CHAPTER 1.

INTRODUCTION TO THE RADIO VALVE

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SECTION 1 : ELECTRICITY AND EMISSION

The proper understanding of the radio valve in its various applications requires some knowledge of the characteristics of the electron and its companion bodies which make up the complete structure of atoms and molecules.

All matter is composed of molecules which are the smallest particles preserving the individual characteristics of the substance. For example, water is made up of molecules that are bound together by the forces operating between them. Molecules are composed of atoms that are themselves made up of still smaller particles. According to the usual simplified theory, which is sufficient for this purpose, atoms may be pictured as having a central nucleus around which rotate one or more electrons in much the same manner as the planets move around the sun. In the case of the atom, however, there are frequently several electrons in each orbit. The innermost orbit may have up to 2, the second orbit up to 8, the third orbit up to 18, the fourth orbit up to 32, with decreasing numbers in the outermost orbits (which only occur with elements of high "atomic numbers"). We do not know the precise shape and positions of the orbits and modern theory speaks of them as "energy levels" or "shells." The electrons forming the innermost shell are closely bound to the nucleus but the forces become progressively less in the outer shells. Moreover, the number of electrons in the outermost shell may be less than the maximum number that this shell is capable of accommodating. In this case, the substance would be chemically active; examples of such are sodium and potassium.

In a metal the various atoms are situated in close proximity to one another, so that the electrons in the outermost shells have forces acting upon them both from their "parent" nucleus and their near neighbour. Some electrons are free to move about throughout the substance and are, therefore, called "free electrons." If an electric potential is applied between two points in the metal, the number of electrons moving from the negative to the positive point will be greater than those moving in the opposite direction. This constitutes an electric current, since each electron carries an electric charge. The charge on the electron is defined as unit negative charge and the accepted direction of current flow is opposite to the net electron movement.

It is interesting to note that the **total current flow,** equivalent to the total movements of all the free electrons, irrespective of their directions, is very much greater than that which occurs under any normal conditions of electric current flow. The directions of movement are such that the external effects of one are generally cancelled by those of another. Thus, in a metal, the oft-quoted picture of a flow of electrons from the negative to the positive terminal is only a partial truth and apt to be misleading. The velocity of the free electrons is very much less than that of the electric current being of the order of only a few centimetres per second. The electron current may be pictured as the successive impacts between one electron and another in the direction of the current. In an **insulator** the number of free electrons is practically zero, so that electric conduction does not take place. In a partial insulator the number of free electrons is quite small.

The **nucleus** is a very complex body, including one or more protons which may be combined with a number of neutrons*. The proton has a positive charge equal and opposite to the charge on an electron but its mass is very much greater than that of an electron. The simplest possible atom consists of one proton forming the nucleus with one electron in an orbit around it—this is the hydrogen atom. Helium consists of two protons and two neutrons in the nucleus, with two electrons rotating in orbits. The neutron has a mass slightly greater than that of a proton, but the neutron has no electric charge. An example of a more complicated atom is that of potassium which has 19 protons and 20 neutrons in the nucleus, thus having a positive charge of 19 units. The number of electrons in the orbits is 19, thus giving zero charge for the atom as a whole, this being the normal condition of any atom. The common form of uranium has 92 protons and 146 neutrons in the nucleus, with 92 electrons rotating in orbits.

Under normal circumstances no electrons leave the surface of a substance since the forces of attraction towards the centre of the body are too great. As the temperature of the substance is raised, the velocity of the free electrons increases and eventually, at a temperature which varies from one substance to another, some of the free electrons leave the surface and may be attracted to a positive electrode in a vacuum. This phenomenon is known as **thermionic emission** since its emission takes place under the influence of heating. There are other types of emission such as **photo emission** that occur when the surface of the substance is influenced by light, or **secondary emission** when the surface is bombarded by electrons.

The radio valve makes use of thermionic emission in conjunction with associated circuits for the purpose of producing amplification or oscillation. The most common types of radio valves have hot cathodes, either in the form of a filament or an indirectly-heated cathode. Many transmitting valves have filaments such as tungsten or thoriated-tungsten, but nearly all receiving valves have what is known as an **oxide** coated **filament or cathode.** The filament, or cathode sleeve, is usually made of nickel or an alloy containing a large percentage of nickel and this is coated with a mixture of barium and strontium carbonates that, during the manufacture of the valve, are turned into oxides. A valve having an oxide-coated cathode has a very high degree of emission as compared with other forms of emitters but requires very great care during manufacture since it is readily poisoned by certain impurities which may be present in the cathode itself or which may be driven out in the form of gas from the bulb or the other electrodes.

