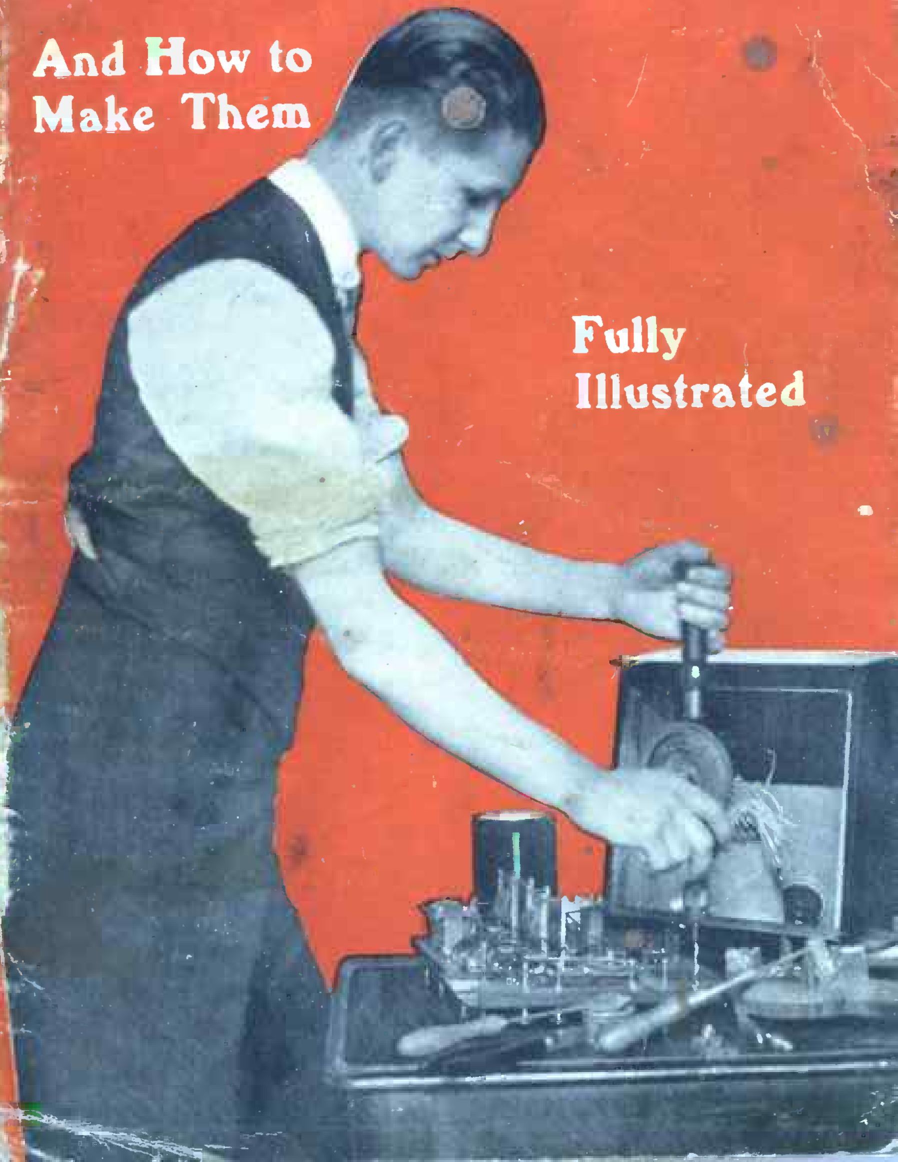
"Amateur Wireless" Handbooks

SIMPLE VALVE RECEIVING SETS

And How to Make Them



Fully Illustrated

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SIMPLE VALVE RECEIVING SETS
AND HOW TO MAKE THEM

EDITED BY
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Editor of "Amateur Wireless," etc. etc.

WITH 113 ILLUSTRATIONS

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PREFACE

THIS book is uniform in style and price with two others—namely, "Wireless Component Parts and How to Make Them," and "Simple Crystal Receiving Sets and How to Make Them," the former containing detailed instructions on the making of the various components forming part of many kinds of wireless receiving apparatus, and the latter treating of crystal sets in exactly the same way as valve sets are dealt with in this present handbook.

The scope of this book will be self-evident. It seeks to show in close detail, and with the aid of over one hundred illustrations, how to make and operate about ten different types of valve sets.

This book has been compiled from the writings of many contributors to the pages of "Amateur Wireless," the well-known weekly journal for wireless amateurs, and the name of the writer responsible for each individual chapter is given in every case immediately below the chapter heading.

It is believed that the information is presented in such simple fashion as not to cause the reader any particular difficulty in putting it into practice, but should he be in doubt with regard to any matter dealt with in this book or to any other subject within the scope of the weekly journal mentioned, he should send a query to "Amateur Wireless," La Belle Sauvage, London, E.C.4, *but should take particular care to accompany his query with a stamped and addressed envelope and a coupon from the current issue of that journal.*

THE EDITOR.

CONTENTS

SIMPLE VALVE RECEIVING SETS
AND HOW TO MAKE THEM

CHAPTER I

A Single-valve Set with Basket-coil Tuner

By H. H. DYER

Why Valves are Used.—Valves are used in wireless reception for four purposes: (1) To amplify the weak high-frequency signals received on the aerial. ("High-frequency" amplification.) (2) To "detect" these signals, that is, to alter their form so as to make them audible in the telephones. (Detection.) (3) To amplify the audible signals so as to get them louder in the telephones. ("Audio-frequency," or generally called "low-frequency" amplification.) (4) To generate high-frequency oscillations for combination with the received oscillations in "continuous-wave" telegraphy. (Heterodyning.)

Now "detection" is always necessary, and as some signals are audible with a detector only, it is proposed to describe first a simple single-valve set with which the reader will be able to receive "spark" signals, for instance, the Paris time signals, weather reports, etc., in code.

Systems Used in Wireless Telegraphy.—Two distinct systems are employed in the transmission of wireless telegraph signals. These are known as "spark" and "continuous wave" (C.W.). The oscillations transmitted by either method are far too rapid to be heard, even when properly "detected." In the case of "spark" transmission, however, these high-frequency oscillations are transmitted in groups at an audible frequency, and when "detected" a musical note is received in the telephone.

Valve Set for Spark Signals.—Fig. 1 shows the simplest possible single-valve set for the reception of these spark signals. The aerial circuit has to be electrically "tuned" to the frequency of the received oscillations, or, in other words, to the wave-length, by which is meant the length in metres of one complete oscillation. For this purpose a "tuning coil" is necessary. Different tuning coils will be required for different wave-lengths, and the reader is advised to use the interchangeable coils in preference to coils with tappings or sliders. It is obvious that to have a coil tuned exactly for each wave-length would mean an enormous number of coils. Fortunately this is not necessary, as by connecting a small variable condenser across the coil it can be made to receive longer waves. The higher the capacity across a given coil, within limits, the greater will be the wave-length for which the aerial circuit is tuned.

Figs. 1 and 2 will give an idea of the appearance of the set, and from this the reader will have no difficulty in connecting it up. For multi-valve sets a telephone transformer and low-resistance telephones are preferable to high-resistance telephones, and as both are

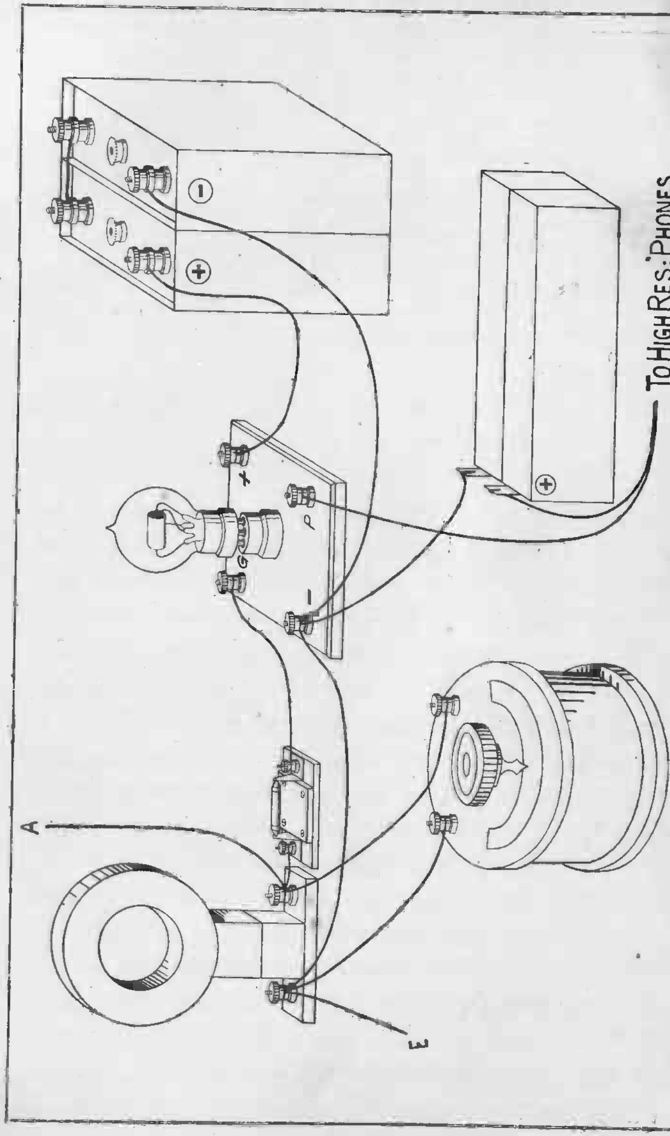


Fig. 1.—The Component Parts of the Single-valve Set

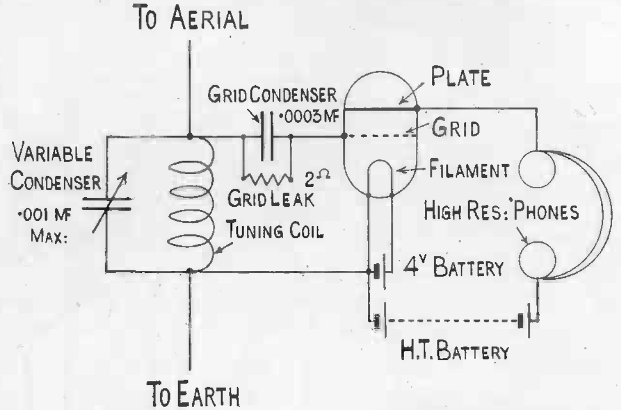


Fig. 2.—Circuit Diagram of Single-valve Set

equally efficient it is advisable to use the former. So that the reader will understand the conventional representation of wireless parts in the diagrams appearing in this book, the diagram (Fig. 3) has been prepared, and he would do well to study it. He will then be able to read a wireless drawing.

The Spark Set in Use.—Having connected everything up and seen that all wires are as short as possible and well separated, and knowing that Paris is transmitting spark and other signals on 2,600 metres, you plug in a suitable coil (the correct size of coil will depend upon the aerial), and, with the telephones on your head, turn the condenser fairly slowly from 0° to 180° and back several times. All being well, at one point in the swing you will hear faint musical dots and dashes. Moving the condenser very slowly round about this point you will soon find the exact position at which the signals are at their maximum strength.

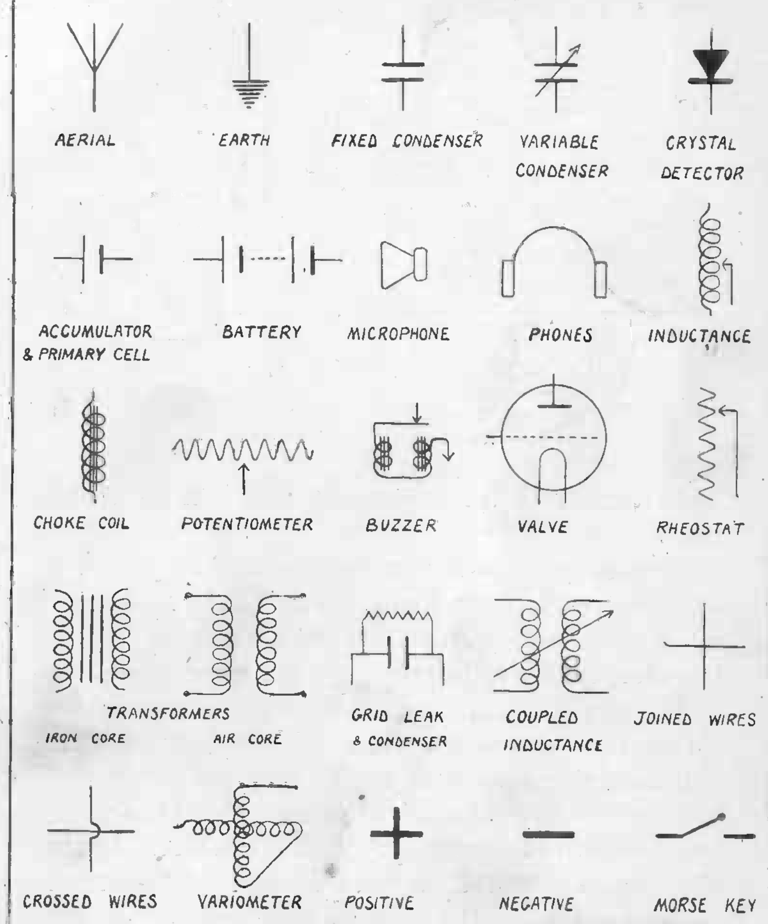


Fig. 3.—Conventional Signs Used in Wireless Diagrams and Circuits

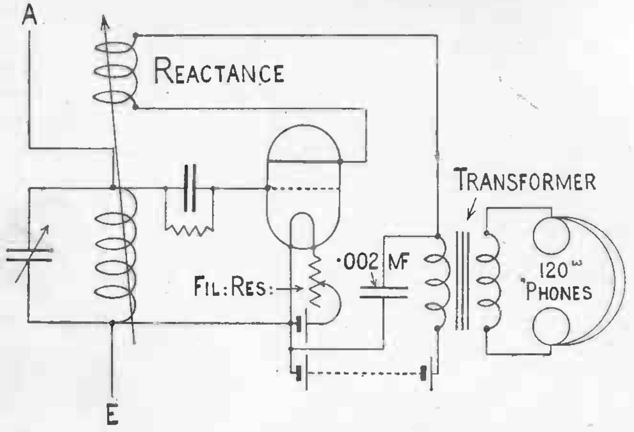


Fig. 4.—Circuit Diagram of Improved Set

Make a note of the adjustment; it will be useful later.

Improvements.—By certain additions to the arrangement shown in Fig. 1, the set can be made very much more sensitive. Great care must be taken, however, in the adjustment, or the valve will start oscillating; that is, acting as a generator and radiating energy from the aerial, which will seriously interfere with receiving stations in the vicinity.

The weak signals received on the grid of the valve cause comparatively large variations of current in the plate circuit, and if we make these plate-current variations act on the grid we shall get still larger variations in the plate circuit and so through the telephones. This is called "reaction," and is usually accomplished by connecting an additional coil in series with the telephones (or telephone transformer

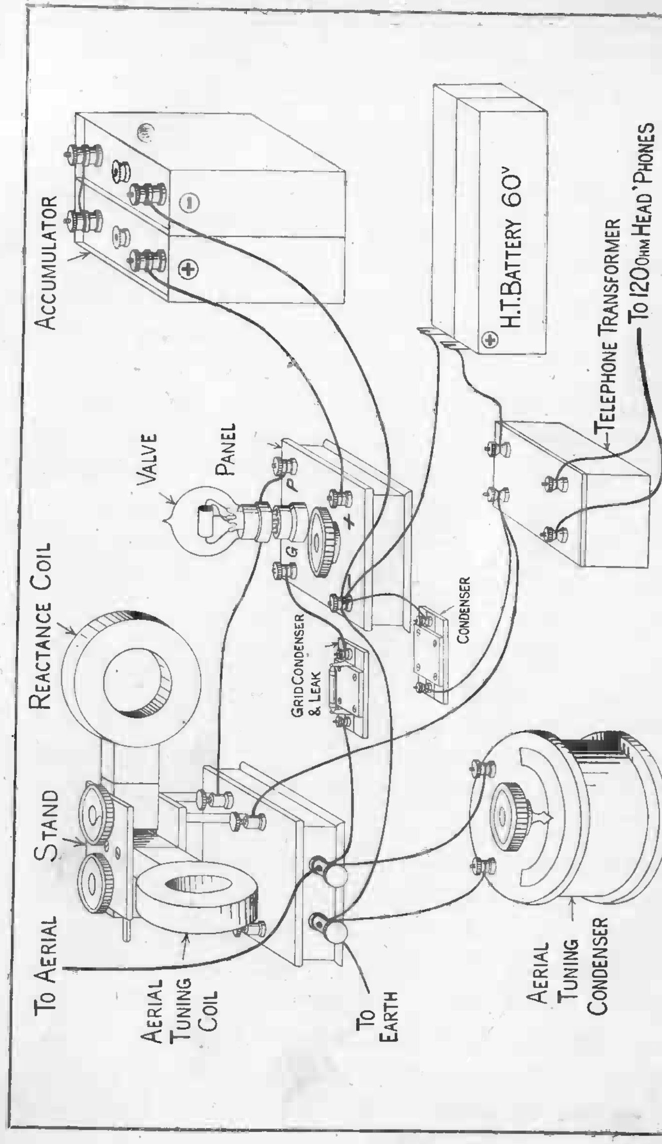


Fig. 5.—The Simple Valve Set with Additional Apparatus for its Improvement

where low-resistance telephones are used), and coupling this coil with the aerial tuning coil, or in other words, bringing the two coils near to one another. This is shown in Figs. 4 and 5. A small fixed condenser must be connected across the high-tension battery and telephones, otherwise the high-frequency oscillations would be choked back. A filament resistance is also included, as it is usual to have a 6-volt battery and to regulate the current by means of this resistance. As most valves will not stand more than 4 volts across the filament to start with, use a 4-volt battery and cut all the resistance out. If signals are louder than required insert a little resistance, and so increase the life of the valve and also of the battery.

Hints on Tuning.—The holder of the reaction coil is hinged so that the coil can be placed at 90° to the aerial coil or brought close up to it as required (this is termed tightening the coupling). After adjusting to maximum signal strength by means of the condenser, move the reaction coil slowly nearer to the aerial coil. The strength of the signals will gradually increase, and if the coil is moved far enough the musical note will suddenly go off and the signals will come in very rough, though stronger. The valve is now oscillating, and you should immediately move the coil back slightly until the musical note is brought in again. If, as you tighten the coupling, signals get weaker instead of stronger, reverse the wires on the terminals of the reaction coil and try again.

The note of a particular spark station is always

the same, but you will find that with other adjustments of the condenser you get notes which vary considerably in pitch as you tighten the reactance coupling. These are C.W. stations, and to receive these at all means that your valve is oscillating.

Receiving Telephony.—Having had experience of the reception of spark signals the reader will be in a position to try receiving telephony.

The reception of telephony resembles that of weak "spark" in so far as it is necessary to get near to the oscillating point without actually reaching it. If the reader is close to a high-power station it should be easy to get good speech without dangerously approaching this point, even with one valve. On the other hand, if it is desired to receive over long distances it will be necessary to get almost on the oscillating point, *but on no account must the valve be oscillating.* If this occurs, not only will it be impossible to receive, but others round about will be unable to do so. There is nothing so annoying when receiving telephony as when someone starts re-radiating.

Those who are unwise enough not to watch this point should remember that they are liable to lose their licence. There are ways and means of tracking down the culprits.

Adjustments for Telephony.—It is considered that the best station to start with is Paris. From previous experience the reader knows the adjustment and the exact position of the reactance to be just short of the oscillating point. Having made these adjustments very carefully, switch on shortly before the time for

Paris to commence. If, when they come on, a note is received in the phones, without any hesitation loosen the reactance coupling, for the valve is oscillating. Now tighten the reactance coupling very very gradually as the critical point is approached. All being well, it should just be possible to hear speech. If speech is heard do not take the reactance adjustment too far, but try moving the aerial condenser ever so slightly to see if speech can be improved that way, always being ready to loosen the reactance coupling should the valve start to oscillate. Having got the best adjustment of the condenser, tighten the coupling the least little bit at a time, making a note of the exact position. The reader will eventually arrive at the point where he gets oscillation, and he must instantly loosen the coupling. Then tighten the coupling again, stopping just short of this point. Telephony should now be received as well as is reasonably possible with the rough adjustments made. With one valve it is necessary to get so near the oscillating point that one cannot avoid occasionally re-radiating, but as this is only for a fraction of a second, so much is permissible until experience is obtained.

Capacity Effects.—It is advisable at this stage to make one or two small additions to the set. As the hand is brought near to the condenser or reactance, it will probably be found that the tuning is altered. This is a capacity effect, and to get over the difficulty fix long handles to the condenser and coil-holder as shown in Figs. 6 and 7. The handles can be made of

strips of hard wood or ebonite about 18 in. long, 1 in. to $1\frac{1}{2}$ in. wide, and $\frac{1}{8}$ in. thick, screwed to the ebonite knob. In order to get the fine adjustment necessary for telephony, it is best to connect one of the small rotary condensers, consisting of about three plates (often called vernier condensers), across the large condenser. A similar condenser should be connected across the reactance coil, the action of this being equivalent to a very fine adjustment of the reactance

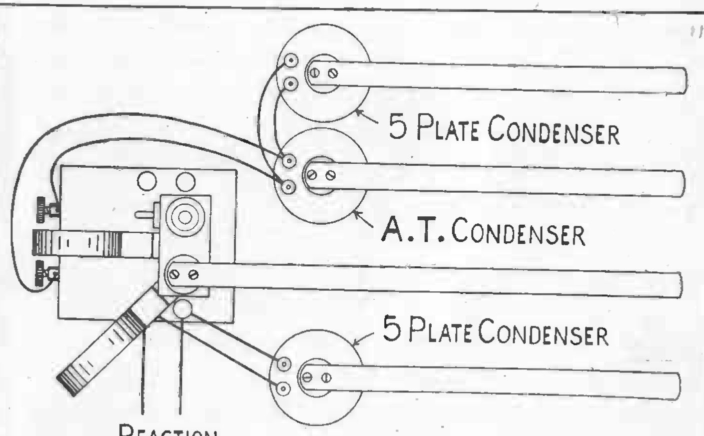


Fig. 6

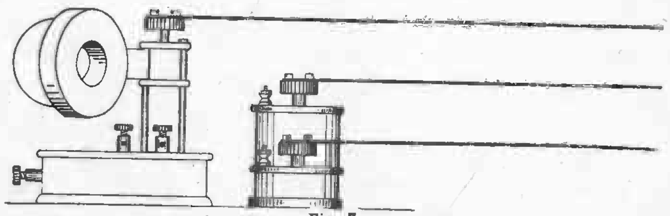


Fig. 7

Figs. 6 and 7.—Long Handles fitted to Condenser and Coil-holder coupling. These small condensers should also be fitted with long handles, and should be left in about the midway position. After getting the best adjustment possible with the large condenser and the reactance coupling as described, finish off with the two small condensers.

