Lamphouse

RADIO INSTRUCTION COURSE

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Radio Instruction Course

By F. H. ADAMS

THE information and instruction given in the Course is intended for Beginners who wish to gain some knowledge of fundamental Radio theory and as a reference-guide for constructors. At the end of each chapter a set of questions is provided for the student to ascertain whether he has understood the theory explained, answers to the questions being given at the end of the booklet.

The original series has been revised and enlarged with a view to assisting the Radio beginner who finds standard text-books difficult to cope with.—Lamphouse.

CHAPTER ONE.

Direct Current.

The purpose of this series is to present the fundamentals of Radio Theory in as simple a form as possible. It is the writer's experience, however, that the most important part of a student's equipment is ability to use and understand technical terms and simple mathematical formulae. It is intended, therefore, to make use of every-day radio terms and phrases and simple formulae, which may be learned as they occur. Ability to read and draw circuit diagrams is also very important. It is hoped that the simple diagrams used will assist progress in this direction.

The logical starting point in any course of study is right at the beginning. It is necessary, therefore, to have a working knowledge of the general principles of electricity, which is the motive power of all radio apparatus. According to the electron theory, an electric current is a flow of electrons. Electrons are negative and will flow towards a point which is positive. It thus becomes necessary to provide a source of electrons and a positively charged element. If two such terminal points are joined by a conductor, current will flow through the conductor.

When a complete path has thus been provided we have a circuit, but if current flows through another unwanted path then the latter constitutes a short-circuit.

All conductors offer some resistance to the flow of current. A good conductor has low resistance, and we therefore use copper wire for wiring as copper is a low-resistance conductor. Sometimes it is necessary to use high-resistance conductors to limit the flow of current. These most commonly take the form of carbon resistances or a certain length of wire of suitable gauge. The longer and the thinner the wire, the higher the resistance. Conversely, a heavy wire is suitable for low resistance connections, whether it is a single wire or consists of many strands twisted together. Some materials offer a very high resistance to current flow. If used in circuits where the positive charge is not sufficiently high to force current through them, they serve to insulate connections from each other so that there may be no short-circuit between such connections. The positive charge is usually termed the electromotive force (electron-moving force) or e.m.f., and it is stated in volts. Sometimes we also refer to so many volts pressure which is another way of saying the same thing.

Assuming a supply of electrons, the amount of current (measured in amperes) will be determined by the amount of resistance (measured in ohms) and the positive voltage available. With a fixed positive voltage the amount of current will depend on the amount of resistance in the circuit. High resistance means low current and low resistance permits a larger flow of current or a greater number of amps or milliamps, the latter being thousandths of amps. These principles are expressed in the mathematical form of Ohms Law:—

$$I = \frac{E}{R}$$

where I is current in amps., E is the emf in volts, and R is the resistance in ohms. Therefore current in amps. equals volts divided by ohms, and the answer may be expressed in decimals of an amp. or in milliamps., one milliamp. being .001 amp.

Let us look at the following circuit:—

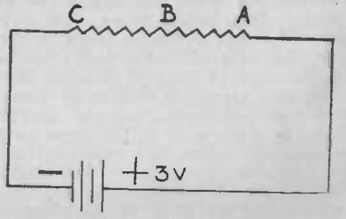


Fig. 1.

At the bottom we see a 3-volt battery, having the positive and negative terminals connected by a conductor which is shown as a resistor, as all conductors have some resistance. The amount of current flowing through the resistance may be calculated from the formula already stated

$$I = \frac{E}{R}$$

We may also use the other forms of this equation:—

$$E = I\,R \text{ and } R = \frac{E}{I}$$

To examine our circuit further we find that we start off with 3 volts positive and end up at the negative terminal with no volts. Therefore it is said that 3 volts have been dropped across the resistance and this where we use $E = I\,R$. If the current and resistance are known the voltage drop may be calculated. In the same way we may calculate R if E and I are known.

It follows now that if we divide R into two sections AB and BC, part of the voltage is dropped across AB and the remainder across BC. The formulae quoted will cover all R. I and E relationships. We may use a single resistor with slider, or two separate resistors in series. In either case we now have a voltage dividing system giving us two different positive voltages with a negative terminal common to both. Or we may wish to drop our positive voltage to a certain value. As a practical example, suppose that we have a 3-volt battery and a single type 30 valve filament to heat. As the 30 filament is rated 2 volts at .06 amps. we must reduce the voltage applied to the filament to 2 volts. Referring to our diagram, if BC represents the resistance of the filament, it becomes necessary to drop one volt across AB. To find the correct AB resistance,

$$R = \frac{E}{I} = \frac{1}{.06} = \frac{100}{6} = 16.6 \text{ ohms}$$

It will be noticed that the current value is .06 amps. (60 milliamps). This value will obtain at any point in the circuit, between the negative and positive terminals, as there is a total resistance and total voltage determining the amount of current throughout.

Our little diagram may also be used to clear up difficulties as to the direction of current flow, in receiver circuits. In the filament example worked out we arranged values so that point A is + 3v, B + 2v and C — or no volts. Therefore B is negative with respect to A as it is at a lower positive potential, and C is negative with respect to both B and A. It follows accordingly that in a given circuit, a point near the positive end is positive with respect to one further away, and a point near the negative end is negative with respect to one further away or nearer the positive end.

In conclusion, it should be noted that our discussion, so far, has been entirely in connection with direct current circuits. The principles outlined, however, will apply equally to D.C. as supplied by batteries, or to the rectified and filtered supply used in electric receivers.

Questions:

1. Describe a simple electrical circuit.
2. What is the difference between a conductor and an insulator?
3. What determines the nature of the insulating material?
4. (a) What factors govern the amount of current in a direct current circuit?
   (d) Write the formula.
5. State two methods of obtaining a lower voltage from a source of fixed voltage.
6. What current will flow at a pressure of 50 volts in a circuit having a total resistance of 1500 ohms?
7. State the three forms of the Ohms Law formula.
8. When are these formulae used?

CHAPTER II.

Resistance and Inductance.

In the last chapter, mention was made of the means adopted for dropping a positive voltage to a desired value. Voltage adjustment becomes necessary because of the heating effect of a flow of current. When current flows through a resistance a voltage drop takes place, and work is done. The rate of doing work is termed power, the unit of power being the watt.

In the case of current flowing through a resistance, power is said to be developed across the resistance, and the power developed is dissipated in the form of heat. Consequently when we buy current-carrying radio components we find that they are rated as to power-handling capacity in watts. If we have too much wattage dissipated across a component, it will over-heat and burn out. In order to calculate wattage, we may use:

$$P = I^2R,\ P = \frac{E^2}{R},\ P = E \times I$$

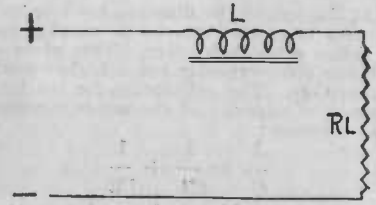
As before, I, E and R must be stated in amps., volts and ohms, and the answer P gives the power in the circuit in watts.

To take a practical example, if we have a loud-speaker with a field-coil of 2,500 ohms resistance and a current of 100 milliamps. flows through it, then the power dissipated in the field coil may be calculated from $P = 1_2R = .1x.1x2500 = 25$ watts. Unless the speaker is specially designed for this high wattage, the field-coil will burn out. It would be

necessary, therefore, to use a more modest circuit drawing less current, or to use a 10 watt speaker with a 1000 ohms field-coil.

The reason for leading current through the field-coil of a speaker brings us to consideration of magnetic effects. When current flows through a conductor, a magnetic field is set up around the conductor, that is, there is an area around the conductor in which magnetic forces are experienced. It is assumed that the magnetic field consists of imaginary lines of force, and the density or strength of the magnetic field is usually stated in the number of lines per square centimetre. As the strength of the field (or magnetic flux) around a straight conductor is insufficient for the purpose of energising a speaker, the field winding is wound to form a coil. By this means, the lines of force are concentrated in a small area and the magnetic field becomes very much denser and stronger. The value of this property of a coil may be appreciated when we consider that coils of varying types are used throughout a receiver.

It should now be noted that a coil is called an inductance, the symbol being L, and the unit is the Henry. To show this in diagrammatic form:—



L = Speaker Field Coil.
RL = Load Resistance.
Fig. 2.

L, in this case, is an iron-cored inductance, as indicated by the lines drawn under the coil, that is, it is wound around an iron or stalloy core, which further intensifies and multiplies the lines of force, by reason of its permeability. Permeability, accordingly, refers to the property of intensifying and multiplying the lines of force of a magnetic field. A speaker field-coil is an iron-cored inductance and is thus represented as shown. When the coil is wound on an insulated form, the straight lines are omitted, and the coil is termed an air-cored inductance.

If we refer back to our diagram we will see that the positive and negative leads are joined through a resistance which typifies the load on the system. This may be a simple resistor as shown, or the resistor may represent whatever apparatus we connect across the supply in order that there may be a flow of current. In other words, we have put the system to work by connecting a load across it. The load may be represented for our present purpose by RL, the load resistance.

Before digressing from resistance to a discussion of other D.C. circuit components, it is necessary to have a clear idea of the effects of different methods of connection.

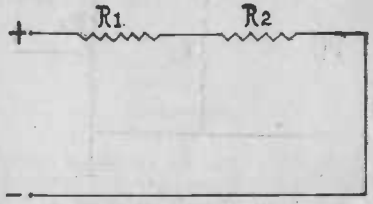


Fig. 3.

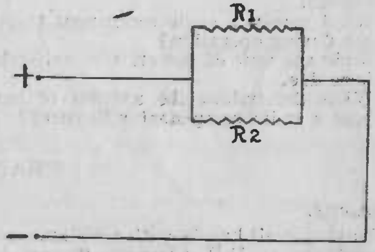


Fig. 4.

Fig. 3 shows Resistors R1 and R2 in series with each other and with the supply, and the total resistance is the sum of the two.

In Fig. 4 there is a certain amount of resistance in series with the supply. R1 and R2 are connected in parallel and the total resistance of the combination may be calculated by means of the formula,

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2}$$

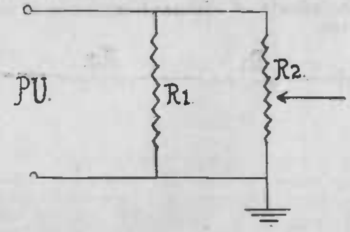
Suppose that we have a magnetic pick-up and find that, wiith a volume control of 500,000 ohms connected across the pick-up the tone is very shrill. (See Fig. 5.) We can improve results by reducing the amount of resistance across the pick-up. If a 200,000 ohms resistor is connected across or in parallel with the 500,000 ohms, the new total resistance becomes:—

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} = \frac{1}{200{,}000} + \frac{1}{500{,}000}$$

$$= \frac{7}{1{,}000{,}000}$$

$$\therefore R = \frac{1{,}000{,}000}{7} = 143{,}000 \text{ ohms approximately.}$$

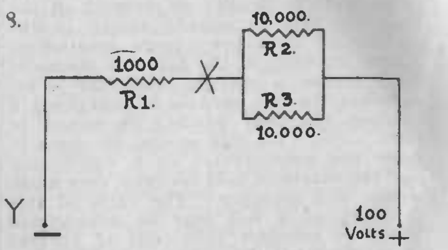
Before concluding it should be remarked that the series and parallel calculations apply equally well to inductance, whether we are concerned with the inductance of a component, or with its resistance. That is, a series connection gives higher resistance and/or inductance, and the parallel connection gives lower resistance and/or inductance.



Pick-up Circuit referred to.
Fig. 5.

Questions:

1. What causes a radio component to get hot during operation?
2. State the unit of power, and write the formulae.
3. What determines the amount of current a radio component will carry?
4. What is the remedy for over-heating?
5. Current flow through a conductor causes heat, voltage drop, and a magnetic field. How may the magnetic field be intensified?
6. What is the advantage of an iron-cored inductance, and what is the important property of the core?
7. State the formulae for
   (a) Series resistances.
   (b) Parallel resistances.
8.



What is the Voltage at X ?
Fig. 6.

CHAPTER III.

Capacity.

Having dealt briefly with resistance and inductance in D.C. Circuits, it now becomes necessary to know a little about capacity. A device designed purposely to have capacity is termed a condenser, and may be of fixed value or variable as to capacity. The symbol for capacity is "C" and the unit is the Farad. As the Farad is too large a capacity for practical work, the common form is the microfarad, which is one millionth part of a farad or .000001 farads. Sometimes it is convenient to use the micro-micro-farad, which is one-millionth part of a microfarad. These two smaller units are written: "mfd" and "mmfd," the abbreviations being obvious.

In many formulae, the farad is the unit, and mfds. must be stated as decimal parts of the farad. However, where we are concerned with simple series and parallel capacities, we may use mfds. or mmfds. throughout, the formulae being the reverse of those used when dealing with resistance. The following diagram illustrates the methods of connection:—

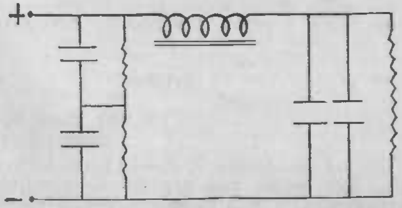


Fig. 7.

At the left of the diagram are two condensers connected across a supply, and in series with each other. This gives us a lower total capacity but a higher working voltage. The calculation for the total amount of capacity of the series combination becomes:

$$\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2}$$

The total working voltage, however, is higher than that of each condenser. If condensers are marked "8 mfds. 450 v wkg.", the total series capacity is now:

$$\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2} = \frac{1}{8} + \frac{1}{8} = \frac{2}{8}$$

$$\therefore C = \frac{8}{2} = 4 \text{ mfds.}$$

The working voltage becomes 900 volts, though to divide the voltage equally between the condensers it is preferable to use a voltage divider of two similar resistors—say, 250,000 ohms each. The current through these resistors can be calculated and the wattage across each. The formulae have been stated previously, and we can thus arrive at the type of resistor to be used.

Referring now to the parallel condensers to the right of the iron-cored inductance, the total capacity of the combination becomes the sum of the two, but the working voltage at this capacity is now that of the lowest rated condenser of the two. With similar condensers, the working voltage is the same as that of a single condenser.

It is apparent that two important alterations have been effected. The series condensers have a higher working voltage with lower capacity, and the pair in parallel give us a higher capacity. Thus it is often possible to use combinations when we need differently rated condensers from those which we have or are able to procure. It should also be realised that it is not good for condensers to use them at their maximum voltage ratings. The same consideration applies, of course, to resistors, or any other current-carrying components. It is preferable to use components with a higher voltage or current rating than the values actually obtaining in a circuit.

It will be noticed that a condenser is shown diagrammatically by two horizontal lines with a space between. This indicates that a condenser consists basically of two plates separated by some intervening material. This material may be air, mica, waxed or oiled paper, bakelite, or the layer of aluminium oxide and gas film formed in a wet electrolytic through chemical action. In every case it is known as the "Dielectric," and its purpose is to insulate the plates from each other, and to determine the amount of capacity in the condenser according to the size of the plates. All of the special dielectrics referred to give a greater capacity than when air is used, and the ratio of increase on the capacity provided by a dry air dielectric is termed the "Dielectric Constant" of the insulating meterial.

Although condensers are used for different purposes, they all have the common properties of blocking the flow of D.C. and of storing electricity. The latter property gives us the term "Capacity." In all cases, the most important facts about any condenser are the capacity and the working voltage. If these ratings are not observed, the condenser will produce a different effect from what is intended, or the insulation between the plates may be broken down by excessive voltage. The result in such case would be resistance and direct current flow, instead of capacity with no D.C. flow.

The action and properties of condensers form a fascinating study, but it would be beyond the scope of this series to investigate at length. It is helpful, however, to consider how the storage of electricity takes place. This occurs by reason of the charge and discharge action of a condenser. That is, when a positive potential is applied to the positive plate and a lower or negative potential is applied to the negative plate the condenser charges up and stores electrons. The instant the voltage or potential difference between the plates falls, the condenser discharges electrons.

Although involved and complicated explanations are common of how the electrons chase around from one plate to the other, etc., the practical uses of a condenser are of more immediate importance. It may be briefly stated that the main purposes of condensers in receiver circuits are:—

(a) Blocking D.C.
(b) Coupling.
(c) Tuning.
(d) By-passing.
(e) Storage.

These functions are not independent of each other but will generally explain the use of a condenser in any particular circuit.

Questions.

1. (a) What is the basic unit of Capacity?
   (b) Express the most commonly used unit in two forms.
2. What is the basic construction of a condenser?
3. What is the effect on capacity of connecting condensers
   (a) In series.
   (b) In parallel.
4. How do these connections affect the working voltage?
5. How may the total capacity be calculated with
   (a) Series connection.
   (b) Parallel connection.
6. If a condenser of .001 mfds. capacity and one of .005 mfds. are available, how would you use these to obtain lower capacity?
   Express the result in micro-micro-farads.
7. If two variable condensers are connected in parallel what control of capacity is available?
8. What is the action of a condenser in circuits of
   (a) Constant voltage.
   (b) Varying voltage.

CHAPTER IV.

Alternating Current.

So far, the type of current considered has been Direct Current, which flows always at the same strength and in the same direction, and is thus referred to as pure D.C. This is the type of current supplied by batteries. When a current is uni-directional but varies periodically in strength, it is called pulsating D.C., and this is the form of current supplied by a rectifier and filter system. The regular pulsations are at an audible frequency, that is they occur at a number of times per second, and produce an audible sound. The same consideration applies to alternating current. This type of current also changes in strength at a regular rate.

A.C. is represented by a sinu-soidal pattern :—

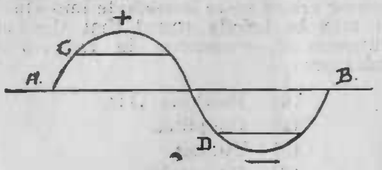


Fig. 13.

The curve indicates diagrammatically that the current commences at zero. rises to the highest positive value, falls to zero, rises to the highest negative value, and falls to zero. The complete series of changes (AB) is termed a cycle and the number of complete cycles per second gives the frequency of the current. Thus alternating current is referred to as having a frequency of so many cycles per second or c.p.s. Accordingly we understand that when our domestic supply is described as 230v 50 c.p.s., this indicates a frequency of 50 cycles per second and an effective voltage (CD of diagram) of 230 volts. The effective value of voltage is the same as that of a direct current which would have the same heating effect as the alternating current in use. The effective value is more exactly described as the root-mean-square voltage and is simply abbreviated to "volts r.m.s."

The square root of one half (the mean value) of the square of the maximum voltage is stated as root-mean-square and equals .707 or 70% of the maximum voltage. It should be noted that average value refers to rectified current and is .636 of maximum values.

The frequency (f) of an alternating current determines the use to which it is put. The audible range is approximately from 30 to 20,000 c.p.s. Higher frequencies are beyond audibility and are used for the transmission and reception of radio signals. Thus the lower frequencies are termed audio frequencies (A.F.) and the higher frequencies Radio Frequencies (R.F.).

Speech or audio signals are superimposed, at the Transmitter, on a constant alternating current system, and the output of the Transmitter is fed to an Aerial system. The result is that alternating current at the specified frequency of the transmitter circulates in the aerial system. Now we know that a flow of D.C. through a conductor produces a magnetic field around the conductor. In the same way AC circulating in an aerial system produces a magnetic field which rises and falls as the current rises and falls. In other words, energy is alternately stored in the field and returned to the aerial. When we consider that a transmitter broadcasting at 1,000 kilocycles is using an alternating current of 1,000,000 cycles per second, it can reasonably be assumed that not all the energy in the magnetic field is returned with each half cycle fall but that some of this R.F. energy is forced into the atmsphere in the form of waves. As the speed with which these waves travel through the atmosphere is 300,000.000 metres per second (the velocity of light) the distance between the crests of the waves or the frequency of the waves may be calculated from the formulae :—

$$f = \frac{300.000,000}{\text{wave-length}}$$

$$\text{wavelength} = \frac{300,000,000}{f}$$

f = Frequency in cycles per second.

Wave-length = Metres, and is the distance between the crests of the waves.

To collect the R.F. energy from the atmosphere we erect a receiving aerial and connect it through an air-cored inductance to ground. The result is that AC at the transmitter frequency flows in the inductance and produces a varying magnetic field. As the field rises and falls it cuts the turns of any inductance placed sufficiently close and the result is that, if a load is connected across the secondary inductance, then an alternating current will flow, still at the transmitter frequency.

The transfer of energy from one inductance to the other in this manner is termed Electro-magnetic Induction. A more correct description of the process: As current flows in the primary inductance, the magnetic field about the primary rises and falls and induces an e.m.f. in the secondary inductance which causes a flow of current at the original frequency. Thus reception of a broadcast becomes possible.

As we wish to receive only one station at a time, some method of tuning must be arranged:

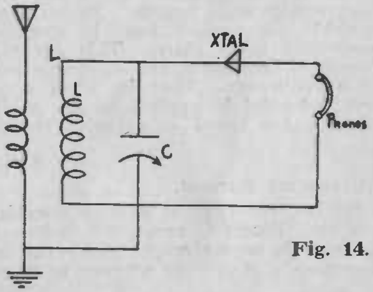


Fig. 14.

The combination of inductance and capacity (L.C. circuit) will have a resonant frequency. That is, at one particular frequency current flow will be at a maximum. Consequently we may wind or buy a coil of a certain inductance, and use with the coil a variable condenser (as shown) so that the amount of capacity may be varied, the combination thus having a different resonant frequency for each setting of the condenser. A given combination will therefore be resonant within a certain range of frequencies as determined by the constants (values) of the L.C. circuit. As the current circulating in the L.C. circuit is A.C. it must be converted to one way current, or "rectified." A crystal detector may be used as a rectifier and the output fed through a pair of headphones back to ground. Audible reception is now accomplished, as the ear pieces of the phones will not follow the rapid R.F. variations but will respond to the more gradual rise and fall of the audio signals superimposed on the carrier wave.

Questions.

1. What is the basic distinction between AC and DC?
2. How is AC voltage usually expressed?
3. What similarity exists between DC and AC voltage ratings?
4. What do we understand from the stated frequency of an AC supply?
5. What type of current is used for radio transmission and reception?
6. Low frequencies are used for audible signals and high frequencies for radio signals. What are the common terms?
7. How are speech frequencies transmitted?
8. What is the important feature of an LC circuit?