Oxide-coated cathodes are generally operated at an average temperature of about 1050° Kelvin (777° C) which looks a dull red. Temperatures much above 1100°K generally cause a short life, while those below 960°K are very susceptible to poisoning of the emission, and require careful attention to maintain a very high vacuum.

The thermionic valve is normally operated with its **anode† current** considerably less than the maximum emission produced by its cathode. In the case of one having a pure tungsten filament no damage is done to the filament if all the electrons emitted

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*This is in accordance with the theory generally held at the time of writing; it is, however, subjec to later modification.

†The anode (also called the plate) is the positive electrode; the cathode is the negative electrode.

are drawn away immediately to the anode. This is not so, however, with oxide coated cathodes and these, for a long life and satisfactory service, require a total emission very much greater than that drawn under operating conditions. In such a case a cloud of electrons accumulates a short distance from the surface of the cathode and supplies the electrons that go to the anode. This **space charge** as it is called, is like a reservoir of water that supplies varying requirements but is itself replenished at an average rate. The space charge forms a protection to the cathode coating against bombardment and high electrostatic fields, while it also limits the current which would otherwise be drawn by a positive voltage on the anode. If the electron emission from the cathode is insufficient to build up this " space charge," the cathode coating is called upon to supply high peak currents that may do permanent injury to the coating and in extreme cases may even cause sputtering or arcing.

In multi-grid valves, if one grid has a positive potential and the next succeeding grid (proceeding from cathode to plate) has a negative potential, there tends to be formed an additional space charge. This outer space charge behaves as a source of electrons for the outer electrodes, and is known as a **virtual cathode.**

An oxide-coated cathode, operated under proper conditions, is self-rejuvenating and may have an extremely long **working life.** The life is, therefore, largely governed by the excess emission over the peak current required in normal operation.

A valve having a large cathode area and small cathode current may have, under ideal conditions, a life of the order of 50 000 hours, whereas one having extremely limited surface area, such as a tiny battery valve, may have a working life of less than 1000 hours.

Under normal conditions a valve should be operated with its **filament or heater at the recommended voltage** ; in the case of an oxide coated valve it is possible to have fluctuations of the order of 10% up or down without seriously affecting the life or characteristics of the valve [see Chapter 3 Sect. 1(iv)D]. The average voltage should, however, be maintained at the correct value. If the filament or cathode is operated continuously with a higher voltage than that recommended, some of the coating material is evaporated and permanently lost, thus reducing the life of the valve. Moreover, some of this vapour tends to deposit on the grid and give rise to what is known as **grid emission** when the grid itself emits electrons and draws current commonly known as **negative grid current** [for measurement see Chapter 3 Sect. 3 (iv)A].

If the filament or heater is operated for long periods at reduced voltages, the effect is a reduction in emission, but no damage is generally done to the valve unless the cathode currents are sufficient to exhaust the " space charge." Low cathode temperature is, therefore, permissible provided that the anode current is reduced in the proper proportion.

During the working life of the valve, its **emission** usually increases over the early period, reaches a maximum at an age which varies from valve to valve and from one manufacturer to another, and then begins to fall. The user does not generally suffer any detriment until the emission is insufficient to provide peak currents without distortion.

Tests for the measurement of the emission of an oxide-coated cathode are described in Chapter 3 Sect. 3(ii)f.

If a slight amount of **gas** is present some of the electrons will collide with atoms of the gas and may knock off one or more electrons, which will serve to increase the anode current, leaving atoms deficient in electrons. These are known as **positive ions** since they carry a positive charge (brought about by the loss of electrons), and the process is known as ionization. The positive ions are attracted by the negative cathode, and being comparatively massive, they tend to bombard the cathode coating in spite of the protection formed by the space charge.

Some types of rectifiers (e.g. OZ4) have no heaters, and the oxide-coated cathode is initially heated by ion bombardment ; this flow of current is sufficient to raise the cathode temperature so as to enable it to emit electrons in the usual manner. The gas is an inert variety at reduced pressure. Although some types of gaseous thermionic rectifiers will operate (once they have been thoroughly heated) without any filament or heater voltage, this is likely to cause early failure through loss of emission.