Valve Oscillations.—The reason for the note in telephones when the valve oscillates is that the high-frequency oscillations, which are inaudible themselves, combine with the high-frequency "carrier-wave" used for the telephony, the difference in frequency causing the note. If the difference is fairly great a high-pitched note is obtained, and if there is only a small difference a very low note. It is possible to get the two practically the same, and when this occurs there is no resultant note, but the speech will be very rough and broken up, and it will be impossible to distinguish what is said.

From this reception "continuous-wave" telegraphy will be understood, the continuous wave in telegraphy being exactly the same as the carrier wave in telephony, but sent out in dots and dashes by means of a sending key.

Other Hints on Receiving Telephony.—Having become proficient in the reception of the Paris telephony, the reader is advised to invite an experienced friend to help him to receive the other stations. This is one of the advantages of a multi-valve set, as one can use a separate oscillator to search for the carrier wave without interfering.

CHAPTER II

A Single-valve Set with Slide Inductance

By J. F. SUTTON

THOSE readers who have already made a crystal set and desire to make a valve set can use most of the apparatus in the set described in this chapter.

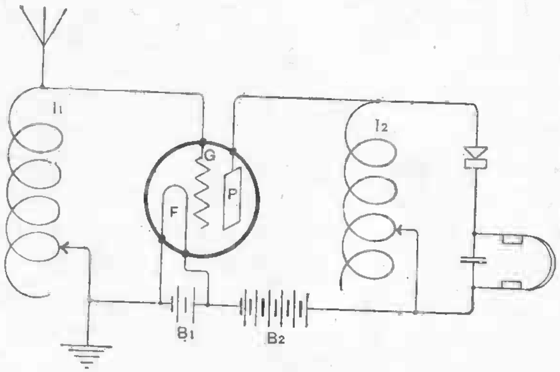


Fig. 8.—Valve as High-frequency Amplifier with Crystal Detector.

The Circuits.—Figs. 8 and 9 show alternative circuits which will give good results if the instructions are carried out in full. In both these circuits the valve acts as an amplifier. In the first it amplifies the radio-frequency currents which oscillate in the aerial circuit, and these magnified currents are passed on to the detector circuit on the right.

Fig. 10 may help to explain the meaning of the terms used. The top line represents two groups of high - frequency oscillations in the aerial circuit. These may be supposed to have been considerably amplified (increased in strength) by the valve. On passing through the detector circuit they are deformed in shape until something like the second line, and the effect produced in the telephone may be likened to the third line oscillations, hence the term audio-frequency. In Fig. 8 the valve magnifies the radio-frequency current and allows it to pass on

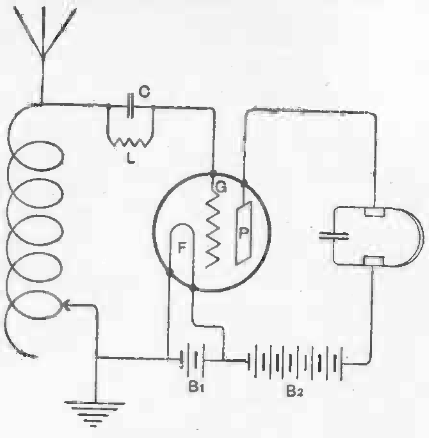


Fig. 9.—Valve as Detector and Low-frequency Amplifier Combined.

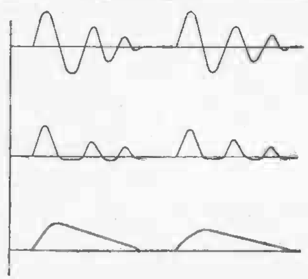


Fig. 10.—Diagrammatic Representation of Oscillations.

to the detector, and in Fig. 9 the valve performs the two operations of amplifying and rectifying together.

Apparatus Required.—The apparatus needed for circuit No. 1 comprises a complete receiving set, an additional aerial tuning inductance, a valve holder, battery B1 of 4 volts and battery B2 of 30-40 volts.

For circuit No. 2 an aerial tuning inductance, a valve holder, batteries B1 and B2, telephones with condenser, and a grid condenser C and grid leak L will be required.

The Valve Panel.—The valve panel is illustrated by Figs. 11 to 15. The top is made of a piece of ebonite 4 in. by $2\frac{1}{2}$ in. by $\frac{3}{16}$ in. thick; $\frac{1}{8}$-in. thickness would do, but the thicker material will be stronger. The edges can be trued up and finished off smooth with an iron smoothing plane set very fine. Failing that, a "dreadnought" file will cut it better than any other. Fig. 13 shows the layout of the holes. The four holes for the valve legs should be marked out very carefully; they are drilled $\frac{3}{16}$ in. in diameter so as to allow a little play for adjusting the valve legs, which are screwed No. 4 B.A. (*see* Fig. 16). They can be adjusted by placing them in position and pushing a valve right home. The nuts are then tightened up.

The legs and terminals should be polished and lacquered or they will quickly get dull on account of the sulphur in the ebonite. After the holes have been drilled the top can be finished off smooth with fine emery cloth, and a little oil rubbed over the surface will give a good colour.

The wooden part is made from two solid pieces of mahogany or teak (or soft wood will do) $\frac{7}{8}$ in. and $\frac{1}{4}$ in. thick respectively. Some of the thick piece has to be carved away to leave room for the terminals, valve legs and connecting wires, this, of course, being done when all the parts are assembled on the ebonite panel. The various terminals should be labelled for identification purposes. The connections of the terminals to the valve should be made with No. 20 gauge bare copper wire. A little piece of rubber tubing should be slipped over the plate connection which has to cross one of the filament wires.

Grid Condenser and Leak.—The next piece of apparatus is the grid condenser and leak, which will be needed for circuit No. 2. These are shown in the diagrams Figs. 17 to 21, and also in the photograph (Fig. 22). The condenser is made up of copper or tinfoil. There are six pieces of mica $1\frac{7}{8}$ in. by 1 in. and about 0.003 in. thick. The mica can be bought in thick pieces and is split with a sharp penknife. The thickness should be checked with a micrometer if possible, otherwise the only way to measure the thickness is to cut up a piece into $\frac{1}{4}$ in. squares with a sharp pair of scissors and pile thirty-three of these little squares together, when they should measure $\frac{1}{10}$ in. total thickness approximately.

Care should be taken to obtain the mica as clear as possible. It can usually be obtained in 2 in. squares, and two of these should be ample for the purpose. The tinfoil is cut up into six strips 2 in. by $\frac{3}{4}$ in. and a hole punched $\frac{3}{16}$ in. from the end of each one. Copper foil is better than tin because it

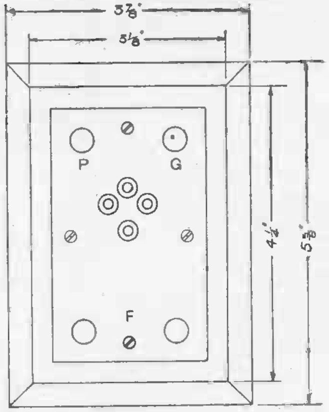


Fig. 11

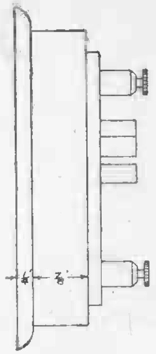
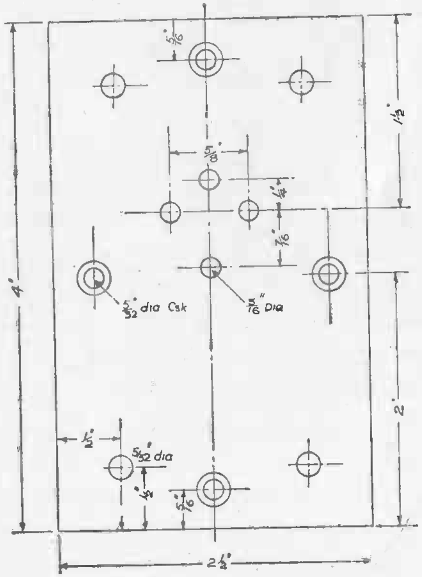


Fig. 12

Figs. 11 and 12.—Plan and Side Elevation of Valve Panel.



Top of panel $\frac{7}{32}$" Ebonite Sheet.

Fig. 13. — Layout of Valve Panel.

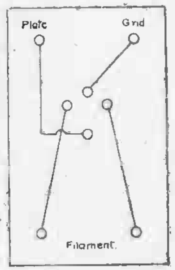


Fig. 14.—Diagram of Connections of Valve Panel.

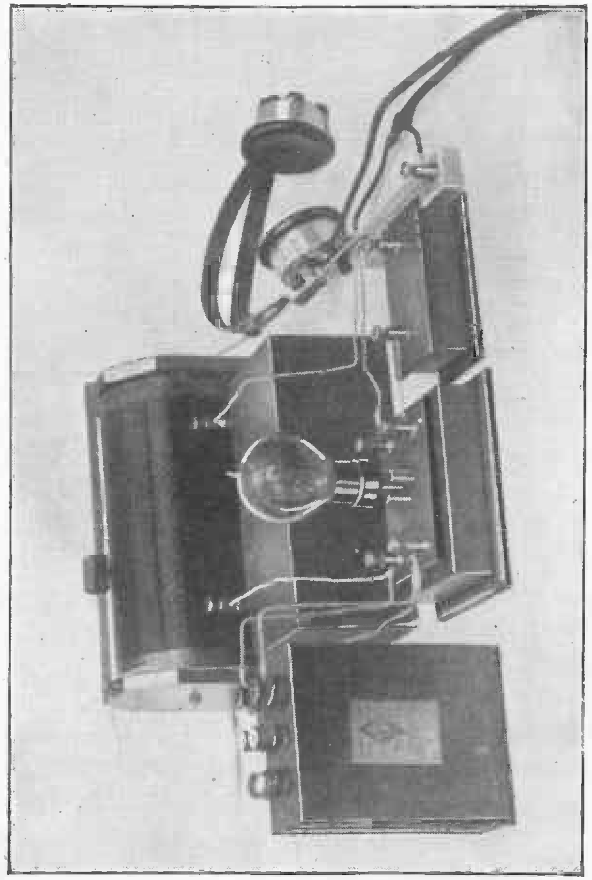


Fig. 15.—Photograph of Receiving Set with Valve as Detector and Low-frequency Amplifier Combined.

will not tear so easily, but tinfoil will answer quite well.

The " leak " is made of a piece of sheet fibre or ebonite $2\frac{5}{8}$ in. by $\frac{3}{4}$ in., with two holes made at each end $2\frac{1}{4}$ in. apart. Fibre is preferable; if ebonite is used it must be roughened with emery cloth. A thick line with an H B pencil is drawn from one hole to the other, and the pencil is well rubbed in round the holes, as shown in the drawing, to make good contact with the clamping nuts. The box for the leak should be made of hard wood if possible. It is easiest to make it solid and carve the centre out like the valve panel, the bottom piece being glued on. A piece of wood or, better, ebonite $\frac{3}{16}$ in. thick is cut to the same size as the leak, with which to clamp the condenser down. The terminals should be as shown in the drawing, with nuts and washers.

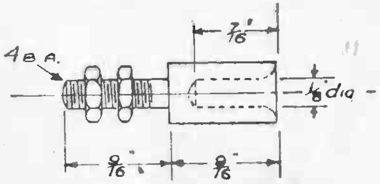


Fig. 16.—Valve Leg.

The condenser can now be assembled. First the terminals are pushed through the holes in the lid of the box, then the condenser is assembled in the following order : A piece of copper foil on one terminal, a piece of mica, a piece of foil on the other terminal, a piece of mica, and so on. These must be carefully laid on, one exactly over the other. When the last piece of foil is in place the ebonite strip should be pushed over the terminals and then the fibre with the pencil mark outwards. Washers and nuts are used

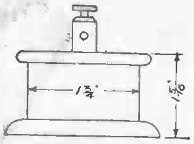


Fig. 17

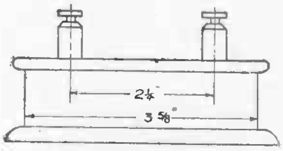


Fig. 18

Figs. 17 and 18.—Case for Grid Leak and Condenser.

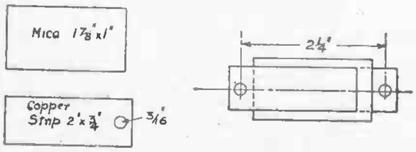


Fig. 21.—Constructional Details of Condenser.

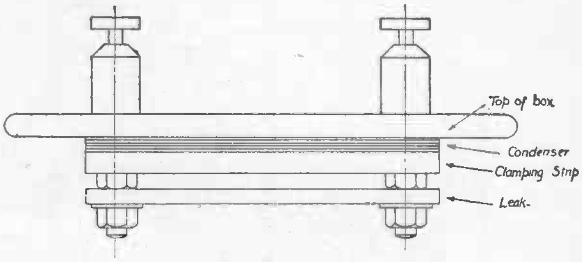


Fig. 19

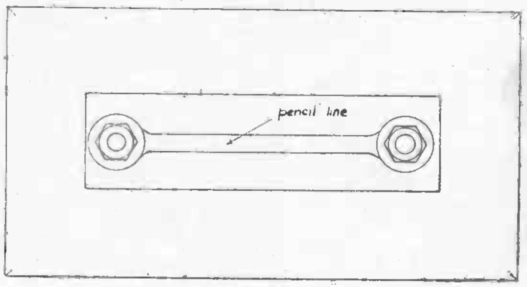


Fig. 20

Figs. 19 and 20.—Elevation and Under Plan of Grid Leak.

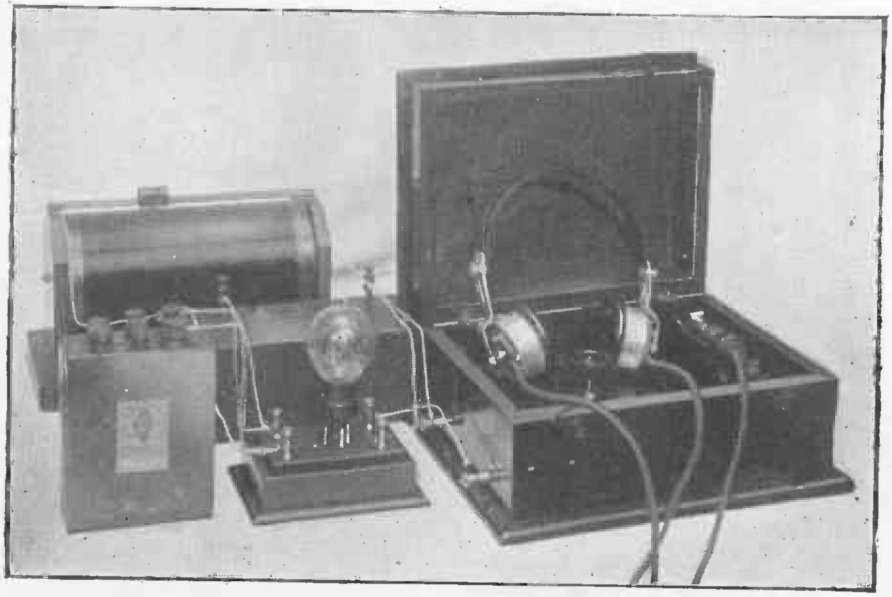


Fig. 22.—Photograph of Receiving Set with Crystal Detector and High-frequency Amplifier.

to clamp the whole tightly together. The capacity of the condenser should be about .0003 microfarads and the resistance of the leak 2,000,000 ohms. The condenser will not need any adjustment once it is put together, as it will be approximately of the stated value if it has been made properly, but the leak will have to be adjusted when the set is in use. The method will be described later.

The Low-tension Battery.—The low-tension battery next claims attention. This is needed to light the filament of the valve, which may be an Ora or R-type. These valves take a current of about $\frac{3}{4}$ amp. The two most suitable sources of current are accumulators or dry cells, and if there is any difficulty in getting accumulators charged, the writer would recommend dry cells. The initial cost of four good cells (they must be large ones) will be about 12s. These should easily have a life of about fifty hours ; a good cell has a total capacity of 70 ampere-hours. If not used too often they would perhaps last for three months or more, and when unfit for this purpose they can be added to the high-tension battery.

A 40-ampere-hour 4-volt accumulator must be charged every month whether it is in use or not.

It will be noticed that no filament resistance is included in the apparatus or diagram of connections. When using accumulators it is not considered worth the extra cost and trouble to have a 6-volt battery and variable resistance. A 4-volt battery can be connected straight on to the filament of the valve without the least danger of burning out, whereas one has

to be careful with a 6-volt battery. When using dry cells it would be worth while including a rheostat, but instead a short piece of resistance wire could be inserted to get over the difficulty.

In this connection the writer would emphasise the need for a voltmeter if valves are used. It should preferably read up to 6 volts. It should also be used to check the voltage across the filament in order to see that it never exceeds 4.5.

The High-tension Battery.—The high-tension battery may be obtained in a number of ways. In the writer's case it consists of about thirty discarded electric-bell dry cells. When the voltage of a cell drops below 1 a hole is drilled in the top and a little water added ; this usually freshens it up. Very little current is taken from the high-tension battery, so that there is no need to have new cells for the purpose if old ones can be obtained. An alternative is made up of three units of eleven cells. Also twelve to fifteen pocket lamp batteries ($3\frac{1}{2}$ volt) might be used. When using old cells care should be taken from time to time to see that the voltage of any cell does not fall below 0.7 volt. The battery should be carefully insulated. It may rest upon glass plates, such as old photographic negatives, and preferably it should be enclosed in a box.

Operating the Set.—Having now described all the apparatus which is needed, a few words on the working of the set may not be out of place.

Always take the valve out of the holder when making connections. If one accidentally connects the high-tension battery across the filament it will be a costly mistake.

To further obviate accidents a piece of $\frac{1}{2}$-ampere fuse wire may be connected in series with the H.T. battery. No. 1 circuit will need two inductances; these should be about the same size, and when everything is connected up tune both circuits at once.

In circuit No. 2 only one inductance is used. The grid condenser is taken out of its box. When signals are heard thicken the pencil line on the grid leak and the signals should gradually become stronger. If too much pencil has been added it can be rubbed out. As it may take a little time to adjust the leak it should be done when a station is transmitting for a long time; for instance, the Paris weather report or the Admiralty signals. When the leak is finally adjusted it is put back in the box and the edges are sealed round with paraffin wax to prevent the ingress of moisture.

CHAPTER III

A Single-valve Autodyne Receiving Set

By J. F SUTTON

THE inductance coils described in the previous chapter were of the single-layer tubular type. Multi-layer coils have, however, come into extensive use and have proved their great value, and the set here described (*see* Fig. 23) makes use of them. The set is primarily intended for those who are only able to use an indoor aerial, and if it is desired to use the set on an outdoor aerial the special construction and modification given later in the chapter must be adopted.

Terms Helix and Spiral Defined.—The terms helix and spiral are often interchanged, and to avoid any confusion it may be advisable here to define the two words as they are used in this chapter. This is done in the sketch, Fig. 24.

Advantages of Multi-layer Coils. — There are numerous varieties of multi-layer coils, each having its own uses and advantages. In general, spiral coils take up much less room than helical coils of the same inductance, and are thus useful for long-wave reception. It will be noted, however, that they cannot be tapped off to vary the inductance with the ease that tubular coils can be, but there are other ways of obtaining the same effect.

When it is desired to tune in widely different wave-

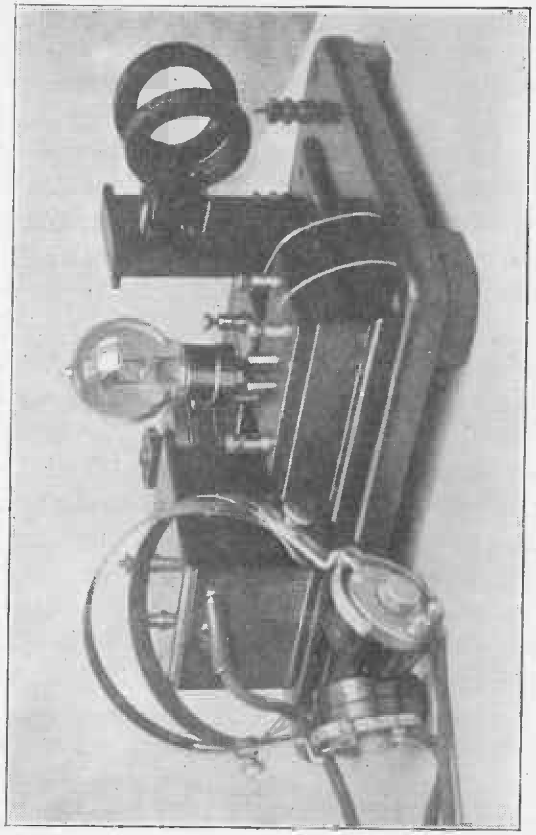


Fig. 23.—The Single-valve Autodyne Receiver Complete

lengths with the same set, the usual practice is to make a number of coils in progressive sizes and then arrange a simple form of attachment to the apparatus so that they are all interchangeable. To get fine tuning a variable condenser is shunted across the coil. To tune a receiving circuit to a definite wave-length either its inductance or its capacity may be varied, or both, but to get the best results from receiving circuits the capacity should be kept as low as possible. Thus in the tubular coils, for low wave-lengths it is not necessary to shunt the inductance by a condenser, as the self-capacity of the coil itself is sufficient, but for long wave-lengths and for spiral coils (except when they are coupled inductively) it is always necessary to have a variable condenser, although it need only be a small one.

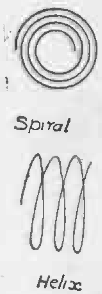


Fig. 24.—Spiral and Helix.

