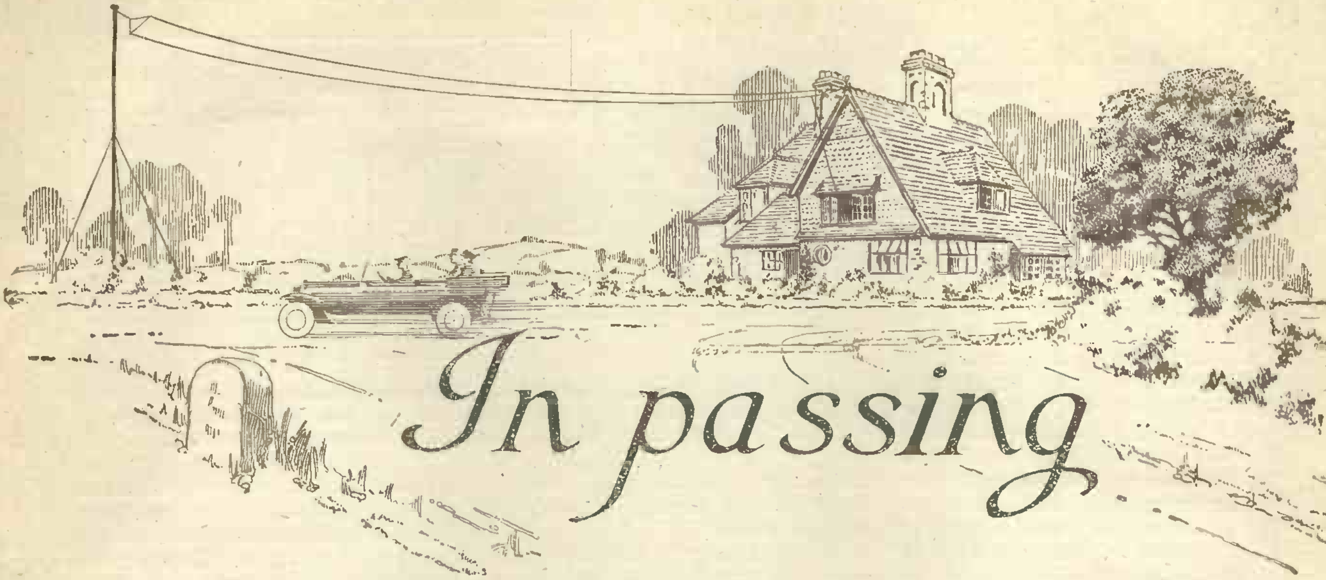
The Mansbridge condenser is best secured by a strip of brass as shown, two long wood screws passing through the holes in the end of the strip. It will be noticed that short flexible leads are attached to the common joining point of the two leads from the I.S. sides of the transformers and the negative filament busbar. These flexible leads are attached to a two-cell flash-lamp battery, which should be stood inside the cabinet.

This battery should last at least a year without renewal, as very little current is taken from it. The wire used for wiring-up is No. 18 gauge tinned copper, obtainable from any wireless dealer. Either round or square section can be used, the square section wire looking slightly neater, although it is a little more difficult to handle.

Wiring up is best done with a soldering iron handy, so that the stiff lengths of wire can be soldered one to another as cut off. If this form of wiring is too difficult for the beginner the more usual method with thinner wire and systoflex tubing can be used.

Operation.

All you need do to tune to a station is to connect up the batteries, aerial, earth and loudspeaker or telephones, switch on and turn the dial until you hear the station wanted. If you want to use a number of pairs of telephones, simply connect them in series (chain formation) and join the two ends of the chain to the telephone terminals. The tuning of this set will be found very sharp, and as there is a detector valve, which is not preceded by a high-frequency stage, it is unlikely that more than one broadcasting stations will be heard. The nearest station, however, should come in at good strength on a loud speaker up to ten or fifteen miles, and should be clearly audible in the telephones for much greater distances. High-resistance telephones should be used and the voltage of the accumulator should be 2 volts for dull-emitter valves and 4 for the ordinary type. I recommend the use of an accumulator to run this set with dull-emitters, as the current consumption of three valves is somewhat too large to take from dry cells. However, the accumulator will last as long with three dull-emitters as it would with a single valve of the bright-emitter type. The voltage of a high-tension battery should be 50 to 75. Once the best adjustment is found on the tuning condenser, careful note should be made of it, for this will be the reading with any aerial. I do not claim that the set can compete with many other more complicated three-valve sets, but it is the simplest I have been able to find to comply with the requirements mentioned at the beginning of my article and can be confidently recommended as simple, safe and reliable. I shall be very glad to hear from those readers who make up this set as to the results they are getting, so that I can advise others in similar parts of the country who may ask what the results are like.



In passing

The Longbow

"Oh, grant that I may catch a fish
So big that even I
When telling of it afterwards
May have no need to lie."

Such was the prayer of the pious angler who never lied except in self defence. Anglers and radiators have much in common. Both really do achieve something, and there is a substratum of the purest truth beneath all their tallest tales. Fish have the uncanny property of putting on weight posthumously to an enormous extent. Similarly, signals from very distant stations grow louder and louder for weeks and even months after they have been received. The still small voice that took all your ear power to catch it is transformed with the passing of time into a deafening roar "clearly audible twenty feet away with the 'phones on the table."

"With the 'phones on the table" is the radiator's pet phrase. As you are listening to his flow of speech you know that it will fall from his lips ere long, and when it does it hall-marks him even as the lion hall-marks silver. My friend Busby affirms that the radiator is readily recognisable at sight by the cut of his jib, or rather by the set of his ears. Other men, such as you or I, who drink in our receptions in the orthodox way, have ears that nestle coyly against our hair, their cumbrance having been chastened by the gentle pressure of the 'phones. But those of the radioliar, knowing no such restraining influence, stand out from his cranium so widely that on windy days you may positively hear them flapping.

Those Stock Phrases

But the radioliar is not the only one who makes use of stock phrases. If you want to hear them *ad nauseam* tune in to the amateurs on a Sabbath morn or on any evening after the broadcasting stations have ceased to monopolise the ether. The first thing that will strike you is the friendship, the brotherliness, that exists between them. Any amateur who is talking to any other calls him "Old man" at least once in every ten seconds. Even if two transmitters have adopted the same wave-length and a dispute breaks forth as to who has the prior right to it, the wranglers still dub one another old man with machine-like regularity, though their tones are becoming more and more charged with acerbity.

The conversations are vastly entertaining at times, but as a rule they consist of two phrases repeated many times with slight variations in the manner of some of the earlier musical composers.

"Hello! Yes, I got you all right, but . . ." is the first. The second refers to the overdoing or underdoing (if there be such a word) of the modulation. And so it goes on. If any amateur transmitter will strike out a new line in criticism with some brand new phrases he may be assured that he will have a large audience whenever he casts abroad his words of wisdom.

A Blind Spot in Wales

I mentioned last month that I was bound for a remote part of Wales that was reported to be a "blind spot." Experiments with my own set and with those of residents in various parts of the valley show that it is, but in a very curious way. Though we are two hundred miles from London and but four score from Cardiff as the crow flies—or perhaps when dealing with broadcasting one should say as the cry flows—2LO is still the big noise when he is on his best behaviour. There are times, however, when after the manner of a whistling rocket he rises to maxmium loudness with a rush and then falls off into silence, the process being repeated every twenty seconds or so. Cardiff is very hard indeed to get even with two H.F. stages, both Newcastle and Glasgow coming in with greater strength. Atmospherics are worse here than I have ever known them at home, though there has been no thunder nor even any sign of it. Those who dwell in the district tell me that it is ever so. I am inclined to think that they are not genuine X's at all, but are produced by the power stations possessed by many of the small communities in the valley whose juice is conveyed about the streets by means of overhead wires suspended from high iron masts.

Disillusionment

Wireless does not seem yet to have obtained the popularity in Wales that it has achieved in England. At first I thought that all Sassenach records had been eclipsed by the Principality, for as we ran into Cardiff it seemed that there was no house that had not its aerial. Rather low, they seemed, with the free ends supported by peculiarly stout masts. Still there was such a forest of them as would put even the London suburbs to very shame. Close investigation revealed the fact that their use was not to snatch music from the ether, but to suspend shirts, socks and intimate garments that no mere man can mention without reddening cheeks. They were, in fact, not aerials at all, but clothes-lines of a very lofty kind, made in all respects like aerials, even to the pulley block and halliards.

My discovery unmanned me for the moment, and I nearly burst into scalding tears at the thought that so noble a design should be put to such base uses. However, calling up my iron self-control I refrained, for is there not a silver lining to this apparently coal-black cloud? Consolation came with the thought that when Wales is visited with a genuine epidemic of radiomaniacs the addition of a couple of insulators and the substitution, where necessary, of wire for rope will enable all and sundry to beat their clothes-lines into aerials, though they may still use them on Monday for displays which bring a blush to the bashful cheek.

A New Friend

It is splendid to make the acquaintance of 5WA, even though one does so under difficulties. He comes in fairly well at times, though; in fact, last night he was clearly audible with the 'phones on the . . . I beg your pardon, reader; this pen of mine has grown so used to writing of wireless that it will do things of that kind off its own nib, so to speak.

At home in England big brother 2LO simply talks and plays from little Cardiff off the map. You hear a snatch or two of him during an interval, but directly London calls he retires into modest silence. Even here, as I have said, 2LO's is the louder voice, but Cardiff manages to make himself heard. I rather fancy that, feeling secure in his own country, he likes having a smack at 2LO and is responsible for the fading of London's transmissions here, just as further east London goes for him and blots him out altogether.

Good Fare for Listeners-in

Cardiff's performances are excellent; well chosen, bright and run on original lines. It is a pity that we cannot hear more of them in the Home Counties. I had expected that my 'phones (made in England) would be hard worked by having to deal with the baffling sounds of Welsh, but such a strain has been put upon them quite seldom. There are times when a singer expands his chest and lets fly about "Morwyn brydferth," or "Y gornant a lif drwy ddolydd blodeuog," or something of that kind. Then the unversed in the language suspects the presence of self-oscillation, and, hastily moistening a forefinger, taps his aerial terminal. But these things do not often occur.

5WA provides right noble entertainments, and the number of his hearers is growing apace, though it is not yet so great as he well deserves that it should be.

The Sad Case of Hippolytus Worplesworth

News of a sad little episode reaches me from home. My old friend Worplesworth, who has no equal as an enthusiastic rotary of wireless, received a visit one day from his most respected maiden aunt from whom he has great expectations. The old lady is a Tory of the old school, a patriot to the backbone, a diehard, a last-ditcher. Whenever one of her visits is impending Worplesworth carefully prepares denunciations of all her pet aversions in the political and diplomatic world, which he fires off at appropriate moments, what time she nods and smiles and tells Worplesworth that he is a noble fellow. He used to call this Consolidating his position. Now, alas, there is no position to consolidate, for Worplesworth, in the plain, homely language of his latest epistle, has been and gone and done it.

Having arrived and seated herself in the most comfortable armchair, this aunt cast her eyes around the room. They fell upon the wireless table, which, though discreetly veiled by a covering, at once attracted her attention. "And what is that, Hippolytus?" she queried. Hippolytus is what Worplesworth's godfathers and godmothers did for him at his baptism; his friends call him Hippy, but the aunt prefers the full four syllables—"Tell me what that is."

A Rash Step

Knowing her innate dislike of new things, Worplesworth was a little backward in coming forward, but she dragged it out of him, listening with many sniffs of disapproval to his description, which waxed cynical as he warmed to his work. "Yes," she said at length, "I've read a great deal about these new fangled things, and much as I deprecate such innovations, I would like, Hippolytus, to hear it working. Let me hear some music."

The fact that the time was outside broadcasting hours was not, Worplesworth knew, one that would carry any weight with her. Music she wanted and music she must have. He cudgelled his brains, then suddenly it occurred to him that Klonigowasterhausen might be on. A little tuning and he was there. A pair of 'phones was handed to the old lady, who donned them and sat with a smile that grew more and more contented as the strains went on.

The Crash

"Beautiful music," she said at length. "And where is it coming from, Hippolytus?" "Paris, auntie," lied Worplesworth glibly, feeling that he was justified in doing so. But just at that moment guttural accents were heard in the 'phones and the words Koinig's "Wusterhausen" was horribly plain. "German!" shrieked the old lady, tearing off the 'phones as if they had been red hot. "Do you mean to say, Hippolytus, that you have had the audacity to make me listen to a disgusting Hun station?"

His explanations were vain. The most valued of aunts insisted upon his ringing forthwith for the brougham, and she departed, shaking the dust of Worplesworth's house from off her feet and telling him icily that she was on her way to her lawyers to cut him out of her will. Poor Worplesworth. 'Tis indeed a hard fate, and had he but relied upon the very useful atmospheric as an excuse and failed to bring in anything at all he would still be a happy man.

THE LISTENER-IN.

THE REDUCTION OF INTERFERENCE

How to Make and Use Wave-Traps

From this article the reader will learn how to cut out the local broadcasting station when he is listening to the more distant programmes

WHEN broadcasting commenced and the stations of the British Broadcasting Co. were allotted definite wavelengths differing from one another by 15 metres or so, most people imagined that it would be a simple matter to tune from one to another without experiencing interference. Practical experience of broadcasting soon put an end to such optimistic expectations and the new listener found two problems to be solved. Firstly, he had to find apparatus sufficiently sensitive to listen to all of the other broadcasting stations and secondly—the bigger problem—he had to find some means of cutting out the tremendous interference from his local station if it were situated less than 6 to 10 miles away. Beyond this distance tuning became progressively simpler and if he was prepared to instal a loose-coupled receiver and practise tuning in two or three circuits at 25 miles or so, there was no difficulty whatever using a multi-valve set to switch from one station to another when conditions were approaching normal. But seeing that the great majority of listeners-in, actual and potential, were situated within about 10 miles of the broadcasting station, and these people were quite keen on listening to other programmes, there was a widespread disappointment at the inability to realise the ideal set forth in the beginning of this article.

A year's experience has shown that even the most expensive apparatus is not free from the possibility of interference from the local station and within the last few months several experimenters have been trying out what can be termed for simplicity "wave-traps."

These are specially designed circuits which can be inserted in front of the receiver so as to absorb the unwanted wave-lengths allowing only that which is wanted to pass to the receiver proper. There are several varieties of these traps, and three of the best with which the present writer has experimented are shown diagramatically in this article.

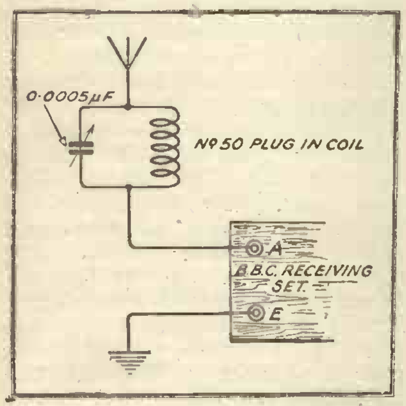


Fig. 1.—The Type A trap—a simple device in series with the aerial.

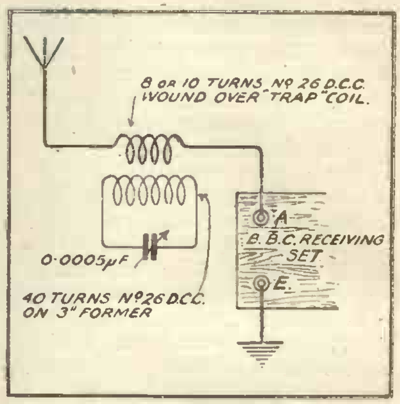


Fig. 3.—Type B trap. This can be made up as shown in Fig. 5.

Type A, the simplest of all to construct, consists of an inductance and a variable condenser connected as shown and placed directly in series with the lead to the aerial terminal of the instrument. If the oscillatory circuit so formed is set to have a wave-length exactly equal to that of the station it is desired to reject, it will absorb that wave-length in itself but will allow all others to pass through. The practical procedure, then, is to connect an inductance and a capacity together and, having approximately tuned your receiver to the wave-length you *want* to receive, to turn the dial of the condenser until the signals from the station you *don't* want practically disappear. It will then be necessary slightly to retune your receiver and give a final touch to the

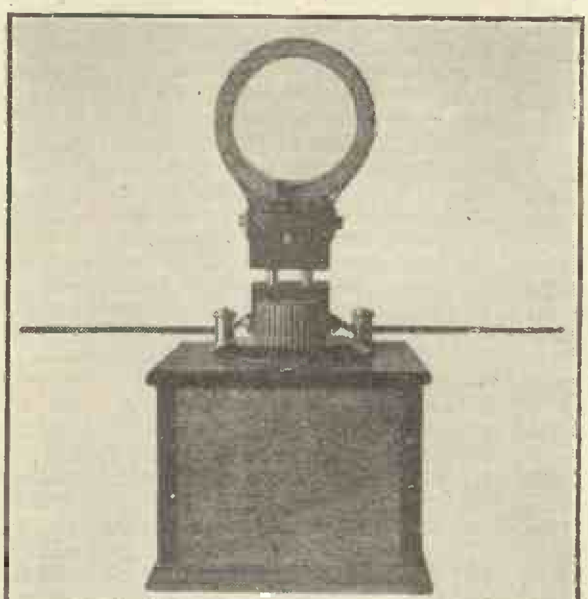


Fig. 2.—How to make up the Type A trap with a variable condenser and plug-in coil.

trap condenser when you will find that a very large proportion, if not all, of your interference will have vanished.

Fig. 1 shows the theoretical circuit of this first kind of wave-trap

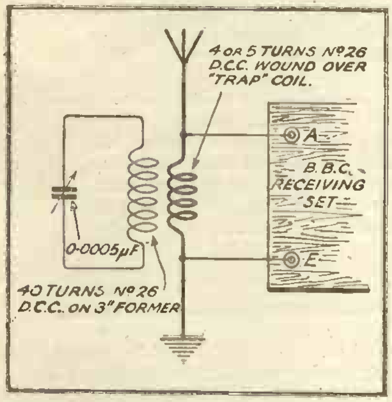


Fig. 4.—The Type C trap, probably the best of all. It can be made up as shown in Fig. 5.

and Fig. 2 is a pictorial representation. A 50-turn plug-in coil and a .0005 uF condenser will cover the wave-lengths of the British broadcasting.

The second type of trap consists of a similar oscillatory circuit inductively coupled to the aerial lead. Fig. 3 shows the circuit and Fig. 5 the practical way of connecting up. You will not be able to use a plug-in coil in this trap owing to the double winding necessary. The number of turns on a 3-inch former is 40 of No. 22 to No. 26 d.c.c. wire and over this should be wound 8 or 10 turns of the same gauge wire to be connected in series with the aerial. A .0005 uF condenser should be used. It is not absolutely essential to use the sizes of wire given and the trap will work with still finer wire and with thicker, but from experience the writer would recommend the first coil to be made with one of the sizes just mentioned. This trap is operated in the way previously mentioned.

The third type of trap, Type C perhaps the best of all, instead of accepting the one wave-length we do not wish to receive and allowing all others to pass through to the receiver, acts in a slightly different way. It by-passes all of the waves which we do not wish to receive and allowing to go to the receiver the one wave-length we want. It is connected in parallel with the receiver and practically identical with the second type. At first sight it might appear that the few turns of wire across the aerial and earth terminal would act as a dead short circuit, but owing to the fact that the trap is inductively connected to these turns, the whole appears to act as one resonant circuit. When it is tuned to the wave-length we wish to receive it will cut out all kinds of interference even if simultaneous interference is coming on several wave-lengths. With this type of trap it is quite possible 5 or 6 miles from 2 LO to listen to Cardiff on the loud speaker with a multi valve set with not the slighest interference from London. The present writer described these three traps in *Wireless Weekly* a few weeks ago, and since that time many letters have reached him from readers who have successfully tried these traps and can vouch for their usefulness.

P. W. H.

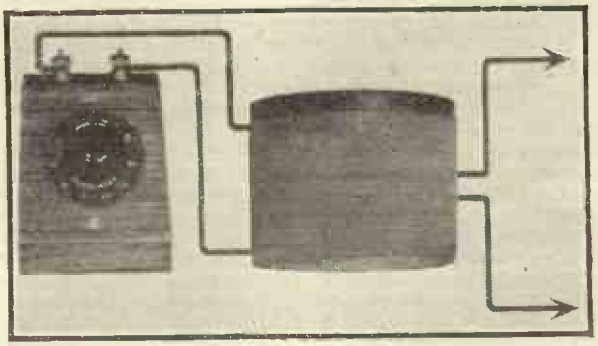


Fig. 5.—How to make both B and C traps. The coil has two windings, as described in the article.

M. W.'s FIRST VOLUME.

OUR readers will have been interested to note that this number marks the commencement of the second volume of MODERN WIRELESS. Appreciating that the majority of readers will desire to have the parts constituting the first volume bound under one cover with a comprehensive index, we have made arrangements to supply binding cases and if desired bind readers' back numbers.

The covers are in two attractive styles, one being a cloth-backed case and the other leather-backed, both lettered in gold. The prices of the cases are 2/6 and 4/6 (post 4d.), while if readers supply the necessary back numbers, they can be returned bound in either of these styles for 4/6 and 7/6 (post 1/-). These prices include the cost of the cover and also an index. The latter can be supplied separately at 1/- (post 1d.). New readers can, of course, obtain back numbers for binding from the publishers at 1/- per number, with the exception of No. 1 (February), the scarcity of which necessitates a price of 5/-. The price of the complete volume bound in either style is therefore 16/6 and 19/6 (post 1/-).

DEVELOPMENTS IN WIRELESS RECEPTION

By JOHN SCOTT-TAGGART, F.Inst.P. (Author of Thermionic Tubes in Radio Telegraphy and Telephony, Elementary Text-book on Wireless Vacuum Tubes, etc., etc.).

A Reproduction of a Paper read before the British Association for the Advancement of Science at Liverpool on September 19th, 1923.

SUMMARY.—The Paper is divided into two parts. The first deals with the selective reception of wireless signals and the minimisation of the effects of atmospherics, with special reference to long-distance commercial communication, while the second part of the Paper deals with apparatus and circuits for the reception of broadcasting or similar signals. Reflex amplification circuits are dealt with and their use in lessening the number of valves required is discussed.

PART I.

A New Invention for Selective Radio Reception and the Minimisation of Atmospheric Interference.

A STAGE in the history of radio telegraphy has been reached when those engaged in communication work view with grave concern the future prospects of the art. Atmospheric interference remains an important problem and the ether is becoming congested.

The ether is rapidly becoming filled with wireless signals of all wavelengths, from 50 metres to over 20,000 metres. Even at the present day, not a little difficulty is being experienced in separating desired signals from those of stations working on adjacent wavelengths.

The syntonisation of wireless receiving apparatus has progressed considerably since the remarkable early work of Lodge and Marconi. The introduction of high-frequency tuned amplifiers has enabled a very high degree of selectivity to be obtained. The use of reaction has also contributed, in no small measure, to the success of modern selective receiving apparatus. Note-frequency tuning has also been elaborated and used for commercial long-distance communication.

The greatest achievement, however, in selective reception is unquestionably the method of continuous wave reception known as the " heterodyne " system, invented by Fessenden. By this beat method of receiving continuous waves, not only is greater selectivity achieved, but a pure, musical signal is obtained which lends itself to selective reception on tuned low-frequency circuits.

In spite, however, of 27 years' of research work and commercial experience, even those with the most intimate knowledge of modern developments regard the future with a certain amount of apprehension. E. F. W. Alexanderson, the Chief Engineer of the Radio Corporation of America, a month or two ago made the following remarks :

" It can now be readily seen that since the ability to receive distinct signals depends on the separation of different frequencies, there is a definite limit to the number of ' channels ' of communication between stations that can be set up.

" If the wavelengths between 11,000 and 22,000 metres are divided into 2 per cent. bands, there are 35 ' channels.' If into 1 per cent. bands, there are 70 ' channels.' Except to such extent as directional reception will permit, the number of one-way channels open for such long distance communication is limited to the number of these bands.

" The congestion of the ether is, therefore, not a mere matter of looking into the future, but a real present-day problem. The necessity for traffic regulation at least enough to prevent reckless driving, so to speak, is just as apparent as the undesirability of hidebound regulations until such time as the limit of possible improvements in technique have been more definitely determined.

" Such is the present situation in the long-distance radio ether. The congestion is due to the necessity for the use of the longer waves for long-distance work and the fact that all high-power stations are broadcast stations ; much improvement is possible in existing practice, but radically new methods of operation must also be considered."

Having pointed out the immediate need for new methods of selective reception, a few remarks regarding present-day methods will not be out of place.

Present-Day Methods

When receiving continuous waves, it is usual to take advantage of two, and often three, methods of selective reception. In the first place, the signals are more or less selectively received by means of high-frequency tuned circuits, valve amplification being used for the purpose. Heterodyne reception is employed to convert the radio-frequency currents into musical notes which will operate telephone receivers or other indicating apparatus. Instead of applying the low-frequency signals directly to the telephone receivers, or like apparatus, note-frequency tuning is often resorted to. In view of the musical notes received by the heterodyne method of reception, the advantages of both high- and low-frequency syntonisation are obtainable. No mention has been made of directive aerial systems, but these are commonly employed in long-distance communication.

That Fessenden's invention has its limitations is disputed by none. Heterodyne reception, remarkable as it is for the selective reception of short wavelengths, is of comparatively little value for the reception of the waves commonly used for long-distance communication. Nevertheless, the beat method of reception, even for long wavelengths, is a sensitive one, and also provides a pure musical note, or, rather, low-frequency currents of regular wave-form.

The very important fact, however, remains, that the full advantages of heterodyne reception are not realised on the longer wavelengths. This, of course, is very unfortunate, as long-distance communication is carried out usually on wavelengths between 10,000 and just over 20,000 metres. These waves have been found to be most suitable for communication over long distances.

The comparative failure of the heterodyne system on commercial wavelengths used for trans-oceanic communication has left us dependent, very largely, on methods of eliminating signals which involve resonance phenomena which were applied to selective reception 26 years ago.

The two great landmarks in the history of selective wireless reception are the utilisation of resonance phenomena and the reception of continuous waves by means of the production of beats. The time has now come when these trusted methods are no longer sufficient. To-day governments are becoming more and more reluctant to issue new wavelengths for radio communication.

The ether is already overcrowded and the allocation of any new wavelengths only makes matters worse. There is, with modern apparatus, a limit to the extent to which wavelength channels may be adjacent to each other. A certain number of kilocycles have to separate the frequencies of two different stations if they are not to interfere with each other. This means that on the longer wavelengths there has to be a greater difference in wavelength between the different stations and only a relatively small number of high-power stations can communicate on the band of wavelengths between 10,000 and 20,000 metres. In other words, on the longer wavelengths, unless existing methods are altered, it will only be possible to have a certain number of transmitting stations, and this number will soon be completed.

We cannot increase the wavelength used indefinitely, owing to innumerable factors, and even if we could, the problem of selective reception would become worse and worse, owing to the necessity of separating out the wavelengths of the stations farther and farther apart.

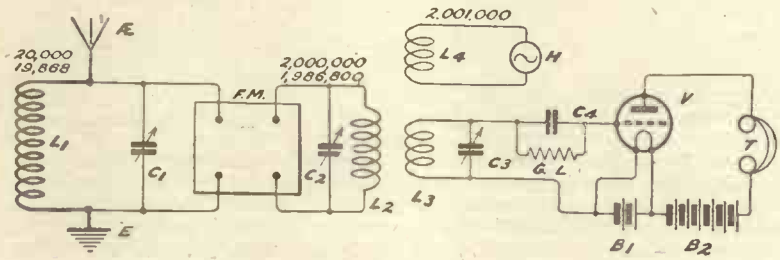


Fig. 1.—Reducing interference by frequency multiplication.

A New Invention

Having outlined the shortcomings of present-day apparatus, I propose to give a very brief outline of an invention which I patented in May, 1920, but which is publicly described to-day for the first time.

The principle is of such a basic character that its application may affect the whole trend of methods of selective reception.

The invention involves the increasing, at the receiving station, of the frequency difference between desired and undesired currents. This method of solving the problem of selectivity and atmospheric elimination has never yet been attempted or suggested. The frequencies have remained the same, and the methods which have been adopted have been calculated to separate the desired from the undesired frequencies without attempting to change the actual frequency of either.

According to part of my invention, the frequency of the incoming currents is increased with the result that the frequency difference between currents of different frequencies is increased.

An example will explain more readily what is meant. Let us assume that two stations are working on wavelengths of 15,000 metres and 15,100 metres. The wavelength difference, in this case, amounts to 100 metres, a very narrow margin and one which, under ordinary circumstances, would lead to the 15,100-metre signals jamming the 15,000-metre signals. If now we apply both sets of incoming currents to a frequency multiplier giving a multiplication of, say, 10 times, currents will be delivered to the receiver proper by both sets of incoming currents. The 15,000-metre desired signals will set up oscillations corresponding to a wavelength of only 1,500 metres, while the 15,100-metre signals will be resolved into signals corresponding to a wavelength of 1,510 metres. There will now be 10 metres difference between the two signals, but 10 metres difference on a wavelength of about 1,500 metres is ten times more valuable than a difference of 100 metres at a wavelength of 15,000 metres.

The number of cycles difference is the controlling factor in considering selective reception without interference. The example of the 15,000-metre signals being jammed by the 15,100-metre signals may be understood more clearly if we deal in cycles of frequency instead of metres. The 15,000-metre desired signal will set up oscillations having a frequency of 300,000,000 divided by 15,000, which equals 20,000. The 15,100 metre signals will correspond to oscillations having a frequency of 19,868. The frequency difference, therefore, is only 132 cycles.

If now, instead of receiving these signals in the ordinary way as, for example, by the heterodyne method, we multiply the frequencies of both signals by 10, we will increase the frequency of the signals due to the 15,000-metres station to 200,000 cycles, this corresponding to a wavelength of 1,500 metres. The 15,100-metres interfering signals will produce interfering oscillations having a frequency of 198,680 cycles.

It will be readily appreciated that the difference between the new desired and undesired currents is now ten times as great, and equals 1,320 cycles. Where before we had to differentiate between signals having a difference in frequency of only 132, we now have the considerably easier task of separating out signals having a difference of frequency of as much as 1,320 cycles. Put crudely, it is ten times as easy to separate out the two stations.

The new currents of multiplied frequency may be applied to selective high-frequency receiving circuits and the heterodyne method of reception may be employed.

Frequency Multiplication and the Use of Beats

It needs very little imagination for a student of these matters to appreciate the remarkable selectivity which is obtainable by a combination of frequency multiplication and heterodyne reception. A theoretical circuit is illustrated in Fig. 1.

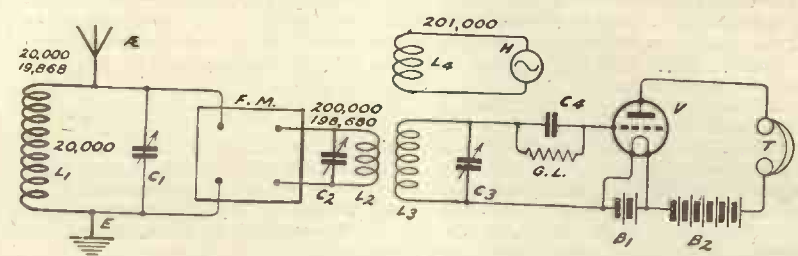


Fig. 2.—Frequency multiplication of 100 times.

In this figure, it is assumed that in the aerial circuit, which contains the inductance L_1 and variable condenser C_1, we have two sets of oscillations. One set has a frequency of 20,000, corresponding to the wavelength 15,000 metres of the desired signals, and the other currents have a frequency of 19,868, corresponding to the interfering signals of 15,100 metres. The circuit is tuned, of course, to the frequency of 20,000, corresponding to the desired signals, but nevertheless, this method of selective reception is grotesquely ineffective when the frequency difference is so small. The next stage in the process is to apply the

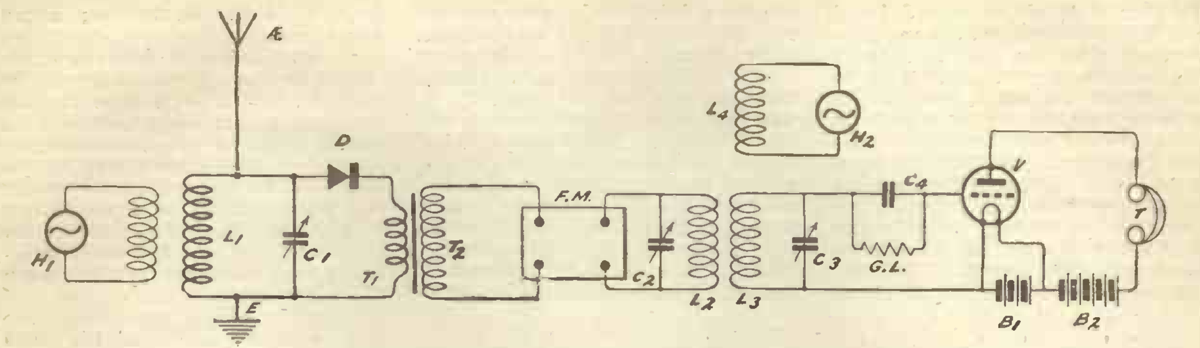


Fig. 3. Multiplication of low-frequency currents.

two sets of currents to a frequency multiplier which is shown, for the sake of convenience, as a box FM. This frequency multiplier may take many forms, and might be a series of frequency-doubling devices, such as valves, or it might be an apparatus for producing harmonics, a selected harmonic being then treated as the fundamental for reception purposes. The output currents from FM pass through the oscillation circuit L_2 C_2, and even here resonance tuning may not be sufficient. Loose coupling between L_2 and L_3 will, however, if the primary and secondary circuits are tuned to the new 200,000-frequency signals—which are really derived from the original 20,000-frequency signals by a multiplication of 10, cause the 198,680-frequency currents, due to the interfering signal which originally had a frequency of only 19,868, to be less effective.

Oscillations are now induced into the circuit L_3 C_3 from the heterodyne H, which may be, for example, a valve oscillator. This heterodyne induces local oscillations having a frequency of 201,000. The result of inducing currents of this frequency into the circuit L_3 C_3 will be the production of two sets of beats. The 201,000-frequency oscillations will beat with the desired 200,000-frequency oscillations producing beats of 1,000 frequency, and these beats will be rectified and detected by the valve V, in the output circuit of which are the telephone receivers T. The 1,000-frequency beats will, of course, produce a musical note in the telephones T having a frequency of 1,000, which is a very convenient frequency for the reception of continuous wave signals. The 201,000-frequency oscillations induced by the local heterodyne, will also produce beats with the oscillations having a frequency of 198,680 which, it is assumed, have not been tuned out by the use of resonance phenomena. The beats, in this case, will have a frequency of 2,300.

We now have in the telephones T two sets of signals. The desired sets have a frequency of 1,000 while the undesired ones have a frequency of 2,300, and no difficulty should be experienced in reading the desired signals without material interference from the other signals. It is important to notice that the incoming signals are not, of course, simply steady streams of continuous oscillations, but consist of dots and dashes of short duration, and that during a considerable period of time, dots and dashes of the undesired signals are received during the intervals between dots and dashes of the desired signals.

Hundredfold Multiplication

A far more striking example of the possibilities of this new principle in wireless reception is when we consider the frequency multiplication to be, say, 100 times. Such conditions are illustrated in Fig. 2.

The frequency multiplier FM now increases the frequency of the desired signals to 2,000,000, corresponding to 150 metres, while the interfering signals now have their frequency raised to 1,986,800. The frequency of the local oscillations of the heterodyne are adjusted to 2,001,000. With the desired currents of 2,000,000 frequency, the heterodyne currents will produce beats of 1,000 frequency which will produce a musical note of 1,000 in the telephone receivers. With the interfering signals, the local oscillations will produce beats having a frequency of 13,300. This frequency, to all intents and purposes, may be treated as above the audible limit, and the desired signals would therefore be received in the telephone receivers without any interference whatever from the undesired signals, even though in the initial aerial circuit the frequency difference amounted to such a small amount as 132 cycles.