Most thermionic valves are **vacuum types** and operate under a very high degree of vacuum. This is produced during manufacture by a combination of vacuum pumps and is made permanent by the flashing of a small amount of " getter " which remains in the bulb ready to combine with any impurities which may be driven off during life. Valves coming through on the production line are all tested for gas by measuring the negative grid current under operating conditions ; methods of testing are described in Chapter 3 Sect. 3(iv)A, where some values of maximum negative grid current are also given. If a valve has been on the shelf for a long time, it frequently shows a higher gas current, but this may usually be reduced to normal by operating the valve under normal conditions, with a low resistance connection between grid and cathode, for a short period. When a valve is slightly gassy, it usually shows a **blue glow** (ionization) between cathode and anode. In extreme cases this may extend outside the ends of the electrodes, but a valve in such condition should be regarded with suspicion and tested before being used in any equipment, as it might do serious damage. A slight crack may permit a very small amount of air to enter the bulb, giving rise to a pink/violet glow which may readily be identified by any one familiar with it ; this is a sign of immediate end of life.

The anode current of a thermionic valve is not perfectly steady, since it is brought about by a flow of electrons from the cathode. When a valve is followed by very high gain amplifiers, the rushing noise heard in the loudspeaker is partly caused by the electrons in the valve, and partly by a somewhat similar effect (referred to as the " thermal agitation " or " Johnson noise ") principally in the resistance in the grid circuit of the first valve—see Chapter 4 Sect. 9(i)l, and Chapter 18 Sect. 2(ii). This question of **valve noise** is dealt with in Chapter 18 Sect. 2(ii)c and Chapter 23 Sect. 6.

Some valves show a fluorescence on the inside of the bulb, which may fluctuate when the valve is operating. This is perfectly harmless and may be distinguished from blue glow by its position in the valve. In occasional cases fluorescence may also be observed on the surfaces of the mica supports inside the valve.

SECTION 2 : THE COMPONENT PARTS OF RADIO VALVES

(*i*) *Filaments, cathodes and heaters* (*ii*) *Grids* (*iii*) *Plates* (*iv*) *Bulbs* (*v*) *Voltages with valve operation.*

(i) Filaments, Cathodes and Heaters

Cathodes are of two main types—directly heated and indirectly heated. Directly-heated cathodes are in the form of filaments which consists of a core of wire through which the filament current is passed, the wire being coated with the usual emissive coating. Filaments are the most economical form of cathodes so far as concerns the power necessary to heat the cathode. They are, therefore, used in most applications for operation from batteries, particularly dry batteries, and for special applications in which very quick heating is required. Filaments are also used in many types of power rectifiers and power triodes, where the special properties of the filament make it more suitable.

Valves having filaments should preferably be mounted with the filament vertical, but if it is necessary to mount them horizontally, they should be arranged so that the plane of the filament of V or W shaped filaments is vertical ; this reduces the chance of the filament touching the grid.

All filament-type valves having close spacing between filament and grid have a filament tension spring, usually mounted at the top of the valve. Some typical filament arrangements are indicated in Fig. 1.1 where A shows a single " V " shape filament suspended by means of a top-hook at the apex, B shows a " W " shape with two top hooks and C a single strand filament with tension spring as used in 1·4 volt valves.

Indirectly-heated cathodes consist of a cathode sleeve surrounding a heater. The cathode sleeve may have a variety of shapes, including round (D), elliptical (E) and rectangular (F) cross section. They are usually fitted with a light ribbon tag for connection to the lead going to the base pin.