CHAPTER V.

Impedance.

Inductance and Capacity have very important effects in alternating current circuits. The term Inductance refers to that property of a coil whereby it resists changes in the current flowing through it. Thus a coil offers ohmic resistance to the flow of A.C., and an additional opposition by virtue of its inductance. The additional opposition is termed Inductive Reactance. The formula for Inductive Reactance (XL) is $XL = 2\,\mathit{pi}\,f\,L$. The Frequency is stated in cycles per second, the inductance (L) in henrys or the decimal part of a henry, *pi* is 3.14, the answer is in ohms.

If the formula for inductive reactance is examined it will be seen that the frequency of the applied current is the most important value. That is, the reactance will vary widely with a given value of inductance if the frequency varies. Frequency determines the amount of reactance of a given coil. Thus, at high frequencies the reactance is high, and at low frequencies the reactance is low. Similarly, the higher the inductance at a given frequency, the higher the reactance. And the lower the inductance, the lower the reactance, at a definite frequency. These statements may seem somewhat involved, but they must be fully understood to appreciate the effect of differing inductances in A.C. circuits.

In the case of capacitative Reactance, the effect differs considerably. It is orthodox condenser theory that no current passes through the dielectric from one plate to the other. Nevertheless capacity is used to couple circuits together at certain frequencies, and functions by reason of its charge and discharge action. If desired frequencies are passed on from one circuit to another, the effect is of coupling the circuits at the desired frequency or frequencies. When certain frequencies are passed on to another circuit to get rid of them, they are said to be by-passed and condensers are used for the by-passing. To understand how this becomes practicable it is necessary to study the effect of capacitative reactance in A.C. circuits. The formula for capacitative reactance (XC) is $XC = \dfrac{1,000,000}{2\,\mathit{pi}\,f\,C.}$ C for the purpose of this formula is stated in mfds., and the answer is in ohms.

Now if we consider the formula for capacitative reactance, the frequency (f) again becomes the critical factor. It is evident that the higher the frequency, the lower the reactance. Therefore a condenser has lower reactance at high frequencies than at low frequencies. So we are able to use a low capacity condenser to pass on or to by-pass high frequencies. But that is not the whole story. Although the reactance at radio frequencies may be very low, it may simultaneously be very high at low frequencies. If we look at our formula again we see that a large answer is obtained when f is small. Therefore reactance at low frequencies will be high. So a condenser of suitable capacity may be used to filter out radio-frequencies without loss of audio frequencies. So far we have considered reactance variations in relation to frequency with a fixed value of capacity for C.

It is apparent that, if frequency is a constant value, changes of capacity will also affect capacitative reactance. Glancing at the formula again, we see that if f is a fixed value, then a low value for C gives a large answer and a high value for C gives a small answer. From this we deduce that, at a given frequency, a large condenser has lower reactance than a small condenser. Thus, if we desire to by-pass or filter out low frequencies from a circuit, it is necessary to use high capacity condensers, so that capacitative reactance may be low at the low frequency. Of if it is desired to pass on low frequencies as well as high frequencies, then a condenser must be used which has sufficiently low reactance at the lowest frequency to be passed on.

Having dealt with the additional opposition provided by capacity and inductance in A.C. circuits we may consider the total opposition. Where resistance and inductance are present the total opposition is the Impedance Z. The formula is $Z = \sqrt{R^2 + XL^2}$.

When resistance and capacity are both present the formula for Impedance is $Z = \sqrt{R^2 + XC^2}$.

Where we have resistance, capacity and inductance present in an A.C. circuit the Impedance.

$$Z = \sqrt{R^2 + (XL - XC)^2}$$

In this case the reactance X is the difference between capacitative and Inductive Reactances as these reactances oppose each other and partially cancel out. When capacitative and inductive reactance are equal they cancel out. These are the conditions in a tuned circuit consisting of Resistance, Capacity and Inductance. Therefore at the particular frequency at which reactances cancel out the only opposition to the flow of current is ohmic resistance. This frequency is the resonant frequency of the combination and we say that the flow of current at the resonant frequency is maximum and is minimum at all other frequencies.

For practical purposes it is usual to refer to the Impedance of an inductive component such as a coil, and the Reactance of a condenser. Impedance varies with frequency or with the size of the coil, and capacitative reactance varies with frequency or according to the capacity of a condenser. This provides a working basis to determine what sized condenser or coil is needed for a special application.

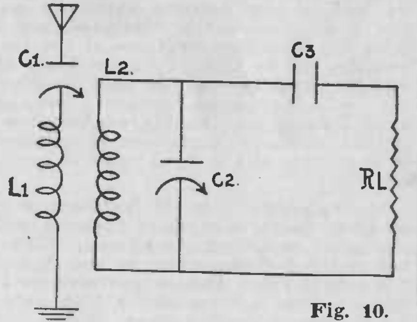


Fig. 10.

We may now pass on to consideration of the above circuit.

A low capacity for C1 has lower reactance at high frequencies than at low frequencies. The aerial condenser may, therefore, be adjusted to favour high-frequency transmissions from short-wave stations. Secondly, C1 couples the aerial to the receiver input If C1 is small. the aerial is loosely coupled. This results in improved selectivity.

The tuned circuit L2C2 will have a different resonant frequency every time the capacity of C2 is altered. As current flow is maximum at the resonant frequency and lower at all other frequencies a station broadcasting at the same frequency as the resonant frequency of the tuned circuit, will be favoured and others simultaneously received will be weakened. Tuning thus becomes feasible.

The formula for the resonant frequency of an LC circuit is $F = \dfrac{1}{2\,pi\,\sqrt{L \times C}}$

The frequency (f) is in cycles per second, L is in henrys or the decimal part of a henry, and C is in farads or the decimal part of a farad. However the general deduction is that L and C must be small for the answer to be large, a large number of cycles per second indicating a high resonant frequency., Thus we use a small coil and a small condenser, or only portion of the capacity of a large condenser to tune in short-wave broadcasts. Similarly a large coil and larger condenser are necessary to tune in lower frequency broadcasts.

Energy is picked up by the aerial. alternating current at radio frequencies flows in L1. Energy is transferred from L1 to L2 by electro-magnetic induction. The coils L1 and L2 are said to be inductively coupled. Alternating current at the resonant frequency of L2C2 flows strongly. The R.F. energy is passed on to other circuits by the coupling condenser C3. The impedance of the following component is represented by RL. A particular station is thus tuned in more strongly than all others.

Condensers are principally used for Tuning, Coupling, Blocking D.C., and By-passing. Capacitative reactance is the vital factor in each of these uses, except the blocking of Direct Current, which is a natural function of a condenser as there is no direct connection between the plates.

An example of by-passing may be seen in each of the following circuits.

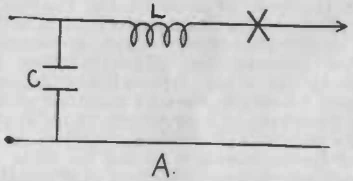


Fig. 11.

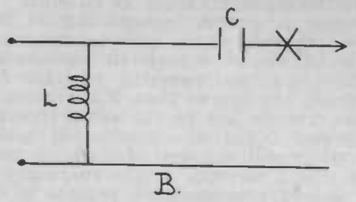


Fig. 12.

In circuit A. the inductance L opposes certain frequencies at which its impedance is high. L opposes high frequencies because inductive reactance rises as frequency rises. If C is small its reactance is very low at high frequencies but high at low frequencies.

The system, therefore, by-passes high frequencies through C, and passes on lower frequencies through L. The circuit forms a low-pass filter.

In circuit B, the inductance L opposes the by-passing of high frequencies, but offers low impedance at low frequencies. If C is small the opposite effect obtains. C has a low reactance at high frequencies and passes them on, but has high reactance at lower frequencies and opposes them strongly. Low frequencies are by-passed back to the source. and high frequencies are passed on. Therefore the system operates as a high-pass filter.

The reactances of L and C may be so proportioned that undesired frequencies are by-passed from the line X, while desired frequencies are passed on to another component.

Questions.

1. Why is a coil termed an Inductance?
2. What opposition additional to ohmic resistance is present in an A.C. circuit containing capacity or inductance.
3. Briefly describe Impedance.
4. Why does impedance vary with changes of frequency?
5. Impedance of a condenser is low at radio-frequencies. The impedance of a coil is high at radio-frequencies. Why is this?
6. A condenser of stated capacity is specified in a circuit. What effect will a different capacity have?
7. A coil of low inductance offers high impedance at high frequencies, but a coil of high inductance is necessary for effective impedance at low frequencies. Why is this?
8. Selectivity may be improved by increasing the spacing between aerial coil and secondary coil or by using a small condenser to couple the aerial to the receiver input. Explain.

CHAPTER VI.

Rectification.

Electrons are provided by a cathode. When the cathode is heated to the correct temperature it emits electrons. The heating may be direct or indirect. In the former case, the filament itself is the cathode and is heated by a steady flow of current from a battery, or from the filament winding on a power transformer. A valve of this kind, therefore, uses a filament-type cathode. In the most popular types of valves for "electric" sets the cathode is a sleeve placed around the filament, but not in direct contact. The filament is heated by flow of current, and, as the cathode is in close proximity, it also becomes heated. When operating temperature is reached, the cathode emits electrons. This type of valve thus employs an indirectly heated cathode. It should be noted that a cathode is a cathode, whether of the filament type, or of the indirectly heated variety.

In order to provide a flow of current, two elements are sealed in a vacuum within a glass or metal envelope. One element is the cathode, the other is the plate. It is usual to omit the filament in an indirectly heated valve when referring to the number of valve electrodes. The cathode is reckoned as the first electrode. and the others follow in the order in which they have been inserted. So a two element valve is a Diode whether the cathode is directly or indirectly heated.

Both plate and cathode have external connecting pins for plugging into a valve socket, as, of course, has the filament. Suitable circuits may be arranged by wiring to the valve socket lugs. Sometimes two plates are inserted in the valve which then becomes a double diode.

When a positive voltage is applied to the diode plate, there is a flow of current. If negative voltages, or no voltage, are on the plate there is no current flow. Therefore, if alternating current is applied to the plate, current flows only on positive half-cycles of the input voltage. The result is a rectified or one way current. A diode is, thus, suitable for the rectification of alternating current to unidirectional current.

Let us consider a practical circuit.

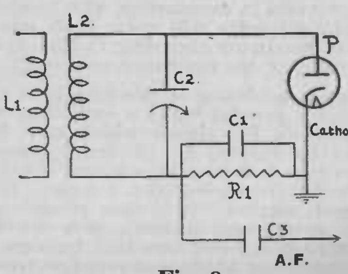


Fig. 8.

R.F. alternating current flows in LI, transfer to L2C2 is effected by electromagnetic induction if L2 is placed sufficiently close to L1. The diode plate P is directly connected to L2. Radio frequency A.C. circulates in L2C2 and an alternating voltage is applied to P. The diode passes current on positive signal voltages but not on the negative half-cycles. R.F. is by-passed by C1 and varying voltages at audio frequency are developed across the diode load resistor RI. The diode circuit for the rectified, pulsating D.C. is from cathode, through R1 and L2 to P., and back to cathode through the valve. C1, C2, C3 all block the passage of direct current. C1 by-passes R1 for radio frequencies, C2 tunes the resonant circuit L2C2, and C3 couples the diode load resistor and the voltages across it to another circuit at audio frequencies. The audio voltages may now be amplified.

An Inductance-Capacity circuit has a natural resonant frequency at which current flow is at a maximum. The resonant frequency depends upon the values of inductance and capacity. If it is possible to alter the amount of capacity while the inductance remains the same, the LC circuit will have a different resonant frequency every time capacity is altered. At every setting of a tuning condenser, there is a different value of capacity in the LC circuit. This comes about because the capacity of any condenser depends principally upon the size of the plates, the distance between the plates, and the nature of the separating material or dielectric. In the case of the usual tuning condenser, there is an assembly of fixed plates and one of moving plates, with air for the dielectric. When the moving plates are rotated, the amount of moving plate area opposite the fixed plates is either increased or diminished. The orthodox tuning condenser may, therefore, be resolved into the basic condenser of two plates separated by a dielectric. The size of the plates may be increased or diminished to provide differing values of capacity. Some types of variable condensers employ different dielectrics such as bakelite or mica. In every case the manual control alters the distance between the plates or the size of the opposing plate areas. Variation in capacity is thus provided in conjunction with manual control. Capacity will range from minimum to maximum according to the capacity rating of the condenser employed.

When a condenser of this type is wired across (in parallel with) a coil, there is available an LC circuit which may be altered by varying C. A tuned circuit of this type is a parallel resonant circuit, and, as C is varied, the resonant frequency is altered. It is thus possible to use C at different settings, each setting producing a different resonant frequency. As current flow at the resonant frequency is maximum, and is lower at all other frequencies, a station transmitting at the same frequency as the resonant frequency of the LC circuit, is received more strongly than stations operating at other frequencies. It follows that, if a number of tuned circuits having the same resonant frequency follow one another in series, selectivity will progressively improve until only signal currents at the frequency of the desired broadcast are present in the final tuned circuit. A series of tuned stages is the characteristic feature of a modern radio receiver, and accounts for present-day selectivity.

Assuming that a broadcast has been tuned in, it becomes necessary (a) to rectify the R.F. alternating current to one-way current; (b) to de-modulate: that is to remove radio frequencies from the signal currents, so that we may use audio signals super-imposed on the carrier wave at the transmitter during the process of modulation. The whole process is (very unsuitably) called "Detection" and the valve or other device used for the purpose is known as a Detector. In any case, rectification and demodulation must be effected prior to amplification at audio-frequencies.

Detection may be accomplished by using a copper-oxide or a crystal rectifier in a suitable circuit. However, the range of such a receiver is limited as there is no amplification at radio frequencies. Also if selectivity is improved by special coil assemblies, sensitivity is reduced. For long range reception and adequate selectivity, it becomes necessary to employ suitable valve circuits.

The radio valve is a wonderful device and it performs amazingly if its requirements are studied and fulfilled. Yet the essentials for operation are simple and straightforward. For a valve to work there must be a source of electrons, an electro-motive force, and a conducting circuit.

The use of the diode is limited to rectification. To obtain more efficient control of plate current, the three element or triode valve was evolved. A control grid was inserted between the plate and the cathode. This grid is of mesh construction which does not appreciably affect the electron flow from cathode to plate. Its control over plate current arises from the fundamental rule that like charges repel each other, and unlike charges attract. Electrons are negative. If the grid is swung alternately positive and negative with respect to a mean or average voltage by an incoming signal voltage, variations in plate current are caused. The variations are considerably larger than if the same signal voltages were impressed on the plate. In other words, small differing signal voltages applied to the grid cause relatively large changes in plate current. If the plate current variations occur in an outside circuit having A.C. impedance, there will also occur varying voltages across the impedance, which are similar to but larger than the signal voltages impressed on the grid. Amplification has been effected. It is usual to speak of the Load Resistance RL when referring to the component connected in the plate circuit, the purpose being to provide a load for the valve to work into. The load may be a coil or a carbon resistance. The purpose is the same in both cases.

In the grid-leak detector, the functions of diode detector and audio amplifier may be both performed by a triode voltage amplifier.

Grid and cathode rectify in the same manner as a diode. The grid is coupled to the LC circuit by C1 for radio frequencies and acts as a diode plate. As a result, rectified voltages appear across Rg and are applied to the grid. The rectified signal voltages applied to the grid, cause variations in plate current, the external flow being through RL. As a result, amplified replicas of the input signal voltage appear across RL. These amplified voltages are at audio frequency, and are similar to the audio voltages super-imposed on the carrier wave at the transmitter. Coupling to another valve is effected by the coupling condenser C3. If a head-set is used in place of RL, the total impedance of the windings supplies the load for the plate circuit. Rectification is not complete, and any remaining R.F. variations in the plate circuits are opposed by the radio frequency choke R.F.C. and by-passed to the cathode by the condenser C2, which must have low reactance at radio frequencies and high reactance at audio frequencies. The valve, accordingly, functions as detector and audio amplifier. Sensitivity is higher than when a diode is used on account of the audio amplification obtained.

It should be noted that, while C2 must have low reactance at radio frequencies and high reactance at audio frequencies, the coupling condenser must have low reactance at audio frequencies, so that audio signals may be passed on to the next stage. Suitable values for C2 would be .00025 or .0005, and for C3 from .01 to .1 mfds.

Questions.

1. When the shaft of a tuning condenser is rotated, what effect has the rotation on the condenser?
2. Why does such rotation tune in a station?
3. What steps are necessary to convert radio frequency currents to audio frequencies?
4. What components could be used for the purpose?
5. Why does a diode rectify?
6. What purpose is served by a diode load resistor?
7. Why is the grid-leak detector more sensitive than the diode?
8. What is the reason for the ability of a triode to amplify?

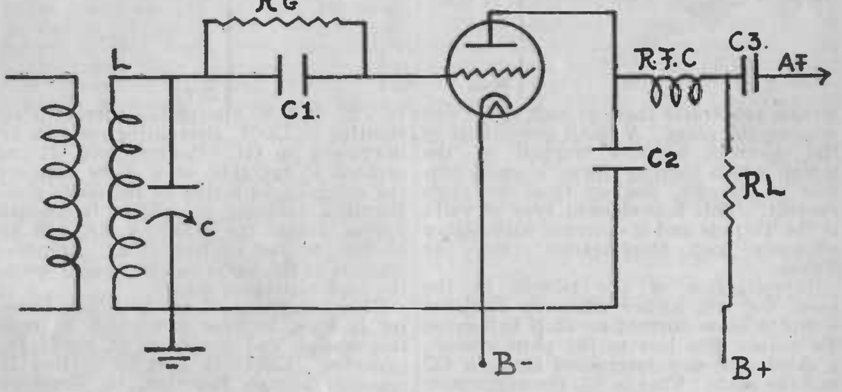


Fig. 9.

CHAPTER VII.

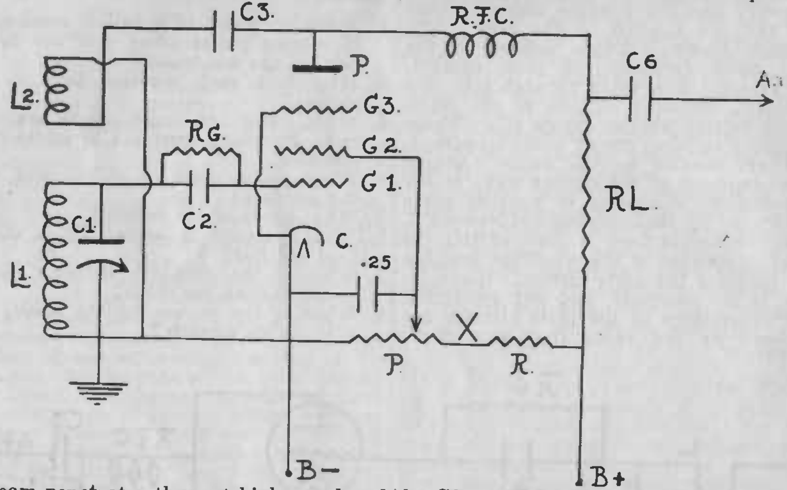
Valves.

A triode valve will amplify because small signal voltages applied to the control grid cause comparatively large excursions of plate current. In the quest for higher efficiency it was decided to minimise the most serious fault of the triode, the large plate to grid capacity. If any two conductors between which there is a difference of voltage or potential are in close proximity, they form a quite efficient condenser and coupling takes place. In the case of the triode, this capacity between plate and grid couples the output circuit to the input circuit. The coupling occurs within the valve and is due to the large inter-electrode plate to grid capacity. The result is feed back of energy from plate to grid, which causes instability and is very troublesome at radio frequencies. Accordingly a second grid G2 was inserted within the envelope between the control grid G1 and the plate, to screen the grid from the plate, and so reduce the plate to grid capacity. In addition, the application of a positive potential to the screen-grid G2 increases the pull on the electron stream already flowing from cathode to plate with a positive voltage on the plate. Both the control grid and the screen grid are of mesh construction and the electron stream penetrates them at high speed and reaches the plate. A small proportion of the electrons becomes trapped on the screen which thereby draws a small current of its own, distinct from the plate current. This four-element type of valve is the Tetrode and it operates with higher efficiency and amplification than the Triode.

Investigation of the tetrode in the quest for still higher efficiency disclosed a dip in plate current on each half-cycle. To reduce this loss to the plate circuit, a third grid was interposed between G2 and the plate. This is G3, the suppressor grid, which is inserted expressly to suppress secondary emission of electrons from plate, back to screen grid. It is assumed that the high-speed electron stream knocks electrons from the plate by force of impact. These free electrons are attracted to the screen grid G2, which is usually at a high positive potential. The result is a loss to the plate current. As the plate is in the output circuit of the valve, increased efficiency accrues as a result of preventing or minimising the loss to the plate circuit. The suppressor grid G3 is usually connected to the cathode which is normally at zero voltage or at a very low positive potential. Thus G3 has little or no attraction for secondary emission electrons, and it also reduces the inter-electrode capacity between plate and screen grid G2. The result is a more efficient valve than either the Triode or the Tetrode. The amplification is higher, and the valve is more suitable for radio frequency service on account of the reduced inter-electrode capacities. As the addition of G3 brings the number of electrodes to five, the valve is called the Pentode.

We may now consider the use of a pentode as a high-gain detector.

The control grid G1 is coupled to the tuned circuit L1C1 at radio frequencies by C2. If R.F. alternating current is circulating in L1C1, alternating voltages are impressed on G1. Control grid G1 and cathode C function as a diode detector, the control grid acting as the diode plate. Rectified voltages at audio frequencies appear across the grid-leak Rg, and are applied to the control grid. Amplified replicas of the audio signals appear across the load resistance RL.



