The "PW" VALVE Experimenter's Handbook

6d.

This handbook has been specially written by E. J. Wyborn, B.Sc., A.C.G.I. The amateur will find the information given on valves and valve circuits written in concise and straightforward language, the text being amply illustrated by diagrams and photographs.

THE "P.W."

VALVE EXPERIMENTER'S HANDBOOK

A VALUABLE AND UP-TO-DATE GUIDE

SPECIALLY WRITTEN FOR "POPULAR WIRELESS"

By

E. J. WYBORN, BSc. A.C.G.I.

THIS book, price 6d. but presented free with every issue of POPULAR WIRELESS week ending October 10th, 1925, contains a mass of useful information on valves and different types of valve circuits. It is up-to-date in detail and has been written by one of "P.W.'s" regular contributors who is an acknowledged authority on Valve Receivers.

The "P.W." Valve Experimenter's Handbook.

Specially Written for "Popular Wireless"

By

E. J. WYBORN, B.Sc., A.C.G.I.

FOREWORD.

The already extensive field of wireless science is continually being still further enlarged by new discoveries and new applications of old principles, in almost all of which the valve is the keystone. It is a matter of difficulty in the limited scope of this book to cover every application of the valve which is of interest to the amateur, particularly as the ranks of the experimenter include those in all stages of wireless craft, from the beginner to the experienced worker.

The object which has been held in mind in the compilation of this handbook has been to set out the multitudinous uses of the valve in such a manner that the beginner will not be "lost," and the connoisseur will not be bored. It is hoped that the book will supply a sound outline of valve knowledge to those who are taking their first steps in the realm of wireless and to those who have hitherto confined their activities to practical experimental work without thoroughly grasping the underlying principles.

At the same time the more advanced experimenter may be assisted in obtaining a clearer grasp of some point which was previously perhaps not quite clear to him, and he may find some suggestion which will open up a new field of interest for his activity.

CHAPTER I.

How the Valve Works.

The life of wireless as a practical means of communication dates from the introduction of the raised aerial and earth by Marconi—who took the early laboratory experiments of Hertz and others, and from them moulded a practical signalling system. The early demonstrations of Marconi to the British Post Office mark the birth of wireless as far as Great Britain is concerned, and since then the science has progressed with extraordinary rapidity to its present high state of development.

From the coherer, with which the reception of the pioneers was carried out, progress advanced by way of the magnetic detector to the crystal, which together with the spark transmitter was for some considerable time the standard equipment on both land and sea.

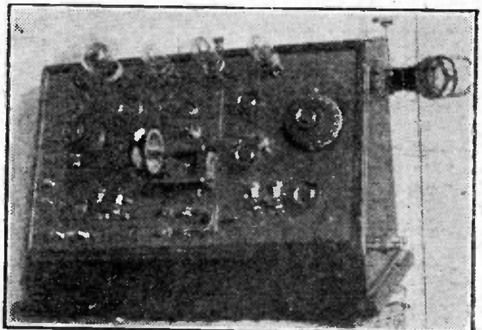
Origin of the Valve.

It was the introduction of the valve, however, which gave the new science the power to meet the demands of to-day for both business and entertainment in every part of the world. Before the advent of the amplifying powers of the valve the scope of a receiver was very limited indeed, and in transmission the valve alone has made possible wireless telephony and broadcasting as we know it. It is, in fact, no exaggeration to say that practically the whole of the modern art of wireless has been built up on the valve.

An experimental receiver built by an enthusiastic reader of "P. W."

The name of Edison is associated with the first experiments which resulted in the discovery of the valve. He noticed that when a carbon electric lamp had been in use for a long time, the inside of the bulb became covered with a uniform black deposit, whilst behind each leg of the filament was a thin "shadow," on which the deposit was very much less dense—pointing to the probability that the deposit had been shot off from the incandescent filament. The attention of Fleming was drawn to this occurrence, and he it was who first grasped the significance of the phenomenon and made use of it in his famous two-electrode valve, which consisted only of a filament and plate. The addition of the grid giving the three electrode valve as it is to-day we owe to Dr. Lee de Forest.

The valve consists of a filament of thin wire surrounded by a nickel sheet known as the plate. A spiral of wire called the grid is placed between



An example of a four-valve set of the "desk" type.

the two, surrounding the filament, the whole being mounted in a glass bulb from which the air has been removed.

Directly the filament is heated to incandescence by the passage of a current, it emits electrons or small particles of negative electricity, which are shot off in much the same way as tiny particles of water leave the surface of a boiling liquid. Now the plate or anode is maintained at a positive voltage (relative to the filament), and as two electric charges of opposite sign attract each other, the negative electrons emitted from the filament are attracted to the positively charged plate. A steady flow of electrons from the filament to the plate is thus set up, and this is known as the plate current of the valve.

Action of the Grid.

Now when the grid is given a positive voltage (relative to the filament) it assists the flow of electrons to the plate, so that the plate current increases. (A very few of the electrons, of course, are attracted to the grid, but the vast majority pass between the turns of the grid on to the plate.) Conversely, if the grid is given a negative voltage, it will repel the electrons and oppose their flow to the plate, thus causing a reduction of the plate current.

We see therefore that by changing the voltage (or "potential" as it is usually termed) of the grid, we can produce similar changes of the plate current, and if we apply a uniformly varying voltage on the grid a corresponding uniform variation of the plate current will be produced. The valve is thus used as an automatic and instantaneously-acting relay; the regular variations of voltage which constitute a wireless signal are

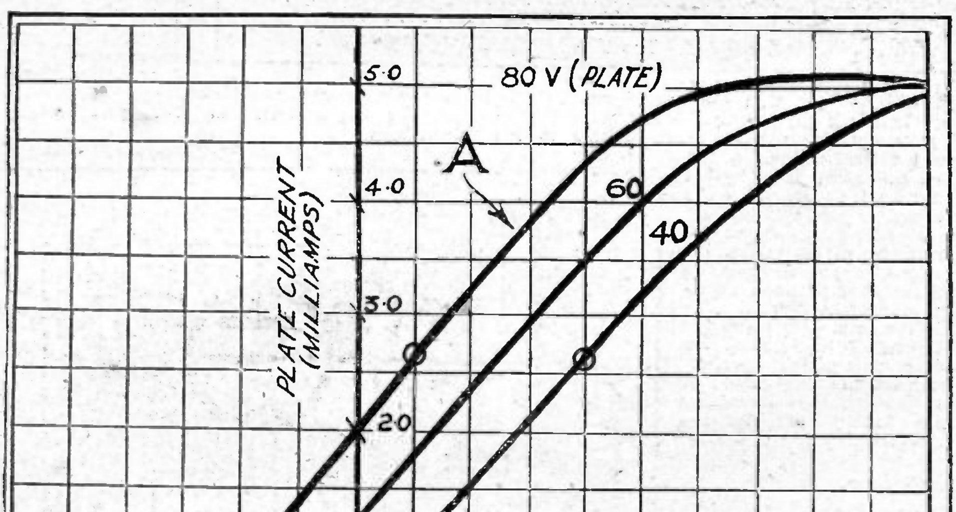


FIG. I. VALVE CHARACTERISTIC CURVES.

impressed on the grid and so set up similar but magnified variations in the plate circuit.

If different values of the grid potential and the corresponding values of the plate current are plotted on a graph (the filament current and plate voltage remaining constant) we shall have a curve similar to A in Fig. 1 (page 5), and this is called the characteristic curve of the valve.

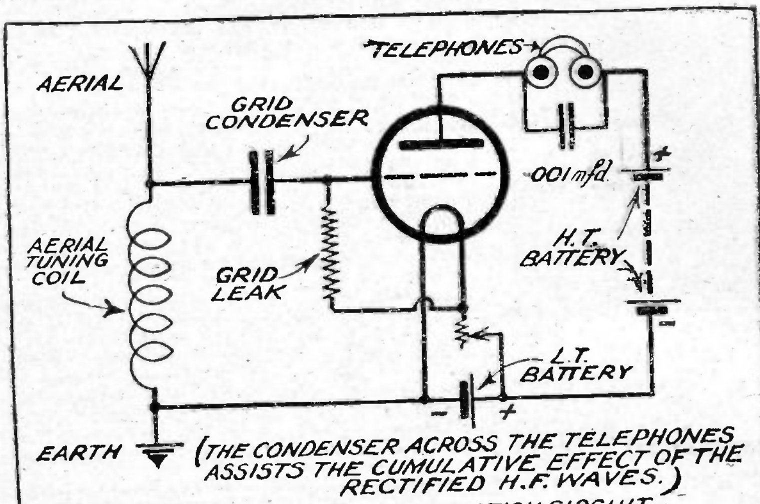


FIG. 2. GRID LEAK RECTIFICATION CIRCUIT.

It will be seen that the central part of the characteristic is straight, that is to say the change of plate current is directly proportional to the charge of grid voltage, and it is on this straight part that we must work if we desire undistorted amplification. At the top end, the curve reaches a condition of saturation, beyond which an increase in grid potential produces no increase in plate current. To raise the saturation point and increase the length of the straight part of the curve, we must raise the temperature of the filament, thus increasing the quantity of electrons emitted.

Magnification.

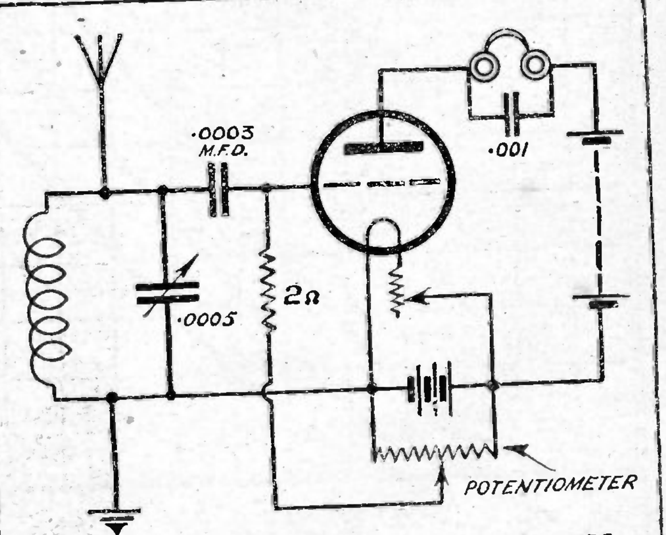
If a number of characteristic curves are taken with different values of the plate voltage, it will be found that the curves are all of the same shape and almost parallel, as shown in Fig. 1, so that increasing the plate voltage has the effect of shifting the curve bodily to the left.

Now there are two important properties of a valve which are indicative of its performance, these are the Magnification Factor and the Plate Impedance, and from them the suitability or otherwise of a valve for a particular duty can be quickly determined. The Magnification Factor of a valve is, as its name indicates, a measure of the amplification given by the valve, and may be defined as the ratio between the *change of plate voltage* required to produce a given change of plate current and the *change of grid voltage* which will produce the same change of plate current.

The impedance of a valve is its resistance to alternating current, and is measured in ohms. It is defined as the ratio of a given change of plate voltage to the change of plate current (amperes) which it produces.

Plate Impedance.

As an example, let us consider the valve in Fig 1. Increasing the plate volts by 40 (from 40 to 80) causes a change in anode current from 1.0 to 2.6 milliamperes, that is 1.6 milliamperes (at 2 volts on the grid). Now the same change in anode current would also be produced by an increase of 6 volts in the grid voltage, therefore:



GRID LEAK RECTIFICATION WITH POTENTIOMETER
FIG. 3.

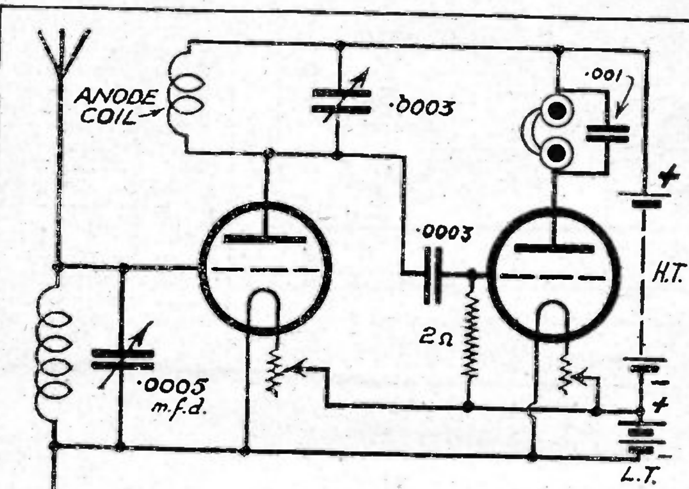
M (Magnification) $= \frac{40}{6} = 6\frac{2}{3}$

Similarly R (Impedance) $= \frac{40 \times 1000}{1 \cdot 6}$
$= 25{,}000$ ohms.

These two expressions are of the utmost importance in valve work, and a thorough grasp of their meaning is essential if progress is to be made.

Use of the Coated Filament.

Valves may differ in Magnification and Impedance, and also in filament consumption. The older valves (such as the R valves) have tungsten filaments, which have to be maintained incandescent in order to give an emission of electrons. In the more recent types a "dull-emitter" filament is used. This consists of either a tungsten wire impregnated with thoria or a platinum wire coated with certain metallic oxides which has the property of emitting electrons at a much lower temperature, thus greatly reducing the filament current. As a result of improved manufacturing processes, the latest valves which are now available require the extremely small filament current of 0.06 amperes.



TWO VALVE RECEIVER WITH TUNED ANODE & H.F. AMPLIFICATION
FIG. 4.

Design of Electrodes Important.

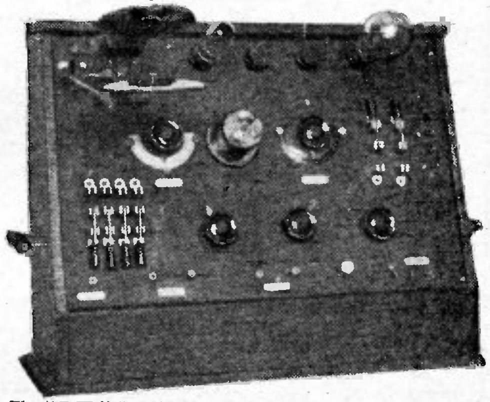
Quite apart from the filament, the characteristics of a valve are determined by the shape and relative positions of the plate and grid. By using a grid with a close mesh—i.e. with many turns of wire close together—a valve can be given a high magnification factor and a high impedance, whilst alternatively a valve with an open mesh grid will have a low impedance and a low amplification factor. Thus both values have to be considered when comparing the performances of different classes of valves, whilst different values of impedance and amplification factor are required for different purposes.

CHAPTER II.
The Valve as a Detector.

THE wireless signals which are picked up by an aerial and tuning circuit are of very high frequency—the frequency of signals on 300 metres is 1,000,000 cycles per second—and this frequency is so high that it would not produce any sound if it could be passed through a pair of telephones.

It is evident, therefore, that some means must be found of securing signals of audio frequency which will operate the telephones. This is achieved by rectifying the high-frequency oscillations, and suppressing one of the half cycles. The other half cycles in each sound-frequency cycle then add together to give sound - frequency waves which will produce sounds in the telephones.