Mounting Multi-layer Coils.—There are many ways of mounting multi-layer coils. Perhaps the simplest way is to connect flexible leads to the ends of the coils and slide them over the former as shown in Fig. 25. This has the objection that accurate adjustment cannot be obtained. A better way is shown in Figs. 26 and 27, and is used in the autodyne receiver shown in the photograph (Fig. 23). A piece of hardwood ½ in. thick is cut to the size shown in Fig. 26, and the coil when finished (coils ½ in. thick are best for these holders) is tied in position with a piece of thread. The ends of the coil are brought out and screwed under washers, the heads of the screws serving as contacts to go in the clips. The coil and holder can then be dipped in molten resin ; this will make a solid job of it and fix the coil firmly to the holder. When set the coil may be given a coat of shellac varnish and allowed thoroughly to dry. This will prevent the stickiness that resin leaves on the fingers.

Range of Coils.—For a range of coils to tune 150 to 3,000 metres the following number of turns will be found suitable : One coil each of 25, 30, 35, 40, 48, 58, 70, 85, 105, and 130 turns.

Connections.—The diagram of connections (Fig. 28) will now be dealt with. Supposing the reactance coil to be removed and the leads short circuited, the diagram would be exactly the same as that for the single-valve set, using the valve as rectifier and high-frequency amplifier combined. The minute currents in the aerial circuit are magnified into stronger and unidirectional currents in the plate circuit. By using the reactance coil as shown these currents will increase the current in the aerial circuit, which will again increase the current in the plate circuit, and so on until the valve becomes what is termed saturated, hence the term regenerative circuit.

It must be remembered that by carelessly adjusting the coils the valve will howl, and the aerial will emit oscillations which may interfere with other stations.

Constructional Details.—The set shown in Fig. 23 gives very good results on a short indoor aerial. The coil mounting for holding the coils in place are

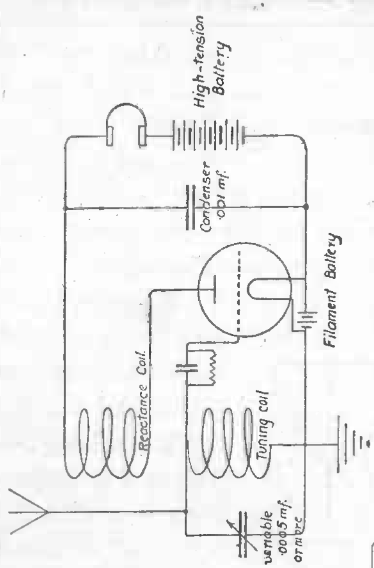


Fig. 28.—Diagram of Connections.

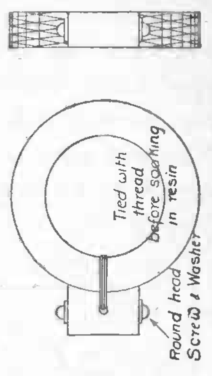


Fig. 26.—Better Method of Mounting Coils.

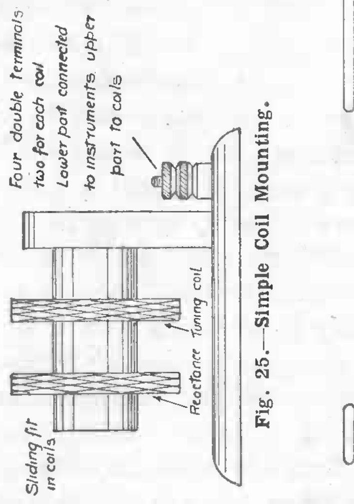


Fig. 25.—Simple Coil Mounting.

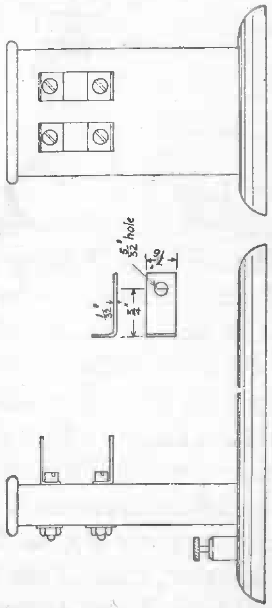


Fig. 27.—Coil Stand, etc.

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made of springy brass or copper strip. They are held in the upright piece by four 1 in. No. 4 B.A. brass screws. The nuts and the connecting wires are clamped under washers.

No dimensions have been given for the woodwork, as these will vary according to the position occupied by the set and the quantity of wood available. The variable condenser can easily be built up from parts or purchased whole.

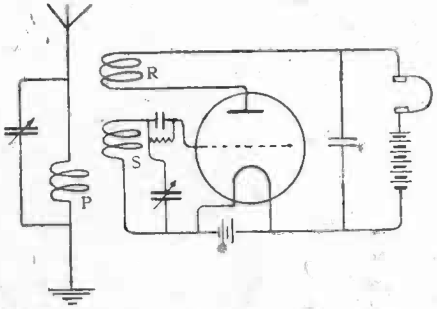

Fig. 29.—Circuit to Prevent Re-radiation.

Tuning.—When the apparatus is connected up the amateur should try the small coils first. The reactance coil may be a little smaller or the same size as the tuning coil. If all the connections are correct and the reactance is the right way round it should be possible to hear continuous-wave stations by turning the knob of the variable condenser and altering the distance between the coils. These stations will come in on a very high note, gradually going down to a low one and then back to a high one again as the knob is turned. If they are not heard the connections to the reactance coils should be reversed. It is no use turning the coil round in the clips, as that will make no difference. If, however, the coil mounting shown in Fig. 25 is used it will be sufficient to turn the coil round.

When the coils are far apart spark stations will be heard with their usual singing note, but when the coils are brought closer together they will sound more like a hoarse croak and the individual note will be lost.

If a loud rushing noise or a whistle is heard the coils must be pushed apart immediately, as the set is then radiating.

The set described in detail in this chapter, as previously explained, is intended for those who are only able to use an indoor aerial. Should the reader wish to make a set to connect up with a standard post-office aerial he must adopt certain modifications. It will be observed that the reactance coil in Fig. 28 is coupled with the aerial tuning coil, an arrangement forbidden by the P.M.G. on a standard aerial.

Fig. 29 shows the modified diagram which must be used in this case. Three coils are used; the aerial tuning coil, the secondary, and the reaction coil. The secondary is between the two others. With this modified arrangement there is no danger of radiation except by gross carelessness on the part of the operator.

CHAPTER IV

One-valve Variometer Set

By F. A. BOYCE

In the set described in this chapter a variometer tuning device is used, which eliminates the need for tuning coils and condensers.

Fig. 30 is a perspective sketch of the set. For clarity the connections have been omitted. V is the variometer tuner, GC the grid condenser and leak, R

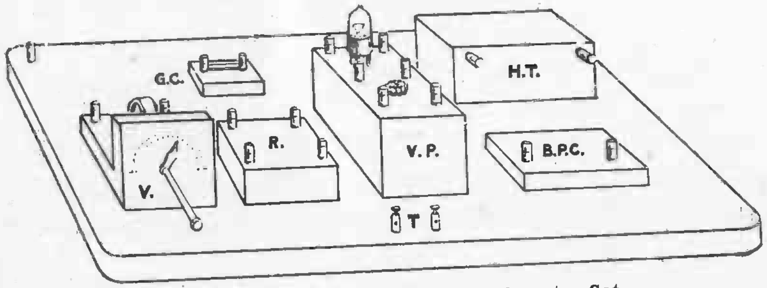

Fig. 30.—Diagram of One-valve Variometer Set.

the intensifier—simply reaction definitely designed to feed-back just short of oscillation point, VP the valve panel, HT high-tension battery box, and BPC the by-pass condenser. The latter is not essential, but is recommended, as without it signals are tinny and weak. The telephone terminals are shown, but not the telephones. The accumulator also is absent.

Variometer.—Fig. 31 shows the variometer, designed to cover the common wave-lengths. Both circular formers are of cardboard, the inner, about $2\frac{1}{2}$ in. in diameter and $\frac{7}{8}$ in. wide; the outer, 3 in. in diameter and $\frac{1}{2}$ in. wide. When wound and covered the inner former should be as close to the outer as possible, compatible with smooth swinging of the smaller within the larger. A cardboard circle of the right size for the movable portion can be cut from the outside covering of a discarded circular dry cell. If unobtainable, the outer circle can be made up from stiff paper.

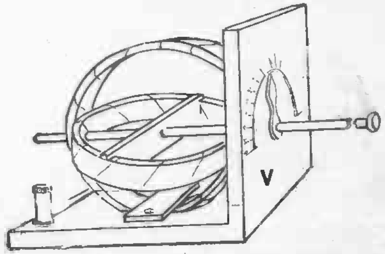

Fig. 31.—Sketch of Variometer.

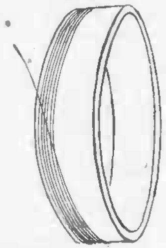

Fig. 32.—Method of Winding Former.

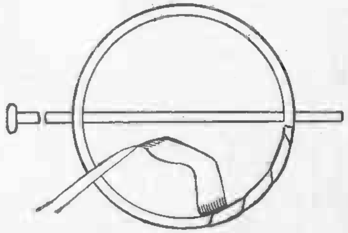

Fig. 33.—Method of Binding the Coils.

Accurately measure off two 18 ft. lengths of No. 26-gauge wire. Wind one upon the inner and one upon the outer former in a simple close-up layer,

(Fig. 32). Melt some candles in a flat tin slowly, and then drop in the two coils, leaving them for a few minutes to get thoroughly impregnated with wax; afterwards suspend them by the leads to drip.

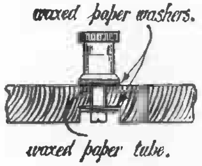

Fig. 34.—Insulation of Terminals.

Now mark off two spots exactly opposite each other on the periphery of each coil. This is not so hard as it would at first appear; an accurate estimate can be made with the eye. With the point of one knitting-needle gently push the wire aside and thrust the needle through the cardboard. This is to be done four times, of course. Assemble the coils and test for clearance. When satisfactory, take them apart again and place the needle through a single coil. Now cut long strips of brown paper, $\frac{1}{2}$ in. wide, and bind the coil, as shown in Fig. 33. The same with the other. Momentarily dip both in the melted wax again.

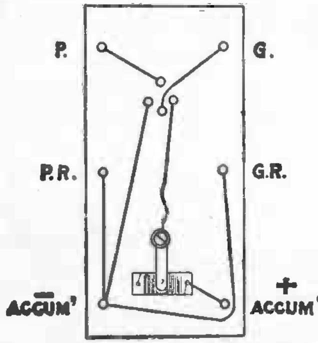

Fig. 36.—Connections for Valve.

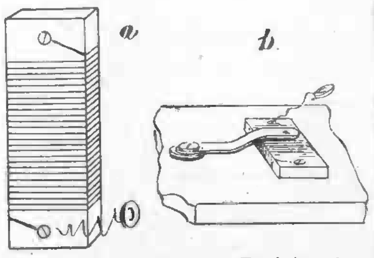

Fig. 35.—Filament Resistance.

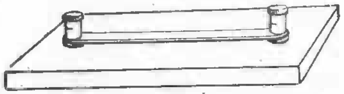

Fig. 38.—Grid Condenser and Leak.

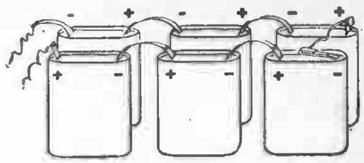

Fig. 39.—Method of Assembling H.T. Battery.

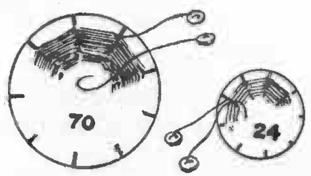

Fig. 37.—Basket Coils.

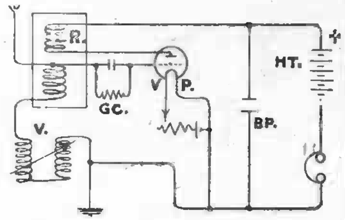

Fig. 40.—Circuit Diagram.

The cross-piece, shown in Fig. 31, is not there to stabilise the centre coil, but to prevent the needle from slipping when the variometer is in use. Any wood will do; it should be a fraction of an inch longer than the diameter of the coil. The hole through which the spindle passes must be in the exact centre and small enough to grip the needle. A spot of glue will assist matters here.

The Baseboard.—The baseboard is $3\frac{1}{2}$ in. by 4 in. In the centre a little wood is scooped out to make standing room for the coil, which sinks almost flush. A piece of three-ply or cigar-box wood, $\frac{1}{2}$ in. by 2 in., is prepared for clamping the coil in position (Fig. 31).

At the far end of the baseboard drill two holes twice the width of the shanks of the terminals. Furthermore, underneath the base the holes should be countersunk to allow the terminal head to sink below the surface.

Insulation.—With regard to the insulation the following procedure is adopted at every terminal point throughout the set.

Two or three thin visiting cards are cut into strips $\frac{1}{4}$ in. wide. Two or three more are used to make washers. All the strips and washers are dropped into the tin containing the candle wax. Whilst still soft the strips are rolled round the terminal shanks. They will probably tend to spring open again ; this does not matter, however, as the initial shaping is enough. Do not leave the washers in the wax to get cold. A superfluity of wax is to be avoided. A waxed cylinder is used round each terminal shank and a waxed washer top and bottom, insulating the terminal from the wood. Fig. 34 shows this plainly.

The Front Board.—The front board is now fitted ; this requires no explanation. The pointer can be cut from a cigar-box with a penknife or fretsaw. The calibration is in degrees, traced from a protractor. Calibration could be done later when actual wave-lengths are known.

Assembling.—Now assemble the parts. Keep one lead from the inside coil and one lead from the outside coil at the far end of the spindle. The other two leads should emerge from their respective wrappings close together near the spindle at the front end. Waxed cylinders are again required to be used where the needle passes through the coils.

This done, solder a thin brass washer to the far

outside lead. The washer carrying the wire is then placed on the terminal shank next the waxed washer, and the rest of the terminal screwed home. The far lead from the inside coil is twisted twice round the spindle between the two formers before a washer is soldered thereon and the terminal connection completed. At the near end both leads are twisted twice round the spindle between the formers and then soldered together.

The connections completed, the wires are comfortably tucked away in a manner to allow a free swing of the inside coil.

The small pointer indicator should remain unfixed until you test the set, for when the coils are in the same plane and the lowest wave-length being received that position is zero on the variometer. The whole 12 inches of the wooden knitting-needle is used as a precaution against body-capacity when making tuning adjustments.

The Valve Panel.—The valve panel is made from $\frac{1}{2}$ in. match-boarding, and the valve sockets and terminals are insulated from the wood by more waxed paper cylinders and washers. A convenient size is 9 in. by 4 in.

Filament Resistance.—The filament resistance should be tackled first. A resistance suitable for such a set as this is easy to make. Fig. 35 shows the details. Cut a piece of match-boarding to $2\frac{1}{2}$ in. long and 1 in. wide ; dry it and let it soak in the melted wax. Make a small hole at one end, afterwards pushing through a brass screw. Grip the other end of the strip in the vice; with the 28 Eureka wire take a turn round the head of the screw and then wind on a full 10 ft. In winding the wire must be made to bite into the edges of the strip, consequently it requires gripping hard in the process. Pliers will probably break it; a glove on the right hand should be used. Wind slowly and tightly, spacing the wire by its own diameter and eventually making fast around another screw, with about 2 in. to spare for future connection (*see a*, Fig. 35).

Next, a piece of springy brass strip about 2 in. long is required. This can be taken from the top of an old flash-lamp dry cell. Find an ordinary round-head wood screw about $1\frac{1}{2}$ in. long; make a hole at one end of the brass strip to take the screw. With the soldering iron tin the surface round the hole, and tin the under part of the screw head. Drop the screw through the hole, then hold the hot iron on the top for a moment and the two will be soldered together. A thin brass washer over the screw and the resistance arrangement will be complete for the under side of the panel (*see b*, Fig. 35).

A knob for the surface of the panel can be made out of $\frac{1}{2}$ in. of curtain pole, the edges smoothed with sandpaper and stained.

Care must be taken in fixing the valve-leg sockets. Hold the valve in the left hand and make pencil marks where the legs touch the wood. Make holes and carry on with the waxed cylinders and washers in the usual way.

Connections.—The connections are shown in

Fig. 36. The grid and plate circuits have their own return terminals. When alterations are contemplated therefore, everything can be done outside. Once closed down the box can be left for good.

It is a good plan to use rubber-covered bell wire for the panel connections. If nothing but the No. 26 instrument wire is to hand two strands of this passed through long waxed paper cylinders will be suitable. With the exception of the lead to the resistance arm, which is soldered direct, every lead end should be soldered to a thin brass washer before assembling.

Unless acquainted with wireless circuits it is advisable to mark the terminals on the top side of the panel. Grid—Grid-return; Plate—Plate-return; Accumulator-positive, Accumulator-negative respectively.

Reaction Unit.—For the fixed reaction unit there is required a sheet of cardboard. Describe two circles, one $1\frac{1}{4}$ in. radius the other $1\frac{3}{4}$ in. radius. Cut out these discs. Inside the first describe another circle $\frac{5}{8}$ in. radius. Inside the larger disc describe a circle of $\frac{1}{2}$ in. radius. Mark off the circumferences of both discs into nine parts and cut thin slots down to the inner circles. In and out of the slots, basket fashion, on the smaller disc wind twenty-four turns of No. 26-gauge wire. On the larger wind exactly seventy turns (Fig. 37). Strict accuracy is essential here since with these amounts we keep within the law regarding oscillation.

Dip the two discs separately into some hot candle-wax; with paper fasteners clip them together through the centre clear spaces. Wrap the whole in brown paper, taking the two leads from the smaller coil to the left and those from the larger to the right. Make a wooden box of the right size, in the top of which should be mounted four terminals—with the usual waxed washers, etc.—to receive the leads underneath. The larger coil forms part of the plate circuit later; the terminals concerned should be so marked to avoid confusion.

Fixed Condensers.—It is not necessary to describe the construction of the fixed condensers; they are of waxed paper and tinfoil for both the grid-condenser and the by-pass condenser of this set. As the valve is acting as detector and amplifier the general efficiency of the whole depends considerably on the right value of the grid-condenser and leak (Fig. 38). It is impossible to give the correct value of either, for this is controlled by the characteristic of the specific valve used. For the best results several values must be tried.

The by-pass condenser approximates .0016 mfd., which value is obtained by using three sheets of tinfoil (four active surfaces) 7½ centimetres by 9 centimetres.

The H. T. Battery.—The high-tension voltage required depends upon the valve used. Usually it runs about 30 volts. There is a critical voltage for every valve. If the value is not known it is a matter for experiment, and merely entails the addition or subtraction of a few flash-lamp refills before final connection is made to the positive terminal on the box side or lid. The value is determined during reception.

Each cell is clearly marked positive and negative.

By bending the brass strips and soldering them together, positive and negative (Fig. 39), the eight cells will give a pressure of 32 volts. Only six cells are shown in the sketch.

In the bottom of a large cigar-box lay a few old photographic negatives; failing these, two or three thicknesses of brown paper. Lift the series of cells into the box. See that they neither touch the sides of the box nor each other. When they are comfortably in position pour hot wax gently into the box and leave it to set. Mount two terminals on the box and mark them positive and negative respectively.

Connections of Reaction Unit.—Connections are made according to the diagram Fig. 40, which can be checked side by side with the perspective sketch Fig. 30. The components are marked in the same manner.

CHAPTER V

A Portable Single-valve Set

By A. W. HULBERT

THE set described in this chapter and shown in the photograph (Fig. 41) consists of a single-valve panel fitted with a long-range tuner, variable condenser, reactance coil, filament rheostat and some terminals; at one side of the panel is mounted the valve, and

Fig. 41.—Photograph of Portable Single-valve Receiver.

placed along the other side is the 36-volt H.T. battery. The whole instrument with valve and battery is fitted in a polished wooden or composition carrying case, as shown in Fig. 42, which gives a general plan view of the arrangement.

Dimensions.—No measurements are given on any sketch, as the actual dimensions may be modified to suit individual requirements.

Supposing, however, that it is decided to adopt a Mullard valve and a 36-volt H.T. battery of the Hellesen type: the battery will measure $6\frac{3}{4}$ in. long by $2\frac{1}{2}$ in. wide and 3 in. deep, exclusive of wander plugs, and a containing case designed in proportion will be as shown in Fig. 42, measuring $7\frac{1}{4}$ in. by 9 in. by 6 in. deep, including the lid, which is 2 in. deep, to clear the tuning knobs, etc. This will form a very compact unit and have the advantage of being entirely self-contained.

With regard to the component parts the same instructions as given in the preceding chapter apply in this case.

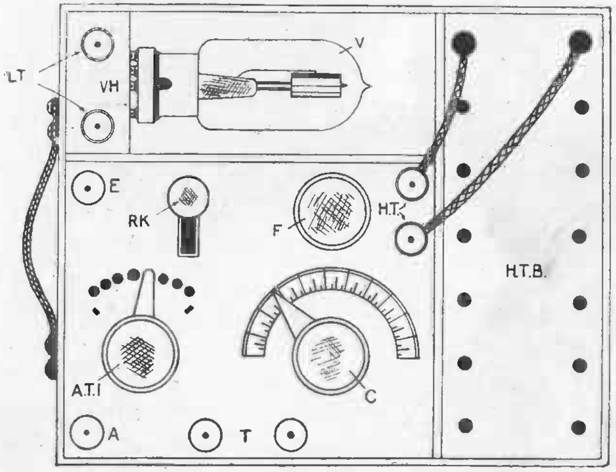

Fig. 42.—General Plan View of Instrument.

The Ebonite Panel.—The ebonite panel, having been cut to size, is carefully measured up and the position of the variable condenser, filament switch, aerial tuning switch, reactance adjustment and various terminals marked and drilled. The general arrangement of the top of the panel is shown in Fig. 42, while Fig. 43 gives details of the fittings on the under side of the panel before the wiring is done. The condenser C is assembled from the bought parts and mounted on the panel in the bottom right-hand corner. If great care is taken it will be possible to drill the holes and mount the condenser without breaking through to the front of the panel.

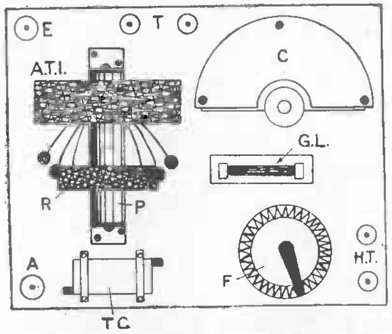

Fig. 43.—Details of Fittings on Under Side of Panel.