The advantages to be gained from the method outlined in this Paper are supplemented by resonance tuning and in practice a frequency multiplication of 100 times would not be necessary. It will readily be appreciated that even a multiplication of only 2 will double the difference in frequency between desired and undesired signals. This means that we can increase the "elbow room," as it were, for signals of any particular wavelength, and greater selectivity is thereby obtained. Alternatively, we can say that by doubling the frequency of the incoming signals we can have twice as many channels of communication in any given band of wavelengths. If, for example, we take Alexanderson's figure of 35 channels of communication between 11,000 and 22,000 metres, by frequency

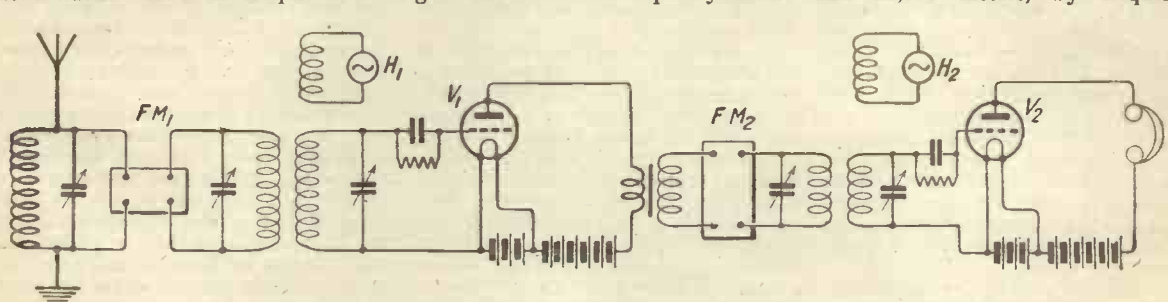


Fig. 4. Multiplication of both the high- and the low-frequency currents.

doubling we can increase this to 70. By multiplying the frequency 10 times, we could have 350 stations working between these two extreme wavelengths. If we multiply the frequency of signals 100 times, we could have 3,500 stations working.

By the application of this invention to long-distance communication, it would therefore seem that the problem of the congestion of the ether has been solved.

While this method of reception marks a third stage in the progress of selective reception, both resonance tuning and beat reception retain all their former usefulness; in fact, heterodyne reception becomes even more important as it now becomes a really effective process in the reception of continuous waves of great length. One way of looking at the invention which is the subject of this Paper is to consider that the long wave signals are brought down to the lower wavelengths where the full advantages of beat reception, as regards selectivity, are obtained. The lower the level to which we bring the incoming signals, the more selective does heterodyne reception become.

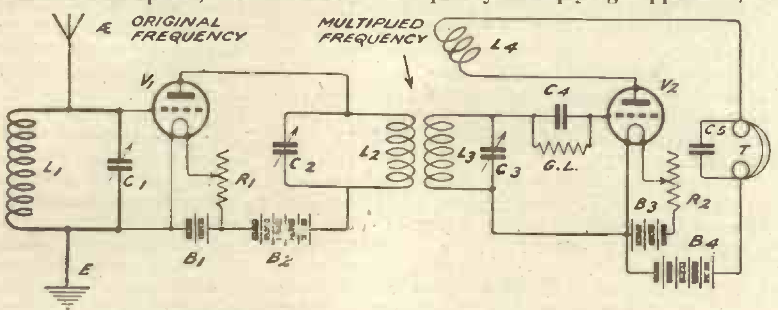


Fig. 5. An application of frequency multiplication to a practical circuit.

Application to Low Frequencies.

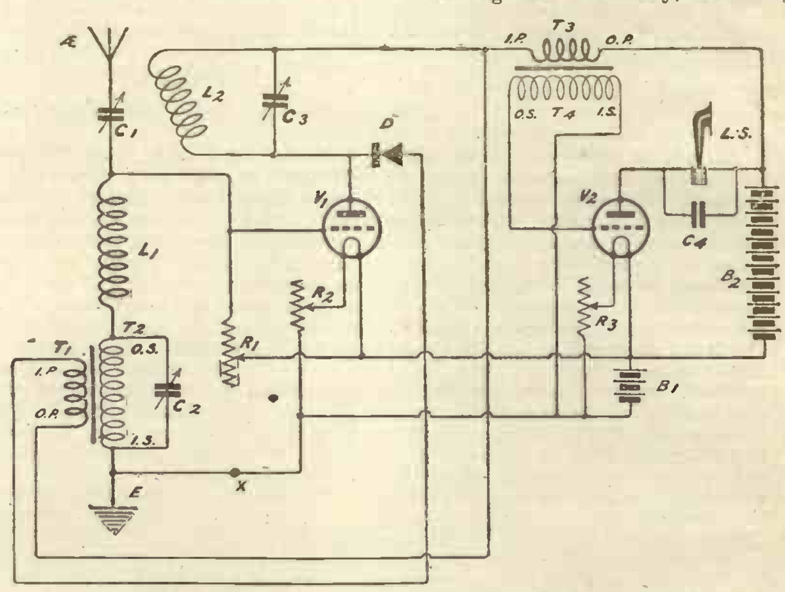
So far, the application of the method to high-frequency signals only is described. The principle, however, is just as applicable to audio frequencies as to radio frequencies. The author's experiments in this direction have fully borne out theoretical expectations, and two signals having a note frequency imperceptibly different have been entirely separated in such a way that one of the frequencies is entirely suppressed.

Such a very remarkable achievement could not be obtained, or even approached, by any other method which has hitherto been proposed. Its significance, of course, is that note tuning becomes a reality; almost the whole of the selective apparatus may be concentrated on the low-frequency side of a wireless receiver. When receiving continuous waves, even the slightest differences between two sets of continuous oscillations will produce different beat notes with a local heterodyne. These will give rise to slightly different audio frequencies which would seriously interfere with each other and entirely prevent the selective reception of a desired signal.

Where existing methods cannot differentiate between signals of slightly differing pitch, it is possible by this invention to magnify their difference to such an extent that either signal may readily be read without interference.

The original audio-frequency signals have their frequency stepped-up by means of harmonic producing, or other frequency-multiplying apparatus, to a radio frequency which should preferably be well above the audible limit. These radio-frequency currents may now be selectively received by the aid of tuned high-frequency circuits and then combined with local radio-frequency continuous oscillations. These local oscillations are produced by a heterodyne, beats being produced. All the advantages of high-frequency tuned circuits and beat reception are thereby obtained, and whereas the original difference in frequency might be only 100 (barely perceptible) the final difference in frequency might be 10,000, a frequency which would enable the interfering signals to be cut out entirely.

Fig. 3 shows a theoretical wireless receiving system in which the invention is applied to the low-frequency currents The high-frequency signals are rectified by the crystal D producing audio-frequency currents through T_1, due to the fact that a local oscillator H_1 induces continuous oscillations into the aerial circuit of a frequency slightly different from that of the desired signals. The currents of musical frequency passing through T_1 are then applied by means of the transformer T_1 T_2 to the frequency multiplier F M, in the output circuit of which we have a circuit L_2 C_2 tuned to a multiple of the desired audio-frequency currents passing through T_1. The circuit L_2 C_2 will be a radio-frequency circuit, and the frequency of the currents in L_2 C_2 should preferably be above the audible limit. The circuit L_3 C_3 is tuned to the same frequency, and by loosely coupling L_2 to L_3 a certain amount of resonance selectivity is obtained. The principal method of obtaining the selectivity, however, is by the introduction of local oscillations produced by a second heterodyne H_2 tuned to produce currents having a frequency differing by, say, 1,000 from the currents in L_3 C_3. The beats of about 1,000 frequency are now detected by the valve V and produce a musical note in T. The beats produced by the interaction of the local oscillations supplied by H_2 and the undesired signals of multiplied frequency are arranged to be above or below the audible limit so as not to interfere with the desired signals



Part II. Fig. 1. A practical dual-amplification circuit.

A Combined High- and Low-Frequency Selective System.

It is, of course, convenient to apply the invention to both the high- and low-frequency sides of a wireless receiver, and Fig. 4 shows a simplified arrangement illustrating the different stages in the reception of continuous waves by this system. It will be seen that the first frequency multiplier FM_1 is for the purpose of increasing the frequency of the original oscillations. The oscillations of multiplied frequency are then heterodyned by H_1 and detected by the valve V_1, producing musical low-frequency currents. The output currents from the valve V_1, which will be of musical frequency, although, of course, it is not necessary that this should actually be so, are communicated to the second frequency multiplier FM_2; the frequency is once more stepped-up so as to reach above the audible limit and the currents are selectively received by the aid of loose coupled circuits and the second heterodyne H_2, which enables a musical note to be obtained in the telephones.

The Apparatus Employed.

It is not possible within the scope of this paper to deal with the various practical circuits for achieving the desired results. The method of obtaining the multiplied frequency is not, of course, an essential part of the basic invention. Thermionic valves, operated under special conditions, have been found suitable for producing harmonics or merely for doubling the input frequency. If harmonics are used, a considerable factor of multiplication may be obtained.

Fig. 5 indicates how the invention might be applied to the reception of incoming waves. The valve V_1 is operated at, say, saturation point, so as to produce harmonics in its output circuit L_2 C_2, which is tuned to one of these harmonics. The valve V_2 is a self-heterodyne receiver which then receives the desired harmonic and treats it as the signal to be received.

The present paper is only intended as an outline of the new system, and at some future date it is hoped to give further technical details.

The Minimisation of Atmospheric Interference.

The system of reception lends itself particularly to the elimination, or rather minimisation, of atmospherics. While this is probably, at the present date, the most important advantage of the system, yet it is mentioned at this stage of the Paper because this process of atmospheric elimination is essentially one of selectivity. The application of the method of frequency multiplication to the low-frequency side of a receiving circuit will automatically cut out all, or most, of the atmospherics, owing to the fact that most atmospherics have lower frequencies than the heterodyne notes due to desired signals. Unless their frequency exactly corresponds with the heterodyne note, the process of frequency multiplication and resonance, combined with further heterodyning, will eliminate the atmospheric interference.

By the application of the method to the high-frequency side of the receiving apparatus, the effect of atmospherics may also be minimised by causing them to produce oscillations (for example, by the impact excitation of a detuned circuit) different from the incoming continuous waves. Frequency multiplication increases the divergence between the two different signals, and in any case currents of the wave-form of atmospherics will not readily produce effective harmonics.

PART II.

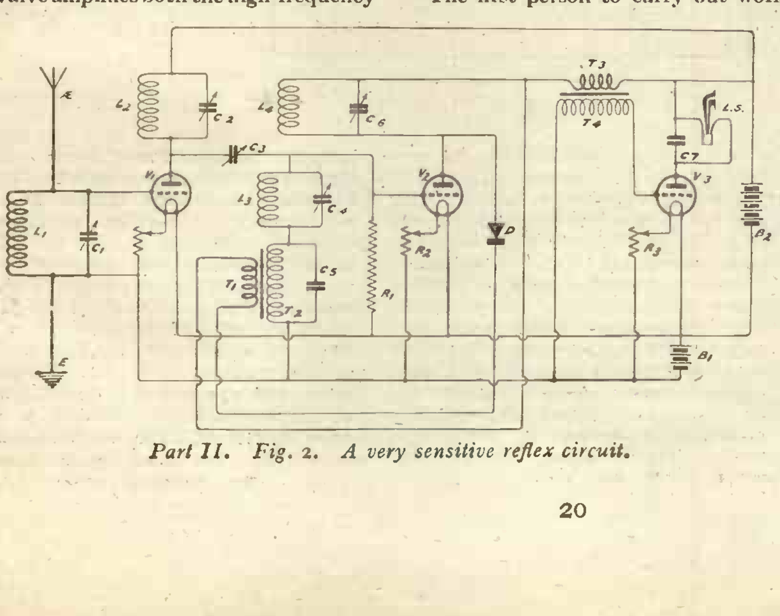
Reflex Circuits for Broadcast Reception.

The three-electrode valve has become an indispensable piece of apparatus in modern receiving work, and it may be used for strengthening the high-frequency oscillations produced by the incoming signals, and it may also be used for strengthening the low-frequency currents which, in the ordinary way, would pass through the telephone receivers after the high-frequency currents had been rectified. A very useful application of the three-electrode valve is as a dual amplifier. This term, of course, is familiar to those acquainted with the subject, as implying that the valve amplifies both the high-frequency currents and the low-frequency currents at the same time. It is found that a three-electrode valve can carry out both duties simultaneously without any trouble, and it is the purpose of the second part of this Paper to give some particulars of successful circuits which I have employed. It must, however, be understood that the principle of dual amplification is nearly ten years old, and that although very little practical use has been made of this important principle, yet several investigators have suggested means of employing the method of dual amplification.

The first person to carry out work on these lines in England was Captain H. J. Round, the Research Engineer of the Marconi Company, and the pioneer of valve work in this country.

Dual-amplification circuits possess the merit of saving one or more stages of separate low-frequency amplification; in other words, a fewer number of valves may be employed. Unfortunately, the additional duties which the valve has to carry out tend to render it unstable, and low-frequency oscillation and distortion are frequently the accompaniment of dual amplification. The self-oscillation tendency in dual-amplification circuits has been the cause of the lack of popularity of reflex or dual-amplification circuits during the last ten years. Two departures from current practice are embodied in most of the circuits which I have found suitable and stable for dual amplification. To lessen the tendency to oscillate a stabilising resistance of about 100,000 ohms is connected across suitable points in the circuit, while the transformer for introducing the low-frequency currents into the grid circuit of the valve is connected in the aerial circuit of the usual direct coupled receiver.

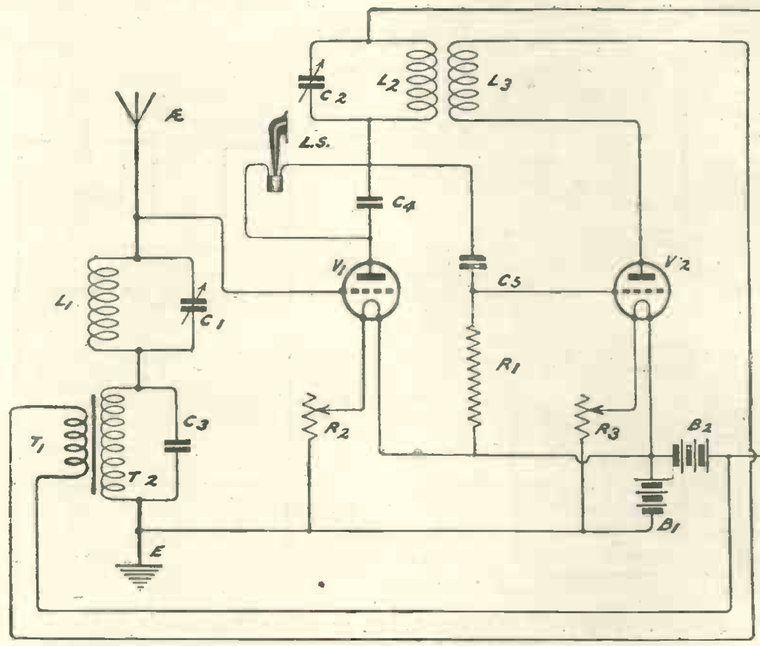
Fig. 1 shows a highly successful reflex circuit in which the first valve V_1 acts as a high-frequency amplifier. The high-frequency oscillations appearing in the circuit L_2 C_3 may be further strengthened by coupling L_2 to L^1



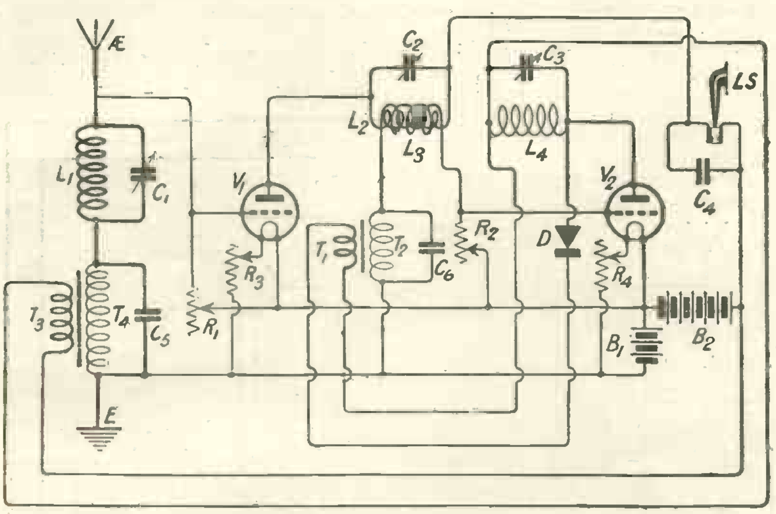
Part II. Fig. 2. A very sensitive reflex circuit.

so as to produce a reaction effect. The crystal detector D and primary T_1 of a step-up intervalve transformer T_1 T_2 are connected across the oscillation circuit L_2 C_3. In the anode circuit of the first valve is also included the primary T_3 of a step-up intervalve transformer T_3 T_4, the secondary T_4 of which is connected across the grid and filament of the second valve. In the anode circuit of this valve is the loud-speaker LS, preferably shunted by a condenser C_4, having a capacity of from 0.002 μF to 0.05 μF. A variable resistance R_1, having a maximum value of about 100,000 ohms, is connected across the grid and the positive side of the filament accumulator. This variable resistance may be replaced by a fixed resistance of 100,000 ohms. The variable condenser C_2 preferably has a capacity of 0.001 μF. It may be replaced by a fixed condenser of that capacity, but this makes the circuit a little less flexible. With this circuit, loud-speaker results are obtainable up to 20 miles from a broadcasting station on very small aerials, and numerous reports are being received from the Glasgow and Aberdeen areas stating that the London station is regularly received on a loud-speaker.

Fig. 2 shows a modification of the circuit by the addition of a stage of high-frequency amplification, which is desirable when long ranges are to be accomplished. It will be seen that the first valve acts as a high-frequency amplifier. The circuits L_1 C_1, L_2 C_2 and L_3 C_4 are all tuned to the incoming wavelength. The circuit L_4 C_6 is also tuned to the incoming wavelength. The second valve acts as a high-frequency amplifier, the high-frequency oscillations in L_4 C_6 being detected by the crystal detector D. The resulting low-frequency pulses pass through the primary T_1 and the low-frequency signals are then impressed on to the grid of the second valve which amplifies them; the amplified currents pass through T_3 and are communicated to the grid of the third valve, in the anode circuit of which we have the loud-speaker LS. The stabilising resistance R_1 has a value of about 100,000 ohms.



Part II. Fig. 4. A reflex circuit employing valve rectification.

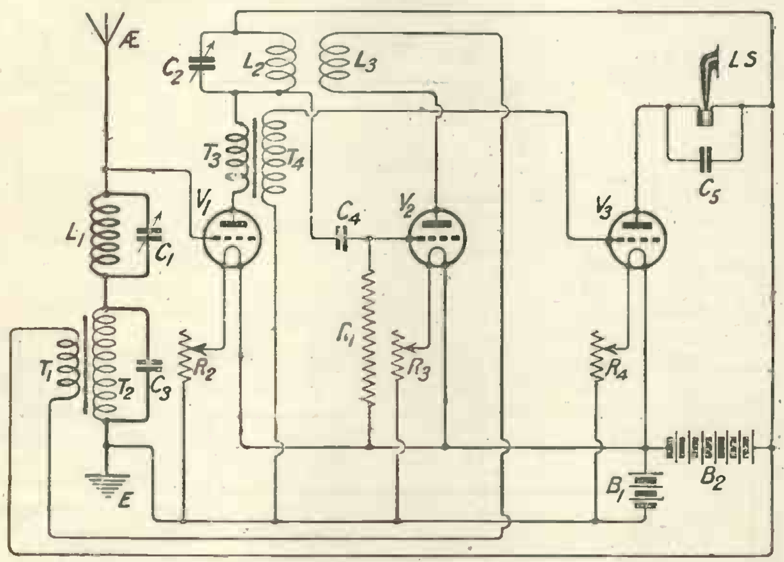


Part II. Fig. 3. A reflex circuit giving two H.F. and two L.F. stages of amplification.

Fig. 3 is a suggestion which has been made to obtain two stages of high-frequency amplification and two stages of low-frequency amplification with the kind of circuit illustrated in Fig. 1. Stabilising resistances R_1 and R_2, each of 100,000 ohms, are used as before. The first valve V_1 acts in the first place as a high-frequency amplifier, the high-frequency oscillations appearing in the circuit L_2 C_2. From here they are communicated to the grid of the second valve by virtue of the close coupling between the secondary winding L_3 and the inductance L_2. In the anode circuit of the second valve is a tuned circuit L_4 C_3, across which we have the crystal detector D and the primary T_1 of the transformer T_1 T_2, the secondary of which is in the grid circuit of the second valve. The low-frequency currents are, as a result, amplified by the second valve and pass through the primary T_3 of the transformer T_3 T_4, the secondary of which is connected in the grid circuit of the first valve. In the anode circuit of this first valve is connected the loud-speaker LS. Reaction may be obtained by coupling L_4 to the inductance L_2.

Coming now to a class of dual amplification circuit which does not involve the use of a crystal detector, we have in Fig. 4 a very efficient example. In this case the incoming signals are amplified by the valve V_1, the amplified currents appearing in the circuit L_2 C_2. The high-frequency potential variations across L_2 are communicated to the grid of the second valve V_2 by means of the condenser C_5, a gridleak R_1 being connected across the grid of the second valve and the positive side of the accumulator. This second valve acts as a detector, and an inductance L_3, coupled to L_2, is included in its anode circuit in order to introduce reaction into the tuned anode circuit L_2 C_2. The rectified currents also pass through the primary T_1 of the intervalve transformer T_1 T_2, the secondary of which is connected in the grid circuit of the first valve which consequently acts also as a low-frequency amplifier. In order to well insulated; trouble is most likely to arise when telephone receivers are used as these have an appreciable capacity to earth. In order to overcome this defect entirely, and to be able to touch the telephone receiver terminals or the loud-speaker terminals without any influence whatever on the signal strength, the circuit of Fig. 6 was evolved. This at first sight may appear a little complicated, but it is not so in reality. The tuned anode circuit, as before, is represented by the inductance L_2, shunted by the variable condenser C_2. Instead, however, of connecting the loud-speaker or telephone receivers directly next to the anode of the first valve, two additional coils L_5 and L_4 are connected in the manner shown; the inductances L_5, L_4 and L_2 are all wound on the same tube of insulating material. The coil L_4 is wound directly over L_2 and is identical with it, as regards numbers of turns, etc. The coil L_5 is likewise the same as L_4 and is wound over L_4. For British broadcasting purposes it was found that each of the coils L_5, L_4 and L_2 could consist of 30 turns of No. 26 gauge double cotton covered wire wound on a 3½ in. diameter ebonite tube. The coil L_3, as before, is coupled to L_2 to produce the reaction effect.

In conclusion, it may be stated that the manifest advantages of using a three-electrode valve as a reflex amplifier are being rapidly appreciated, and it is highly likely that the use of this type of circuit will be widespread in the immediate future.

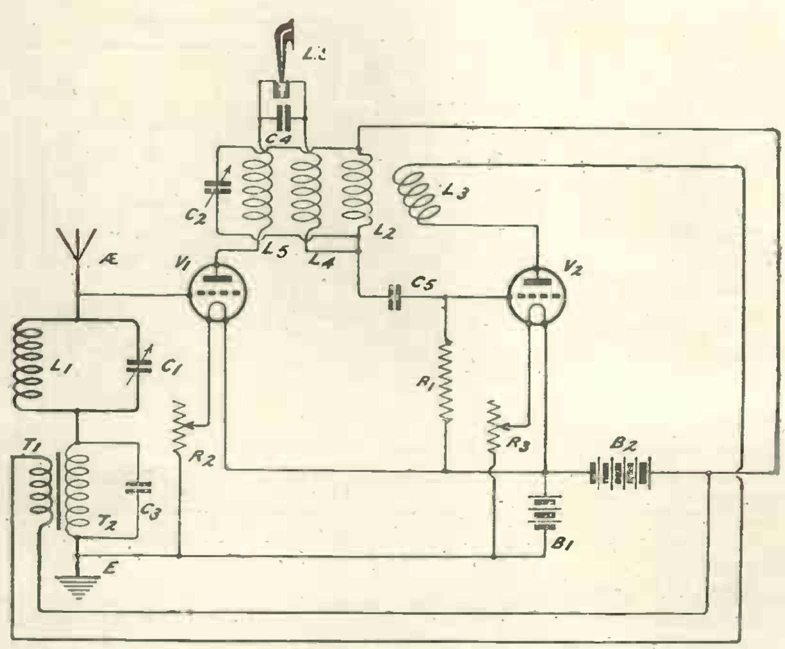


Part II. Fig. 5. The circuit of Fig. 4 with the addition of a further stage of L.F. amplification.

detect the signals the loud-speaker LS is ncluded next to the anode of the first valve, the condenser C_4, of about 0.05 μF being connected across the loud-speaker. The value of these condensers across loud-speakers varies with the different types of reproducer used.

Very good results have been obtained with this circuit and Fig. 5 shows a modification in which the third valve acts as an additional low-frequency amplifier. In this circuit, the loud-speaker is replaced by the primary T_3 of the step-up intervalve transformer T_3 T_4 the secondary of which is connected in the g id circuit of the third valve. The loud-speaker is connected in the anode circuit of this third valve.

In both Figures 4 and 5 there are technical objections to connecting a loud-speaker telephone receivers, or the primary of a step-up intervalve transformer, next to the anode of a high-frequency amplifying valve. The insertion of a piece of apparatus of this character at a point of high-frequency potential to earth is not really sound, although the author has not found any real disadvantage in practice, provided the apparatus is



Part II. Fig. 6. Fig. 4 with the addition of stabilising refinements.

SPECIAL NOTE:

Owing to pressure on our space Mr. Scott-Taggart's article on "Two-Valve Receivers," mentioned on p. 584 of the September issue, is unavoidably held over until next month.

THE VALVE FOR THE MAN IN THE COUNTRY

A simple explanatory article on the much-talked-of dull-emitter valves and how to use them.

By R. W. HALLOWS, M.A., Staff Editor.

HITHERTO the dweller in the depths of the country has been at a great disadvantage so far as wireless was concerned. To be able to work a valve set an

The Marconi Osram D.E.R. valve, a well-known dull-emitter.

accumulator was an absolute necessity, and, except perhaps in Wales and in some of the Yorkshire Dales, where the water power laid on by nature has induced the authorities to install electric lighting plants, there are very few villages indeed in which it is possible to get charging done. Some dogged souls use accumulators in spite of all difficulties, taking them into neighbouring towns to be recharged when necessary, but this, though praiseworthy, is not as a rule productive of good results unless the owner is able to take the battery in directly its voltage begins to fall off. Too often accumulators have to stand for days in a partly run-down state, with the result that sulphating sets in and the battery, after several repetitions of such treatment, grows old before its time and eventually becomes quite useless.

Now the man in the country is just the one who most needs the aid of the valve. His fellows who live in large cities may use the crystal to bring in broadcasting if they are fortunate enough to be at or near one of the B.B. Co.'s centres, and when the new scheme for the installation of relay stations is carried out there will be eventually few large towns that are not within crystal range of some transmissions. Even the prospect of the relay stations brings no hope to the man in the country in most cases. He has had to use his crystal because valves were outside his scope, and there is little likelihood that the crystal will ever bring country places into wireless contact with the music, the lectures and the news that are now doing so much to enliven the cities.

Prospects then were frankly black for country dwellers until a few short weeks ago. There were wonderful valves that worked with only the tiniest filament current, but their cost was so fabulous—none of them was to be had for less than £2, and there were others at £21 5s.—that they were not to be thought of. We were aware that a valve at £2 was really an economy, since it cost so little for accumulator recharging and had so long a life; but most of us remembered that a £2 valve is just as easily dropped and just as liable to be burnt out by accident as the 15s. variety, and we not unnaturally shied at the price.

To-day there are no less than four patterns of dull-emitter valves that can be purchased for £1 7s. 6d. apiece, and at that price they are no longer the unattainable though hoped-for things that they once were.

What exactly is a dull-emitter valve? Let us see. To make the valve pass a high-tension current from filament to plate we must heat the filament, which causes it to emit electrons. The heating would possibly be done in a variety of ways, but the most convenient is to use a current of electricity.

The material used for valve filaments is the extremely refractory metal called tungsten. It will emit a small quantity of electrons at temperatures as low as 600 degrees Centigrade, but it does not function efficiently until a temperature of about 2,000 degrees Centigrade is reached. At this temperature the metal is incandescent, giving out a dazzling white light.

The filament of the ordinary valve, which we may call a "bright-emitter," must be heated to this temperature to ensure proper working. This brings several results in its train. In the first place, we require a considerable current at voltages varying from 3.5 to 6; secondly, the life of the filament is comparatively short, since its entire composition undergoes a change under the influence of the great heat and it becomes very brittle; thirdly, a bright filament is apt to produce crackling noises, which are anything but an improvement to reception.

Mullard L.F. "Ora." One of the new dull-emitter valves.

The most economical of "bright-emitters" consume when new rather less than 0.5 ampere of current. Others draw from 0.5 to 1 ampere from the battery, and all become more greedy as their filaments age with use. If you have a three-valve set whose valves have been in service for two or three months, the total current required is probably not much less than 3 amperes at round about 5 volts.

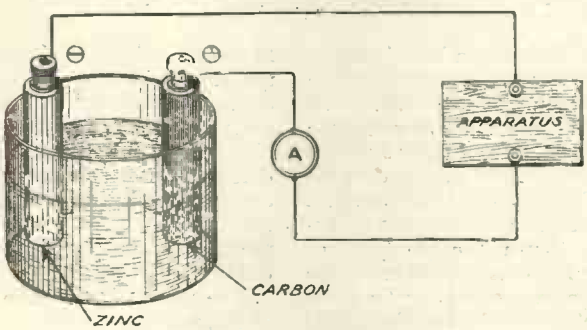


Fig. 1.—A simple test.

No primary battery, unless of enormous size, could possibly stand up to such a demand; hence the only feasible source of current supply is the accumulator, which is capable of giving a high rate of output without becoming unsteady.

It was discovered many years ago that if certain substances were blended with tungsten its electronic emission at a given temperature could be enormously increased, or conversely, that a given emission could be obtained with the metal heated to a far lower temperature. This discovery led to more research, and it was found that a coating of lime upon the filament would enable a valve to be made which would work when glowing red instead of blazing at white heat.

The early dull-emitters largely used in America had these coated filaments; they certainly worked, but they were distinctly noisy, and those who gave them a trial soon went back to the old type of valve with a plain filament.

Then came the discovery which was in the writer's opinion to do more to popularise wireless than any other that has been made.

It was found that instead of using a coating of lime the tungsten could be blended with a material known as thoria. This is the oxide of the metal thorina, and it occurs in the form of a rare earth found only in one or two parts of the world. It had been used previously for the manufacture of incandescent gas mantles.

If we add a small percentage of thoria to the tungsten of a filament the electronic emission is enormously increased. Place such a filament in a valve and it needs to be brought only to red heat to do all that a "bright-emitter" can do. Those who possess valve sets can easily discover what this means. Place an ammeter in series with the low-tension supply and take the reading when the filament of an ordinary valve is heated to its proper working temperature. Now turn the knob of the rheostat gradually so as to reduce the brilliance of the filament, and watch the ammeter. Its pointer will fall back rapidly, until when a dull-red heat is reached only a very small current consumption is registered. In the dull-emitter valve provided with a thoriated filament that dull-red heat is all that we require for efficient working. Hence the dull-emitter consumes far less current, thanks to the fact that its filament has not to be brought to incandescence by the low-tension battery.

The dull-emitter valve, then, is in general construction identical with the ordinary pattern. The difference is that it contains a blended filament which at red heat has the same emission as a pure tungsten filament in a state of incandescence. In the "bright-emitter" a great deal of current is used in order to maintain the filament at white heat; the dull-emitter needs only enough to bring its filament to redness.

This being so, the current consumption can be cut down to very small proportions indeed, and the voltage can be reduced to something much below that needed by any "bright-emitter." A valve has been produced that works very well indeed on 0.25 ampere at 1.1 volts. This is the American W.D.—11, which is very widely used now on the other side of the Atlantic. Another American valve, the U.V. 199, takes only 0.06 ampere at 3 volts. A complete four-valve set can be worked off a single ordinary bell cell! The U.V. 199 is not, however, a very good valve; the writer has tried a set of them and found that they are not at all stable. Possibly the makers have tried to do too much.

But we need not go to the States to look for an efficient dull-emitter. The best in the world are made in our own country, and all of them can be used with dry cells instead of accumulators. We will discuss these valves in detail in a moment. Meantime, it may be well to see something of the dry cell itself.

These cells are simply a special form of the Leclanché cell, which is so much used for working electric bells. In its simplest form this cell consists of a glass jar in which are placed a positive element of carbon and a negative element of zinc, the electrolyte being a solution of sal ammoniac and water. If such a cell, which has a commencing E.M.F. of about 1.5 volts, is connected as shown in Fig. 1 to any kind of apparatus the ammeter (A) will register quite a respectable current for a short time. Very shortly, however, the needle will begin to fall back, and if the apparatus is left connected up the current will fall away in a short time to zero, or very nearly so. If now we disconnect the cell and after leaving it for a few hours connect it up again, we shall find that the current supplied is once more quite a good one.

The cell is then capable of supplying a fair current for a very short time only, but after a period of rest it is good again for work. The falling off in current is caused by the accumulation of hydrogen bubbles upon the carbon element. As they increase in number they set up a greater and greater internal resistance until finally the potential difference of the elements is insufficient to drive any but the tiniest current. When the cell is rested the bubbles disappear; the resistance falls and current can flow once more through the electrolyte.

To counteract this "silting up" effect the positive element of the

Valve.	Filament Volts.	Filament Amperes.
L.F. Ora A.	1.8	0.2
L.F. Ora B.	1.8	0.3
L.F. Ora C.	1.8	0.4
A.R. D.E.	1.6	0.3*
M.O. D.E.R.	1.8	0.4
M.O. D.E.V.	3.0	0.2*
M.O. D.E.Q.	3.0	0.2*

* Slightly under.

Table 1.

Leclanché cell is placed in a porous pot containing a quantity of manganese dioxide (MnO_2). As hydrogen (H) forms it combines with the oxygen of the manganese dioxide in the proportion of two atoms of hydrogen to one of oxygen; this forms H_2O, or water. The formation of hydrogen bubbles causes what is known as the polarisation of the cell, and the manganese dioxide is known as the depolariser.

It prevents the voltage and current of the cell from falling off so rapidly, and when the cell is rested it enables it to recover far more quickly.

A "dry" cell is not really dry. It consists of a pot of zinc, which forms the negative element, containing a kind of jelly made of gum mixed with sal ammoniac solution. In the middle is a carbon rod contained in a bag filled with depolarising compound. Fig. 2 shows a section of a typical dry cell.

The manufacture of dry cells has now been brought to such a pitch of perfection that one of moderate size will maintain its voltage and give a steady output of about 0.25 ampere for several hours on end. If the cell is used for longer the output may begin to fall off, but it will recover when the cell is rested. The E.M.F. of a new dry cell is always about 1.5 volts. It will diminish gradually with use owing to the chemical change that occurs in the electrolyte and the depolariser and the increasing internal resistance, but the current given will remain fairly steady until the E.M.F. has dropped to 0.75 volt.

In the dry cell then we have the means of obtaining a moderate output of current at a voltage that will be maintained for a long period if the cell is used only for two or three hours at a time and is given ample opportunities of recuperating. Few of us use our receiving sets for more than three hours a day on the average, and as we do most of our listening-in between 8 and 11 o'clock in the evening, the cells, if used for heating the filaments of dull-emitter valves, will have 21 hours in which to recuperate.

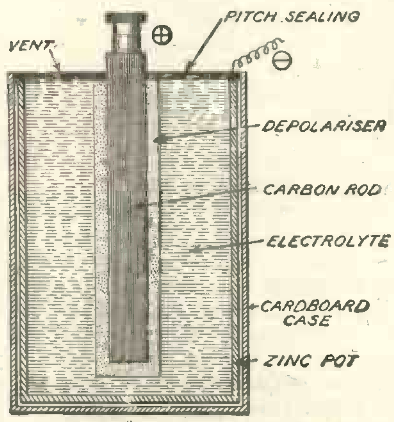


Fig. 2.—A typical dry cell.

If then we can find valves that consume only a small amount of current, there is no reason why we should not use either single cells or combinations in parallel, series, or series-parallel to supply our low-tension current.