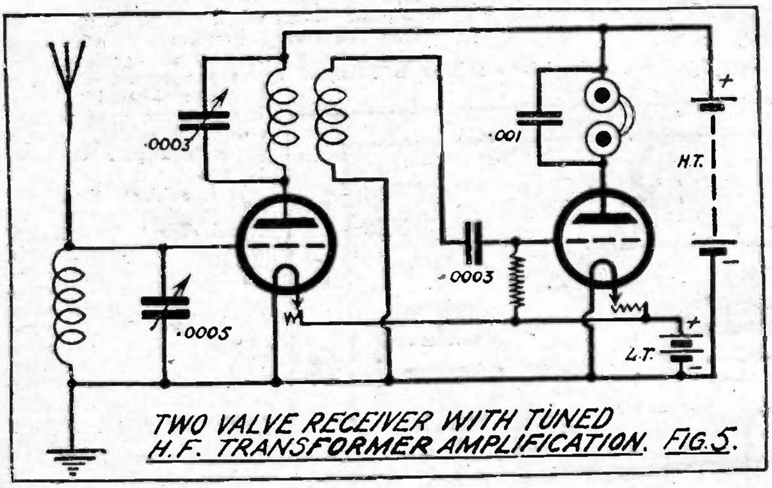
There are two ways in which the three electrode valve may be used for rectification. The first, known as "Anode Rectification" makes use of the bend at the bottom of the Plate Current — Grid Voltage Curve. If we give the valve whose characteristic curve is shown in Fig. 1 a negative grid potential of 4 volts corresponding to the lower bend of the curve (Plate voltage 40), the positive half-cycles of voltage oscillations applied to the grid will produce anode current pulses whilst the negative half-cycles will not. The latter are therefore suppressed, giving rectification.



The "P.W." Combination Set, as built by one of "P.W.'s" readers.

Sir Oliver Lodge is scientific adviser to "P.W."

This method is, of course, almost identical with the operation of the crystal detector, and in order to obtain efficient rectification, a valve with a high magnification factor is essential so that the characteristic curve is as steep as possible. The "Q," "QX," and "DEQ" valves are examples of special valves designed for anode rectification, as with proper H.T. voltage no added grid potential is required.



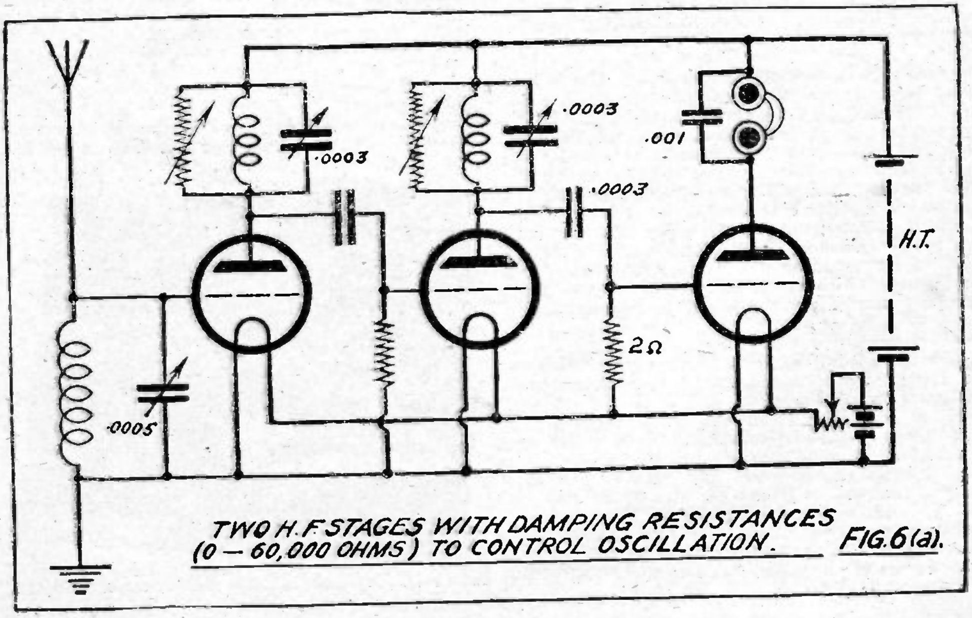
TWO VALVE RECEIVER WITH TUNED H.F. TRANSFORMER AMPLIFICATION. FIG. 5.

Grid Leak Rectification.

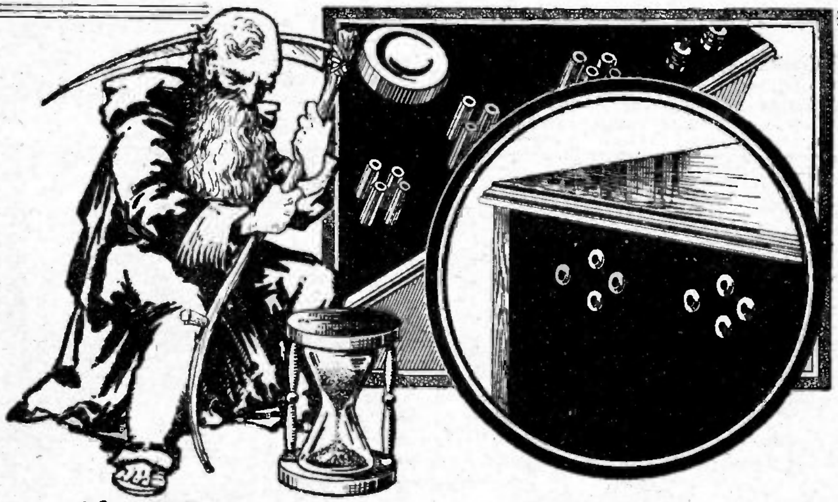
Often, however, this method is not very efficient, and the second method utilising a grid leak and condenser will usually give at least double the signal strength. The circuit is shown in Fig 2 (page 6), and it will be seen that a fixed condenser is inserted in the grid leak and a high-resistance leak (usually 2 or 1 megohm) is connected from the grid to the positive side of the filament or sometimes across the condenser.

Now when a positive half cycle reaches the grid, the latter becomes slightly positive and thus attracts to itself some of the electrons which are leaving the filament, giving the grid a slight negative potential. The corresponding negative half cycle makes the grid negative so that no more electrons are attracted, but the next positive half cycle attracts more electrons, and so makes the grid a little more negative. In this way the grid acquires an increasing negative potential (relative to the filament) which, of course, cannot leak away through the condenser and which is proportional to the amplitude of the H.F. oscillation.

The result of this negative grid potential is that the plate current is reduced. Now we come to the grid leak, the value of which is so chosen that the negative change caused by each batch of H.F. cycles, which constitutes a note-frequency cycle, leaks away before the commencement of the next

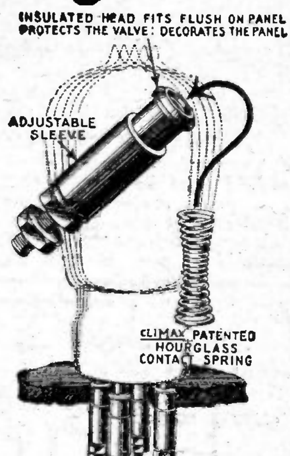


TWO H.F. STAGES WITH DAMPING RESISTANCES (0—60,000 OHMS) TO CONTROL OSCILLATION. FIG. 6 (a).



"Times change"

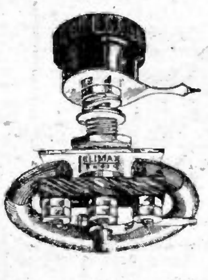
Times change—but in your own interests do not stand still and allow yourself to be left behind. The CLIMAX ANTI-MICROPHONIC VALVE SOCKET fitted with the CLIMAX HOUR-GLASS SPRING is the echo of advance which Climax makes hand-in-hand with modern scientific development. If you want to be up-to-date, to give a new lease of life to your valves, and at the same time immeasurably improve your wireless reception, FIT CLIMAX ANTI-MICROPHONIC VALVE SOCKETS TO YOUR SET.



The **CLIMAX ANTI-MICROPHONIC VALVE SOCKET** is designed to eliminate mechanical shocks from the valve while avoiding the introduction of additional electrical capacity between the valve stems.

The barrel of the socket is provided with a circular rim which enables the socket to be mounted flush on the panel, the upper surface of this rim being insulated to prevent accidental burning out of the valve. The Valve Stem is supported on the **CLIMAX PATENT HOUR-GLASS SPRING**, the waisted portion of which makes an excellent electrical contact and keeps the stem absolutely clear of all other parts of the mechanism.

PRICE: One set of four Climax Anti-microphonic Valve Sockets, fitted with patent hour-glass contact springs, complete with nuts and washers. Per box **2/-**
(hour-glass spring patent applied for).



CLIMAX RHEOSTATS & POTENTIOMETERS.

If you believe in metal—and who does not?—use exclusively Climax Rheostats and Potentiometers. They are wire wound on metal cooling cores with vitreous enamel insulation.

PRICES:

Climax Rheostats, 6-ohm pattern for one, two or three bright valves	3/-	each.
Climax Rheostats, 30-ohm pattern, Universal pattern for D.E. or Bright valves	4/-	each.
Climax Potentiometers, 300-ohm pattern ..	5/-	each.

MAKE SURE IT'S CLIMAX!

If you have difficulty in obtaining genuine CLIMAX productions and are asked to accept inferior imitations, kindly send your order direct to us, enclosing P.O. or cheque to the correct amount, when immediate attention will be given to your instructions.

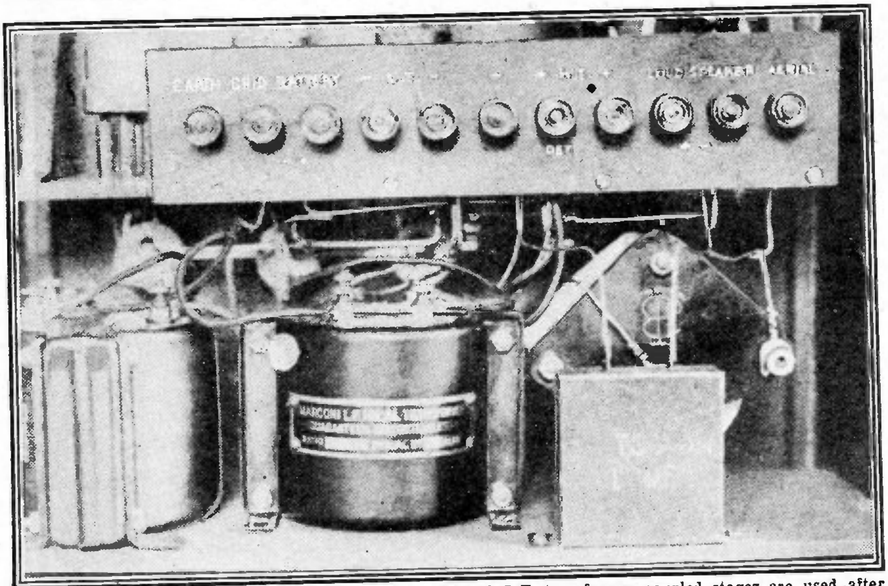
CLIMAX RADIO

CLIMAX RADIO ELECTRIC LTD., *Head Office & Works:*
Quill Works, Putney, London, S.W.15.
Telephone: Putney 2599. All communications to Head Office.
Showrooms: 257, High Holborn, London, W.C.1. Tel.: Holborn 2538.

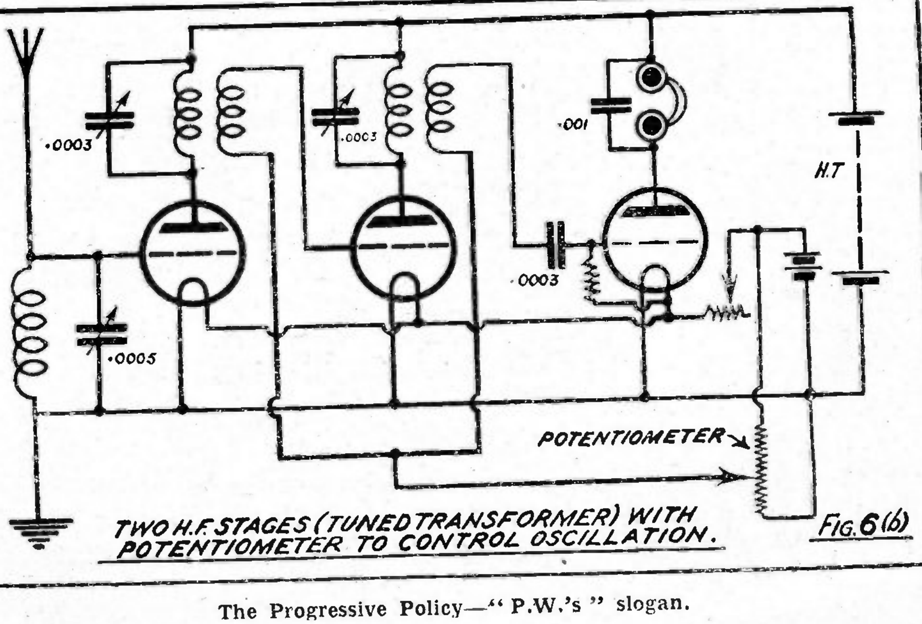
batch. In this way a decrease in plate current is produced for each low-frequency pulse—and, of course, a decrease in plate current is just as good as an increase as far as operating the telephones is concerned. It will be seen, therefore, that in its initial condition, the grid must be sufficiently positive to attract to itself some of the electrons from the filament, in other words there must be a "grid-current."

Grid Leak Connections.

Now in the case of many modern valves it is necessary to give the grid a positive potential in order to obtain grid current, and so greater signal strength is often obtained when the grid leak is connected to the positive side of the filament. In some cases, however, this causes objectionable "backlash" in the reaction control, and the best arrangement consists of a potentiometer (Fig. 3,



The interior of a three-valve loud-speaker set in which 2 L.F transformer-coupled stages are used after a valve detector.



TWO H.F. STAGES (TUNED TRANSFORMER) WITH POTENTIOMETER TO CONTROL OSCILLATION.

FIG. 6 (b)

The Progressive Policy—"P.W.'s" slogan.

page 6), by means of which the grid potential may be adjusted to the best value.

The potentiometer consists of a high resistance, usually 300 or 400 ohms wound with resistance wire, connected across the filament battery with a sliding contact, to which the grid leak is connected. The grid potential can thus be varied by moving the sliding contact.

The actual values chosen for the grid leak and condenser are usually not critical, and in this country .0003 mfd. for the condenser and 2 megohms (2 million ohms) for the leak are in common use.