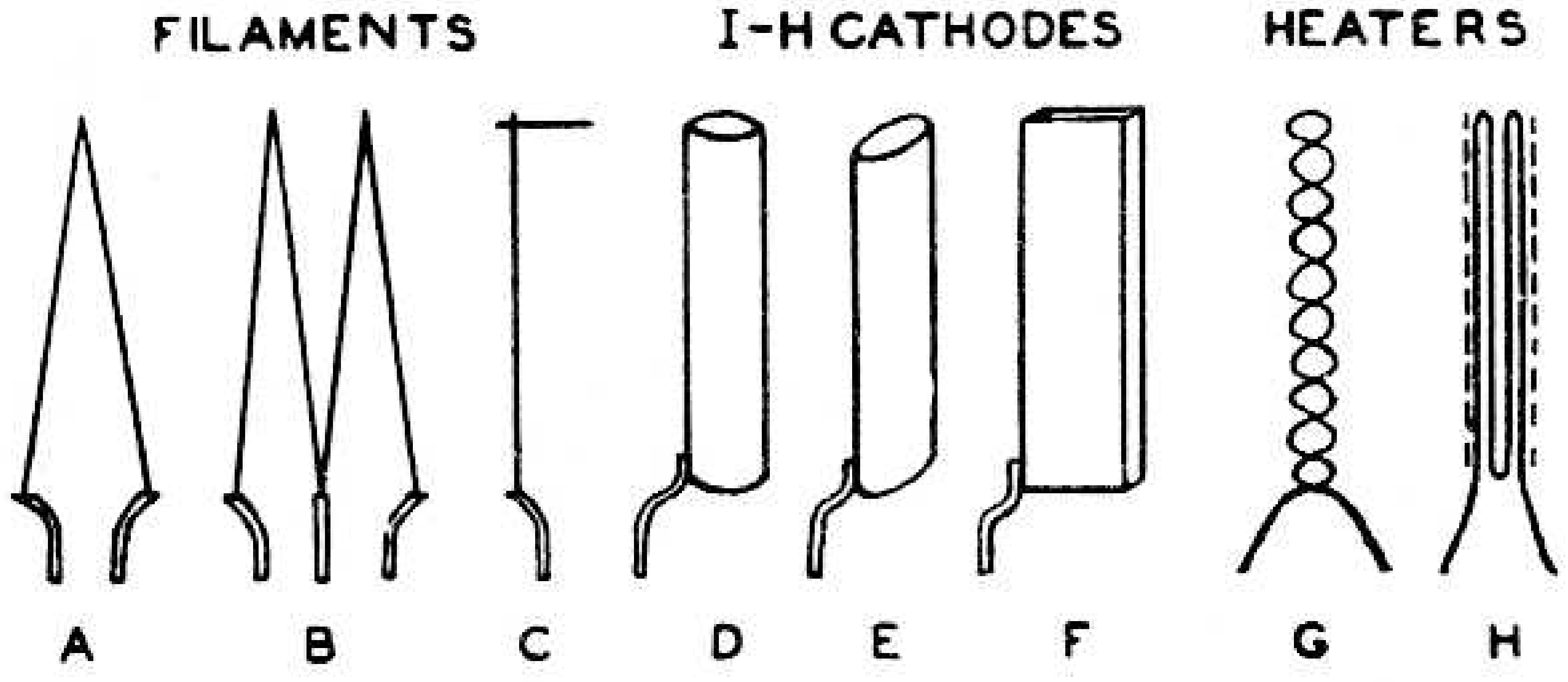

FIG. 1.1

Fig. 1.1. *A, B, C types of filaments ; D, E, F types of cathodes ; G, H types of heaters.*

In an indirectly-heated valve, the function of the heater is solely to heat the cathode. No emission should take place from the heater and the insulation between heater and cathode should be good. The heater is generally made of tungsten or a tungsten alloy wire coated with a substance capable of providing the necessary insulation at high temperature, such as alundum. In all applications where hum is likely to be troublesome, the heater is preferably of the double helical type, as G in Fig. 1.1. Power valves and other types having elliptical or rectangular cathode sleeves, often employ a folded heater as in H. These are not generally suitable for use in very low level amplifiers whether for radio or audio frequencies.

(ii) Grids

Grids are constructed of very fine wire wound around one, two or four side rods—two being by far the most common. Some valves have two, three, four or five grids inside one another, but all of these are similar in general form although different in dimensions.

In the case of some grids it is necessary to take precautions to limit the grid temperature either to avoid grid emission, in the case of control grids, or to limit the grid temperature to prevent the formation of gas, in the case of screen grids. These may, for better heat radiation, be fitted with copper side rods and blackened radiators either above or below the other electrodes. Grids are numbered in order from the cathode outwards, so that No. 1 grid will be the one closest to the cathode, No. 2 grid the one adjacent to it, and No. 3 the one further out again.

(iii) Plates

The plate of a receiving valve is the anode or positive electrode. It may be in one of a great number of shapes, dependent on the particular application of the valve. The plates of power valves and rectifiers are frequently blackened to increase their heat radiation and thereby reduce their temperature.

(iv) Bulbs

The inside surfaces of glass bulbs are frequently blackened. This has the effects of making them more or less conductive, thereby reducing the tendency to develop static charges, and reducing the tendency towards secondary emission from the bulb.