There are seven types of low-temperature valve available to the experimenter. Five of these cost only £1 7s. 6d. apiece. They are the Mullard L.F. Ora B and C, the Ediswan A.R. D.E. and the M.O. D.E.R. The writer has used most of them for considerable periods, and he has found them all exceptionally good. Speaking generally, it may be said that they are slightly—very slightly—less efficient than ordinary valves, but that there is a complete absence of filament noises and that they are very long-lived. Unlike ordinary valves, they do not seem to grow markedly more greedy with age. A set of D.E.R.s that has been in use for more than 1,000 working hours consumes to-day very little more current than when new many months ago, and there is absolutely no noticeable loss in efficiency.

The L.F. Ora B takes 0.3 ampere at 1.8 volts on the filament. The C pattern consumes 0.4 ampere at the same voltage. These two valves are in appearance exactly like the well-known "bright-emitter" Ora, and they can be used to replace it on any existing set. Both are rectifiers, and as amplifiers they are all that could be desired.

The Ediswan A.R. D.E. needs rather less than 0.3 ampere at 1.6 volts. It is a very well made valve, quite free from microphonic noises and a remarkable all-round performer.

The D.E.R. consumes 0.4 ampere at 1.8 volts. The old pattern was an extremely good valve. It was cylindrical in shape and rather small in size. Now, however, a new pattern has been turned out which is, in the writer's humble opinion, not so good. The bulb is large and pea-shaped and the electrodes are mounted on very long, slender supports. This renders the valve distinctly microphonic and makes the risk of injury through accidental jarring considerably greater.

The D.E.R. is, however, a very satisfactory valve to use on the receiving set, and, as has been shown, it has a long life.

The three more expensive types

Cell.	Size.	Weight.
Ever Ready E.	$2\frac{5}{8} \times 6\frac{1}{2}$	2 lb. 4 oz.
Siemens B.	$2\frac{11}{16} \times 7$	2 lb. 4 oz.
Siemens 640	$2\frac{5}{8} \times 6\frac{3}{4}$	2 lb. 3 oz.

Table 2.

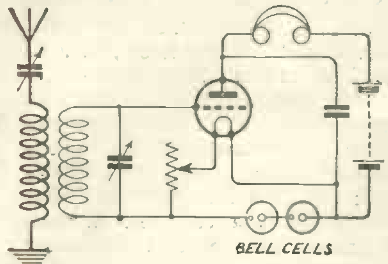


Fig. 3.—How to use bell cells.

are the Mullard L.F. Ora A, the M.O. D.E.V. and the M.O. D.E.Q. The first of these takes 0.2 ampere at 1.8 volts. D.E.V. and D.E.Q. have the smallest current consumptions amongst British-made valves, their requirements being less than 0.2 ampere. The voltage needed for them is 3.

L.F. Ora A has much the same characteristics as B and C; but owing to the thinness of its filament it is not a valve to be used by those whose sets receive any kind of rough treatment.

D.E.V. and D.E.Q. are also delicate valves, but if carefully used they will stand a great deal of work. The writer can speak from experience here again, for he has had four of them in constant use for the last eight months on one set.

D.E.V. is the low-frequency amplifier; D.E.Q. the rectifier and H.F. amplifier. The latter is the more satisfactory valve of the two, for D.E.V.'s filament is liable to become slack even if it is used in an upright position. If this happens it jumps on to the grid at almost regular intervals when the set is in use, and its light can be observed to flicker like that of a candle flame in a draught. A " toc " is heard in the receiver at every flicker, and the valve becomes useless, though it may recover if laid aside for a time.

To tabulate the requirements of dull-emitters now on the market we can sum them up as shown in Table 1.

It will be seen that there is no valve which comes within the compass of a single dry cell as regards the E.M.F. required, but two cells in series would give voltage enough for any of the first five, even when the E.M.F. had fallen off to half its original value. Using a good rheostat we can work any of these valves in this way, provided that we use cells of suffi-

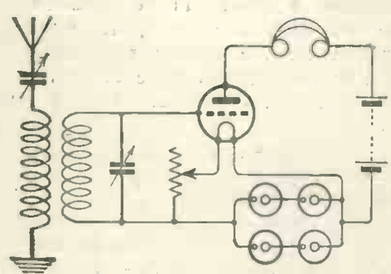


Fig. 4.—Series-parallel arrangement of cells.

cient size. With ordinary bell cells, however, it is better to use a single pair in series only for L.F. Ora A (Fig. 3); the low-priced dull-emitters should be worked with the circuit shown in Fig. 4, where four cells are used in series-parallel. For D.E.V. and D.E.Q. three cells are used in series, as seen in Fig. 5.

Even if quite big cells are used

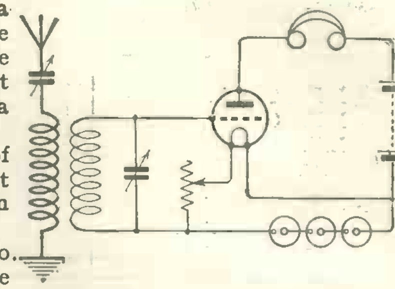


Fig. 5.—How to use cells for D.E.V. and D.E.Q. valves.

it is not advisable to work more than one valve off the same combination. The multi-valve set should be wired as shown in Fig. 6, each valve having its own battery of dry cells.

If bell cells are used it is best to purchase those that are of good make and of respectable dimensions. Typical cells suitable for the purpose are the " E " cell made by the Ever Ready Battery Company, and the Siemens " B " or No. 640 cells. The dimensions of these are as shown in Table 2. All are round in shape.

Four of these cells in series-parallel would, if well used, give at least 100 working hours with a discharge rate of 0.4 ampere, all as is required for the D.E.R. and L.F. Ora C. At the end of this time their voltage will have dropped to about 0.9, but their useful life is by no means ended. By placing other cells in series as the voltage falls, cells can be worked until their E.M.F. has fallen to 0.5, and even then they may be given a new lease of life if holes are bored in them and they are placed in jars filled with sal ammoniac solution.

Both of the companies mentioned make special batteries for heating dull-emitter filaments. These are of very large size and have a long working life. Particulars of some of them are shown in Table 3.

To know what these big batteries can do it may be said that the Ever Ready D.S. 62 will give 500 burning hours with D.E.R. or Ora C, and about 700 with either L.F. Ora B or A.R. D.E.

The Ever Ready batteries have two terminals only. The Siemens types have several. The first pair give the voltages indicated in the table, the third and fourth terminals provide 1½-volt step-up, so that additional voltage may be brought in as the battery's initial pressure begins to fall off.

When purchasing dry cells it

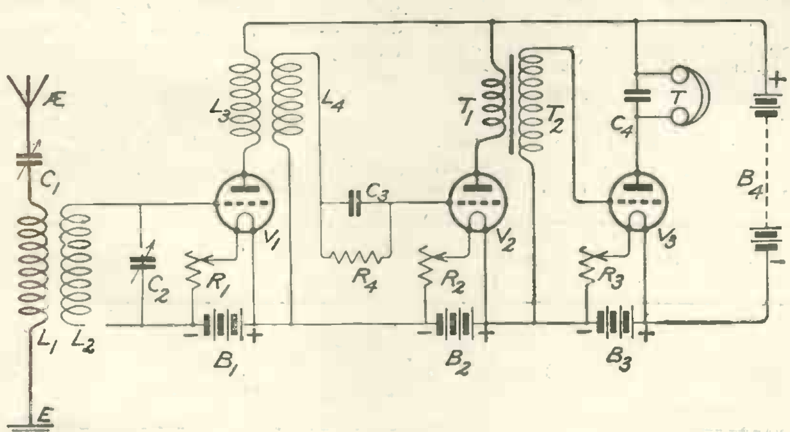


Fig. 6.—If several valves are used it is wise to use separate cells for each valve.

Battery.	Volts.	Size.	Weight.	Price.
Ever Ready W. 562	3	8½ in. × 8½ in. × 8 in.	34 lb.	40/-
Ever Ready W. 615	3	8½ in. × 4¼ in. × 8 in.	18 lb.	20/-
Ever Ready W. 616	4.5	12¾ in. × 4¼ in. × 8 in.	26 lb.	30/-
Siemens 853	3	13¼ in. × 5¼ in. × 6⅞ in.	26 lb.	31/6
Siemens 908	3	13 in. × 3¼ in. × 7⅜ in.	22 lb.	30/-
Siemens 907	3	13 in. × 3¼ in. × 7⅜ in.	22 lb.	30/-

Table 3.

should be borne in mind that their weight gives a very fair guide to their capacity. If, for example, a 2 lb. cell gives a certain number of working hours, then one of 4 lb. will give considerably more than double that number, and one of 1 lb. considerably less than half.

Used with care and discretion, dry cells will work dull-emitter valves in the most satisfactory way. The set should never be run for very long periods, and the filament current should be always switched off when even a short interval in a broadcasting programme is announced. Cells should be kept dry, but they should not be in too warm a place, otherwise the moisture that they contain will evaporate gradually and render them inactive.

The ordinary dry cell tends to "go off" in time if stored, even though it is not in use, owing to the evaporation of its moisture. Therefore, if reserve cells are kept in stock, as they should be in case they are required to bring up falling E.M.F., it is well to lay in, not *dry* cells, but *inert* cells. The latter are quite inactive until water has been poured into them. Until they are moistened they will retain their qualities indefinitely if properly stored.

FROM OUR READERS

NEWS AND VIEWS

The "M. W." Portable Dual Set.

To the Editor of MODERN WIRELESS.

DEAR SIR,—I thought you would like to know that I have had very satisfactory results with the portable 1-valve (dual) set described in No. 6 of your splendid journal.

As stated, the strength of the signals is very surprising.

In place of the variometer I have used a No. 75 Igranic coil tuned by a .0005 condenser in series and have succeeded in bringing in all the broadcasting stations (including Glasgow) with fair strength on telephones.

Personally, and from friends' opinions, I should think that the above results are somewhat above the ordinary.

Yours faithfully,

(Signed) J. A. OTTLEY.

S. Tottenham, N. 15.

American Broadcasting on "M.W. All Concert" Set.

To the Editor of MODERN WIRELESS.

SIR,—May I congratulate you on the design of the 1 R 1 "All Concert" receiver given in this month's MODERN WIRELESS. I finished a set on Monday night, and have been able to receive Glasgow on an Amplion junior, sufficiently loud to be comfortably audible. To my surprise on Friday between 3 and 3.30 a.m. I picked up a concert; also a talk to farmers and reference among other things to dollars and cents, and the United States. I missed the name of the station.

The set has been made up exactly as directed, except that I used a telephone jack and have not yet purchased a 1 μF condenser.

Yours faithfully,

J. L. C. GREGORY.

Bush Hill Park, Middlesex.

More about the S.T. 100.

To the Editor of MODERN WIRELESS.

DEAR SIR,—*Re* the S.T. 100 circuits in MODERN WIRELESS, I have tried them all in turn, and find the circuit No. 4, page 528 August issue, is the finest circuit I have ever worked, both as a long-distance receiver and as general Broadcast receiver.

At first I could get nothing, but found by experiment that I was using the wrong value coils on the second plate and as H.F. Choke coil.

I use home-made basket coils wound on ebonite discs and pins, leaving disc in coil to make it a strong, well-mounted unit, and it is rather difficult to decide what number of turns equal the given Igranic coils in your book.

It may be of assistance to some readers to know that using basket coils and .0005 tuning condensers in parallel, the number of turns of 28 enamelled wire on 1½ in. formers is :—

For A.T.I coil, 45 or 50 turns, for B.B. Stations.
For 1st Plate coil, 66 turns.
For 2nd Plate coil, 70 turns.
H.F. Choke coil, 75 turns.

I also find a master filament resistance is of great assistance if placed in the positive filament between accumulator and set.

Newcastle and Cardiff are received with remarkable clearness and strength, and Birmingham and London come next; Manchester for some unknown reason is not so good; but Newcastle comes in quite equal to a 4-valve set of ordinary circuit design.

Thanking you for such a splendid circuit, which I find very stable and free from A.C. hum (6,000 V. mains are 20 yards from my aerial) and 120 V. A.C. lighting mains run within a few feet of the set on the wall).

I remain,

Yours faithfully,

W. H. M. GOODWIN, S/S, R.E.

D.O.R.E., Bulford Camp, Wilts.

Several Interesting Letters are Unavoidably Held Over.

A "RING-SLIDER" CRYSTAL SET

By G. P. KENDALL, B.Sc., Staff Editor.

Here is yet another design for a crystal receiver. Readers will be interested to compare its merits with those of previous M.W. sets.

THE crystal receiver which is to be described in this article possesses certain features of interest which should appeal to the crystal enthusiast who is tired of the conventional designs and wants something novel but yet efficient and easy to make. This instrument certainly fulfils these requirements, its chief attraction being the type of variable inductance which it incorporates. The coil is of a type rather resembling the one used by Mr. Percy W. Harris in the crystal set which he described in last month's *Junior Wireless*, which was adapted from it in a way which simplified its construction. It has not, I think, yet been described in a British publication, but it is not new, consisting as it does of a winding put *through* the tubular former instead of *round* it, thus producing a ring-shaped coil like the resistance element of a filament rheostat, which has a contact-finger running round its edge to vary the number of turns in circuit, again exactly like a filament resistance. The detailed instructions which follow will, I think, enable a successful instrument of a similar description to be made without difficulty.

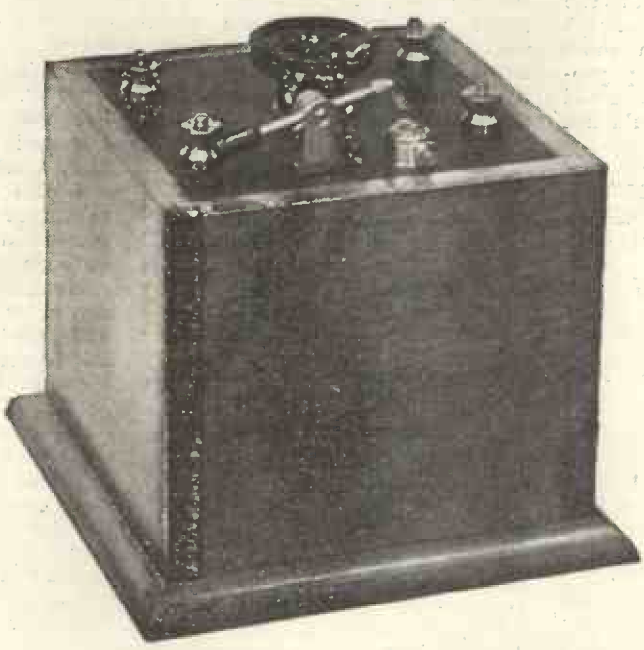


Fig. 1.—The complete receiver occupies little space and is tuned by turning the central knob.

The Box

The small cabinet which I used for the receiver shown in the photographs is one of a standard pattern supplied by Messrs. Scientific Appliances, and was obtained complete with an ebonite panel at a figure which made it scarcely worth while to make it for myself. Some constructors, however, appear to take a pleasure in the woodwork part of the making of a set, and for their benefit the dimensions of the box are given in Fig. 3.

It may be made of any hard wood of a thickness of ⅜ inch and a varnish finish will improve its appearance. The only point in its construction demanding some care and accuracy is the fitting of the four square pieces in its corners to support the ebonite panel. These should be attached with glue, and if their length is limited to, say, two inches they can be accurately adjusted to the correct height by placing the panel in position and sliding them up and down until the panel is supported at each corner and is flush with the edges of the box.

Drilling the Panel

The dimensions of the panel and the positions of the holes for the attachment of the parts are given in Fig. 4. The thickness of the ebonite should preferably be quarter-inch, but since it is small and has little weight to carry three-sixteenths will suffice and is cheaper. If the thinner grade is used a little care is necessary in drilling to avoid breakages and the "pilot hole" method should be adopted for safety's sake. (Put a small drill, such as a ⅛ inch through first at each point and follow it with one of the size required).

The Inductance

The coil consists of a winding of No. 26 enamelled wire, completely filling the former with the exception of a section about half an inch wide. The former upon which it is wound is a ring cut from 3¾-inch fibre tube having a ¼-inch wall and 2 inches long. The method of winding will be quite plain from an inspection of the photograph of the underside of the panel. It was done in the case of the receiver illustrated by fastening the end of the wire through two holes in the former in the usual way and then winding by passing the bobbin of wire repeatedly through the fibre ring, placing the turns neatly in position as each was made. This, obviously, is a laborious process, as I realised before much of the job was done. A little more forethought and less impetuosity would have shortened it very much by the adoption of the simple expedient of a saw-cut through the former to enable the turns to be slipped into the ring without passing the bobbin through it. The cut, of course, should be made at the point previously mentioned which is not to be covered with the winding,.

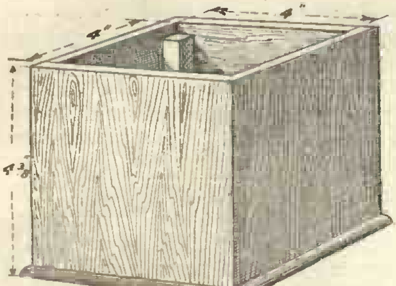


Fig 3.—Dimensions of box.

When the winding is finished the wire is to be rubbed bare with sand-paper along the edge of the coil to provide a track for the contact arm.

The method of a attaching the coil to the panel consists of the use of two small brackets attached by screws at opposite sides of the ring. One of the brackets is best placed in the ½-inch section of the ring which is not occupied by winding, while the other should be screwed to the fibre before the winding is done, so that the wire may be carried round and to some extent over its upper part, thus preserving an unbroken surface of turns on the upper edge of the ring for the contact arm to run upon. This will be found quite easy if the turns are bunched a little on either side of the bracket.

The brackets which I used are made of ebonite for the reason that my scrap-box chanced to contain two ready to hand, but failing such a piece of good fortune they should be made from strip brass to the dimensions indicated in Fig. 5.

The contact arm is a simple arrangement consisting of a strip of springy brass, copper or phosphor-bronze, ⅜ inch wide and 2 inches long, clamped between two nuts upon a piece of 2 B.A. threaded brass rod which passes up through the panel and terminates in a knob. The rod is supplied with a brass bush to carry it through the panel, and furnished with a spring-washer kept under compression by two nuts to ensure that the rod shall revolve steadily. The tension of the contact arm must be adjusted by screwing the two nuts which hold it up or down the spindle until it presses moderately firmly upon the edge of the coil. The assembly of these parts is shown in Fig. 6.

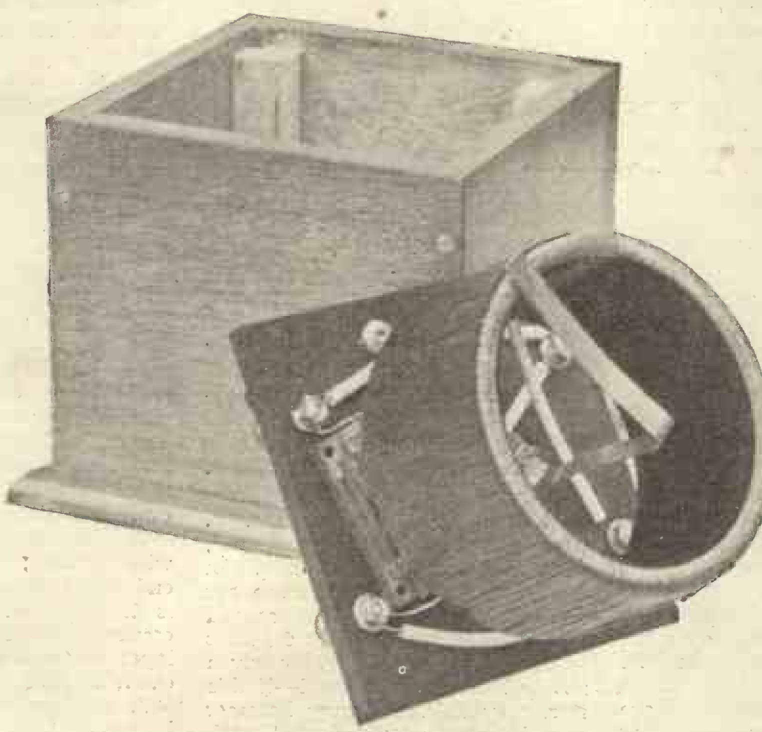


Fig. 2.—Showing the method of tuning on a ring coil.

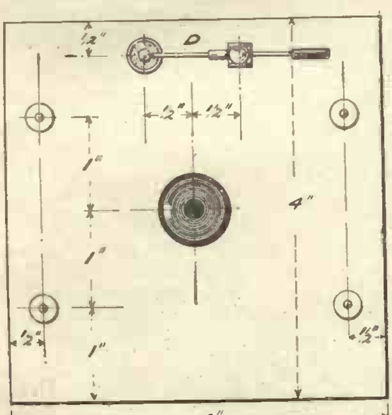


Fig. 4.—Drilling diagram.

Crystal Dectector.

The detector shown was assembled from one of the cards of parts which are now upon the market, and gives quite good results with a gold cat-whisker and a piece of Hertzite. A form of detector passing a screw motion for adjusting the pressure of the contact upon the crystal would be a considerable improvement, however, both in giving ease of adjustment and in increasing the strength of signals.

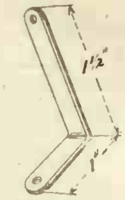


Fig. 5.—Bracket for attaching coil to panel.

Telephone Condenser.

The capacity of the telephone condenser should be about 0.002 μF, and no doubt most readers will prefer to buy one ready made. It can be made, however, by assembling two sets of copper foil sheets, five foils in each set, and each sheet one inch square, interleaved with mica and clamped against the underside of the panel with a piece of ebonite 1½ inches square with screws through its corners.

If the purchased variety is used it need not be fastened to the panel, since if the two wires which connect it to the telephone terminals are reasonably stiff (use No. 18 or 20 S.W.G.) they will hold it in place quite securely.

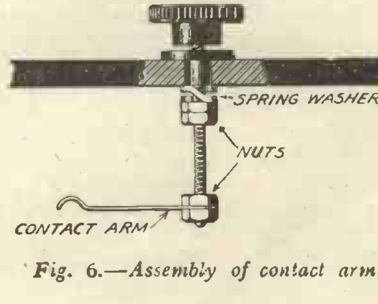


Fig. 6.—Assembly of contact arm.

Wiring-Up

The wiring of the receiver is shown clearly in Fig. 7, and is so simple that no difficulty will be experienced. As will be seen, my set is wired with No. 18 tinned copper wire sleeved in white systoflex, but this was only done to make the connections show in the photograph, and bare wire will serve just as well.

Results

The efficiency of the set appears good, and compares favourably with that of other receivers employing a tapped or otherwise variable tuning coil wound with a similar gauge of wire. Upon an indoor aerial at a distance of five miles from 2LO it gives quite good signal strength, and should be good up to about 20 miles with an outdoor aerial of reasonable efficiency.

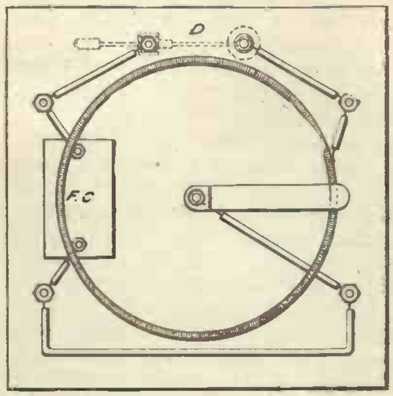


Fig. 7.—Wiring diagram.

A Hint.

A good idea which won a prize in a wireless competition some while ago in an American magazine was to have several cat-whiskers bearing on the same crystal, the various cat-whiskers being taken to stnds of a switch, so that by moving the switch arm you could choose very rapidly one point or another according to which was the best.

A NOTE ON ANCHORING MAST STAYS

By R. W. HALLOWS, M.A. (Staff Editor).

THE security of the aerial mast, particularly if it be a high one with long wires to support, depends to a very large extent upon the quality of the anchorages provided for its stays. If these have no sound "grip of the ground" they will very soon work loose. The mast will then begin to sway more and more, and as the gales of winter wreak their fury upon it, it may become so tottery as to be a menace to the lives and the property of the neighbours.

The best of all anchorages are made by sinking holes and filling them with concrete after the iron attachments for the mast stays have been placed within them.

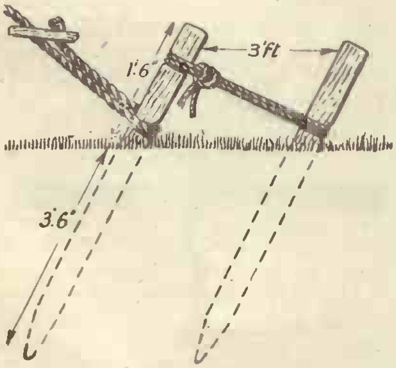


Fig. 1.—A useful ancnorage of great strength.

But not many of us are sufficiently versed in the art of concrete mixing to be able to undertake this job ourselves, and if we call in the local builder to help us, his bill is likely to be heavier than we care about.

A very simple form of safe anchorage is shown in Fig. 1. Two 5-foot stakes are required, pointed at their lower ends. In one of them two notches are cut at opposite sides. The second has a single notch 1 foot 6 inches from its top. The stakes are driven nearly home with a maul—if this is not available a heavy hammer may be used provided that each stake is bound with wire for a few inches near its top, to prevent it from splitting under the blows.

The mast stay is now fixed to the lower notch of the first stake, and a wire cable or a stout rope is taken from the upper notch of this stake to the single notch made in the other. Both stakes are now driven home.

This combination of a pair of stakes is called a hold fast, and provided that the line of pull is almost at right angles to their slope they will stand a terrific strain before beginning to draw.

Another good anchorage is shown in Fig. 2. In this case pieces of railway sleeper are used. The ordinary sleeper is 6 feet in length by about 10 inches in width and four in thickness. One sleeper sawn in halves will make two anchorages. Old sleepers can be purchased from the railway companies, and as they are impregnated with creosote they can be relied upon to last for a long time, even if buried in damp soil.

A hole 3 feet deep and 3 feet in width is dug; the sleeper with the end of the mast stay secured to it is then placed in the hole and covered with large stones and a layer of earth. This is rammed down hard, and the hole is filled in.

A still moae secure job can be made if the hole is made only 2 feet in width, a further foot being undercut by means of a crowbar, so that one end of the sleeper rests under undisturbed soil. R.W.H.

Fig. 2.—This method will often help to make an even more secure anchorage.

WIRELESS IN THE NEXT WAR

Possible Lines of Development

Will the predictions of the novelists prove accurate? The writer of this note thinks otherwise.

WHAT will be the role of wireless in the next war? The war clouds in Greece and the Balkans, which have happily cleared away, remind us that human nature has not altered sufficiently to warrant the hope expressed a few years ago that there would be no more war, and it is only to be expected that the minds of many people have turned to the thought of the possible achievement of radio in any future hostilities.

The outbreak of the Great War in 1914 found wireless only moderately useful, for since its invention there had not been any previous large war to stimulate its development along military lines. Of course, on board ship it was of immense use and with the aid of codes a considerable degree of secrecy was obtained; but there remained the risk that the code might be stolen, intercepted or translated. Further, as directional wireless was in its infancy, the necessity still held of broadcasting a message in every direction if it was to reach its desired goal. Even now directional transmission from ships is in an early stage of development, and although it is possible to direct a beam for many miles in one direction only, it cannot by any means replace the present all-round transmission when distance and reliability are to be obtained.

Now, strictly directional transmissions would be of immense use in naval warfare, for not only should we ensure a considerable degree of secrecy, but it would be possible to carry on many simultaneous transmissions on the same wave-length in different directions without mutual interference. The ether is now so crowded and tuning needs to be so very sharp to utilise the narrow band of wave-lengths not actually occupied at any moment that we may be sure that under stimulus of further warfare directional transmission will be developed to a very high degree of perfection. Directional *reception* was largely developed in the last war with deadly efficacy in localising enemy stations, and has continually improved since the cessation of hostilities. This, combined with the directional transmission which we have foreshadowed, should alter very considerably the aspect of wireless in war.

In another direction—that of the elimination of interference—we may also expect very great developments. Unintentional interference itself is a very great worry in peace-time, and when we have added to this interference of a type set up by an enemy with no other purpose than to upset the opposing communications, we need the most ingenious and elaborate method to secure immunity. Natural interference from atmospheric disturbances of whatever sort is the greatest bugbear in practical radio at the present time, and the steps being taken and the experiments being made by numerous radio scientists throughout the world will also serve to help in reducing the deliberate interference.

Long before the outbreak of the 1914 war we had heard a great deal, and read still more, about the wonderful possibilities of wireless control. This aspect of radio has always appealed very strongly to imaginative writers, and usually the smaller the knowledge of radio on the part of the writer, the greater his predictions of future possibilities. Indeed, we used to hear that, should there be a war, wireless controlled aeroplanes and ships would race about, darting into enemy harbours, destroying ships, forts, towns, and even whole armies. And yet wireless control was hardly used in the last war, and then only in minor action, where indeed its use was fraught with nearly as much danger to the controllers as to the possible victims. So far, to the best of our knowledge, it has been found impossible to obtain the three prime requisites of range, reliability and immunity from interference by the enemy in wireless control of instruments of warfare. By wireless control, of course, we refer to the complete operation by wireless, not to the transmission of orders from one point to another where by further human agency the apparatus can be operated.

Whatever new inventions may come along (and the man who is clever enough to describe future inventions is usually sufficiently clever to invent them for himself), the greatest use of radio in future warfare will be in the organisation and elaboration of communications everywhere. Secrecy and immunity from disturbance will doubtless be obtained by strictly directional transmissions and reception, together with a possible use simultaneously of several wave-lengths, so that unless the receiver is tuned to them all, nothing whatever will be received. The deciphering of enemy messages will thus be so difficult a matter as to tax the ingenuity of the greatest experts, for the mathematical chances of an investigator lighting upon the correct combination, directions and other variable factors will be exceedingly small, and before the chance of deciphering has arrived, new changes can be introduced. At present, whatever wave-length is being used, a search on all waves is a comparatively simple matter, while the use of multi-valve amplifiers enables us even now to listen to weak signals over incredible distances. Finally, we are inclined to think that the uses of wireless will be far less sensational and far more practical than is usually predicted. Such is generally the case in warfare.

H. W. P.

A CORRECTION.

On page 581 of the September issue of MODERN WIRELESS, Fig. 7 contains an error. The lead from O.P. of the inter-valve transformer should go, not to the telephones, but to the bottom of condenser C4. Fig. 8, the pictorial representation, was correct.

THE PRINCIPLES OF THE RECEPTION AND TRANSMISSION OF BROADCASTING

By ***E. REDPATH*** *(Assistant Editor).*

A Simple Explanation of the Essentials of the New Art.

UNTIL fairly recently, the writer was frequently asked the question : " Can apparatus designed for the reception of wireless *telegraphy* be used for the reception of wireless *telephony* ? " The answer to this question is, of course, in the affirmative, provided that the apparatus in question is capable of adjustment to the wavelength employed by the transmitting station.

In other words, if the receiving apparatus can be tuned to resonance with the transmitter, the same detecting devices which enable Morse signals to be heard will similarly enable speech, music, etc., radiated from a broadcasting or other radio-telephone transmitting station, to be received.

The Transmitting Apparatus

The transmission of satisfactory radio-telephony was made possible by the development of continuous-wave transmitters, employing an arc or, more usually, three-electrode valves, and capable of radiating electro-magnetic waves of very high frequency and constant strength or amplitude as long as the transmitting key was depressed.

These waves, impinging upon a receiving aerial tuned to have the same oscillation frequency, set up oscillatory currents in it and its associated circuits, but, on account of the high frequency of the currents and the entire absence of any break or interruption *at an audible frequency*, the telephones connected to the receiving apparatus give no indication of their presence.

If there were not a definite " break," but merely a variation in strength or amplitude of the incoming waves, occurring at a frequency within the audible limits, then such variations would produce corresponding sounds in the telephone receivers as the diaphragms were attracted to the poles of the magnet with greater or less force.

The essentials, therefore, at a radio-telephone transmitting station are, firstly, the usual aerial system by means of which electro-magnetic waves may be radiated; secondly, apparatus capable of impulsing the aerial with sufficient rapidity to maintain the radiation of continuous waves of constant amplitude; and, thirdly, a means of varying (or modulating, as it is termed) the amplitude of the emitted waves by the action of, and in exact accordance with, actual *sounds* (speech, music, etc.) at the transmitting station.

Consider the action involved in the case of ordinary *line* telephony. Here the essentials are a piece of apparatus known as a microphone, the electrical resistance of which is varied by the impact of sound waves upon a carbon diaphragm ; a battery ; the connecting line-wires and a telephone receiver.

Upon a person speaking into the microphone, its electrical resistance is altered and more or less current from the battery flows through the circuit, which, in the simple arrangement now used merely as an illustration, includes the microphone itself, the battery, the line-wires and the windings of the telephone receiver. The fluctuating current through the telephone windings alters the " pull " of the permanent magnet and a slight movement of the diaphragms results. A series of fluctuations causes a series of diaphragm movements, and the sounds emitted by the telephone receiver correspond to the original sounds addressed to the microphone.

Fig. 1 represents diagrammatically a complete radio-telephone transmitting station. The aerial circuit comprises the aerial itself, Æ, the aerial tuning inductance ATI, the earth or " blocking " condenser EC, hot-wire ammeter HWA and the earth connection E.

The anode circuit includes the anode of the valve, a certain number of turns of the ATI (common to both aerial and anode circuits), the reservoir condenser RC, across which is connected the high-tension supply (1,000 to 2,000 volts) *via* the two iron-core choke coils C_1 and C_2, and the negative side of the valve filament.

The grid circuit, which in an ordinary C.W. transmitter would include the grid itself, grid condenser and leak, GC and GL respectively with a connection to the negative side of the filament *via* the transmitting key, now has the key removed, and in its place there is the secondary winding T_2 of an iron-core transformer, the primary T_1 of which, in series with a microphone M, is connected across the 6-volt filament lighting battery B_1.

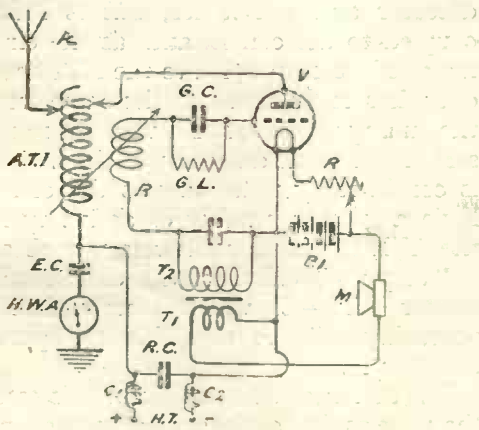


Fig. 1.—The circuit of a radio telephone transmitter.

The Action of the Transmitter

When the valve filament is glowing, the high-tension supply connected and all circuits complete as shown in Fig. 1, continuous oscilations will be set up in the aerial circuit Æ, ATI, EC, E; and continuous waves will be radiated from the aerial, the wavelength (and frequency) being determined by the electrical dimensions of the complete aerial circuit.

At a distant station, the aerial circuit of which is in resonance with the transmitting aerial, continuous oscillations will be set up in the aerial and associated circuits, but, as already explained, there will be no audible indication of their presence.

If the microphone M is now spoken into, the changing currents in the transformer primary T_1 induce currents into the secondary T_2, but at considerably higher voltages owing to the "step-up" ratio of the transformer. These comparatively high voltages are applied to the grid of the valve, so varying its potential with respect to that of the filament and, in accordance with the well-known principle of the three-electrode valve, varying the flow of electrons to the anode, or, in other words, the anode current.

As the amplitude of the radiated waves depends upon the strength of the anode-current impulses given to the ATI, the "voice variations" due to the microphone are accurately reflected by the variations in amplitude of the emitted waves.

By this means, the steady wave-stream from the transmitting aerial, known as the "carrier-wave," and which may be considered as taking the place of the connecting wires of the ordinary line telephone, has super imposed upon it, as it were, the varying "ripple" of the audio-frequency speech variations.

There are several methods by means of which the carrier-wave may be modulated by the microphone currents. That illustrated in Fig. 1 is known as "grid modulation." Other methods were described in the article, entitled "Methods of Telephony Control," by Mr. Eckersley, which appeared in *Wireless Weekly*, Vol. 2, No. 4. It remains to consider how the receiving apparatus deals with the incoming carrier-wave with its super imposed audio-frequency variations.