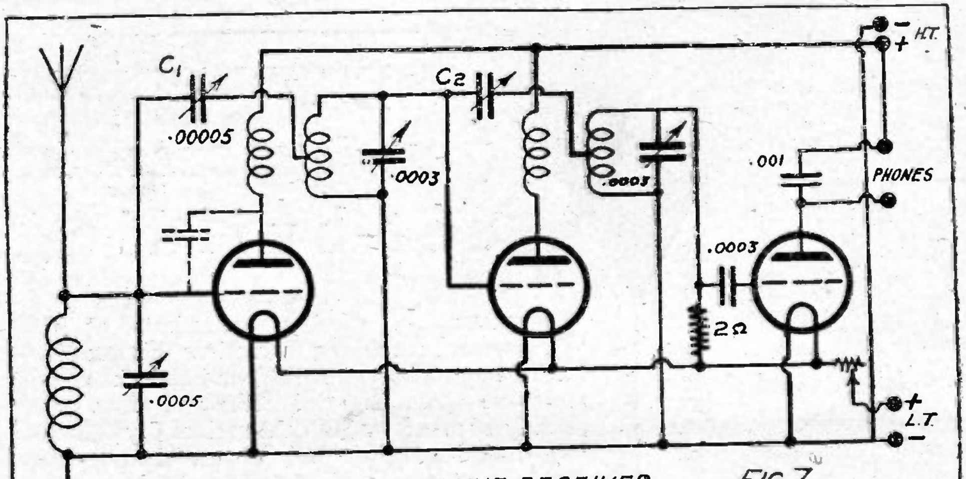
Variable Grid Condenser Advantageous.

These values are by no means necessarily the best, however, and considerably improved results can often be obtained by experimenting with different values. For this purpose a variable condenser of .0005 mfd. and a variable grid leak of say ½ to 5 megohms are very useful. It will frequently be found that by increasing the value of the grid leak greater signal strength will be obtained with weak signals, whilst better quality from a nearby station will be obtained with a lower value.

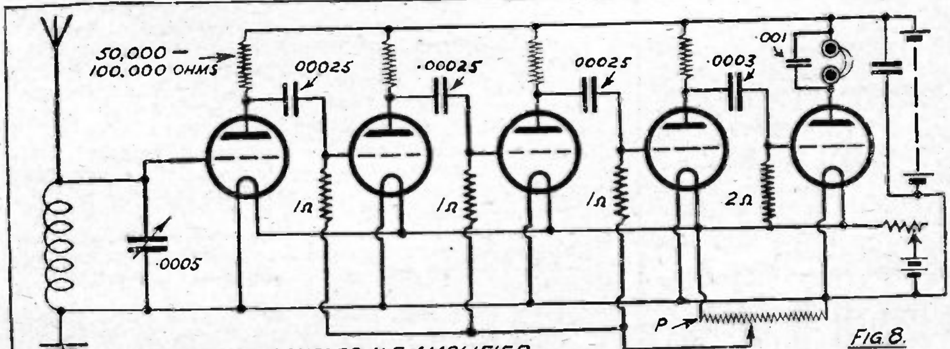
Use of "Soft" Valves.

Increased signal strength can usually be secured by employing a "soft" valve for rectification. By the term "soft" is meant a valve in which the vacuum is not perfect—i.e. there remains a very small quantity of air. Soft valves are not manufactured, however, in this country, and when soft valves of foreign origin are employed, the life of the filament is usually rather short. "Soft" valves should never be used for amplification.

The chief advantages which the valve possesses over the crystal for rectification lies in the use of reaction, which is discussed in Chapter IV., and in its reliability and freedom from irritating adjustments. The valve is, however, more inclined to produce distortion, particularly in the case of the grid leak system, and when the utmost purity of reproduction is desired the crystal is probably preferable.



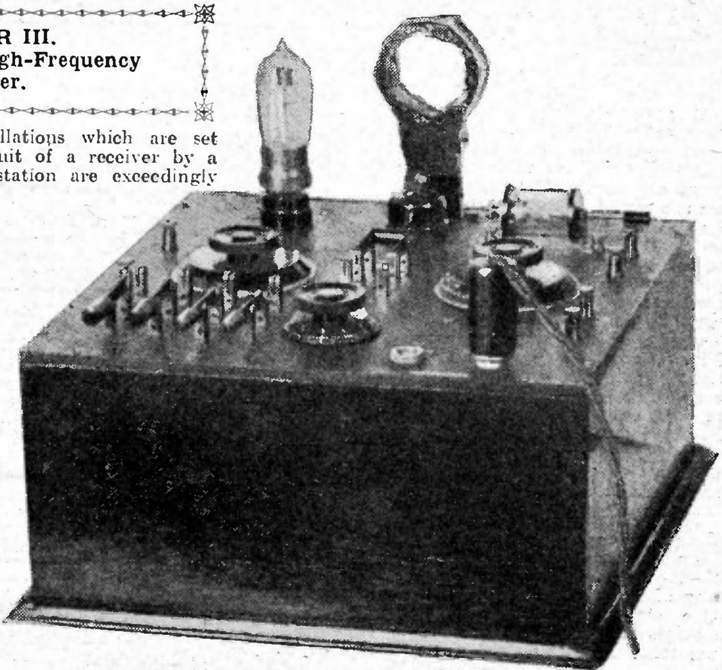
3 VALVE NEUTRODYNE RECEIVER FIG. 7.



RESISTANCE-COUPLED H.F. AMPLIFIER. FIG 8.

CHAPTER III.
The Valve as a High-Frequency Amplifier.

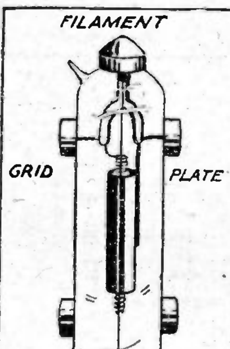
The high-frequency oscillations which are set up in the aerial circuit of a receiver by a distant transmitting station are exceedingly small, and it is therefore often desirable to magnify them before they are rectified. This *high-frequency* amplification, as it is termed, is all the more desirable in that the rectifier obeys a "square" law for weak signals, that is to say the rectified pulsations in the plate current are proportional to the square of the high-frequency voltages which are impressed on the grid. Thus if we magnify the H.F. signal four times, the rectified pulsations of plate current will have an amplitude 16 times as great as previously.



A "P.W." Combination one-valve reflex receiver constructed by a reader of "P.W." The coil at the back is the anode loading coil.

Tuned Anode Coupling.

Owing to this square law of rectification, it will be seen that if the signals become exceedingly weak, a limit will be reached at which practically no response will be obtained. It is clear, therefore, that some form of high-frequency amplification is extremely desirable for weak signals. The thermionic valve can readily be applied to the magnification of high-frequency signals, and in Fig. 4 (page 7) is shown the complete circuit diagram of a two-valve receiver, utilising one stage of H.F. amplification and gridleak rectification, which illustrates well the general principles involved.



'LOW CAPACITY VALVE' FIG.9.

The aerial tuning circuit (which may consist of a variometer or a coil and condenser) is tuned to the wave-length of the station which it is desired to receive, and the maximum voltage fluctuations are thus obtained across this coil. Now the voltage of the bottom end of the coil is fixed at earth potential so that it is the voltage of the top end of the coil which is oscillating. This voltage oscillation is applied directly to the grid of the first valve and produces corresponding fluctuations in the plate circuit, in which is connected the anode tuning coil, tuned to the same wave-length as the aerial circuit.

The voltage fluctuations across this coil (which are of the same wave-form as those in the aerial circuit but considerably magnified) are then applied to the grid of the rectifier valve via the rectifying grid condenser. The low-frequency pulses which are then produced in the plate circuit of the rectifier valve are passed through the telephones.

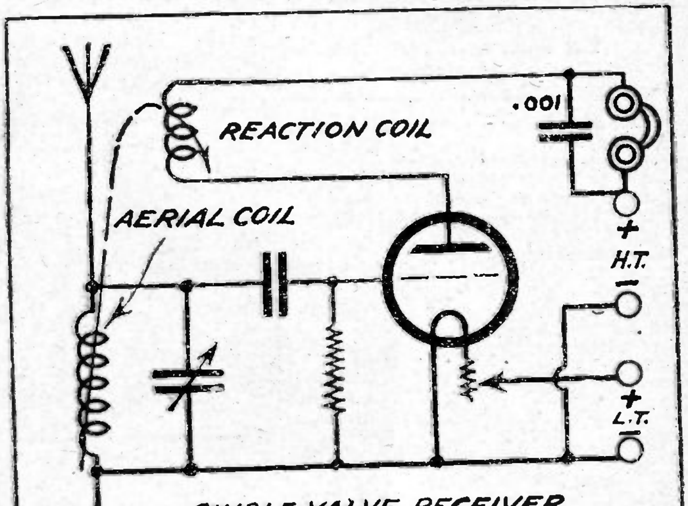
It must be thoroughly understood that (with the exception of the plate circuit of the last valve) we are always concerned with *voltage*, and that some form of impedance is connected in the plate circuit of a valve in order to secure a voltage variation which may be passed on to the next valve. Thus the greater the value of this impedance, the greater the voltage fluctuations which will be passed on to the next valve. Now the maximum impedance is obtained when the coil is turned to be exactly in resonance with the incoming oscillations, and this is the reason for the use of a tuned plate circuit.

Increased Selectivity Obtained.

The effect of adding capacity across a coil is to reduce its impedance at resonance, so that maximum signal strength is obtained when the parallel capacity is a minimum. A variable condenser of low maximum capacity, such as .00025 or .0003 mfd. should therefore be used to tune the plate circuit.

In addition to the advantage of increased sensitivity, high-frequency amplification gives greatly increased selectivity, which results in reduced interference when listening to distant stations.

The "tuned anode" system of H.F. amplification (shown in Fig. 4) is extremely popular, the anode inductance usually taking the form of an interchangeable basket or honeycomb coil tuned by a variable condenser of .0003 mfd. maximum capacity. A variometer with a small fixed condenser (say .0001 mfd.) in parallel may be used instead, but limits the wave-length range of the receiver. The other commonly used method of high-frequency coupling is by means of the tuned transformer (shown in Fig. 5, page 8), in which two tightly coupled windings are used. The transformer may be of several types—e.g. two basket coils mounted side by side, or an ebonite former with one winding placed on top of the other in a slot.



SINGLE VALVE RECEIVER WITH MAGNETIC REACTION. FIG.10.

Having now considered all the advantages which accrue from the use of H.F. amplification, we will consider the way of its practical application. One stage of amplification is usually quite straightforward; it is when we endeavour to use more than one stage that troubles begin.

Preventing Self-Oscillation.

Owing to the fact that the grid and plate circuits of the amplifying valves are tuned to the same frequency, there is a feed back of energy caused by the capacity between the grid and the plate inside the valve and in the valve holder and wiring, and this is sufficient to throw the valve into self-oscillation. The trouble can be overcome either by connecting a damping resistance in series or in parallel with the grid coil, or by putting a positive potential on the grid of the valve. Figs. 6a and 6b (pages 8 and 10) show practical arrangements of these methods which are frequently used.

A third method of overcoming the tendency to self-oscillation is by means of small condensers which are connected so as to neutralise the feed back of the grid-plate capacity. The idea can be applied in a number of different ways, and is generally referred to as the Neutrodyne system.

In Fig. 7 (page 12) is shown the circuit diagram of a Neutrodyne receiver with two stages of H.F. amplification. It will be seen that a small variable condenser, marked C, is connected from the mid-point of the secondary winding of the first transformer to the grid of the first valve. The feed back of energy by the plate-grid capacity (represented by the dotted lines) is thus neutralised by the feed back of the condenser C1, the value of which is adjusted so that the neutralisation is complete. A similar condenser C2 is used for the second stage, the maximum value being about .00005 mfd.

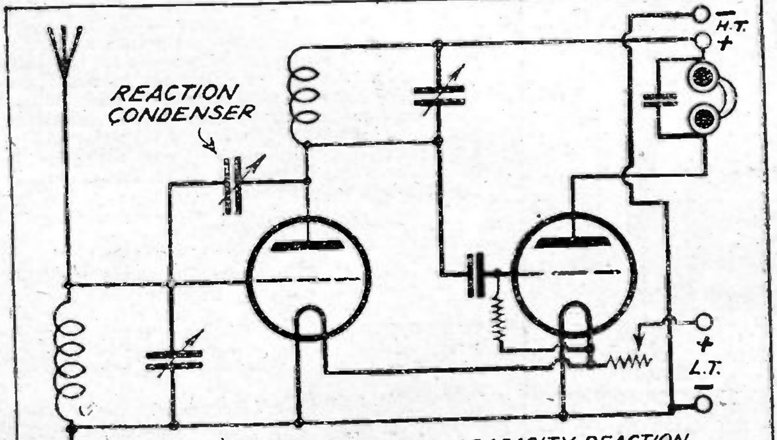


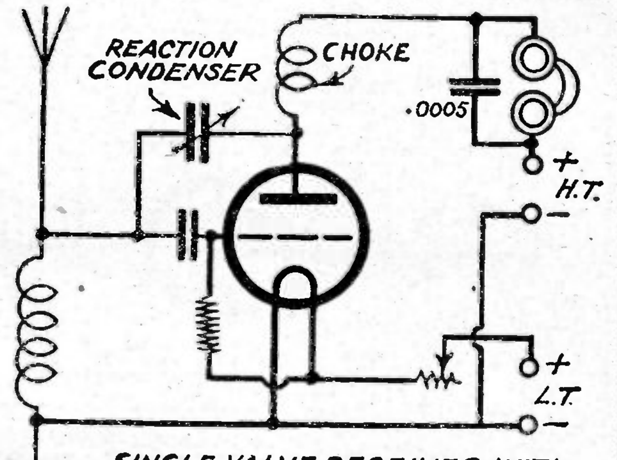
Fig.11 TWO VALVE RECEIVER WITH CAPACITY REACTION.

Aperiodic Coupling.

Apart from the self-oscillation trouble, however, the tuning of three circuits, two of which are quite critical, together with control of the oscillation tendency does not conduce to easy manipulation, and more than two stages becomes very clumsy. There are two methods of overcoming this trouble of multiplicity of tuning controls—namely, by the use of the Super-Heterodyne principle, or the use of Aperiodic or Semi-Aperiodic coupling.

The Super-Heterodyne receiver is gaining more and more popularity, and is dealt with separately in Chapter VI.

Aperiodic and Semi-Aperiodic methods of coupling high-frequency stages have been used on a large scale in the past, particularly in commercial receivers. The principle involves the use of a high resistance, instead of a tuned coil in the plate circuit of the valve. The circuit diagram of a resistance-coupled H.F. amplifier is shown in Fig. 8 (page 12), the fluctuations of voltage across each resistance being communicated to the grid of the next valve by a coupling condenser. A grid leak is connected from the grid of each valve to the slider of a potentiometer to maintain the correct mean potential of the grid.



SINGLE VALVE RECEIVER WITH CAPACITY REACTION.

FIG.12.

Low Capacity Valves.

The amplification obtained with resistance coupling is less than half that given by a tuned coupling, and the efficiency falls off rapidly as the wave-length is reduced, owing to the increased shunting effect of the capacity of the valves and leads which reduces the impedance of the anode resistances. This falling off in efficiency is so bad that resistance coupling is of practically no use below 1,000 metres. A higher efficiency may be obtained by substituting for the resistances transformers wound with resistance wire so that the resonance curve has a very flat top. Such transformers will only cover a relatively small wave-length range, however.

Multi-valve receivers with aperiodic or semi-aperiodic couplings are usually fitted with low capacity valves such as the V.24 and QX and their dull-emitter counterparts, the D.E.V. and D.E.Q. These valves have their connections brought out to contacts situated as shown in Fig. 9 (page 13), so that there is an absolute minimum of capacity in the valve and valve-holder. A special type of valve-holder with spring contact strips is necessary for this type of valve.

These low capacity valves are especially useful on short waves, 100 metres and under, on which stray capacities are extremely undesirable.