The sensitivity of the grid-leak Detector is high, because it rectifies at radio frequencies and amplifies at audio frequencies. Efficiency may be further increased through Reaction, or Regeneration. An additional coil L2 may be used for this purpose. Regeneration becomes possible on account of rectification not being complete. A residue of R.F. energy remains in the plate circuit. This is prevented from reaching RL by the high impedance of the radio frequency choke R.F.C. at radio frequencies. R.F. in the plate circuit, therefore, flows through C3 which has low reactance at radio frequencies, and through L2 back to the cathode. If L2 is sufficiently close

to L1, the plate circuit is inductively coupled to the grid circuit for radio frequencies. The result is that some of the R.F. energy in the plate circuit is returned to the grid and re-amplified. Transfer of energy occurs as the result of electro-magnetic induction between L2 and L1. The regenerative effect may be increased by increasing the capacity of C3. by adding turns to L2, or by moving L2 closer to L1. The constant building up of R.F. in the grid circuit results in phenomenal sensitivity just below the instability caused by excessive regeneration.

Manual control of the amount of regeneration is had by making C3 variable as to capacity, that is, by using a variable condenser. A more convenient method is regulation of the screen voltage. If resistor R and potentiometer P are connected between B positive and B negative, they form a voltage divider. A calculable voltage exists at X and forms the maximum voltage that may be applied to the screen. This potential may be varied from maximum down to zero by movement of the slider along the internal resistance strip as the shaft of P is rotated. Variation of the screen voltage controls the operation of the valve by virtue of the effect on plate current, and thereby controls the amount of R.F. energy in the plate circuit. The screen must be de-coupled by a large capacity (.25 or .5) mfds.) to provide a low-resistance path to cathode for both R.F. and A.F. present in the screen circuit.

For the reception of C.W. or unmodulated Morse signals, the detector is brought unto oscillation by increasing reaction until an audible note is heard. Oscillation takes place when more energy is fed back from the output to the input than is necessary to make good losses in the grid circuit. The result is a constant back and forward movement of energy from plate to grid. and from grid to plate. These oscillations are regulated as to frequency by adjustment of the tuned circuit L1C1. The audible note is a heterodyne note which has a frequency equal to the arithmetical difference between the frequency of the station signalling and the frequency of the oscillations. The beating together or heterodyning of the original frequencies produces a third frequency which is the one heard. Suppose that a station is transmitting unmodulated code (C.W.) at a frequency of 15,000 kcs. This means that a continuous wave at that frequency is broken periodically by the action of a telegraph key. The frequency is too high for audibility. Accordingly an oscillating detector may be tuned to 14,999 kcs. or to 15,001 kcs. The heterodyne note produced in both cases is 1 kc. or 1,000 C.P.S., and the dots and dashes become audible at this frequency. The principle is important as it is the heart of super-heterodyne design.

A regenerative grid-leak detector, as outlined, performs a number of operations. The various operations are apparently performed one after the other. Yet the entire operation of the different circuits is simultaneous, judging from practical results. We are thus confronted with the problem of several effects following one another, and yet occurring all at the same time. It is evident that a theory to cover the complete operation must approach the subject from a different angle from that of time. Time relationships are hardly relevant. Orthodox theory as to phase relations does, however, clear up our difficulties considerably.

If two men are marching along, exactly out of step, one right foot will be forward, when the other right foot is back. Yet both move together, in time. If circuit phenomena are substituted for the right feet, there exists a difference in phase of 180%. One circuit operation is 180% out of phase with the other. If the position were exactly half-way to that described, then the phase angle would be 90%. In the case of a radio valve, the grid and plate circuits are 180% out of phase.

When energy is fed back to one valve circuit from another, the phase relations cause regeneration or degeneration. If the feed-back energy is out of phase with that of the circuit to which it is returned, cancellation takes place and there is a loss of signal strength. The action is degenerative. If the energy fed back is in phase with that of the circuit to which it is returned, regeneration occurs. That is, there is a gain in signal strength.

Phase relations in regenerative detectors provide an instructive example. The plate circuit is 180% out of phase with the grid circuit. But there is a phase reversal of 180%. The plate circuit energy coupled back to the grid by inductive coupling undergoes a 180% phase change. The feed-back energy appears in the grid circuit without phase difference, and the action is regenerative.

Questions.

1. How many electrodes has (a) a Diode. (b) Triode, (c) Tetrode, (d) Pentode? Name the electrodes in each case.
2. What is the advantage of the Screen Grid?
3. What is secondary emission, and how is it reduced?
4. Why is the Pentode more efficient than the Triode?
5. At radio frequencies the Pentode is more efficient and stable than the Triode. Why is this?
6. What are the phase relations between plate and grid of a radio valve?
7. How is regeneration effected?
8. What is a heterodyne frequenc

CHAPTER VIII.

Grid Bias.

We have seen that a diode consists of a cathode and a plate. The cathode, on being heated, emits electrons, and current will flow if a positive voltage is applied to the plate. In the Triode a control grid is inserted for the express purpose of controlling the plate current. This grid is placed between the plate and the cathode, and, if it is made negative with respect to a pre-determined fixed potential, the effect will be a drop in plate current. If made positive there will be a rise in plate current. As small alterations to the grid potential cause relaively large variations in plate current, amplification becomes feasible. The control grid exercises the same function in whatever type of valve it is used. However there is a starting-point for the process of amplification, and this initial adjustment consists of the provision of bias for the grid.

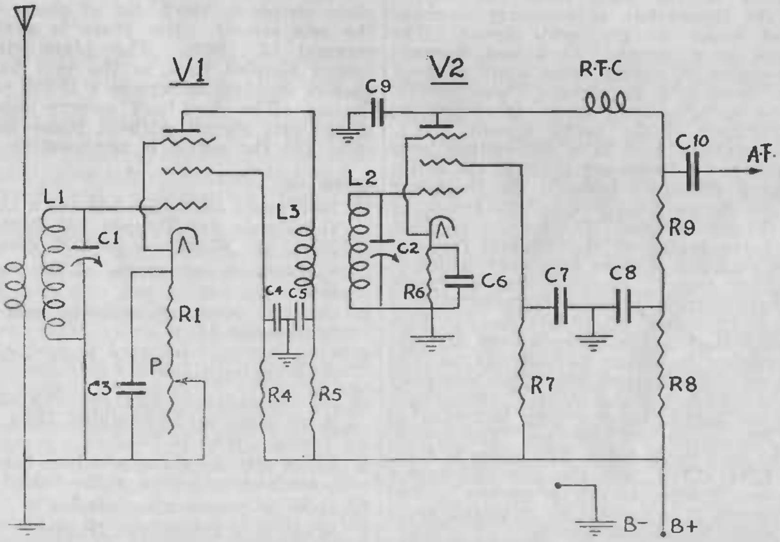
On looking up, in a valve manual, the recommended operating conditions for any particular valve, it will be seen that the grid voltage is specified as so many volts negative. These conditions must be observed for satisfactory valve life and operation. The specified negative grid potential may be obtained from a bias or C battery. The positive voltage is applied to the cathode, or filament-cathode, and the correct negative voltage is applied to the grid. The grid is thereby made negative with respect to the cathode by the required number of volts. The result is that the plate current is set at the proper operating value.

The same considerations apply to A.C. valves. The grid must be negative with respect to the cathode by the recommended number of volts. The method most commonly used in "electric" sets is to connect the grid to ground through a grid-leak, and to make the cathode positive with respect to ground. The voltage difference between grid and cathode provides the necessary grid bias. If the cathode is positive with respect to the grid, then the grid is negative with respect to the cathode. It must be understood that "ground" is not "earth." Ground is the reference point in a circuit, so that voltages may be checked by measuring them all with respect to ground. It is thus a common reference point, and may be connected to earth without upsetting operating voltages. Ground is most commonly at zero potential, but in some circuits is at a positive potential. This does not matter, as, when voltages are measured, they are all measured against ground. That is, they are either positive or negative with respect to ground by the measured number of volts. Voltage differences between specific circuit points are measured across those points, but the voltage differences between such points and ground still obtain.

To use a radio valve to amplify it is necessary to observe the following requirements:—

(a) Signal input to the control grid.
(b) Correct grid bias.
(c) Suitable voltages for screen (if any) and plate.
(d) A load for the valve to work into.
(e) Coupling to the next stage.

We may use the following circuit diagram to see how these requirements may be fulfilled.



(a) R.F. current induced in the aerial coil L is present in the tuned circuit L1C1 as the two windings are placed sufficiently close to be inductively coupled. The windings are on the same former and the assembly is called an Aerial Coil. As a result of inductive coupling, there is a transfer of energy from L to L1 and R.F. currents circulate in L1 C1, principally at the resonant frequency of the tuned circuit L1 C1. Therefore a station transmitting at the same frequency as the resonant frequency of the tuned circuit is received very much more strongly than other stations operating on other frequencies. As energy is transferred from L to L1 through electro-magnetic induction, and without any direct connection, the coil combination operates as an R.F. transformer. Alternating voltages in the L1 C1 circuit are applied directly to the grid of V1 and supply signal input.

(b) Current flow through R1 causes a voltage drop, and the cathode is positive with respect to ground by the amount of voltage dropped across R1. The grid is connected to ground through L1. and is negative with respect to the cathode by the number of volts the cathode is positive with respect to ground. For example, if the cathode is 3 volts positive, and if the grid is at zero potential, then the grid is negative with respect to the cathode by 3 volts and the grid has a negative bias of 3 volts. Most R.F. amplifiers employ changes in grid bias to vary the amount of amplification. If the bias is high, the gain is low. If the bias is low, the gain is high. This type of valve is called a variable-mu R.F. amplifier, "mu" meaning gain. It thus becomes practicable to use a variable resistor of the wire-wound potentiometer type in the cathode circuit so that the grid bias may be varied manually. This provides manual control of the R.F. gain. P in the circuit diagram illustrates this method. The condenser C3 serves to by-pass R.F. from the cathode circuit to ground and earth.

(c) A positive voltage is applied to the screen through R4 which drops the screen voltage to the correct amount. The screen is de-coupled from other circuits by R4 C4 which form a de-coupling filter. The impedance of R4 is high at all frequencies, and the reactance of C4 is low at radio frequencies. R.F. is by-passed by C4 to ground and earth instead of penetrating into other circuits. Exactly the same considerations apply to the plate potential applied through R5 and L3.

(d) The A.C. load for the valve is supplied by the impedance of L3 which is 2pifL (ignoring resistance) and is high at high frequencies.

(e) Variations in plate current caused by varying signal voltages on the grid produce a varying magnetic field about L3, which is inductively coupled to L2. Alternating current circulates in L2 C2 which is tuned to the same resonant frequency as L1 C1. There is, thus, one stage of selection following another, and the resultant over-all selectivity is adequate for the separation of local stations. The coupling between the two circuits is inductive, and is effected by means of the R.F. transformer L2 L3. The two windings are on the same former and the assembly is known as an R.F. coil.

The type of detector employed in the circuit is called variously (a) Anode-bend detector, (b) Plate detector, (c) Grid-biassed detector, (d) Biassed detector. Detection is effected in the plate circuit, and the grid is heavily over-biassed. Hence the different names. The operation of the detector is as follows:—

Grid bias is heavy on account of a high-resistance cathode resistor, and the initial plate current is a fraction of a milliampere. Positive impulses on the grid cause increases in plate current. but negative swings have little effect. The current may only be reduced to zero with very slight variation from the initial value. The valve, therefore, rectifies in the plate circuit. Rectification is not complete and R.F. variations in the plate circuit are removed by the radio frequency filter R.F.C. (radio frequency choke) and C9. The impedance of R.F.C. is high at radio frequencies, and the reactance of C9 is low at these frequencies, but high at audio frequencies. The result is that audio voltages are developed across the load resistance R9 and coupling to another stage is effected by the coupling condenser C10, which has low reactance at audio frequencies. This is the resistance-capacity method of coupling, sometimes called "resistance coupling."

Plate and screen potentials are applied in the same manner as in the circuit of V1. De-coupling of the screen and plate circuits is accomplished in the same way by means of the de-coupling filters R7 C7 and R8 C8. The result is that audio and R.F. currents in the circuit of V2 are restricted to that circuit, and unwanted coupling with other circuits does not occur.

The biassed detector has the following advantages:—

(a) R.F. amplification occurs in addition to rectification.
(b) On account of the heavy grid bias, the detector can handle large input signals.
(c) Unlike the diode and grid-leak detectors, it does not draw current from the tuned input circuit. and thereby maintains the efficiency and selectivity of the LC current at maximum.

It should be noted that the A.C. impedance of a carbon resistor is constant at all frequencies, assuming that such a resistor has negligible inductance and capacity. This does not affect the efficiency of a de-coupling filter employing a carbon resistor, as the reactance of the by-pass condenser is necessarily very low at the frequency it is desired to by-pass.

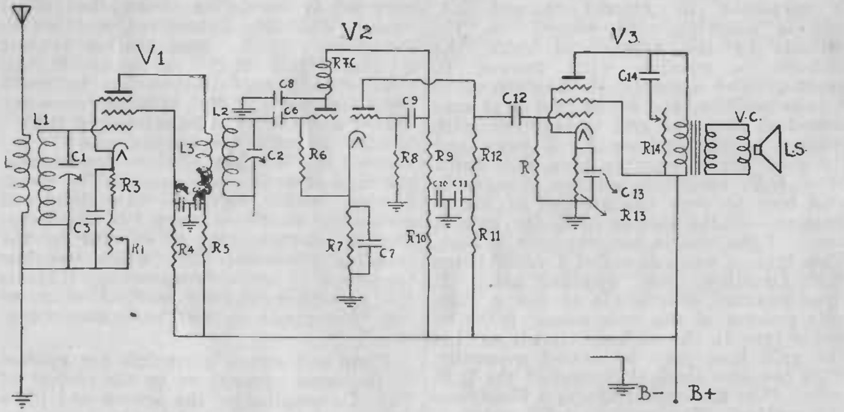
Questions.

1. What is meant by grid bias?
2. Why is grid bias essential?
3. State two commonly used methods of providing grid bias.
4. If alternating voltages are applied to the grid, what effect has this on the grid potential?
5. State one method of varying the gain of a variable-mu R.F. amplifier.
6. What is meant by de-coupling?
7. What is the reason for de-coupling?
8. When an alternating voltage is applied to the grid of a biassed detector rectification is obtained. Why?

CHAPTER IX.

Circuits.

It is recommended that, at this stage, the student should commence to analyse published circuits. The worrying-out of circuit features, and practice in the drawing of circuit diagrams, with a reason for every line and every component, helps tremendously if one wishes to become radio-minded. It is most important that the fundamental theory be firmly grasped. In this chapter it is intended to apply the theory already explained to a complete receiver of the local station type.



As a starting point, we see that there are two tuned circuits, L1 C1 and L2 C2. These are both tuned to the frequency of the broadcast it is desired to receive, which frequency is a radio frequency. Therefore the design is that of a Tuned Radio Frequency receiver. To proceed with a preliminary examination of the entire receiver, it is evident that there are four stages. V1 operates as an R.F. amplifier. V2 consists of a detector and audio amplifier, V3 is a power amplifier to supply power to a loud-speaker. Consequently the entire circuit adds up to a T.R.F. receiver of four stages: one R.F. amplification, one detector stage, one audio stage, and a power stage. This should be seen at the first glance.

Now to consider the details, we may commence with the aerial. This is shown as grounded through a coil. The aerial is, therefore, of the Marconi type. If a different type of aerial was coupled to the receiver input without being grounded, it would be some type of Hertz antenna. Secondly, the aerial is coupled to the receiver through an untuned coil. This is called aperiodic coupling, that is, untuned. L and L1 form an R.F. transformer as the two windings are inductively coupled and there is transfer of energy without direct connection between the windings. So much for the aerial circuit.

V1 operates as an R.F. amplifier. and amplifies the R.F. signals received, the resonant frequency of L1 C1 being the same as that of the station received. A fixed minimum bias is provided by R3. The bias may be increased by manual control of R1, the gain of the stage falling as R1 is increased. The plate of V1 works into L3 and transfer of energy in the plate circuit, to the next stage, is effected by the transformer action of L3 L2. Plate and screen circuits are de-coupled from other stages by the de-coupling filters R4 C4 and R5 C5. There is, therefore, no direct connection, with respect to R.F., to other stages, and the stage is isolated except for the common B+ and B— lines.

V2 Consists of a Grid Leak Detector and an Audio Amplifier.

Description of Operation of V2.

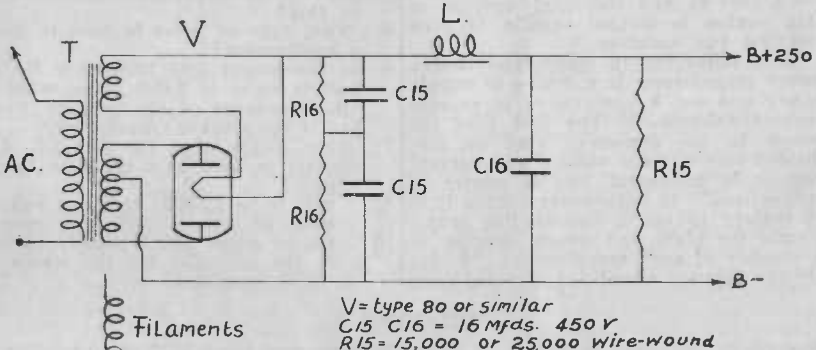
V2 is a multiple tube, being a dual triode assembly, both units being distinct but having a common cathode. The grid of one triode is connected to the tuned circuit of L2 L3, for radio frequencies, by a small mica condenser C6, and to the cathode through the grid-leak R6. The stage operates as a grid-leak detector, audio voltages appearing across the plate load R9. A large condenser C9 couples the detector output to the grid of the next stage for audio frequencies. Any residue R.F. in the plate circuit is filtered out by the high-frequency filter R.F.C. and C8. The radio frequency choke opposes high frequencies which are coupled to the cathode and ground by C8, which has low reactance at radio frequencies.

The third stage consists of the second triode section of V2 which operates as an audio amplifier. The grid is connected through the grid-leak R8 to the ground end of the cathode resistor R7, and bias for the grid is provided by the voltage drop across R7. Audio voltages are applied to the grid through the coupling action of C9 and are amplified in the plate circuit. A load is provided for the plate by the load resistance R12, and the amplified voltages across R12 are applied to the grid of the next stage by the coupling effect of C12 which has low reactance at audio frequencies. Each triode plate circuit is de-coupled from other stages by a de-coupling filter: R10 C10, and R11 and C11. Both stages are, therefore, isolated from others except for the common B supply line, and coupling is restricted to the effect of the coupling condenser in each case. In practice R5 and R11 C11 are sometimes omitted. Greater stability witih less noise is obtained with full de-coupling, particularly in the case of short-wave receivers.

The fourth stage is one of power amplification. As power is necessary to drive a loud speaker, V3 must, therefore, be a power amplifying valve drawing comparatively heavy current. When audio voltages are applied to the grid the valve delivers power in the plate circuit to the load presented across the primary of the speaker transformer. The latter, like all audio transformers, is "iron-cored." To be more exact it has a core built up of laminations of stalloy, etc. The purpose of the core is to increase the density of the magnetic field about the primary so that coupling efficiency may be high. The ratio of the number of turns in the secondary to the number in the primary winding is such that the voice-coil impedance of the speaker is reflected across the primary as an apparent load of the correct load impedance for the valve. It is characteristic of a pentode working into an inductive load, that amplification rises with the higher frequencies, producing excessive high note response. R14 C14 form a corrective filter which causes the very opposite effect. That is it reduces amplification at the higher frequencies so off-setting the effect of the inductive load. If R14 is made variable, an efficient tone control is available.

POWER SUPPLY.

T is a power transformer having a certain amount of power in the primary winding owing to the flow of alternating current. The power in the primary is transferred to the secondary by electromagnetic induction. There is some loss in the transfer and the remainder may be sub-divided into three sections as shown. That is, one winding supplies power to the rectifier filament, a second supplies power to the total parallel connection of the receiver valve filaments, and the third supplies power for the plate and screen circuits.



V= type 80 or similar
C15 C16 = 16 Mfds. 450 V
R15 = 15,000 or 25,000 wire-wound
R16 = 250,000. ohms 1 watt.

The rectifier is a double-diode and is used as a full-wave rectifier, each plate operating on alternate half-cycles of the induced AC present in the secondary. The coil and condenser assembly forms a filter to smooth out the ripple. The input shows two electrolytics in series—this raises the working voltage to withstand peaks, which rise to 50% more than the average value. Resistors R16 serve to divide the total voltage in the system equally so that one-half is applied to each condenser, thus assuring comfortable working conditions and long life.

L may be a choke or a speaker field used as a choke. The inductance of L opposes changes in current, the input capacity C15 is large, and the ripple frequency (usually 100 c.p.s.) is by-passed back to the source. C16 acts as a reservoir charging up to peak values, and discharging as the voltage falls, thus helping towards a steady supply. R15 is a bleed resistor which draws a steady small current.

The bleed resistor warrants a full-length article, but it may be taken for granted as highly desirable for many reasons. With a rectified and filtered voltage as shown it could consist of three 1 watt carbon resistors of 10,000 ohms each connected in series. The wattage across each would approximate two-thirds of a watt. If it is desired to obtain voltage for the R.F. amplifier screen from the bleed resistor, it would be preferable to use four 10,000 ohm one-watt resistors in series, and connect the screen to the 20,000 ohm point which must be by-passed by a .25 or .5 mfds. condenser. The positive half of the resistor combination will then carry the screen current as well as the bleed current and the total wattage in this section is divided equally between the first two resistors.

It is important to understand that a power transformer is a device to supply power and not a contraption to provide various voltages. The fact that the power in the secondary may be subdivided into various voltage and current ratings is incidental, and a matter of convenience. In high-power outfits it is customary to use a two-winding transformer for plate and screen circuits, or a number of such transformers. Power for the filament circuits is obtained from a separate transformer with suitable windings or from a number of such transformers. The power rating of a transformer is an over-all rating and must not be exceeded. For cool operation it is desirable to use a transformer with slightly higher current rating than the total current required.

Note.—The student is referred back to the Tuner Circuit of Chapter VIII. The addition of the power amplifier and power supply just described would furnish a complete 4-valve receiver design entirely adequate for local station reception. It is recommended that the complete circuit be drawn and checked against the originals.

Questions.