The filament rheostat F should be mounted in the same way, while the aerial-tuning switch A T I (Fig. 42) will be secured with a nut and spring washer. The position of the studs of the tuning switch should be carefully marked to ensure their being equidistant, while two small stops should be fitted to confine the range of the switch arm. A narrow slot is cut in the panel, as shown in Fig. 42, to allow the reactance knob and plunger to pass through and slide backwards and forwards for a distance of 2 in. or so.

On the under side of the panel are mounted the grid leak and condenser G L, and also the telephone condenser T C. The grid leak is secured by means of two small screws, the telephone condenser with the aid of two small strips of black fibre.

Aerial-tuning Inductance.—The aerial-tuning inductance should now be constructed, a honeycomb coil proving the best and most compact for the purpose. An ebonite former should be roughly put together for winding and for holding the coil when dipping in paraffin wax. The former may be $2\frac{1}{2}$ in. in diameter with two sides 4 in. in diameter and 1 in. apart. The wire, No. 26 d.c.c., should be wound on the former and tappings taken at the following turns, 18, 25, 35, 50, 75, 100, 150, the tappings being looped back and soldered to the contact studs of the tuning switch. The reaction coil should be wound in a similar fashion, the centre hole being the same diameter as that of the A.T.I., to enable them both to be slipped on the ebonite rod P. The arrangement of these coils is clearly shown in Fig. 44, wherein it will be seen that the ebonite rod P is mounted between two brackets B, which are of sufficient length to give clearance for the coils.

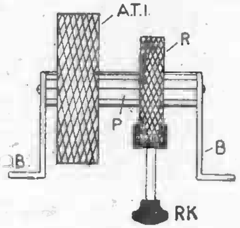

Fig. 44.—Tuning Arrangements.

The reaction coil R is made to slide freely on the ebonite rod P, while the position of the A.T.I. is fixed. A small ebonite holder is carefully fitted to the reaction coil with the aid of

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Chatterton's compound, the ebonite block also carrying a short brass rod terminating in the ebonite knob R K. It will be seen that by the aid of the knob R K the reaction coil may be moved nearer or farther away from the A.T.I. as required.

Fitting-up the Case.—This completes the assembly of the panel, and the next point for attention is the fitting of the battery, valve and panel into the case. It will be noticed on referring to Fig. 42 that the battery, valve and panel are separated from one another by means of partitions fitted in the case. The H.T. battery should first be fitted in the end of the case opposite to the carrying strap, the wooden partition is then inserted and secured in place by means of countersunk wood screws passing through the side of the case.

The instrument panel, if it has been carefully cut to size, should fit in the remaining space, as shown in Fig. 42, leaving room for the valve in the top right-hand corner. The panel is supported in the case on small angle pieces of wood glued in the corners at such a height that the top surface of the ebonite panel is flush with the edge of the case.

The valve, in its holder, is mounted on a small block of ebonite, which carries, in addition, the terminals for connection to the low-tension supply from the accumulator.

Connections.—The panel should now be wired up, the diagram of connections being given in Fig. 45.

The reference letters in the diagram of connections are the same as those in Fig. 42, A being the aerial

terminal, C the tuning condenser, E the earth terminal, A T I the aerial tuning coil, R the reactance, G L the grid leak, V the valve, F the filament resistance, T C the telephone condenser, L T the low-tension terminals leading to the accumulator, H T B the high-tension battery, T the telephone terminals, and P H the phones. All connections should be as short and straight as possible, and must be carefully soldered to avoid trouble through bad contacts.

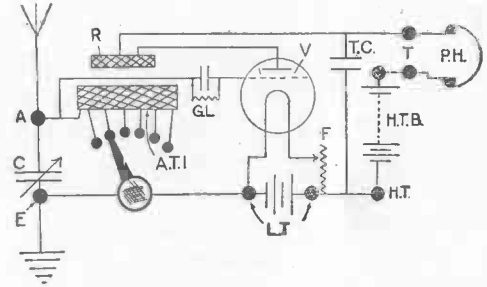


Fig. 45.—Circuit Diagram of Portable Receiver.

If it is found necessary to cross any of the wires they should be kept as far apart as possible. Connections to the H.T. battery are made with the aid of wander plugs on flexible leads running from the terminals marked H T on the panel.

Using the Set.—With regard to the manipulation of the set: The aerial and earth connections having been made, the accumulator switched on and the phones put on, the A.T.I. switch is moved in conjunction with the tuning condenser until signals are obtained. For weak signals it will be necessary to tighten the reactance coupling by moving it nearer to the A.T.I. by the use of the sliding knob R K shown in Fig. 42.

Variation in the H.T. voltage will also affect the clearness of speech and music to a considerable extent, and the wander plugs will be found most useful.

Portable Aerial.—When used as a portable set for operation at picnics, etc., a single-wire aerial wound on a reel and uncoiled as required will suit the purpose well. One end may be slung on a tree by means of a short length of cord and an insulator, the earth being a short brass rod to which is sweated a terminal for connecting up to the set. The brass rod is stuck in the ground in a moist position and the set placed on the ground in such a way that the aerial has a straight and uninterrupted path to the aerial terminal.

CHAPTER VI

Adding a Valve

By H. H. DYER

H. F. or L. F. Amplification ?—An additional valve can be connected either to amplify the high-frequency oscillations before detection, or to amplify the audio-frequency current variations in the plate circuit after detection. The function of the detecting valve is to rectify the high frequency oscillations, i.e. to make

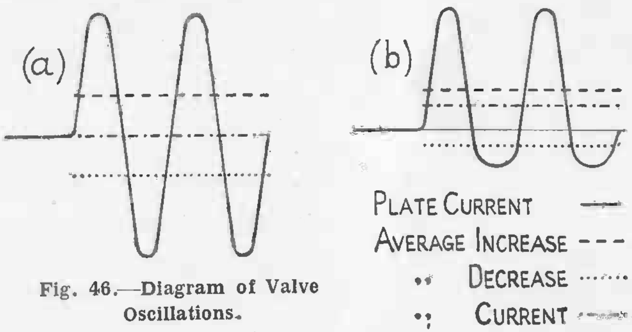


Fig. 46.—Diagram of Valve Oscillations.

the average increase in the plate current greater than the average decrease or vice versa. It will be seen from Fig. 46 that if the average increase is equal to the average decrease, the average plate current will remain the same and the telephone diaphragm will not be affected. When the signals are rectified there is an increase or decrease in the average plate current depending on the connections of the rectifying valve.

With very weak signals there is practically no rectification. Therefore low-frequency amplification is out of the question. In this case the additional valve should be connected as a high-frequency amplifier so as to get the greatest possible variations of potential on the grid of the rectifying (detecting) valve.

With signals of moderate strength there is little difference in the result between one stage of H. F.

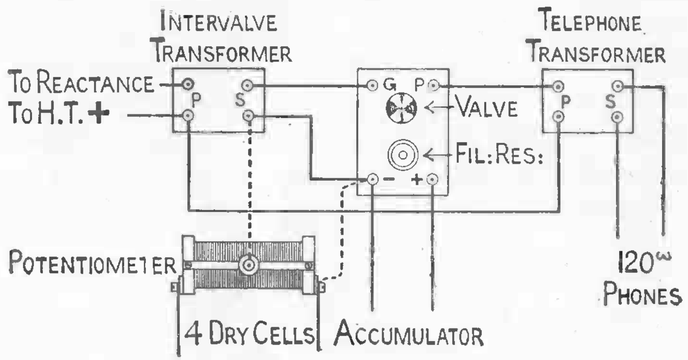


Fig. 47.—Method of Connecting Intervalve Transformer.

and one stage of L. F. amplification. H. F. amplification generally means another tuned circuit with the consequent critical adjustments for each wavelength With L. F. amplification, when once the valve is working correctly, no further adjustments are required as one changes from one wavelength to another. As far as telephony is concerned, if speech can be heard at all on a single valve, L. F. amplification may be tried first.

Adding L. F. Amplification.—Another valve and

valve panel, and low-frequency intervalve transformer will be required. Disconnect the primary of the telephone transformer and connect the primary of the low frequency intervalve transformer in its place as shown in Fig. 47. One end of the secondary of the intervalve transformer should be connected to the grid, and the other end to the filament negative of the additional valve. The primary of the telephone transformer is then connected in the plate circuit of this valve, leaving the telephones connected across the secondary as before. There only remain the wires to be connected to the accumulator and the set is ready for use.

The same accumulator may be used for the two valves if it is large enough. Its capacity should be at least twenty actual ampere-hours or forty ampere-hours at ignition rating. If it is less than this, separate accumulators should be used. Remember that the voltage must be kept up, for if it falls much below four volts the signals will be considerably decreased in strength.

An H. T. battery may be used as shown in Fig. 49, but it is better to use separate batteries as in Fig. 50, for each valve requires the correct H. T. voltage to suit the characteristics for the function it has to perform. If a common H. T. battery and separate L. T. batteries are used, the filament negative of the two valves must be connected together.

Testing the Arrangement.—After connecting everything up, tune in as before, and if everything is in order the signals should come in several times as loud as with the single valve.

Try varying the initial potential on the grid of the second valve. With most valves now used for amateur work, the normal point of the grid potential on the characteristic curve is somewhere near the best for amplification when one end of the secondary of the intervalve transformer is connected to the grid, and the other end to the filament negative. The normal point can be altered by giving a small initial potential to the grid. This may be done by connecting a potentiometer in the grid circuit, as shown by the dotted lines in Fig. 47. The connection from the secondary of the intervalve transformer to the filament negative must, of course, be taken off.

The potentiometer consists of a coil of resistance wire connected across a battery of about four fairly large dry cells. One end of this coil should be connected to the filament negative, and the wire from the secondary of the intervalve transformer to a slider which makes contact with the turns of the coil. When the slider is at the end connecting the wire from the filament negative, there will be no additional voltage on the grid. When the slider is at the opposite end there will be the full voltage of the battery. At intermediate points the voltage will be proportional to the number of turns of wire on each side of the slider. For instance, if there are twice as many turns on one side as there are on the other, the voltage on one side will be two-thirds and on the other side one-third of the voltage of the battery.

Having tuned in some weak signals with the slider right up to the zero end, move the slider gradually

up to the far end. There may be a point where you get increased signal strength, but if not, reverse the potentiometer battery and repeat the test.

When using a loud speaker for the reception of telephony, it is sometimes possible to obtain greater amplification by using a higher plate voltage on the L. F. valve. This, however, may produce distortion, which can probably be corrected by adjusting the voltage on the grid to exactly the right value.

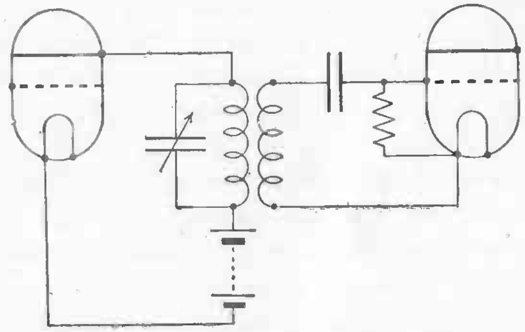


Fig. 48.—Connections of H.F. Transformer.

Do not crowd the two valves and the other apparatus together, but spread them well out, always remembering to keep the wires reasonably short and well separated.

Adding a High-frequency Amplification Stage.—In a single-valve set small variations of potential on the grid of the valve cause relatively large rectified current variations in the plate circuit, as previously described. These current variations, when acting on the telephone diaphragm, produce the various sounds heard in the telephones. Considering speech, it will be obvious that the sounds must be the same whether the transmitting wavelength is 300 metres or 3,000 metres, or, in fact, any other length. The speech waves consist chiefly of combinations of waves of frequencies between about 200 and 2,000 per second, whereas the frequency of the carrier wave may be a hundred thousand or a million or more.

A low-frequency intervalve transformer, when properly designed, will transform with very little distortion all frequencies within audible range. Above this range it becomes necessary to tune the transformer to the particular frequency just as it is necessary to tune the aerial and the secondary circuits, the higher the frequency (or the lower the wavelength) the more exact must be the tuning.

This will give some idea of the essential difference between low-frequency and high-frequency amplification. In one case the current waves which produce the sounds in the telephone are amplified, and in the other case we amplify the inaudible carrier wave.

High-frequency Amplification.—When the first valve is used as an H. F. amplifier, the plate current variations are of exactly the same form as the variations of potential on the grid due to the received signals. It is necessary to transfer these H. F. plate current variations, in the form of variations of potential, to the grid of the second valve. There are several ways by which this may be done and until fairly recently the two most general were (1) high-frequency

transformer coupling, and (2) resistance-capacity coupling.

The latter is quite satisfactory for the longer waves, and requires no adjustment, but it is only efficient with wavelengths above about 1,000 metres.

Fig. 49 shows a two-valve set employing H. F. amplification. A is the aerial tuning inductance, B the secondary tuning inductance, C the plate circuit tuning inductance, and R the reactance. These coils A, B, C and R may consist of basket coils for the lower wavelengths and honeycomb coils for the higher wavelengths. D is the grid leak and it will be noticed that it is connected directly between the grid and the filament, and not across the grid condenser *d*, as previously shown. The variable condenser *a* should have a maximum capacity of about .001 mfd., whilst *b* and *c* may each have a maximum capacity of .0005 mfd. For broadcast and other short-wave reception, suitable values are .0005 mfd. for *a* and .0002 mfd. for *b* and *c*, but these values do not generally give sufficient range for the longer waves. For simplicity the small variable condensers (three plate) for fine tuning have been omitted. One of these should be connected across each of the condensers *a*, *b*, and *c*, and one across the reactance R. High-resistance phones have been shown, but low-resistance phones may be connected through a telephone transformer in place of these.

The reactance can be coupled with the secondary B, but very good results can be obtained by coupling it with the inductance C as shown in Fig. 49. In this position the interference caused when the valve oscillates is very much reduced, and it is the only position in which it is allowed for broadcast reception. For this purpose another stand will be required for the coils C and R, with a movable coil holder.

Tuning the Set.—There are three circuits to adjust to the wavelength of the station that you wish to receive, i.e. the aerial circuit, the secondary circuit, and the plate circuit of the amplifying valve. It will be understood how very difficult it is to find the correct values of coils and condensers if none of these adjustments are known. With very weak signals it is necessary to have all three circuits tuned exactly, and if none of the adjustments were known it would be almost hopeless trying to tune in the signals. Having proceeded step by step and noted the various adjustments of the aerial circuit and secondary circuit for different wavelengths, it will only be necessary to find the correct adjustment for the plate circuit. When the two former are adjusted and the reactance coupling is fairly tight, by moving the plate-circuit condenser round slight noises will be heard at one point. Until the circuit is properly adjusted everything will seem quite dead, but when it is tuned to the same wavelength as the other two circuits the telephones will become "alive." Signals should then be received quite well, and the operator will then be able to adjust all three circuits to the best values.

Try also a potentiometer in the grid circuit of

the first valve as shown by the dotted lines in Fig. 49. This was suggested in connection with low-frequency amplification, but as we are now dealing with high-frequency oscillations, a small fixed condenser about the same size as the telephone condenser *e* (.002 mfd) must be connected as shown at *f*, to pass these oscillations.

H. F. Transformer Coupling.—A common and efficient way of coupling the H. F. amplifying valve to the detecting valve is by means of an H. F. transformer. This consists of a former, preferably of ebonite, about 2½ in. in diameter with a slot about ⅛ in. wide in which are wound the primary and secondary coils. The wires of these coils should be wound on together in order to get as tight a coupling as possible. The ends of the windings are usually brought out to pins arranged so as to fit a standard valve socket.

For coupling the reactance to the transformer the reader will have to arrange a special four-pin plug to fit the coil holder on the stand. The connections for the H. F. transformer are shown in Fig. 48.

It has been mentioned that it is necessary to tune the transformer to the wavelength of the signals being received. Obviously different transformers will be necessary for different wavelengths. By connecting a variable condenser across the primary it will be possible to tune one transformer to a number of wavelengths. For instance, if a transformer is about right for 300 metres, it will be possible to

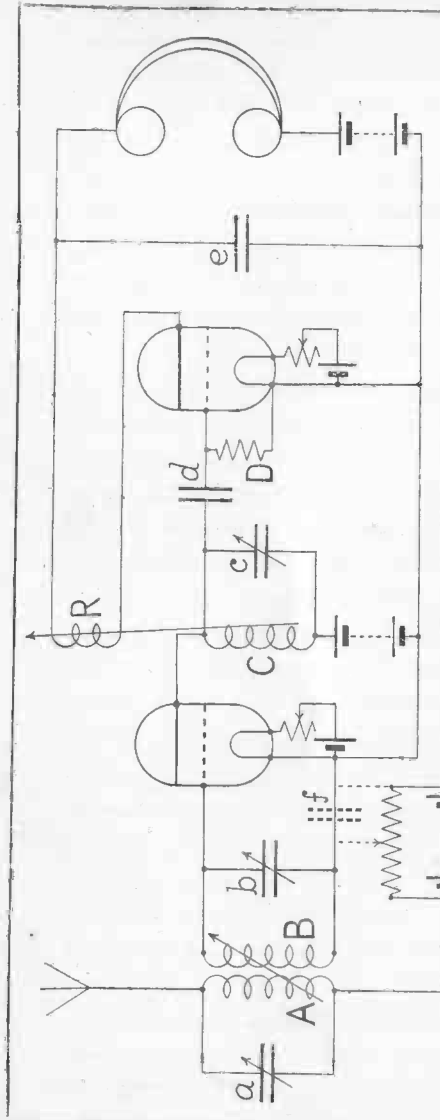


Fig. 49.—Two-valve Set with H.F. Amplification.

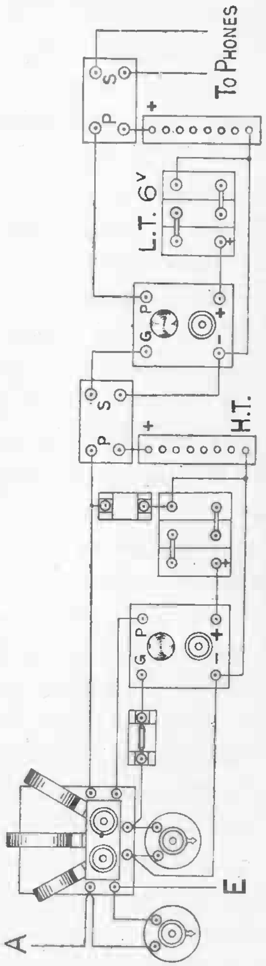


Fig. 50.—Circuit Employing Two Separate Batteries.

tune to 600 metres or more by means of the condenser.

Resistance Coupling.—Transformer coupling is efficient for all wavelengths, but above, say, 4,000 metres the windings become expensive. Above this wavelength resistance-coupling is quite satisfactory and has the advantage that it requires no adjustment as the operator changes from one wavelength to another.

If a high non-inductive resistance is connected in place of the inductance C in Fig 49, the variations of potential across this resistance, due to the variations of plate current, will be impressed on the grid of the second valve. The variable condenser *c* will not be required. Not only will it not be required, but it must be disconnected, as the capacity even when the pointer is at zero is quite sufficient in some cases to cut out signals.

The H. T. battery for the first valve will have to be increased to make up for the additional resistance in circuit.

As there is now no coil in the plate circuit of the second valve, the reactance will have to be coupled with the secondary inductance B (Fig. 49).

CHAPTER VII

A Two-Valve Set

By E. H. W. BANNER

This instrument (Fig. 51) has two valves, although one valve only is generally used. The tuner, detector, and amplifier are in the cabinet, and two condensers in separate cases. The set is normally used loose-coupled, but a switch is provided to change to direct-coupled.

Reaction.—In the loose-coupled position the reaction must not act on the primary circuit, but

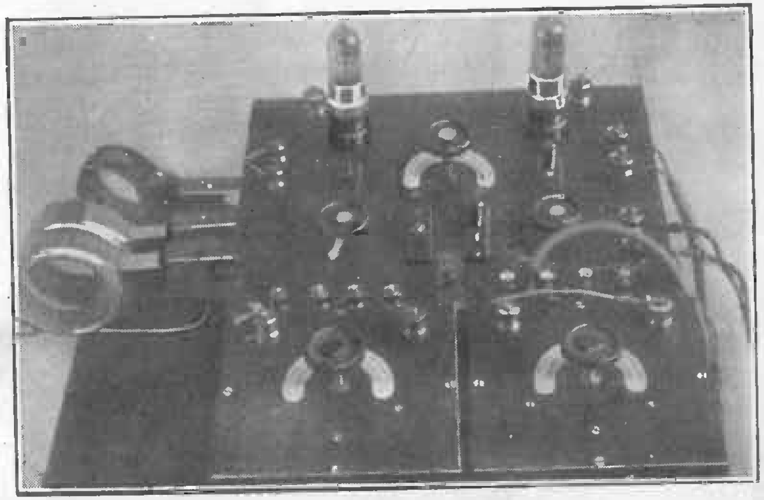


Fig. 51.—General View of Two-valve Set.

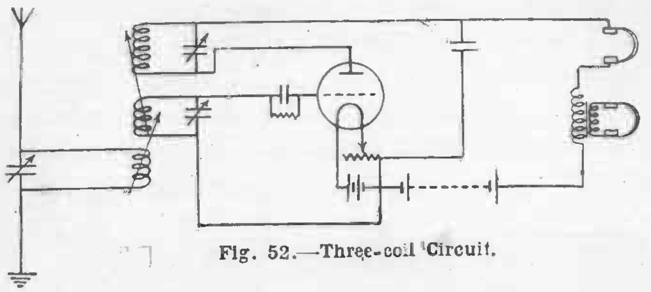


Fig. 52.—Three-coil Circuit.

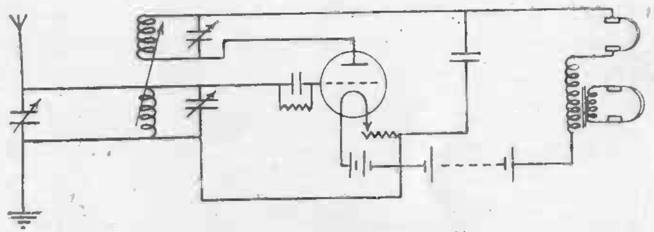


Fig. 53.—Two-coil Circuit.