Valves used for high-frequency amplification need have very little power-handling capability, but should have a high magnification and a fairly high impedance.

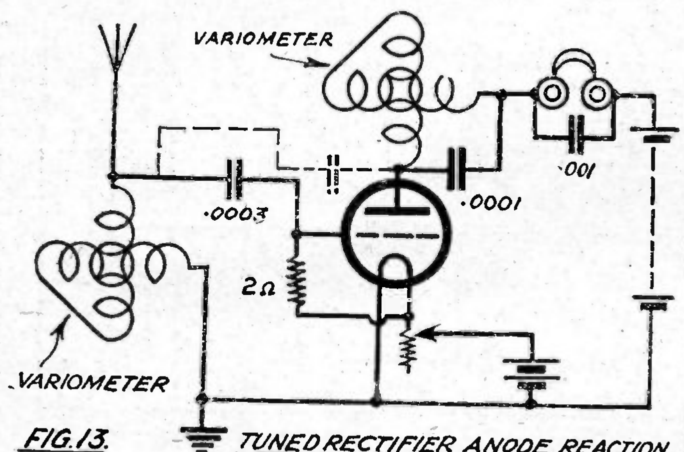
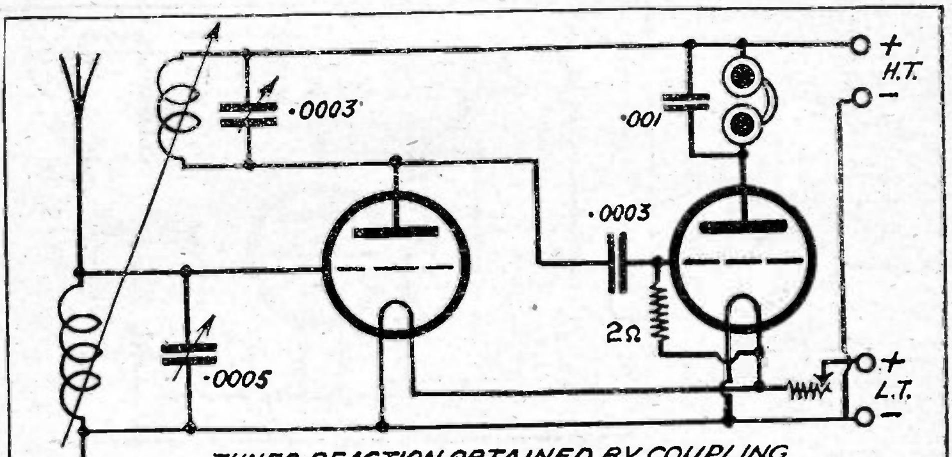


FIG.13. TUNED RECTIFIER ANODE REACTION.

CHAPTER IV.

Reaction.

In point of efficiency, the valve is inferior to the crystal as a detector when the "anode" system of rectification is used, and it is very little superior when a grid leak and condenser are employed. As regards distortion also, the valve is usually inferior to the crystal. We are therefore impelled to ask: Why is the valve employed at all



TUNED REACTION OBTAINED BY COUPLING TUNED ANODE COIL TO AERIAL COIL. FIG. 14.

for rectification? The answer may be summed up in two words—Reliability and Reaction. The valve detector eliminates the delicate adjustment and uncertainty of the crystal rectifier, and in addition eliminates the damping effect which a crystal exerts on the circuit across which it is connected, and which results in flat tuning.

Advantages of Reaction.

The possibilities of reaction constitute, however, the chief advantage of the valve rectifier. Reaction consists of a controlled feed-back of energy from the plate circuit of a valve to the grid circuit of the same valve or of a previous valve. This regenerative action has the effect of making up for the damping effect of resistance in a circuit, and may be carried theoretically up to the point when the resistance is completely

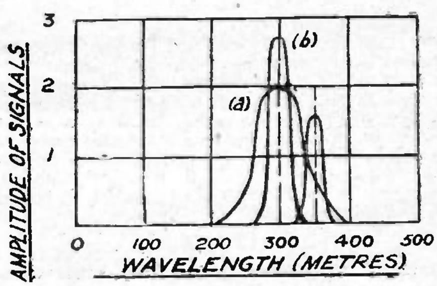
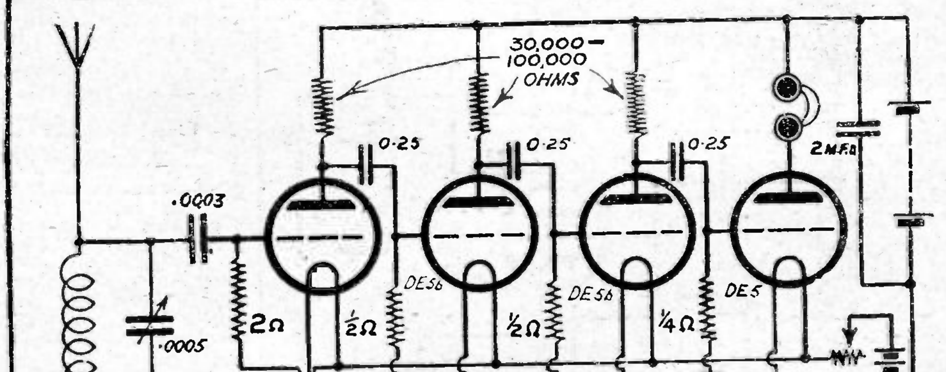


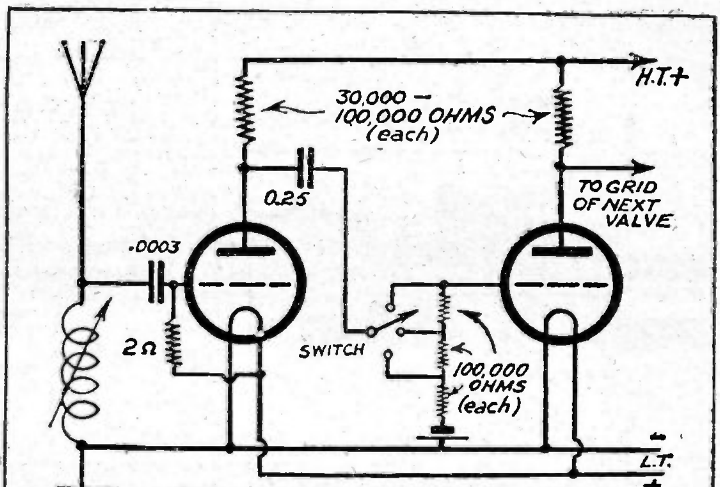
FIG. 15.



FOUR VALVE RESISTANCE COUPLED L.F. AMPLIFIER. FIG. 16.

neutralised. If reaction is carried beyond this point, the valve will burst into oscillation.

Actually it is undesirable, and, indeed rather difficult to work a valve right on the very edge of oscillation (although very great amplification can be obtained if this is done) owing to the distortion which results, and to the interference caused to other listeners. Reaction up to a reasonable limit is, however, an extremely convenient and inexpensive means of obtaining a certain amount of high-frequency amplification, and is an almost universal feature in modern receivers.



POTENTIOMETER CONTROL OF VOLUME IN RESISTANCE-COUPLED L.F. AMPLIFIER. FIG. 17.

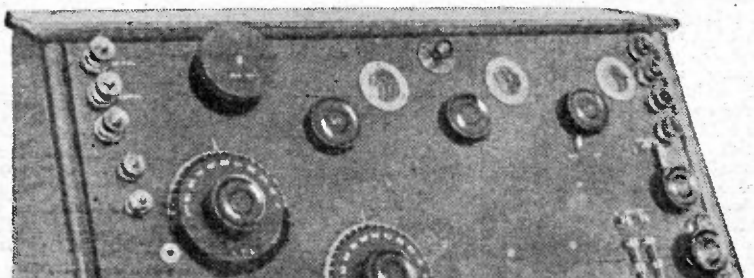
The most usual method of obtaining reaction is by coupling a coil which is connected in the plate circuit of a valve to another coil in the grid circuit. This is known as "Magnetic" coupling, and in Fig. 10 (page 14), is shown a single valve receiver with magnetic reaction on to the aerial—probably one of the most popular receivers. For the lower broadcasting range of wave-lengths (300—500 metres), the aerial coil may be a No. 35 or 50 honeycomb coil or a corresponding basket or other coil, and a No. 50 or 75 coil is usually suitable for reaction. The two coils are mounted in a coil holder, so that the distance between them, and hence the reaction coupling, may be varied. Both coils must be changed when reception on other wave-lengths is desired.

In Chapter III., when dealing with H.F. amplification, we saw how the capacity between the grid and plate of a valve resulted in a feed back of energy which might be sufficient to set up oscillation.

Capacity Reaction.

Now we can employ a similar capacity feed back in a controllable form to obtain reaction.

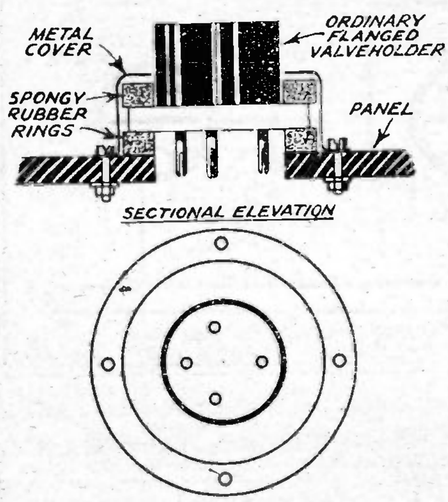
This is shown in Fig. 11 (page 14), which is the



A three-valve receiver employing transformer coupling between the H.F. and detector valves, and vernier condenser control.

circuit of a two-valve receiver with tuned anode high-frequency coupling, the reaction being from the plate of the high-frequency valve.

This system has the disadvantage, from the point of view of easy handling, that the reaction is not "aperiodic"—when the anode coil is tuned to the same frequency as the aerial coil the reaction is very much stronger. In order to obtain aperiodic reaction, the feed back must be from the plate of the detector, and a choke coil must be connected in the plate circuit of the rectifier as shown in Fig. 12 (page 15). The choke coil should have a high inductance and low self-inductance, a honeycomb or basket coil for example being suitable, and best results are usually obtained when the natural wave-length of the choke is above that on which it is desired to receive. A honeycomb coil, No. 250 for example, would be suitable on wave-lengths up to 500 metres. The value of the feed-back condenser must be low, a variable condenser of .0002 mfd. maximum being ample on broadcast wave-lengths.



ANTI-MICROPHONIC VALVEHOLDER.
FIG. 18

"Tuned Plate" Method.

Instead of using a fixed inductance and a variable condenser, it is possible to use a fixed condenser and to vary the inductance in the plate circuit of the detector. This brings us to an arrangement much favoured by American amateurs, the so-called "tuned plate," shown in Fig. 13 (page 15). In the plate circuit of the rectifier valve is a variable inductance, usually a variometer, whilst a small fixed condenser is connected to the grid. As the inductance of the variometer is increased, the reaction is increased, and the size of the feed-back condenser should be adjusted so that the receiver oscillates *before* the anode circuit comes into tune with the aerial. The value of the condenser will always be low—.00005 mfd. is a typical value, and in many cases te valve capacity alone is sufficient to cause oscillation.

Cause of Interference.

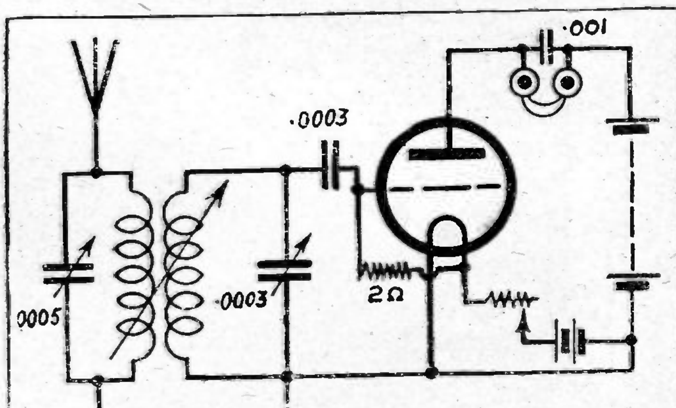
A number of circuits are in use, particularly in America, which involve a direct connection between the grid and plate of the valve, together with some control of the amount of high-frequency oscillation which is fed back through this connection. These circuits are rather "tricky" as a general rule, and are dealt with more fully in Chapter VI.

When a stage of high-frequency amplification is in use, it is possible to couple the reaction coil or condenser to either the aerial coil or the anode coil, and it is sometimes difficult to know which is the better.

Now the function of reaction is to counteract resistance, so that it would appear logical to couple the reaction coil to the aerial circuit, which is usually more highly damped than the anode circuit. There is, however, another side to the question, and that is the interference which is caused to other listeners. When the aerial circuit of a receiver oscillates, it radiates a carrier wave which will interfere with other listeners, particularly if it sets up a heterodyne whistle with the carrier of a broadcasting station. Now, when the reaction coil is coupled to the anode circuit, the interference is very much less, particularly if the resistance of the aerial is fairly high.

Reaction on the Anode.

When a reflex circuit is in question, it is usually preferable to use reaction on to the anode circuit owing to the fact that the mean potential of the



LOOSE COUPLING. FIG. 19.

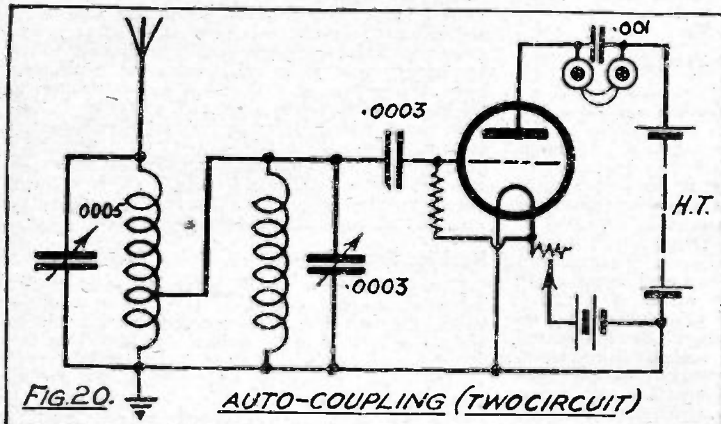


FIG. 20. AUTO-COUPLING (TWO CIRCUIT)

It will be seen that if another station is working on 360 metres, its signals will be heard at about one third the strength of the signals it is desired to hear, and this will cause serious interference. Curve (b) shows the effect of increasing the selectivity—it will be seen that the interfering signal is now so small as to be practically inaudible.

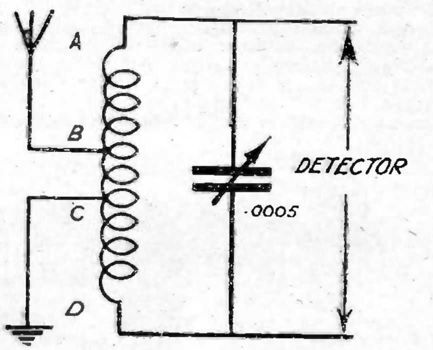
The shape of the resonance curve of a circuit depends principally on its resistance, the selectivity increasing as the resistance is reduced. Now the effect of reacting on to a circuit is to neutralise its resistance, and thus increase its selectivity. An excessive use of reaction, however, causes distortion for the following reason. The frequency of the various

grid of the first or dual valve is varied by the low-frequency pulsations.