The Receiving Apparatus

As mentioned in the opening paragraph of this article, any form of receiving apparatus which can receive and detect Morse signals and which can be tuned to the wavelength employed by a radio-telephone station can be successfully used for reception from that station.

A question will here arise in the minds of many readers as to why it is that, although quite good "spark" signals are receivable over a few hundred miles upon a crystal receiver, and trans-Atlantic C.W. signals upon a single-valve set, fairly elaborate apparatus is required for the reception of broadcast transmissions if the distance to be covered exceeds (say) one hundred miles.

There are two main reasons for this. Firstly, the power employed by some of the high-power stations is of the order of 80 kilowatts, whilst that of the British Broadcasting Stations is merely $1\frac{1}{2}$ kilowatts, and, secondly, the "modulation" of the carrier-wave is rarely complete; that is to say, the voice variation represents only a portion, and sometimes a comparatively small portion, of the total power radiated.

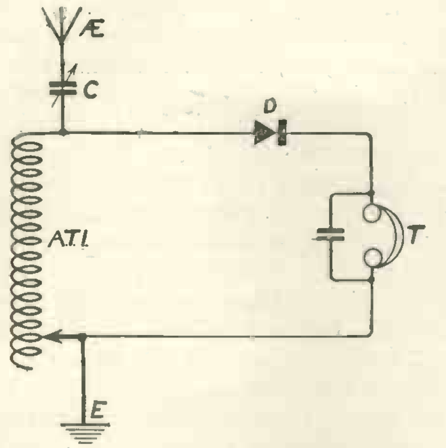


Fig. 2.—A simple form of crystal detector.

Certain sounds, or portions of sounds, may cause only slight variations of the strength of the carrier-wave.

A Crystal Receiver

Fig. 2 represents the simplest form of crystal receiving set. A set of this type will usually give good results when used in conjunction with a good aerial up to a distance of about 15 to 20 miles from a broadcasting station.

The great disadvantage of this type of set is that owing to the damping effect produced by connecting the detector and telephones directly across the ATI, the efficiency is lowered and the tuning is not at all selective.

The action of a receiving set, as illustrated in Fig. 2, is as follows:

The aerial circuit being tuned to resonance with the incoming waves, oscillatory currents are set up in it and the differences in potential caused between opposite ends of the ATI are applied to the crystal detector and telephones. Obviously any currents which flow through the telephone windings have to pass across the contact of the detector and, owing to the special properties of the latter, pulses in one direction are permitted to pass, whilst those in the opposite direction are stopped.

The carrier-wave, therefore, sets up oscillatory currents in the ATI, and rectified pulses of current flow through the telephone windings. Owing to the high frequency of the oscillatory currents (and, of course, the rectified pulses, for the operation of rectification alone does not alter the frequency in any way), no sounds are produced in the telephones.

When the microphone at the transmitting station is spoken into, however, the amplitude of the carrier-wave, also of the oscillatory currents and rectified pulses in the receiver, are varied at *audible* frequency and the telephone diaphragms respond, reproducing the actual words spoken at the distant station.

Fig. 3 shows an arrangement which is a considerable improvement upon that of Fig. 2. It will be seen that the aerial circuit is now distinct and separate and that the crystal detector D and telephones T are connected across the variable condenser C in the closed oscillatory circuit LC. Thus the aerial circuit does not part with its energy direct to the detector and telephones, but is inductively coupled to the coil L, and, as the circuit LC may be loosely coupled to the ATI and, moreover, has to be tuned to the same frequency, the tuning of the set as a whole is much more selective and the damping of the aerial circuit is considerably reduced. As the coil L may have a greater number of active turns than the ATI, the further advantage is obtained of a "step-up" effect in the oscillation transformer ATI—L, which means that higher potentials will be available to operate the detector D.

The action of this modified set is essentially the same as that of the set represented in Fig. 2, but on account of the advantages mentioned, the inductively-coupled receiver is greatly to be preferred for the reception of radio-telephony and, if carefully used in conjunction with an efficient aerial, should give quite good results at distances up to about 20 to 25 miles from a broadcasting station.

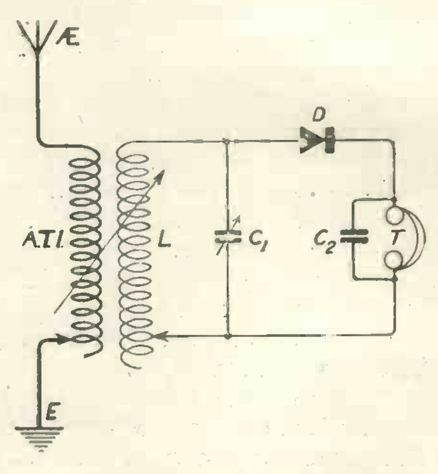


Fig. 3.—An improvement upon the circuit of Fig. 2.

A Single Valve Receiver

Either of the arrangements illustrated in Figs. 2 and 3 may readily be used with a three-electrode valve replacing the crystal detector, as shown in Fig. 4, which represents an inductively-coupled tuner with a valve as rectifier.

The aerial circuit comprises the aerial itself, Æ, the aerial tuning inductance ATI with separate primary coupling coil P and the earth connection E. The closed oscillatory circuit comprises the inductance coil L and the variable condenser C, opposite sides of the latter being connected to the grid (*via* the condenser and leak) and positive side of the filament of the valve. The anode circuit includes the anode itself, the high-tension battery B_2, 45 to 100 volts, the telephone receivers T (shunted by the usual small fixed condenser) and the valve filament.

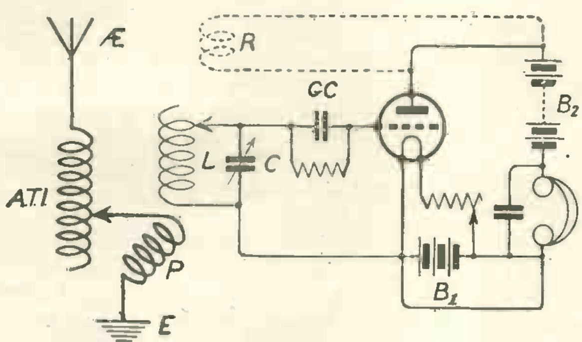


Fig. 4.—An inductively-coupled receiver using a valve as detector.

Although this arrangement gives quite satisfactory results and is very reliable in operation, it is not very much better than a good inductively-coupled crystal set, as far as receiving range and strength of signals are concerned, unless the principle of reaction is employed by the introduction (in the anode circuit) of the additional "reaction" coil R. This coil, which is to be variably coupled to the closed circuit inductance L, is shown dotted in Fig. 4.

Unfortunately (or perhaps fortunately for those who are closely adjacent to receiving stations where the principle might be used carelessly or recklessly), this method of employing reaction is contrary to the regulations, and may on no account be used on the broadcasting wavelengths during broadcasting hours.

It may be tried, however, on the longer-wave telephony, such as that of The Hague, Radiola, Eiffel Tower, etc., but should always be used with care and with a loose coupling between the aerial and closed oscillatory circuits. In this connection it will be found that, as the coupling is loosened, the tendency of the set to generate oscillations is increased, and to prevent this occurring the coupling between the reaction coil R and the inductance L should also be weakened.

The action of the set, as illustrated in Fig. 4, is as follows: The oscillatory currents set up in the aerial circuit when in tune with the distant station are induced into the closed circuit LC and applied to the grid and filament of the valve. Except for the high-resistance leak (probable value about 2 megohms), the grid is insulated as far as *direct* current flow is concerned by the condenser GC, although the condenser affords a ready passage to the oscillatory currents from the variable condenser C.

To commence, there will be a small but appreciable steady current from the H.T. battery flowing through the telephone windings. Upon the arrival of the carrier-wave, the secondary oscillations applied to the grid of the valve cause a sudden change in its potential, and consequently a change in anode-telephone current. Once this change has occurred, however, and a new steady current value is arrived at, no further sound is emitted by the telephone diaphragms, beyond possibly a slight "breathing" sound due to slight and unavoidable irregularities in the carrier-wave.

When the carrier-wave is modulated, however, by the action of a voice upon the transmitting microphone, the audio-frequency variations in amplitude of the oscillations in the receiving set, rectified at the grid due to the action of the grid condenser and grid leak, give rise to audio-frequency changes of anode-telephone current, and the telephone diaphragms vibrate in sympathy, giving forth a reproduction of the original speech.

Where reaction is employed, some of the energy in the anode circuit is "fed back" into the grid circuit, where, provided that the direction of winding of the reaction coil and the secondary coil are in the correct sense, it strengthens the original oscillations and so increases the variations of grid potential.

If the reaction coupling is excessive, self-oscillation will occur; the carrier-wave will be "heterodyned" and will be heard as a persistent note, the pitch of which will vary as the tuning of the aerial or closed circuits is altered, and even though the pitch of the note is lowered until the "silent point" is reached (*i.e.*, until transmitter and receiver are exactly in resonance), the received telephony will probably be greatly distorted.

The foregoing principles apply whatever combination or arrangement of apparatus is employed. A valve or valves may be employed as high-frequency or low-frequency amplifiers, in conjunction with either a crystal or valve detector, whilst the methods of coupling the various valves may vary considerably.

The only additional principles which the reader is advised to keep in mind are as follows:

(1) A valve may readily be used in conjunction with a crystal, either for high-frequency amplification (where an increased range is desired) or for low-frequency amplification (where considerable amplification of already audible signals is aimed at).

(2) The smallest number of valves to form a set in which reaction may be employed in accordance with the P.M.G.'s regulations is two. The reaction coil (in the anode circuit of the second valve) may be coupled to the tuned transformer secondary (in the grid circuit of the same valve) or to the anode tuning coil of the first valve.

(3) Excessive "reaction," whether capable of causing interference or not, is certain to cause distortion of the received telephony.

A SIMPLE POTENTIOMETER

An efficient potentiometer may easily be constructed from an old wire bobbin about 3 in. long and a few odd accessories. A useful addition to the usual type of potentiometer is involved in this design, namely, a pointer and scale for the purpose of reading the voltage. In Fig. 1 the general arrangement is shown. The bobbin is first wound with some No. 40 S.S.C. wire along its entire length, leaving about ¼ in. each end clear of the flange. The ends are passed through a small hole drilled through each flange respectively. The wire is then varnished. A slot is cut in the top and bottom flange, as shown on the right of the figure, to receive the spindle of the rotating contact blade. The bobbin is now fixed by means of two screws passing through the top flange to the underside of the panel, and a hole is drilled in the panel to correspond in position with the inside extremity of the slot in the flange. The end of the wire, at the top of the reel, must be pulled clear before fixing. The rotating contact blade is next made as shown in the illustration. The length of the blade itself is slightly less than the distance between the internal edges of the two flanges. To each end of the blade is soldered a short spindle of a diameter to suit the slot. The top spindle passes through the hole in the panel and rests in the slot, a washer being placed between the underside of the flange and the blade. The bottom spindle rests in its corresponding slot, a washer also being placed between the blade and the top side of the bottom flange. A spring is attached to the bottom spindle and passed over to a small screw fixed in an opposite position on the underside. The top spindle is treated in a similar manner, the spring passing from the spindle on the upper side of the panel to a screw in a corresponding position. The end of the top spindle is threaded to receive a pointer and knob, and a scale divided into 4, 8 or 12 equal parts is fixed to the panel. The rotating contact blade itself must be twisted to one half of a pitch along its entire length, and the scale is accordingly semi-circular. The edges of the blade must be quite smooth, and the wire winding should be bared along the line of contact. The springs at each end of the blade give the correct tension on the wire.

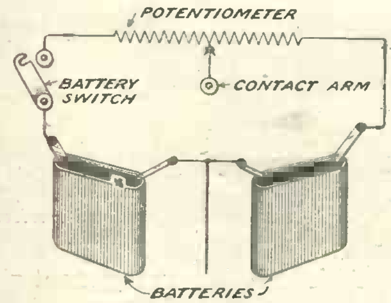


Fig. 2.—Connections.

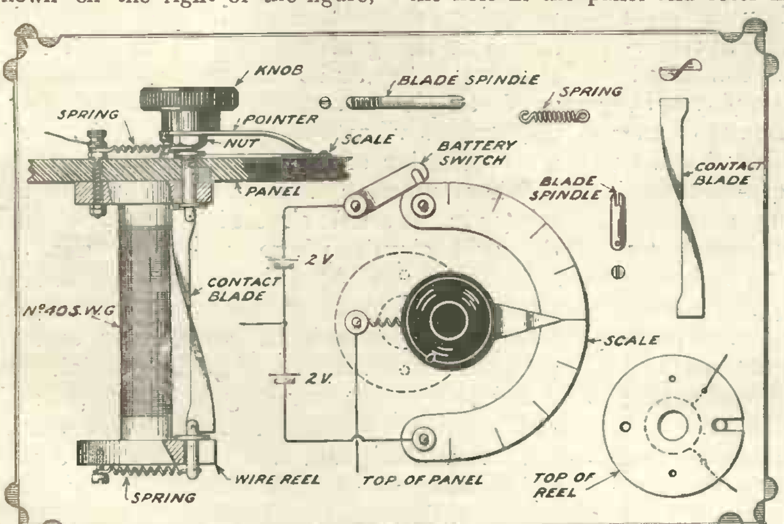


Fig. 1.—Details of construction.

Above & below the Broadcast Wavelengths

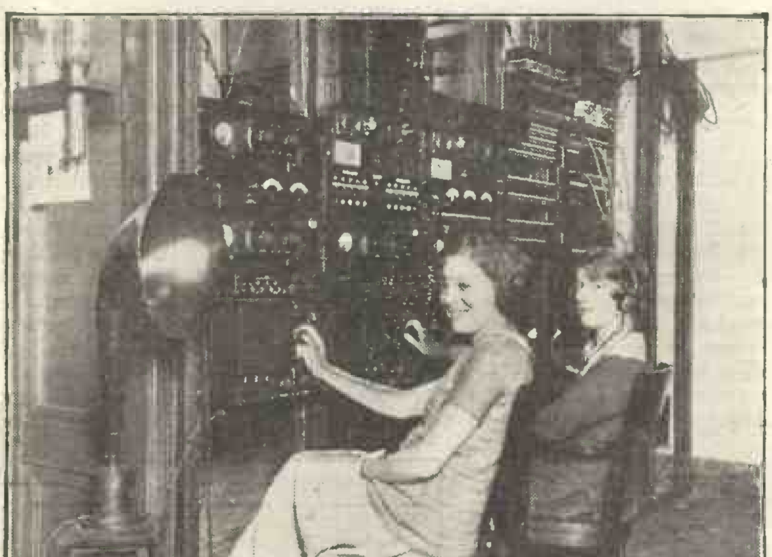
American Broadcast Reception

NOW that lengthening evenings and days that grow rapidly shorter show that the autumn is upon us, a great number of wireless men will be taking again to the fascinating, if at times exasperating, pastime of listening for broadcast transmissions from the United States of America. During the summer months the results obtained are usually so poor that it is not worth while to make the attempt. The writer did so on three or four occasions between the beginning of May and the end of August, using each time a set which had consistently brought in these transmissions whenever conditions were favourable during the winter months. Very little was achieved. At every attempt *something* was heard, but it was never possible to hear a whole programme, or even to listen, save on one occasion, to a single item in its entirety.

As a rule one sat tuning delicately for a long time before anything at all was picked up; then one would get into touch with a carrier wave, which was lost entirely as soon as endeavours were made to tune in the transmission belonging to it. Sometimes a brief snatch of barely audible speech or music would come in, but not even the most careful adjustment of controls availed to capture it for more than a few fleeting seconds.

Summertime Results

It would be interesting to hear something of the experiences of others and to see whether they confirm the rather curious conclusion to which the writer has come, which is that stormy, that is to say, windy and rainy weather, *without* thunder, is the most favourable for transatlantic reception. It may be that it is a mere coincidence that the log should show that the best results occurred during the winter or rather wild nights, and that similar weather prevailed on the June night, or rather early morning, when the only respectable reception of American broadcasting was obtained. The station then heard was W.J.Z., and two items, a song and an orchestral piece, came in quite distinctly, though very faintly.



Lady operators in an American Broadcasting Station.

The aerial used is not at all a good one, for owing to the slope of the ground upon which the house stands, and to telephone wires crossing at right angles, it is impossible to obtain an effective height of more than about 25 feet. The aerial is also badly screened at both ends; at the one by the house itself, for the chimneys are too ancient to be used to support poles, and the wire must necessarily be below the level of the roof top; at the other by a belt of high trees, which make their presence felt far more in summer, when they are covered with dense foliage, than in winter, when they are, of course, quite bare.

Do Others' Experiences Tally?

It is possible, therefore, that in these special circumstances climatic conditions exercise a greater influence upon reception than they would if the aerial were of better quality electrically. Perhaps some of those readers of MODERN WIRELESS who rejoice in the possession of lofty unscreened wires will place their experiences of summer reception of U.S.A. broadcasts on record. They would certainly make interesting reading, and a comparison of the results obtained might enable some reliable conclusions to be drawn as to the weather and other conditions that are most favourable.

Winter Reception

Autumn and winter reception is an altogether different matter. Here the transmissions are travelling from one country over which darkness already broods eastwards to another which they reach from eight to twelve hours after the sun has set. Darkness, as is well-known, is particularly favourable to wireless, possibly because the ether is less disturbed by light and heat oscillations, and in the darker months one can make fairly certain of hearing American stations with any reasonably good set.

Comparatively few people realise that it is by no means a superhuman feat to pick up transatlantic broadcasting in this country. It has been accomplished in several instances on one-valve, and there is no reason why anyone with a set consisting of one stage of high frequency amplification, a rectifier and a note magnifier should not accomplish it *if*, and it is a big "if," he has the necessary patience.

Some Requisites

He must also be gifted with the power of keeping awake until the small hours, at any rate, if he lives anywhere within "mush" radius of Leafield and Northolt. These huge arc stations—one hears they are shortly to be converted to valve transmission—produce such powerful harmonics upon wavelengths in the neighbourhood of 360 metres when they are working that it is almost a hopeless task

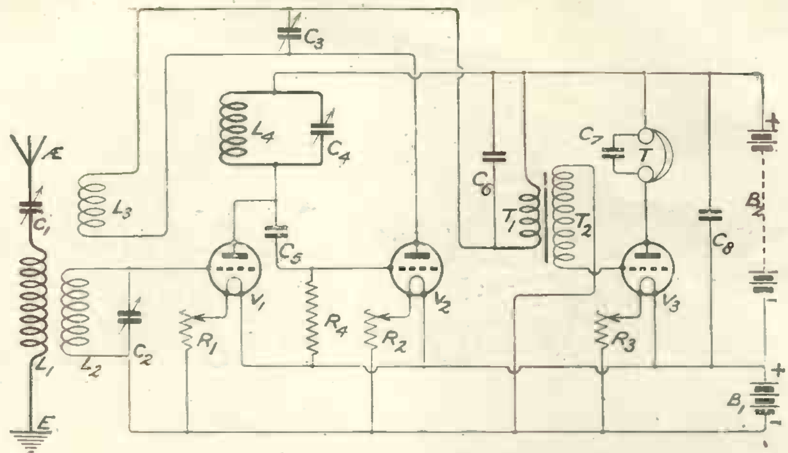


Fig. 1.—A circuit for transatlantic reception.

to use the set until they have closed down, as they usually do towards half-past-two in the morning.

After that hour one can usually count on a period of peace, during which attempts may be made with a reasonable hope of success. If the set has been timed earlier in the evening to the wavelength of either 2 L.O. or 5 W.A., it will be very nearly in correct adjustment. So nearly, in fact, that much searching can be done merely with the condensers of the secondary circuit and of the tuned H.F. transformer or tuned anode. It will often be found that if other circuits are left untouched, U.S.A. transmissions can be brought in by careful manipulation of the coupling between the reaction coil and the inductance—secondary, H.P. transformer or anode coil—with which it is allied.

Couplings and the Reaction Coil.

As the Postmaster-General's regulations governing reaction do not apply after the close of British broadcasting hours, it is recommended that with the three-valve set (H.F.—R.—L.F.) the reaction coil should be coupled directly to the closed circuit inductance as shown in Fig. 1. In this case a three-coil stand should be used for the coils of L1, L2, and L3. If the closed circuit is eliminated and the reaction coil coupled to L1, there is a slight gain in signal strength, but the loss in selectivity is so great that the advantage in one direction is more than discounted by the set-back in the other.

It will be found that when fine tuning upon these weak signals is being done, it is most important that one should be able to make tiny variations in the coupling between primary and secondary and between secondary and reaction inductances. For this reason the ordinary type of three-coil stand, which permits only of an increase or decrease of the angle between the coils, is hardly delicate enough. The stand in which the coils pass-

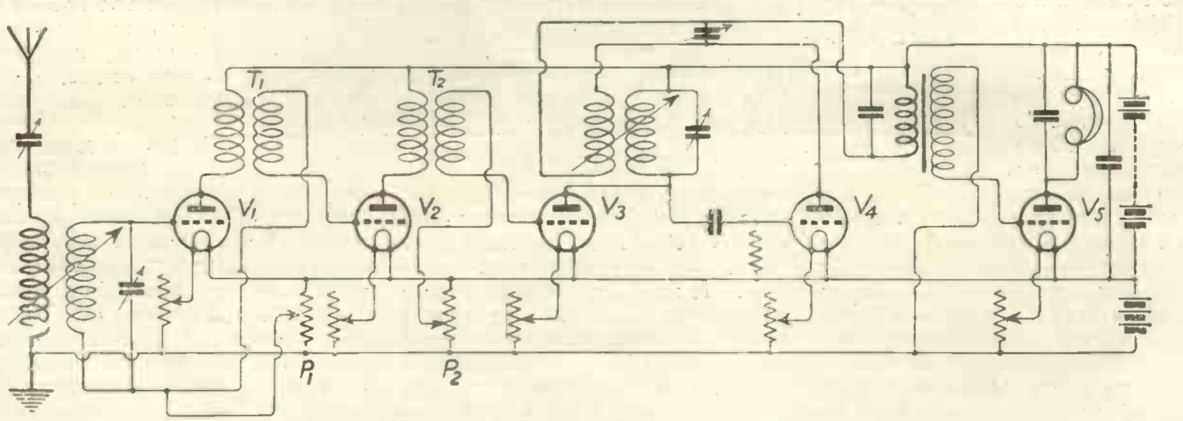


Fig. 2.—Circuit using three stages of H.F. amplification.

from side to side over one another is better, but the most satisfactory of all is a stand which shows two motions to take place.

The Igranic stand for gimbal-mounted De Forest coils is very good indeed, and a simple stand that can be made in any amateur's workshop was described in the August issue of MODERN WIRELESS. This latter allows the coils to be moved directly towards or away from one another and also provides for a tuning movement.

A Short Wave Lay-Out

Though it is possible to obtain results under favourable conditions with a three-valve set, such as that to which reference has been made already, it is better in every way to make use of two or three stages of high frequency amplification. And here we come to a rather difficult problem, for multiple H.F. amplification is very difficult to handle owing to its inherent tendency to fall into self-oscillation. Fine tuning is essential, but if we tune plate and grid circuits to precisely the same frequency with either tuned transformer or tuned anode, oscillation will occur owing to the coupling provided by the filament-plate capacity existing within the valve itself. Even if we make use of anti-capacity valves of the V.24 type two tuned transformers or tuned plates will cause a heap of trouble.

The Circuit

The circuit which the writer has found most satisfactory for all short-wave work on weak signals is shown in Fig. 2. V1, V2 and V3 are H.F. amplifiers. The couplings between V1 and V2 and between V2 and V3 consist of transformers (T1, T2) of the semi-aperiodic type. Those actually used are of the Sullivan pattern with four tappings (200-400, 400-1,000, 1,000-3,000 and over 3,000 metres). The grid potentials of V1 and V2 are controlled by the potentiometer P1. A second potentiometer, P2, is responsible for the grid circuit of V3.

Between V3 and the rectifier, V4 tuned anode coupling is used, the reaction coil being coupled with the anode inductance. V5 is a note-magnifier, and a second valve performing this duty may be added if required. It will be noticed that the L.T. negative busbar is connected to earth. This is found to assist tuning and to improve the stability of the set.

Though it cannot be claimed that the set is absolutely stable when fine tuning on short waves is being done, yet it works extremely well, and it enables three stages of high frequency amplification to be handled without any great difficulty. The potentiometers provide a ready means of controlling the H.F. valves.

Coil Stands

For a set of this type a pair of two-coil stands is necessary, and both should be of the double movement type described. When so arranged the set is very selective indeed owing to the extreme variability between both sets of couplings. Both reaction and tuned anode condensers should be of such maximum capacity in order that very small variations may be made by any movement of their knobs. For the former 0.0003 μF. is a suitable size; for the latter, 0.0002 μF.

Short Wave Tests from Home Stations

Short-wave enthusiasts have now a splendid means of testing the sensitiveness of their sets in the low powered relaying stations of the B.B.C. One of these is already working at Sheffield and others are to be in operation before very long. The set that will pick up these transmissions regularly at ranges of 150 miles or so can be labelled first-class without any hesitation. In addition to the relay stations, tests may be made at almost any time of the day upon aeroplanes. If one tunes in Croydon, Manchester or Lympne, the operators may be heard at frequent intervals asking pilots to give their position. As the pilot's reply is always confirmed by the operator (" Hullo Handley-Page Beer India, I understand you are now passing over Amiens ") one can tell at once whether he is out of range or not. If he is within 75 miles or a little more of your station, you should be able to pick up the pilot's replies. It is not as a rule necessary to alter the condenser adjustment from the position which brings in the aerodrome. If the loosest possible coupling is used when the first tuning is done, a tightening up of the inductance will usually suffice to bring in the 'plane if it is within range of the set.

Obtaining Selectivity

The advantages of using a loose coupling are not appreciated as they should be. One frequently finds a misguided enthusiast working with A.T.I. and C.C.I. jammed tightly together and complaining that his set is not nearly so selective as he would like it to be! An interesting experiment can be made upon such crowded wave bands as those in the neighbourhood of 600 and 12,000 metres. Tune in a strong signal with the coupling tight. Do what you will, there will still be an under-current of weak signals that are distinctly audible. Now move the coils apart. The loud signal loses strength; the weak ones vanish. Continue to separate the coils until the previously strong signal is quite weak; then readjust A.T.C. and C.C.C. Its loudness returns and it can be tuned in quite by itself at good readable strength. Two signals of equal strength can often be separated in the same way, and it is frequently possible to bring up a weak signal whilst tuning down almost into silence others of greater original loudness.

Wave Metres and Calibration

One of the difficulties that one has on the long waves is that no ordinary wave-meter of either buzzer or heterodyne type has a range large enough to cover them. Most of the metres available at prices that bring them within the average man's reach do not go beyond 3,500 or 4,000 metres. If De Forest or other approximated calibrated coils are used, one knows to some extent where one is when tuning. The set can be made to serve as a wave-meter in a rough and ready way if the position of the condenser pointers is noted down in the log whenever a long wave transmission's call letters are picked up, the wave length being obtained from the table of regular transmissions. When a fair number of these have been logged, a graph can be drawn on squared paper which will give the approximate wavelength for any setting of the condenser with a particular coil. LAMBDA.

A PORTABLE BROADCAST RECEIVER

How to Convert it into S.T.100

By G. P. KENDALL, B.Sc., Staff Editor.

Full instructions are contained in these notes for the conversion of the receiver described in the July issue to the more powerful circuit.

THE broadcast receiver described on p. 431 of the July issue, employed, as may be recalled, a single-valve and crystal reflex circuit of the general type from which S.T.100 evolved, and it has been remarked that it is quite a simple matter to convert it into that well-known two-valve circuit.

Such a conversion would seem desirable when the set is regarded as a fixed broadcast receiver in which a certain amount of compactness can be sacrificed, since it enables one to operate a loud-speaker with good volume and a minimum of distortion. Provided that the conversion is done by means of components added externally, the disconnection of a few wires will always restore the receiver to its original portable form when it is desired to carry it about.

Furthermore, since the set does not contain reaction it makes a very stable and easily handled S.T.100 which can be recommended to even the beginner. A certain degree of sensitiveness is lost, of course, but it remains a highly effective circuit.

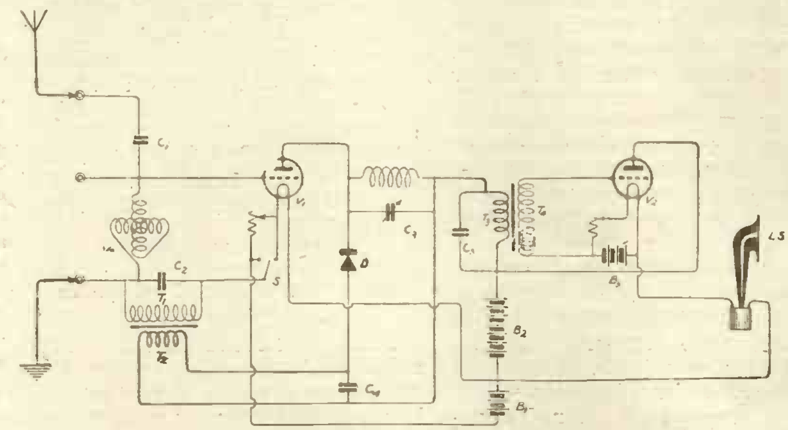


Fig. 2.—A condenser in parallel with the loud-speaker may be necessary with this arrangement, as shown in Fig. 3.

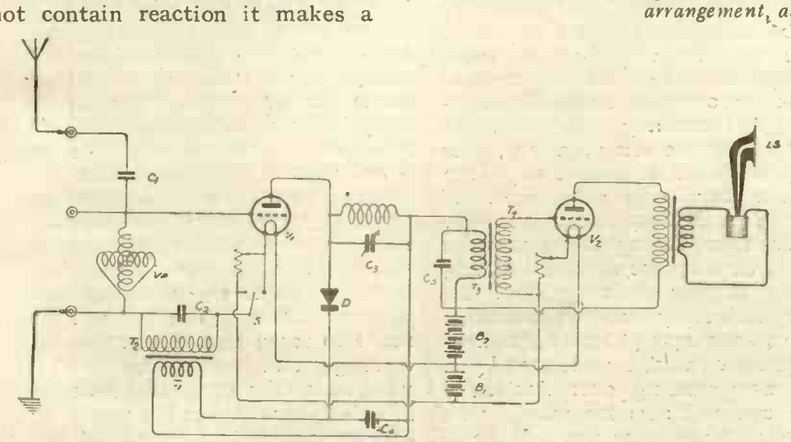


Fig. 1.—One method of conversion.

Some experiments were carried out with a view to determining the best method of conversion, and in the course of these trials certain rather peculiar phenomena were observed, some account of which may prove of interest: it will certainly show that he who experiments with reflex circuits must be prepared for surprises, not necessarily gratifying ones.

The first attempt at conversion consisted in simply adding a stage of L.F. amplification in a perfectly straightforward manner, connecting the primary of a second intervalve transformer to the telephone terminals of the set, and placing the loud-speaker between H.T. positive and the plate of the second valve. The resulting circuit is shown in Fig. 1, from which it will be seen that it only differs from S.T.100 in that no stabilising leak is provided across grid and filament of the first valve and a condenser C_4 is connected across the primary of the first L.F. transformer T_1T_2, and another, C_5 across that of the second transformer, T_3T_4.

The leak may be omitted in the case of this receiver with reasonable safety, since no reaction is intentionally introduced in the H.F. circuits, and the arrangement of the parts in the box is such as to reduce troubles in the L.F. circuits. The two by-pass condensers C_4 and C_5 would be fatal to a true S.T.100 circuit and were merely left in place because they happened to be soldered in circuit inside the box and it was desired to ascertain whether they would interfere with the operation of this particular receiver.

It was found that when a telephone transformer and low-resistance loud-speaker were used, not the slightest trouble from howling or distortion resulted, and signals came in with tremendous volume.

A high-resistance loud-speaker was then substituted, with the result that an over-powering howl was generated, through which the signals came in a very distorted form. This seemed rather puzzling, but was put down to the fact that the H.R. loud-speaker had a lower impedance than the primary of the telephone transformer. In hopes of confirming this surmise the transformer was put back *in series* with the H.R. loud-speaker, whereupon an even more appalling howl was heard. Such disappointments are always liable to occur when one goes a-reflexing.

Various leaks and condensers were tried in all sorts of positions, but without avail, and it was found that so long as the H.R. loud-speaker remained in circuit between the plate of the second valve and H.T. positive the only way to stop the howl was to cut the condenser C_5 out of circuit. This can be done quite easily by taking out the little brass screws which fasten the tags to the condenser, which can then be removed without any un-soldering.

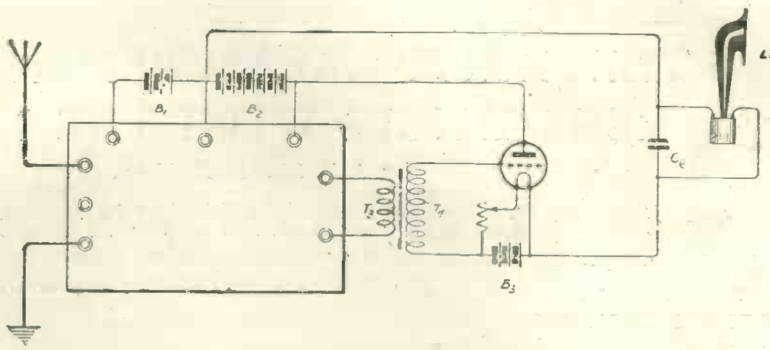
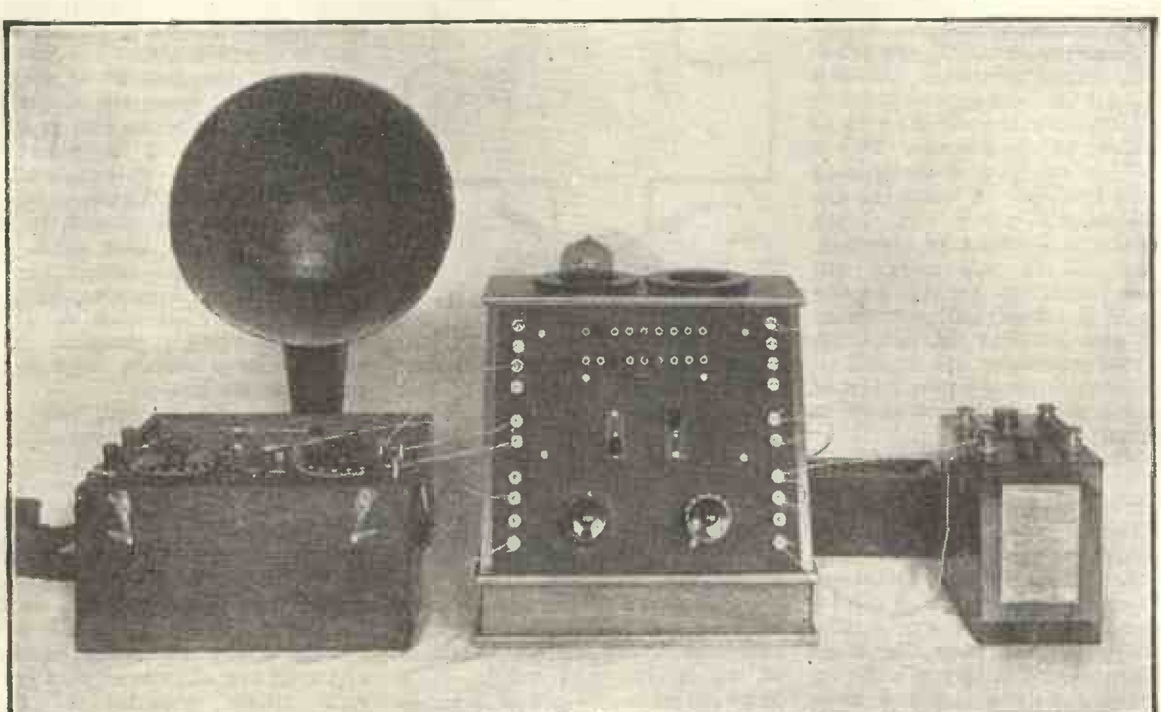


Fig. 3.—Showing the connections of the various parts to the terminals on the receiver.

An alternative method which enables the receiver to be used without any alteration consists in placing the loud-speaker between H.T. negative and the filament of the second valve, shunting it with a condenser of .005 μF, as illustrated in Fig. 3. This, of course, necessitates the use of a separate accumulator B_3 for the filament of the second valve.