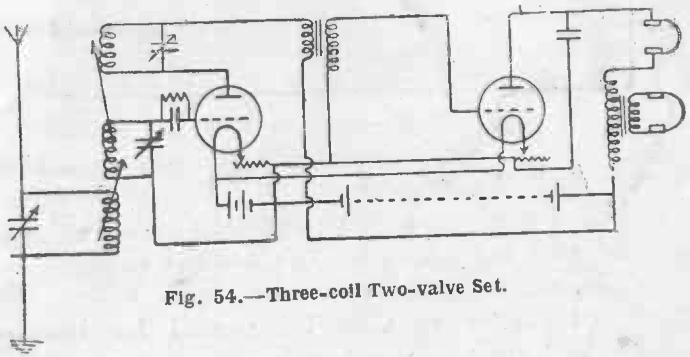


Fig. 54.—Three-coil Two-valve Set.

on the secondary, so the coils are from rear to front on photographs, and top to bottom on diagrams, Figs. 52 to 54. (1) Three-coils; (2) two-coil circuit; (3) three-coil two-valve set.

When in the direct-coupled position the reaction is required to act on the aerial (for non-broadcast wavelengths), so the middle coil becomes the aerial

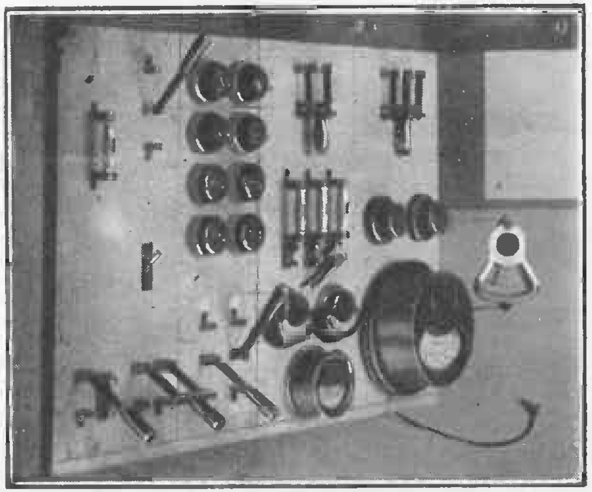


Fig. 55.—Switchboard.

circuit and the original primary is disconnected. Further, the closed-circuit condenser (C.C.C.) is in parallel with the A.T.C. for this method of working.

Coils.—Honeycomb coils are used, a set of Burndept short-wave coils being used for broadcasting and amateur wavelengths.

Switches, etc.—There are five telephone-type

switches fitted; these are two-pole change-over, and serve the following purposes: (1) Filament reversing. The reader will find this frequently recommended, and the writer has certainly found it useful, and advocates its adoption in the set. (2) Anode-battery switch, on and off. (3) A.T.C. series—parallel. (4) One or two valves (L.F. optional). (5) Loose or direct coupling (3 or 2 coil).

Each valve has a separate filament rheostat with "off" position, the amplifying-valve filament only coming on when the switch (4 above) is set to "Two valves."

A phone induction coil is fitted for low-resistance phones, and high-resistance phones are wired in series with the primary.

Two terminals are fitted across the reaction coil-holder, so that they can be shorted and reaction cut out when required. A seven-plate condenser is connected across the reaction coil, and is invaluable.

Rectification is produced by a grid-leak and condenser. The grid-leak has been tried from grid to filament, but does not give such good results in this case as across the condenser.

Components.—The following are the particulars of the components:

A.T.C.: 43 plates, nominally .001 mfd. C.C.C.: 21 plates, nominally .0005 mfd. Valves: Mullard Ora; 4 volts across filament. 35 volts across filament and anode. Intervalve transformer: 1 to 4. Phone induction coil: 10 to 1. Aerial: 100 ft.

long, 32 ft. high at free end, lead-in through glass tube. Earth: Water main.

In the diagrams the switches are omitted to simplify the figures, the connections for A.T.C. series or parallel are as usual.

The current is obtained from batteries through the switchboard, shown by Fig. 55, which is complete with ammeters, volt-meters, fuses, etc.

CHAPTER VIII

A Three-valve Amplifying and Detecting Unit

By A. J. COOPER

THE unit shown in the photographs (Figs. 56 and 57) has been expressly designed as a self-contained amplifying and rectifying unit, one stage high- or radio-frequency amplification and one stage low- or audio-frequency amplification (sometimes termed a "note magnifier").

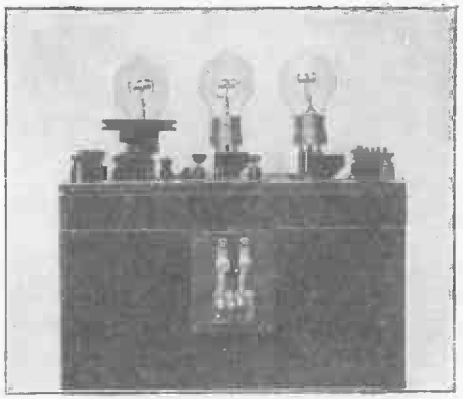


Fig. 56.—Front View of Three-valve Receiver.

Description.—The arrangement of the switching is such that the experimenter can commence operations with the instrument immediately he has purchased the first valve and necessary batteries (high- and low-tension). The remainder of the valves can be purchased as desired, but the panel should be prepared to receive all the fittings at the outset.

Reaction is embodied on the panel between the rectifying valve and the high-frequency amplifier, and whilst this adds materially to the efficiency of the instrument, such an arrangement does not re-radiate energy from the aerial.

The terminals shown on the right-hand side of the instrument are for extension purposes, and the

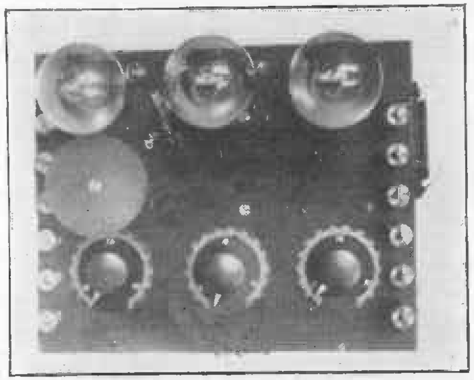


Fig. 57.—Top View of Three-valve Receiver.

experimenter by their use will be able to add further stages of low-frequency amplification to operate a loud-speaker if desired.

Assuming that the experimenter is in possession of a crystal detector and tuner and wishes to amplify the signals which he is already receiving with those instruments, work can be begun on the construction of this unit with the low-frequency amplifier.

Materials.—No doubt the constructor has re-

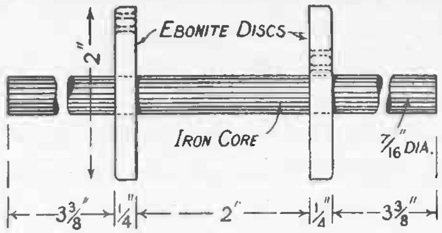


Fig. 58.—Details of Transformer Core.

solved to gradually add to his amplifier as time and funds permit, and will therefore embody all three valves in his set. The following materials will be required:

$\frac{5}{16}$-in. ebonite, 12 in. by 9 in.

$\frac{5}{16}$-in. ebonite for base of two-way switch, 3 in. by $2\frac{1}{2}$ in.

$\frac{1}{4}$-in. ebonite for L.F. transformer former, 4 in. by 2 in.

5 oz. No. 46 single-silk-covered copper wire.

1 lb. No. 22 soft iron wire in 10-in. lengths.

18 terminals.

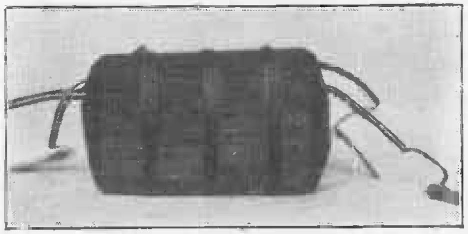


Fig. 59.—Photograph of L.F. Transformer.

1 filament rheostat (or material as specified hereunder).

4 valve-socket tubes for legs of L.F. valve, or 12 for the three valves.

12 $\frac{1}{8}$-in. Whitworth screws with nuts.

12 $\frac{1}{16}$-in. Whitworth screws with nuts.

6 1-in. No. 6 brass countersunk wood screws.

6 1-in. No. 8 brass countersunk wood screws.

1 yd. 1-in. empire cloth or tape.

1 piece of red fibre (for fixing L.F. transformer).

Small quantity of scrap thin-gauge brass (for switches).

Oak, mahogany, walnut or pine (for case).

1 R-type valve.

4-volt accumulator.

H. T. battery (60-75 volts according to valve).

Intervalve Transformer.—The inter-valve L.F. transformer should be built according to the following particulars :

First bundle up the 22-gauge soft iron wire with thread so as to make a core $\frac{7}{16}$ in. in diameter, and wrap with three or four layers of thick brown paper (or drawing paper) and secure the overlap by means of liquid glue. Shellac the paper after fitting it in position, and leave to dry on the iron core. Take the 4-in. by 2-in. piece of ebonite and prepare two circular pieces according to the details specified on the diagram (Fig. 58). The small holes for the ends of the primary and secondary coils should be slightly countersunk or chamfered each side so that the sharp edge of the ebonite does not chafe and cut the fine

wire used in the transformer. Fit the prepared ebonite pieces on the iron core already prepared and see that they are a tight fit on the core. Now remove the end pieces and the paper former.

Coil Winding.—To wind the coils it will be advisable to construct some simple form of winding machine such as is described in "Wireless Component Parts," which may be left to the reader's ingenuity.

When this has been done fit the paper former on the centre shaft, secure the clamping plates in position and commence winding the 46 s.c.c. wire. The first coil to be wound will be the primary. This should be wound to a depth of $\frac{5}{32}$ in., the windings being evenly and firmly put on and each layer completed between the plates before the next layer is begun. A loose end of wire about 4 in. long should be left both at the beginning and end of the coil for connection purposes. Two layers of empire cloth should be wound round the primary, and then the secondary coil should be commenced. Leave a free end of 4 in. as with the primary, but on the opposite end of the transformer. This winding should be in the same direction as that of the primary, and wound to a depth of about $\frac{5}{8}$ in.

Bind the whole of the surface of the wire with adhesive tape, and remove the coils and former together from the winding machine, after which secure the free ends of the wire to the body of the coils by small strips of adhesive tape.

An ebonite end piece should be mounted in position on the iron core and the core slipped into the former on which the coils are wound, each end of the primary or secondary being pushed through the holes in the end piece, the other end piece now being mounted and the same procedure followed. The primary ends and secondary ends should now be at opposite ends of the transformer.

Before finishing off the transformer short lengths of flexible instrument wire should be soldered to the primary and secondary free ends, and this wire should be secured to the ebonite pieces by molten pitch or adhesive tape in order that any slight pull made on the wires after completion of the transformer might not be taken by the windings, but by the flexible wire thus fixed.

Now complete the transformer by bending the iron wires back on to the body of the windings, star fashion, leaving the free ends of the flexible wire protruding through the iron wire, and secure the whole by strong carpet thread. The completed transformer is shown in the photograph (Fig 59), and it is of the type known as the "hedgehog" transformer.

The Filament Resistance.—The filament resistance is the next consideration.

Obtain a piece of ebonite $2\frac{5}{8}$ in. square and $\frac{3}{8}$ in. thick and scribe out a circle $2\frac{1}{2}$ in. diameter on it, and file to this line to make a disc. Make a groove round the periphery of the disc about $\frac{3}{8}$ in. deep to act as a seating for the resistance wire.

A hole should be bored through the centre of the disc to take a $\frac{1}{4}$-in. Whitworth bolt. Another hole to one side of the centre hole ($\frac{3}{4}$-in. radius) should

be bored and tapped for a $\frac{1}{8}$-in. Whitworth screw (B, Fig. 60). A similar hole is bored in a line with the two already made, but this is to be clear of thread and to allow a $\frac{1}{8}$-in. Whitworth screw to pass through to the panel for fixing purposes (A, Fig 60). In the groove on the periphery of the disc two holes are bored and tapped $\frac{1}{8}$-in. Whitworth to take screws for fixing the resistance wire in position. These should be about $\frac{3}{4}$ in. apart.

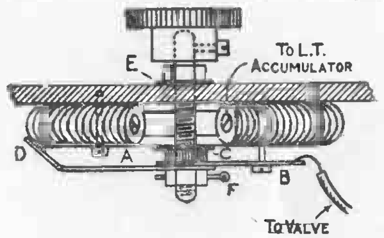


Fig. 60.—Filament Resistance.

Now take about 3 yd. No. 21 S.W.G. "Chronic" resistance wire and wind it tightly round a lead pencil with the spirals touching. When removed from the pencil the spirals will keep their shape and the coil can be fixed to the ebonite disc in the place allotted to it. The turns of wire should not touch then.

A brass bolt $\frac{1}{4}$-in. Whitworth and about $1\frac{1}{2}$ in. long is now required with two nuts, one loose collar or bush, three plain washers and one spring washer. Next prepare a piece of springy brass 2 in. long, $\frac{3}{8}$ in. wide, with a $\frac{1}{4}$-in. hole bored at one extremity and the tip bent at the other end for contact on the resistance wire (D in the diagram). Prepare a similar piece of brass $1\frac{3}{8}$ in. long and bore two holes, one $\frac{1}{4}$ in. to take the centre shaft and the other $\frac{3}{4}$ in. from the $\frac{1}{4}$-in. hole to take the $\frac{1}{8}$-in. Whitworth screw (B in the diagram).

The resistance may now be mounted in place on the panel by first screwing on the ebonite disc with the resistance wire already on it and inserting the $\frac{1}{4}$-in. Whitworth bolt through the centre. Slip on the bush or collar (C), then a washer and a spring brass piece without the bend, then the piece with the bend at the tip (when this is adjusted to correct position it should be soldered), and finally a nut, which is also soldered to the bolt and rotating arm. When the unbent piece of brass is slipped on the centre shaft this should be secured to the ebonite disc by a $\frac{1}{8}$-in. Whitworth screw to prevent it from rotating when the contact arm is revolved. The object of the former brass member is to carry the current via the rotating arm to the valve filament, and for this purpose it should be gripped tightly against the rotating arm by means of a nut and spring washer on the face of the panel (E in the diagram). An ebonite knob is attached to the $\frac{1}{4}$-in. bolt on the face of the panel for operating the resistance, and split pins may be passed through the nut (F in the diagram) to prevent any possibility of it working loose by friction.

The ebonite knob may also have a set screw as shown in the diagram, but if the $\frac{1}{4}$-in. bolt is screwed right in there is little danger of it working loose.

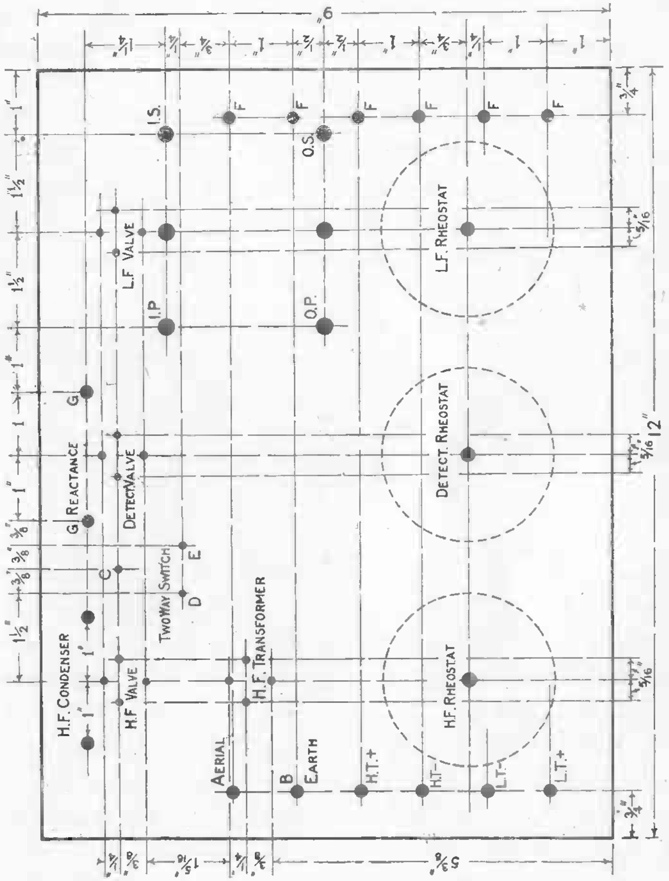


Fig. 61.—Diagram showing Lay-out of Ebonite Panel.

The Ebonite Panel.—The ebonite panel should now be prepared as shown in the diagram Fig. 61. First remove the rough edges and make the sides true, and finish off with fine glass-paper or emery-cloth.

Scribe all the lines shown in the diagram on the ebonite with the tip of a sharp knife, and centre-punch all the holes. If this is done the drilling of the holes can be carried out expeditiously.

When all the holes have been drilled the panel

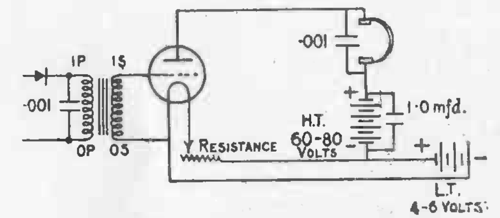


Fig. 62.—Circuit Diagram of L.F. Valve.

should be cleaned up with fine emery and a very thin dressing of oil or turpentine applied to restore the black surface.

Wiring.—Having now prepared the panel the wiring can now be proceeded with. The circuit diagram for a low-frequency valve or note-magnifier is given in Fig. 62.

In connecting up, the telephones are removed from their present position on the receiver and the "in-primary" or the beginning of the primary of the transformer is connected to the terminal

which leads to the crystal detector. The "out-primary," or the end of the primary, is connected to the earth terminal in a single-circuit receiver or in the loose-coupler to the terminal carrying the opposite end of the secondary coil wire; that is, the other telephone terminal in each case. "In-secondary," or the beginning of the secondary coil of the transformer, is attached to the grid of the valve, whilst "out-secondary," or end of the secondary, goes to the negative side of the low-tension accumulator.

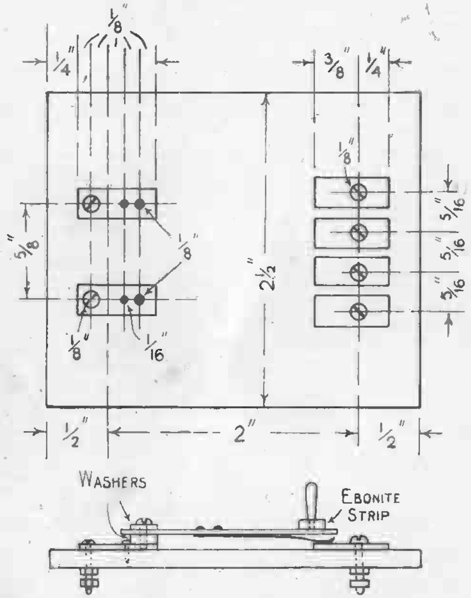


Fig. 63.—Details of Switch.

The remainder of the circuit is positive high-tension through phones to anode or plate, negative of high-tension to negative of low-tension accumulator. Positive of low-tension goes to the filament via the rheostat.

The Case.—The case should be of wood and measure 12 in. by 9 in. by 6 in. deep and be provided with a hole cut in the front. The case should have a hinged lid which facilitates inspection of the wiring. Screw the panel to the case by means of suitable wood screws and connect up the batteries to the respective terminals. When signals are received through the crystal they will be approximately five times as loud as they would be without the valve.

Care should be exercised in connecting up the high-tension battery, otherwise should the wire come

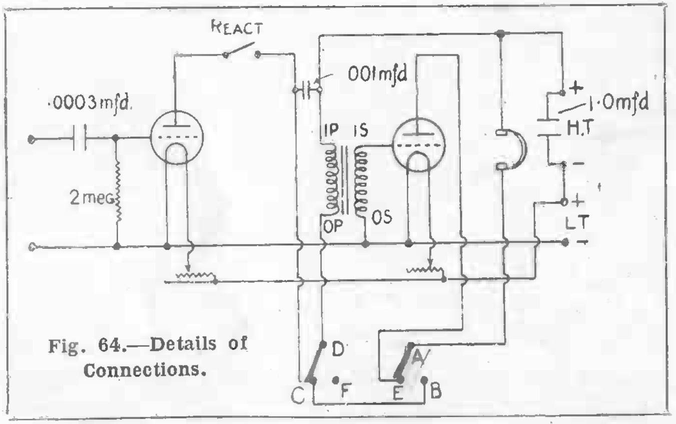


Fig. 64.—Details of Connections.

into contact with the filament legs the valve will be ruined.

A switch should first of all be prepared in accordance with the particulars given in Fig. 63 and mounted on the front of the case over the hole previously referred to.

Parts Required.—The components required for the detector valve are :

1 filament rheostat (resistance).

1 grid condenser .0003 microfarads.

1 2-megohm grid-leak or slate-pencil type of grid-leak.

1 R. or R.4 b-type valve.

Making the Grid-leak.—The grid-leak consists of two right-angle brackets made of spring brass, with a hole in each of the members of the brackets, which may conveniently be 1 in. long. An ordinary slate pencil is mounted between the brackets and

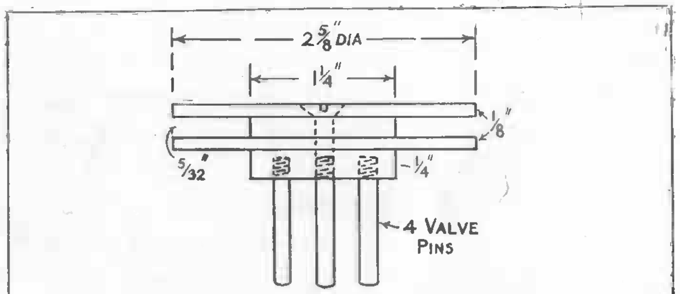


Fig. 64a.—Details of Former.

retained in position by suitably adjusted spring pressure.

The leak is made by drawing lines on the slate pencil with an ordinary soft graphite lead pencil. This should be done with the valve glowing and when it is known that signals are being received on the aerial. Lines may be added until maximum signals are received in the phones.

Connections.—The circuit should be wired up as shown in Fig. 64. Possibly the details of switching may not be clear. The path of the high-tension

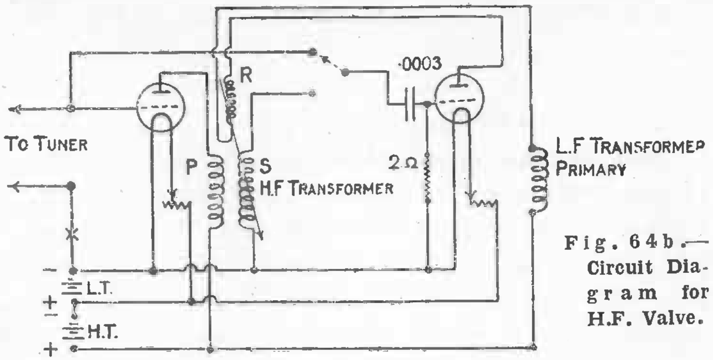


Fig. 64b.—Circuit Diagram for H.F. Valve.

current is from H.T. positive through telephones to stud A, and from thence via the switch arm to stud B or C to the detector valve or L.F. valve according to the position of the switch.