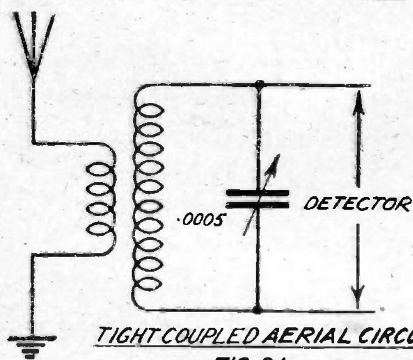
When a receiver comprising a stage of tuned high-frequency amplification is employed, it is possible to obtain reaction by coupling the tuned anode coil to the aerial coil, as shown in Fig. 14 (page 16). This system has the same disadvantage as that shown in Fig. 11, that is, with a given coupling of the coils the reaction will be very much fiercer when the two coils are tuned to the same wave-length. This makes for inconvenience in tuning, and it is very desirable when listening for distant stations to throw a set into oscillation and then "search" for the heterodyne whistle caused by the carrier wave. This "aperiodic" reaction can only be obtained by using reaction from the anode of the rectifier valve.

Resonance Curves.

One of the chief advantages of reaction lies in the increased selectivity which it confers on a receiver. A very simple method of expressing selectivity is by means of resonance curves, which are obtained by plotting the amplitude of signals of different frequencies when a circuit is tuned to a given frequency. The curve (a) in Fig. 15 (page 16), for example, is the resonance curve of an unselective circuit tuned to 300 metres.



P.W. ULTRA COIL FIG. 22.
(SAME NUMBER OF TURNS IN 'AB' AS 'CD'.)



TIGHT COUPLED AERIAL CIRCUIT
FIG. 21.

sound frequency oscillations which are impressed on the carrier wave of a broadcasting station extend up to approximately 6,000 cycles per second, so that the "spread" of the carrier wave produced by the modulation is 6,000 cycles per second above and below the frequency of the carrier. The modulated carrier wave can therefore be represented by a square top curve. Now it is clear that if the resonance curve of a tuned circuit is too narrow, the outer edges or side bands of the carrier will not be reproduced, so that the high tones of the music will be lost.

Eliminating Distortion.

Selectivity can be increased without producing distortion, by the use of several circuits of medium selectivity one after another, as this tends to produce a square top resonance curve. The superiority of tuned H.F. amplification for increasing selectivity is thus clear, as each stage H.F. brings in another tuned circuit.

CHAPTER V.

The Valve as a Low-Frequency Amplifier.

In no branch of wireless has progress been more rapid in the last two years than in the loud-speaking reproduction of music and speech. Those who recall the raucous-voiced utterances of the early loud-speakers which were in vogue when broadcasting started in this country, can realise to the full the immense progress which has been made. On the other hand, we still occasionally come across a loud-speaker which is emitting sounds reminiscent of the gramophone in its earliest and most unmusical days. Such distorted reproduction can usually be robbed of its worst terrors by very simple adjustment of the low-frequency amplifier, for really bad distortion usually has its origin in the amplifier rather than in the loud speaker.

Almost any type of modern loud speaker, in fact, is capable of giving good reproduction if it is supplied with undistorted low-frequency currents, and by the observance of a few simple rules it is possible for every amateur to enjoy really excellent quality reproduction.

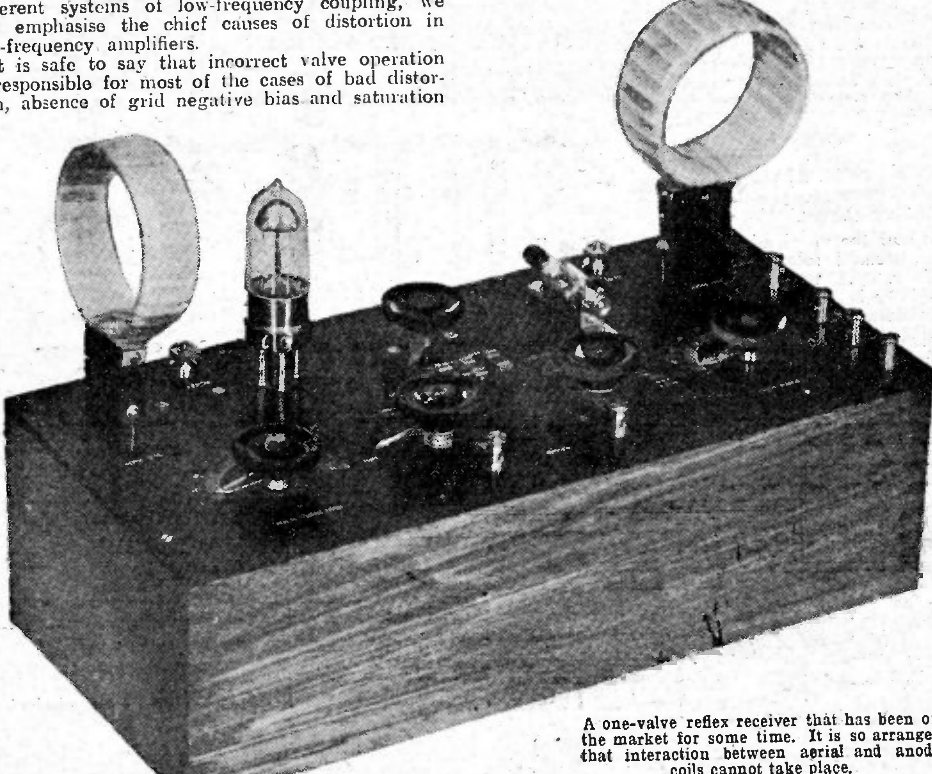
Before considering the actual details of the different systems of low-frequency coupling, we will emphasise the chief causes of distortion in low-frequency amplifiers.

It is safe to say that incorrect valve operation is responsible for most of the cases of bad distortion, absence of grid negative bias and saturation being the principal faults. The flow of grid current which takes place when the grid of a valve becomes positive is productive of very bad distortion in low-frequency work, so that each low-frequency amplifying valve must be given the correct negative grid potential corresponding to the mid-point of the straight part of the characteristic curve which is on the negative side of the zero grid line. (See Fig. 1). The negative grid voltage is most conveniently applied by means of a small dry battery (say 9 volts), which is fitted with a tapping at every cell, so that 1½, 3, 4½ volts, etc., can be used at will.

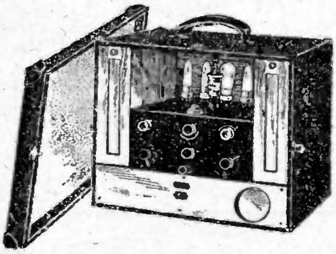
Need for Power Valves.

Even when the grid potential is correctly adjusted, serious distortion may be caused by overloading a valve. This occurs when the voltage pulsations applied to the grid are so large that the plate current swings right off the straight part of the curve, producing both rectification at the lower end and grid current at the upper end.

The maximum H.T. voltage (in conjunction with the correct grid negative) should therefore be used with low-frequency valves, as this ensures the maximum power-handling capacity for a given valve. (See Fig. 1). Now, overloading is much more common in the case of the last valve, so that if it is desired to use more than one stage of L.F. amplification a special power valve should



A one-valve reflex receiver that has been on the market for some time. It is so arranged that interaction between aerial and anode coils cannot take place.



Making a

VALVE SET?

Before building your valve set do not fail to call and inspect the latest of the world's radio productions—the marvellous "Remler" Condenser, and the latest Vernier Dials which give positively accurate tuning. These, together with your panels cut from our special High Grade Ebonite, can alone make for perfection in your set.

A visit to our showrooms or a copy of our latest catalogue will convince the most sceptical that here we have set a higher standard on the apparatus we handle than any other House in the trade.

Write to-day, mentioning this paper, for free copy of our latest catalogue.

SPECIAL LINES.

- Dayzite Crystals.
- Square Law Positive Low Loss Condensers.
- Rheostats from 6 to 45 ohms.
- Our new Supersonic Wave Coupler with a range of from 80 to 3,000 metres.
- Special Aermonic Valve Holders.
- Cockaday Coils.
- New High Tension Battery units and all other of the latest and best components on the market.

WILL DAY, Limited,

19, Lisle St., Leicester Sq., London, W.C.2.

Phone: Regent 4577. *Telegrams: "Titles, Westrand, London."*

EFESCA

Regenerative

AERIAL TUNER

The Efesca Regenerative Aerial Tuner is a specially designed form of Tapped Aerial Coil incorporating Aerial Reaction as an integral part of the unit. Reaction is effected by means of a rotor revolving in a separately wound section of the Aerial coil, thereby effecting maximum and uniform reaction over the whole wave band covered by the coil. Wave-length range 150 to 2,600 metres.

Price Complete 32/-

Other Components in the Efesca Series of One-Hole-Fixing Tapped Coils are the H.F. Transformer, Anode Tuner, Aerial Tuner, and H.F. Reactance Coil. ***Ask your Wireless Dealer or write for the complete catalogue No. 559 to***

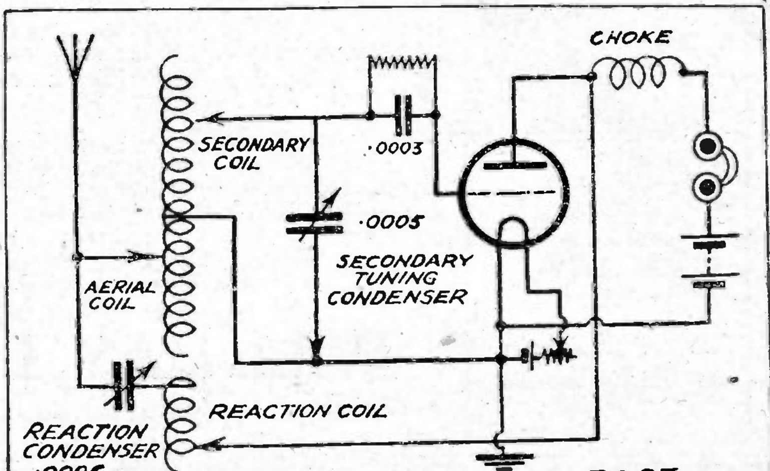
WHOLESALE ONLY:

FALK, STADELMANN & CO. LTD., ***Efesca Electrical Works,***
83-93, FARRINGDON ROAD, LONDON, E.C.1. And at Glasgow, Manchester & Birmingham.

be used which will handle a considerable power without overloading. The D.E.6, D.E.5, B.4, Mullard D.F., etc., are examples of special power valves suitable for the last stage.

There are three systems which are available for low-frequency amplification—namely, Resistance, Choke, and Transformer coupling. Of these the first gives the best quality of reproduction and the least amplification, whilst transformer coupling, which is easily the most popular, gives the greatest amplification combined with more loss of quality.

Resistance coupling has the additional disadvantage of requiring a high value of H.T. voltage, owing to the drop of voltage across the anode resistances. The circuit diagram of a three-stage resistance-coupled amplifier is shown in Fig. 16 (page 16), and it will be seen that the variations of voltage drop across the anode resistance are communicated to the grid of the next valve by means of a coupling condenser, whilst a grid leak is used to maintain the correct mean grid potential. The value of the grid condenser is not critical, but there is a minimum value below which the lower notes will suffer reduced amplification; 0.25 microfarad is a usual satisfactory value, the Mansbridge type of condenser being quite suitable. The value of the grid leak is similarly not critical, ½ megohm being satisfactory, with ¼ megohm or 100,000 ohms in the last stage when considerable volume is required.



REINARTZ RECEIVER FIG. 23.

Calculating Value of Resistance.

Now as there is no step-up of voltage with resistance-coupling, a valve with a high magnification factor, such as the D.E.5.b, should be employed. The actual value of the voltage amplification which is obtained being given by the expression

$$M = \mu \times \frac{R}{R + R_V}$$

(Where R_V is the internal impedance of the valve, R is the value of the anode resistance, and μ is the amplification factor of the valve).

It will be seen that theoretically the greater the value of R, the larger the amplification. In operation a limit is, however, imposed on the value of R by the voltage drop across it, and, in practice, R is generally taken at 1½ to 2 R_V. With a 50,000 ohms resistance in the plate circuit of a D.E.5.b (μ = 20, R_V = 30,000 ohms), for example, the magnification is

$$M = \frac{20 \times 50{,}000}{80{,}000} = 12.5.$$

Notwithstanding the low amplification, resistance coupling is favoured in cases where the utmost purity of reproduction is desired.

By substituting an iron core choke of high inductance for the anode resistance, an increased magnification per valve is obtained and the disadvantage of high H.T. voltage avoided, at the expense of a slight loss of amplification on the extreme upper and lower notes. The primary and secondary windings of a transformer connected in series (in the correct sense) are often used as a choke, the desirable features being high inductance and low self-capacity. The values of coupling condenser and grid leak are the same as in the case of resistance coupling. The third system of low-frequency coupling, by means of a transformer, is easily the most popular of the three, owing to the much greater amplification per valve which it gives. The primary winding of the transformer is connected in the plate circuit of the valve, and corresponds to the choke in choke coupling. Instead of a coupling condenser and grid leak, however, the voltage fluctuations are impressed on the grid of the next valve by means of a secondary winding of many more turns, which is wound on the same core as the primary winding.

By making the ratio of the number of turns on primary and secondary 3 or 4, a voltage amplification of 25 to 30 can easily be obtained. Now this increase of amplification is obtained at a sacrifice of some quality of reproduction, particularly when a cheap transformer or one of too high a ratio is used. Owing to the necessity of the large secondary winding, the primary has a much lower inductance than is usual in the case of a choke, so that the amplification begins to fall off at a higher frequency, often at 1,000 or even 1,500 cycles. The capacity of a transformer is also usually quite considerable, resulting in reduced amplification of the higher frequencies.

Reducing Resonance Distortion.

It will be seen therefore that notes of different pitch receive different amplification, and this results in distortion. In really good transformers, however, the primary inductance is kept high and the capacity low, and the quality of reproduction

is then barely distinguishable from that given by resistance coupling.

The tendency to resonance which is present in the majority of transformers may be reduced at the expense of amplification by connecting a damping resistance, say ½ megohm, of the grid leak type, across the secondary winding. By using a switch which will connect different values of this resistance, a very convenient volume control is obtained, suitable values being 500,000, 200,000 and 50,000 ohms, the volume being reduced, of course, as the resistance is decreased. It is very often desirable to alter the pitch of music or speech, and this can be effected by means of a switch which connects different condenser values across the primary of a transformer, preferably the second transformer where two are in use. The best values of these condensers depend on the type of transformer, but .0005, .001 and .003 are often useful. The quality can also sometimes be improved by means of a condenser (.001—.005 mfd.) connected across the loud-speaker terminals.

Choice of L.F. Valves.

A very convenient method of volume control in the case of a resistance-coupled amplifier is obtained by employing the grid leak of the first valve as a potentiometer. Three 100,000 ohm grid leaks may be used in series, as shown in Fig. 17 (page 17), one third of the maximum volume being obtained when the switch is on stud 1, and two-thirds on stud 2.