(v) Voltages with valve operation

All voltages in radio valves are taken with respect to the cathode, in the case of indirectly-heated valves, and the negative end of the filament with directly-heated valves. The cathode is usually earthed or is approximately at earth potential, so that this convention is easy to follow under normal conditions. In some cases, as for example phase splitters or cathode followers, the cathode is at a potential considerably above earth and care should be taken to avoid errors.

Some directly-heated valves may be operated with their filaments on a.c. supply, usually with the centre tap of the filament circuit treated as a cathode. In all such cases the valve data emphasize the fact that the filament is intended for operation on a.c. The plate characteristics are usually drawn with d.c. on the filament and these curves may be applied to a.c. operation by increasing the bias voltage by half the filament voltage.

In cases where resistors or other impedances are connected between the positive electrodes and the supply voltages, the electrode voltages (e.g. E_b, E_{c2}) are the voltages existing between those electrodes and cathode under operating conditions. The supply voltages are distinguished by the symbols E_{bb}, E_{cc2} etc. See the list of symbols in Chapter 38 Sect. 6.

For further information on valve operation see Chapter 3 Sect. 1.

SECTION 3 : TYPES OF RADIO VALVES

(i) Diodes (ii) Triodes (iii) Tetrodes (iv) Pentodes (v) Pentode power amplifiers (vi) Combined valves (vii) Pentagrid converters.

(i) Diodes

A diode is the simplest type of radio valve consisting of two electrodes only, the cathode and anode (or plate). The cathode may be either directly or indirectly heated and the valve may be either very small, as for a signal detector, large as for a power rectifier, or any intermediate size. One or two diodes are frequently used in combination with a triode or pentode a-f amplifier as the second detector in receivers ; in most of these cases, a common cathode is used. For some purposes it is necessary to have two diode units with separate cathodes, as in type 6H6. Amplifier types with three diodes, some with a common cathode and others with separate cathodes, have also been manufactured for special purposes. Fig. 1.2 shows the circuit of a diode valve in which battery A is used to heat the filament or heater, and battery B to apply a positive potential to the anode through the load resistor. The plate current is measured by a milliammeter connected as shown, and the direction of current flow is from the positive end of battery B towards the anode, this being the opposite of the electron current flow. It should be noted that the negative end of battery B is returned to the negative end of battery A in accordance with the usual convention. It would be quite permissible to connect the negative end of the battery B to the positive end of battery A so as to get the benefit of the voltage A applied to the anode, but in this case, the total voltage applied to the anode would be A + B. If voltage of battery B is reversed, it will be noted that the plate current is zero, thus indicating the rectification that takes place in a diode. If an alternating voltage is applied, current will only flow during the half-cycles when the anode is positive. This is called a half-wave rectifier since it is only capable of rectifying one half of the cycle.