This arrangement is perfectly stable and gives remarkably good signals. Its actual connections are given in Fig. 3, which shows the terminals on the broadcast set and their respective leads to batteries, etc. Further stabilising precautions which might prove desirable in some cases are the provision of the usual 100,000 ohm leak across the terminals B and C (Fig. 3, p. 432) and the connection of the earth lead to the negative of the L.T. battery instead of to the earth terminal on the panel.



The composite S.T. 100 *receiver in use. Note that only the first valve of the power amplifier is employed.*

THE RAPID MEASUREMENT OF HIGH RESISTANCES WITH THE NEON LAMP

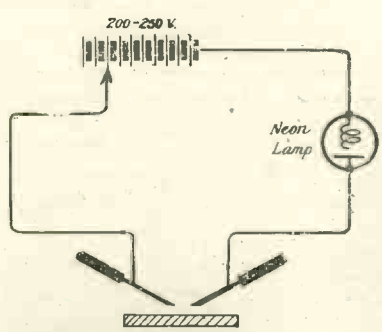
By A. D. COWPER, M.Sc., Staff Editor.

Experimenters have been anxiously waiting for an explanation of some easy means of measuring the value of grid leaks and other high resistances. In this article Mr. Cowper describes for the first time an extremeely simple and inexpensive method which can be applied at once by any readers.

In radio experimental work the problem often arises of the determination of the approximate value of very high resistances, such as grid-leaks, anode resistances for resistance-capacity coupling, stabilising resistances in dual circuits, and insulation resistances in general. In a testing laboratory equipped with the necessary apparatus this is an easy matter; but the apparatus required is of an expensive and delicate character, and generally beyond the resources of the amateur experimenter. In particular, the "Megger"—an instrument specially designed for measuring high insulation resistances of the order of several megohms—is a very expensive and somewhat complex instrument, consisting generally of a hand-driven, constant-voltage dynamo giving a high voltage, and a sensitive galvanometer calibrated so as to read resistances directly. This is connected in series with the dynamo and the terminals to which the unknown resistance is joined. Since the voltage supplied is constant, the current in this circuit will depend practically entirely on the value of the (high) unknown resistance, and therefore the deflection of the galvanometer will depend on the latter: hence the possibility of having a scale reading directly in megohms.

However, in the Neon lamp we have a means of detecting and measuring readily these very high resistances with the simplest apparatus and with an accuracy sufficient for all ordinary purposes. The cost of the lamp (which can be procured from advertisers in this journal) is no more than that of an ordinary electric lamp; in addition are needed only a standard two-megohm grid-leak for comparison, a large fixed condenser with good insulation (the Mansbridge type is very suitable), and a source of high-tension up to, say, 200 volts—readily made up by adding a few flash-lamp batteries to the ordinary H.T. battery.

Several articles and accounts have appeared recently relating to the Neon lamp and its uses as an oscillator in conjunction with magnetic relays for special purposes combined with valve circuits, etc.; and the lamps are becoming fairly familiar through their use in advertising devices. It will be recalled that the lamp is similar in superficial appearance to an ordinary metal-filament electric lamp. It fits into an ordinary bayonet-fitting lampholder; but in place of the usual filament it has merely two electrodes, one often a spiral of wire and the other a plate. The bulb contains Neon gas at a low pressure. A discharge takes place directly through the gas, when about 160 volts is applied across the terminals, and a soft glow of small illuminating power is obtained. The current consumption is very small (of the order of 10 milliamperes only). If a large resistance be placed in series with the lamp, it still lights up, but the glow is much more feeble, and is frequently localised on one part only of the electrodes, flickering about in an extremely unstable manner with slight changes in the current. In the commercial lamp a fairly high resistance is permanently connected in series with the lamp, to steady it and limit the current. This is wound on a tiny fibre former and mounted in the base of the lamp.



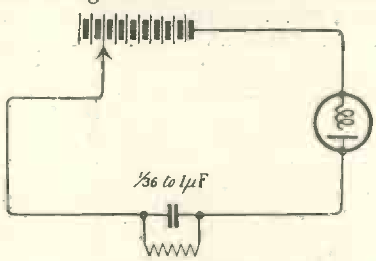
The first method described in the article.

A peculiar property of the lamp, and one on which its use both as a means of measuring resistance and as an oscillator proper depends, is that, once started, the glow-discharge continues when the P.D. across the lamp is lowered considerably below the value necessary to start it. This overlap is usually about 20 volts, but depends on the condition of the lamp, particularly on the temperature.

For the purposes of resistance measurements there are suggested here two methods, the first being a direct, rapid and approximate method giving only comparative results, and applicable over a fairly limited range; the second, by an adaptation of the Neon oscillator, makes possible quite accurate comparison of high resistances, and, if desired, the calculation of their absolute value, provided the capacity of a certain large fixed condenser be known.

For the first method, only the Neon lamp, a high-tension supply of 200 volts or so, and a standard high resistance are required. The writer uses for routine tests a lamp supplied by the Economic Electric Company, in an ordinary lampholder with porcelain insulation, about 240 volts H.T. made up of the cheap flash-lamp batteries sold by the dozen by many dealers, and a calibrated two-megohm grid-leak kindly provided of this standard value by Messrs. The Dubilier Condenser Company. The series resistance can be left in the lamp, and protects the H.T. battery from too heavy discharge. Commercial firms who take a pride in their products have been using this simple qualitative test for some time for insulation tests, looking for short-circuits, etc.; but by refining the methods of observation and adopting a comparative method of judging values it can be made roughly quantitative. For this purpose, the lamp is placed in a box open only in front, and the observations are made in a darkened room. The lamp is connected simply in series with the H.T., and a pair of "electrodes"—stout wires with bare ends and well-insulated handles. The latter are easily improvised by wrapping a few turns of stout insulated wire round small pieces of ebonite or sealing-wax. A small sheet of good ebonite on which to place the objects under test is an advantage. The resistance under test is connected in the circuit by means of these electrodes, and the degree of glow of the lamp observed and compared with the glow when the standard high resistance alone is in circuit. If the disparity is wide, a series of approximate secondary standards can be readily made, of the ordinary graphite line, or Indian ink on paper variety, by direct comparison with the standard 2-megohm: then by putting these in series or in parallel, and noticing the intensity and character of the glow, the value of the unknown can be quite closely matched, and hence its value determined with greater accuracy than would appear on casual perusal of this account. By adjusting the H.T. to a favourable value the unstable flickering stage is obtained, when quite small changes in a series resistance effect large changes in the appearance of the discharge when observed under these conditions. A reliable variable grid-leak facilitates comparison greatly, of course—though the method has a way of showing up some variable grid-leaks in a very unfavourable light!

The second, or strictly quantitative, method consumes rather more time, and requires in addition the large condenser, with good insulation, already mentioned. Mansbridge condensers of $\frac{1}{36}$th to 1μF. capacity have usually surprisingly good insulation; but some ex-Government stock which has received rough usage is not so good, and it may be necessary to try a couple or so before a really good one for this purpose is found. As several accounts have been published recently of the Neon oscillator, it is sufficient here to reiterate that the principle is to supply the lamp with a steady high voltage above the "starting P.D." of 160 volts or so through a series condenser of fairly large capacity, and to shunt this condenser either directly or through the rest of the circuit by a high resistance as leak. The condenser charges up, giving a momentary flash in the lamp, until the voltage it has reached, acting in opposition to the supply, cuts down the P.D. across the lamp below the lower critical value (about 140 volts), and the lamp goes out. The circuit is then completely broken; the charge in the condenser leaks



The second or quantitative method.

away, until the voltage across it has fallen some 20 volts. Now the P.D. across the lamp reaches 160 volts (or thereabouts) again; it lights up with a sudden flash, and the cycle is repeated. The lamp acts then as a voltmeter of practically infinite internal resistance, indicating when a fall of (around) 20 volts has taken place, across the fixed condenser. Since this difference of some 20 volts is constant for a given lamp and condition of operation and the condenser has a definite fixed capacity, the charge or quantity of electricity that has leaked away through the shunting resistance is definite and constant. If the time is observed in which this definite charge escaped, the average rate of escape is known—*i.e.*, the current. Then since the average P.D. across the condenser is also known (being approximately the whole H.T. minus 150 volts) by Ohm's law the resistance of the leak is determined. (Strictly speaking, a more complex "exponential" formula should be used in averaging the P.D., but this will suffice for our purposes.) Either a comparative method can be used, relying as before on a standard resistance of known value; or, assuming the capacity of the Mansbridge condenser be known, the absolute value of the resistance can be calculated. The first method is described here, as it is simpler and liable to fewer sources of error, especially those due to poor insulation in other parts of the circuit.

First of all the large condenser must be tested by simply putting it in circuit with the Neon lamp, H.T., and electrodes arranged as before described. The lamp should give one short flash and then remain dark for a considerable period, after which another short flash will appear, and so on. If the flashing is rapid, the condenser must be discarded. Then the standard 2-megohm leak is placed across the condenser. There should be a regular succession of short flashes. If too slow—*i.e.*, at intervals of several seconds—the H.T. may be increased and *vice versa*. The rate should not be too high to count; then the number of flashes in a convenient short time is observed (*e.g.*, in 15 seconds). The unknown resistance is then substituted for the standard, and the flashes counted in the same time. By making, as before, secondary standards by comparison with the standard—they can be adjusted very accurately now—and using these in series parallel, the rate can be matched with as great precision as the experimenter desires by counting flashes over longer or shorter periods. As before, a uniformly variable adjustable grid-leak is very convenient in this work, as also a collection of the cheap types of fixed grid-leak put out by some dealers and which give a wide assortment of values useful at least here.

High insulation resistances are measured best with a small fixed condenser, to bring down the period of oscillation to a convenient small value for observation; smaller resistances require a 1μF. or even larger condenser if the flashes are to be counted. The method is obviously capable of considerable extension and is of wide application; enough has been shown here, however, to indicate the mode of procedure for simple measurements.

It is quite feasible to measure insulation resistances running into hundreds of megohms by careful insulation of the lamp-leads and wiring and with an exceptionally good condenser.

SOME USEFUL LONG-WAVE CIRCUITS

By G. P. KENDALL, B.Sc., Staff Editor.

Those readers who have not yet made a choice of a circuit for their long-wave work, or who are dissatisfied with the receiver which they are using, will find these notes helpful, as will those who require practical guidance in the operation of such circuits.

THE choice of a circuit for long-wave reception is a matter upon which experimenters differ considerably, since it is one wherein individual tastes influence the operator's choice to a much greater extent than in the decision upon, say, a circuit for broadcast reception. The governing factor, of course, is the fact that the waves between about 10,000 and 15,000 metres carry an enormous volume of traffic between a large number of high-power stations, and there is a great deal of congestion. Some experimenters pin their faith to ultra-simplicity of operation, using circuits which are so easy to manipulate that the tuning-in of a given signal is fairly simple, and with which the separation of the desired signal from others is rather dependent upon the skill in adjustment of the user than upon the natural selectivity of the circuit.

Others, again, prefer to sacrifice a certain amount of simplicity and rely rather upon the selectivity of the circuit than upon its ease of adjustment to pick out the signal from the required station. Circuits of both types will be considered in these notes, and also some examples of an effective compromise between them.

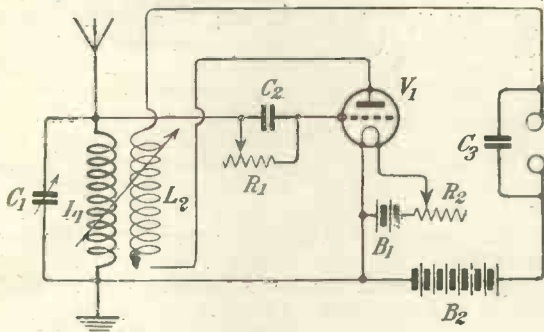


Fig. 1.—The simplest long-wave set.

A Single Valve Circuit.

Fig. 1 shows what can almost be described as the simplest possible valve receiving circuit. Using only one valve and possessing only two adjustments, it is a good example of the ultra-simple type, and is capable of producing surprisingly good results upon all wave-lengths. It is a circuit in which the quality of the results obtained depends largely upon perfect adjustment, the use of good components, proper treatment of the valve, and so on, and consequently it appeals strongly to the experimenter who likes to achieve feats of long-distance reception by skill in the design and construction of his apparatus and in its manipulation.

As I have already said, the results given by the circuit under good conditions are often surprising to those accustomed to the performance of multi-valve sets, and moreover, its ease of handling is such that the amount of skill necessary for its successful use is readily acquired. As instances of its sensitiveness may be quoted the following receptions upon a standard single-wire P.M.G. aerial: Moscow, Budapesth, Vienna, Sofia, Marion (U.S.A.), and Malta. All these stations gave readable signals, while New Brunswick and Annapolis (U.S.A.) were generally audible but could only occasionally be read. This list was compiled before the high-power station on Long Island commenced work, the signals from WQK being within easy reach of such a receiver.

Such amplifying power as the circuit possesses is provided by the strong reaction which it uses, and pains must be taken to utilise it to the full while preserving the efficiency of the valve as a rectifier. The most important points are concerned with the choice of correct sizes for the grid leak and condenser, and the adjustment of the

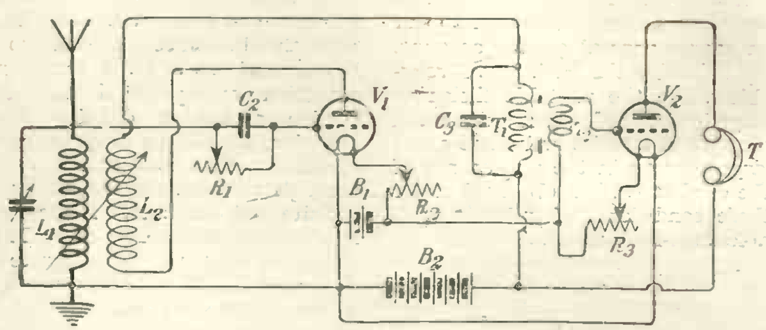


Fig. 2.—Increasing the audibility of the signals produced by the circuit of Fig. 1.

reaction coupling to the most effective value.

The standard values of 0.0003 μF for the grid condenser and 2 megohms for the leak will give quite good results, but with most valves it is a considerable advantage to make either leak or condenser variable. The leak should in any case be of thoroughly reliable make, since nothing is more unsatisfactory than one which varies its resistance in the course of time and upsets the carefully-made adjustments of the circuit.

The best position of the grid leak should be determined by experiment; try connecting it direct between the grid and one or other end of the filament, and note whether the strength of signals is affected and whether the smoothness of the adjustment of the reaction is best with one particular arrangement. The reaction adjustment should be such that, as the coupling between L_1 and L_2 is tightened, the circuit passes smoothly from the non-oscillating to the oscillating state *without* a loud click or pop at the moment of breaking into oscillation. Test the receiver on a spark signal; it should be found that as the reaction coupling is tightened the loudness of the signal gradually increases up to the point at which self-oscillation commences. On passing this point it suddenly becomes louder still, but of a harsh, rough note, and upon tightening the coupling still further and so increasing the strength of the oscillations generated by the receiver the loudness should begin to diminish again.

The loudest signals should be obtained when the coupling is set at the minimum value to maintain oscillations, while the loudest "true note" signals should be produced by tightening the coupling almost but not quite to the point of setting up oscillations.

A very little practice should enable these adjustments to be found with ease, and once found they should be quite stable. Should this not prove to be the case, or should it be found that others of the above-mentioned conditions do not obtain, the constants of the circuit are incorrectly proportioned and must be readjusted before it will do its best. Try varying both plate voltage and filament current separately and simultaneously, and then vary the resistance of the grid leak or the capacity of the condenser. A smaller reaction coil may also be tried, and if all these expedients fail to give the desired characteristics, substitute another valve. These points are essential to real success with a single-valve reaction circuit, and they apply in a more general way to all receivers in which the reaction principle is used.

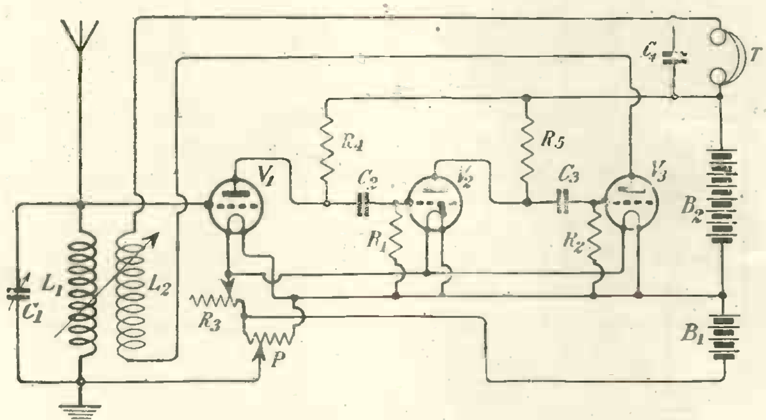


Fig. 4.—A three-valve resistance-capacity circuit.

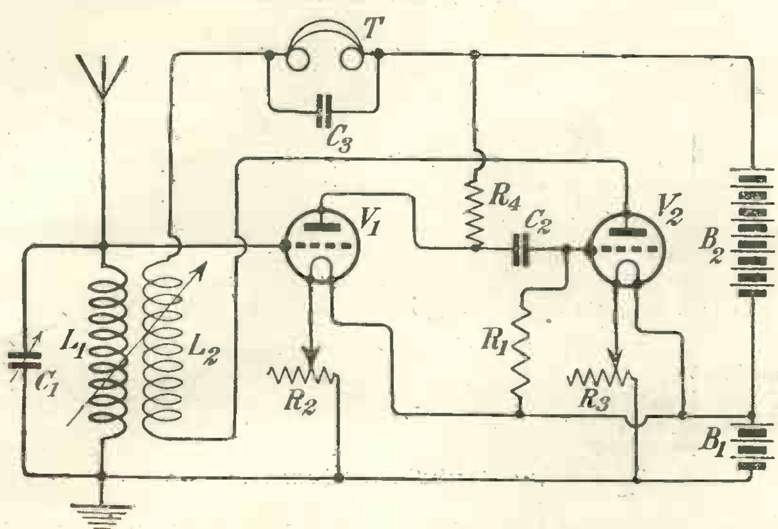


Fig. 3.—A simple resistance-capacity coupled circuit.

Since the amount of amplification obtainable is very limited, it is important that all the customary losses in the circuit should be kept as low as possible. Take care to maintain high insulation and low high-frequency resistance throughout, paying particular attention to the inductance L_1, which should be of good efficiency. It is really worth while to wind a special set of long-wave coils for use in this circuit, taking pains to ensure that their self-capacity and resistance are low.

The set may consist of six coils having 300, 500, 750, 1,000, 1,250 and 1,500 turns, the first three being wound with No. 26 double cotton-covered wire and the others with No. 30. The coils may be either of the lattice or duo-lateral type, full instructions for whose winding were given in MODERN WIRELESS No. 4.

These coils will be rather bulky, but of higher efficiency than many of those upon the market, especially if they are taped up without impregnation with wax or varnish. They will cover the range of wavelengths from 2,500 to 20,000 metres, while if it is desired to obtain the highest efficiency upon the longer waves only (5,000 metres upwards), only the last three coils need be wound, and purchased coils can be used upon other waves.

To obtain the maximum signal strength it is necessary to keep the ratio of inductance to capacity as high as possible in the circuit L_1C_1. Use as large a coil as possible, so that the desired station is tuned-in near the zero end of the scale of C_1.

The use of a soft valve will often give very considerably improved results in this circuit, but it is advised that a hard one should be used at the outset, until the operator has learnt to handle the receiver and to know the indications which tell him whether it is functioning correctly.

The values of the various components which have not yet been given are as follows :

C_1 = 0.0005 or 0.001 μF.

L_2 = any size capable of giving the required amount of coupling.

C_3 = 0.002 μF.

T = 4,000 ohms.

B_1 = 4-volt 40-ampere hours is a convenient size, but this, of course, has no effect upon the functioning of the receiver.

B_2 45 to 80 volts adjusted to the best value.

Since the signals produced by this circuit are often somewhat weak, a second valve operating as a low-frequency amplifier may be added with advantage, and Fig. 2 shows how it may be done. A practical article upon a receiver employing the single-valve circuit appeared in MODERN WIRELESS No. 5, but it must be remembered that it is forbidden for broadcast reception.

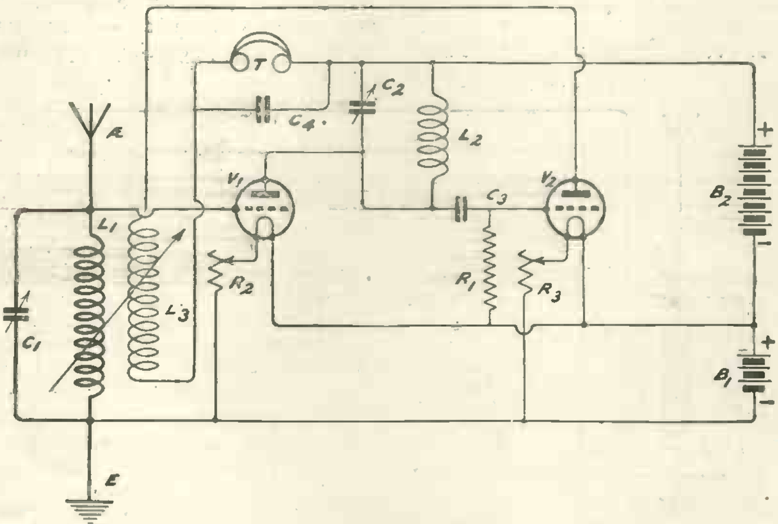


Fig. 5.—The standard tuned anode circuit with reaction upon the aerial.

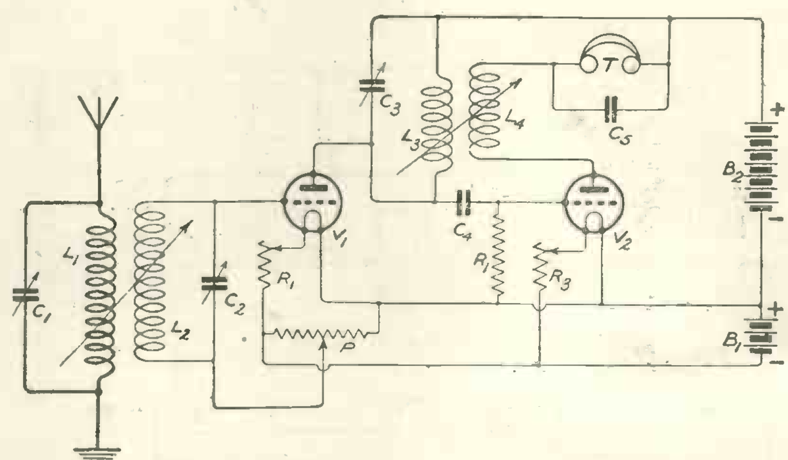


Fig. 6.—An ultra-selective tuned anode circuit.

Resistance Coupled Circuits.

Fig. 3 shows a circuit which falls into the category of receivers whose chief merit is their extreme simplicity of operation, but which is decidedly more sensitive than the preceding one, since it employs two valves, one being a high-frequency amplifier.

The resistance-capacity method of intervalve coupling is used in this circuit, which system has many advantages for long-wave work. Although it does not give quite so high a degree of amplification per valve as the tuned anode or tuned transformer methods, it is considerably cheaper and much simpler to operate, in that valves can be added to the single-valve reaction circuit without increasing the number of adjustments. Thus in tuning-in a station with the circuit of Fig. 3, it is only necessary to vary the same two adjustments as in Fig. 1, namely, the setting of the condenser C_1 and the coupling between L_1 and L_2.

The working of the circuit is simple : the variations of potential across the grid and filament of the first valve which the incoming signals produce are reproduced on a larger scale in the variations in its anode current. These variations of current are accompanied by fluctuations in the voltage drop across the anode resistance R_1 which fluctuations are communicated via the condenser C_2 to the grid of the second valve, which performs the functions of rectification and reaction, the grid leak and condenser being proportioned to enable it to do so efficiently. The standard values of 0.0003 μF and 2 megohms are usually correct, but a somewhat higher leak resistance is occasionally desirable, say 4 or 5 megohms, depending upon the valves in use.

In any case, different resistances should be tried, and the various other adjustments made which were mentioned in connection with the single-valve circuit for the purpose of obtaining a smooth and easily controlled adjustment of reaction. Separate variations of the anode voltages of the two valves should be tried, since the first valve usually requires a considerably higher potential than the second, chiefly to compensate for the drop of voltage across the anode resistance R_4.

A smaller reaction coil than that used in a single-valve circuit will usually be found to give the most convenient handling.

Suitable values for the other components used in this circuit are as follows:

C_1 = 0.0005 μF or 0.001 μF.

L_1 and L_2 = multi-layer coils of sizes chosen from the table given in MODERN WIRELESS No. 6, assuming an aerial capacity of about 0.0003 μF (this can be allowed for in a rough way by assuming that the condenser C_1 has a minimum capacity of 0.0003 μF and a maximum of 0.0008 μF or 0.0013 μF).

C_3 = 0.002 μF.

R_4 = 70,000 or 80,000 ohms.

B_1 = 6-volt 60-ampere hours. A 6-volt battery is to be preferred whenever more than one valve is used.

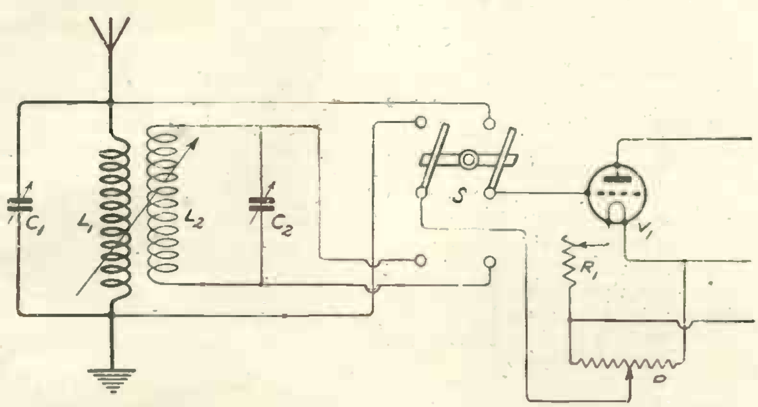


Fig. 7.—The connections of a switch for direct or inductive coupling.

B_2 = 100 volts, with tappings.

One of the advantages of resistance-capacity coupling is that it uses no coils or transformers, and consequently there are no strong H.F. magnetic fields to produce unwanted reaction effects. Receivers incorporating this system are therefore very stable and easy to control, having little tendency to self-oscillation, and a considerable number of H.F. valves can be used. For example, a receiver made to my design with four H.F. valves was so stable that a reaction coil had to be used to make it oscillate, and yet it gave quite good signal strength, slightly in excess of that produced by an efficient 2 H.F. and detector set using tuned anode coupling.

The method can, then, be extended to a number of valves, and Fig. 4 shows a three-valve circuit which will be found very useful for general long-wave work. The potentiometer P is a decided advantage, but it is by no means essential. Other circuits employing a larger number of valves can be easily drawn from a study of Figs. 3 and 4.

Resistance-capacity inter-valve coupling is, of course, only efficient on the longer wave-lengths, above about 1,000 metres, and since few experimenters care to make a separate receiver for long-wave work only, some device must be adopted to make it interchangeable with tuned anode coupling. This could be done by the use of a somewhat complicated arrangement of switches, but such an expedient is not recommended; a better way is to mount the anode resistances upon standard coil plugs by means of brass clips so that they shall be literally interchangeable with the coils of the tuned anode system. A single-pole switch is desirable for each of the variable condensers of the plate circuits in order that they may be cut out of circuit when the resistances are in use.

Reactance Coupled Circuits.

The term "reactance-capacity" or "impedance-capacity" coupling is usually taken to mean a system in which the anode resistances of the last two circuits are replaced by H.F. impedance coils designed to cover a certain band of wave-lengths. The theory of operation of such circuits is rather similar to that of the resistance-capacity type, the difference lying in the fact that the variations of potential across the ends of the plate circuit coils are produced not by their resistance but by the impedance which their inductance causes them to offer to H.F. currents of certain frequencies fairly close to that of their natural wave-length.

The impedance coils are roughly tuned to the wave-length which it is desired to receive by means of tappings, care being taken to render their resonance curves very flat by winding them with fine resistance wire, so that they operate with roughly equal efficiency over a broad band of waves. An efficient impedance coil for wave-lengths of 1,000 metres upwards may be made by winding 2,500 turns of No. 42 single silk-covered resistance wire on a bobbin turned from half-inch ebonite having a diameter of 3 in. and a groove $\frac{3}{8}$ in. wide by $\frac{1}{2}$ in. deep in its edge. Tappings should be taken out at 300, 500, 700, 1,000, 1,500, and 2,000 turns, a switch being used to vary the number of turns in use. This is best connected to short-circuit those *not* in use.

Reactance-capacity coupling gives somewhat greater sensitiveness than the resistance system, but it is less stable and not so simple, and consequently it has never become very popular with amateur constructors. Very efficient tapped reactance coils to cover all wave-lengths can be purchased, however, and good universal amplifiers can be made up by their use. Such circuits do not possess the sensitiveness or selectivity of the tuned anode type, but they are simpler to handle, and they can be recommended to the experimenter who wishes to use a circuit which is a good compromise between the ultra-simple and the ultra-selective types.

Tuned Anode Circuits

So much has been written upon tuned anode circuits, and they are so widely used, that I do not propose to deal with them very fully here. The tuned anode system is undoubtedly the most sensitive and selective method of inter-valve coupling at present used, and its only serious drawbacks are the slight difficulty of tuning when two or more tuned circuits must be adjusted, and its strong tendency to self-oscillation when more than one H.F. valve is used.

Its selectiveness is very valuable upon the congested wave-lengths round about 12,000 metres, and it is not usually necessary to use more than one stage of amplification, since its efficiency is high enough for general purposes when used with an out-door aerial of reasonable size.

Fig. 5 illustrates the standard circuit, with reaction upon the aerial circuit. This type of reaction seems to give decidedly better results upon long waves than the method of reacting into the plate circuit, probably because the high resistance of long-wave tuning coils introduces so much damping into the aerial circuit. The amount of radiation from a P.M.G. aerial when using this circuit upon *long* waves is very small indeed, so that it may be used with little fear of creating interference. When the circuit is used for broadcast reception, however, the reaction must be either cut out altogether or transferred to the plate circuit. This last can be done very simply by arranging two sockets for the reaction coil, one coupling with L_1 and the other with L_2, and wiring them in parallel. The reaction coil then merely needs to be transferred from the one socket to the other, the change being so easy that it greatly reduces the temptation to use what has been aptly described as "criminal reaction."

The condenser C_1 may be of 0.001 μF capacity, C_2 of 0.0005 μF, while C_3, C_4 and R_1 should be of the standard values previously given. The coils L_1 and L_2 must be chosen for a given wave-length from the MODERN WIRELESS table, as has been explained already, while L_3 will usually be a size smaller than L_1 for ease of adjustment. For example, on the longer waves around 12,000 metres L_1 would be a 1,000 or 1,250 coil, L_2 a 1,500, and L_3 a No. 750. This circuit should give good readable signals from the following American high-power stations; Annapolis, New Brunswick, Marion, Long Island, and Tuckerton, while the time-signals from NBA (Balboa, Panama) should be audible under good conditions.

Fig. 6 shows a circuit of the ultra-selective type which is capable of giving remarkably good results in skilled hands, but it must be admitted that it is rather difficult to operate, containing as it does three tuned circuits. The coils L_1, L_2, L_3 and L_4 should be of the standard plug-in type mounted in two separate two-coil holders.

This arrangement of loose-coupled tuner and plate circuit reaction simplifies the operation of the circuit as much as is possible.

The coils L_2, L_3 and L_4 will normally be all of the same size, while L_1 will be one or two sizes smaller with an average aerial. This multiplicity of large coils involves a good deal of expense, of course, and only those experimenters who crave for extreme selectivity would care to use such a circuit.

The values of the tuning condensers for the most convenient handling are as follows: $C_1 =$ 0.001 μF, C_2 and $C_3 = 0.0005$ μF. The potentiometer P will be found a considerable convenience in controlling the circuit.

To make the circuit convertible at will into that of Fig. 5 a double-pole change-over switch may be connected into the circuits of the loose-coupled tuner, as shown in Fig. 7. One position of the switch connects the valve to the secondary circuit and the other to the aerial circuit.

In connection with tuned anode circuits may be mentioned the question of the use of a separate heterodyne for long-wave reception, since they are particularly suited to its employment. It is easy to introduce the local heterodyne current into any desired circuit by means of small coupling coils, or one may simply place the local oscillator in the vicinity of the receiver and move it about until the position for best results is found.

The advantages of using a local oscillator to supply the heterodyne current for continuous wave reception, instead of making the receiver itself provide it by self-oscillation, are very great on the longer waves, and it seems a pity that more experimenters do not use this method. It seems that they often grudge the "waste" of a valve in this way, but one has only to use a properly designed local oscillator to realise that it gives an increase of signal strength which is often equal to that produced by the addition of another valve as an amplifier, and its effect in increasing the selectivity of the receiver is greater than that conferred by a loose coupled tuner.

To understand the reason for this it must be remembered that, in order to produce a beat note, the frequency of the locally generated oscillations must differ from that of the continuous wave signals by such a number as will give a musical note. If the local oscillations are generated by the receiver itself the latter must be de-tuned from the true wave-length by an amount corresponding to the desired difference of frequency. This difference of frequency, which will usually be between 500 and 1,000 per second, amounts to only a very small percentage of the signal frequency upon short waves, and consequently the required de-tuning is only slight, and does not lead to an appreciable loss of efficiency.

Upon long waves, however, the matter is far otherwise, for here the necessary de-tuning may amount to a thousand metres. Remembering the extreme sharpness of tuning of continuous waves and the selectivity of circuits employing reaction it may easily be seen how inefficient self-heterodyne really is for long-wave reception. Use reaction by all means, but use it to increase the strength of the long-wave signals, not for the production of heterodyning oscillations.

The easiest method of tuning-in a given station with a local oscillator and reaction in the receiver is as follows: With the oscillator switched off, make the receiver oscillate and search for signals in the ordinary way. When the required station has been picked up, tune to the "silent point" of its signals (*i.e.*, midway between the points at which signals are heard) and gradually reduce the reaction until the set just ceases to oscillate. If difficulty is experienced in ascertaining whether the set is still oscillating during this operation, keep touching the aerial terminal with a damp finger; clicks denote self-oscillation.

Next switch on the local oscillator and adjust it until the signals are heard again, after which slight re-adjustment of tuning and reaction will give signals of greatly improved strength and reduced interference from other stations.

A further article on this subject will appear in a later issue.

RECENT ADDITIONS TO EXPERIMENTAL CALL-SIGNS

To be appended to Radio Press Wireless Directory.