The use of more than two stages of transformer coupling is not to be recommended, although five stages of resistance coupling are quite manageable. Almost any type of valve can be used for the first stage, but a power valve should be used for the last stage. The "P.W." Valve Guide should be rigidly adhered to when choosing L.F. valves.

A very annoying feature of many amplifiers is a tendency to go off into a loud low-frequency howl. This is usually due to excessive "microphonic" noise in the detector valve, and can be cured by mounting this valve on a rubber pad or in a special sprung valve-holder, such as that illustrated in Fig. 18 (page 18), in order to insulate it from vibration. A large condenser, say 2 mfd. capacity of the Mansbridge type, should always be connected across the high-tension battery, and the transformers and their leads should be kept well apart to prevent interaction.

A low value of anode impedance is of advantage in L.F. work, a higher ratio of transformer being permissible after a low impedance valve.

A 3 or 4 to 1 transformer, for example, is the highest ratio which should be used after a general purpose valve (40,000 ohms), whilst a 6 to 1, or even an 8 to 1 may be used after a low impedance valve such as the D.E.5 (8,000 ohms).

CHAPTER VI.

Special Circuit Arrangements.

In the short space available in this book, it is only possible to give a very brief outline of some of the more interesting of the many special circuits which have been developed. For fuller details of these individual circuits, the reader is referred to the pages of "Popular Wireless," in which they are fully dealt with from time to time.

Before commencing with these special receivers, however, mention must be made of loose coupling, by means of which the selectivity of a receiver can be considerably increased. In Fig. 19 (page 18) is shown the circuit of the most popular type of loose-coupled receiver, in which, instead of the grid of the valve being connected direct to the aerial, a tuned secondary circuit is coupled to the aerial tuning coil. The looser the coupling between the aerial and secondary coil the greater the selectivity obtained. Instead of magnetic coupling, an auto-coupling (Fig. 20, page 19) can also be employed.

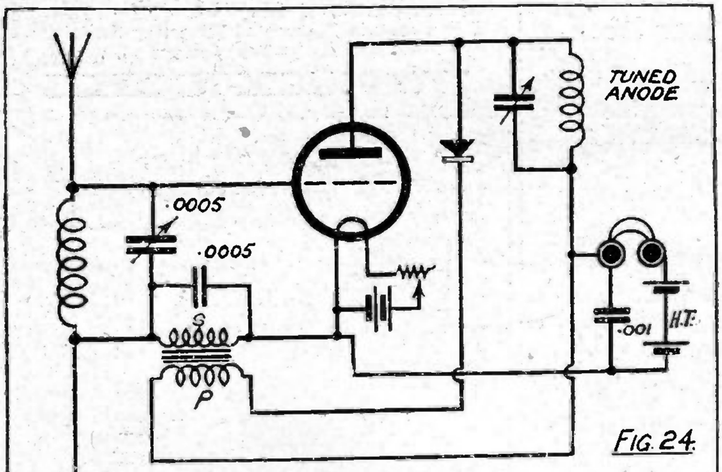


FIG. 24.

SINGLE VALVE REFLEX RECEIVER.

A type of coupling which does not involve an additional tuning control is shown in Fig. 21 (page 19). The aerial coil consists of a few turns tightly coupled to a tuned secondary circuit. By using an auto-coupling, we come to the well-known "P.W." Ultra coil (Fig. 22, page 19).

Reflex Receivers.

A coupled receiver which gives very good results on the lower wave-lengths is the Reinartz, of which the circuit is shown in Fig. 23 (page 22). It will be seen that a combination of magnetic and capacity reaction is used, the fine control of reaction being obtained by means of the condenser which is in series with the reaction coil.

One of the most popular methods of obtaining increased amplification is by using a valve for simultaneously amplifying at both high and low frequency, so that one valve does the work of two.

In Fig. 24 (page 24) is shown the circuit diagram of a simple form of single-valve reflex receiver, a crystal being used for rectification. The signal oscillations across the tuned aerial coil are impressed on the grid of the valve, a tuned anode coil being connected in the plate circuit. Across the anode coil is a crystal which rectifies the amplified high-frequency oscillations, and the resulting L.F. pulsations are thrown back on to the grid by a low-frequency transformer of which the primary is connected in series with the crystal. The L.F. pulsations pass through the aerial coil on to the grid, and a condenser must be connected across the secondary of the transformer to by-pass the H.F. oscillations.

The "Super Heterodyne."

By substituting a valve for the crystal rectifier, greater stability will be obtained, and reaction can be more conveniently applied. A very large up to three or four stages of sharply tuned high-frequency amplification. The circuit diagram of a super-heterodyne receiver with three stages of amplification is shown in Fig. 25, a frame aerial being used.

The "Ultra Audion."

This arrangement has the disadvantage of requiring a large number of valves, but by combining the functions of different valves, the number can be reduced, whilst good results can often be obtained with a Carborundum crystal as the last rectifier. It is also advantageous to use a stage of high-frequency amplification before the first detector, and this valve can also be used as an intermediate frequency amplifier.

An interesting one-valve circuit originated by Dr. de Forest is shown in Fig. 26 (page 26). The voltage fluctuations impressed on the grid are those across the series condenser, and in order that these shall be as great as possible, this condenser must be kept small. The reaction adjustment is very critical. The variations of this and other

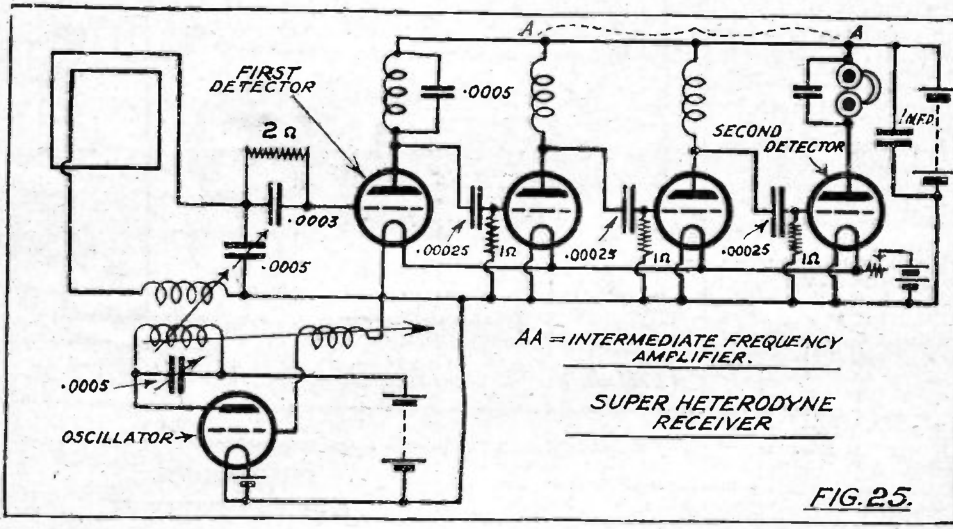


FIG. 25.

number of variations have been developed on this principle, and the subject is one of considerable interest.

In Chapter III. we referred to the super-heterodyne system of high-frequency amplification, which is capable of giving superlative sensitivity and selectivity. In this type of receiver, which is intended especially for wave-lengths below 500 metres, the wave-length of the signals is changed to a higher value, on which amplification can be efficiently and conveniently carried out in several stages. The wave-length change is carried out by means of a local oscillator which heterodynes with the signals and gives rise to a beat oscillation of the frequency to which the amplifier is tuned.

The wave-length of the amplifier is fixed at a value between 5,000 and 10,000 metres, and the frequency of the beat oscillation is adjusted to this value by altering the frequency of the local oscillator. The number of tuning controls is thus reduced to two—the aerial circuit and the heterodyne, and by means of these two we can control unusual circuits are very considerable in number, and some are productive of extremely good results.

For more detailed descriptions, the reader is referred to "Popular Wireless," in which a large number of these special single valve circuits have been dealt with.

Super-regeneration.

Major Armstrong, an authority on the super-heterodyne receiver, has been responsible for a striking departure from the conventional practice—the super-regenerative receiver. This arrangement gives more amplification from one valve than is obtainable by any other means, although unfortunately it has disadvantages which offset its wonderful amplification.

When reaction is applied to a circuit, we know that the signal strength is increased up to a point when the circuit bursts into oscillation, after which no further amplification is obtained. If, however, we can arrange to quench this oscillation regularly many times a second, and allow the H.F.

signal oscillations to build up between the quenching, much greater amplification can be obtained. This is what is done in the super-regenerative receiver, the H.F. oscillations being quenched by another oscillation at a frequency of, say, 10,000 cycles per second. A high-pitched whistle due to the quenching oscillation is therefore often heard in the telephones.

The circuit diagram of a super-regenerative receiver is shown in Fig. 27 (page 27). In series with the frame aerial is a coil to which is coupled the reaction coil.

The Quenching Coils.

The other side of the frame is connected to the negative side of the filament via a large coil, which, together with a coil in the anode circuit, forms the quenching circuit. Rectification is by means of grid leak and condenser. The coupling between the quenching coils and also that of the reaction coil must be critically variable. Condensers of .006 mfd. capacity are connected across each quenching coil, a .003 mfd. condenser across the telephones, and a 1 mfd. condenser across the H.T. battery.

If maximum amplification is desired, a 1,250 plug-in coil should be used for the grid quenching coil, with a 1,500 coil in the plate circuit. A healthy whistle will then be audible, but at a sacrifice of some amplification the pitch of this whistle may be raised above audibility by using smaller or quenching coils, or loosening the coupling between them.

A very popular modification of Armstrong's receiver is the Flewelling receiver (Fig. 28, page 28), in which the quenching oscillations are generated by a bank of condensers and a variable leak. Many other variations have been evolved, and the whole field of super-regenerative reception is one of very great interest.

The Unidyne Receiver.

No matter dealing with valves would be complete without the inclusion of the well-known "Unidyne" receiver, which was introduced last year by the technical staff of "Popular Wireless." The Unidyne receiver employs the four-electrode valve—a valve with two concentric grids—and by ingenious utilisation of the properties of this type of valve dispenses with the necessity for the high-tension battery. The consequent saving in expenses and trouble, as well as the freedom from battery noise and the risk of burning out valves will be appreciated by the amateur in direct ratio to his wireless experience.

The principle of the Unidyne can be most easily explained by reference to the circuit diagram of a single-valve Unidyne receiver in Fig. 29 (page 28). It will be seen that the plate of the valve is connected via the telephones to the positive terminal of the 6-volt accumulator. The outer grid, which is the control grid, is connected in the usual way to the aerial circuit and receives the incoming signal oscillations. The inner grid is connected direct to the positive accumulator terminal, so that it has a positive potential of 6 volts relative to the negative side of the filament.

Now a positive potential of six volts on the grid is equivalent to a very much greater positive voltage on the plate, so that the second grid enables the plate voltage to be reduced to the 6 volts provided by the accumulator.

The Unidyne principle can be applied equally well to H.F. and L.F. amplification with slight modifications from ordinary practice.

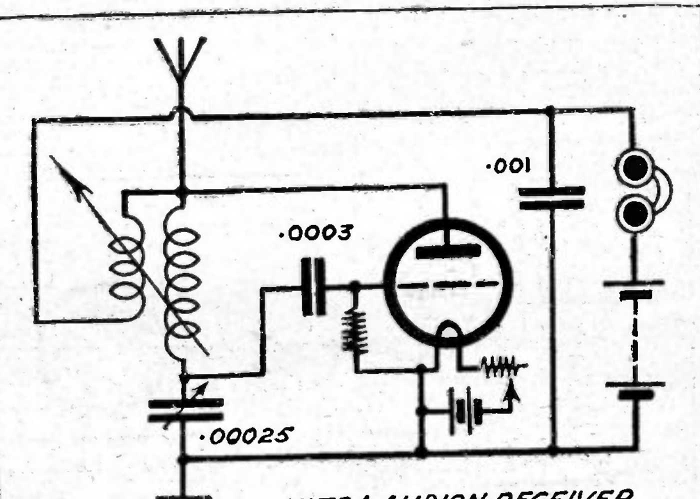


FIG. 26. ULTRA AUDION RECEIVER.

CHAPTER VII.
Modern Developments.

Up to the present we have only dealt with the use of the valve in receiving sets; in this chapter we will briefly consider its application in some other spheres and its probable future developments.

Quite apart from its use in wireless reception, the three-electrode valve is very extensively used for amplification in land telephone lines; in fact, the very long trunk line may be said to owe its existence to the valve. It is interesting to note that some of the best modern power valves, such as the L.S.5, were originally developed for land-line work.

In the field of wireless transmission, the valve is coming more and more into general use for telegraphy, whilst it is used almost exclusively for broadcasting purposes. As an example of the latter, let us take the standard equipment which is fitted in the majority of B.B.C. stations. The minute low-frequency currents from the microphone are first of all amplified in a five-stage resistance coupled amplifier, and then passed to a second amplifier which consists of three power stages, with three valves in parallel in the last stage, resistance coupling being again used. The amplified currents are then carried to the transmitter proper where they receive further amplification in the modulator (resistance coupled again) before being impressed on the carrier wave.

Water-cooled Valves.

Extremely large air-cooled valves are used in the transmitter, and large two-electrode valves are used for rectifying the high-tension supply (which is taken from alternating current machines). The development of these transmitting valves for larger and larger powers takes place simultaneously with the development of receiving valves consuming less and less filament current.

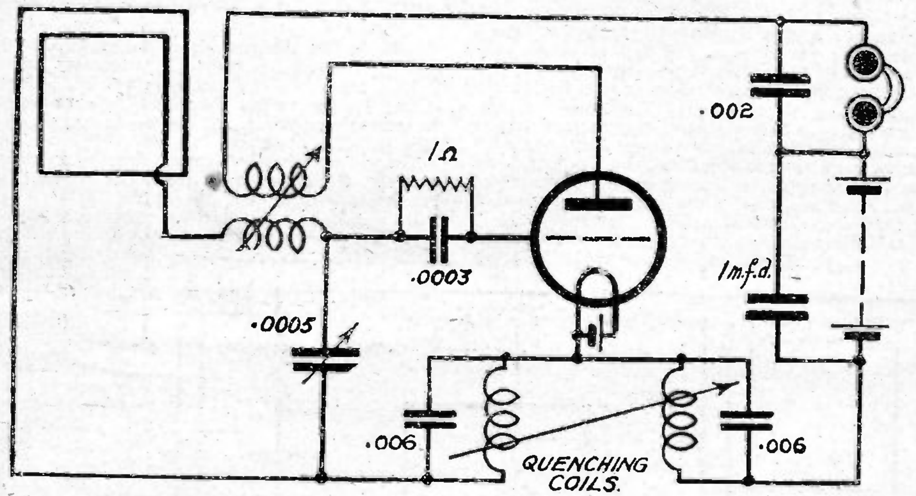
The difficulty which has hitherto limited the power of transmitting valves is that of cooling. A very large amount of heat energy is dissipated in the plate of the valve, and the trouble has been that of getting rid of this heat. Even when a blast of cooling air is directed on to the bulb the maximum power per valve is limited to a few kilowatts, so that a large number of valves have to be used in parallel to handle a large power. In the most modern transmitting valves, however, the anode takes the form of a large copper tube which is cooled by circulating water, so that over 20 kilowatts can be handled by a single valve. Water-cooled valves of this type are used at the B.B.C. high-power station and the new post-office station at Rugby will also use them.