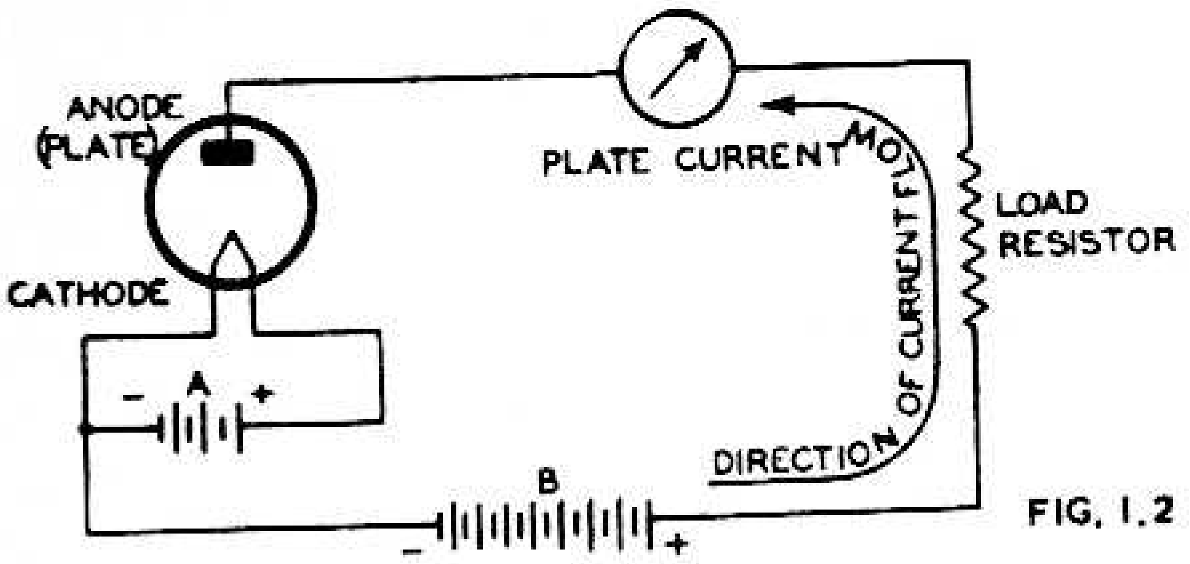

Fig. 1.2. Fundamental circuit including diode, A and B batteries and load resistor.

Full wave* rectifiers are manufactured with two anodes and a common cathode and these are arranged in the circuit so that one diode conducts during one half-cycle and the other during the other half-cycle.

(ii) Triodes

A triode is a three electrode valve, the electrodes being the cathode, grid and anode (or plate). The grid serves to control the plate current flow, and if the grid is made sufficiently negative the plate current is reduced to zero. The voltage on the grid is controlled by battery C in Fig. 1.3, the other part of the circuit being as for the diode in Fig. 1.2. When the grid is negative with respect to the cathode, it does not draw appreciable current ; this is the normal condition as a class A_1 amplifier. Although an indirectly heated cathode has been shown in this instance, a directly heated valve could equally well have been used. The heater in Fig. 1.3 may be supplied either from an a.c. or d.c. source, which should preferably be connected to the cathode or as close as possible to cathode potential.

As the grid is made more negative, so the plate current is decreased and when the grid is made more positive the plate current is increased. A triode is, therefore, capable of converting a voltage change at the grid into a change of power in the load resistor. It may also be used as a voltage amplifier or oscillator.

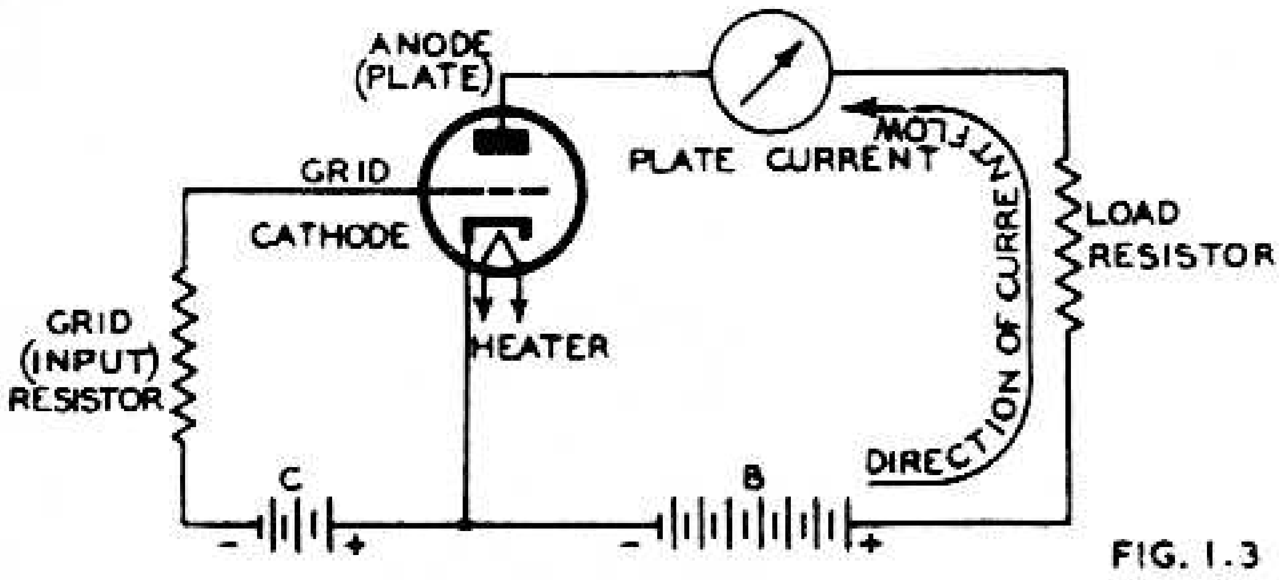

FIG. 1.3

Fig. 1.3. Fundamental circuit including indirectly-heated triode, B and C batteries, and load resistor in plate circuit.