1. What is the distinguishing feature of a T.R.F. receiver?
2. What is an R.F. transformer?
3. Should the grid of a grid-leak detector be connected to ground?
4. A low capacity condenser must be used to by-pass or to pass on radio frequencies.
   A higher capacity must be used to pass on or to by-pass audio. Why is this?
5. What type of valve is used to drive a loudspeaker?
6. If the proper load impedance for an output valve is 7,000 ohms, what is the impedance of the primary winding of the speaker transformer?
7. What occurs when the field-coil of a speaker is used as a choke in the B supply?
8. Would it be feasible to use a voltage divider of two 10.000 ohm carbon resistors across the B supply to furnish the potential for the screen of an R.F. amplifier?

CHAPTER X.

Super-hets.

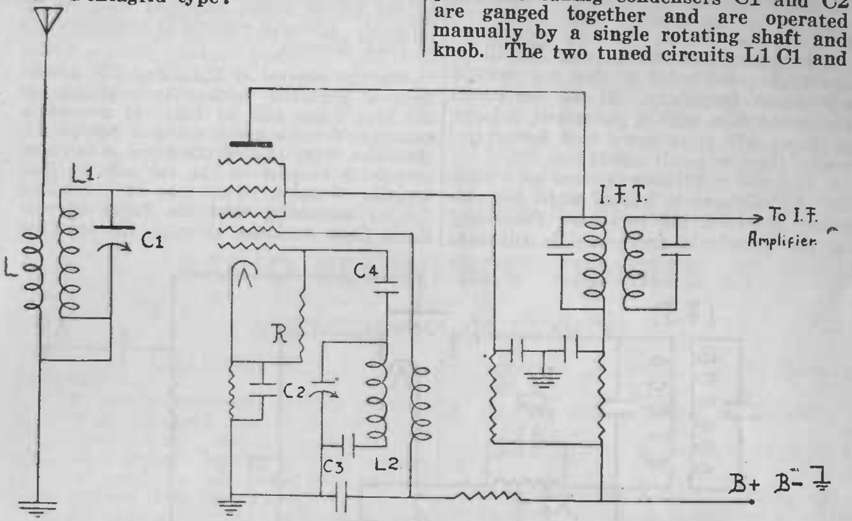
All radio receivers may be broadly classified as being either of the Tuned Radio Frequency or the Super-heterodyne type. The essential distinction is that of the frequency at which the major part of the radio-frequency amplification is effected.

In a T.R.F. receiver all R.F. amplification is effected at the frequency of the particular station tuned in. It thus becomes necessary to employ a number of tuned circuits, which must all be adjusted simultaneously to resonance at the same frequency, if adequate selectivity is desired. In practice, it is difficult to keep a number of tuned circuits in line at all frequencies when using a single manual tuning control. This difficulty is largely overcome in super-heterodyne design. The correct term is super-sonic heterodyne and means above-sound different forces.

In a super-het. receiver, broadcast frequencies are converted to a lower radio frequency which is always the same. It thus becomes possible to use a number of tuned circuits all tuned permanently to the new frequency which is the well-known intermediate frequency. The result is that I.F. tuned circuits after initial adjustment, require no further attention. If the main R.F. amplification takes place at the fixed intermediate frequency, there are fewer tuned circuits to be varied manually and kept in line. In addition, higher gain with better stability results from amplification at the lower frequency. Important advantages are, thus, better selectivity and higher sensitivity.

To produce the lower intermediate frequency, a frequency is generated in the receiver by an oscillator valve. This frequency is beaten against or mixed with the frequency tuned in, and a third frequency is produced which becomes the intermediate frequency. It is usual to employ a multiple unit valve which may be used to produce the required oscillator frequency and mix this frequency with the broadcast frequency being received. The plate circuit of this mixer-oscillator may then be tuned permanently to the intermediate frequency while the control grid is tuned manually to the broadcast frequency.

Let us examine a mixer-oscillator valve of the Pentagrid type:



Close to the cathode are placed two grids, the first being the oscillator grid. The second is the oscillator anode-grid, which serves as a plate. This section of the valve may therefore be used as a Triode oscillator. As the oscillator plate is inductively coupled to the grid circuit, feed-back takes place, and the triode oscillates steadily at the resonant frequency of L2 C2. A grid leak and condenser are provided by R and C4. The frequency of the oscillations may be varied by adjustment of C2.

The mixer section consists of control grid, screen grids and plate. The control grid is tuned to the incoming broadcast frequency by L1 C1. As a result two different frequencies (oscillator and broadcast) affect the electron stream from cathode to plate. Four principal frequencies, accordingly, appear in the plate circuit. If the broadcast frequency tuned in is 1000 kcs. and the oscillator frequency is 1465 kcs., two frequencies are produced in addition to the two original frequencies. One of these heterodyne frequencies is the sum of the two frequencies affecting the electron stream = 2465 kcs. The other is the difference between the two original frequencies = 465 kcs. The plate circuit is tuned to the latter frequency which becomes the intermediate frequency. Rejection of the unwanted frequencies is effected by a series of I.F. tuned circuits, and one or more stages of amplification at the intermediate frequency may be employed. Ultimately, rectification and demodulation are effected by a detector valve, and the remaining audio frequencies may be amplified for loud-speaker results.

The effect of the padder condenser C3 may now be considered. In the first place the tuning condensers C1 and C2 are ganged together and are operated manually by a single rotating shaft and knob. The two tuned circuits L1 C1 and L2 C2 are thus adjusted simultaneously, both tuning condensers having the same capacity. The difference or intermediate frequency must be kept the same at all points within the tuning range. A difficulty immediately arises, as the difference frequency will not be the same at both high and low frequency ends of the tuning ranges. This trouble is caused by the tuning ratio of the tuned circuits.

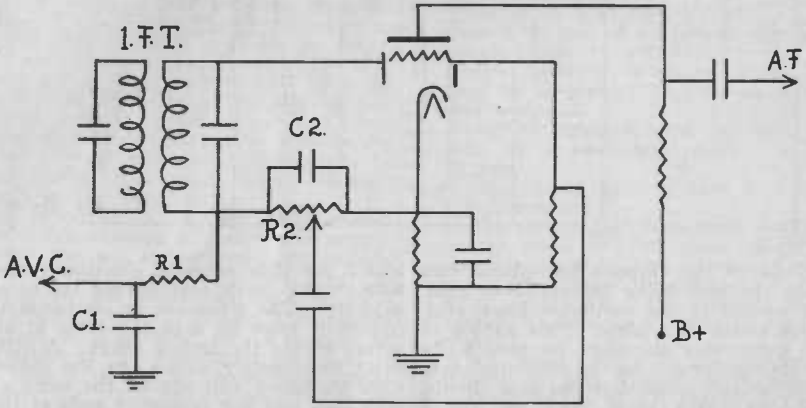
To take a concrete example, the tuning range of a broadcast receiver is approximately from 500 to 1500 kcs. This represents a tuning ratio of 3 :1. Now if reception ends at 1500kcs. the oscillator frequency at this point on the dial must be 1965 kcs. if the I.F. transformers are tuned to 465 kcs. Therefore the maximum oscillator frequency is 1965 kcs. If we apply the normal tuning ratio of 3 :1 the minimum oscillator frequency becomes 655 kcs. the difference frequency being 655-500 kcs. = 155 kcs. This will not do at all as the difference frequency must be 465 kcs. to coincide with the frequency of the I.F. transformers. Also this difference must remain constant at all points on the dial. The problem is, therefore, to reduce the oscillator tuning range so that the minimum oscillator frequency is 965 kcs., which gives the required difference of 465 kcs. This is accomplished by connecting a padder condenser in series with the oscillator tuning condenser. The result is that the minimum capacity of C2 is very little effected but the maximum capacity of this condenser is reduced. The lowest resonant frequency of L2 C2 will be higher on this account. Referring to the formula for the resonant frequency of an L.C. circuit, we find that $F = \frac{1}{2\pi \sqrt{L \times C}}$

If L remains at a constant value and C is reduced, then the answer F will be a greater number of cycles per second or a higher frequency. It will be found in practice that with a given coil, a large condenser will tune down to a lower frequency than a small condenser.

A variable condenser is used as a padder. Adjustment is varied until the difference between the oscillator frequency and the broadcast frequency is substantially the same at all points on the dial, and corresponds with the resonant frequency of the I.F. Transformers. The padder is left at the correct adjustment and need not be varied until or unless the receiver needs re-aligning after a period of use.

The other principal feature of the usual super-het. receiver is the provision of automatic volume control. The normal manual volume control operates at audio frequencies after rectification and demodulation of the modulated R.F. wave. As strength of reception varies considerably from station to station, the rectifier audio voltages vary accordingly, and tuning would necessitate simultaneous control of both tuning and volume. To obviate this, and to provide steady signal input to the detector valve, automatic volume control regulates the gain of R.F. and I.F. amplifiers. This is accomplished by automatic reduction of gain when strong signals are tuned in.

Let us consider a simple A.V.C. circuit:



The secondary winding of the I.F. transformer is connected to the diode plate. The diode rectifies on positive half-cycles of the incoming radio frequency A.C. Radio frequencies are bypassed by C2 and varying audio voltages are developed across R2. If the diode load resistor R2 takes the form of a volume control, audio input to the grid of the triode audio amplifier may be regulated. Efficient control of audio volume is thus effected.

For the control of R.F. and I.F. amplifiers a negative voltage is available at the left hand end of R2. If a certain number of volts are developed across R2, then the diode end of the resistor is negative with respect to the cathode by that number of volts. This may be accounted for by assuming that the diode current flows from cathode, through the load resistor R2 and I.F. secondary to the diode plate. The negative voltage thus available will vary at audio frequencies. As we intend to apply this negative voltage to the grids of I.F. and R.F. amplifiers, the variation in the voltage must be reduced so that audio frequencies are not applied to R.F. grids. This is accomplished by the A.V.C. filter R1 C1, which is so proportioned that the negative potential varies at a frequency of about 10 cycles per second, which is below audibility. The action of the filter comes about through the discharge rate of C1, which is regulated by the RC combination. When building from published circuits it is, therefore, advisable to use the specified values for all resistors and condensers in the A.V.C. circuit.

It will be noticed that, in published circuits, the diode plates are connected in various ways. The two plates may be simply connected together, or alternatively, one plate may be used for detection and the other for A.V.C. In this case, the A.V.C. diode may be fed with R.F. through a condenser, from either the primary, or the secondary of the final I.F. transformer. The object in all cases is to cause a flow of current when positive half-cycles act on the diode plate. It will be appreciated that the stronger the signal input, the greater the voltage developed across the rectifier load resistor and the A.V.C. load resistor. This will apply whether these two resistors are identical or independent. As a result heavy signals produce heavy A.V.C. voltages. When the A.V.C. negative voltage is applied to the grid of a variable-mu amplifier, the gain of the amplifier falls. The heavier the negative voltage, the greater is the reduction in gain. Therefore the gain is reduced for strong stations, and an average signal input to the rectifying diode is maintained.

Questions.

1. What is the distinctive feature of a super-het. receiver?
2. What is meant by the difference frequency?
3. Why are four main frequencies present in the plate circuit of a mixer-oscillator?
4. Which is the Intermediate Frequency?
5. For correct operation, a padder condenser is wired in the oscillator tuned grid circuit. What effect has the padder?
6. What is the general effect of A.V.C.?
7. Why is A.V.C. desirable?
8. A.V.C. is efficient with certain valve types and not with others. Why?

RADIO BEGINNERS' COURSE

ANSWERS TO QUESTIONS

CHAPTER I.

Answers:

1. A simple electrical circuit consists of an electron source, an electron-moving force, and a conductor.
2. In a circuit having a fixed voltage or e.m.f., a conductor will permit current flow through it.
   An insulator will not pass current at the pressure or voltage employed.
3. The insulating material must withstand the applied voltage. High voltages require special insulating materials.
4. (a) The current in amperes in a direct current circuit is governed by the resistance in ohms and the e.m.f. in volts.
   (b) $1 = \frac{E}{R}$
5. A resistance may be used in series in the circuit, or resistance may be connected in series across the supply, that is from positive to negative. The latter case is that of a voltage divider, and increasingly lower voltages are available from the positive end down to the negative end. This is illustrated in the diagrams.
6. .033 amps., or 33 milliamps.
7. $I = \frac{E}{R}$ $E = IR$ $R = \frac{E}{I}$
   The key is $\frac{E}{IR}$ Whichever letter is taken away from this fraction equals what is left.
8. The Ohms Law formulae are used to calculate current, resistance, or voltage dropped across a resistance, in D.C. circuits, or with rectified and filtered supplies.

CHAPTER II.

Answers.

1. When current flows through a resistance, power is developed, and the power is dissipated in the form of heat.
2. (a) The unit of power is the watt.
   (b) $P = 1^2R$, $P = \frac{E^2}{R}$, $P = E \times I$.
3. Any radio component is designed to dissipate a maximum number of watts. Too many watts means over-heating.
4. If a component overheats, either too much current is flowing or the resistance is too high. Either condition causes high wattage and excessive heat. Alternatively, a component of higher wattage rating may be employed.
5. The magnetic field around a conductor may be intensified by winding the conductor to form a coil. This intensifies the lines of force in the area of the field.
6. When an iron core is inserted in a coil the magnetic field is further intensified.
   The permeability of the core multiplies and intensifies the lines of force.
7. (a) $R = R1 + R2$.
   (b) $\frac{1}{R} = \frac{I}{R1} + \frac{1}{R2}$
8. (a) Total resistance is 1000 ohms plus the resistance of the parallel combination. Result 6000 ohms.
   (b) Total current depends on total resistance and total voltage. Result .016 amps., or 16 milliamps.
   (c) Voltage at X is 100 volts, less the drop across the parallel resistors. X is 20 volts positive with respect to Y. (Exact answer=16.6 volts.)

It should be noted that the total current divides equally between R2 and R3 (equal resistances) and each resistor carries 8 milliamps.

CHAPTER III.

Answers.

1. (a) The farad.
   (b) The micro-farad (mfd.) which is .000001 farad.
2. A condenser consists essentially of two plates separated by a dielectric.
3. (a) Lower capacity.
   (b) Higher capacity.
4. (a) Series connection raises the total working voltage above that of a single condenser.
   (b) The working voltage of a parallel combination is that of the lowest rated condenser employed.
5. (a) Series capacity $\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2}$
   (b) Parallel capacity $C = C1 + C2$
6. Connect in series. The total capacity becomes 833 mmfds.
7. The total minimum capacity is higher than that of either condenser. The total maximum capacity may be gradually increased from minimum to a maximum of the sum of the individual capacities.
8. (a) With constant voltage a condenser charges up and remains charged.
   (b) When the applied voltage varies, a condenser charges up to peak value and discharges as the voltage falls.

CHAPTER IV.

Answers.

1. DC flows in one direction at constant strength. AC varies in strength and direction periodically.
2. AC voltage is rated, unless otherwise stated, at the effective (E eff) or root-mean-square (r.m.s.) value.
3. AC effective voltage causes a current flow with the same heating effect as DC voltage of the same value.
4. The number of cycles per second or c.p.s.
5. Alternating current.
6. (a) Audio frequencies or A.F.
   (b) Radio frequencies or R.F.
7. Audio frequencies are super-imposed on a carrier wave of constant radio frequency. The process is called Modulation.
8. Any LC circuit has a resonant frequency. That is, the flow of current at one particular frequency, according to the value of L and C, is at maximum.

CHAPTER V.

Answers.

1. Because of its property of resisting changes in current.
2. Reactance—either Inductive or Capacitative.
3. Impedance is the total opposition to changes in current in an A.C. circuit containing capacity and/or inductance.
   Impedance $Z = \sqrt{R^2 + X^2}$. Where R is resistance in ohms and X is reactance in ohms, Z = impedance in ohms.
4. Reactance varies with changes of frequency thereby affecting impedance.
5. Capacitative reactance lessens as frequency increases. Inductive reactance rises as frequency rises.
6. Higher capacity will pass frequencies lower than intended by the circuit designer.
   Lower capacity will discriminate against lower frequencies intended to be passed on, on account of higher reactance at low frequencies.
7. Inductive reactance rises with frequency. If the frequency is high, a low inductance still offers high impedance. At low frequencies XL is low as $XL = 2\pi fL$. The inductance must be increased to provide high reactance.
8. In both cases the aerial is loosely coupled to the tuned circuit. Loose coupling improves selectivity.

Note: The student should consider the answers concerning reactance in conjunction with the appropriate reactance formulae to simplify understanding.

CHAPTER VI.

Answers.

1. Rotation of the shaft of a variable condenser rotates the moving plates. As a result, the moving plate area opposite the fixed plates is altered, and the capacity of the condenser is changed.
2. If a station is broadcasting at the same frequency as the resonant frequency of the tuned LC circuit, current flow at that frequency is maximum. The station comes in strongly by comparison with other stations which are weakened, because current flow at other frequencies is very low.
3. Rectification to uni-directional current. De-modulation, or removal of R.F. variations from the carrier wave.
4. A crystal detector, or a valve detector.
5. A diode rectifies because current flow occurs only when positive signal voltages are applied to the plate.
6. Varying current through the load resistor causes varying voltages across it.
7. The grid-leak detector acts as a detector at radio frequencies, and amplifies the rectified audio voltages. The diode rectifies but does not amplify.
8. A triode amplifies by reason of the fact that small voltages applied to the control-grid causes a much greater varation in plate current than if the same voltage were applied to the plate. There are, therefore, larger voltages developed across the load resistance than those impressed on the grid.

CHAPTER VII.

Answers.

(a) A diode has two electrodes—plate and cathode.
(b) A Triode has three—Cathode, Grid, Plate.
(c) A Tetrode has four—Cathode, Grid, Screen, Plate.
(d) A Pentode has five—Cathode, Grid, Screen, Suppressor, Plate.

2. The Screen Grid reduces inter-electrode capacity between plate and control grid. Also a positive voltage may be applied to the screen, thus increasing the electron stream and giving greater control to the grid.
3. Secondary emission electrons are knocked off the plate by the impact of the electron stream and are attracted back to the screen. A loss to the plate circuit results. A Suppressor Grid is inserted between screen and plate and is connected to the cathode. The Suppressor is thus at zero voltage or at a low positive voltage, and has little or no attraction for the free electrons.
4. The Pentode is more efficient than the Triode because a small voltage applied to the control grid causes a greater variation in plate current.
5. At radio frequencies, feed-back from output to input occurs if plate to grid capacity is high. The feed-back is regenerative and causes instability. The inter-electrode capacities of a Pentode are lower than in a Triode.
6. Plate and grid circuits differ in phase by an angle of 180%. The plate circuit is 180% out of phase with the grid circuit.
7. Regeneration is effected by feeding back energy to the input circuit. If the energy fed back arrives in the input in phase with the input, the result is an increase in signal strength. The effect is regenerative.
8. If one frequency beats with another, a third frequency is generated. This is the heterodyne frequency and is equal to the arithmetical difference between the original frequencies.

CHAPTER VIII.

Answers.

1. The grid is biassed by the amount of voltage difference between grid and cathode.
2. Grid bias is essential to set the initial plate current at the correct level.
3. The positive terminal of a C battery is connected to the cathode and the proper negative voltage is applied to the grid.
   The use of a cathode resistor places the cathode at a positive potential with respect to ground. The grid is connected to ground. The voltage difference between grid and cathode provides grid bias.
4. The grid is swung alternately positive and negative with respect to the initial grid biassing voltage.
5. Varying the grid bias of a variable-mu R.F. amplifier varies the gain. As the bias is raised, the gain falls. As the bias is lowered, the gain increases.
6. A stage is uncoupled or de-coupled when varying R.F. or A.F. voltages are held within the stage circuit.
7. The penetration, through the common power supply line, of R.F. or A.F. voltages from one stage to another constitutes unwanted coupling between stages. Coupling of this nature causes degeneration with loss of gain, or regeneration with instability.
8. The initial plate current of a biassed detector is almost zero. Positive signals cause an increase in the plate current. Negative signals reduce it to zero, which is a very slight alteration from the original value. Rectification is not complete, theoretically, but gives practical results.

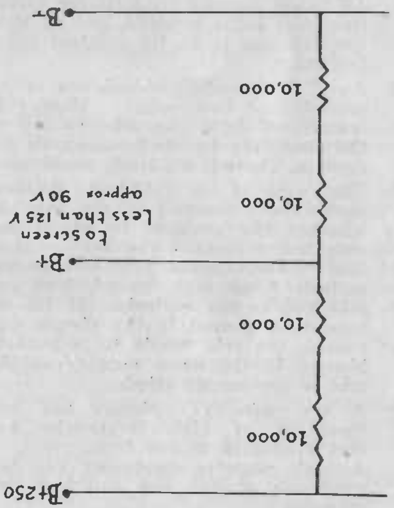
CHAPTER IX.

Answers.

1. All tuned circuits are adjusted to the frequency being received, and all R.F. amplification is at the original radio frequency.
2. An R.F. transformer consists of an assembly of two coils. Energy is transferred from the primary coil to the secondary by electro-magnetic induction. There is no direct connection.
3. The grid of a grid-leak detector should be connected to the cathode, whether the cathode is at ground potential or not. · The D.C. connection is through the grid leak to the cathode, or through the grid leak and grid coil to the cathode. If R6 returned to ground in the circuit discussed, the grid would be negatively biassed in the same manner as the grid of the second triode.
4. A low capacity condenser has low reactance at high frequencies, and high reactance at low frequencies.
   A high capacity condenser has low reactance at both low and high frequencies.
5. A power amplifier is necessary to drive a loud-speaker. Power is needed for speaker operation.
6. Assuming that the receiver is not in operation. and that the primary of the transformer has an inductance of 10 henries, then the impedance at 400 cycles would be $2\pi fL = 6.28 \times 400 \times 10 = 25,000$ ohms approximately. The resistance is low and may be disregarded for approximate calculation.
   If the receiver is in operation, then the voice coil of the speaker has an impedance at 400 cycles which is re-

flected across the primary as an apparent load of 7,000 ohms for the plate of the valve.

7. (a) There is a drop in voltage according to the amount of current and the resistance of the field coil. E = IR.
   (b) Power is dissipated in the field coil according to the current and the resistance of the field. $P = I^2R$.
   (c) A magnetic field is set up around the field coil, owing to the flow of current through it. This energises the speaker.
   (d) The field coil acts as a choke. Its inductance opposes changes in the current through it. This helps to smooth the pulsating rectified D.C.
8. The resistors would not be suitable. With a supply of 250 volts, the wattage across one would be over $1\frac{1}{2}$ watts. The other would dissipate over 2 watts. Wire wound resistors would be necessary on account of their higher current or wattage rating. Alternatively, four carbon resistors could be used as indicated.