The "Cold" Valve.

To return to receiving valves, the tendency is to use smaller and smaller filament currents, resulting from lower temperature emission. The ultimate aim, of course, is a "cold" valve—i.e. one which will function without any filament current, but this is looking a long way ahead. The most recent dull emitters consuming 60 milliamperes, can, however, be run off dry batteries if desired, and this is of great value to those who live in the country away from accumulator charging facilities.

Battery Charging.

Accumulator charging has always been a bugbear, and the advent of power valves with a large plate current has pushed up the cost of renewing H.T. batteries. Both filament current and H.T. current can, however, easily be supplied from direct mains where these are available, and the saving in time and trouble should be sufficient inducement to take the matter up. As regards H.T. supply, we must reduce the voltage if it is in excess of that required, and we must smooth out the ripples which are always present in public supply, and which cause most objectionable noises.



SINGLE VALVE SUPER REGENERATIVE RECEIVER.
FIG. 27.

The voltage reduction can be carried out very conveniently by using two or more lamps as a potentiometer, and the supply can be smoothed by means of condensers and series chokes as shown in Fig. 30 (page 29). If the supply is 240 volts and only 120 volts is required, for example, two 120 volt lamps may be connected across the mains, and a tapping taken from the mid-point, whilst if 60 volts is also required for a detector, four lamps may be used in series.

Lighting Filaments from Mains.

For the filament lighting, we must reduce the voltage to that required for the filaments of all the valves connected in *series*. If four D.E.5 valves are used, for example, the supply must be reduced to 24 volts, and this is effected by means of a series connected lamp or lamps, as shown in Fig. 31 (page 29). For the present example, we require to pass a current of 0.25 amps., and the voltage drop across the lamp will be 200 volts.

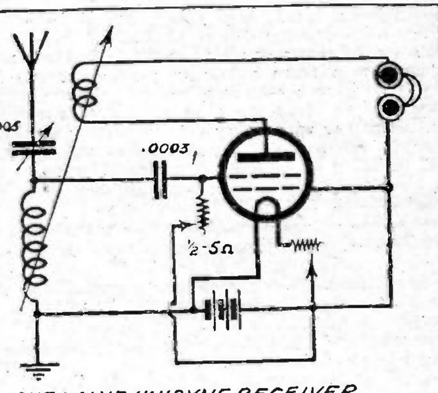
Now, a 240-volt 100-watt lamp will have a resistance of 576 ohms, and will pass 0.34 ampere at 200 volts, so that such a lamp will be suitable provided that a parallel rheostat of 10 ohms is used across each valve filament as shown in Fig. 31. The maximum value of each of these rheostats can easily be calculated for any condition, being lower the larger the current which has to be by-passed.

From the foregoing a complete unit can be made for supplying both H.T. and L.T. A series condenser of, say, 1 mfd. (Mansbridge), should be connected in the earth lead of the receiver, as the negative main must not be earthed.

When alternating current mains only are available, the supply must be rectified for ordinary valves, but a new type of valve has recently been produced in America in which the filament is heated indirectly, the current being passed through another conductor which is in contact with the filament. Such a valve can be run directly from A.C. mains, and its early introduction into this country would be very welcome.

There are a few final points that may be of assistance to valve users, the first of which concerns dull emitter valves, especially the .06 types. It will have been noticed by some that the valves sometimes lose their sensitivity after some use, due generally to over-voltage being applied to the filaments. Sometimes the valves may cease to function even though the filaments are intact, at other times a peculiar buzzing sound is heard and signals are weak, oscillation being hard to obtain and reaction erratic in action.

Sensitivity may sometimes be restored by one of two processes. First, the valve or valves affected

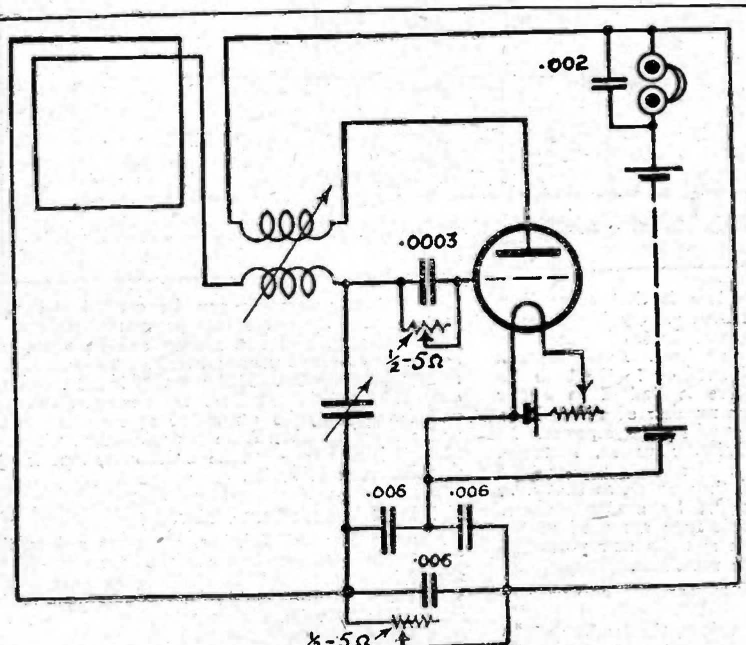


ONE VALVE UNIDYNE RECEIVER.
FIG 29.

should be lit for periods of from ½ hour to 3 hours, occasionally more is necessary, at the proper rated voltage, no high tension being on. After this period the filament may have regained its former properties, and the valve may be operative as before.

The second remedy is more drastic, and should only be employed in extreme cases, for it may result in burning out the valve. It consists in "flashing" the filament by connecting one filament leg to one terminal of an H.T. battery (20 volts will suffice) and very lightly and rapidly brushing the other leg with a wire connected to the other terminal of the battery. This should light the filament very brightly for a fraction of a second; not sufficient to allow it to fuse, of course.

Which of these two methods will be found effective depends upon the nature of the valve filament. Sometimes neither is of avail, and at other times the former acts quite well. Always try the former before resorting to the more drastic method. If both these methods fail, there is only one thing to be done, and that is to look upon the valve as no longer any use and to use it as a bright emitter, tuning up the filament only just enough to enable normal results to be obtained, and



FLEWELLING RECEIVER FIG 28.

using more voltage than stated by the makers.

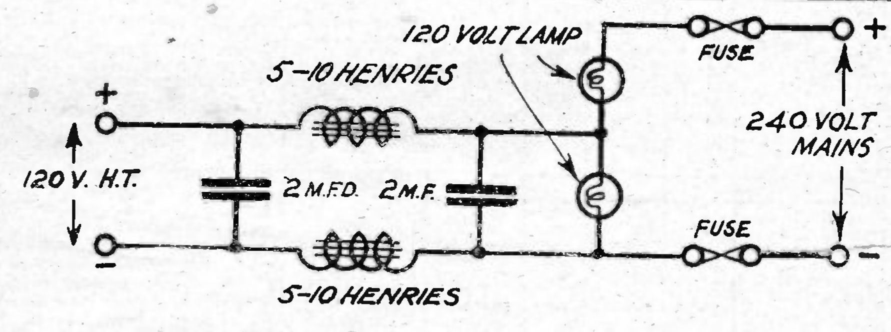
The Choice of Valve.

Another hint is worth while passing on, and this concerns transformers of the L.F. type. Switching off the high tension before the low tension may be better from the point of view of the valve filaments, but it causes unnecessary surging in the transformer windings, and has before now resulted in burnt-out transformers. The strain on the filaments of the valve if the H.T. is left on, and the L.T. slowly turned off by means of a rheostat is very slight, and as this avoids the surging currents set up in the transformer windings by the other method, it is advisable to make it a rule to turn off the L.T. first. The same procedure, but reversed in order, should be carried out when the set is turned on, the low tension current being slowly increased to its maximum by means of a rheostat—an L.T. switch giving a sudden increase should not be used if due care regarding filaments and transformer windings is to be taken.

Lastly, about the choice of valves. If the best is to be obtained from the set you are using it is absolutely essential that the correct valve, suitable for the work required of it, be employed, and that this valve be used under conditions best suited to it.

Conclusion.

For instance, if a two valve set is being employed, using 1 H.F. and 1 Det. stage, it would be asking for poor results if a soft detector valve were used in the H.F. stage and a hard L.F. valve with the detector stage. No doubt results would be obtained, but they would not be anything like the maximum obtainable if proper valves were used. There is no space for any further dissertation on this subject, but careful study of the valve guide following will enable anyone to choose the valves most suitable for any receiver. It is useless to expect the best results unless such details are studied, and everyone using a valve set will be well advised to study his valves, make sure they are the correct ones for the tasks they have to fulfil, and then make certain they are given a chance to operate properly.



H.T. SUPPLY FROM D.C. MAINS FIG. 30.

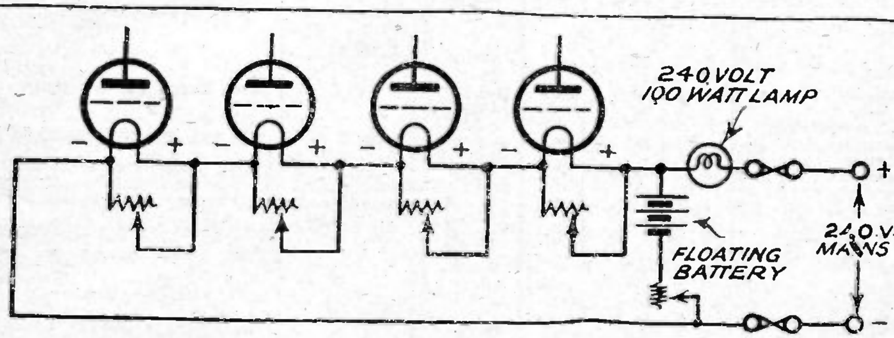


FIG. 31. L.T. SUPPLY FROM D.C. MAINS. (FLOATING BATTERY OF SMALL CAPACITY USEFUL FOR TAKING UP SMALL VARIATIONS OF MAINS VOLTAGE.)

THE "POPULAR WIRELESS" VALVE GUIDE.

Compiled by K. D. ROGERS.

DETECTORS AND GENERAL PURPOSE VALVES. (Similar types of Valves are bracketed.)

These are suitable for either H.F., Det., or L.F. work unless otherwise stated.

*Denotes Dull Emitter Valves.

Make and Type of Valve.	Price. s.	d.	Fil. Volts.	Fil. current amps.	Anode Volts.	Type of Battery advisable.	REMARKS.
D.E.R.* Marconi	14	0	1·8–2·0	·35	30–50–80	2-volt accumulator, or, if only 1 or 2 valves to be used, large dry cells such as the Ever Ready "Hercules" type, or special Siemens cells.	Good all-round valve. Very good 1st stge L.F.
A.R.D.E.* Ediswan (Red)	14	0	1·8–2·0	·35	30–50–80		Good valve for H.F. or Det.
B.3* B.T.H.	14	0	1·8–2·0	·35	30–50–80		Good all-round valve. Good H.F.
"Six-Sixty" * Electron Co.	14	0	1·5–2·0	·35	30–50–80		Good all-round valve. Good H.F.
W.1* Cossor	14	0	1·8–2·0	·30	20–50–80		Not suitable for H.F. work. Good L.F.
W.R.1* Cossor	16	0	1·8–6·0				
D.3* Mullard (Red Ring)	14	0	1·5–2·0	·30	20–50–80		Not suitable for L.F. Good H.F.
S.P.18 (Red Spot)* Cosmos.	12	6	1·7–1·8	·30	20–60–120		Good General Purpose valve.
Weco Valve*, Western Elec. and Mullard	18	0	·8–1·1	·25	40–80–150	2-volt accumulator, or, if only 1 or 2 valves to be used, dry cells such as Ever-Ready "L.T.1" or special Siemens cells.	General Purpose valve.
D.E.11* Cosmos	12	6	1·1	·25	40–80–150		General Purpose valve.
C. & S. "227" D.E.*	10	6	2·0	·20	25–60–100		General Purpose valve.
Dextraudion *	14	0	2·0	35	25–100		
Radion D.E. ·34*	10	6	1·6–2	·34	20–50–100		·34 type G.P. (H.F. ·34 for H.F. and Detector).
D.E.V.* Marconi	30	0	3·0	·20	20–30	4-volt accumulator, such as D.T.G. type (Exide battery) or dry cells of the type L.T.3, L.T.6, L.T.7 (Ever-Ready) or special batteries by Siemens Bros.	Detector and H.F.
D.E.Q.* Marconi	35	0	3·0	·20	20–30		Good Detector.
D.E.3* Marconi	16	6	2·8–3·0	·06	20–40–80		Good all-round valves for either H.F. or Detector work, though former two can be used as L.F. with success.
B.5* B.T.H.	16	6	2·8–3·0	·06	20–40–80		
A.R. ·06* Ediswan (Red)	16	6	2·8–3·0	·06	20–40–80		
D. ·06* Mullard (Red Ring)	16	6	3·0	·06	50–80–125		
Dextraudion*	16	6	2·5–3·0	·06	25–100		Good General Purpose valves.
C. & S. "227 L"*	13	6	3·0	·06	25–100		
Radion H.F. D.E. ·06*	10	6	2·5–3·0	·06	20–60–100		H.F. and Detector.
Unidyne K.4 (For Unidyne Sets)	13	6	4–6	·5	nil	4-6 volt accumulator, 6 volts if more than 1 valve is used.	Suitable for Unidyne Sets or 4-electrode valve circuits. (Latter type of circuits need H.T.)
Mullard D.G. (For Unidyne Sets)	27	6	3·4–3·8	·65	nil		
C.A.C.	7	6	3·5–4·5	·6	30–100	4 or 6 volt accumulator. 6 volts for more than 1 valve in every case.	Good General Purpose valves.
Radion G.P.	7	0	3·8	·48	30–80		
A.45 Cosmos	7	6	4·5	·65	30–60–120		
R.A. Mullard	8	0	3·6–4	·65	40–80–150		
O.R.A. (A & B) Mullard	8	0	3·4–3·8	·65	30–70–90		
H.F. Mullard (Red Ring)	8	0	3·2–3·8	·65	30–50–90		H.F. and Detector. Not advised for L.F.
A.R. Ediswan	8	0	4·0	·75	30–40–80		Good all-round valves, though P1 should not be used as H.F., as P.2 should be used in this case (*see* List of H.F. valves).
P.1 Cossor	8	0	4–4·5	·75	30–80		
R. Marconi	8	0	4·0	·7	20–60–100		
R. Ediswan	8	0	4·0	·75	50–100		
R. B.T.H.	8	0	4·0	·7	20–60–100		
Louden F. 1	7	0	4·8–5	·4	20–80		Advised for Detector or L.F. work.
Louden F.E.R.1*	12 13	0 6	4·0	·1	20–80		" " " " " "
S.5 Mullard	27	6	3·4–3·8	·65	30–50		Detector only.
S.3 Mullard	25	0	3·4–3·8	·65	15–30–50		General Purpose valve.
R.5V. Marconi	8	0	5·0	·70	20–60–120	6-volt accumulator.	Good all-round valve.
D.E.5* Marconi	22	6	5–6	·25	20–60–120		Good all-round valve. Best as L.F.
V.24 Marconi	25	0	5–6	·75	20–30		Best for Detector and H.F. and 1st stage L.F. (Special type of mounting)
Q.X. Marconi	27	6	5–6	·75	20–100		

VALVES SPECIALLY DESIGNED FOR H.F. AMPLIFICATION.