(iii) Tetrodes

The capacitance between the grid and plate can be reduced by mounting an additional electrode, generally called the screen or screen grid, between the grid and plate. The valve thus has four electrodes, hence the name tetrode. The function of the screen is to act as an electrostatic shield between grid and plate, thus reducing the grid-to-plate capacitance. The screen is connected to a positive potential (although less than that of the plate) in order to counteract the blocking effect which it would otherwise have on the plate current—see Fig. 1.4. Owing to the comparatively large spaces between the wires in the screen, most of the electrons from the cathode pass through the screen to the plate. So long as the plate voltage is higher than the screen voltage, the plate current depends primarily on the screen voltage and only to a slight extent on the plate voltage. This construction makes possible a much higher amplification than with a triode, and the lower grid-to-plate capacitance makes the high gain practicable at radio frequencies without instability.

Fig. 1.4. Fundamental circuit including indirectly-heated tetrode, B and C batteries, and load resistor in plate circuit.

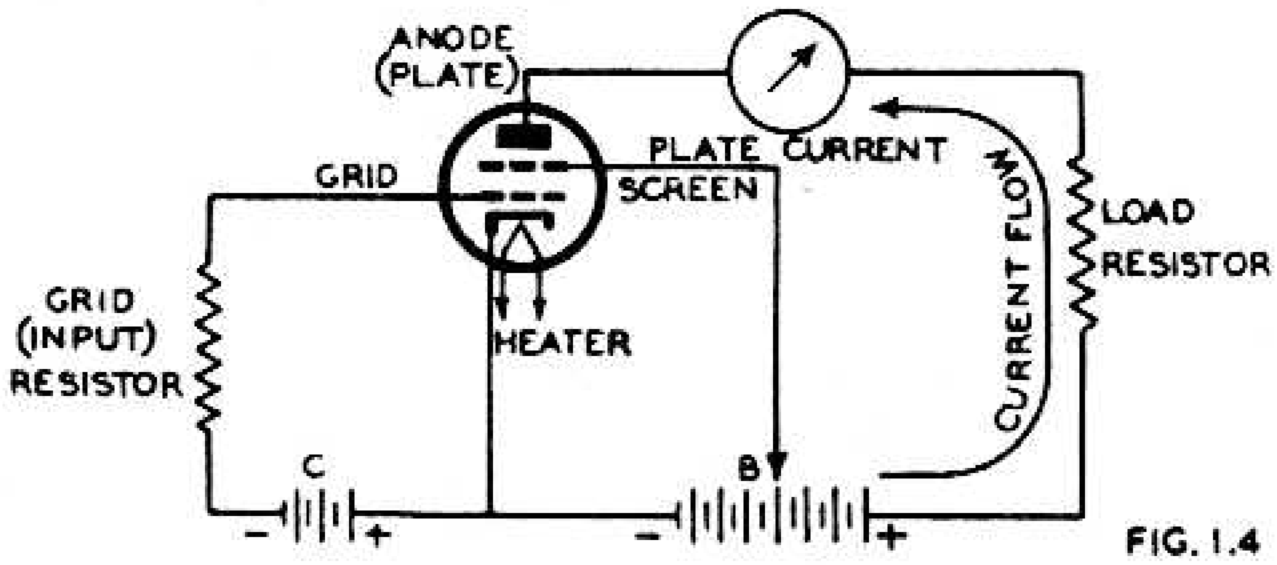

FIG. 1.4

(iv) Pentodes

Electrons striking the plate with sufficient velocities may dislodge other electrons and so cause what is known as " secondary emission." In the case of tetrodes, when

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*These are sometimes called biphase half-wave rectifiers.

the plate voltage swings down to a low value under working conditions, the screen may be instantaneously at a higher positive potential than the plate, and hence the secondary electrons are attracted to the screen. This has the effect of lowering the plate current over the region of low plate voltage and thus limits the permissible plate voltage swing. This effect is avoided when a suppressor is inserted between screen and plate. The suppressor is normally connected to the cathode as in Fig. 1.5. Owing to its negative potential with respect to the plate, the suppressor retards the movements of secondary electrons and diverts them back to the plate.

A valve with three grids is known as a pentode because it has five electrodes. Pentodes are commonly used as radio frequency amplifiers and as power amplifiers. Pentode r-f amplifiers are of two main varieties, those having a sharp cut-off* characteristic and those having a remote cut-off*. Valves having sharp cut-off characteristics are generally used as audio frequency voltage amplifiers and anode bend detectors, while remote cut-off amplifiers are used as r-f and i-f amplifiers. The remote cut-off characteristic permits the application of automatic volume control with a minimum of distortion ; this subject is treated in detail in Chapter 27 Sect. 3.