2 DR	S. R. Wright	14, Bankfield Drive, Shipley, Yorks.
2 FK	F. L. Glover	20, Rutland Road, Ilford, Essex.
2 GF	J. V. Jenson	139, Ormside Street, London, S.E. 15.
2 GO	L. Bland Flagg	61, Burlington Road, Bayswater, W. 2.
2 GR / 2 GS	T. Forsyth	Wenslea, Ashington.
2 KC	H. T. Longuehaye	96, Barnmead Road, Beckenham.
2 NK	P. Priest	174, Woodside Road, Lockwood, Huddersfield.
2 OK	H. D. Butler	222, Gt. Dover Street, London, W.
2 OL	H. D. Butler	Trebarwith, South Watfield.
2 OZ	Worcester Cadet Signal Company	R. C. of Signals, Junior Technical School, Sansome Walk, Worcester.
2 PV	Capt. G. T. Smith-Clarke ...	"Glenroy," Kenilworth.
2 PW	J. Matthewson	35, Capel Road, Forest Gate, E. 7.
2 QG	J. S. Alderton, M.J.Inst. Engineers	1542, Stratford Road, Hall Green, Birmingham.
2 QZ	Brian H. Colquhoun ...	3, Eastbrook Road, Blackheath, S.E. 3.
2 RJ	Major F. S. Morgan ...	East Farleigh, Kent.
2 RN	D. W. Richards	36, Bontnewydd Terrace, Treleurs, Glam., S. Wales.
2 RW	T. Belshaw and D. M. Burn	6, Manor Gardens, Merton Park, S.W. 20.
2 UF	H. Bailey	51, Manchester Road, Denton, Manchester.
2 UP	Dept. of Physics	Armstrong College (University of Durham), Newcastle-on-Tyne.
2 VR	H. J. Jackson	8th Walthamstow Troop Boy Scouts.
2 WK	G. R. Lewis	10, Lansdowne Road, Ashton-on-Mersey, Manchester.
2 ZO	L. H. Soundy	60, Bellevue Road, Ealing.
5 AN	Walter J. Joughin	Edison Bell Works, Glengall Road, Peckham.
5 BA	Chase Motors, Ltd.	Sandyford Square, Newcastle-on-Tyne.
5 BB	Vickers, Ltd.	Vickers House, Broadway, Westminster, S.W.
5 BC	Sir Trevor Dawson, Bart....	Edgwarebury House, Elstree, Herts.
5 BG	J. B. Kaye	Close Hill, Huddersfield.
5 CF	F. G. S. Wise	12, Crouch End Hill, N. 8.
5 CK	L. H. Pearson...	Long Row, Nottingham.
5 CV	R. J. Harrison	"Blacklands" Sydney Road, Walton-on-Thames.
5 CX	Leslie Gordon	133, Old Street, Ashton-under-Lyne, Lancs.
5 DN	Capt. L. A. K. Halcomb ...	South Leue, 106, Millhouses Lane, Sheffield.
5 DO	E. J. Watts	6, Ashley Road, Salisbury.
5 DS	Arthur W. Fithian	51, St. James Road, S.W. 17.
5 DY	The Chelmsford Radio Engineering Co.	Rainsford End, Chelmsford, Essex.
5 FI	H. D. Webb	59, Bradford Street, Walsall.
5 GI	R. Horrocks	65, Leander Road, Thornton Heath, Surrey.
5 HN	D. R. Etchells	"Kingsley," Oaken, near Wolverhampton.
5 IF	H. Featherstone	8, Cumberland Gardens, Tunbridge Wells.
5 JC	Ivor Morris	The Compton, Cemaes Bay, Anglesey.
5 KF	W. Bird	Llangrove, Hednesford Road, Cannock, Staffs.
5 LA	L. H. Soundy	60, Bellevue Road, Ealing.
5 LG	J. F. Johnson	48, Borough Road, Altrincham, Cheshire.
5 LZ	A. Gwinn	61, Carnarvon Road, Stratford, E. 15.
5 NU	H. L. Thomson	100, Old Fallow Road, Cannock, Stafford.
5 PW	F. H. de Veulle	Meriden House, Trinity Road, Handsworth, Birmingham.
5 RZ	A. G. Wood	93, Upper Tulse Hill, S.W. 2.
5 SW	C. Bedford	Turton Hall, Gildersome, near Leeds.
5 TI	J. Bonnett	159a, Turner's Hill, Cheshunt.
5 TQ	H. Rayner	32, Grange Road, Cleckheaton.
5 TU	J. Leitch-Rodger	"Woodside" Western Terrace, Falmouth.
5 TW / 5 TX	R. S. Baugh	"Longfield," Wake Green Road, Moseley, near Birmingham.
5 UM	H. Allchin	78, Chester Road, Forest Gate, E. 7.
5 VX	J. H. Ives	49, Acme Road, Watford, Herts.
5 ZO	W. F. Mills	11, Stoney Hey Road, New Brighton, Cheshire.
5 ZR	F. Austen	52, Church Street, St. Peter's, Broadstairs.
6 AF	Robert H. Rice	70, Seaside, Eastbourne.
6 AH	R. H. P. Collings	4, Dean Place, Liskeard, Cornwall.
6 AJ	George Ensoll	25, Victoria Road, Dukinfield, Cheshire.
6 AL	James Parker Morter ...	49, Westow Hill, Upper Norwood.
6 AO	A. V. Ruddlesden	24, Wakefield Road, Dewsbury, Yorks.
6 AP	J. A. Hobson	Hill Close, Berkswell, near Coventry.
6 AQ	A H. Bird	35, Bellwood Road, London, S.E. 15.
6 AW	Edward James Jarvis ...	"Naseby Cottage," High Street, Waltham Cross.
6 BB	John Bolt	Crouchley, Lymm, Cheshire.
6 BC	W. Douglas Clague	White House, High Heworth, Gateshead-on-Tyne.
6 BJ	C. Solomon	10, Cavendish Road, Brondesbury, N.W. 6.
6 BR	G. H. Ramsden	Overdale, Ilkley.
6 BW	J. C. Mason	8, Westmorland Road, New Brighton.
6 CF	W. C. Lingard	Bridgeholme Green, Chapel-en-le-Frith, Derbyshire.
6 CG	A. W. Eagle	42 Park Lane, Tottenham, N. 17.
6 CI	C. E. Tilley	10, Guthlaxton Road, Leicester.
6 DJ	A. C. Copsey	27, Sutherland Road, Tottenham, N. 17.
6 DM	C. Knight-Coutts	16, Vine Street, Evesham.
6 DP	Norman Crowther	219, Roundhay Road, Leeds.
6 DU	E. J. Newton	1, Jerningham Road, New Cross, S.E. 14.
6 DW	Douglas H. Johnson ...	131, Clapton Common, London.
6 DZ	Capt. L. A. K. Halcomb ...	South Leue, 106, Millhouses Lane, Sheffield.
6 FB	W. Grocott	Church Road, Oxley, near Wolverhampton.
6 FJ	C V. Jarvis	21, Baltic Road, Tonbridge.
6 FK	Worcester Cadet Sig., Coy., R. C. of Sigs	Junior Technical School, Sansome Walk, Worcester.
6 FQ	A. B. Richardson	9, Quarry Road, Hastings.
6 FV	W. H. Taylor	37, Bridge Street, Warrington.
6 GM	E. A. Wilson	"Roxburgh," 42, Heber Road, N.W. 2.
6 GO	Leonard A. Sayce	5, Toward Terrace, Sunderland.
6 GT	G. Turton	3, Lydford Road, Maida Hill, W. 9.
6 GV	... ...	Otley.
6 GW	Percy Brian	79, Lakey Lane, Hall Green, Birmingham.
6 GZ	R. C. Neale	Farnborough Road, Farnborough.
6 HO	National Wireless & Electric Co., Ltd.	Church Road, Acton, W. 3.
6 HK	J. W. F. Cardell	Tretherras, Newquay, Cornwall.
6 HR	W. D. Keiller	51, Highworth Road, New Southgate, N. 11.
6 HS	H. Saville	Delamere Works, Longford Road, Stretford, near Manchester.
6 HV	W. J. Butler	15, Algernon Road, Edgbaston, Birmingham.
6 HX	C. H. Nokes	Misidia, High Street, Ripley, Surrey.
6 IC	Arnold Jowett	310, Hopwood Lane, Halifax.
6 IG	Edward Brady	6, Coltsgate Hill, Ripon, Yorks
6 IM	L. G. Kamm	88, Hornsey Lane, Highgate, N.
6 IX	W. G. Fudger	"Brora," Priviswood Road, Godalming.
6 JB	Wimbledon Radio Society	Red Cross Hall, 59, Church Road, Wimbledon.

To be Continued.

SINGLE AND DUPLEX BASKET COILS.

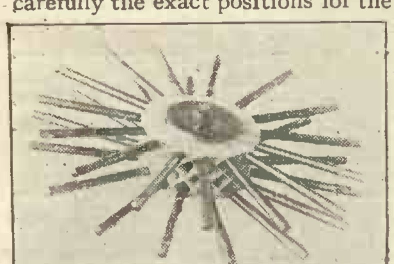
By ERNEST R. GILBERT.

An interesting method of making self-supporting coils.

THE following description of a method of winding basket coils which have been found to be particularly efficient may be of interest to readers of MODERN WIRELESS.

There is no doubt that one of the chief disadvantages of the basket coil is that, in its usual form, it has only a small wave-length range. Few basket coils are made of a greater diameter than 4½ in., and in order to obtain a coil sufficient to receive up to, say, 2,600 metres, a coil of a much larger diameter and using a much thinner wire would be required. It was to get over this difficulty that the writer evolved a method which, so far as he knows, has not yet been made public.

A brass former was made with its core ½ in. thick, having a diameter of 1¾ in. Around the periphery were fitted fifteen brass pegs each 2½ in. long. With a lathe this is quite a simple operation, but even if a lathe is not available, quite a good substitute can be obtained by using a piece of good hard wood such as a broom handle and 3-in. nails. Care should be taken to see that the pegs are exactly equidistant from one another. To do this it is necessary to take a piece of paper the exact length of the circumferance of the brass disc, and to plot out very carefully the exact positions for the

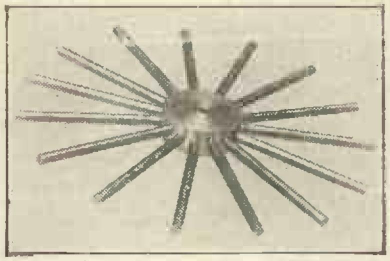


Former for duplex winding.

pegs. If this paper is pasted upon the brass centre and each hole marked with a centre punch, no difficulty should be found.

FLAT BASKET COILS.

For single basket coils of the improved pattern the wire should be wound over two pegs at a time and not over one. The result will be a perfectly *flat coil* of very neat design. When the whole of the former (or as much as is required) has been wound, melt a little paraffin wax in a tin, and, using a fine brush, paint the coil



The fist former.

on both sides with wax. Leave it to dry and in a few minutes the pegs can be withdrawn. It will be found that this type of coil is more convenient for handling than the ordinary basket coil, because it is much more solid and robust. Owing to the fact that it is perfectly flat, it can be clamped between two pieces of ebonite for a very rigid mounting without fear of damage.

DUPLEX BASKET COILS.

For duplex basket coils, two identical formers are required, bolted together at the centre. They should be arranged so that the pegs are equally staggered, that is to say, that looking at the formers from the front, the pegs of the front former are exactly half-way between the pegs of the rear former. The two formers should be securely bolted together so that there is no possibility of their coming adrift during the winding.

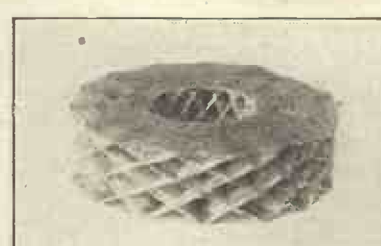
When ready to wind, loop the end of the wire over one of the pegs. The wire should then be taken across the former to the third peg to the right on the opposite former. Pass it round two pegs and bring it back to No. 6 peg on the first former. Again pass it round two pegs and carry it across to the second former, five pegs away from its previous position.

Carrying out this method you will see that the wire passes round two pegs each time and misses five, and eventually arrives back one peg behind No. 1. Keep on winding until you have completed your coil.

The result should be a particularly efficient air-spaced coil which can easily be made to run up to 3,000 metres. Any gauge of wire can be used from 26 D.S.C. to 34 D.S.C., according to the purpose for which the coil is intended. For an aerial tuning coil it is always advisable to use a wire as heavy as possible, but for a reaction coil much finer wire can be satisfactorily used.

Where tappings are required they can be very easily arranged for. When winding, see that the tapping is taken at a predetermined peg and a generous loop made. If a series of tappings are required they can be neatly arranged to occur exactly opposite the same peg and so preserve an appearance of neatness.

When the coil has been wound, it is only necessary to brush it over with melted paraffin wax on the outside, and after allowing it to set the pegs can be easily withdrawn. The last stage is to push out the brass centre and to cover the coil with a layer of Empire cloth. The writer has found from practical experience that these coils—with their generous air



The finished coil.

spacing—have less self-capacity than any coils he has yet tested. Certainly they involve a little trouble in making, but for sharpness of tuning they are unexcelled.

The photographs show a complete coil, a coil in process of winding and the brass formers.

Tested by Ourselves

SPECIAL NOTE.—All apparatus described in this section has been tested by our expert, and readers can therefore rely fully on the opinions given.

An American Low Frequency Transformer

It is interesting to compare the products of another country with those of our own radio manufacturers; in particular those of the country which has had something like a year's advance on us in popular broadcast reception. Accordingly we have welcomed an opportunity of testing the Con-

The Connecticut Transformer.

necticut Co.'s Type J-121 Audio Transformer, handled by Messrs. R. A. Rothermel, Ltd. This is a small, compact, enclosed type, with a high finish and general appearance unfamiliar to English eyes. Four terminals are fitted with spring lock-washers, the primary and secondary pairs being on separate insulating strips and well separated.

On test, the insulation resistance between windings and to the frame was excellent. The primary resistance was 850 ohms, with a resistance ratio of about 7 to 1. On practical test in various circuits it compared quite favourably with standard English makes, and gave good amplification and little distortion in spite of its small size. It was noticed that the effective capacity across the primary winding was higher than usual, while that from "I.S." to "O.P." was unusually low (.000030 μF only).

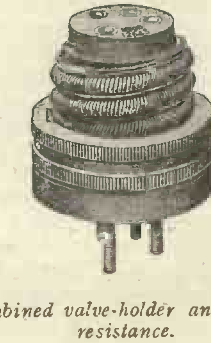
A Combined Filament Resistance and Valve-Holder

Messrs. George F. Watts, Son & Co. have sent us for test a sample of their combined valve-holder and rheostat. This is a neat device arranged for mounting on the panel in place of a conventional valve-holder, the usual four pins projecting through the base; an ebonite barrel body carries an ingenious spiral filament resistance, adjustable contact to which is made by a screw collar riding on it; and the valve is accommodated in the usual sockets on the top. Considerable space can thus be saved on the panel.

On test, the resistance was found to be unusually large, about 12 ohms; the long spiral form making this practicable—this is a commendable point for many purposes. It carried the current for one valve without undue heating; and the insulation was good. It was noted that there did not seem to be a positive stop at the minimum position, nor a definite "off" position, so useful in many-valve set. In general, it is an effective, smooth-working and useful device.

A Filament Resistance

There has been submitted to us for trial a conventional circular type of filament resistance, by H. Edwards. This is for fixing behind a panel by two small screws, a good-quality knob and pointer being provided. The contact arm, we were glad to note, was mounted in a substantial manner, being screwed up against a shoulder on the spindle, and fixed by two lock-nuts; so that no trouble should be experienced in regard to working loose. A positive stop is provided, and a definite "off" position; and one terminal for connections, the other being provided by the resistance



A combined valve-holder and filament resistance.

fixing-screw. On test, the insulation was good; the resistance about 3 ohms; with the current corresponding to two R valves it heated up considerably, but carried the current for one valve easily. Accordingly it is suitable for controlling the filament current for an individual valve. The adjustment proved silent and effective in action.

A Crystal and 'Phone Attachment for Wavemeter

A useful attachment for the Bowyer-Lowe Wavemeter, already noticed in these columns, is the crystal rectifier and 'phone-connecting fitting, arranged to hook on in place of the small dry cell used for metering wave-lengths by transmission of buzzer signals; so that the meter, with its existing graduations, can be used for receiving and measuring outside transmissions, by direct observation with 'phones. This is a well-finished, neat little fitting, carrying 'phone terminals and a form of small plug-in detector, already noticed elsewhere; on test it proved quite effective for its purpose.

Terminal strips for panel mounting.

Terminal Strips.

Messrs. Carter & Akroyd, of Halifax, have sent for test and inspection samples of terminal strips for mounting on wood baseboards, in the manner that is becoming increasingly popular in experimental work. These provide a good assortment of the necessary nomenclatures; and consist of handsome, substantial terminals mounted on ebonite strips with engraved letters filled in neatly in white. Some are provided with the large double terminals so invaluable in radio connections, where often two or even three wires come to a single connecting-point. On test on high voltage the insulation resistance was found too high to measure.

"Cryst-Clip" Crystal Holder

A simple little device which will appeal to the home experimenter is the "Cryst-Clip" crystal holder, marketed by Messrs Mickelwright. The sample submitted, which is in the form of a wire spring-clip, with fixing screw to make fast on the panel, proved handy for quick mounting and replacement of even a small fragment of crystal, all the faces in turn being readily exposed to the search of the cat's whisker, and no Wood's metal or set-screws are needed, whilst the grip of the spring holder is adequately firm.

An Intervalve L.F. Transformer

Messrs. Woodhall have submitted for test a low-frequency intervalve transformer of the open type, with substantial coils and iron circuit. Both primary and secondary are of fairly high resistance. On test the amplification ratio, with R valve and 120 volts H.T., was as high as with any other transformer we have tested, and there was an absence of distortion and extraneous noises, which gave a very favourable impression. On the S.T. 100 and various valve dual circuits it operated extremely well.

On testing the insulation resistance, this was found to be noticeably less, both between the primary and secondary coils, and between either of these and the frame, than one could desire to see for permanently satisfactory operation. If the makers remedy this matter, which should be an easy matter, they will have a transformer which will challenge comparison with any on the market at the moment.

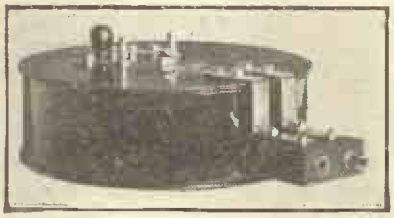
A Filament Resistance

A type of circular filament-resistance in which special care has been taken to provide silent operation, by ensuring continuous good contact to the moving spindle, is produced by Messrs. Woodhall. On testing the sample submitted it was found that this had been effectively provided for by a spiral spring connection, eliminating one rubbing contact, while the contact arm was secured against looseness by a positive mechanical keying effect. A knob and pointer are supplied, and the instrument is suitable for fixing under the panel by two small screws. A long bearing gives steady and smooth operation; terminals are provided for connections and stops. It was noticed that the arm would not stay in a definite "off" position.

The resistance worked out at a little over 3 ohms, with 1.2 amperes, corresponding roughly to the filament current for two valves—it got quite hot, but carried the current for one valve safely. It should not be used with more than one, as the heat tends to soften the composition former. When cold, the insulation was found to be excellent.

A Plug-in Tapped Inductance.

For those who prefer a less cumbersome device than the usual set of separate plug-in coils, but who have the usual plug-and-socket



A new plug-in inductance with tappings.

fitted on their receiver, there is now available a tapped plug-in coil, which covers the most interesting range for telephony, from 335 to 1,240 metres on a P.M.G. aerial and with a .0005 μF tuning condenser in parallel, made by Messrs. Burne-Jones & Co., On trial of a sample submitted, the range indicated was covered conveniently, with ample overlap, the inductance of the five-point tapped coil corresponding roughly to that of coils of the ordinary plug-in pattern of nearly 40, 50, 75, 88, and 100 turns respectively. The signal strength on the lower range with crystal compared favourably with that given by standard plug-in coils in actual reception.

The unit is neatly finished, and takes the form of a cylinder 4 in. diameter by 1¼ in thick, mounted on the conventional plug-in fitting.

An ST100 Set.

Messrs. Peto Scott have submitted an ST100 set, complete in a box with ebonite top. On test both with a frame and outdoor aerials it works as the circuit should and is quite stable in operation. Complete sets of parts for home construction are also supplied.

AN ECONOMICAL HIGH-TENSION BATTERY

As a rule, experimenters use the "dry" form of Leclanché cell for high-tension supply. The cells are not really dry, as the solution is made in a thick paste. Therefore, after a few months' use when the cells do become dry, clicks and other irritating noises are heard in the telephones, caused by the fluctuating voltage. On the other hand, there are the amateurs who use small capacity accumulators and a few who use the mains. The chief disadvantages of the high-tension accumulator are its great weight and the necessity of having it charged, generally at an inconvenient time. If the mains are used, elaborate filters must be fitted to stop the hum. It thus remains to select some battery in which the voltage is steady. The most convenient form of primary cell is the wet Leclanché type. A battery of these small cells will give quite enough current for a multi-valve set without becoming polarised.

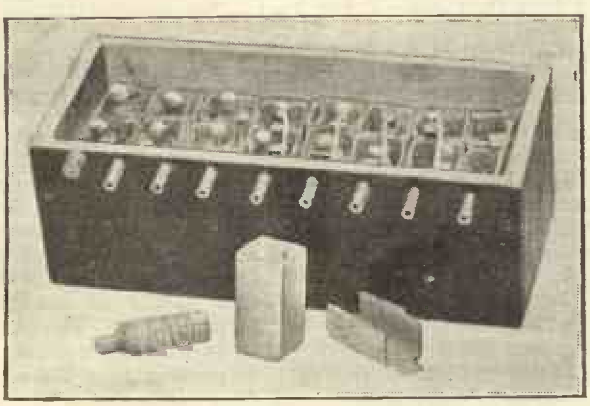


Fig. 1.—The finished battery.

Having decided to make a liquid battery, the first point to consider is the container. Small glass pots or "specimen tubes" would be ideal, but their cost is prohibitive. An efficient substitute is made from paper soaked in wax. For each cell a piece of stiff brown paper is cut out, according to the dimensions shown in Fig. 2. It is then folded along the dotted lines so that A overlaps B, and C, D and E fold up inside F and G. Thick gum or glue should be used to fasten them together. Having made the required number (24 are needed for a battery of 36 volts) they are dipped in molten paraffin wax. It is desirable to have a bowl of water handy as the containers can be cooled in it after being waxed and at the same time can be tested for their ability to hold water.

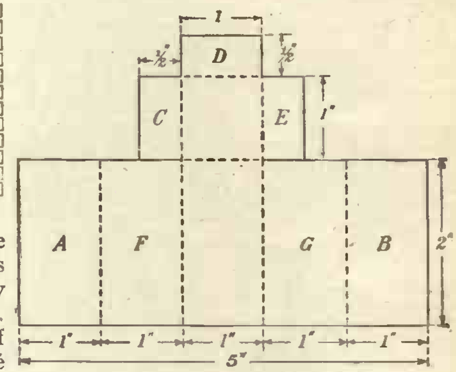


Fig. 2.—How to cut the paper cases.

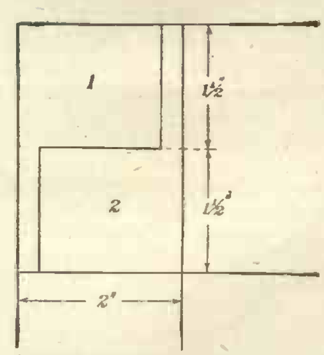


Fig. 3.—Dimensions for zinc.

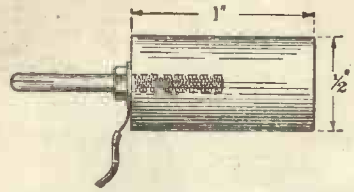


Fig. 4.—Construction of plug.

The positive electrodes of the cells, namely, the carbon rods, are obtained from old batteries of the pocket flash lamp size. The paper covering is removed first and then the old zinc shells. When removing the carbons care must be taken not to damage the depolarising compound, which is formed round the electrodes in blocks. After removing the linen coverings they are washed and recovered. Connections are made by twisting 3 in. lengths of copper wire round the tops of the carbon rods. To prevent creeping of the solution they are inverted and dipped into molten wax, covering only the top portions of the electrode which will remain above the solution.

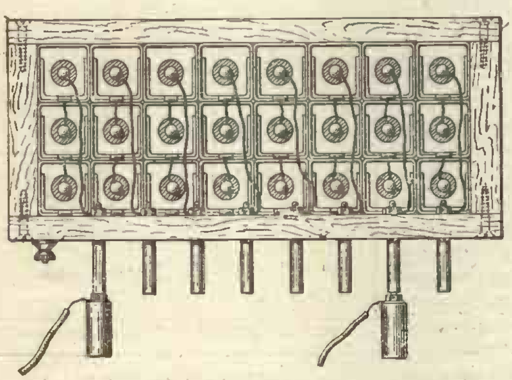


Fig. 6.—Internal connecttions.

The other electrodes are cut from thin sheet zinc to the size shown in Fig. 3. The diagram also indicates how to cut them economically. They are bent at right angles along the dotted lines so that they just fit inside the waxed containers.

A box is now needed. One having the inside measurements of 8 in. by 3 in. by 3 in. would be quite suitable. It is advisable to take tappings from the cells, say, at every 4½ volts. These leads should be taken to valve legs secured in a row along the front of the box. Special insulated plugs can be bought, but may be easily constructed from valve pins threaded into pieces of ½ in. ebonite rod, 1 in. long, see Fig. 4. The completed cells are placed in the box in three rows of eight, and tappings are taken from every third cell, as shown in Fig. 5.

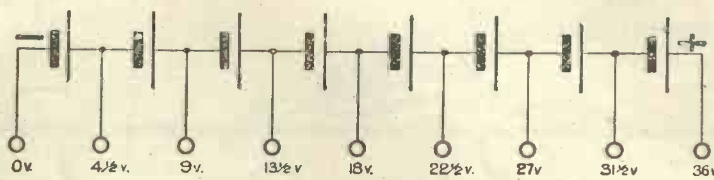


Fig. 5.—Arrangement of tappings.

It now remains to fill the cells with the solution made by dissolving half a pound of sal-ammoniac in water. This quantity will be found quite sufficient to fill 24 cells and to keep them full for several months.

A final word of advice. Take great care not to let any of the solution remain on the copper connecting wires. If this does happen the copper will corrode and eventually break the circuit.

SOME HANDY TOOLS

By R. W. HALLOWS, M.A., Staff Editor.

A Useful Little Saw

When mounting potentiometers or measuring instruments on an ebonite panel one is often called upon to make either a rectangular hole or a round one that is beyond the compass of any drill. For jobs of this kind the little saw illustrated in Fig 1. will be found most useful. The hole to be made is marked out with the scriber. A ¼ in. or ⅜ in. hole is drilled in the part to be cut away; the point of the saw can then be inserted and a cut made without difficulty. When it becomes necessary to turn a corner another hole is drilled to give the saw clearance room. For large round holes the drill is put through at various points just inside the circumference scribed out and the holes are run together with the saw. In either case the work is finished up with a file, the saw being used to remove the bulk of the unwanted material and the file to cut away what is left.

To make it, take a piece of a broken hacksaw blade about 5 inches in length and drill a 4 B.A. clearance hole about 1½ inches from the larger one that is already there. It is best to choose a piece of blade that will allow the saw to cut "Chinese fashion," that is on the pull rather than on the thrust, for if this is done the blade is less likely to buckle or break when in use. Grind off the far end of the blade to a rounded point as shown in the drawing.

Next take two pieces of ½ in. wood measuring 3 inches by 1 and plane each to a D-shaped section. Clamp them together in the vice and drill 4 B.A. clearance holes to correspond with those in the blade through the two. In one piece make recesses for the heads of countersunk screws; in the other enlarge the outer end of each hole until a 4 B.A. nut will lie flush in it. The blade can now be fixed firmly in place. Used with reasonable care the saw will give excellent service.

Guide Block for Drills and Taps

Many amateur constructors find it most difficult to keep either brace or breast drill perfectly upright when making holes in panels, with the result that terminals, valve-legs and so on do not stand out from the panel exactly at right angles when mounted. If the hole for the bush of a rheostat, variable

Fig. 1.—A handy saw.

condenser or variometer is not true the spindle will bind as it turns. Others, again, have the same trouble when tapping.

If you have difficulty in either or both of these ways the guide block shown in Figs. 2 and 3 will make matters very much easier. It consists of a piece of $\frac{1}{2}$ in. brass or mild steel $2\frac{1}{2}$ inches long by $1\frac{1}{2}$ inches wide in which are drilled two rows of holes. Those in the upper are for the drills measured in fractions of an inch that one most commonly uses; those in the lower are for the even-numbered B.A. sizes from 0 to 6.

As it is essential that the guide-holes shall be perfectly true, they must be made in a drilling machine or a lathe. A garage, a cycle repairing shop, or better still, an obliging friend with a well-provided workshop will drill them for you. The clamp can be bought from any ironmonger quite cheaply. To use the block, clamp it over the work so that the punch mark already made is in the centre of the appropriate guide-hole. You will then have no difficulty in keeping the drill upright. If the hole is to be threaded turn the tap in before removing the block.

Soldering-Irons for Fine Work

For fine work or for getting into awkward corners the ordinary soldering iron is too clumsy a tool for most people to handle with success. The miniature irons seen in Fig. 4 will be found a great boon when jobs of these kinds have to be tackled. Their only drawback is that owing to the small amount of metal in their business ends they do not retain their heat for very long. This, however, is not very serious, for if one keeps a spirit lamp, provided with a suitable rack for holding the iron, alight on the bench

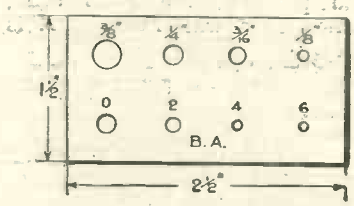


Fig. 2.—A useful drilling block.

whilst soldering is in progress the tool can always be brought back to the proper temperature in a few moments.

The bits of both tools are made from pieces of good copper $\frac{1}{4}$ in.

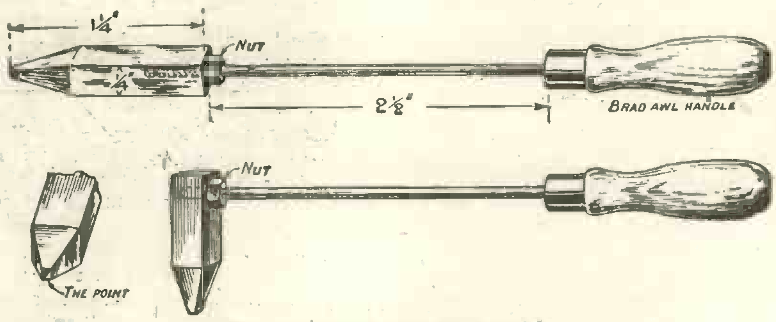


Fig. 4.—Soldering-irons for fine work.

square and $1\frac{1}{4}$ inches in length. In one end a 4 B.A. hole is drilled and tapped. The other is tapered off with the file to the shape shown.

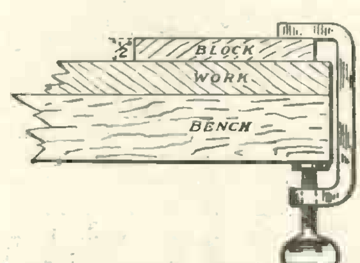


Fig. 3.—How the block fits against the work.

A 4-inch length of 4 B.A. screwed rod is cut off and screwed tightly into the hole in the bit, the nut shown being then turned hard down so as to form a lock grip. The other end of the rod is then driven into a bradawl handle.

The straight iron will be found handy for joining fine wires and for doing small straightforward jobs. The right-angled iron is particularly useful for soldering leads to the tips of valve legs and for other work that is not easy to get at.

R. W. H.

STAINING VALVES

A number of methods have been described and suggested for reducing the glare from valves, such as cardboard sleeves, sections of bicycle inner tube slipped over the bulb, and so on, but they all seem to me more troublesome and less effective than the expedient which I have used for some time.

This method is very simple and requires merely a sixpenny bottle of green lamp-stain and a small brush; give the glass bulbs of all your valves a fairly liberal coat, let them dry for half-an-hour or so, and you will find that the trying glare has been replaced by a soft green glow. Moreover, the interior details of the valve remain perfectly visible when the filament is illuminated.

The stain can be obtained from most of the large electrical firms, and in a variety of colours.

G. P. K.

MOUNTING CRYSTALS IN WOOD'S METAL

The best way to mount crystals in Wood's metal is to take a few fragments (sufficient to half fill the cup) and then to hold a hot soldering iron, poker or, indeed, anything hot enough, against the outside of the cup until the Wood's metal inside just begins to melt. Immediately it melts, remove the soldering iron, wait a second or two, and then press the crystal into the Wood's metal with the aid of a pair of tweezers. The pressure of the crystal will make the melted metal rise up round it and when it sets the crystal will be properly secured.

A COMPACT INDOOR AERIAL

An indoor aerial of any type looks much more presentable when out of sight or at least when it is not conspicuous above all the other articles of furniture which the room may contain; further, it is not always desirable to install a wireless set in the attic, especially on a cold winter night. An ordinary type of aerial built on the usual lines, but made to nearly enclose itself in a wall bracket when not in use, is described in the following diagrams. The aerial in use is shown in Fig. 1. One end consists of a wooden case to which are fixed two brackets which act as bearings for an ordinary type of roller blind fixture. The roller holds the three wires at this end, and the whole case is fixed to the wall. The other end is much the same as any aerial of this type. At the extreme end a small ring is attached to slip on to a hook in the opposite wall. In Fig. 2 the aerial is shown in its closed position, the leads being attached to a wall hook. It is important to note that in making this aerial the roller blind attachment is worked in the right way, that is to say, the blind cord must be unwound from the pulley wheel when the aerial is closed, so that when the aerial is pulled out and hooked on to the opposite wall the blind cord becomes fully wound. Therefore by pulling the cord we unwind it again and at the same time close the aerial. A string lead across the room will be necessary. In Fig. 3 the constructional details are given. A represents the case, which is made up of $\frac{3}{8}$ in. wood. B shows the brackets, which are fixed each end by means of four screw holes shown. These also act as bracket for fixing to the wall and as bearings for the roller. C shows the roller with a pulley one end and a bearing at the other end. Three holes are drilled through the roller, through which the wires are passed and fixed. These holes may be bushed with ebonite if desired. This aerial could probably be made a little more efficient by employing the use of a spring blind attachment, but the one described will be found to be quite satisfactory given proper usage.

H. B.

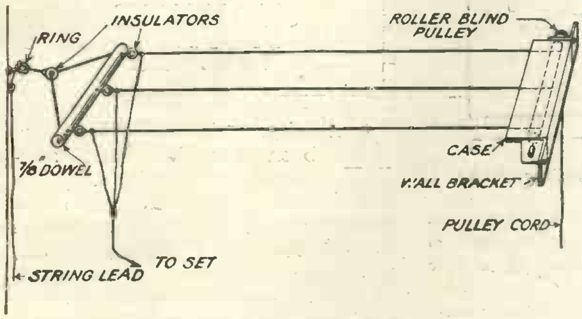


Fig. 1.—The aerial in use.

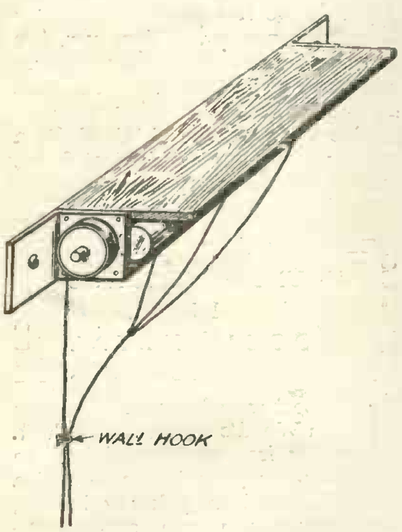


Fig. 2.—The aerial closed.

A BASKET COIL FORMER

For short wave reception work, basket coils are very efficient; moreover, their construction is simplicity itself, provided one has a well constructed former upon which to wind the coils. If a former is made up on the lines given below it will serve its purpose over and over again, and is, in fact, to all intents and purposes indestructible. Such a former is known as a "spider," and, briefly, consists of a circular mandril round the periphery of which are inserted an *odd* number of pegs projecting radially outwards.

First of all procure a piece of steel rod $\frac{3}{4}$ in. in diameter and 8 in. long and turn this in a lathe to the dimensions given in Fig. 1.

The object of the reduction in diameter for 6 in. of its length is that such a size is less tiring to hold in one's hand during the process of winding. If, however, a lathe is not available, an 8 in. length of $\frac{3}{4}$ in. diameter rod will suffice. Now with a pair of dividers scribe a line round the $\frac{3}{4}$ in. end, so that it is in the centre of this portion of the rod. This is shown in Fig. 2. Using the dividers again mark off round this circle 15 equal points and at each of these points make a slight indentation with a centre punch.

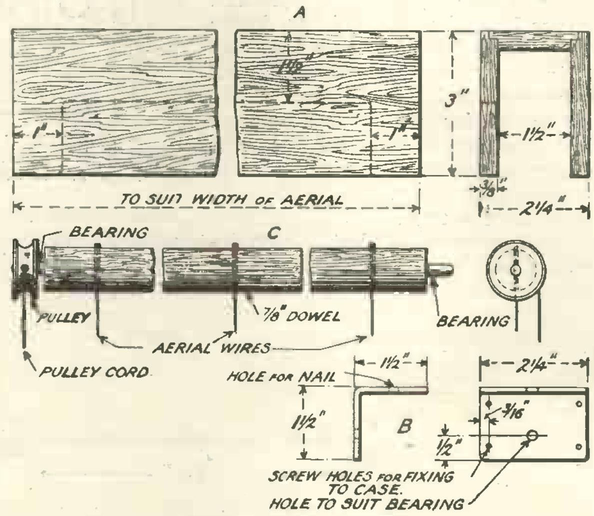


Fig. 3.—Constructional details.