CHAPTER X.

Answers.

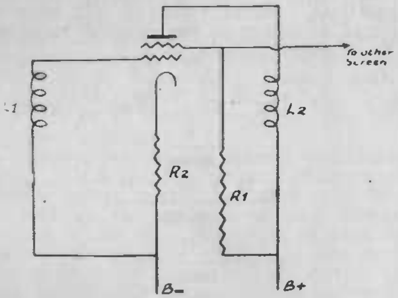
1. In a super-het. the broadcast frequency is converted to a lower frequency before being applied to the detector valve.
2. The difference frequency in a super-het is the difference between the broadcast frequency and the oscillator frequency.
3. Two original frequencies, the broadcast frequency and the oscillator frequency are mixed in the valve. As a result four principal frequencies appear in the plate circuit. These are (1) The broadcast frequency. (2) The oscillator frequency. (3) The sum of the broadcast and the oscillator frequencies. (4) The difference between the broadcast and the oscillator frequencies.
4. The intermediate frequency is the resonant frequency of the I.F. Transformers. This resonant frequency corresponds arithmetically with the difference frequency.
5. The padder reduces the tuning range of the Oscillator tuned circuit, so that the difference frequency may be the same at all points on the dial. As a padder is in series with the Oscillator tuning condenser it progressively reduces the capacity of the tuning condenser as the latter is advanced from minimum capacity to maximum.
6. The general effect of AVC is to reduce the RF and IF gain on strong signals.
7. AVC is desirable to maintain a constant signal input to the detector valve. This minimises use of the audio frequency volume control.
8. An AVC circuit provides additional negative bias for the grids of RF and IF amplifiers, to reduce the gain when strong stations are tuned in. The RF and IF amplifiers so controlled must be of the variable-mu type. This type is expressly designed so that variations in grid bias cause variations in stage gain, heavy negative bias effecting low gain per valve.

CHAPTER XI.

THE PRACTICAL USE OF RESISTORS AND CONDENSERS.

The practical effect of resistance in an electrical circuit is that some of the volts are used in forcing a flow of current, and we say that there is a voltage drop across the resistance. When constructing a receiver, low resistance copper wire is used in circuits where it is desired to maintain the voltage, as far as possible, without appreciable loss. In other circuits in the receiver it is necessary to use lower voltages to comply with valve requirements. In such circuits suitable values of resistance, generally in the form of carbon resistors, are used to drop the voltage to the required value. It will be found that in practically every application of resistance in receiver design, a drop in voltage takes place, whether such voltage drop is the primary purpose of the resistor, or not. In order to use resistors intelligently, it is essential to be able to calculate the value of resistance required, or the voltage drop across a particular resistor. Voltage drop may be calculated from E=IR. For the purpose of this formula, E represents the number of volts dropped, I is the current in amperes or the decimal part of an ampere, and R is the resistance in ohms.

Let us examine the following circuit :—



It will be seen that a positive voltage is applied to the plate of the tube through a coil L2. If the current in the plate circuit is 8 milliamperes, the voltage drop across L2 is E=IR=.008 R. If the resistance of L2 is 100 ohms, then E=IR=.008 × 100=.8 volt. Therefore the 250 volts positive has been retained at maximum for all practical purposes.

To evaluate the optimum value of RI it is necessary to refer to the recommended value of voltage and current for the screen circuit. If these are stated as 100 volts and 2 mills. respectively, the calculation becomes E=IR

$$\therefore R = \frac{E}{I} = \frac{150}{.002} = 75{,}000 \text{ ohms.}$$

Accordingly 150 volts are dropped across the 75,000 ohms, 100 volts are applied to the screen, and the current in the screen circuit is 2 mills., which is the correct value.

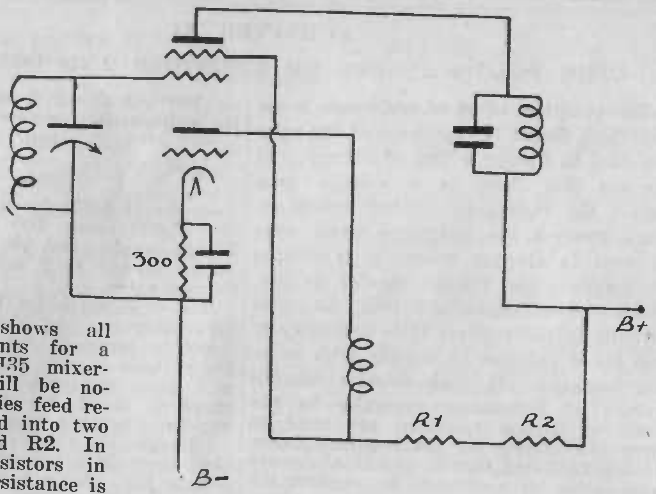
The calculation for R2 is done in the same manner. As the cathode is the negative terminal for the entire tube, the cathode current is the sum of screen and plate currents = 10 mills. If we check up on the recommended grid voltage for the grid and find that this is — 3 volts, the value of R2 must be such that there is a voltage drop of 3 volts across R2. As a result the grid is 3 volts negative with respect to the cathode. Actually the cathode will be 3 volts positive, and the grid will be at zero voltage. In any case the necessary voltage difference between grid and cathode is fixed by using the proper value for R2:—

$$R = \frac{E}{I} = \frac{3}{.01} = 300 \text{ ohms.}$$

The net result, then, of the circuit arrangement is that plate, screen, and grid are all at correct operating voltages. This desirable effect has been secured by choice of the proper values of resistance in each circuit, and a knowledge of their function in each case. So there is something in Ohms Law, E = IR.

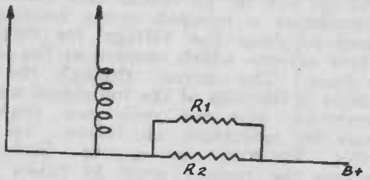
Arranging voltages by the means described is known as the series feed method. That is, the dropping resistor is connected in series with the maximum voltage and the particular tube electrode. Sometimes a common series resistor is used to drop the voltage for two or three screens which operate at the same voltage. The current through the resistor is the sum of the individual screen currents, and the resistance required may be calculated as before. In this case, however, the power dissipated across the resistor must be taken into account. This may be calculated from $P = I^2R$. That is, Power in Watts= amperes squared x ohms. If a total of 5 mills is flowing through a resistance of 30.000 ohms to give a drop in voltage of 150 volts, then P = .005 × .005 × 30,000 = .000025 × 30,000 = .75 watt. A resistor of genuine one watt rating will be necessary for this application.

Resistors may be used in a series connection or in parallel to give certain total amounts of resistance. Series connected resistors are shown in the following circuit :—



The design shows all voltage adjustments for a 6K8 or an ECH35 mixer-oscillator. It will be noticed that the series feed resistance is divided into two resistors, R1 and R2. In every case of resistors in series the total resistance is the sum of the resistors employed. It should not be assumed that the example is merely that of using resistors which may be on hand. The proper resistance for the 6K8 is 15,000 ohms, and total current through the resistor is about 10 mills. Power $= I^2R = .01 \times .01 \times 15{,}000 = .0001 \times 15.000 = 1.5$ watts. To use a half-watt resistor or a one-watt type would be simply asking for trouble. A single three-watt 15.000 resistor would be necessary, two good one-watt 7,500 could be used, or three 5,000 ohm one watters. In the two latter cases, the wattage is divided equally between the resistors employed the power in each case being $P = 1^2R$.

An alternative method would be to use suitable resistors in a parallel circuit. In such case the RIR2 circuit becomes :—



The calculation of total resistance is entirely different from that of a series assembly. Total resistance R is evaluated from $\frac{I}{R} = \frac{I}{RI} + \frac{I}{R2}$

This is a simple calculation and should not be shirked, familiarity with the formula being absolutely essential. If two 30.000 ohm resistors were used in parallel, the total resistance would be 15,000 ohms. This may be proved by the formula :—

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} = \frac{1}{30{,}000} + \frac{1}{30{,}000} = \frac{2}{30{,}000}$$

$$R = \frac{30{,}000}{2} = 15{,}000 \text{ ohms.}$$

It will be noted that the total resistance is one-half of that of one resistor if the two resistors are identical. In the same way, if three identical resistors are in parallel, the total resistance is one-third. The wattage, in both cases, is divided evenly between the resistors employed. This comes about because the total current divides equally between identical parallel resistors. It may be found necessary to use unequal resistors. An example follows :—

$$\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} = \frac{1}{40{,}000} + \frac{1}{50{,}000} + \frac{1}{60{,}000}$$

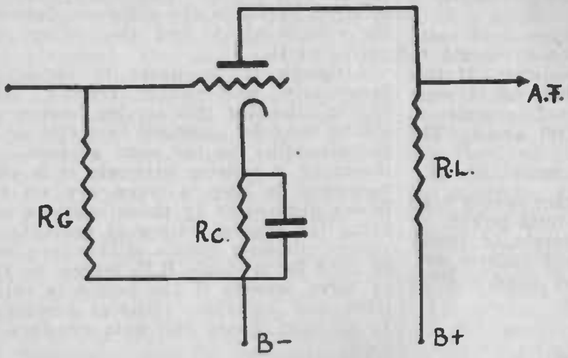
$$= \frac{15 + 12 + 10}{600{,}000}$$

$$= \frac{37}{600{,}000}$$

$$\therefore R = \frac{600{,}000}{37} = 16{,}216 \text{ ohms}$$

The total resistance is a trifle high, but will result in only a slight additional drop in voltage. While on the subject of converter tubes it is as well to mention that the proper dropping resistor for the screen and oscillator anode of an ECH35 is 20,000 ohms. Current flow in the series feed circuit is lower and the resistance must be increased to drop the necessary number of volts. The wattage is approximately 1 watt; too much for a 1 watt resistor.

If we understand that, when current flows through a resistor, voltage is dropped, then it follows that, if the current varies, then the voltage drop also varies. This is the basic principle of resistance coupled amplifiers.

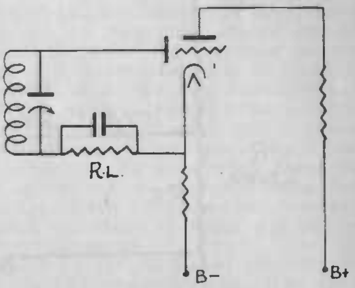


In the above circuit the first resistor to consider is Rg. This is the grid leak and its functions are to return the grid to a point in the circuit which is negative with respect to the cathode, and also to furnish a path by which any electrons trapped on the grid may leak away to the cathode return circuit. The value of this resistor is usually from 250,000 ohms to 1 megohm. The higher value gives greater sensitivity, but the lower value has important advantages. Often a value of 500,000 ohms is used, and will generally be found suitable.

The cathode resistor Rc fixes the amount of voltage difference between grid and cathode as already described. The grid is, accordingly, biassed negatively with respect to the cathode, and the amount of voltage drop becomes the negative grid bias.

Resistor RL merits careful consideration. When the tube is in a static condition before signal voltages are impressed on the grid, there is a steady voltage across RL. However, as soon as signal voltages are applied to the grid the plate current of the tube varies in accordance with the varying signal voltages. The result is that the voltage drop across RL varies as the flow of current through it fluctuates. The effect is described by saying that voltages are developed across RL which are similar to the signal voltages impressed on the grid. Owing to the ability of the tube to amplify, the voltages across RL are larger than those impressed on the grid. Amplification has been effected, and the amplified signal voltages may be coupled to another circuit. The function of RL is to provide a load for the tube to work into, and it is referred to as the Load Resistance, or sometimes as the Plate Load. An important effect of RL is that Tube Manual operating conditions which apply when there is a positive voltage of 250 volts on the plate are completely invalidated on account of the drop in D.C. voltage across RL. Data for resistance coupled amplifiers should, therefore, be taken from the charts available for this service, or the value of components in published circuits should be adhered to.

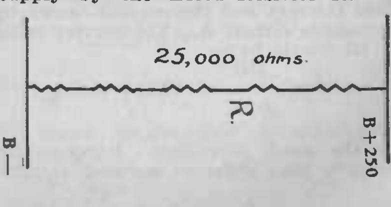
So far, we have discussed the use of a resistor to provide a load for the plate circuit of a tube. Another important instance of the use of a resistor as load resistance occurs in the conventional diode detector circuit.



The diode circuit is from cathode through RL and L to the diode plate, and voltage variations occur across RL as a result of the varying current drawn by the diode plate when subjected to varying signal voltages. Suitable values for RL are from 250,000 ohms to 500,000 ohms.

Any discussion of resistors would be incomplete without some mention of the Bleed Resistor, subject of continually recurring examination questions.

If a resistor is connected across a supply from positive to negative, constant current will flow through the resistor according to Ohms Law. The steady current thus drawn is called the Bleed Current, as it is bled from the supply by the Bleed Resistor R. The



value of this current may be simply calculated:—

$$\therefore I = \frac{E}{R} = \frac{250}{25,000} = .01 \text{ amps.} = 10 \text{ mills.}$$

If we now consider the power dissipation, it is apparent that 10 mills through 25,000 ohms is a bit too much for a carbon resistor.

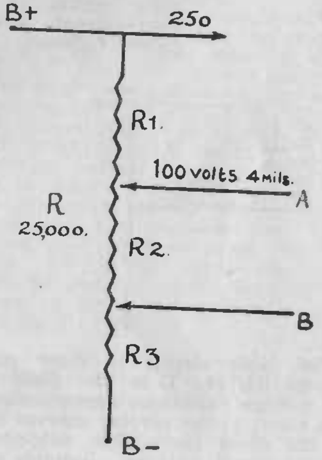
$$P = I^2R = .01 \times .01 \times 25,000 = 2.5 \text{ watts.}$$

The most suitable component would be a 10 watt wire-wound resistor. If this is not available, five 5,000 ohm 1 watt resistors could be connected in series to give a total R of 25,000 ohms. The wattage across each would be:—

$$P = I^2R = .01 \times .01 \times 5000 = .5 \text{ watt.}$$

In other words, the wattage across each resistor is 1-5ths of the total power.

The necessity for a margin of power rating arises when a bleed resistor system is used to supply a fixed voltage lower than the maximum.



The diagram indicates that we start at the negative end with no volts and arrive at the positive end with 250 volts. Accordingly, if some method of dividing the total resistance is devised, reduced voltages will be available at the point or points of division. In this instance the voltages will depend upon the resistances of R1, R2, and R3, and the amount of current through each.

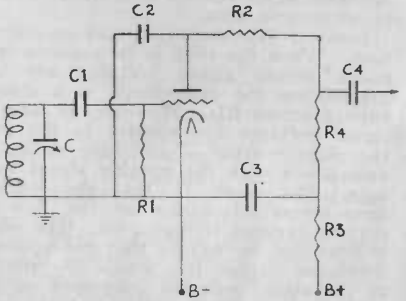
The first consideration is the current through R1. In the example given this becomes 14 mills—the sum of the fixed Bleed Current and the current drawn by the outside circuit A. The correct value for R1 would be:—

$$R = \frac{150}{.014} = 10,714 \text{ ohms.}$$

All resistance calculations would follow the same procedure. Suppose, for example, that different reduced voltages were required at A and at B, then the current through R1 would be the Bleed Current, plus the current to A, plus the current to B. The total current would determine the value of R1 for a required voltage drop at A. The current through R2 is the Bleed Current, plus the current to B. The voltage to be dropped by R2 is the difference between the voltage at A and the voltage required at B.

Although it is usual to employ a heavy-duty wire-wound resistor with sliding clips for this service, carbon resistors may be arranged in series or in series-parallel for the same purpose. In designing a resistor network, it is only necessary to keep a wary eye on the power dissipation in those resistors carrying the highest values of current. A voltage dividing system of this type may be used for a single R.F. screen, or two or three screens if the power is calculated and suitable resistors employed. In no case should half-watt resistors be used.

The use of resistance-capacity combinations necessitates some consideration of Reactance. The term refers to the additional opposition to the flow of current in circuits where constantly varying signal currents circulate. The reactance of a carbon resistor is practically uniform at all frequencies and is substantially the same as the D.C. resistance. On the other hand, a condenser of any type will offer widely differing reactance at different frequencies. The general rule is to use low-capacities for R.F. currents and high capacity in audio circuits. Thus a mica condenser of low capacity may be used for coupling circuits at radio frequencies or to by-pass R.F. from a circuit where it is not desired. These functions are performed by C1 and C2 in the following design.



The LC circuit is coupled to the tube by C1 and radio frequencies are applied to the control grid so that the latter may function as a detecting element. Residue R.F. variations in the plate circuit are opposed by R2 (from 10,000 to 30,000 ohms) and by-passed back to the cathode by C2. A capacity of .00025 mfds. is suitable in both positions as reactance is low at high frequencies. It is also simultaneously high at audio frequencies. It may accordingly be assumed that R.F. is by-passed from the system and audio frequencies retained in both instances. Such, at any rate, is the practical effect.

Condenser C4 serves to couple audio variations across R4 to the next stage, and therefore must have low reactance at audio frequencies. The greater the capacity employed the lower will be the reactance. In practice, condensers of from .01 to .1 mfds. capacity are suitable, the higher value providing increased bass response, and hum-level, which is the same thing. The same considerations apply to conventional tone-control circuits—the higher the capacity employed, the greater the treble attenuation. A value of .02 mfds. is recommended.

The de-coupling filter R3C3 serves to prevent audio frequencies in the system from reaching other stages through the common B+ line. R3 (from 25,000 to 50,000 ohms) offers a high reactance at all frequencies, and C4 by-passes audio variations back to the cathode of the tube. A capacity of .5 mfds. has low reactance at audio frequencies compared with the reactance of R3 and is suitable for this service. It is recommended that the reactance of a de-coupling condenser should be about one-tenth of that of the associated resistor at the lowest frequency to be by-passed. The formula is stated in Chapter IV, and may be worked out at 100 cps. for audio circuits.

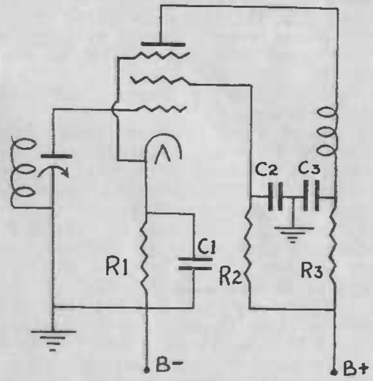
It will be noticed that by-pass condensers C2 and C3 return to the cathode of the tube. This practice is strongly recommended in lieu of indiscriminate ground connections.

The use of condensers in biassing circuits depends upon the frequencies at which the stage in question is operating.

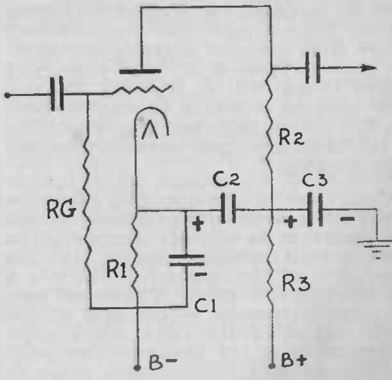
In the first circuit the tube operates as an R.F. amplifier and C1 serves to by-pass the biassing resistor R1 for radio frequencies. The capacity of this condenser must be comparatively high on account of the low resistance of R1, which is usually about 300 ohms. A condenser of .1 mfds. capacity has sufficiently low reactance at high frequencies for this service. Generally, all by-pass condensers in R.F. or I.F. circuits may be of a similar capacity, and .1 mfds. is suitable for C2 and C3 in the de-coupling filters R2C2 and R3C3. For R2 a 75,000 or 100,000 ohms resistor is the usual value, but R3 should not exceed 5000 ohms for the plate voltage for the tube to be maintained at a reasonable level.

Circuit B represents an audio amplifier operating at considerably lower frequencies than the tube in Circuit A. On account of the low frequencies in the system, C1 must be of high capacity for reactance to be sufficiently low to effectively by-pass R1. For this reason an electrolytic condenser of 25 mfds. capacity is usually employed and, as is the case with all electrolytics, must be connected with the negative end to ground. The de-coupling condenser, C2, to have sufficiently low reactance, should not be less than .5 mfds. C3 is rather in the nature of a refinement, but is particularly useful in eliminating instability in a high-gain circuit. An 8 mfds. electrolytic is recommended and will improve the performance of any audio amplifier. This component is practically standard in the circuit of a high-gain amplifier where the latter is connected ahead of the usual one stage of audio and one of power amplification.

The other principal use of electrolytics occurs in the power supply. The type of condenser employed is well known, and it is sufficient to state that a capacity of 8 mfds. ahead of the usual field-coil or choke is suitable, but 16 mfds. is recommended at the output of the filter system.



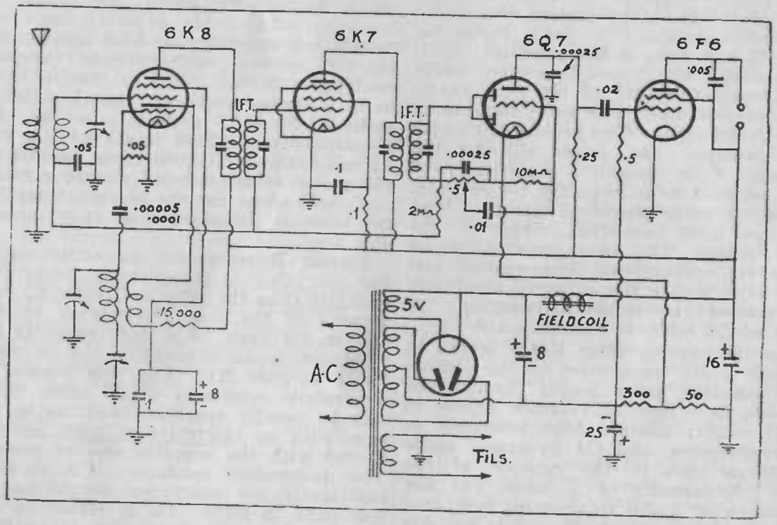
CIRCUIT A.



CIRCUIT B.

CHAPTER XII.

SUPER-HETERODYNE RECEIVERS.