The current also proceeds from H.T. positive through the primary of the L.F. transformer to stud D, and thence to the detector valve via the switch arm and stud E, with the switch in the left-hand position. No circuit is made through stud F with the switch in the right-hand position, only the detector valve then being in operation, but when the switch is moved to the left both valves are ready for use.

In any case, providing no crystal detector is used, the detector must always be in circuit.

Material Required for H.F. Amplifying Valve.—One filament resistance, 1 valve (Marconi V24 or Ediswan A.R.), 1 H.F. transformer (4-pin plug-in type), odd pieces of brass for two-way switch.

As this valve performs a different function from

either of the others already described, that is, it acts as an amplifier of high- or radio-frequency current, a separate filament resistance is required. The valve used should be either of the types specified above.

H.F. Transformer.—Whether or not the desired wavelength is attained depends largely upon the tightness of the winding of both coils (and therefore self-capacity), number of turns and diameter of former. For these reasons it is suggested that the constructor should purchase such transformers already wound, as the cost is negligible. Should, however, the experimenter desire to make the transformer, the following particulars are offered as a guide, and the eventual result will be a matter for experiment.

Four formers should be prepared as specified in the drawing, Fig. 64*a*.

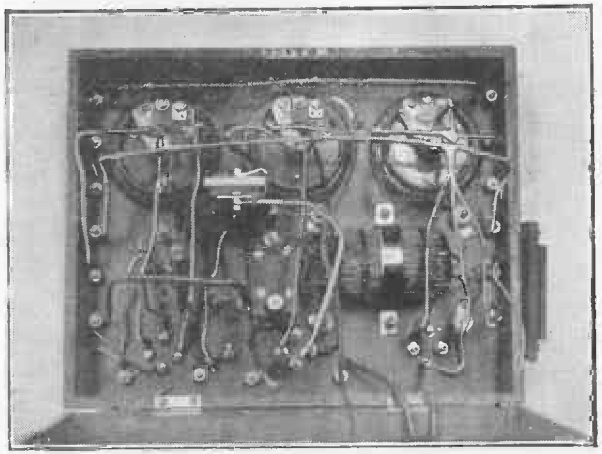


Fig. 64c.—Photograph of Back of Panel showing Wiring.

The windings consist of 50 turns of No. 44 s.s.c. primary and secondary for No. 1, 100 turns of the same wire for primary and secondary of No. 2 former, 250 turns similarly wound for No. 3 former, and 400 turns for No. 4. Both windings should be put on in the same direction.

Alternatively the former may consist of a piece of $1\frac{1}{8}$-in. diameter ebonite rod on which may be wound a primary and secondary winding of 450 turns each of No. 36 or 42 s.s.c. wire. The ends of these windings may terminate on four valve pins screwed into the end of the rod and arranged to fit into a standard valve holder. This arrangement will tune from about 360 to 440 metres, so it obviously covers the broadcasting band of wavelengths.

After the purchase or construction of the transformer and filament resistance a small two-way switch should be prepared or purchased and mounted on the ebonite panel in the position allotted to it.

Wiring the Panel.—The panel may now be wired up as illustrated in Fig. 64*b*. The photograph (Fig. 64*c*) gives an impression of the back of the panel when the wiring is completed. All wire should be kept as short as possible. The condenser shown on the right-hand side of the panel has been put outside by the author for the purposes of experiment. It is a telephone condenser of ·003 mfd. capacity.

The operation of the H.F. valve may be improved by the impression of a small positive potential on the grid by means of grid cells, which should be inserted at the position shown at x on the diagram. The best

value will be found by experiment according to the valve in use, and the writer has found that + 1 volt is useful for this purpose, and effectually prevents self-oscillation of the valves.

Range.—The set so far described will pick up broadcast telephony with a fair aerial within 100 miles of any broadcasting station. When the L.F. valve is switched in for the same station it operates a loud-

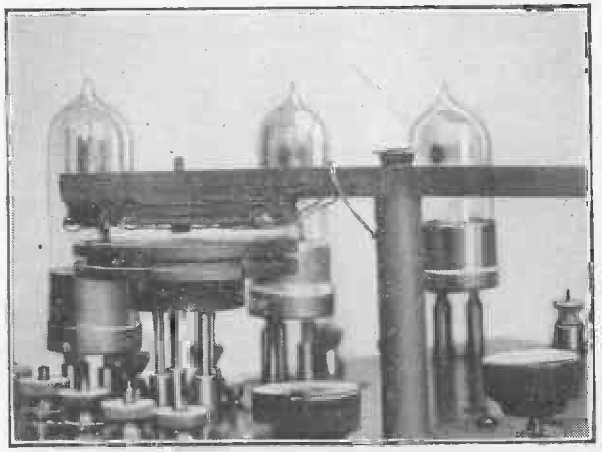


Fig. 64d.—Photograph showing Reaction Coil.

speaker comfortably. The Newcastle broadcasting station and Continental station L'Ecole Supérieure may be clearly received with the set.

Possibly experimenters residing some distance from a broadcasting station will desire to use a loud-speaker, and they may find it necessary to add a further L.F. valve. This, however, should be avoided if possible, as iron-core transformers inserted in the circuit inevitably give rise to a certain amount of distortion. Although H.F. valves do not give the same amount of amplification valve for valve as L.F., they are preferable owing to the fact that iron-cores are not used in the transformers. It is for the purpose of these additions that the terminals are on each side of the panel and correspond one to the other, and by their use further stages of amplification may be added without modifying the wiring, so that the three-valve set is really the nucleus of a unit set which can be added to at will. It has probably been noticed that no mention has been made of reaction although terminals have been provided for it.

Reaction.—The Postmaster-General forbids the use of reaction on broadcast wavelengths when it is applied direct to the aerial circuit, and therefore the experimenter should bridge the two terminals with a piece of strip brass when operating on these wavelengths. He may, if he desires, however, embody reaction in the instrument between the anode of the detecting or rectifying valve of the H.F. transformer. The photograph (Fig. 64*d*) shows a convenient method of doing this.

First obtain a piece of ebonite rod 2 in. long and $\frac{1}{2}$ in. in diameter and bore a hole at each end and thread $\frac{1}{8}$-in. Whitworth. Prepare a strip of ebonite $\frac{5}{16}$ in. thick to the particulars given in the working diagram (Fig. 64*e*). Now prepare a former either of cardboard or ebonite to the dimensions given and wind with about 100 turns No. 28 S.W.G. d.c.c. wire, bringing the two ends one to each of the reaction

terminals. Screw the reaction coil thus made to the ebonite strip and the ebonite strip to the $\frac{1}{2}$-in. ebonite rod, which latter is secured to the panel in a vertical position by means of a screw put through from the under side. Two special terminals are embodied in the panel for this reaction coil, and if desired two wires can be taken from these to the reaction terminals already on the back of this panel via its under side.

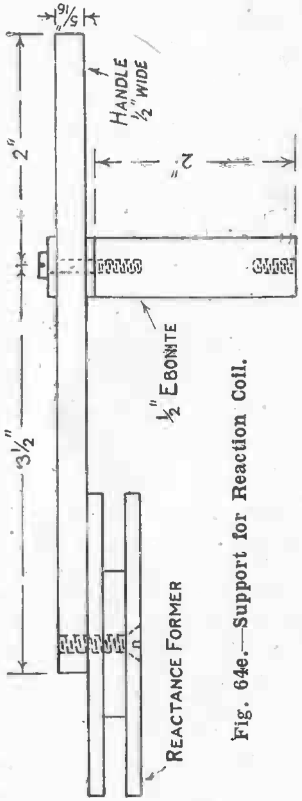


Fig. 64e.—Support for Reaction Coil.

Using Reaction. — In operation the reaction coil is swivelled to an angle of 45 degrees from the transformer when tuning in, and after tuning, the coupling is gradually tightened by bringing the reaction coil closer to the H.F. transformer and, if necessary, over the top of it. Should the telephony become hoarse and distorted too much reaction has been applied, and the coils should be separated until the music is clear again. Reaction applied in this way does not cause interference with neighbouring listeners-in and is permitted by the Postmaster-General.

When using reaction for long wavelengths the broadcasting reaction coil can be disconnected and the reaction taken direct on to the aerial circuit via the terminals at the back of the instrument.

As regards tuning the H.F. transformer, this is done by means of a ·0003 mfd. variable condenser across the primary coil. This condenser is not embodied in the instrument, but can be attached to it by means of two wires to the terminals provided. These are the two top left-hand terminals looking at the panel from the front.

The constructor has now a three-valve set which he may use in any desired manner. He can, by altering the switching, use the detector valve only, or detector and H.F., or L.F., or all three valves together. Reaction is available for use on short or long wavelengths.

CHAPTER IX

The "Amateur Wireless" Unit Set

By R. W. HALLOWS, M.A.

WHEN the amateur makes his first incursion into the realms of wireless he is faced with the problem of paramount importance, and that is the question of what type of set to make or buy. In most cases the state of his finances is the chief factor in bringing about a decision. He purchases the best set that he can afford—crystal, single valve, or perhaps an apparatus with one or more stages of amplification.

The Unit Set.—Fortunately there is a way out of all these difficulties by means of the unit set, which is built up like an expanding book-case. It consists of a number of panels, identical in size and shape, each of which does its own particular job. Make the first one, which may consist of the simplest crystal rectifier, and you have a complete working set, which can be brought gradually to its highest state of efficiency before further refinements are added. It is possible to construct further units as spare time and finances permit, and each of them will bring the set one stage nearer perfection. When several panels have been made up, any combination of them may be tried in a matter of seconds, whilst in a set such as that which will be described in this chapter, the wiring is so readily accessible that circuits can be altered at will.

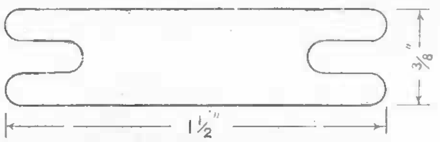


Fig. 65.—Panel Connecting Piece for "Amateur Wireless" Unit Set.

By mounting each stage on its own panel one has everything to hand in the neatest and most compact form. To change a panel not a wire need be touched. The units are connected by deeply notched brass strips of the shape shown in Fig. 65. When adding a panel one simply loosens the heads of four terminals, slips the new-comer into place, and tightens down. It is absolutely impossible even for a beginner to connect up the set wrongly, for the proper pairs of terminals always come opposite one another, and the brass strips will bridge no others.

Fig. 66 shows a photograph of the set arranged as a four-valver, with two stages of high-frequency amplification, a rectifying valve, and a note magnifier. In Fig. 67 the rectifying valve has been replaced by a panel containing a crystal detector and a high-frequency valve with tuned plate. The set has thus been changed in a moment to 3 H.F., crystal rectifier and 1 L.F. A third photograph (Fig. 68) shows the unit with crystal detector and high-frequency amplifier.

The panels are made of the blocks used by electricians for mounting switches. A stock size, 9 in.

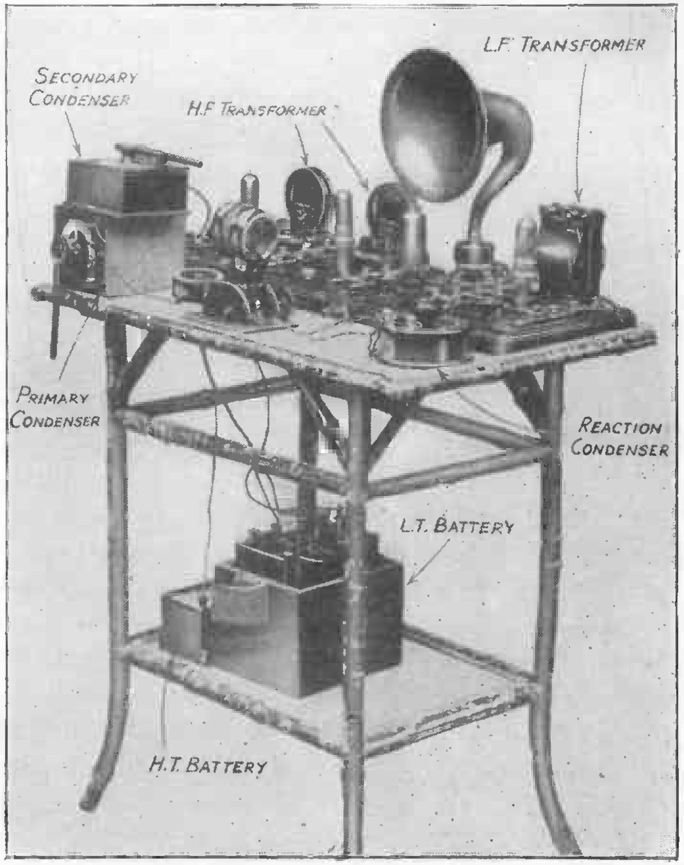


Fig. 66.—Photograph of the Units Arranged as a Four-valve Receiver.

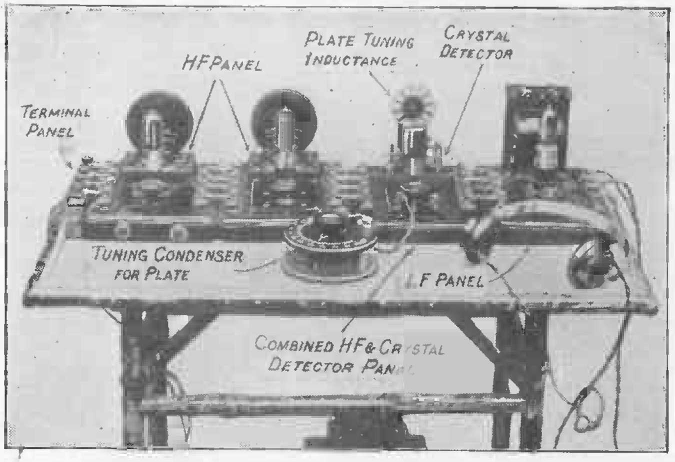


Fig. 67.—Photograph of Set Arranged for Crystal Reception and Valve Amplification.

by 6 in., with a depth of about 1 in., is very convenient, and these can be obtained from any electrical supply shop in polished hardwood for about one shilling each.

Mounting Terminals.—The terminals are mounted on ebonite strips 1 in. wide and 8 in. long. Below each terminal a ½-in. hole is bored through the wood; this ensures perfect insulation by keeping the brass well away from the material of the panel —a necessary precaution, since even seasoned wood is strongly hygroscopic, and may in damp weather be the cause of all kinds of unexpected "shorts." As the panels are hollow all wiring is done underneath their surfaces, the leads being brought to the terminals by means of the ½-in. holes already mentioned. Rheostats and condensers are also placed under the

panel out of harm's way, the only exception being the grid condenser, which is fixed to the top of the rectifying panel, so that the leak, which is of the cartridge type, may be changed in a moment to suit any particular valve.

The more advanced reader can begin with the valve rectifying panel, to which other units of various kinds may be added from time to time.

Leads.—All leads from batteries, as well as those from the secondary coil and condenser of the tuning inductance, are taken to the terminal panel, seen on the left of the photographs. This is a fixture, being screwed to the table. It is a most convenient arrangement, for any panel that one slides up to its brass strips is automatically and instantaneously connected up and ready for work.

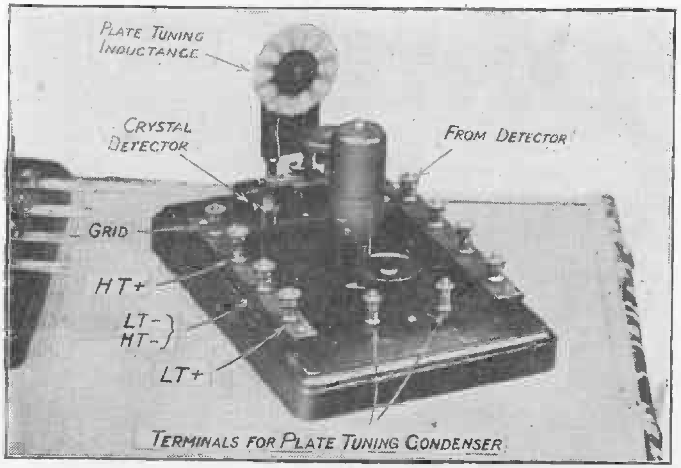


Fig. 68.—Crystal Detector Panel with H.F. Valve and Tuned Plate.

The Table.—The table used is a bamboo affair measuring 30 in. by 18 in.—again a stock size—which just takes any combination of four panels, and provides ample room for the condensers and the tuning inductances. The lower shelf holds both high-tension battery and accumulator, as well as spare coils, and any "bits and pieces" that one may wish to have at hand.

Soldering Wires to Washers.—There is no great difficulty in soldering a wire to a washer, which is one of the best ways of making connections to terminals. Scrape the wire and washer bright, and bore a small hole through the rim of the latter. Pass the wire through the hole, as shown in Fig. 69, and twist it up tight with pliers. Then dab on a little fluxite. Heat the soldering iron until a greenish or bluish flame begins to show round it, put a little fluxite on to it, and then run on some solder so that the surface for about $\frac{3}{4}$ in. from the point is well tinned. Now pick up a little solder with the point and apply it to your joint. If the iron is held on the joint for a few seconds, to give it time to heat up both the wire and the washer, the solder will run on quite easily, with the result that a good firm connection is made. Be careful when you have finished to wipe off all traces of the flux. The photograph (Fig. 70) shows a transformer-coupler high-frequency panel.

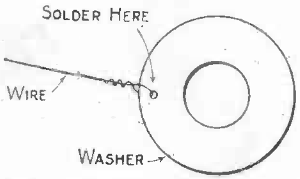


Fig. 69.—Terminal Washer with Wire Attached.

The Terminal Panel.—Whether it is intended that the first unit of the apparatus shall be a crystal detector or a valve rectifier, the reader is strongly advised to begin by making the terminal panel, which is the foundation of the whole set. Once it is in place certain leads can be attached permanently to it, so that labour is reduced to a minimum.

The photograph (Fig. 71) shows the panel with four terminals, and the same number appears on all the other units. It is always handy to have an extra terminal, particularly when experimenting with new circuits. For this reason the reader will do well to adopt five-terminal units rather than those with four only. One set of terminals will normally not be in action, but it will be seen later how they may be used to advantage when we come to discuss possible refinements of the circuits shown.

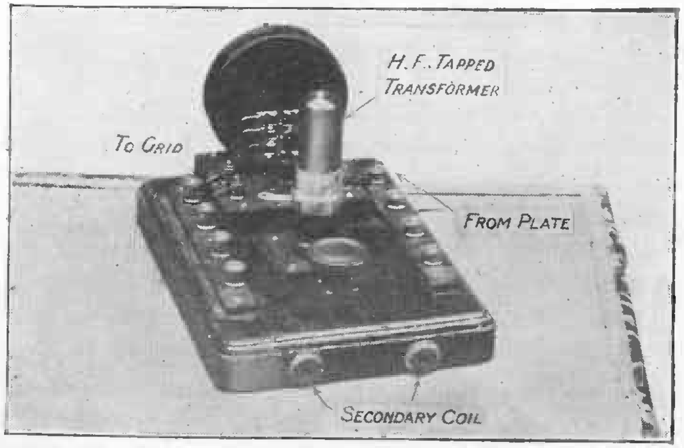


Fig. 70.—High-frequency Transformer-coupled Unit.

For the terminal panel a strip of ebonite measuring 8 in. by 1 in. by $\frac{3}{16}$ in. or $\frac{1}{4}$-in. thick is required. This should be bored as shown in Fig. 72. All the holes are $\frac{3}{16}$ in. The two nearest the ends are for the screws which fix the strip, and the wood block upon which it rests, to the table. The remaining five are for the 3 B.A. terminals, whose heads should be as large as possible, with good flat contact surfaces.

The block for the terminal panel should be of

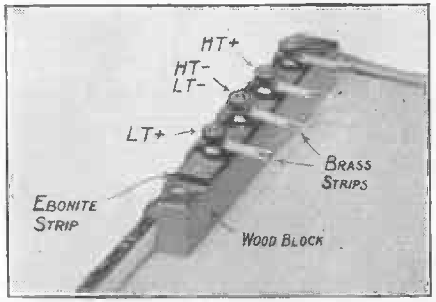


Fig. 71.—Photograph of Terminal Panel.

hardwood of exactly the same height and length as the unit panels. Clamp the strip on to it and make a prick in the wood exactly in the centre of each terminal. Next remove a strip and bore a $\frac{1}{2}$-in. hole about $\frac{3}{4}$ in. deep at each mark. Fit the terminals to the strip and put it in place, seeing that the nuts or bolt-heads on the under side are quite clear of the wood. If there is any contact the offending hole or holes must be slightly enlarged. Cut a small notch in the wood leading to each hole, as shown in Fig. 73. These should be just large enough comfortably to

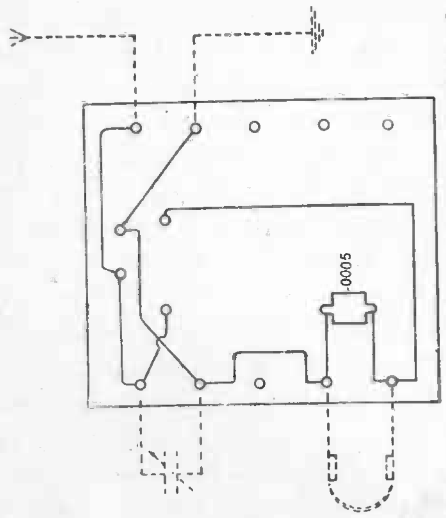


Fig. 75.—Wiring Diagram of Crystal Unit Panel

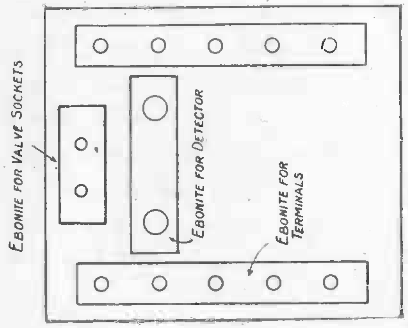
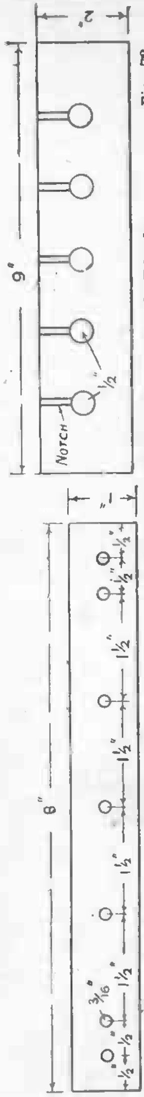


Fig. 74.—Diagram showing Positions of Ebonite Strips



Figs. 72 and 73.—Details of Ebonite Strips and Wood Block.

take the insulated wire that is used for the battery and other leads. If it is intended to proceed straight away with the construction of the valve rectifying panel, these leads may now be attached to the lower ends of their respective terminals, and the strip and its block can be fixed to the table. If, however, the crystal detector is to be the next step, no wires need be attached before the panel is screwed down.