The next process is to obtain a length of 45 in. of $\frac{1}{8}$ in. mild steel rod, which should be cut into 15 equal lengths of 3 in. each. These are to form the arms of the "spider." Screw each of these pegs with an $\frac{1}{8}$ in. Whitworth die for a length divisions in the winding of the coil.

Lastly, tap each of these 15 holes $\frac{1}{8}$ in. Whitworth and screw the pegs home. The spider is now complete; it should have the appearance of Fig. 2. As each peg is 3 in. long

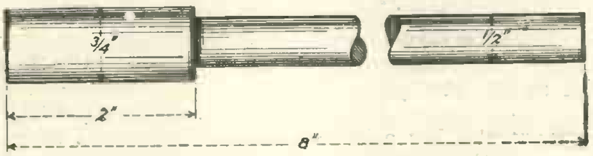


Fig. 1.—*The spindle.*

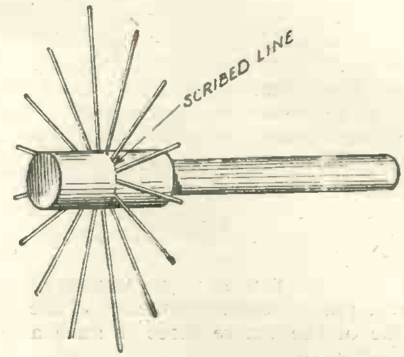


Fig. 2.—*The finished former.*

of about $\frac{1}{4}$ in. at one end and then proceed to drill the 15 corresponding holes round the periphery of the $\frac{3}{4}$ in. rod, using the centre punch dots to show the position of the holes. Care should be taken that these holes—which should be a shade over $\frac{1}{4}$ in. deep—are drilled radially, since the pegs are screwed into these and which if the holes are *not* radial will cause unequal and is screwed into the mandril for a length of $\frac{1}{4}$ in. the projecting length of the pegs will be $2\frac{3}{4}$ in., which will be found ample for coils of this type up to 800 or 900 ms. (when parallel with a .0005 mfds. condenser). The method of winding is well known, being simply to make the wire fast to one of the pegs, and, commencing from the inside, to wind the wire in and out round the pegs until a sufficient number of layers have been wound.

The coil, with the pegs intact, is then given a *thin* coating of good shellac, and when dry, the pegs are unscrewed, thus enabling the coil to be slid off the mandril. Having replaced the pegs the spider is ready for winding the next coil, and so on.

R. W. H.

A TUNING-STAND FOR FINE ADJUSTMENTS

In a recent issue of *Wireless Weekly* the editor referred to the absence of an instrument providing both lateral and rotary movement to the coil on a stand, and pointed out the obvious advantages of this type over the ordinary variety.

The writer evolved the instrument described in this note to use standard plug-in coils.

The cost of construction is quite moderate, and largely employs articles usually found in an experimenter's box of oddments. They are :—

Two standard coil holders.

Two pieces of $\frac{1}{4}$-in. ebonite 3 in. by $1\frac{1}{2}$ in.

One piece of $\frac{1}{2}$-in. ebonite 3 in. by $1\frac{1}{8}$ in.

Two lengths of $\frac{1}{4}$-in. ebonite rod 5 in. long.

Four strips of $\frac{1}{16}$-in. soft brass or aluminium 3 in. by $\frac{9}{16}$-in.

Two strips of $\frac{1}{16}$-in. soft brass or aluminium $1\frac{1}{2}$ in. by $\frac{9}{16}$-in.

One strip of $\frac{1}{16}$-in. soft brass or aluminium $2\frac{5}{8}$ in. by $\frac{9}{16}$-in.

One Meccano worm.

One Meccano gear wheel, 25 teeth.

One 2 B.A. spindle $1\frac{5}{8}$ in. long.

One phosphor bronze shaft $4\frac{1}{2}$ in. long.

Two knobs.

One $\frac{1}{4}$-in. special shaft 6 ins. long, spiral thread.

Two $\frac{3}{16}$-in. brass washers.

One internal worm to suit shaft

Various screws and nuts.

The various components are shaped and drilled as shown in the sketches.

One end of each slider rod may be screwed into the end piece, the

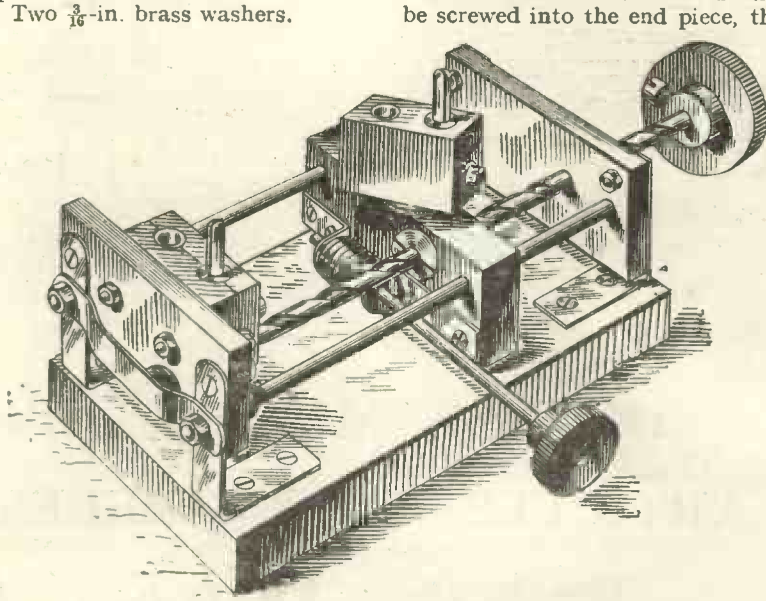


Fig. 1.—*A perspective view of the finished stand.*

opposite ends being provided with two nuts, one on either side of the end piece, and tightened up so as to bring the end pieces square.

The variable-coil holder is mounted on a spindle which passes through the centre block of ebonite and has screwed on to its bottom end the 25-tooth gear wheel.

The worm, with shaft, is carried in a pair of clips screwed into the side of the centre piece in such a manner as to bring it into mesh with the gear wheel. This provides the rotary movement to the coupling or reaction coil. If necessary the coil may be turned through 180°, thus reversing the direction of its winding in relation to the fixed coil.

The lateral movement is provided by means of a spiral shaft, mounted at the fixed-coil end, so that it may be free to turn.

A bush provided with a pin to fit the spiral in the shaft is fitted to the centre piece; so that when the shaft is revolved by means of the knob provided at the end of the centre piece, this holder will travel laterally along the shaft. The bush has an internal diameter to clear the shaft and the pin is provided by screwing into it, from the circumference, a small screw (say, 6B.A.), which has been shaped at the point to suit the thread of the spiral.

If the experimenter has a lathe the provision of the shaft is a simple matter, otherwise it will probably be necessary to get a piece of phosphor bronze rod turned at a machine shop.

A rack and pinion may be used should the spiral offer too great a difficulty, but the result would not yield so smooth an action.

The construction of this useful instrument is not nearly as complicated as might appear, and the satisfaction resulting from its possession is considerable.

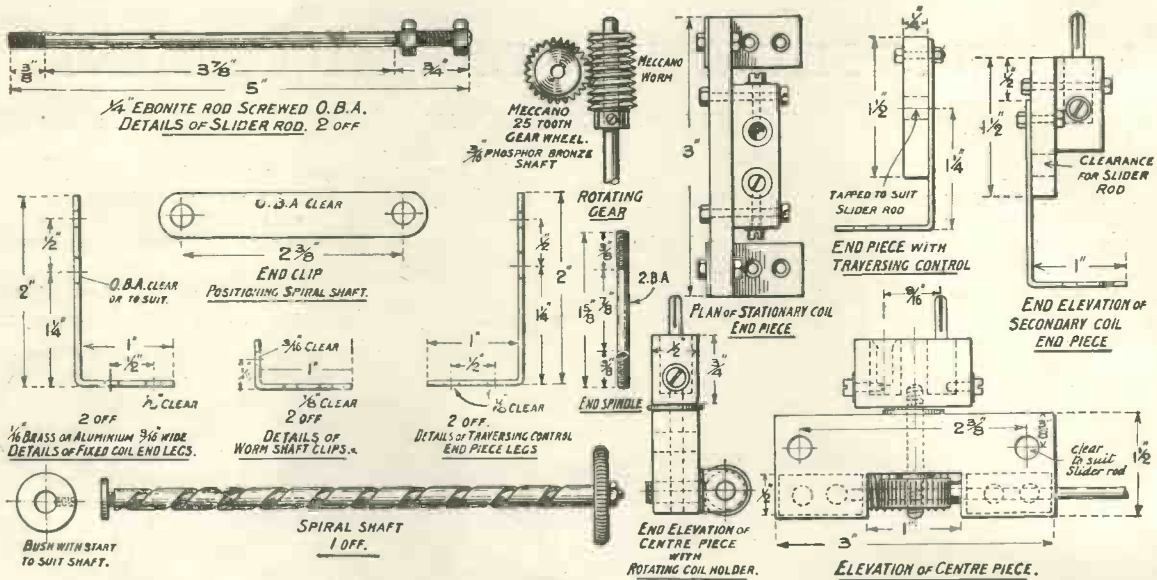
With a tuning stand of the ordinary swinging type the coupling must necessarily be irregular in operation, the first 30° or so of the swing being critical and the remaining 60° having a very small effect, it being sometimes found that the bases of the coils remain coupled and the degree of separation of the bases is not great enough to lessen this appreciably.

The two coil holders of the present instrument may be wired in series for use as a variometer, or separately for coupling circuits.

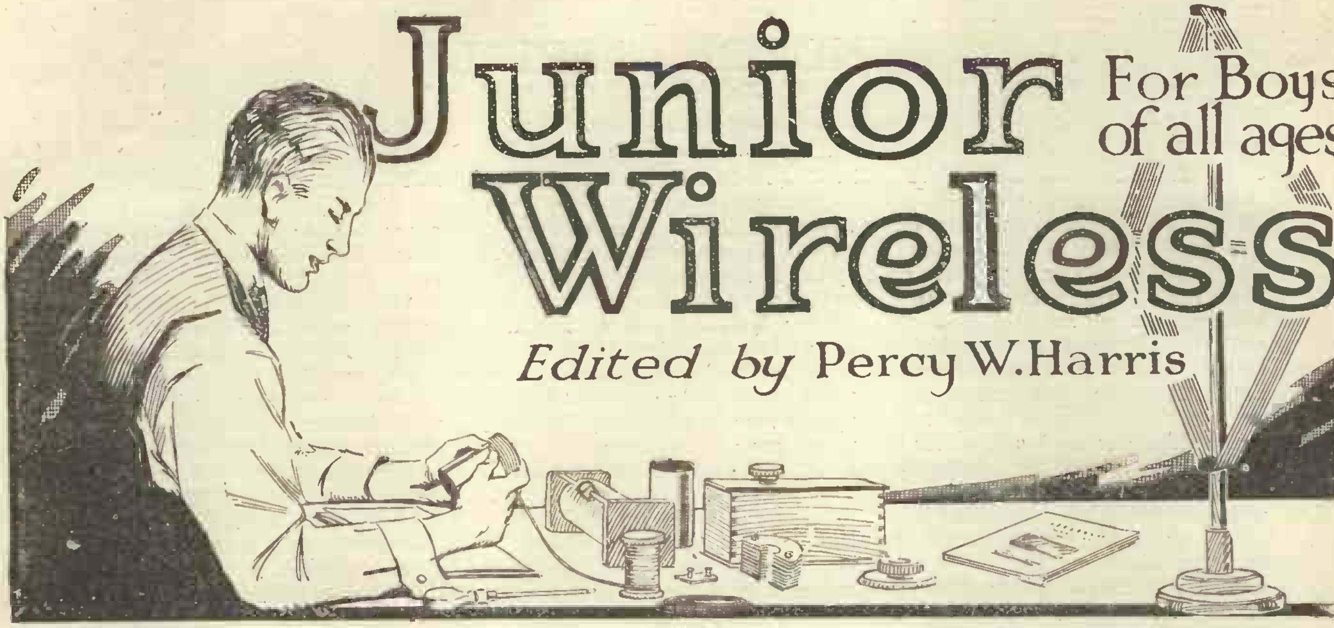
If required a further coil holder may be provided to move on the other side of the fixed coil to give reaction.

Much of the howling and "chirping" from an oscillating circuit is due to the difficulty of the operator in obtaining sufficient reaction effect without oscillation. This holder should go far to avoid the trouble.

R. L. R.



Constructional details of the tuning stand.



Vol. 1. No. 2. OCTOBER. Published Monthly.

THE EDITOR'S CHAIR

GENTLEMEN'S outfitters all over the country are scratching their heads and wondering why there has been a sudden demand for tie-clips. These almost forgotten oddments had to be hastily brought out from the bottoms of drawers where they had reposed for several years. The demand is all the more surprising as most of the purchasers are boys who firmly reject the more modern slip-on form of clip and insisted on being shown the old-fashioned kind which open on a hinge! Now that boys have been raiding their father's shops for the same purpose it has come out that there is a sudden desire to manufacture wireless sets on the lines described in last month's *Junior Wireless.*

This month there should be another rush for tie-clips as on another page we are describing a two-valve receiver in which the tuning is carried out in just the same way. But let me give you a practical tip. Very good spring clips for wireless purposes—much better than the old-fashioned tie-clip—are now available in the shops of the wireless dealers if you ask for them.

The first letter I have received from a reader of *Junior Wireless*, who has made the Junior Wireless Crystal Receiver, comes from a young man who lives in Dunmow, Essex, some 30 miles from 2 LO. He tells me he is receiving London quite clearly, which is excellent for a crystal set of even the most expensive kind. Those of us who write "how to make" articles make a point of never recommending crystal sets for use more than 10 or 15 miles away from a broadcasting station, although, of course, this distance is by no means the greatest which has been attained. I wonder how many miles my readers will be able to receive on the two-valve set this month? Who will be the first to let me know his results?

It is one of the greatest advantages of wireless as a hobby that you can so easily and rapidly change from one kind of apparatus to another without great expense once you have a few of the necessary components. For example, last month I told you how to make a crystal set and a two-valve note magnifier. If you want to make the two-valve receiver this month, you will be able to utilise practically all of the parts in the other set and spend only a few shillings to buy the additional parts. *Junior Wireless* will specialise on sets which can be made from parts already in the possession of readers, so that by following our articles each month, it will be possible to learn a great deal about making and working wireless receivers at very small expense. If several boys club together and buy their parts, such as wire, in quantity the cost will become even lower, for wire is much cheaper to buy in quantity than in small portions. This is where school wireless clubs are so useful. Next month I hope to give you an article telling you how to form a club at your school and how to conduct it to the best advantage.

THE EDITOR.

Contents.

INDOOR AERIALS

By E. REDPATH

In this article Mr. Redpath explains how all kinds of aerials can be erected inside your house when no garden space is available.

MANY would-be wireless experimenters are deterred from making a start by the difficulties in connection with the erection of an aerial. Some will not care to go to the trouble and expense of erecting a regular aerial complete with mast until convinced by a preliminary trial that their home-made apparatus is capable of performing properly. Others, probably a much greater proportion, simply have not the space available for the erection of a good outdoor aerial.

Although an orthodox outdoor aerial is always to be preferred, a carefully installed indoor aerial will be found an excellent substitute; and, in the present article, several types which have been found by experience to give quite satisfactory results will be illustrated and described.

The types illustrated are as varied as possible, so that readers should not have much difficulty in selecting one and modifying it as necessary to suit individual circumstances.

Wires Beneath the Roof

Fig. 1 illustrates an arrangement consisting of a number of bare copper wires suspended upon insulators attached to the underside of the wooden framing immediately beneath the roof slates. Five parallel wires are shown, spaced about 3 feet apart, but more wires may be used with advanatage if space is available.

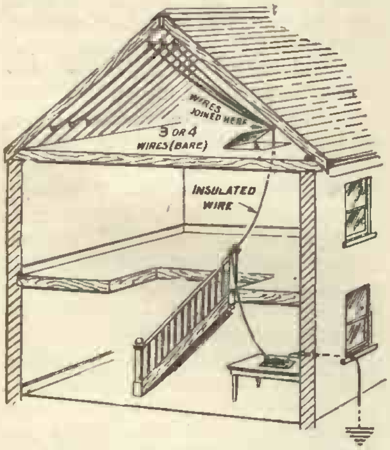


Fig. 2.—Another arrangement of indoor "roof" aerial.

Quite small insulators, of the bobbin type will suffice, and these may be screwed directly on to the wooden framing. If insulators are placed upon every second, or even upon every third frame, the wires, which may be of from No. 24 to No. 18 S.W.G., should be adequately supported.

Make the fullest possible use of the length available; that is to say, have each of the parallel wires as long as possible, and spare lengths of wire should be left hanging at the end from which the down-lead is to be taken, the ends of these wires being carefully cleaned and

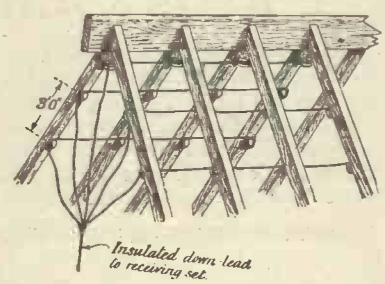


Fig. 1.—Several parallel wires beneath the roof, form a useful aerial.

soldered together and to the bared end of a well insulated down-lead, which, on its way to the receiving apparatus should be kept as far as possible from adjacent walls, gas pipes, or other earth-connected bodies.

Good quality electric bell wire makes a fairly satisfactory down-lead, but wire with a more dependable indiarubber insulation, such as some of the ex-Government cable extensively advertised by the New London Electron Works, Limited, is to be preferred.

An alternative arrangement of wires beneath the roof is shown in Fig. 2. In this case three wires are shown, which spread out "fan-wise" from the lead-down point, where they are all joined together to three insulators fixed below the ridge of the roof, and spread out still further to three more insulators secured near the opposite eave. More than three wires may be employed if desired, and, of course, the actual positions for the various insulators will be determined by the number of wires and the actual space available.

The down-lead of well insulated wire is shown passing through the manhole wedged slightly open for the purpose. If it is considered undesirable to have the manhole slightly open, a standard type of "lead-in tube," consisting of an ebonite tube with a screwed brass spindle through its centre and provided with wing nuts and washers at each end, may be fitted through the manhole cover itself. The aerial wires themselves may then be all joined together and attached to the upper end of the lead-in tube, whilst the insulated down-lead may be attached to the lower end.

The down-lead on its way to the receiving instrument, shown as being situated upon the ground floor, should take a route as direct as possible, and, as mentioned in the previous case, should avoid close proximity to walls, etc.

Wires Across Upper Rooms

The object of erecting the aerials illustrated in Figs. 1 and 2 close beneath the roof is to obtain the greatest possible height. In some cases, however, access to the space beneath the roof may not be possible, and the highest point

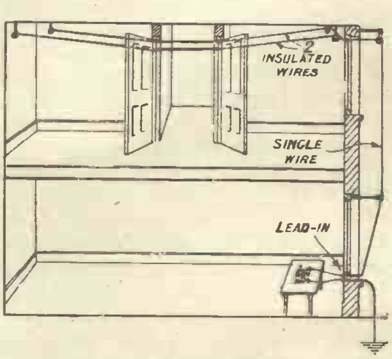


Fig. 3.—A combined indoor and outdoor aerial.

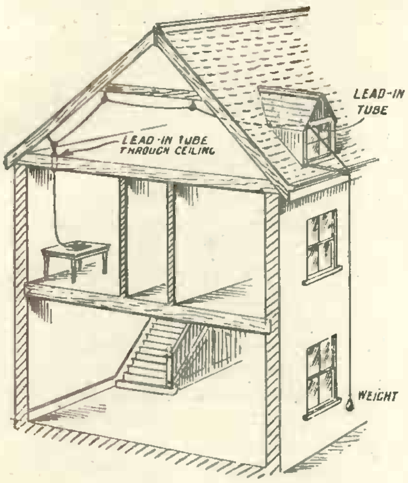


Fig. 4.—An indoor aerial with outdoor extension.

available may be an upper room or attic.

In such a case, an aerial consisting of two insulated wires arranged as shown in Fig. 3 is recommended. If small brass "cup-hooks" are screwed into the highest convenient woodwork in each of the rooms shown, or alternatively into Rawlplugs driven into small holes in the wall, and the aerial wires are cut off to exact length and fitted with insulators which may be simply hooked into position, the complete aerial will be readily removable. As the wires themselves will, no doubt, come into contact with the upper portion of the door frame through which they pass, the use of insulated wire is desirable.

The two wires should be carefully joined together at the end from which the down-lead is to be taken, whilst the down-lead itself may be arranged indoors as in the previous case (Fig. 2), or it may pass through an insulating tube fitted in the upper part of a convenient window frame and down outside of the house to a standard lead-in fitting arranged convenient to the receiving apparatus, as shown in Fig. 3.

Such an arrangement, of course, is really a combination of outdoor and indoor aerial, the down-lead, which should be held some two or three feet away from the wall by means of two light wooden or bamboo rods carrying insulators at their outer ends, also acts as an aerial.

Combined Indoor-Outdoor Aerial

Another arrangement, which may be regarded as a combination of indoor and outdoor aerial, is shown in Fig. 4, and will be found advantageous where the receiving apparatus is situated in an upper room and where the total space available in the roof cavity is only small.

Referring to Fig. 4, it will be seen that a single wire (preferably well insulated) passes from the receiving set through a small ebonite tube fitted in the ceiling to two insulators suspended at the highest possible point, and thence through the upper part of an attic window frame to the outside of the house down which the wire hangs, being retained in position by means of a lead weight attached to its end.

Here, again, it is necessary that the hanging wire should be kept at a distance of 2 or 3 feet from the wall, and this may be accomplished as shown in the illustration, by means of a light wooden or bamboo

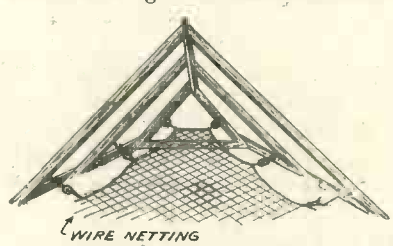


Fig. 5.—Good results can be obtained with wire netting arranged as shown.

rod fixed beneath the attic window and carrying an insulator at its outer extremity.

Wire Netting Aerials

One has become so accustomed to regarding long lengths of copper wire as being *essential* for aerials, that the possibility of using other materials in order to obtain the desired effect of a wave-absorbing capacity suspended at a height above the ground is often overlooked. In very dry weather it is often possible to employ a lead roof as an upper capacity or aerial, though such an arrangement is not recommended for reliable performance.

A piece of galvanised wire netting say 20 to 30 feet long by 3 or 4 feet wide, suspended upon insulators as high as possible and having a down-lead soldered to one corner of the netting, will be found to give excellent results.

Fig. 5 shows a convenient method of supporting the length of netting at the highest point available inside a house—namely, immediately beneath the rafters of the roof—and using an arrangement exactly as illustrated the writer has, in pre-broadcasting days, received signals over considerable distances using only a crystal receiving set.

Fig. 6 shows an alternative method of suspending wire netting beneath the ceiling of an attic or of an upper landing or corridor, a method which can be adopted when access to the rafter space cannot be gained.

There is, of course, one particular disadvantage about this type of aerial for the reception of short waves. Owing to the fairly large capacity, the inclusion in the aerial circuit of quite a small amount of inductance is sufficient to bring the aerial circuit into tune. This defect may be overcome to a large extent by the use of a series aerial condenser having a maximum capacity of from 0.0003 to 0.0005 μF. If a small fixed condenser is to be used, the former value is recommended.

Many alternative and more or less ingenious forms of indoor aerials will, no doubt, occur to readers, and the writer will be pleased to receive particulars of any which are found to give good results with a view to publishing details for the benefit of other readers.

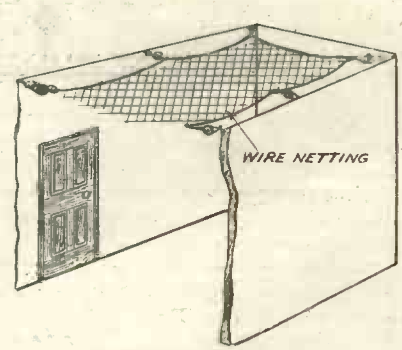


Fig. 6.—Method of suspending the netting in an upper room or attic.

AN EXPERIMENTER'S CRYSTAL DETECTOR.

THE detector described in this article has the advantage of being highly efficient in its functions and is particularly useful to the crystal experimenter. It possesses a wide range of selectivity, involving both the perikon and the cat-whisker, coupled with an extremely fine adjustment. It will be noted that in Fig. 2 three adjusting arms are shown. Each of these arms has an independent adjustment, which is a considerable advantage. The adjustment is obtained by means of the milled insulated knobs on the standards. The springs give a downward tension, working in opposition to the milled knob, which actuates an upward tension. The two forces working in opposition, together with the extremely fine movement given by the insulated screwed knobs, give an adjustment which is hard to equal. The complete details of construction are shown in Fig. 3. The base is made of $\frac{3}{8}$ in. mahogany, in which a slot is cut 3 in. × $\frac{1}{2}$ in. This slot allows a radial movement to be given to the cup-holder, which is fixed to the base by a single terminal. The cup-holder is built up from a piece of ebonite 3 in. × $\frac{5}{8}$ in. and drilled as shown. A piece of strip brass $2\frac{5}{8}$ in. × $\frac{1}{2}$ in. is drilled in a similar manner and laid on top of the ebonite. A further piece of brass strip, $1\frac{1}{2}$ in. × $\frac{1}{2}$ in., with two holes drilled 1 in. apart, is placed in position over the centre hole of

(Continued on page 30.)

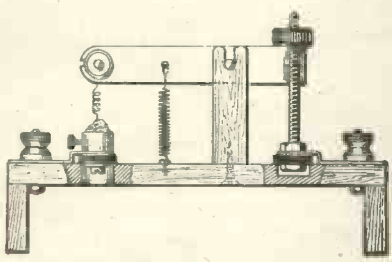


Fig 1.—Side view of the detector.

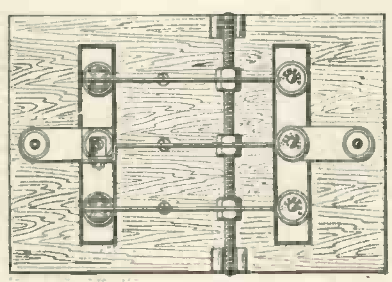


Fig 2.—Top view showing the three cups.

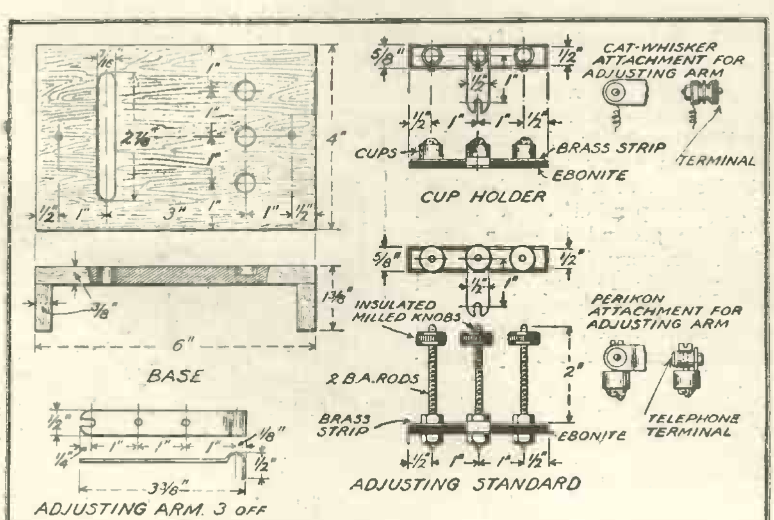


Fig. 3.—Constructional details.

POINTS ON FRAME AERIALS

ALTHOUGH relatively insensitive by comparison with the ordinary aerial, the frame or loop, as it is sometimes called, possesses such advantages, particularly in the reception of British Broadcast transmissions, that its more general adoption is to be looked for and some notes on the subject may be appropriate.

The open aerial receives fairly uniformly from all directions, unless its horizontal length is very great compared with its height, or unless it is screened in any way by adjacent conductors; but the frame aerial receives signals emanating from points in its own plane, and does not receive signals reaching it from points in a plane perpendicular to this and passing through its centre. In other words, if the edge of the frame is pointed towards a transmitting station, reception is obtained, and if it is then turned at right angles about a vertical axis, nothing will be received from that station.

This brings out one of the advantages previously referred to, since it is clear that interference from jamming stations, "birdies" and atmospherics will be less under such conditions than when reception is uniform in all directions. The frame is also more easily constructed, and is less expensive in first cost and upkeep than is the ordinary aerial; it is more convenient, is unaffected by weather conditions, immune from lightning, and, being a poor radiator, is less likely to interfere with other listeners-in should the circuits inadvertently be allowed to oscillate. But those experienced in the use of both frame and open aerials will probably agree that the comparative immunity from interference is the crowning advantage.

The disadvantage of the frame is its relative insensitiveness, but it is well to bear in mind that this is relative only, and is dependent upon geometrical dimensions. 2LO comes in very well with a 50-foot open aerial on a three-valve set at 50 miles, and is hardly audible at that distance on 50 feet of wire coiled up into an 18-inch frame.

THE "JUNIOR WIRELESS" TWO-VALVE RECEIVER

By THE EDITOR.

This is an exceedingly cheap and simple Receiver which will operate a Loud Speaker up to five or six miles from a broadcasting station.

LAST month I showed you how to make a crystal receiver and, if you wished for sufficient volume to work a loud speaker, a two-valve note magnifier. Many boys have been asking for a simple two-valve set to consist of a detector and one stage of note magnification, and so I have designed specially for "Junior Wireless" a two-valve instrument incorporating the "flat-coil-with-clip" tuner which was used in last month's crystal receiver. I know you will like this new set when you try it—anyone can make it up in a very few hours, and as the cost, apart from the valves, batteries and telephones, is well under £2, the reader who expects more for his money is, indeed, difficult to satisfy!

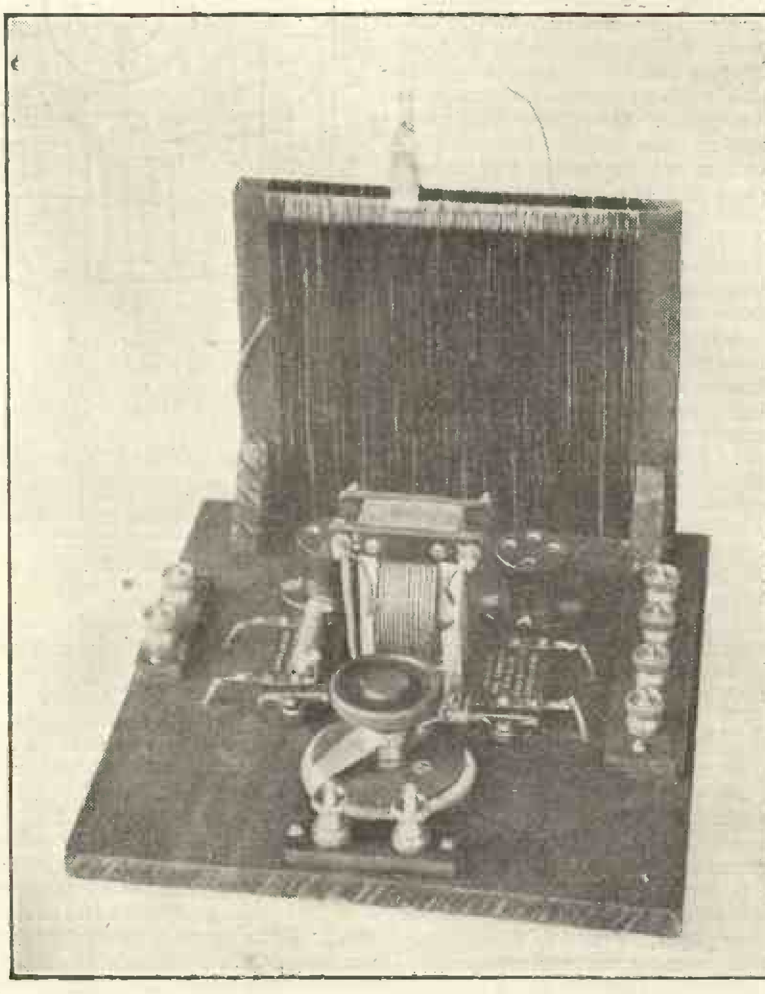
To make this set you will need the following parts:—

Component Parts

- A wooden baseboard, 8½ in. long by 8 in. wide and ⅜ in. thick.
- 1 piece of wood 6½ in. long by 5½ in. wide and ⅜ in. thick.
- 2 small triangular pieces of wood as supports.
- A few ounces of No. 20 enamelled copper wire.
- 8 terminals.
- 3 ebonite strips, two of them measuring 2¼ in. by ¾ in. and one 1 in. by 4½.
- 2 flange-type valve sockets.
- 1 grid leak and condenser (.0003 and 2 megohms).
- 1 fixed condenser .001 μF.
- 1 filament resistance for board mounting (several of this type are now on the market).
- 1 intervalve transformer of any good make.
- 4 small pieces of wood or else 4 rubber feet to put at the corners of the board to hold it away from the table.
- Some Systoflex or other insulating tubing and some No. 22 tinned copper wire for connections.
- 1 clip.

If you look at the illustrations you will see that the parts are symmetrically placed about the board. I should not advise you to alter the positions of these parts until you are more experienced. First of all you should cut the baseboard and mount the four rubber feet or pieces of wood at the corners of the underside. When you have done this, you should sand or emery paper the top of the board and set it on one side. Next cut the back board and two small triangular pieces of wood which can be screwed to the base and to the back board to support it. Stain and varnish the wood if you wish.

The only tedious work in making this receiver is in the winding of the coil. You should first of all bore two small holes about 1 in. or so



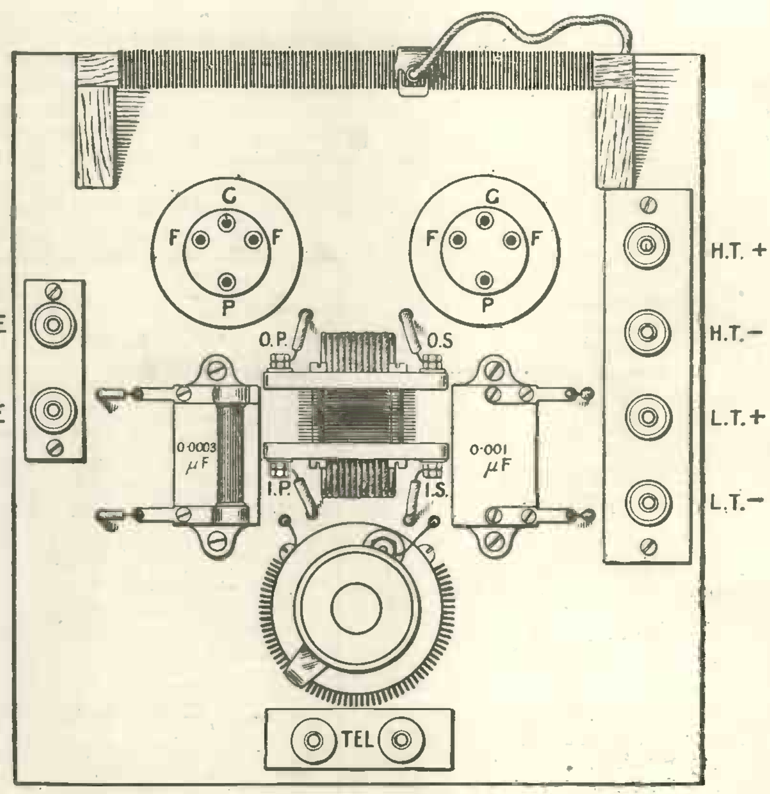
This instrument uses the clip method of tuning described in last month's "Junior Wireless."

apart and ½ in. from one end. Now drive a long nail into a heavy piece of wood and set the bobbin of wire over the nail so that it will rotate easily as you pull. This will save you a great deal of trouble in winding the coil and will prevent the reel running under the table and getting mixed up with the table legs and thus giving all kinds of annoyance. Put the heavy board with its coil on a table or some convenient place and thread one end of the wire through one of the holes and back through the other, and then back once more to the first hole, when, if you pull it, you will find it is held quite tightly. Leave about 1 ft. of wire projecting for connecting afterwards. Now start winding the coil by holding the back board in your hand and very carefully wind the first turn so that it lays evenly. To wind the remaining turns rotate the board and guide the wire with your thumb; in this way you will be able to keep the turns touching one another and not overlapping. Do not trouble about counting the turns, but simply continue winding until you come to a point ½ in. from the opposite end, when if you drill two more holes and thread the wires through in the way previously described, everything will be ready.