The schematic diagram is that of a simple five valve receiver. So much is evident from the fact that included in the circuit are tuned stages, a diode detector, audio amplifier, power amplifier, and power supply. The receiver type is determined by the two I.F. transformers employed, the use of an Intermediate Frequency being typical of super-heterodyne design. Consideration of the power supply may first be undertaken.

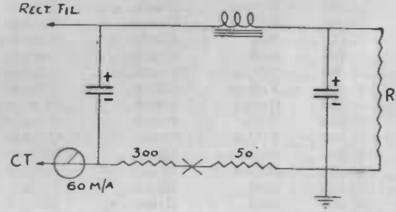
The circuit shows a twin-diode valve connected as a full-wave rectifier, the plates acting alternately, one on each half cycle of the induced A.C. present in the main secondary winding of the power transformer. As a result the full wave is rectified. A conventional filter system follows and the rectified D.C. supply from the final electrolytic condenser may be traced to the plate and screens to which it is applied. The rectifier filament is heated by current from the 5 volt winding, and the remainder of the filaments draw current from the third winding.

The receiver proper may best be analysed by commencing with the aerial. The latter is inductively coupled to a tuned circuit which connects to the signal grid of the first tube, which is a multiple-electrode valve. The second tuning circuit connects to the grid of the triode section of the valve which oscillates steadily at the resonance frequency of the associated tuned circuit owing to the constant feed-back of energy from the plate (oscillator anode-grid) to the grid provided by inductive coupling between these two electrodes. Each section of the tube operates at the frequency of the tuning circuit to which it is connected, the respective LC constants being such that there is a difference between the two frequencies which corresponds arithmetically with the resonance frequency of the I.F. transformers. The plate of the tube connects to the primary winding of the first I.F.T., and signal voltages are transferred to the next stage by inductive coupling between the two windings of the transformer. The stage is conventional excepting for the biassing circuit which controls the first, second and fourth tubes, and is discussed later in this chapter. It should be noted that the series oscillator plate-screen voltage supply circuit is suitable only for types 6K8 and ECH35 as discussed in the last chapter. Other mixer-oscillator types require different circuit arrangements.

The second valve functions to provide a stage of I.F. amplification, and its operation is identical with that of an R.F. amplifier. The over all gain is usually very high, owing partly to the voltage step-up provided by the I.F. transformers and partly to the low frequency employed which enables full advantage to be taken of the MU of the tube. Selectivity is assisted by the sequence of four tuned circuits provided by the I.F. transformers, and is adequate for normal requirements. These are the main advantages of super-heterodyne design.

The diode plates of the third valve serve to rectify the incoming R.F. signals and to provide automatic volume control for the grids of the mixer oscillator and the I.F. amplifier. The diode load resistor takes the form of a potentiometer which operates as a voltage divider so that the strength of the audio signal voltages coupled to the grid of the triode by the .01 coupling condenser may be adjusted to any desired level. Negative bias for the triode grid is established by reason of the very high resistance of the 10 megohm grid-leak which thereby tends to hold a negative charge of electrons on the grid sufficient to maintain that electrode at a negative potential with respect to the cathode. The fact that the cathode returns to a point in the biassing circuit is immaterial, as the connection between grid and cathode is direct.

The fourth tube operates as a power amplifier, the audio signal voltages applied to the control grid causing corresponding variations in the plate current. Voltage and current in the plate circuit are high, and sufficient power is available to drive a loud-speaker to a volume level suitable for normal household requirements. The cathode of the tube is directly grounded, which raises again the question of grid bias. The following simplified diagram may serve to explain the biassing circuit adopted.

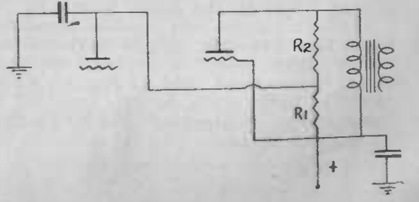


If the receiver is typified by RL, a complete circuit exists from the rectifier filament, through the receiver, to the transformer centre-tap, and through the rectifier back to the filament. Assuming a total current of .06 amp., the voltage dropped across 50 ohms becomes $E = IR = .06 \times 50 = 3$ volts. Therefore point X is negative with respect to ground by 3 volts. The grid of the mixer oscillator and the I.F. amplifier connect to this point through the diode load resistor. The result is that a fixed negative bias is applied to both grids if the cathodes are grounded. This minimum bias is further increased by the action of the A.V.C. circuit which operates to decrease the amplification of strong signals.

In the case of the power amplifier, the grid is returned to the centre-tap of the power transformer, and the voltage difference between that point and ground may be calculated similarly. $E = IR = .06 \times 350 = 21$ volts. As a result, if the cathode is grounded, the grid is at a negative potential of 21 volts with respect to the cathode. The system is known as "back-biassing" and is substantially the same as cathode-resistor bias, inasmuch as the cathode is at a positive potential with respect to the grid in both cases. The fact that the ground circuit is thus positive with respect to the transformer centre-tap renders necessary three principal precautions. Firstly, the power amplifier grid must return through the grid-leak to the centre-tap. Secondly, the negative terminal of the first electrolytic must also be connected to the centre-tap. If a can-type condenser is used on a metal chassis the can must be insulated from the chassis, which is usually an integral part of the ground system. Thirdly, the 25 mfd. condenser shown in the circuit diagram must have the positive end connected to ground, as ground is positive to the extent of the total voltage drop across the biassing resistors. Often this condenser may be omitted, but is of assistance in reducing hum and preventing instability. At first sight it may appear that the bias on the power amplifier is excessive. It may in fact be reduced by substituting 250 ohms for the 300 ohms resistor specified. However, the higher value has its merits in that the current through the tube is reduced, thus ensuring cool operation and long life.

A point of general comment is the high gain of the audio amplifier-power amplifier combination. Careful placement of the leads to the various valve electrodes will usually prevent undesired capacitative coupling and consequent instability. Audio instability generally takes the form of motor-boating, and may be prevented by efficient de-coupling of the plate circuit of the audio amplifier. A resistance-capacity combination of 50,000 ohms and 8 mfds. forms a very efficient de-coupling filter, particularly in view of the fact that the plate is by-passed for R.F. by the .00025 mfds. mica condenser. There are other methods of improving the audio circuit, such as the addition of inverse feed-back.

If the plate of the audio amplifier is connected to the junction of two resistors across the speaker transformer instead of going directly to the high tension supply. normal B voltage is still applied to the plate. if R1 is not of high resistance. However R1 and R2 will function as a voltage divider for audio signal voltages present in the plate circuit of the power amplifier. As a result



a proportion of the audio voltages equal to

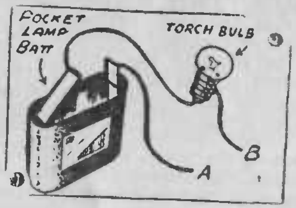
$$\frac{R1}{R1 + 2}$$

will be fed back to the plate of the audio amplifier in inverse phase. For example if R1 be 20,000 ohms and R2 is 100,000 ohms then one-sixth or approximately 16 per cent. inverse feed-back is obtained. The percentage may be reduced by lowering the resistance of R1. . . . . The practical effect of negative feed-back is reduction in gain, in distortion, and in noise. Owing to the gain reduction the principle must therefore be applied with discretion.

Further theoretical amendments to the circuit could provide for de-coupling of the mixer-oscillator plate and the I.F. amplifier plate. Owing to the relatively heavy current drawn by R.F. tubes it is necessary to use low values of resistance in the plate circuit to avoid excessive voltage loss. A maximum value of 5000 ohms is recommended, and, in practice, 2000 ohms will often suffice if used in conjunction with a good .1 mfds. condenser. Any remaining instability may be combated by including a grid stopper in the grid circuit of the power amplifier. A 10,000 ohms resistor connected between the .02 coupling condenser and the grid terminal of the valve socket will usually serve to prevent any tendency towards parasitic oscillation. The latter condition is often present at too high a frequency to be audible, but, on occasion, can be heard as a high-pitched whistle.

The points dealt with relating to circuit amendments have been mentioned principally from the angle of technical interest, and it is suggested that the student should re-draw the circuit so that some of the refinements mentioned take their proper place in the schematic design.

SIMPLE TESTING



Probably the simplest of all testing instruments. Easily made. Test prods can be fitted to the leads A and B.

With it anyone can conduct numerous tests. In use this simple device forms an excellent tester of contacts and terminal connections, and of low resistance metallic paths such as are provided by loudspeaker connecting cords, battery leads, and so on.

STANDARD RESISTOR COLOUR CODE

In the R.M.A. (American) standard coding, ten colours are assigned to the figures as shown in the following table:

Figure.	Colour.	Figure.	Colour.
0	Black	5	Green
1	Brown	6	Blue
2	Red	7	Violet
3	Orange	8	Grey
4	Yellow	9	White

The body of the Resistor is coloured to represent the first figure of the resistance value. One end of the resistor is coloured to represent the second figure. A band or dot of colour, representing the number of ciphers following the first two figures, is located with the body colour.

EXAMPLES :—

Ohms.	Body.	End.	Dot.
100	Brown	Black	Brown
150	Brown	Green	Brown
200	Red	Black	Brown
250	Red	Green	Brown
300	Orange	Black	Brown
350	Orange	Green	Brown
400	Yellow	Black	Brown
450	Yellow	Green	Brown
500	Green	Black	Brown
750	Violet	Green	Brown
1,000	Brown	Black	Red
2.000	Red	Black	Red
3,000	Orange	Black	Red
4,000	Yellow	Black	Red
5.000	Green	Black	Red
6.000	Blue	Black	Red
10,000	Brown	Black	Orange
15.000	Brown	Green	Orange
20,000	Red	Black	Orange
25,000	Red	Green	Orange
30,000	Orange	Black	Orange
40,000	Yellow	Black	Orange
50,000	Green	Black	Orange
60.000	Blue	Black	Orange
75,000	Violet	Green	Orange
100,000	Brown	Black	Yellow
150,000	Brown	Green	Yellow
200.000	Red	Black	Yellow
250,000	Red	Green	Yellow
300,000	Orange	Black	Yellow
500.000	Green	Black	Yellow
750.000	Violet	Green	Yellow
1,000,000	Brown	Black	Green
2,000,000	Red	Black	Green

LATEST AMERICAN RESISTOR CODING

When using 1RC or similar type resistors the colour code is the same though shown in a different manner. The resistor has four bands of colour at one end. To find out the resistance hold the resistor with the colours on the left and read from left to right.

The first band is (Body), second band is (End), third is (Dot). The fourth band denotes the tolerance, i.e.

Silver = 10% +/-
Gold = 5% +/-

LAMPHOUSE RADIO DICTIONARY

A-BATTERY: The battery used to supply heating current to the filament of a valve.

A.C. (ALTERNATING CURRENT): A current of constantly changing direction of flow.

ACCEPTOR CIRCUIT: A circuit consisting of inductance and capacity in series constitutes an acceptor circuit, current flow being maximum at the resonance frequency of the combination and less at other frequencies. May be inserted in the aerial circuit to improve selectivity.

ACCUMULATOR: A device for storing electricity. The most common type consists of a glass or composition container in which is fitted two sets of plates immersed in a dilute sulphuric acid called the electrolyte.

ACOUSTICS: In connection with the production and transmission of sound.

AERIAL: A conductor used for the transmission and reception of wireless waves. The golden rule to follow being to have the aerial as high and as clear of all earthed objects as possible. An overall length of 70ft. may be considered ample for modern receivers.

AERIAL, INVERTED L: This type of aerial consists of a flat top portion with a vertical lead in from one end.

AERIAL T: This is similar to above, but with the lead in brought down from the centre.

AERIAL, UMBRELLA: This type consists of a centre support with wires extending radially from it, thus giving an umbrella-like appearance.

AERIAL, LOOP: This consists of one or more turns of wire wound on a frame, which may be rotated. This type is directional and used mainly with portable radios.

A.F. (AUDIO FREQUENCY): In connection with frequencies normally capable of producing an audible sensation.

AIR CONDENSER: A variable or adjustable condenser in which air serves as the dielectric.

AIR CORE COIL: A coil in which no magnetism is used to increase the magnetic effect.

ALIGNMENT, RECEIVER: Adjustment of R.F. and I.F. Tuned circuits so that all circuits are resonant at the correct frequencies at any point within the tuning range of the receiver.

ALTERNATING CURRENT: A.C.

ALTERNATION: The portion of the alternating-current cycle between two successive zero values.

ALTERNATOR: A machine designed for the production of alternating current.

AMMETER: An instrument for measuring in amperes the flow of current in a circuit.

AMPERE: The standard unit used in measuring electric current and is the current which will flow through a resistance of 1 ohm at a pressure of 1 volt.

AMPERE HOUR: This is the quantity of electricity which passes when a current of one ampere flows for one hour. The capacity of an accumulator is generally stated in this unit and is found by mutliplying the rate of discharge in amps. by the number of hours for which it is delivered.

AMPERE TURN: A unit of electro-magnetic field strength. A current strength of one ampere passing through a turn of wire.

AMPLIFICATION: Increasing the strength of a voltage or current.

AMPLIFICATION FACTOR: The ratio of the change of plate voltage to the change of grid voltage to produce a given change in plate current.

AMPLIFIER: A unit or units generally including one or more valves capable of producing amplification.

AMPLIFIER AUDIO: The stages following the detector in a receiver to enable the audio signal to be amplified sufficiently to operate the speaker.

AMPLIFIER, RADIO FREQUENCY: The stages in a set designed to amplify the incoming R.F. signal before detection.

AMPLIFIER, CLASS A: An amplifier whose plate output waveform is the same as that of the applied grid voltage is termed class A. Tubes used for such work are biased so that the signal voltage is applied to the centre of the straight portion of the tube's characteristic curve, plate current flowing throughout the entire cycle.

AMPLIFIER, CLASS B: An amplifier in which the grid bias is equal to cut-off value so that with no signal applied to the grid the plate current is zero or nearly so. For audio purposes two tubes must be used in push pull, the tubes operating for alternate half-cycles.

AMPLIFIER, CLASS C: An amplifier in which the grid bias is considerably in excess of cut-off value, possibly two to four times. Used mainly in transmitting apparatus, as it allows the tubes to be operated very efficiently.

AMPLITUDE: The measure of the maximum deviation reached by voltage, current, or power during one cycle.

AMPLITUDE MODULATION (A.M.): A type of modulation whereby the amplitude of a carrier wave is varied in accordance with an applied signal. This type of modulation results in the production of side bands.

ANODE: The plate of a vacuum tube. In a cell the electrode from which the electricity enters the electrolyte.

ANTENNA: See Aerials.

ANTENNA HALF-WAVE: The fundamental form of antenna. A single wire whose length is equal to half the transmitter wave-length. Sometimes called a Hertz Antenna. Is not connected to ground or earth, and must be cut to the right length.

APERIODIC: Means "not tuned." An aperiodic circuit is not resonant at any particular frequency. The aerial circuit of most receivers is an aperiodic circuit inasmuch as it is not tunable to the various frequencies.

ARMATURE: The moving portion of a magnetic unit. In radio the moving portion of a loud speaker or the reed of a relay.

ATMOSPHERICS: Noises heard in the receiver due to electrical discharges in the atmosphere.

ATOM: Smallest particles of chemical elements, believed to consist of a nucleus with a positive electrical charge round which revolves one or more negative electrons.

ATTENTUATION: To produce the power of radio frequency or audio signals.

AUDIO FREQUENCY: A frequency corresponding to a normally audible sound wave. The upper limit ordinarily lies between 10,000 and 20.000 cycles.

AUDIO-FREQUENCY TRANSFORMER: A transformer for use with audio-frequency currents.

AUDIO OSCILLATOR: An oscillator capable of producing radio frequency.

AUTODYNE: A heterodyne circuit in which one valve acts as both oscillator and mixer.

AUTODYNE RECEPTION: A system of heterodyne reception through the use of a device which is both an oscillator and a detector.

AUTO-INDUCTIVE COUPLING: The coupling between two amplifying or oscillating systems due to an inductance common to both. Connection of a valve cathode to a point in the grid coil is an example, and is the preferred method for producing regeneration or oscillation.

AUTOMATIC FREQUENCY CONTROL: A device which causes a circuit to be automatically tuned correctly after the manual control has been tuned to aproximately the correct frequency.

AUTOMATIC VOLUME CONTROL: An automatic reduction of gain for all radio signals. An A.V.C. circuit operates automatically to reduce the gain of R.F. and I.F. amplifiers. Strong signals are affected more than weak signals as the amount of negative bias provided by the circuit increases as the signal strength increases. The result is a levelling down of strong signals or of surges.

A.W.G.: American Wire Gauge.

B-BATTERY: A battery supplying voltage to the plate circuit of a tube.

BAFFLE: A partition of wood or non-resonant material placed in front of a speaker to prevent the low frequency sound waves from getting to the back of the speaker and causing a loss of low notes.

BALLAST TUBE: A ballast resistor constructed in the form of a tube.

BAND SPREAD: A method of giving a finer control over the tuning of a given frequency band. Generally done by a low capacity variable condenser in parallel with the main tuning condenser.

BARRETTER: A barretter or ballast tube is simply a resistance in the form of a lamp used in certain types of receivers to break down excess voltage.

BATTERY: A combination of chemical cells.

BATTERY CHARGER: A unit used for recharging a secondary cell. When operated from A.C. a rectifier is necessary.

BEAM POWER VALVES: Tetrodes with special element structure so that the electrons are concentrated in desired paths to the plate. The beam principle results in high power sensitivity without secondary emission.

BEAT FREQUENCY: When two frequencies are beaten together two additional frequencies are produced. These are equal to the sum of and differences between the two original frequencies and are termed Beat Frequencies, or sometimes, Beat Notes.

BEAT FREQUENCY OSCILLATOR: A valve operated in an oscillating condition at a definite frequency. The oscillator frequency is injected into other circuits to produce beat frequencies.

B-ELIMINATOR: An outfit used to replace B-batteries in D.C. radios.

BIAS: The difference in voltage or potential between the control-grid of a valve and the cathode. The grid may be at the same potential as the cathode or may be negative or positive with respect to the cathode according to the manufacturer's recommended operating conditions.

BLEED RESISTOR: Any resistance or system of resistances wired across a D.C. supply from negative to positive to bleed a small amount of current from the supply. Usually a wire-wound resistor connected between the positive and negative terminals of a rectified and filtered supply.

BLOCKING CONDENSERS: Used to introduce a high resistance to the flow of D.C. without appreciably affecting the flow of A.F. or R.F. currents according to circuit requirements.

BREAKDOWN VOLTAGE: The voltage at which an insulator becomes a conductor.

BRIDGE: An arrangement constituting capacitors, resistors or inductors, used for measuring purposes.

BROADCAST BAND: Generally taken to be those bands of frequencies between 500 and 1500 kilocycles.

BUCKING COIL: A coil used in a Radio Speaker in which a voltage is produced to oppose the voltage in the principal coil.

BUFFER: A connection of devices used to prevent interactivity between two additional circuits.

BY-PASS CONDENSER: A condenser used to by-pass undesired frequencies from a circuit. The reactance of the condenser must be low at the frequencies to be by-passed.

C-BATTERY: A battery for supplying the biasing voltage to the control grid of a valve.

CAPACITY: Measure of the quantity of electricity a condenser will store up, this being determined by the area of the condenser plates, the distance between them and the nature of the dielectric, that is the type of material separating the plates.

CAPACITIVE COUPLING: The association of one circuit with another by means of capacity common or mutual to both.

CAPACITIVE FEEDBACK: Energy returned from the output to the input of a circuit by means of a condenser.

CAPACITIVE REACTANCE: The opposition to the flow of A.C. or pulsating D.C. caused by a capacitor. The unit for the above is the ohm.

CAPACITOR: A unit designed to achieve the effect of capacitance.

CARBON: An element. It is different from other metal elements in that its resistance decreases as the temperature increases.

CARBON RESISTOR: A resistor extensively used in radio circuits composed of carbon particles suitably bound in a cylindrical binder.

CARRIER WAVE: The wave-form of the alternating current introduced into a transmitter radiating system at the specified frequency for the particular transmitter. The energy radiated from the antenna forms the carrier wave and serves as the carrying medium .for the signals superimposed at the transmitter during the process of modulation.

CATHODE: In a radio valve the element which emits electrons.

CATHODE RAY OSCILLOSCOPE: A combination of components including a cathode ray tube used to study the characteristics of alternating voltages and to indicate alignment of resonant circuits.

CATHODE RAY TUBE: A vacuum tube in which a stream of electrons is manifested on a fluorescent screen to produce a visible trace.

CATSWHISKER: A fine piece of wire, usually in the form of a spiral coil, used in conjunction with a crystal detector, upon which it rests when in operation.

CHARGES, ELECTRICAL: All atoms are made up of charges of electricity. Electrons are negative charges. If an object has a surplus of electrons it is negatively charged. If it lacks electrons it is positively charged.

CHOKE AUDIO: A coil wound usually on an iron core, designed to impede the passage of audio currents.

CHOKE COIL: An inductor which through the production of a counter e.m.f. disallows the passage of a variable current through its circuit.

CHOKE, FILTER: An iron-cored inductance with low resistance and high inductance used in a power supply to offer high impedance at the ripple frequency of rectified current.

CHOKE, R.F.: A coil wound generally on some non-magnetic material and designed to impede radio frequency currents.

CIRCUIT: A collection of components so arranged that there exists a complete electrical path.

CIRCUIT BREAKER: A device designed to break a circuit should the current rise above a pre-determined level.

CIRCUIT, TUNED: A combination of capacity and inductance. At the resonance frequency of the system current flow is at maximum. If the circuit employs a variable condenser it may be tuned to resonance over a band of frequencies.

COAXIAL CABLE: A two lead cable in which a central lead is supported within the outside conductor in the form of a conducting tube. Usually by insulating beams.

CO-EFFICIENT OF COUPLING: A figure of merit representing the efficiency of the coupling between two coils. Complete transfer of energy without loss is termed Unity Coupling. The Co-efficient of Coupling is stated as a decimal part or as a percentage of Unity Coupling.

COIL: A number of turns of wire.

COIL HUM BUCKING: An additional coil usually wound over the field of an electro dynamic speaker to neutralise hum effects.

CONDENSER: Fundamentally two or more metal plates separated by an insulator.