The Crystal Unit Panel.—The crystal unit does not actually require the full number of terminals, but as later it will be shown how to convert it into a combined high-frequency valve and detector panel, it is just as well to provide it with them when it is first made up.

Prepare two strips as before, but bore the $\frac{1}{2}$-in. holes beneath them right through the wood of the panel. Now take a piece of ebonite measuring 2 in. by 1 in. and mount on it a pair of valve-sockets 1 in. apart from centre to centre. Bore $\frac{1}{2}$-in. holes through the wood to take their lower ends, and fix the block quite close to the top edge of the panel (Fig. 74). Another strip to take the detector is fitted as shown in the drawing. Place it quite near the piece containing the valve-sockets, so that plenty of room may be left on the panel for the valve-holder and rheostat which will be added later. Mount the detector on this strip, boring $\frac{1}{2}$-in. holes as before below the crystal cup and the pillar.

The wiring may now be carried out as shown in Fig. 75. Use fairly stout wire, about No. 24 S.W.G., and pass each piece through a length of insulating

tubing. Each end of all wires should be soldered to a 3 B. A. washer, as described earlier; these can then be clamped tightly by the lower nuts of the terminals.

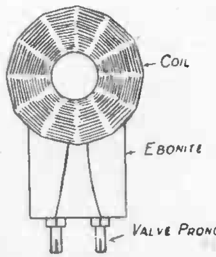


Fig. 76.—Detail of Coil Holder with Coil.

If now the aerial lead-in is taken to terminal 1 and the lead from the earth is fastened to No. 2 of the terminal panel, the detector unit can be connected to it by means of two notched brass strips. The telephones and variable condenser are wired up as shown, and as soon as the reader has made the inductance coil to fit the valve-sockets the unit is complete. He cannot do better than use a set of basket coils. Make sure that the coils are heavily shellacked and not merely dipped in paraffin wax, otherwise

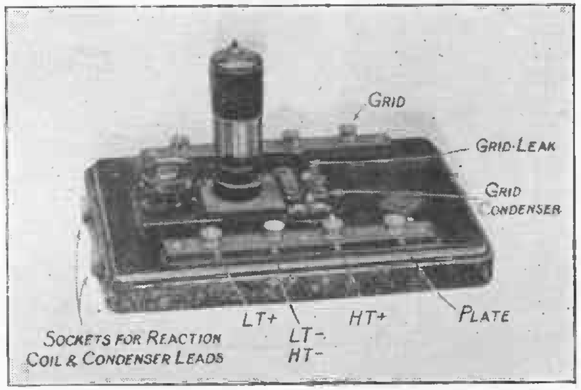


Fig. 77.—Photograph of Valve-rectifying Panel.

they will not last long. Mount each on an ebonite block, as shown in Fig. 76, provided with a pair of valve prongs spaced to fit the sockets. This is done most easily by sandwiching the coil between the ebonite block and a strip or disc of the same material held in place by a screw.

The Valve-rectifying Panel.—The valve-recti-

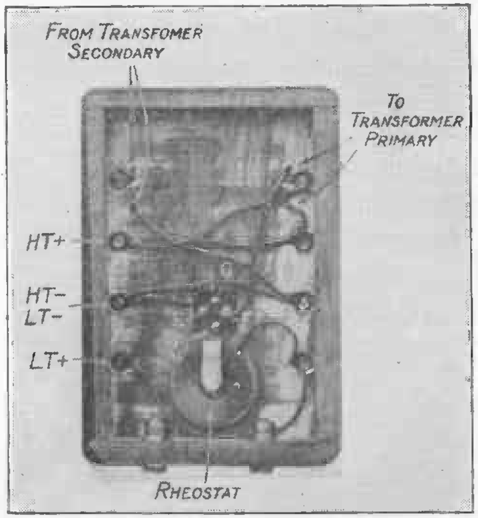


Fig. 78.—Bottom View of Valve-rectifying Panel.

fying panel is not at all difficult to make. Figs. 77 and 78 show its appearance when seen from above and from below. To fix the valve-holder in place bore a hole $1\frac{1}{4}$ in. in diameter in the panel, which will give the legs plenty of clearance, and then fasten with screws.

The rheostat should have a resistance of 8 ohms.

The way in which the rheostats are fitted to the panel depends entirely upon their design. It is necessary, as a rule, to let them into the wood for $\frac{1}{4}$ in. or so in order to allow plenty of clearance below the end of the spindle, but this is a matter that presents little difficulty if a chisel or gouge is available. If the spindle passes through a brass bush, it is best to make in the wood a hole big enough to clear it entirely. The bush is then passed through a thin piece of ebonite which is screwed down to the top of the panel.

The Grid Condenser.—Place the grid condenser on the upper side of the panel just in front of the valve. The leak can then be changed without any trouble if its value does not suit the valve in use.

In the photograph the leads for the reaction coil are shown as running to a pair of sockets at the lower

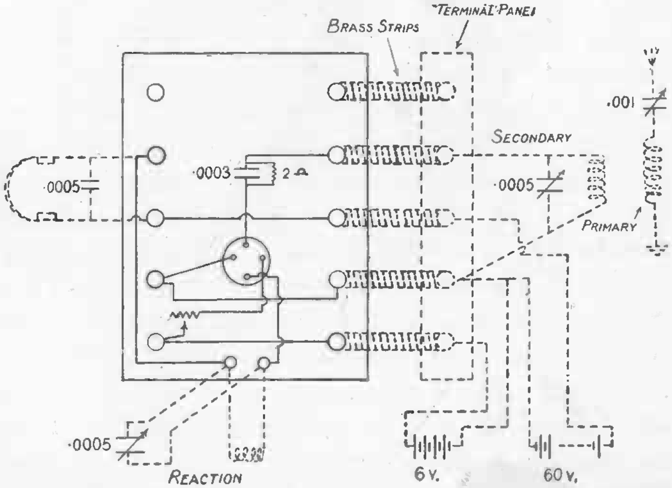


Fig. 79.—Wiring Diagram of Valve-rectifying Panel.

end of the panel. This is a convenient arrangement, for it enables the coil and the condenser to be plugged in in a moment, whilst if reaction is not in use the sockets are short-circuited by means of a pair of plugs mounted on a brass strip.

The valve used for the rectifying panel should be preferably of the rather soft type.

Fig. 79 shows the wiring of the panel, which should not present any great difficulty. See that all wires on the under side of the panel are a little slack.

Accumulator Connections. — A useful tip for making accumulator connections is shown in Figs. 80 and 81. A valve-leg is screwed into the top of each terminal, a prong being soldered to each lead running from the low-tension battery to the terminal panel.

The Inductances.—Any type of three-coil tuner will work well with this set. For short-wave reception basket coils mounted as already described are particularly recommended owing to their low self-capacity. It is not difficult to make an adapter which will allow them to be used on holders designed to take honeycomb or lattice-wound coils. A very cheap set of coils can be made by mounting a set of seven baskets and the five largest of a set of eight slabs in the way mentioned. The baskets will tune to 4,000 metres, beyond which wavelength the slabs can be used for receiving any existing stations.

Amplifiers.—Most of those who use multi-valve sets will agree that if there are to be several steps

of amplification the majority of them should be of the high-frequency type. The reader will therefore do well to begin with three panels — one radio-frequency amplifier, a rectifier and one note-magnifier—and to add to his set by fitting up some further high-frequency units rather than those which amplify at audio frequency.

Fig. 80.—Photograph of Accumulator with Valve Sockets Fitted to Terminals.

The high-frequency impulses may be passed on in several ways, two of the best of which for short-wave reception, the tuned plate and the air-core transformer, are shown diagrammatically in Figs. 82 and 83 overleaf.

A third method, the resistance-capacity coupling, though excellent for wavelengths of over 1,000 metres, does not give very good results with the shorter waves. For the conver-

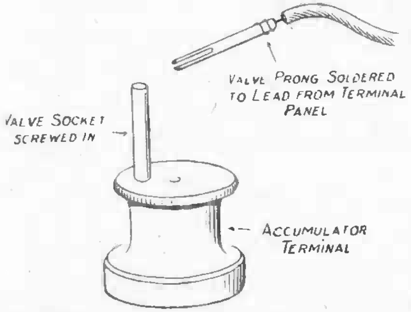


Fig. 81.—Detail of Accumulator Terminal with Valve-socket Connector.

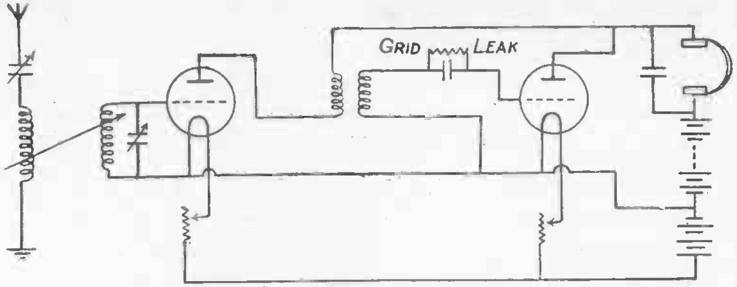


Fig. 82.—High-frequency Air-core Transformer Coupling.

sion of the original crystal detector panel make use of the first of these methods, using the basket coil originally mounted for the aerial tuning inductance as the coil in the tuned-anode circuit.

Fig. 68 shows the finished panel. The valve-holder and filament rheostat are mounted as before, and two extra terminals are required at the lower ends of the panel. These are to take the leads from the variable condenser which tunes the anode inductance. About ·0003 mfd. will be found to be a suitable value for this condenser.

Wiring.—The wiring, which is shown in Fig. 84,

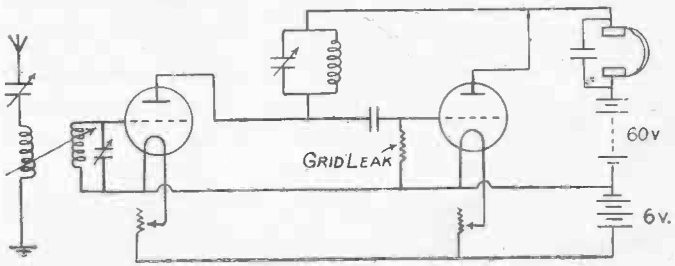


Fig. 83.—Tuned-anode Coupling of H.F. to Rectifying Valve.

looks at first sight rather a formidable undertaking, but actually it does not present any great difficulty, especially if the anode circuit, shown in heavy black lines, is completed first. It is a good tip when making up any of the panels described in this chapter to draw pencil lines on the under side of each corresponding to the leads themselves. The wiring, having been first mapped out in this way, is then quite an easy task; further, if at any time temporary changes are made in the circuits, the pencilled lines showing the original positions of the wires are always there to act as guides and time-savers when the connections come to be remade. Records of several circuits can be kept by using pencils with different coloured leads.

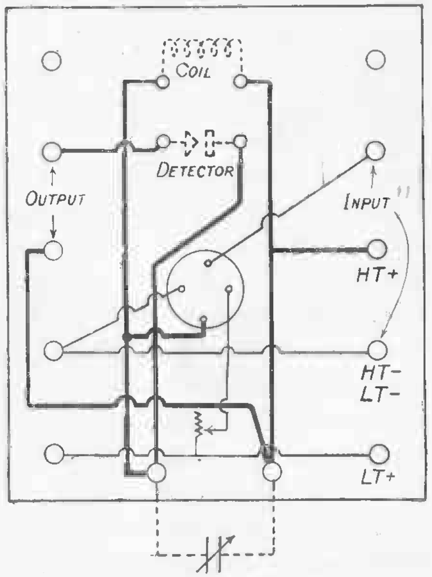


Fig. 84.—Wiring Diagram of H.F. and Detector Panel.

With some kinds of crystals it will be found advantageous to place a small fixed condenser between the detector and the top output terminal; this acts as a block, preventing any of the high-tension current from passing through the crystal.

Using the Amplifying Panel.—The panel can now be used with any kind of two-coil tuning inductance as a complete receiving unit by clipping it to the terminal panel and attaching the head-telephones to the output terminals on the other side. Those who have previously used only the unaided crystal will be surprised at the increase in both range and volume of sound which follows on the addition of even one high-frequency valve.

High-frequency Panel.—The high-frequency panel containing a valve alone is most conveniently made with transformer coupling. A high-frequency transformer consists of two coils of equal, or almost equal, size coupled together. The primary receives the output of the valve, inducing in the secondary a current which is passed on to the grid of the succeeding valve. A perfectly efficient transformer can be made by using two basket coils which are simply laid one on top of the other, the upper one being moved about until the most effective degree of coupling has been found. With this type of transformer it is an advantage, though it is not absolutely necessary, to tune one of the coils with a variable condenser. Fig. 85 shows how a three-coil holder may be used as a high-frequency transformer, the reaction coil from the rectifying panel being coupled in this case to the secondary of the transformer, a method which entirely eliminates the risk of causing annoyance to others by re-radiation from one's own set.

Either of these improvised instruments can be mounted on the high-frequency panel in the place occupied by the transformer shown in the photograph (Fig. 70). There are two main types of transformer on the market to-day, the "plug-in" and the tapped. The former are small mushroom-shaped affairs provided with four prongs (one pair for the primary and the other for the secondary turns) which fit into an ordinary valve holder. They have one serious

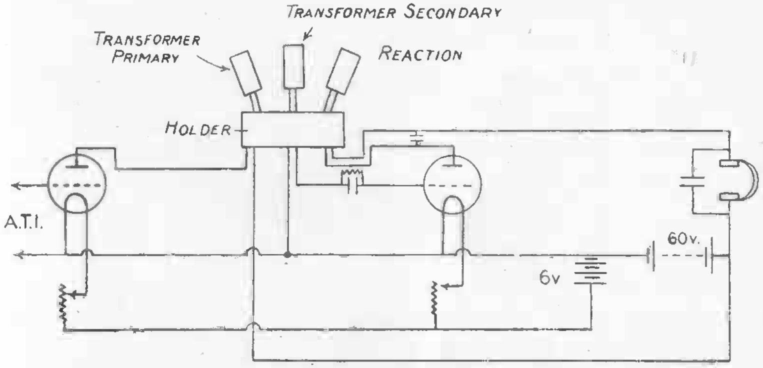


Fig. 85.—Diagram of Coil Holder used as H.F. Transformer.

drawback, which is that each covers a very limited range of wavelengths, so that a set of eight or so is necessary in order to receive all transmissions from 250 to 25,000 metres. If the set is to be used only for the reception of broadcasting the plug-in transformer will answer admirably; but if it is desired to receive everything that is going in the way of both telephony and telegraphy, the tapped transformer is much more convenient. If two or more transformers are used, their electrical values must be identical, otherwise they will work against instead of with each other.

The high-frequency panel differs from the valve-rectifying unit in that it has only the ten terminals arranged in two rows of five on the long ebonite strips. The input or primary side of the transformer receives impulses from the plate circuit of the valve,

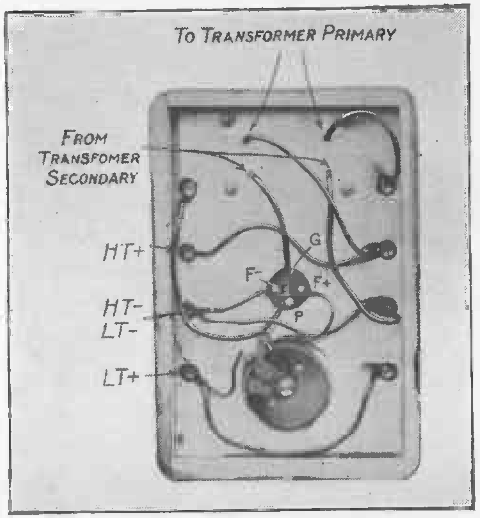


Fig. 86.—Under Side of High-frequency Panel.

which makes it in some cases rather difficult to mount it so that the lead to the grid of the valve shall not run near that going from its plate to the transformer. It is important to keep these wires well apart.

Fig. 86 shows the under side of the panel, whilst Fig. 87 shows the wiring diagram, which is applicable to any type of transformer.

Valve for Amplification.—Though a soft valve may be used with advantage as a rectifier, this type will not give good amplification. A really hard valve, that is one with a high degree of vacuum, will give by far the best results, but care should be taken to select one which works best with the same plate potential as the valve used on the rectifying panel.

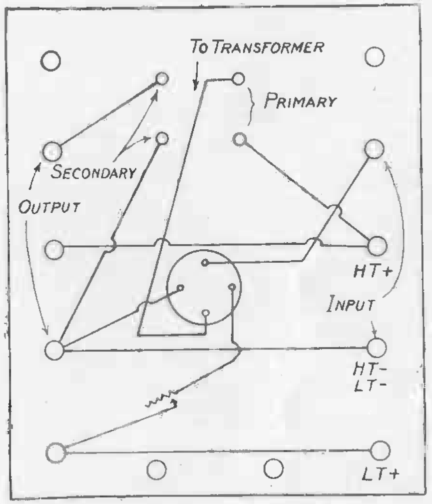


Fig. 87.—Wiring Diagram of H.F. Transformer Panel.

If amplifying and rectifying valves require quite different voltages on their plates, the unit system becomes unsatisfactory unless a potentiometer is used in the anode circuit of the rectifier, since normally the H.T. leads supply the same potential to each valve.

Testing the High-frequency Unit.—When the high-frequency unit has been completed it should be tested in conjunction with the rectifying panel. Fig. 88 shows the rectifying panel used alone as a complete receiver. The H.F. panel is simply inserted in front of it. You cannot go wrong in the connections, since the correct pairs of terminals come opposite each other when the units are placed side by side. It will probably be found that the tuning of the aerial

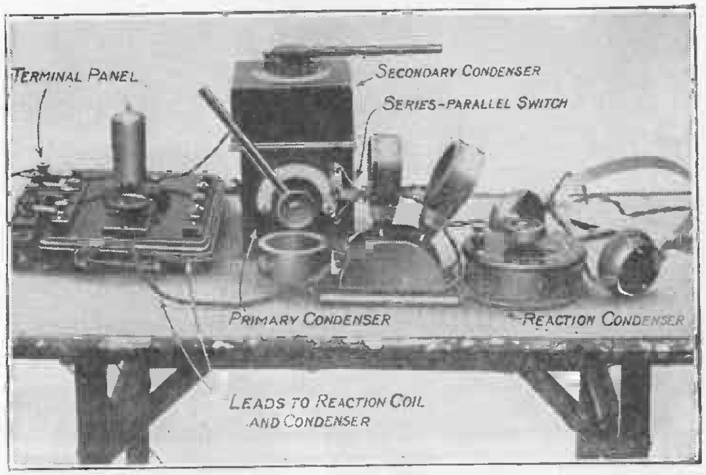


Fig. 88.—Photograph of Rectifying Panel in Use as "Single-valver."

and secondary inductances alters considerably as a high-frequency valve is added. As soon as signals are coming in as well as it is possible to get them, turn to the filament rheostats and adjust them, moving at the same time the wander-plugs of the high-tension battery until the best combination of filament current and plate potential has been found. In both cases use the least amount of "juice" consistent with good signal strength.

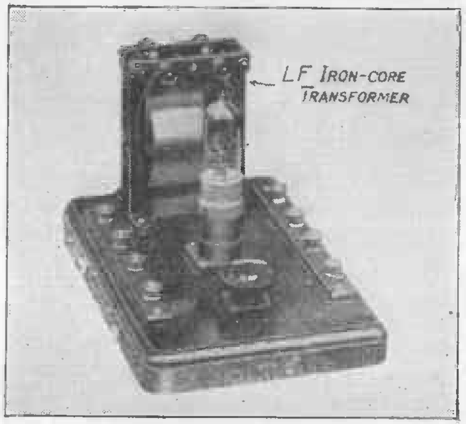


Fig. 89.—Photograph of Low-frequency Panel with Iron-core Transformer.

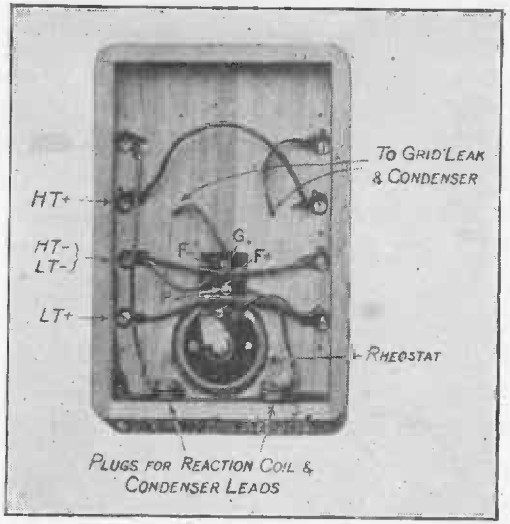


Fig. 90.—Under Side of Low-frequency Panel.

Self-oscillation.—Each additional step of high-frequency amplification increases the tendency of the set to fall into self-oscillation. The signs of this can be readily recognised : signals become " woolly," and if the aerial terminal is touched with a wet finger a distinct " tap " is heard in the phones. The question of eliminating self-oscillation will be dealt with later ; for the present it will suffice to say that it can usually be prevented in small sets (1) by using the smallest efficient reaction coil ; (2) by lessening filament current or anode potential ; (3) by working always with the loosest possible coupling.

The Low-frequency Panel.—The low-frequency unit used with the set is shown in Figs. 89 and 90, which give details of its economy both above and below the panel. It will be noticed that the transformer is so arranged that its windings are at right angles to the long side of the panel. If the reader comtemplates the employment of more than one such unit he is advised to mount the transformer with its coils parallel to the ebonite strip, otherwise its effect upon its next-door neighbour may be so serious as to impair the working of the set.