Now lay this flat coil upon the table and place a strip of wood (a ruler or anything else quite straight) along one side of it about ½ in. from the edge (at right angles to the winding of the wire). Take a piece of sand or emery paper and rub backwards and forwards until all of the enamel is removed between the ruler and the edge of the coil. You need not trouble to bare both sides of this; only one side is needed. When you have finished this you can screw the two triangular pieces of wood to the baseboard and then screw the back board on to these. With a little care you can fix the back board quite firmly.

The next step is to drill the holes in the ebonite strips to take the terminals. If you do not care for this work you will be able to buy terminal strips ready for mounting on a board. If you are making your own, rub the ebonite with emery paper, to remove the surface polish, using a circular movement, and then on the *back* of each short strip scratch a central line. On this line and evenly spaced from each end make two dots, so that the dots are separated 1 in. from one another. Two small holes should be made at each end for the holding screws. On the four-terminal strip you will need four dots, 1 in. from one another, and two holes for screws. Now drill holes sufficiently large to allow the shanks of your terminals to pass through and when they have been pushed through the holes secure them with lock-nuts on the other side.

The next part of the work requires a brace and a bit big enough to cut ½ in. holes. When you have prepared the ebonite strips, carefully mark immediately underneath where they will be fixed, dots corresponding with the centres of the screws. Now with a brace and bit drill holes ½ in. in diameter, so that when the strips are laid in place there will be a circular space around each nut to prevent the shank of the terminal and the nut coming into contact with the woodwork. You must be very careful not to split the wood in boring these holes. You must also cut holes about 1 in. in diameter underneath where the flange type valve sockets will come. You can use a ½ in. bit to drill these holes and then enlarge them up to 1 in. in diameter with your pocket knife. If you want to mark out a circle 1 in. in diameter lay a halfpenny in the place, for this coin is of the exact width. Before mounting the terminal strip and the flange socket you should take a smooth file and rub the ends of the screws and the pins of the valve sockets quite brightly so that you will be able to solder wires to them.



This diagram will enable you to set out your panel correctly.

The next step is to mount the strips and the sockets in place, screw down the two fixed condensers, the filament resistance and the intervalve transformer, and when these are secured satisfactorily, drill small holes just big enough to take the insulating tubing in the positions shown in the illustration. This will enable you to take the leads through from the top to the underside of the panel.

All you have to do now to finish the instrument is to wire it up. About this I can tell you little because all you need to do is to examine the photographs and diagrams which accompany this

(*Continued on page* 27).

A BASKET-COIL CRYSTAL SET AND HOW TO MAKE IT

Anyone can make this set in a couple of evenings. It is very easy to tune and there are no sliders.

To amateurs, more than half the enjoyment received from wireless telephony is in the construction of the set itself, and to do this without the aid of specially prepared and purchased material is certainly an added pleasure.

For instance, ebonite sheet of any appreciable dimensions and purchased retail is expensive, and to obviate this the writer has constructed quite a number of sets having spacious wooden baseboards by using in scrap pieces of celluloid and even waxed cardboard. One great advantage in fusing celluloid is that it can be cut to the correct size with a pair of scissors and needs practically no further working. To this end drawings of a simple though very effective set are shown herewith and will illustrate how such a receiver can be built for a very modest sum and in a very short space of time.

Principal Feature

The chief point which the writer would like to emphasise is the method of fixing the terminals shown in Fig. 6, in which a piece of insulating material cut to a convenient size is screwed over a hole bored in the base, which, in this case, is stained whitewood. If the diameter of the hole is such that the sides are well clear of the terminal there is absolutely no fear of leakage.

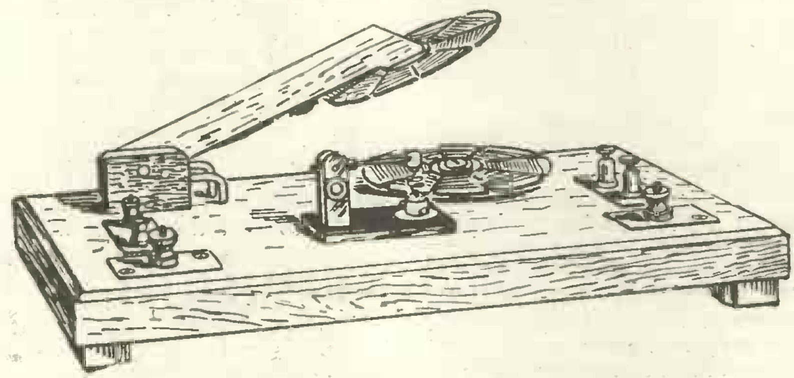


Fig. 1.—When finished the set looks very neat.

In Fig. 5 is shown the simple circuit of the receiver, the wiring diagram for which can be seen on reference to Figs. 2 and 3, where the upper and lower inductance coils are

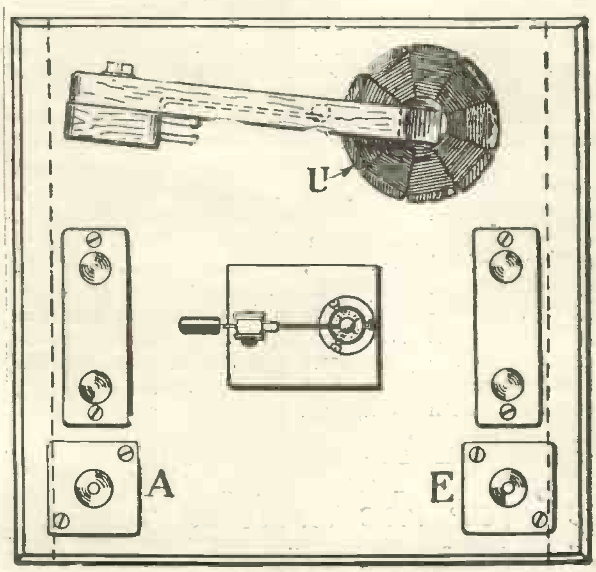


Fig. 2.—The top arrangement.

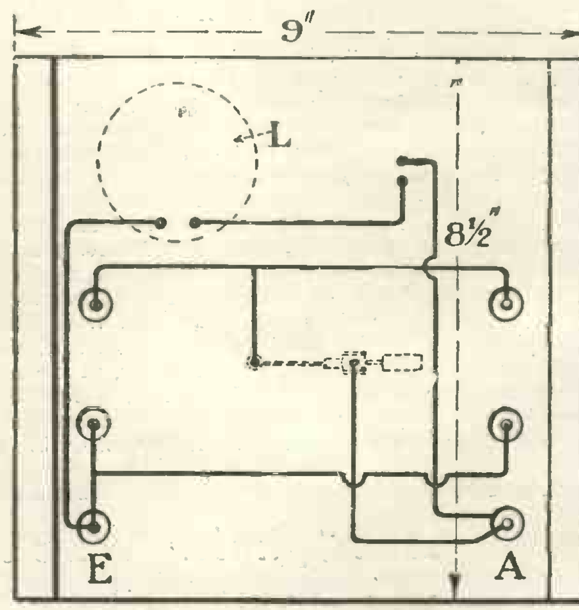


Fig. 3.—The wiring underneath.

indicated by U and L respectively. The two pairs of telephone terminals T1 and T2 (of course, one pair need only be fitted) are also shown.

Construction

The outside dimensions of the base are 9 in. × 8½ in. and ½ in. thick. In the bottom corners are

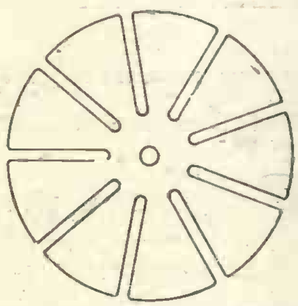


Fig. 4.—The card former.

ocated the aerial and earth terminals A and E, while the crystal detector is mounted similarly, though this time on a scrap piece of ebonite 2 in. × 2 in. and ⅛ in. thick. This is of the usual type—crystal cup, copper wire contact and ball joint—a most satisfactory arrangement.

Coming to the inductance coils, it will be seen that they are of the "basket" type wound on a permanent former of waxed cardboard, indicated in Fig. 4. It is 3 in. diameter and contains 9 slots about ⅛ in. wide. On this is wound turns of No. 26 D.C.C. wire, which quantity is found suitable for the writer's aerial, but may have to be adjusted slightly for others of different electrical length. (One or two turns more or less is all that is required.)

Mounting the inductance coils is extremely simple, and one can cast to the winds the expensive apparatus sold for fulfilling this function. The lower coil L in Fig. 3 is screwed to the base through a central hole in the former and a rubber washer ¼ in. thick. It is necessary to adjust only the upper coil U, and this is carried out by screwing it to an arm A, cut from wood ⅜ in. thick to the shape shown, and pivoted to a block B simply by means of a wood screw and metal washer; by this screw the correct pressure can be applied so that the movement of the arm is of the requisite stiffness. The upper coil, by this means, is able to travel through 180 deg., which is ample for all ordinary purposes. A point to be mentioned here is that the two wires, one leading to and the other coming from this coil, are attached to the underside of the arm and pass through separate holes in the base drilled as near the fulcrum as conveniently possible.

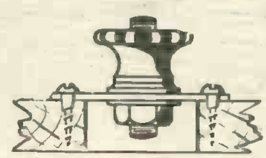


Fig. 6.—How the terminals are secured.

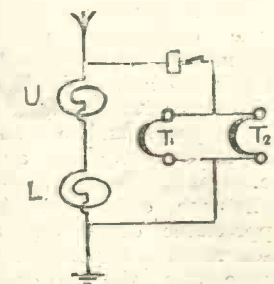


Fig. 5.—The theoretical diagram.

In conclusion, the connections are taken underneath the base, and all joints are soldered and waxed so that they may be completely covered by gumming to the base a sheet of brown paper about 8 in. square. Four rubber supports are screwed to the corners and ensure the vital parts being well clear of anything the instrument should rest upon.

AN INTERESTING EXHIBITION

The popularity of "Wireless" during the coming winter promises to exceed all previous records. Significant among many indications in this respect is the fact that arrangements have now been made to hold an All-British Wireless Exhibition and Convention at the White City, Shepherd's Bush, W. 12, from November 8th to 21st.

That familiar home of many famous Exhibitions will undoubtedly provide splendid facilities for the display and demonstration of "Wireless" on a scale worthy of its prominence in the public mind. This Exhibition is being organised in conjunction with The National Association of Radio Manufacturers, an organisation whose activities have always been so closely devoted to the maintenance of the highest standards of Wireless development. As a result all the best and most powerful Wireless interests in the country will be fully represented.

It had previously been decided to hold a Wireless Exhibition at the Horticultural Hall, Westminster, at the end of the present month, but having regard to the more comprehensive arrangements necessitated in connection with The National Association of Radio Manufacturers it was felt that the White City would furnish more fitting accommodation. Consequently the arrangements for the earlier Exhibition were postponed and revised so as to amalgamate with this larger Exhibition in November.

The organisers are Messrs. Bertram Day & Co., Ltd., 9 and 10, Charing Cross, S.W. 1. Among a number of special attractions it is worthy of mention that the Wireless broadcast demonstrations will be in the capable hands of The British Broadcasting Co., Ltd.

TRICKS WITH WIRELESS

Most of us like to try experiments with our apparatus. Here are a few "stunts" which will interest and amuse you.

THE telephone, as you know, is a device which converts sound waves into pulsations of electricity which pass along a wire and are reconverted into sound waves. Now the wireless valve is a very perfect magnifier of electric currents, large or small, and if we connect a valve in the telephone line with suitable apparatus, we can magnify these currents into much more powerful current which will give a great volume of sound at the other end. Each additional valve adds to the volume of the sound and that is why, as described on p. 13 of "Junior Wireless" last month, the tiny currents generated by the action of sound waves on the loud-speaker were sufficiently strong to work our telephones. Now, if we can get hold of some device much more sensitive as a "pick-up" than a loud-speaker (which is really very insensitive for the particular purpose) we can perform all kinds of useful and interesting experiments. For a few shillings at any wireless dealer you can buy a small device known as the Skinderviken transmitter button. This is really a tiny microphone something like that into which you speak when you use a wire telephone. If we connect to it a single dry cell in the way shown on the little leaflet of instructions, and then connect it to the input terminals of our note magnifier, we can listen with a pair of telephones on the output terminals to various tremendous noises from sources we hadn't previously thought of.

Lay your watch on the table near the transmitter button and you will hear, instead of quiet little ticks, loud hammer strokes as if one were striking some great piece of metal. Fasten the microphone to a piece of wood with a suitable handle and you can use it as a stethoscope to listen to the heartbeats of your friends. Carefully adjusted, and when you get used to it, you can make it sufficiently sensitive to hear the footsteps of a fly as it walks across a thin piece of wood. Connect it behind a picture frame in such a way that the front of the picture acts as a sounding board, run a pair of wires in some concealed position out of the room into another part of the house, and you can astonish your friends by repeating every word they have said in the room while you have been out of it, even if they have been talking very quietly, for the microphone will pick up the sounds and your note magnifier will magnify them for the requisite degree.

Even if you have not a loud-speaker and do not wish to buy a microphone button there are many experiments to be conducted simply with a pair of telephones. Most telephones have easily detachable earpieces, and if you take one from the band and leave the other in place, you can wear one of them and use the other for experiment. The first experiment I would suggest to you is to connect a pair of wires to the detached telephone earpiece and take these to the input terminals of the note magnifier. Lay your watch on top of this earpiece and you will hear very loud ticks, although they will not be so loud as if you were using a microphone button. Now bring the two earpieces gradually together. Nothing will happen until they are about an inch apart, and then you will hear a musical note that will vary slightly as you move the relative positions. By moving the earpieces across one another you can produce a fair imitation of a cat's "miaow."

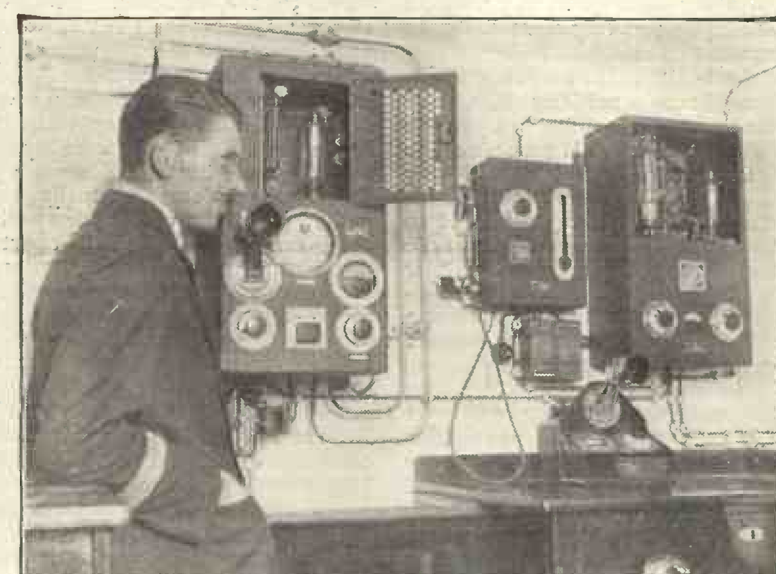
Where does this noise come from? Next month we shall have an article on reaction and you will be shown how to apply it in wireless apparatus to get much greater sensitivity in your set. Meanwhile we must explain that if a slight sound occurs by the earpiece connected to the input, a much louder magnified noise will come out from the other earpiece. This, facing the first one, will pass the sound into it again, it will be re-magnified and so the cycle of events will continue making a persistent howl. The pitch of this howl will vary with different kinds of telephones and in different positions. Occasionally you will need to tap the earpiece to start the sound, but in most cases it will start of its own accord.

In practical wireless we can arrange that some of the magnified signal energy is handed back to the input side and re-magnified much in the same way as we have done with the sound you have heard.

And now for some experiments of a different kind. If you live within a few miles of a broadcasting station and have a two or three valve set, you will be surprised what you can use for an aerial. You can, for example, connect the aerial terminal with the gas-pipe and the earth terminal with the water-pipe and get very loud signals. If you are using the set in your bedroom you can similarly try the bedstead as the aerial and the gas-pipe as the earth. Indeed, I have often known wireless signals received on no other aerial than a galvanised bath set on the table with another bath underneath as the earth connection!

If you have a few friends interested in wireless, get them to your house one evening and see which of you can devise the simplest crystal receiver. Each person should be lent the telephones, a crystal and the connections for the lead-in and earth wires. The rest of the set should be made from things to be found in the room or round the house. One boy I know got splendid signals with a pair of compasses, the back of a clothes brush, a piece of silver paper and a couple of short lengths of wire. One point of the compasses was pushed into the back of the clothes brush, the other point was used to rest upon the crystal and the cat whisker, the silver paper was wrapped round the crystal and the aerial and earth wires were taken to the compass and silver paper respectively. The telephones were connected by a short piece of wire to one leg of the compasses and to the same silver paper. As the broadcasting station was not far away the results were excellent. Perhaps you can think of something simpler than this!

Wireless on a German Liner.



Several German liners are fitted with wireless telephones. This picture shows the operator of the new liner "Albert Ballin" standing by the transmitter ready to speak into the wireless telephone. Notice the large valves in the cabinets.

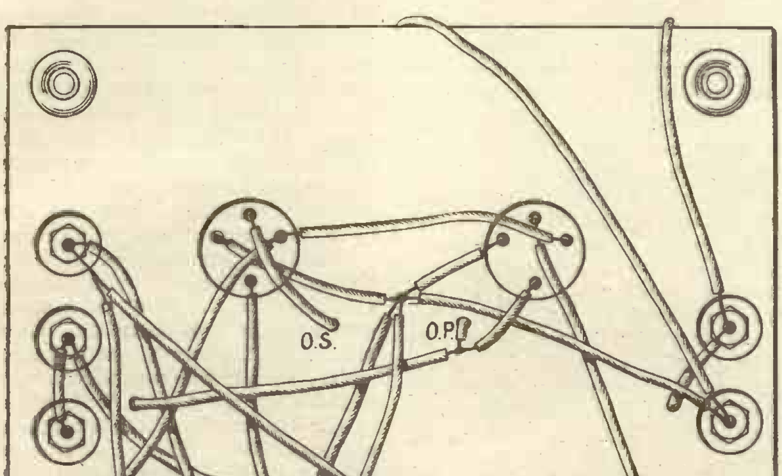
Junior Wireless Two-Valve Set—continued from page 22.

article. Soldering, of course, is not very easy for the beginner, but if you get a friend who is an expert at the work to come round one evening and show you how to start, you will find no difficulty in carrying on.

The right-hand end of the flat coil must have two wires connected to it. One is a short length of flexible wire (a single strand of electric lighting flex insulated with rubber will do excellently) and on the end of this flexible wire is soldered a tie clip or other similar clip for clipping on to the coil. The other wire goes to the underside of the instrument and leads to the aerial terminal.

Be very careful that the wires are connected to the right terminals of the intervalve transformer. You will see that they are marked I.S., O.S., I.P., O.P. on the diagram in a certain order. This is the order on the particular transformer used. Some makes of transformer do not have I.P. and I.S. opposite one another, I.P. being opposite O.S., but it does not matter how it is made or how these terminals are arranged if you connect the wires which are marked to go to I.P., O.S., etc., to these terminals.

When everything is ready for trial, connect your aerial and earth wires to the top and bottom left-hand terminals. The two front terminals are for connecting your telephones or loud speaker, for you will be able to use a loud speaker with this set if you are not more than 5 or 6 miles away from a station and your aerial is a good one. You should light the valves by turning the filament resistance on till the valves light up. If you are using a 6-volt battery with the ordinary valve it will mean that the filament resistance must be turned just on, and do not on any account turn the valves up more brightly than this until you have found the best position for tuning. To tune the set take the clip in your hand and rub the edge of it along the bared portion of the coil until you hear signals at the best strength, then clip on. If you use dull



The wiring beneath the panel. The circles in the corner indicate rubber feet.

emitter valves you should connect a 2-volt accumulator to the low-tension terminals and turn the filament resistance round almost as far as it will go. On no account use any higher voltage than 2 on the dull emitter valves unless the makers particularly tell you to do so. A high-tension battery of about 60 or 70 volts is recommended for this set. A lower voltage will work, but in practically all cases you will find that up to 100 volts the higher the voltage of your high-tension battery, the better the signals will be.

When you have found the best tuning position by rubbing the clip up and down the side of the coil, clip it in place and listen to your signals. Now very carefully turn the filament resistance round clockwise and you will notice the valve get brighter. Stop turning immediately there is no further increase in signal strength, for if you are getting the right strength of signals it is far better for the valve to burn it as dull as possible.

The wavelength range of this set is well over 700 metres with the ordinary amateur aerial and even with a small aerial it should go up to 600 metres to enable you to hear ship and shore stations working.

The range of this set is sufficient to hear one and perhaps, two, broadcasting stations at practically any place, and I have no doubt that when conditions are good even better results will be obtained. It should be pointed out that no reaction whatever is used in this set and therefore you will not get so strong signals as would be possible with a reaction receiver, but against this you must reckon that the set is extremely simple to handle, there being only one tuning adjustment.

In future issues of MODERN WIRELESS we shall show you how to build other kinds of two-valve sets which will give you better results for distant stations in return for slightly greater complication in making and in handling. Any boys who get this set working satisfactorily are invited to write to the Editor and tell him how they are getting along.

CRYSTAL NOTES

Many a Slip

THERE are many kinds of excellent crystal on the market which properly used with the right kind of cat-whisker should give satisfactory results in a well-designed receiver, but it cannot be too strongly emphasised that crystals can be spoilt in dozens of ways between the time you buy them from the dealer and your first attempt to listen-in. First of all, if the dealer is not careful he may pick the crystal out of a box with warm fingers, thereby depositing upon the surface a thin invisible film of grease which will prevent proper rectification. If he is wise he will pick the piece out with a pair of tweezers and wrap it carefully in tissue paper. The purchaser should handle it with equal care when he gets home.

Crystal Cups.

Many crystal detectors are sold with a cup fitted with a side screw. The object of this screw is to grip the crystal without the need of using any Wood's metal or other similar compound. Care is needed in using these cups because the crystal is so hard that contact is only made in one or two places and this is rarely sufficient to give the best results. If you use one of these detectors with a side screw I would recommend you to wrap the bottom half of the crystal in silver paper, tinfoil or any other soft metallic substance and then tighten up the screw. In this way the screw will make contact with the tinfoil and the tinfoil with practically the whole of the underside of the crystal. This is almost as good a method as using Wood's metal.

A Carborundum Hint.

A new gramophone needle makes an excellent steel contact for use with carborundum. To get the best from this crystal you must use a potentiometer, a description of which will be found in any book dealing with crystal detectors.

WHISKERS.

A FILAMENT RESISTANCE FROM AN ARMLET BAND

THE following is a constructional description of a rheostat which can be made with the simplest of tools, and should appeal to the boy who derives pleasure from making his own component parts, and making them cheaply. All you require is :

1 Ebonite knob.
1 Length of 3 B.A. threaded brass rod (2½ ins.).
4 3 B.A. nuts.
1 Armlet band.
1 Spring washer.
1 Flat washer.
1 Strip of springy brass (2¼ ins.).
6 ⅜ in. countersunk wood screws.
1 Piece of board.

The size of this rheostat is not important, but I will give the dimensions actually used. A pair of spring-type armlet bands may be purchased at any outfitter's for the sum of about 4d. Personally I procured mine from a street vendor, thereby saving 2d. and causing several of my so-called friends to disclaim acquaintance with me.

First take the piece of board, which must be ⅝ in. thick, and describe two circles by means of compasses. One is to be 3⅜ in. in diameter, and the other 3¼ in. Now cut round the pencil lines with a fret-saw. If you do not happen to be the proud possessor of a fret-saw, no doubt one of your friends will oblige you.

The next step is to fix the armlet band around the smaller wooden disc. This is done by driving two screws (A. Fig. 1), 1¼ ins. apart, into the edge of the disc. Now straighten out a few turns of wire at one end of the band and twist once or twice round the right-hand screw, leaving about 6 ins. of wire free for connections. The band is now spread round the edge of the disc, and the other end fastened to the left hand screw in the same manner, only in this case the wire is cut off as close to the screw as possible. It will probably be found that one band provides sufficient wire for two rheostats. In any case, the band must be cut to such a length that, when stretched round the disc (D1. Fig. 1), each individual turn is just separated from its neighbour.

This disc (D1) must now be firmly clamped down to the larger disc (D2. Fig. 1). This is done by driving in three of the wood-screws about ½ in. from the edge of D1.

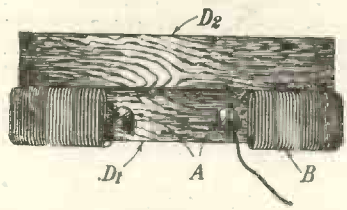


Fig. 1.—The armlet secured to the wooden boss.

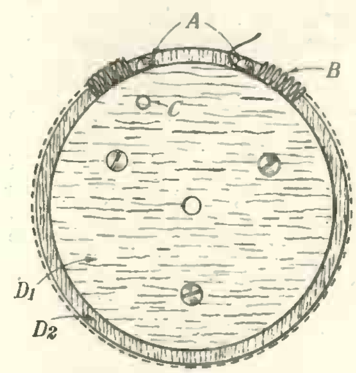


Fig. 2.—The underside, with coil in place.

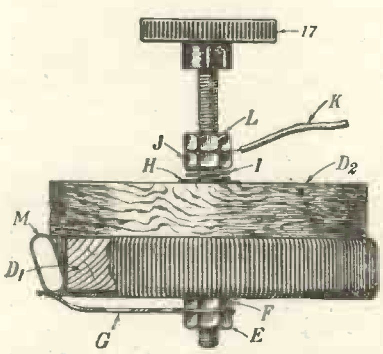


Fig. 3.—The assembled rheostat.

A glance at Fig. 2 will make the position of these quite clear. It will now be found that D2 provides a small ledge around the base of D1, upon which the band (B, Fig. 1) will lie quite evenly. It will be noticed that with the band bedding firmly all round the ledge, the bottom edge will protrude a fraction of an inch below the level of D1. It is upon this edge that contact is made.

Next, a hole, large enough to comfortably take the length of 3 B.A. brass rod, must be drilled right through the centre of the two discs. There should be no difficulty in finding the exact centre, as the point of your compasses has probably left a small hole.

Now pass one end of the rod through the hole and attach 3 B.A. nut as shown at F, Fig. 3. Next follows the strip of springy brass, which must be drilled at one end to take the 3 B.A. rod, and is bent as shown at G, Fig. 3. In this instance a strip of Meccano was used. If the reader can lay hands on a short strip he will save himself the trouble of drilling the necessary hole. These strips are always rounded at the ends; and the correct length may be obtained by breaking at the fifth hole from one end, the rounded end being attached to the spindle. The nut E, Fig. 3, is now screwed up tight.

We next come to the top end of the spindle and fix in position the flat washer, spring washer, nut, wire lead, lock nut, and ebonite knob, as shown at H, I, J, K, L, and M, Fig. 3, respectively. It is advisable to put a blob of solder upon the nuts E and L, in order that any chance of them coming unscrewed may be prevented.

The brass strip must be so bent that its pressure upon the band will be sufficient to bulge out the band over the ledge at the point of contact as shown at M. This insures a smooth and even contact being made.

Finally we fix the remaining wood-screw to act as a stop for the brass strip. This is best done by pencilling a straight line on the disc D_1 from the right-hand screw securing the band, to the centre spindle, and placing the screw ½ an inch along the line from the edge of the disc. This may be seen at *c* Fig. 2.

The second connection is taken from the centre spindle. This may be conveniently done by fixing the piece of wire, K, Fig. 3, between the nuts J and L, Fig. 3. A short length of ordinary lighting flex is to be recommended for this purpose.

In conclusion, make sure that your band is made of steel wire. Readers should be warned against purchasing armlets that are yellow in colour. These are made of springy brass wire, and are, of course, quite useless for this purpose. The rheostat, constructed to the above dimensions, has a resistance of from four to five ohms.

R.T.M.

An experimenter's crystal detector ***(Continued from page 20)***

the ebonite and the three cups are fixed in the positions shown. The whole of the holder can easily be removed from the base to which it is secured by means of the terminal which holds the projecting piece of brass on the holder. The adjusting standard is made on similar lines with corresponding dimensions, but in place of cups three 2 B.A. standards are built, each having a milled insulated knob, which is tapped 2 + to suit. The adjusting arms are also made from brass strip 4 in. × ½ in. and drilled as shown. One end is bent over to pass round the 2 B.A. standard and under the milled knobs. The cat-whisker holder shown is made from an ordinary small terminal, and can easily be placed and replaced or turned in any desired position. The perikon holder is made by passing the crystal cup screw through the hole of a telephone terminal, which is in turn slipped on to its corresponding adjusting arm in the manner shown, and can also easily be placed or replaced to effect a change of cups. Quite a selection of combinations can easily be obtained with this detector, and, if desired, where the crystals are permanently set, two or three crystal holders could be made.

H.B.

Tell your Friends of Junior Wireless.

THE BEGINNER'S TOOL OUTFIT

By R. W. HALLOWS, M.A.

If you make your own apparatus you will find many valuable hints in this article.

THE first problem that faces the boy who decides to make up his own receiving set is that of the provision of the necessary outfit of tools. Ebonite is luckily a fairly easy material to work in, and does not demand special tools reserved entirely for itself. It can be cut without difficulty with either a wood or a metal saw, whilst drills, taps and files suitable for working in brass or mild steel will be just the things when it comes to doing work in ebonite.

The absolutely essential tool outfit is a small one, and several of its components are probably in your possession already. Let us see what is needed. For cutting ebonite, nothing can be better than a small stiff-backed tenon saw, which like all other tools, should be lubricated with turpentine when used for this material, otherwise it will soon become blunt. Since, however, we want to be able to cut brass as well as ebonite, it will be best to invest in a hacksaw, which does equally well for either substance. A respectable frame can be bought for eighteen pence, and this with a couple of blades, one fine and one medium cut, will do all that is needed.

Before we can use the saw successfully, we must first mark out our material. For this purpose we need a scriber and a set square, neither of which is an expensive item. It will also be an advantage to have a pair of dividers.

For finishing up the sawn edges we require two files. The first should be a medium-cut tool, 8 inches long and preferably of D section. If this type of file is bought the flat side comes in handy for lining up straight edges, whilst the round portion is useful if large holes or curved edges have to be dealt with. The second file will be used for smoothing when superfluous material has been cut away with the first. It should be of the same size or a little smaller, and it should be a flat fine cut tool.

When the edges have been treated with the files we give them their final dull polish by means of emery cloth of the finest grade, a sheet of which should always be kept in the tool drawer. An old piece of cloth should be used for finishing ebonite, and a little turpentine should be employed as a lubricant in order to avoid making unsightly scratches.

We next require some means of making holes for terminals, valve legs, spindles, and the other fittings that must be mounted on the panels. Nothing can be better for the purpose than a bevel-geared hand drill, which does the work cleanly and quickly, and is not at all difficult to use. Select one with a large chuck so that drills ranging from 4 B.A. to ¼ inch may be used in it. Of drills we shall need six: 4 B.A. tapping, 4 B.A. clearing, 2 B.A. tapping, 2 B.A. clearing, ¼ in. and ⅜ in.

It is quite unnecessary to make use of other B.A. sizes for most wireless constructional work, and besides reducing the necessary expenditure upon tools it is far more convenient to have only these two sizes of screws in the set. The ⅜ in. drill will not go into the drill chuck: but it can be used in an ordinary brace, and as it is only occasionally wanted one can usually manage either to borrow the brace or to get some friend to drill the necessary holes. They are required when we have to mount rheostats or variable condensers, the bushes through which the spindles pass being usually of this size.

We must have the 2 and 4 B.A. drills in two sizes, because some of our fittings will be screwed into the panel, whilst others will simply be thrust through it and secured by nuts on the underside. The tapping drill makes a hole of diameter slightly less than that of the screw of corresponding size. This allows the tap to be forced in and to cut a thread as it goes. Only two taps are needed—2 and 4 B.A.—and we must have a tap wrench to hold them as they are being turned in.

Before we can start drilling we mark out the panel with scribes and set square, then we use a centre punch to make a little hollow in which the point of the drill is placed. If we do not centre-punch the work, the drill is sure to slip, and the holes, when made, will be out of their proper positions. The punch should be of medium size, and we must have a small hammer with which to tap it.

Our next requirement is a soldering iron, for all connections beneath the panel should be soldered and not merely held by nuts. Screwed up connections work loose; soldered ones do not, and they offer much less resistance to the passage of the tiny currents with which we have to work. The " iron," which is really made of copper, should be of rather small size. A large one remains hot longer, but it is an unwieldy tool for a beginner to use.

Our last item completes the essential outfit, and that is a pair of milliner's pliers. These have cone-shaped noses, and wire cutting edges. They can therefore be used for shaping the ends of wires as well as for cutting off pieces. The minimum outfit, then, consists of:

- Hacksaw (or tenon saw).
- Set square.
- Scriber.
- Two files.
- Emery cloth.
- Hand drill.
- Six drills (2 and 4 B.A. tapping and clearing, $\frac{1}{4}$ in. and $\frac{3}{8}$ in.).
- Two taps (2 B.A. and 4 B.A.).
- Tap wrench.
- Centre punch.
- Hammer.
- Soldering iron.
- Pliers.

If every item has to be purchased new, the total cost will not be more than about twenty-five or thirty shillings. Most boys, however, will already own a number of tools which can be pressed into service even if they are not exactly like those described.

Later on, additions of a very useful kind can be made to the nucleus of absolute essentials. A few additional files, such as small flat, rat's tail, triangular and square will help when more difficult jobs are tackled than those usually undertaken at the outset.

The ordinary hacksaw may be partnered by a small fellow such as jewellers use. Though quite inexpensive this is a most useful little tool. It has six inch blades which make a much finer cut than those of the ordinary hacksaw, and it is very handy for neat small work.

An original stock of half a dozen drills may be increased as time goes on by the addition of other B.A. sizes, and of others measured in fractions of an inch from $\frac{3}{32}$ to $\frac{5}{16}$. With these, and a set of B.A. and Whitworth taps (2, 3, 4, 5 and 6 B.A. and $\frac{1}{8}$ in. to $\frac{3}{8}$ in. by sixteenths), we can tackle any drilling and tapping job that is likely to crop up in connection with the construction of a wireless receiving set. To hold the work firmly whilst we are engaged upon it, it is desirable to have a table vice with 4 inch jaws. These can often be picked up cheaply from firms that deal in disposal goods. To prevent the jaws from marking ebonite they should be provided with protectors made of sheet lead.

Though we started with only a single pair of pliers, we shall find it convenient to add others made for special purposes to our outfit from time to time. Round-nosed pliers are most useful for shaping the ends of leads. Those with flat noses help us to straighten wires and to bend them neatly, as well as being most useful when we are dealing with sheet brass. For tightening up nuts, nothing is better than a pair of pliers specially made to grip them without slipping, for nuts whose edges have been worn away by the jaws of ordinary pliers, which *will* slip no matter how careful one is, do not add to the appearance of the set. Nut pliers cost only about 1s. 6d. a pair. To begin with we shall heat our soldering iron over a gas ring, but later we will find it better to purchase a blow lamp, which does the job very much more quickly, and also come in useful for many other purposes.

So far we have spoken only of tools for ebonite, and brass work. If we intend to make our own cabinets we shall need a few more, though not very many. Our requirements will be met by the provision of a saw, a small iron plane, half-inch and quarter-inch chisels and a brace with two or three bits, preferably of the auger type.