CONDENSER, BY-PASS: A condenser used to by-pass audio or radio frequency currents, thus tending to keep them out of parts of the circuit where they are not required or cause instability.

CONDENSER, ELECTROLYTIC: A condenser consisting of two aluminium plates separated by an electrolyte which is usually a borax solution. When voltage is applied to the positive plate and the negative plate (outer can) is grounded, current, at first, flows through the electrolyte. Chemical action quickly produces a hydroxide coating on the positive plate and a film of gas over the hydroxide layer. The two layers or films serve as the dielectric or insulating material between the plates and the condenser is "formed." It is important to apply the positive voltage to the positive plate whether the electrolytic is the wet type or of the semi-dry tubular type. In the latter, oiled material takes the place of electrolyte, but the action is the same.

CONDENSERS, GANGED: Variable condensers so arranged that the moving plates or vanes of all may be rotated from one control. In modern receivers 2 and 3 gang condensers are most commonly used.

CONDENSER, NEUTRALISING: A small variable condenser used in the R.F. circuit of certain sets to neutralise or balance out the capacity existing between the elements of the valve and thus helping to make operation more stable.

CONDENSER, PADDING: A Condenser, either fixed or variable, connected in series with a tuning condenser so that the maximum capacity of the latter may be reduced.

CONDENSER, TRIMMING: A small variable condenser connected across a larger variable condenser so that fine adjustment of capacity may be available.

CONDENSER, VARIABLE: A condenser the capacity of which may be varied.

CONDUCTANCE: A measure of the ease with which an electric current may flow through a circuit. Unit of conductance is the MHO.

CONDUCTOR: Any material through which current may pass. Silver, copper and gold are the best conductors—owing to its relative cheapness, copper is used extensively.

CONTROL GRID: The element in a valve to which a signal is applied for rectification or amplification.

CONTINUOUS WAVES: Continuous waves are waves in which successive cycles are identical under steady state conditions.

CONVERTER, FREQUENCY: A valve used to convert radio frequencies to an intermediate frequency. Also referred to as Mixer, Mixer-Converter, Pentagrid Converter.

CONVERTER, S.W.: Generally a single tube receiver the output of which connects to the aerial and earth terminals of broadcast sets. The valve is operated in an oscillating condition and the frequency of the oscillations may be varied by means of a tuning condenser. The short wave signals are tuned in and mixed with the oscillator frequency to produce an intermediate or beat frequency which falls somewhere in the tuning range of the broadcast receiver, generally about 600 kilocycles. The receiver is left tuned to this frequency and the short wave stations are tuned in on the converter. The signal is changed to 600 kilocycles and fed into the aerial and earth terminals of the broadcast set, which amplifies and makes the signal audible in the same manner as if it were receiving an ordinary broadcast station

CORE: The laminated construction on which a coil is wound. The insertion of an iron or stalloy core within a coil used as an electro-magnet increases the strength of the magnetic field.

COULOMB: Unit of quantity, being equal to one ampere flowing for one second.

COUPLING: A method of transferring electrical energy from one unit to another.

COUNTERPOISE: A system of wires, usually insulated and placed directly under an aerial. The object is to provide a substitute for earth when the soil is dry and rocky, as a high resistance earth connection causes loss of signal strength.

CRYSTAL: A quartz plate used to control the frequency of a transmitter. The frequency is determined by the size and shape of the plate. Crystals of Rochelle salt are used for microphones and pick-ups. The action of the crystal is such that minute pressures on the crystal element result in the generation of proportionate audio voltages.

CRYSTAL DETECTOR: A crystal used as a rectifier of R.F. Signals.

CRYSTAL MICROPHONE: The microphones using Rochelle salt crystals for changing mechanical motion to electrical energy.

CRYSTAL PICK-UP: A radiogram pick-up using a Rochelle salt crystal to generate an e.m.f. which varies in unison with the indentation of the record.

CURRENT: A flow of electrons. The unit of electrical current being the ampere.

CURRENT, EDDY: Current set up in nearby conductors by a magnetic field.

C.W. (CONTINUOUS WAVE): A wave in which the amplitude of successive oscillations remains constant.

CYCLE: One complete set of changes after which the initial condition is restored; that is from zero to maximum positive, to zero, to maximum negative, back to zero.

DAMPING: The gradual decay or reduction in amplitude of oscillation due to resistance.

D.C.C.: Double cotton covered.

DECIBEL: Measure of sound beginning at the threshold of hearing, a change in level of 1 decibel being rarely perceptible. This unit is used extensively in sound work as the ear does not respond to sound energies of different values in a linear manner. The use of the decibel enables the power output of different amplifiers to be expressed in a unit which bears relation to their effect on the ear.

DECOUPLING: Method by which "motor-boating" and instability is prevented in a receiver by means of decoupling resistors and by-pass condenser. In resistance-coupled circuits of more than two stages it is generally necessary to decouple one of the stages, a resistor about one-tenth of the plate resistor being connected in series with it and a by-pass condenser connected from the junction of the resistors to earth.

DEGENERATION: Loss of signal strength caused by feeding-back out-of-phase energy to a circuit.

DEMODULATION: The operation of extracting the audio signal from the modulated carrier.

DETECTION: The process of changing the received radio frequency oscillations into varying undirectional current. The act of rectifying.

DETECTION, LINEAR: A detector is linear when its A.F. output is proportionate to the R.F. input.

DETECTOR: Device for converting high frequency currents into currents capable of affecting telephones or similar instruments.

DIAPHRAGM: Section of a reproducer which makes audible the electrical impulses fed to it. The cone of a speaker.

DIELECTRIC: The insulating material between the conducting plate of a condenser.

DIELECTRIC CONSTANT is the specific capacity of a given material. The dielectric contant of air is taken as 1. The ratio of the capacity of a certain sized condenser having a given material as a dielectric to the capacity of the same condenser with air is the dielectric, will give the dieletric constant of that material.

D.C., DIRECT CURRENT: Current which flows in one direction only.

DIODE: A two element valve.

DISCRIMINATOR: A circuit in which the output varies in keeping with the deviation of a received signal from an original resting frequency.

DISTORTION: A change in wave form occurring in a transducer or transmission medium when the output wave form is not a faithful reproduction of the input wave form.

D.S.C. Double Silk Covered.

DOUBLET ANTENNA: An aerial system composed of two units, the physical length of each having distinct relationship to its resonant frequency.

D.X.: Abbreviation meaning "distance."
E: Symbol of voltage.

EARTH: In a Marconi aerial system (such as the L type) the earth acts as one plate of a condenser of which the aerial is the other plate. The ground circuit of a receiver may be connected to earth, but earth and ground are not synonymous.

EBONITE: An insulating material used for panels, etc.

EDISON CELL: A secondary chemical cell sometimes called a nickel-iron-alkaline cell.

EDISON EFFECT: An effect observed by Edison. When a filament is heated and another electrode placed in the same bulb, current would flow when a positive potential is applied to the electrode.

ELECTRIC EYE: A style of electronic tube which is impelled by light impulses.

ELECTRODES: An element of an electrical unit such as an element in a valve or one of the elements of a chemical cell.

ELECTROLYTE: A liquid which is subjected to decomposition by an electric current.

ELECTRO-MAGNET: A magnet formed by the flow of an electric current through a conductor. The conductor is wound in the shape of a coil to intensify the magnetic force.

ELECTRO-MAGNETIC INDUCTION: Transfer of energy from one inductance to another by virtue of the action of an electro-magnetic field around the primary inductance. If the magnetic field is in a state of movement an E.M.F. is induced in the secondary inductance.

ELECTROMOTIVE FORCE: Voltage.

ELECTRON: One of the fundamental constituents of matter. A minute particle of negative electricity.

ELECTRON EMISSION: The liberation of electrons from an electrode into the surrounding space. In a vacuum tube it is the rate at which the electrons are emitted from a cathode.

ELECTROSCOPE: Device used for detecting static electricity.

ELECTRON TUBE: A tube making use of an electron stream in its operation.

ELECTRO STATICS: Science which deals with the phenomena occasioned by electricity at rest.

EMISSION CHARACTERISTIC: A graph plotted between a factor controlling the emission (such as the temperature, voltage, or current of the cathode) as abscissas, and the emission from the cathode as ordinates.

E.M.F. Electromotive Force.

ETHER: The hypothetical medium suggested to occupy all space by means of which light, heat and radio waves are transmitted.

F: Symbol for frequency, generally given in cycles per second.

FACSIMILE TRANSMISSION: The electrical transmission of a copy or reproduction of a picture, drawing or document. (This is also called picture transmission.)

FADER: Consists essentially of a centre tapped volume control so that it is possible to change from microphone or radio to pick-up without a sudden break. Rotating the control gradually fades one unit out and brings up the strength of the other.

FARAD: Practical unit of electrical capacity. A condenser is said to have a capacity of one farad if a charge of one coulomb causes a potential difference of one volt.

FEEDBACK: The feeding back of energy from a point in a circuit to a preceding point.

FIDELITY: The degree to which a system, or a portion of a system, accurately reproduces at its output the signal which is impressed upon it.

FIELD: Name given to lines of force built up round a conductor during the passage of current. Also name given to coil which energises a dynamic speaker.

FIELD COIL: In radio a coil normally used in an electro-dynamic speaker which serves the purpose of producing an intense magnetic field.

FIELD STRENGTH: The field strength of a transmitter at any given point is expressed in millivolts per metre. Should the field strength be 3 millivolts per metre an aerial four metres high would theoretically have twelve millivolts induced in it.

FILAMENT: Wire in a vacuum tube which when heated gives off electrons.

FILAMENT WINDING: A transformer winding designed to furnish common voltage.

FILTER: Device used in a power supply or to exclude unwanted signals from a circuit.

FLUORESCENT SCREEN: A screen coated with a fluorescent material which reproduces light impulses when actuated by an electron stream.

FLUX DENSITY: The number of lines of force per square centimentre around a magnet or electro-magnet.

FREQUENCY: The number of cycles per second of an alternating current.

FREQUENCIES, AUDIO: Those frequencies audible to the human ear ranging approximately from 15 cycles to 20,000 cycles per second.

FREQUENCIES, RADIO: Frequencies ranging from about 20,000 cycles per second to many millions of cycles per second.

FREQUENCY, INTERMEDIATE: Frequency to which the incoming signal is converted in a super-heterodyne receiver.

FULL-WAVE RECTIFIER: A double element rectifier arranged so that current is allowed to pass in the same direction to the load circuit during each half cycle of the alternating-current supply one element functioning during one-half cycle and the other during the next half cycle.

GALENA: A type of crystal consisting of lead sulphide.

GALVONMETER: Instrument for detecting and measuring minute electrical currents.

GASEOUS TUBE: An electronic valve using a gas to produce some specific operational function.

GENERATOR: A device which converts mechanical energy to electrical energy.

GRID: Open wire mesh placed between the plate and filament of a valve.

GRID BIAS: The amount of voltage difference between the control grid and the cathode of a valve.

GRID, CONTROL: Grid to which input signal is applied. A small amount of grid voltage being able to control a relatively large amount of plate current.

GRID LEAK: A resistance connected between control grid and cathode or a point in the cathode circuit in order that the grid of the tube may be set at the proper voltage relationship with respect to the cathode. The tube may operate under zero bias, positive bias, or negative bias for the grid according to the maker's recommendations.

GRID, SCREEN: A mesh placed between control grid and plate of a valve to shield the control grid from the plate and so reduce the self capacity between these two elements.

GROUND: That point in a circuit against which all operating voltages are measured—the common reference point. Ground may be at zero voltage or at a positive potential, but in all cases may be connected to earth without upseting operating voltages.

GROUND WAVE: The section of a transmitted wave which follows the surface of the earth.

H: Symbol of magnetic flux density.

HALF-WAVE RECTIFIER: A rectifier which changes alternating current into pulsating current utilising only one-half of each cycle.

HARMONIC: Frequency which is a multiple of the fundamental.

HARMONIC DISTORTION: The generation of false frequencies, generally integral multiples of the fundamental frequencies in an electronic device.

HEATER: An electric heating element for supplying heat to an indirectly heated cathode.

HEAVISIDE LAYER: A layer of electrified atmosphere above the earth's surface which is considered to have a reflecting effect on radio waves.

HENRY: Unit of inductance. A circuit has an inductance of one henry when a rate of charge of 1 amp. per second produces a back electromotive force of 1 volt.

HETRODYNE: To combine forces or frequencies.

HETRODYNE RECEPTION: The production of beats by reaction between oscillations received and those locally generated for the purpose of reception is called hetrodyne reception.

HIGH FIDELITY: The ability of a circuit to pass a band of audio frequencies from 30 to 15 thousand cycles per second without amplitude discrimination.

HOT-WIRE AMMETER, EXPANSION TYPE: An ammeter dependent for its indications on a change in dimensions of an element which is heated by the current to be measured.

HOOK-UP: A circuit diagram.

HYDROMETER: Instrument used to measure the specific gravity of wet batteries.

HYSTERESIS: The lagging of an effect behind cause producing it. In transformers the magnetism produced in the core lags behind the force which produces it.

I: Symbol used to denote the current flow in amperes.

I.F.: Intermediate frequencies.

IMPEDANCE: The combined effect of resistance and reactance. The total opposition offered by a circuit to alternating current.

INDIRECTLY HEATED CATHODE: A cathode of a thermionic tube, in which heat is supplied from a source other than the cathode itself.

INDUCED VOLTAGE: The voltage induced ("led in") in a coil by the action of a carrying magnetic field.

INDUCTANCE: When an alternating current is passed through a coil a magnetic flux is set up, the lines of force cutting the turns of coil induces a voltage in the opposite direction thus retarding the flow of current.

INDUCTION: The property by which one circuit may induce energy into another circuit without electrical contact.

INDUCTIVE COUPLING: Transfer of energy from one coil to another without any direct connection. As a result energy is transferred from one circuit to another without electrical connection. (See Electro-magnetic Induction.)

INDUCTIVE REACTANCE: The opposed effect set up to a change of current flow in a circuit due to the inductive quality of the circuit.

INPUT: The grid of a tube. That portion of a circuit to which the signal voltage is applied.

INSULATOR: Material of high resistance properties. The opposite to conductor.

INTERELECTRODE CAPACITANCE: The direct capacitance between two electrodes.

INTERMEDIATE FREQUENCY: The radio frequency to which an incoming carrier wave is converted in a super-heterodyne circuit. The intermediate frequency is the resonance frequency of the I.F. Transformrs, and conversion of broadcast frequencies to the I.F. is obtained by mixing the B.C. frequency with another frequency produced by an oscillator valve in the receiver.

INTERMEDIATE FREQUENCY AMPLIFIER: The portion of a super-heterodyne receiver which amplifies the intermediate frequency.

I.F. TRANSFORMER: A transformer tuned to pass a particular frequency. It is used for coupling purposes in the intermediate frequency amplifier.

INTERMODULATION: The production, in a non-linear circuit element, of frequencies corresponding to the sums and differences of the fundamentals and harmonics of two or more frequencies which are transmitted to that element.

INTERRUPTED CONTINUOUS WAVES: Interrupted continuous waves are waves obtained by interruption at audio frequency in a substantially periodic manner of otherwise continuous waves.

INVERSE FEED-BACK: The feeding back of out-of-phase energy to a circuit to reduce distortion. The action is degenerative, and a loss of gain results. High-gain tubes should be used.

ION: An atom with an excess or a deficiency of electrons.

IONISATION: The liberation of charged particles of gas known as Ions, generally the result of collision between high-speed electrons and gas atoms.

I.R. DROP: The Potential drop or voltage across the terminals of a resistor.

JACK: Appliance generally used to connect phones or a speaker into a circuit.

J-OPERATOR: An operational factor used to indicate that the value which it precedes is the out-of-phase component of a complex expression.

JOULE: Unit of energy. The amount of energy expended in a circuit when 1 amp. flows at a pressure of 1 volt for 1 second.

KEEPER: Iron bar placed across Poles of a magnet which helps it to retain its magnetism.

KILOCYCLE: One thousand cycles (shown usually as k.c.).

KILOWATT: One thousand watts of electrical power.

L: Symbol for inductance.

LAMINATIONS: Thin metal strips used for the cores of chokes and transformers.

LEAD-IN: That portion of an antenna system which completes the electrical connection between the elevated outdoor portion and a receiver.

LEAKAGE LOSS: Loss in condensers, etc., due to the fact that no insulating medium is perfect.

LIGHTNING ARRESTOR: A device with a very small spark-gap, one side of which is connected to the aerial and the other to earth. If the aerial is struck by lightning, discharge occurs across the gap to earth, thus saving damage to the receiver.

LIMITER: A hook-up in which amplitude variations are removed from a modulated wave.

LINEAR DETECTION: That form of detection in which the audio output voltage under consideration is substantially proportional to the modulation envelope throughout the useful range of the detecting device.

LINE FILTER: The combination of Condensers and/or Coils placed in the electric mains to prevent power-line noises reaching the set through the mains.

LINE VOLTAGE: The voltage shown at the terminals of an electrical service line.

LINES OF FORCE: The imaginary lines in space along which electrical or magnetic action is said to take place.

LITZENDRAHT WIRE: Commonly called "Litz" wire, consists of several fine strands of wire insulated from each other, plaited together, and generally covered with silk. This wire is used where losses must be kept at a minimum. The surface area is increased over a single wire, thus reducing the "skin effect" (which see).

LOAD: Generally refers to the resistance or impedance placed in the plate circuit of a valve.

LOUD SPEAKER, MOVING COIL: A light coil placed in a strong magnetic field. As the audio current flows through this coil the interaction causes the cone attached to the coil to vibrate and produce sound waves corresponding to the audio current variations.

MA: Milliampere.

MAGNETIC FIELD: The space surrounding a magnet in which magnetic forces are experienced. The magnetic field is assumed to consist of lines of force.

MAGNETIC MICROPHONE: A microphone whose electrical output results from the motion of a coil or conductor in a magnetic field.

MAGNETIC PICK-UP: A type of phonograph pick-up in which the record indentions impel a moving vane pivoted between the poles of a magnet. The resulting change in magnetic reductance causes the production of an e.m.f. in a surrounding coil.

MAGNETIC SPEAKER: A type of radio speaker in which the actuating mechanism is a lever pivoted between the pole of a permanent magnet.

MEG: A prefix meaning one million.

MEGACYCLE: When used as a unit of frequency, is a million cycles per second.

MERCURY-VAPOUR RECTIFIER: A mercury vapour rectifier is a two-electrode, vacuum-tube rectifier which contains a small amount of mercury. During generation, the mercury is vapourised. A characteristic of mercury-vapour rectifiers is the low-voltage drop in the tube.

METRE: The unit length in the C.G.S. system of units. One metre equals 39.37 inches.

METER: An instrument used for measuring. Generally refers to an instrument capable of measuring one or all of the following: volts, ohms or milliamps.

MHO: Unit of conductance, found by dividing unity by the resistance in ohms; e.g., a circuit with a resistance of 5 ohms will have a conductance of one-fifth or .2 ohms.

MICA: A mineral consisting of thin flexible scales used as an insulating material.

MICA CONDENSER: A condenser, generally fixed, using mica as a dielectric.

MICRO: One millionth.

MICRO AMPERE: One millionth of an ampere.

MICRO FARAD: One millionth of a farad.

MICRO HENRY: One millionth of a henry.

MICROHM: One millionth of an ohm.

MICRON: One thousandth part of a millimetre.

MICROPHONE: A device for transforming audible sound energy into electrical impulses.

MICROPHONIC: An audible sound coming from an amplifier usually due to the independent vibration of various elements in one or more valves or components in the amplifier.

MICROPHONE CARBON: A diaphragm placed in contact with carbon granules. Sound waves cause the pressure of the diaphragm on the granules to vary—the resistance of the circuit varies accordingly.

MICROPHONE CRYSTAL: A pair of Rochelle salts crystals are used in this type of microphone. Variations of sound pressure cause the crystals to vibrate giving rise to pieza electric voltages.

MICROPHONE VELOCITY: A Microphone which has a metal ribbon suspended between the poles of a magnet.

MILLI: A prefix denoting one thousandth

MILLIAMETER: Instrument used for reading current in milliamps. A milliameter should always be connected in series with, not across the points to be measured.

MILLIAMP: One thousandth part of an ampere.

MIXER: The tube in a superheterodyne receiver which "mixes" the received signal with that of the local oscillator producing the intermediate frequency. Also refers to controls used to mix or blend several sources of sound, such as combining music and sound from two different microphones.

MODULATED AMPLIFIER: The stage in a transmitter in which the audio signal is impressed on the carrier wave.

MODULATED WAVE: A modulated wave is a wave of which either the amplitude frequency or phase is varied in accordance with a signal.

MODULATION: The process by which the audio frequency wave is combined with the radio frequency carrier wave.

MODULATOR: A device which performs the process of modulation.

MOLECULE: The minutest particle of a substance which retains all of the characteristics and properties of that substance.

MOTOR: A unit or machine which converts electrical energy to mechanical energy.

MOTOR-BOATING: Low frequency oscillation of an audio amplifier.

MU: Greek letter used to denote the amplification factor of a vacuum tube.

MUTUAL CONDUCTANCE of a valve is the ratio of a change in plate current to the change in grid voltage required to produce the change in plate current. It is a measure of a valve's ability to amplify and is sometimes called Transconductance.

NEGATIVE: A point in a circuit having an excess of electrons.

NEGATIVE BIAS: A negative voltage applied to the control element of a vacuum tube with respect to the cathode.

NEGATIVE FEEDBACK: Inverse Feedback.

NEON LAMP: A glass bulb containing two metal electrodes and filled with Neon gas at a low pressure. When a sufficiently high potential difference is applied across the electrodes, the negative electrode glows, owing to a discharge taking place through the gas.

OHM: The unit of electric resistance. A circuit has a resistance of one ohm when a current of one amp. flows at a pressure of one volt.

OHMMETER: A combination of electrical components, including a meter calibrated to read in ohms the value of a resistor placed between two terminals.

OSCILLATOR: A non-rotating device for producing alternating current, the output frequency of which is determined by the characteristics of the device.

OSCILLATORY CIRCUIT: A circuit containing inductance and capacitance, such that a voltage impulse will produce a current which periodically reverses.

OSCILLOGRAPH: A device which produces a permanent visual trace of a wave shape.