Make and Type of Valve.	Price. s.	d.	Fil. Volts.	Fil. current	Anode Volts.	Battery.	REMARKS.
A.R.D.E.* Ediswan (Red Line)	14	0	1·8–2·0	·3	20–100	2-volt accumulator or "Hercules" type of dry battery, or special Siemens' battery.	Good H.F. valves. W.R.2 and W.R.1 Cossor *can* be used with 4- or 6-volt L.T.
W.2* Cossor	14	0	1·8–2·0	·3	20–80		
W.R.2* Cossor	16	0	1·8–6·0	·3	20–80		
D.3* (H.F.) Mullard ..	14	0	2·0	·3	50–100		
D.E.V.* Marconi	30	0	3·0	·20	20–30	4-volt accumulator or "Hercules" type of dry cell.	Anti-capacity type of valve (special holder required).
H.F.DE.34* Radion ..	10	6	2·5–3·0	·34	—		
D. ·06* (H.F.) Mullard ..	18	0	3·0	·06	50–100	4-volt accumulator or L.T.6 or L.T.7 type Ever-Ready dry cell.	Dull Emitter specially made for H.F. work.
P 2 Cossor	8	0	4·0	·75	50–100	4- or 6-volt accumulator	Good H.F. valves.
Red Ring Mullard ..	8	0	4·0	·75	50–100		
Louden, Blue Top	7	6	4·0	·5	30–80		
V.24 Marconi	25	0	5·0	·75	20–40	6-volt accumulator ..	Anti-capacity type of valve requiring special holder.

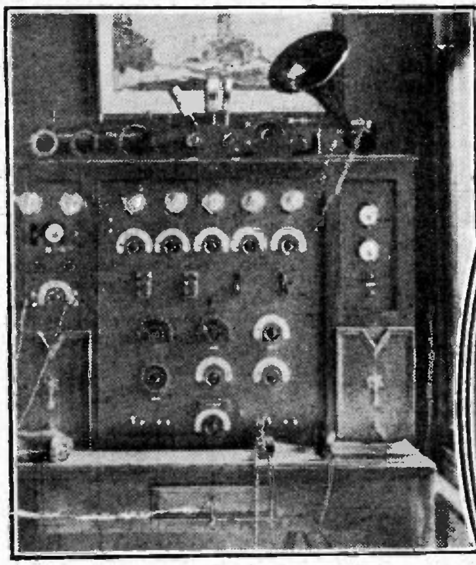
VALVES SPECIALLY DESIGNED FOR L.F. WORK, INCLUDING POWER VALVES.

Make and Type of Valve.	Price. s.	d.	Fil. Volts.	Fil. Amps.	Anode Volts.	Neg. Grid Bias Volts.	Battery.	REMARKS
Cossor W.3*	18	6	1·8	·5	80–120	0 –9	2-volt accumulator or dry cell of "Hercules" type or special Siemens Cells.	Good L.F. Power valve.
A.R.D.E.* Ediswan (Green Line).	14	0	1·8	·30	30–100	1½–6		Good L.F. valve 1st or 2nd stage.
D.3* Mullard (L.F.)	14	0	2·0	·30	30–100	3 –6		
D.E.6* Marconi ..	18	6	1·8	·40	60–120	3 –7½		Good L.F. valve 1st and 2nd stages.
P.V.6* D.E. Ediswan	18	6	1·8–2·0	·40	60–120	3 –7½		Good power valves 2nd and 3rd stages
D. ·06* Mullard (L.F.)	16	6	3·0	·06	30–100	3 –6	4-volt accumulator or dry cell of "Hercules" type or special Siemens cells.	Good L.F. valve 1st and 2nd stages.
B.6* B.T.H.	22	6	3·0	·12	60–120	3 –7½		Good L.F. valve 1st and 2nd stages.
D.E. 3b* Marconi	16	6	2·8–3	·06	20–120	1½–9		For resistance coupling.
D.E. ·06* Radion	10	6	2·5–3	·06	20–120	1½–6		Good L.F. valve.
P.M.4* Mullard ..	22	6	3·5–4·0	·1	50–120	1½–9	4 volt. acc. ..	Power Valve.
D.F.A.2* Mullard..	22	6	3·0–3·5	·20	50–100	3½–8	4-volt accumulator or "Hercules" battery (4½ volts).	For 2nd or 3rd stage L.F. work.
D.E.4* Marconi ..	22	6	3·8	·30	60–120	1½–7½		For 2nd or 3rd stage L.F. work,
D.F.A.O.* Mullard	22	6	3·5	·35	50–100	3 –8		For 2nd or 3rd stage L.F. work.
P.1 Cossor	8	0	4·0	·7	60–100	1½–3	4–6 volt accumulator.	For 1st stage L.F.
Mullard (Green Ring)	8	0	4·0	·7	60–100	1½–3		
P.V.3 Ediswan ..	22	6	4·0	·7	70–110	1½–9		
L.S.3 Marconi ..	22	6	4·0	·7	60–120	3 –7½		
Pyramid (2)* Radion	22	6	4·0	·34	40–120	3 –9		Power valve.
L.S.5* Marconi ..	40	0	4·5	·8	60–400	3 –15	6-volt accumulator is necessary.	Power valve for 2nd and 3rd stages.
P.V.2 Ediswan ..	22	6	6·0	1·5	200–400	3 –15		Power valve for great volume.
L.S.1 Marconi ..	35	0	5–6	1·5	150–160	3 –21		Power valve for great volume.
P.V.1 Ediswan ..	22	6	6·0	1·5	300–600	3 –21		Power valve for very great volume.
L.S.2 Marconi ..	35	0	5–6	1·5	150–600	3 –21		Power valve for very great volume.
D.E, 5a*	26	0	5–6	·25	60–120	3 –6		Power valve for last stage.
D.E.5b* Marconi	22	6	5–6	·25	60–120	3 –15		For resistance coupling for 1st stge
D.E 5* Marconi	22	6	5–6	·25	60–120	3 –15		Power Valve for 2nd and 3rd stages
B.4* B.T.H.	22	6	5–6	·25	60–120	3 –15		Do. for 2nd and 3rd stages.
P.V.5D.E.* Ediswan	22	6	5·0	·25	50–150	3 –15		Do. for 2nd and 3rd stages.
D.F.A.4* Mullard..	22	6	5·5	·20	100–300	1½–4½		For Resistance Amplifiers.
D.F.A.1* Mullard..	22	6	5·5	·20	50–100	3 –7		For 2nd and 3rd stages.
D.F.A.3* Mullard..	24	6	5·5	·06	50–100	1½–6		For 2nd and 3rd stages.
B.7* B.T.H.	24	6	6·0	·06	60–120	1½–6		For 2nd and 3rd stages.
Pyramid (1)* Radion	22	6	5·5	·34	40–120	3 –9	6-volt accumulator	Power valve.

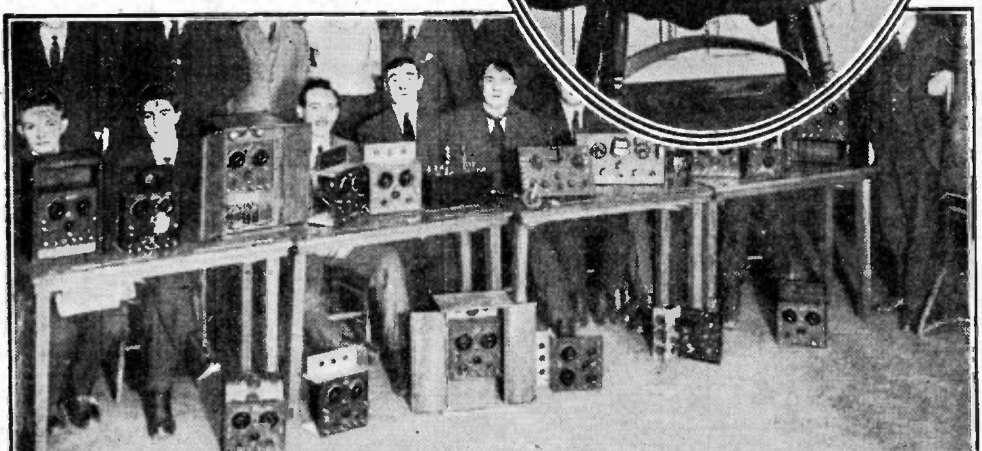
Sir Oliver Lodge heads "P.W[illegible]" Tech[illegible] Staff.

Types of Amateur Receivers.

Some Varied Designs in Home Constructed Sets.



Above: Experimental station built by Mr. T. W. Stephanson. 1777a, Chester Road, Stretford. Right: A two-valve set (Det. and L.F.) made by Mr. W. Blackledge, 321, Longe Moor Road, Bolton.



Amateurs of Swansea Valley and some of the receiving sets built by members of the local education classes.

Interviews may be had with the Technical Staff.

POPULAR WIRELESS

AND WIRELESS REVIEW

THE RADIO WEEKLY WITH THE PROGRESSIVE POLICY

Edited by NORMAN EDWARDS, M.I.R.E., F.R.S.A., F.R.G.S.
Technical Editor, G. V. DOWDING, Grad. I.E.E., A.C.G.I.

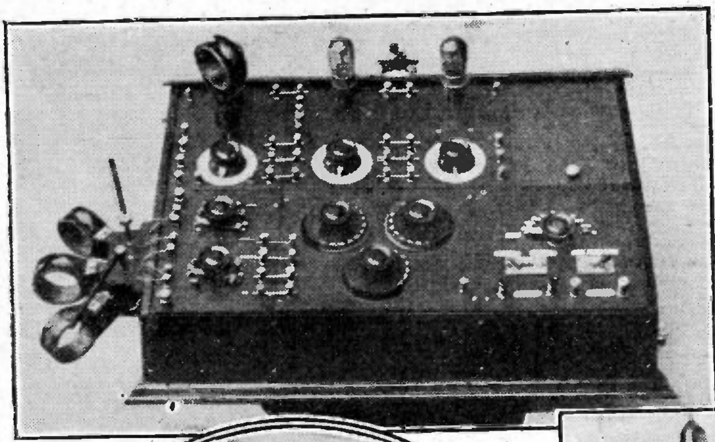
SIX months before the B.B.C. was formed No. 1 of "Popular Wireless" was on sale to the public, price 3d. weekly. Since that day it has retained its position as the most popular and leading wireless periodical published in the country.

IT is the progressive policy that pays, and by affording unique assistance to its readers in the matter of answering queries, giving personal advice and assistance, testing sets, etc., "P.W.'s" success has been continuous.

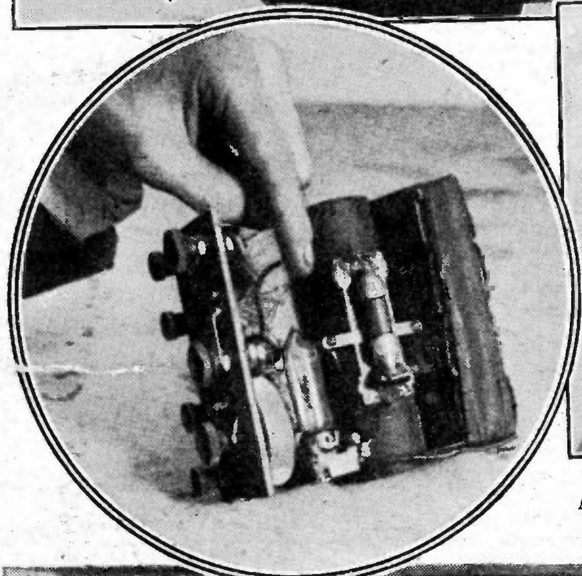
IF you are a newcomer to the hobby of wireless you will need a friendly and helpful guide: you will not want to spend too much money on making a set unless you feel sure it is reliable—in fact, there are dozens of things you will want advising on. Let the "P.W." Technical Staff help you. A special department is at your service—a department made up of experts, who can save you money, time, and worry. Make it a rule to write to the "P.W." Query Department when in doubt. Then you won't go far wrong.

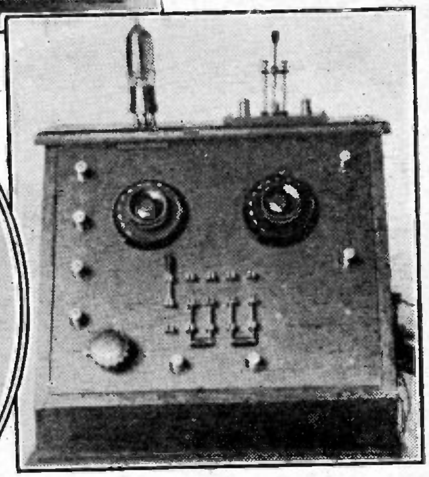
Remember:—

"P.W.'s" Consulting Staff is headed by one of the world's greatest scientific authorities—Sir Oliver Lodge. All queries (a charge of 6d. per query is made and 1/- for a diagram lay-out) should be sent to the "P.W." Technical Queries Dept., Fleetway House, London, E.C.4.



Left : A Two-valve Unit Set built up in cabinet form.
In circle : An American miniature set that fits in a camera case.





Above : A One-valve "P.W." Combination Set Reflex Receiver built by a "P.W." reader.

A typical example of American design—the exterior view of a Neutrodyne Receiver.

Sir Oliver Lodge heads "P.W.'s" Technical Staff.

The Wuncell Dull Emitter.

Voltage 1.8 volts. Consumption ·3 amp.
W1 for Detector and L.F. 14/-
W2 for H.F. amplification 14/-
W3 Cossor Loud Speaker Valve
Voltage 1·8 volts. Consumption ·5 amp.
Price 18/6

Like wine, the Wuncell improves with age—

IT is a remarkable fact that the Wuncell—alone among Dull Emitters—actually improves with age. Whereas in most dull emitters the filament loses much of its emission through course of time, that used in the Wuncell actually gains in productivity of electrons.

The Wuncell filament is unique. It is built up layer upon layer under an entirely new process. As a result it is exceptionally robust. When next you get the opportunity to examine a Wuncell compare its filament with that used in any other dull emitter—or even in any bright emitter. You will be amazed at its thickness. It is practically as stout as that used in the average bright emitter. Yet its wonderful economy of current will enable a six-volt accumulator (with its cells re-connected in parallel to give 2 volts) to give 70 hours' use where it gave but 9 before.

Couple that exceptional economy with the fact that the filament never gets hotter than a very dull red and you will readily realise that even if Wuncells cost twice as much they would be much cheaper in the long run than any bright emitter.

Eventually you'll use Wuncells—why not begin now? Buy them one by one as your present valves become useless. If they will save you money in a month's time, they will save you money now.

Cossor

A. C. Cossor, Ltd., Highbury, N.5. Gilbert Ad. 3600.

The Amalgamated Press (1922), Ltd., The Fleetway House, Farringdon Street, London, E.C.4. Advertisements for this Handbook supplied by JOHN H. LILE Ltd., 4, Ludgate Circus, London, E.C.4 (sole Advertising Agents for POPULAR WIRELESS). 'Phone: City 7261.