Interaction Effects.—There are several ways of minimising the interaction effects of low-frequency transformers connected in cascade. None of them can be relied upon to eliminate entirely the unwanted effects, but they certainly make a great improvement. Test the set for interaction effects by using flexible leads, say a yard in length, instead of the short brass strips, to connect two low-frequency panels. Before

switching on move the panels away from each other to the fullest extent of the wires. Now turn on the current, tune into a strong signal and listen carefully. Slide the outlying panel gradually towards the other, remaining at the same time on the look-out for any change in the quality of the signals. If they become blurred or accompanied by outside noises as the dis-

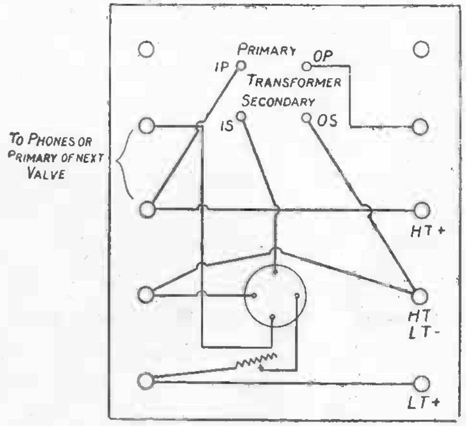


Fig. 91.—Wiring Diagram of Low-frequency Panel.

tance between the panels is decreased, then interaction is present.

Should interaction effects be noticed, try soldering a wire to each iron core, and taking it to earth. This will sometimes work a cure ; but if it fails, the best thing to do is to enclose each low-frequency transformer in an iron case, which will confine the greater part of its magnetic field to its own immediate neighbourhood.

Fixed Condenser.—The rectifying valve does not function quite perfectly, for it allows a number of high-frequency pulsations to pass through it, and these go on to the transformer mingled with low-frequency impulses. Their presence in audio-frequency circuits is undesirable, and some means of getting rid of them must be found. This is done by providing a capacity in the primary of the transformer which will act as a by-pass for them. It usually takes the form of a fixed condenser of .001 mfd. shunted across the primary terminals, but some transformers, such as the usual open-core type, are so wound that their own self-capacity is sufficient for the purpose. The low-frequency panel, when made up, should be tested with and without such a condenser in order to see which gives the best working.

Wiring.—Fig. 91 gives a wiring diagram of the panel; do not forget to make the necessary change in its position if you intend to have two or more note-magnifiers.

There is one point of importance in the wiring up of the transformer. Some of them have the input and output terminals of primary and secondary marked 1 P, 0 P, 1 S, and 0 S, but others are merely lettered "primary" on one side and "secondary" on the other. The input and output terminals can, however, be readily found if you remember that the input lead will always come from a point nearer the centre of the coils than the output lead. Fig. 92 makes this quite plain. In connecting up the wires join the terminal leading from the plate of the

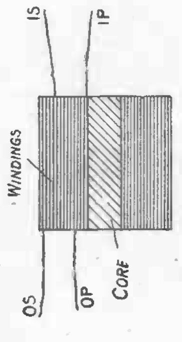


Fig. 92.—Leads of Low-frequency Transformer.

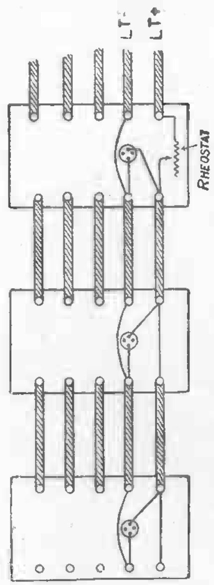


Fig. 93.—Diagram showing Control of Three Low-frequency Panels with one Rheostat.

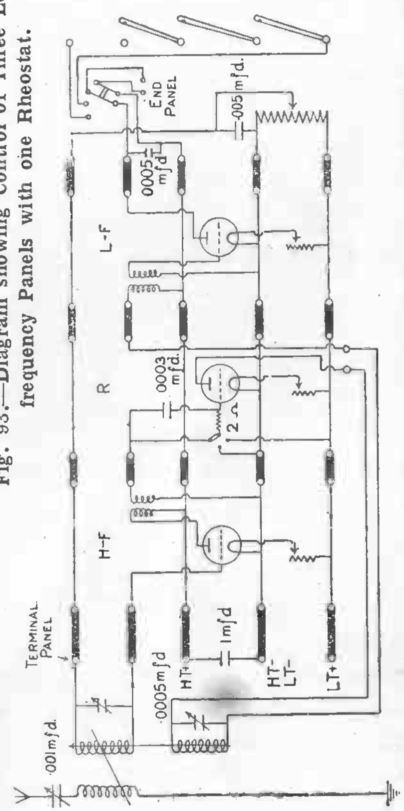


Fig. 94.—Wiring Diagram of Three-valve Unit Set with Terminals, H.F., Rectifying, L.F. and End Panel.

preceding valve to 0 P, and 1 P to H.T +. 1 S is joined to the grid, and 0 S to L.T –. If the connections are not made as shown the transformer will not work properly.

There is no need to have a separate filament rheostat for each low-frequency unit, for since the valves are doing the same work they will require the same amount of current. Fig. 93 shows how one resistance may be made to control all of them. If a single rheostat is used it must be capable of carrying 2½ amperes.

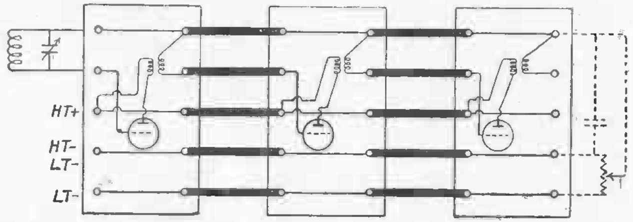


Fig. 95.—Grid-control Circuits of Three High-frequency Valves.

Self-oscillation. — Though slight self-oscillation is unlikely to cause re-radiation or interfere with other people, so long as the reaction coil is loosely coupled to the secondary it will make the reception of telephony very indistinct.

Many owners of receiving sets suffer from self-oscillation troubles without recognising them or knowing that they can be cured. Comparatively few "ready-made" sets have any form of grid control, but it is luckily not a difficult matter to add it to most types of apparatus.

The apparatus required is simple and inexpensive,

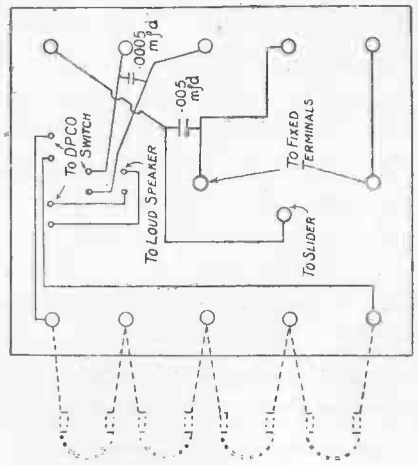


Fig. 97.—Wiring of End Panel with Four Pairs of Phones in Series.

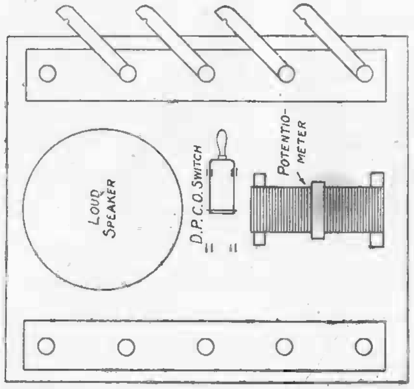


Fig. 96.—Upper Side of End Panel.

consisting of a condenser of about .005 mfd. capacity and a potentiometer with a maximum resistance value of from 300 to 450 ohms.

With high-frequency valves the tendency to oscillate is at its strongest when the grids are supplied with a negative potential. As this potential is reduced towards zero the oscillation noises die down, ceasing altogether when the potential becomes slightly positive.

The way in which the problem is solved will be seen from a study of Fig. 94, which shows the wiring diagram of a small complete unit set consisting of three valves, a radio-frequency amplifier, a rectifier and a note-magnifier. The fifth terminal is now brought into play, and an end panel, whose details will be described later, has been fitted.

Grid-voltage Control.—If the course of the grid potential of the H. F. valve is traced, it will be seen that before reaching its destination it must pass through a variable amount of the resistance windings of the potentiometer, whence it travels by way of the fifth terminals and their connections to the secondary coil of the tuning inductance. After passing round this coil it arrives on the grid of the high-frequency valve. Thus the potentiometer controls the grid voltage, but does not interfere with the passage of high-frequency oscillations in the circuit, a by-pass for them being provided in the ·005 bridging condenser, which, by the way, should have mica, not paper, as its dielectric.

When two or more high-frequency valves are

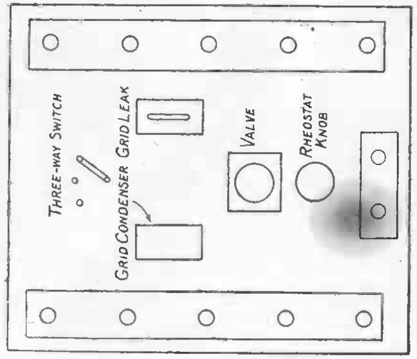


Fig. 98.—Upper Side of Improved Detector Panel.

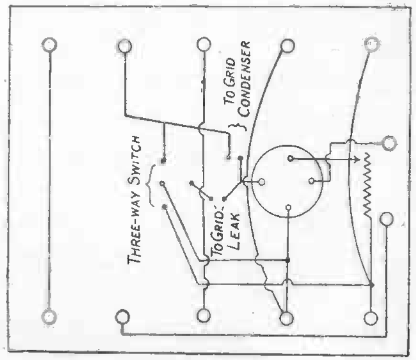


Fig. 99.—Wiring Diagram of Under Side of Improved Detector Panel.

in use the wiring of their panels is as shown in Fig. 95.

End Panel.—Details of the end panel are given in Figs. 96 and 97, which show respectively its upper and under sides.

Below this again is the grid-control potentiometer. If it is desired to use low-resistance phones and loud-speaker, the telephone transformer should be mounted on this panel.

Improvements.—The high-tension battery should be bridged by a by-pass condenser as shown in Fig. 94. Besides providing a free path for oscillating currents this condenser serves to eliminate battery noises by keeping the H.T. current constant. It should be of large capacity—a 1 mfd. Mansbridge condenser will do admirably.

Figs. 98 and 99 show how the valve-rectifying panel may be improved by the addition of a three-way switch, which can be made up on a small ebonite base, by using three of the studs made for the selector switches of tapped inductances and a laminated arm.

In making up this arrangement grid-leak and condenser are separated, the former being mounted on its own ebonite block. The condenser is wired as before between the grid and the input terminal. A second lead is taken from the grid to the leak, and thence to the switch arm. The studs are wired respectively to the input terminal, low-tension negative and low-tension positive.

CHAPTER X

An Improved Unit Set

THE modifications to the "Amateur Wireless" unit set detailed in this chapter, whilst not being absolutely necessary, may be regarded as refinements to be undertaken as time and expense permits. These improvements are best carried out after the set has been experimented with in the form already shown, so that the final finish may not be impaired.

Fig. 100.—The Improved Unit Set.

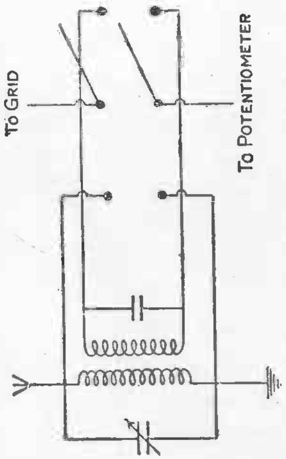


Fig. 101.—Wiring of Tune-stand-by Switch.

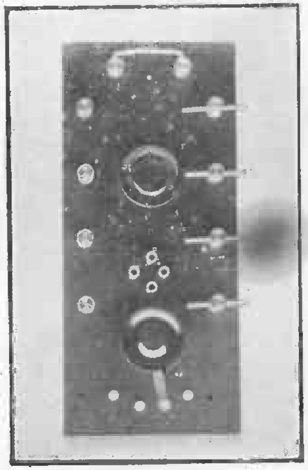


Fig. 102.—Upper Side of Rectifying Unit.

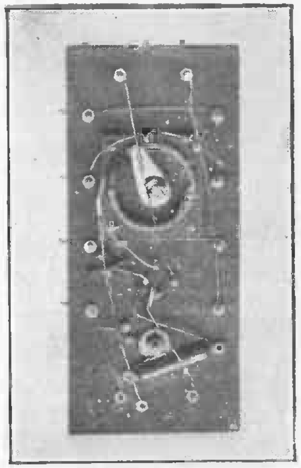


Fig. 103.—Under Side of Rectifying Unit.

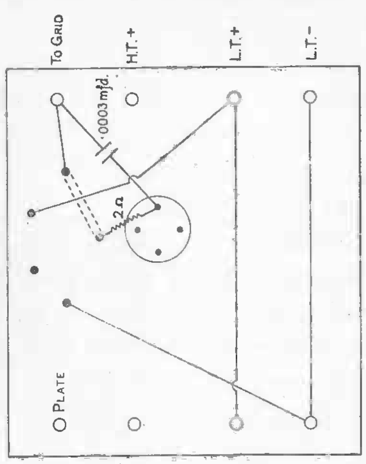


Fig. 104.—Diagram showing Wiring of Switch.

Modifying the Tuner Arrangements.—The modified set is shown in Fig. 100.

The terminal panel seen on the left is a box 16 in. long by $1\frac{1}{2}$ in. wide and 2 in. deep. The leads from it to condensers, secondary tuning coil and H.T. battery are taken underneath the table, insulated wire being used.

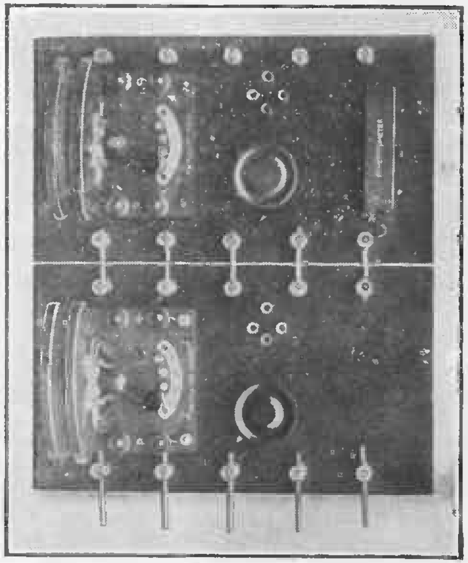


Fig. 105.—Upper Side of Two H.F. Transformer-coupled Units.

A small series - parallel switch, mounted on the terminal panel, will be found handier than the swinging arms fitted to the primary condenser. These switches can be made at trifling cost at home in accordance with the following instructions :—Two strips of brass, each $1\frac{1}{2}$ in. long by $\frac{5}{16}$ in. wide, are cut out. The bridge which connects them is made of $\frac{1}{8}$-in. ebonite. In the middle of it a hole is tapped for a 4 B.A. screw, which retains the handle. The latter is a length of ebonite tube countersunk at the top in order to allow the head of the screw to lie flush. The connecting piece is fastened to the brass arms by 6 B.A. screws, with ends lightly riveted.

The positions of the three studs are best ascertained by making up the switch roughly on a piece of wood before drilling the ebonite panel.

The condensers are of the mica-dielectric type.

In the middle of the front part of the table a tune-stand-by switch is placed, and at the far end is seen a small panel containing a switch for cutting out or reversing the reaction coil.

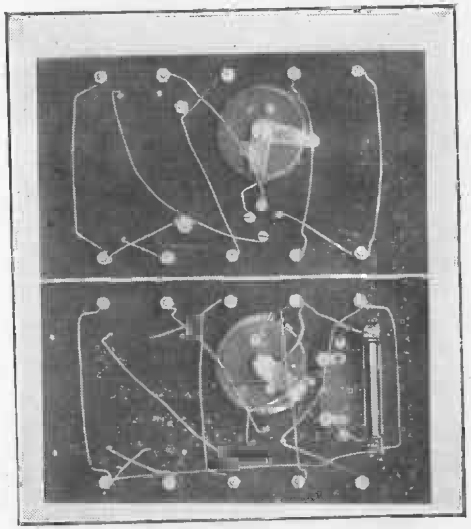


Fig. 106.—Under Side of H.F. Transformer-coupled Units.

Rectifying Panel, etc.—When two tuned-plate units are in use, the tune-stand-by switch (Fig. 101) is essential. Thrown over towards the terminal panel, it cuts out the secondary coil and condenser, connecting the aerial to the grid of the first valve and earth to the slider of the grid potentiometer. One has to adjust only the primary condenser and the condensers of the tuned plates.

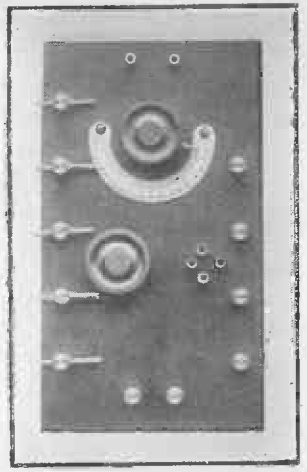


Fig. 108. — Upper Side of Tuned-plate H.F. Amplifier.

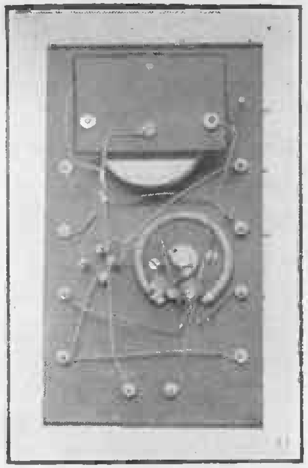


Fig. 109.—Under Side of Unit Panel shown in Fig. 108.

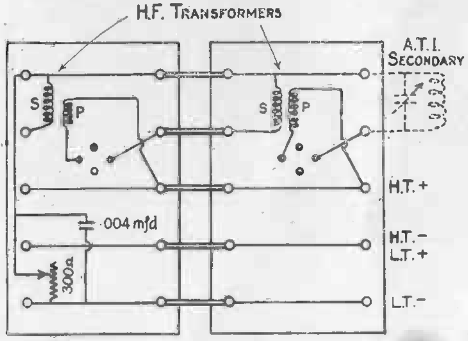


Fig. 107.—Potentiometer Connections of H.F. Transformer Panels.

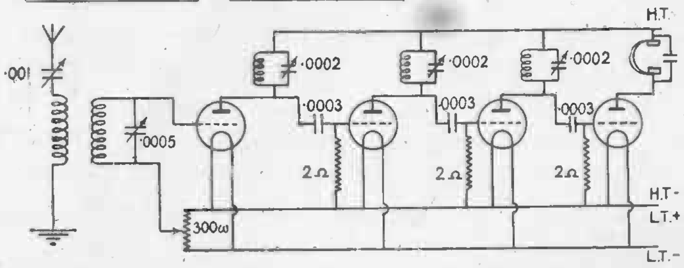


Fig. 110.—Method of Wiring Three Tuned Anodes and Rectifier.

Figs. 102 and 103 show the upper and under sides of the rectifying panel. If switch arm (*see* Fig. 104) is on bottom stud the leak is in parallel with the grid condenser; the next connects it directly to L.T. +, the third throws it out of action altogether, and the fourth takes it to L.T. –. The rectifying panel has

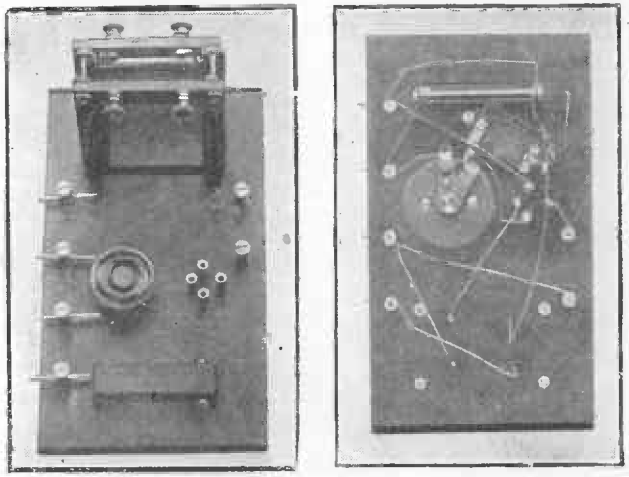


Fig. 111.—Upper and Under Views of Low-frequency Panel.

only four terminals at each side. The two terminals at the lower edge of the rectifying unit takes the leads of the reaction coil when required. Normally they are kept shorted.

In Figs. 105 and 106 is seen a pair of transformer-coupled H.F. units, which can be used on all waves from 200 to 25,000 metres, without tuning condensers.

The potentiometer seen at the bottom of the

second panel has a resistance of 300 ohms. The wiring is shown in Fig. 107.

Tuned-plate Units.—An innovation in the present set is the use of tuned-plate units for H.F. amplification. One of these is seen in Figs. 108 and 109. Fig. 110 shows the circuit diagram for three tuned-anodes followed by a rectifier. More than two tuned-plate units are not advised generally, as the tuning becomes critical.

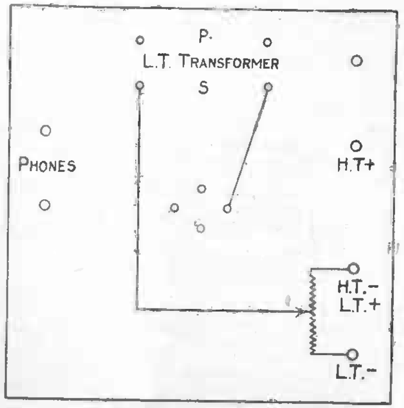


Fig. 112.—Grid-control Wiring of Low-frequency Unit.

Fig. 111 gives views of the low-frequency panel as seen above and below. It is provided with a separate potentiometer in order that maximum am-

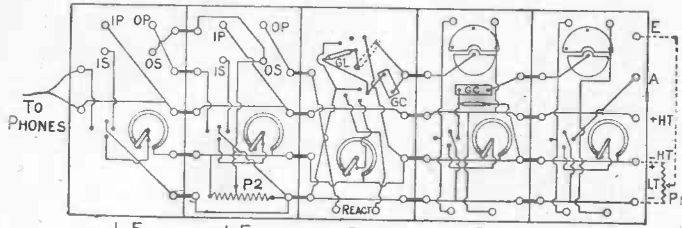


Fig. 113.—Wiring Diagram of Improved Set.

plification may be obtained. Fig. 112 shows a wiring diagram of the grid-control circuit, while Fig. 113 shows the wiring for the modified five-unit set.

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