OSCILLOSCOPE: See Cathode Ray oscilloscope.

OUTPUT METER: A meter indicating the output of an electrical device. It may be calibrated in watts, amperes, volts or decibels.

OUTPUT TRANSFORMER: A transformer used to couple the final amplifier stage in a system to the speaker.

OUTPUT TUBE: The final valve in an amplifier system generally converting a large input signal voltage to a large power output.

P: Symbol used to denote electrical power in watts. Used alternately with W.

PARALLEL: Where two or more resistors, etc., are connected across the same points in a circuit they are said to be in parallel.

PEAK: The maximum value during a current or voltage cycle, this being 1.414 of the effective value of alternating current.

PENTODE: A type of thermionic tube containing a plate, a cathode, and three additional electrodes. (Ordinarily the three additional electrodes are of the nature of grids.)

PERCENTAGE MODULATION: The ratio of half the difference between the maximum and minimum amplitudes of a modulated wave to the average amplitude, expressed in per cent.

PERMANENT MAGNETIC SPEAKER: A moving coil or dynamic radio speaker in which the steady magnetic field is produced by a permanent magnet.

PERMEABILITY refers to the property of mulitplying and intensifying the lines of force of a magnetic field. A stalloy core insrted within a coil has this effect.

PERMEABILITY TUNING: A type of electrical circuit tuning in which the inductance of a coil is varied by the insertion of a magnetic core.

PERMEANCE: The ease with which lines of force may pass through a given substance. The opposite to reluctance.

PHASE INVERSION: Literally change of phase by an angle of 180 deg. Usually refers to the method employed in resistance-capacity coupled amplifiers to supply the grids of push-pull tubes with alternate half-cycles of the signal voltage. The circuit arrangement is such that one push-pull grid is positive with respect to a common cathode connection when the other grid is negative. The same result may be achieved by connecting each grid to a centre-tapped coil, such as the secondary of a push-pull transformer. The ends of the coil are of opposite polarity with respect to the centre-tap.

PHON: Unit of loudness.

PHONO PICK-UP: A contrivance which converts the indentation on a gramophone record into electrical or mechanical audio impulses.

PHOTO-ELECTRIC CELL: A device for converting variations in light to electrical impulses.

PHOTOTUBE: A vacuum tube in which electron emission is produced by the illumination of an electrode. (This has also been called photo-electric tube.)

PIEZO ELECTRICITY: Property possessed by Rochelle salts crystals and certain other substances whereby voltages are formed when mechanical pressure is applied.

PLATE: A common name for the principal anode in a vacuum tube.

PLATE CIRCUIT: The circuit in which plate energy is dissipated, including the external load, power supply device and internal element connections.

POLE: An electrode one end of a magnet or in a cell.

POTENTIAL DIFFERENCE: The force which causes electricity to flow. The difference in voltage between two points in a circuit.

POTENTIOMETER: Refers to resistance shunted across a circuit equipped with a sliding arm to enable voltage to be tapped off at any point.

POWER AMPLIFICATION (of an amplifier): The ratio of an alternating-current power produced in the output circuit to the alternating-current power supplied to the input circuit.

POWER FACTOR: The ratio of apparent power to true power in a reactive circuit.

POWER PACK: Device to enable all the receiver power requirements to be supplied from the mains. Generally includes a rectifier transformer and a combination of filter chokes and condensers.

POWER TRANSFORMER: The transformer in an A.C. operated device supplying operating voltages to the various sections of the circuit. The transformer obtains its operating power from the A.C. line.

PRIMARY: The circuit to which electrical energy is led; as in a transformer.

PROTON: One of the units from which all matter is built up. A positive particle of electricity. Nucleus round which electrons revolve.

PULSATING CURRENT: A periodic current; that is, current passing through successive cycles, the algebraic average value of which is not zero. A pulsating current is equivalent to the sum of an alternating and a direct current.

PUSH-PULL AMPLIFICATION: The use of two valves for one stage of amplification which may be either voltage amplification or power amplification. Each valve works on one half of the incoming cycle. The practical result is higher power output with lower distortion than when a single valve is used. The plates are connected to a centre-tapped transformer winding.

Q: The symbol used to denote electrical quantity in coulombs.

QUARTZ CRYSTAL: A crystal exhibiting Piezo electric effects.

R.: The symbol for resistance.

RADIATION: In radio, the process of sending out a wave by exciting the ether through which transmission is thought to take place.

RADIO CHANNEL: A band of frequencies or wavelengths of a width sufficient to permit of its use for radio communication. The width of a channel depends upon the type of transmission.

RADIO COMPASS: A direction finder used for navigational purposes.

RADIO FREQUENCY: A frequency higher than those corresponding to normally audible sound waves. (See Audio Frequency).

RADIO FREQUENCY CHOKE: An inductance presenting high impedance to an R.F. impulse, while allowing the passage of low frequencies. and direct current.

RADIO-FREQUENCY TRANSFORMER: A transformer for use with radio-frequency currents.

RADIO RECEIVER: A device for converting radio waves into perceptible signals.

RADIO TRANSMISSION: The transmission of signals by means of radiated electromagnetic waves originating in a constructed circuit.

RADIO TRANSMITTER: A device for producing radio-frequency power, with means for producing a signal.

REACTANCE: The opposition offered to alternating current by a coil or a condenser.

REACTANCE, CAPACITIVE: This term is used to denote the opposition offered by a condenser to alternating currents, the reactance of a condenser being inversely proportional to its capacity and the frequency of the current. Thus the greater the capacity or the higher the frequency the less the reactance.

REACTANCE, INDUCTIVE: With an inductance the effect is totally opposite from that of a condenser, reactance being zero to direct current and increasing directly as the frequency rises.

RECTIFIER: A device for converting alternating current to one-way current. Such devices include vacuum-tube rectifiers, mercury-vapour rectifiers, detector valves, crystal detectors, etc. The rectified current is pulsating D.C.

REFLECTED LOAD: The apparent load reflected across the primary of a transformer when an impedance is connected across the secondary winding. The reflected load may be either higher or lower than the secondary load according to the turns ratio of the transformer.

REFLEX: A circuit whereby a valve may act both as a radio frequency and audio frequency amplifier at the same time.

REGENERATION: The process by which a part of the output power of an amplifying device reacts upon the input circuit in such a manner as to reinforce the initial power, thereby increasing the amplification. (Sometimes called "feedback" or "reaction.")

REGENERATIVE DETECTOR: A vacuum valve detector combined with regenerative feed-back.

RELAY: An electro-magnetic unit used to control the action of circuits by the application of an elecrical impulse. Relays are usually used to control circuits at a distance, for protective purposes and to actuate heavy-duty circuits by the use of relatively low power.

RESISTANCE: The opposition offered to a flow of current. The resistance of any material is inversely proportional to its cross sectional area and directly proportional to its length.

RESISTIVITY: Specific resistance.

RESISTOR: Device used to drop voltage and oppose the flow of current in a circuit. An increase in operating temperature causes an increase in resistance with wire-wound resistors and a decrease in resistance with carbon resistors. All resistors therefore should be operated well within their maximum wattage ratings if the correct resistance is to be maintained.

RESONANCE: In an A.C. circuit containing inductance and capacity, there is present inductive and capacitative reactance in addition to ohmic resistance. At one particular frequency the inductive and capacitative reactances cancel out and there remains only pure resistance to oppose the flow of current.. This circuit condition is known as Resonance, and the circuit is said to be resonant at the appropriate frequency.

RESONANCE FREQUENCY: The frequency to which a cube circuit is resonant.

R.F.: Radio frequency.

RHEOSTAT: A variable resistance connected in a circuit to vary the amount of current flowing through it.

R.M.S.: Root mean square. The effective value of alternating current units.

ROTARY CONVERTER: A machine for converting direct current into alternating current.

ROTOR PLATES: The movable plates of a variable condenser.

SCREEN: In a cathode ray tube the surface on which the visual graph appears.

SCREEN GRID: An element in a valve used to shield one element from another.

SECONDARY: In a transformer the winding in which a voltage is induced.

SECONDARY EMISSION: Electron emission under the influence of electron or ion bombardment.

SELECTIVITY: The ability of a receiver to discriminate against signals of frequencies differing from that of the desired signal. The overall selectivity will depend upon the selection of the individual tuned circuits and the number of such circuits.

SELF-BIAS: A bias produced by the flow of grid current through a resistor.

SENSITIVITY: The degree to which a radio receiver responds to signals of the frequency to which it is tuned.

SERIES: Method of connecting cells, resistors or other components in such a way that the current flows through each in turn.

S.G.: Screen Grid.

SHUNT: In meters a low resistance placed across the meter movement to carry a proportional part of the total current flow.

SIDE BANDS: The bands of frequencies, one on either side of the carrier frequency, produced by the process of modulation.

SIGNAL: The intelligence message or effect conveyed in communication.

SIGNAL GENERATOR: An oscillator.

SINE WAVE: The wave traced by the sine of an angle as the angle is rotated through 360 deg. Alternating current values follow a sine wave with respect to time.

SINGLE SIDE-BAND TRANSMISSION: That method of operation in which one side band is transmitted, and the other side band is suppressed.

SKIN EFFECT: Due to the fact that radio frequency currents do not act in the same manner as direct or low frequency ones, the current tending to flow on the outside of the conductor rather than through the centre. For this reason stranded wires or wire with a fairly large surface are used for short waves.

SOLENOID: Coil of wire wound in the form of a cylinder, acts like a magnet when a current is flowing through the winding.

SPACE CHARGE: Electrons emitted from the filament which tend to crowd round the filament.

STABILITY: The ability of a receiver to remain on a given frequency once it is tuned on to it.

STATIC: Atmospheric electricity.

STATOR PLATES: The fixed plates of a variable condenser.

STRAYS: Electromagnetic disturbances in radio reception other than those produced by radio transmitting systems.

SULPHATION: The forming of a hard deposition of lead sulphide on the plates of an accumulator. Unless immediate steps are taken to remove this the accumulator will soon become useless. Due usually to allowing the accumulator to stand for long periods in a discharged condition. It is quite often possible to decompose this lead sulphate by giving the accumulator a long overcharge at a low rate.

SUPERHETRODYNE: Type of receiver in which the incoming signal is changed to a lower (intermediate) frequency. It is possible by this means to obtain greater selectivity and also higher stability and gain.

SYNCHRONOUS: Two or more operations occurring in unison.

TELEPHONE RECEIVER: An electro-acoustic transducer actuated by power from an electrical system and supplying power to an acoustic system, the wave form in the acoustic system corresponding to the wave form in the electrical system.

TELEVISION: The electrical transmission of a succession of images and their reception in such a way as to give a substantially continuous reproduction of the object or scene before the eye of a distant observer.

TETRODE: A tube having four elements—Cathode, Control Grid, Screen Grid and Plate.

THERMIONIC EMISSION: Electron or ion emission under the influence of heat.

THERMIONIC TUBE: An electron tube in which the electron emission is produced by the heating of an electrode.

TOTAL EMISSION: The value of the current carried by electrons emitted from a cathode under the influence of a voltage such as will draw away all the electrons emitted.

TRANSCEIVER: A unit which combines both the transmitter and receiver. Used extensively in field work where size and portability are of major importance.

TRANSCONDUCTANCE: The ratio of the change in the current in the circuit of an electrode to the change in the voltage on another electrode, under the condition that all other voltages remain unchanged.

TRANSDUCER: A device actuated by power from one system and supplying power to another system. These systems may be electrical, mechanical, or acoustic.

TRANSFORMER: Consists essentially of two coils in close proximity but not directly connected. Energy is transferred from one winding to the other by virtue of electro-magnetic induction.

TRANSMISSION LINE: A system of conductors carry signal impulses from one place to another.

T.R.F. RECEIVER: A radio in which the signal frequency is led through several amplifying stages resonant with the incoming signal.

TRICKLE CHARGER: A battery charger which charges at a low rate, generally about ½ an ampere.

TICKLER: The reaction winding on a former.

TRIMMER: A small condenser used to balance out small differences existing between sections of a gang condenser or coils.

TRIODE: A valve of three electrodes, consisting of cathode or filament, grid and plate.

TUBE: Valve.

TUNED CIRCUIT: A circuit in which one or more components are adjustable to produce resonance to a desired frequency.

TUNING: The adjustment of a circuit or system to secure optimum performance in relation to a frequency; commonly, the adjustment of a circuit or circuits to resonance.

TWEETER: A loud speaker designed to reproduce the higher audio frequencies.

UNDIRECTIONAL: In one direction.

V: Voltage. Volts.

VACUUM TUBE: A device consisting of a number of electrodes contained within an evacuated enclosure.

VACUUM TUBE VOLTMETER: A device utilising the characteristics of a vacuum tube for measuring alternating voltages.

VALVE: A tube containing two or more electrodes, usually exhausted of air or may be gas filled.

VIBRATOR: A mechanical interruptor.

VIBRATOR UNIT: This consists of a transformer connected to a Vibrator, which enables high tension (voltage) for a radio receiver to be obtained from a low voltage battery or accumulator.

VIDEO: Term meaning a picture or vision used in television.

VOICE COIL: The small coil attached to the diaphragm of a dynamic speaker, and actuated by connection to the secondary winding of a matching transformer.

VOLT: The unit of electrical pressure. A pressure of one volt will force one ampere of current through one ohm of resistance.

VOLTAGE AMPLIFICATION: The ratio of the alternating voltage produced at the output terminals of an amplifier to the alternating voltage impressed at the input terminals.

VOLTAGE DIVIDER: Any resistance or system of resistances connected across a D.C. supply from positive to negative so that differing values of voltage are available from the voltage dividing system. A volume control or potentiometer also acts as a voltage divider, when used for controlling audio voltages.

VOLTAGE DROP: The voltage developed across the component by the passage of current through it.

VOLT METER: A meter designed to measure electrical pressure.

W: Symbol for electrical power in Watts.

WATT: The practical unit of power and is the product of volts and amps.

WATTAGE RATING: The amount of power a given device is capable of dissipating.

WAVE: (a) A propagated disturbance, usually periodic, as an electric wave or sound wave; (b) a single cycle of such a disturbance; or, (c) a periodic variation as represented by a graph.

WAVELENGTH: The distance between the crests of a wave is called the wavelength and is measured in metres.

WAVEMETER: An instrument consisting fundamentally of a coil condenser and a calibrated dial used for checking the frequency or wavelength of the signal received.

WAVE TRAP: An inductance capacity combination used to prevent unwanted signals from interfering with the wanted signal.

WHEATSTONE BRIDGE: Device used for the measurement of resistance by means of balancing the unknown resistor against known ones.

WOOFER: A speaker designed for the reproduction of bass or low frequency notes.

X: Symbol for reactance.

XC: Capacitive reactance.

XI: Inductive reactance.

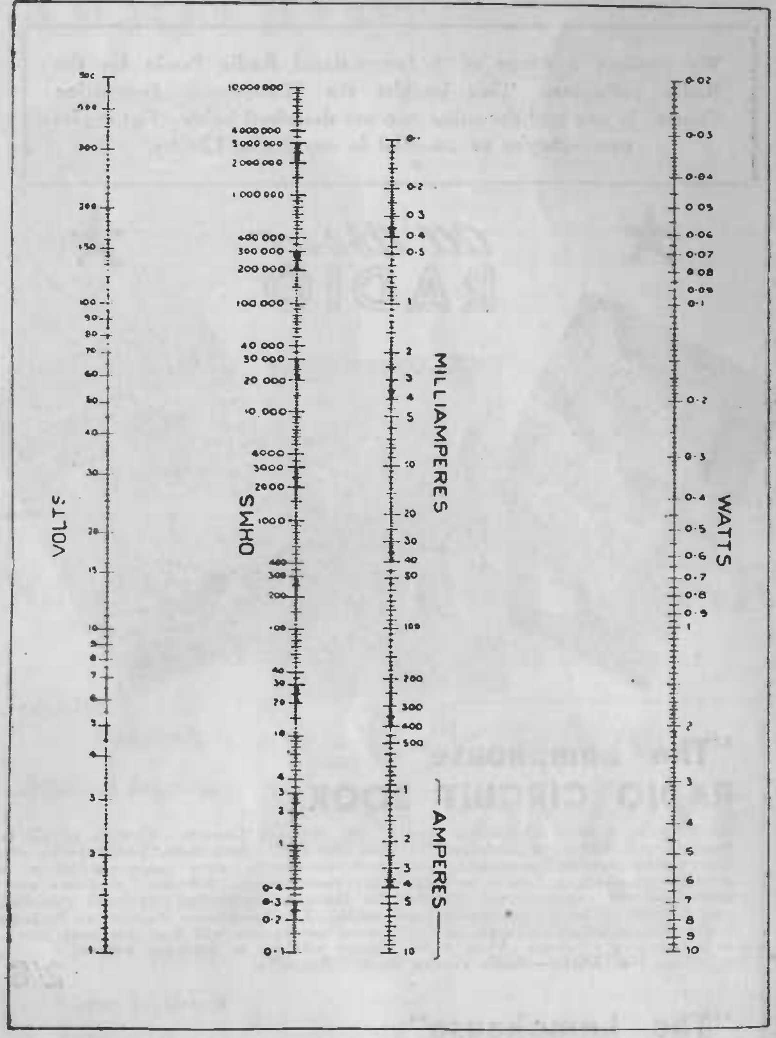
X-RAY: The rays produced by a flow of electrons projected at high velocity against a target. The frequency is much higher than those used in radio communication.

Y: Symbol used to denote admittance in ohms.

Z: The symbol for electrical impedance measured in ohms.

ZERO BEAT: A condition wherein two frequencies being fixed have exactly the same numerical value.

HANDY MEASUREMENT CHART



A straight edge placed across any two known quantities will enable any two unknown quantities to be read off.

WARNING.—Our attention has been drawn by the Post and Telegraph Department to the effect that unless regenerative Receivers, such as the Rahob Single, Hiker's One and All-Wave Double Forty-Nine are operated correctly they are liable to cause interference in neighbouring sets, and in doing so would contravene the radio regulations. It is essential that all users of these types of sets should make certain that they do not attempt to operate the Receiver in an oscillating condition.

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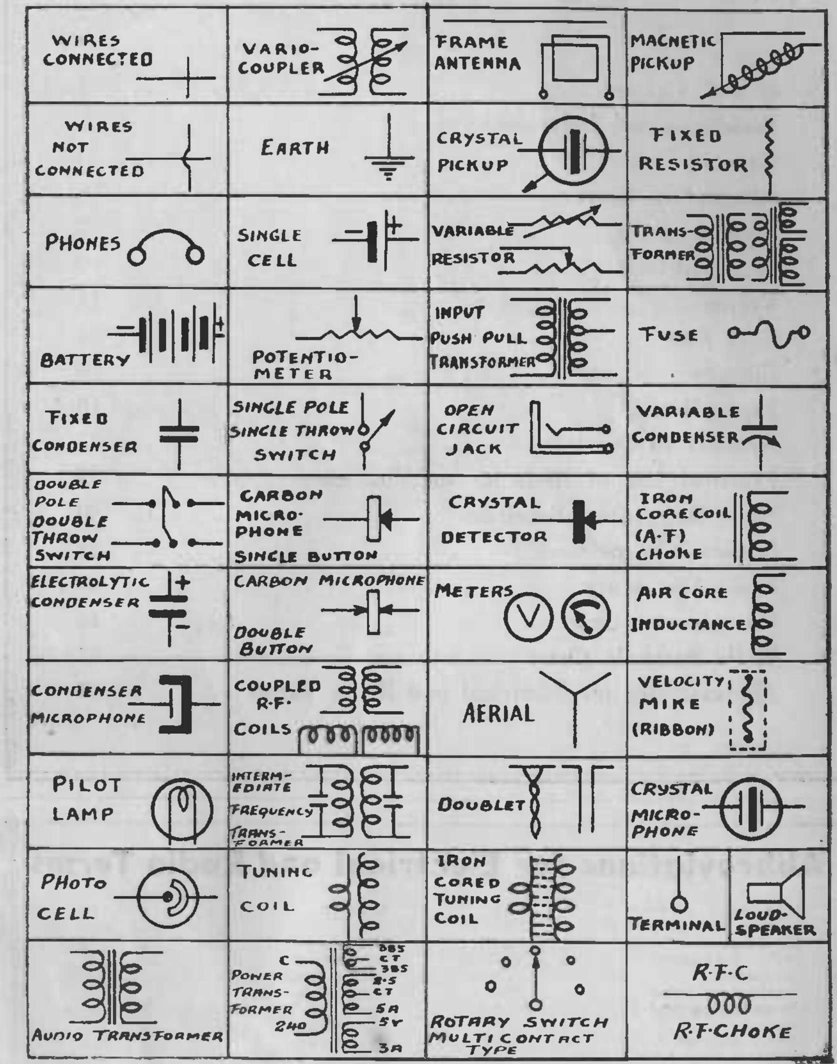
RADIO SYMBOLS CHART



There is a wide variety of components used in radio today, and in order to make their representation simple in circuit diagrams, conventional symbols have been devised. It is unfortunate that no absolute standardisation of radio symbols has been accepted by engineers and designers in all countries, but the above chart shows most of those that are in popular use in this country.

INDEX

Abbreviations for Electrical and Radio Terms

Alternating current	a.c.	Megohm	MΩ
Ampere (amperes)	a.	Meter	m.
Antenna	ant.	Microfarad	μfd.
Audio frequency	a.f.	Microhenry	μh.
Centimeter	cm.	Micromicrofarad	μμfd.
Continuous wave	c.w.	Microvolt	μv.
Cycles per second	c.p.s.	Microvolt per meter	μv/m.
Decibel	db	Microwatt	μw.
Direct current	d.c.	Milliampere	ma.
Electromotive force	e.m.f.	Millivolt	mv.
Frequency	f.	Milliwatt	mw.
Ground	g.n.d.	Modulated continuous waves	m.c.w.
Henry	h.	Ohm	Ω
High frequency	h.f.	Power	P.
Intermediate frequency	i.f.	Power factor	p.f.
Interrupted continuous waves	i.c.w.	Radio frequency	r.f.
Kilocycles (per second)	kc.	Ultra-high frequency	u.h.f.
Kilowatt	kw.	Volt (volts)	v.
Megacycle (per second)	Mc.	Watt (watts)	w.

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