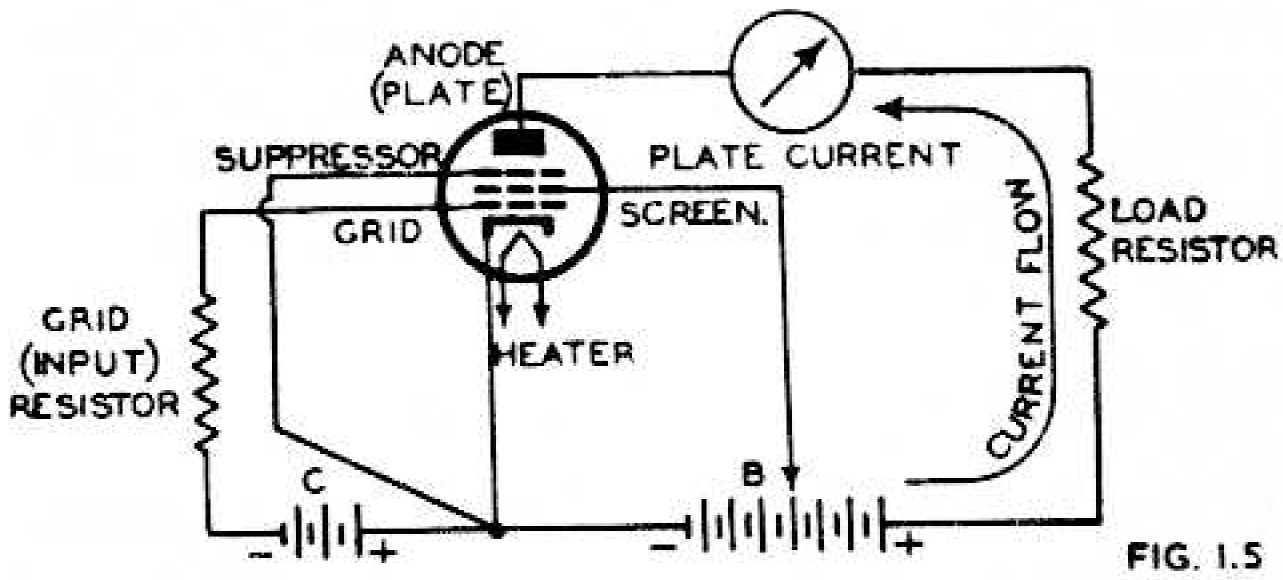

FIG. 1.5

Fig. 1.5. Fundamental circuit including indirectly-heated pentode, B and C batteries, and load resistor in plate circuit,

(v) Pentode power amplifiers

Pentode power amplifiers are commonly used in receiving sets to produce a-f power outputs from about 1 watt up to about 5 watts. They differ from r-f amplifiers in that no particular precautions are made to provide screening, and they are designed for handling higher plate currents and screen voltages. In principle, however, both types are identical and any r-f pentode may be used as a low-power a-f amplifier.

Beam power valves with " aligned " grids do not require a third grid to give characteristics resembling those of a power pentode ; a typical structure is shown in Fig. 1.6. Some " kinkless " tetrodes are also used as r-f and i-f amplifiers. All of these may be treated as being, in most respects, equivalent to pentodes.

(vi) Combined valves

Many combinations of valves have been made. Two triodes are frequently mounted in one envelope to form a " twin triode." One or more diodes are frequently combined with triodes and pentodes to form second detectors. A combination of triode and pentode in one envelope is also fairly common, one application being as a frequency changer. Other combinations are triode-hexodes and triode-heptodes, all of which are primarily intended for use as frequency changers or " converters." In these, the triode grid is generally connected internally to No. 3 grid in the hexode or heptode to provide the necessary mixing of the oscillator and signal voltages. A hexode has four grids while the heptode has five, the outermost of which is a suppressor functioning in the same manner as in a pentode.

In addition to this wide range of combinations, entirely different valves may be combined in one envelope to save space in very small receivers. This is a practice which appears to be dying out, particularly as the envelope size becomes smaller.

(vii) Pentagrid converters

Pentagrids are valves having 5 grids, so that they are really heptodes, but the name pentagrid appears to make a convenient distinction between valves in this group

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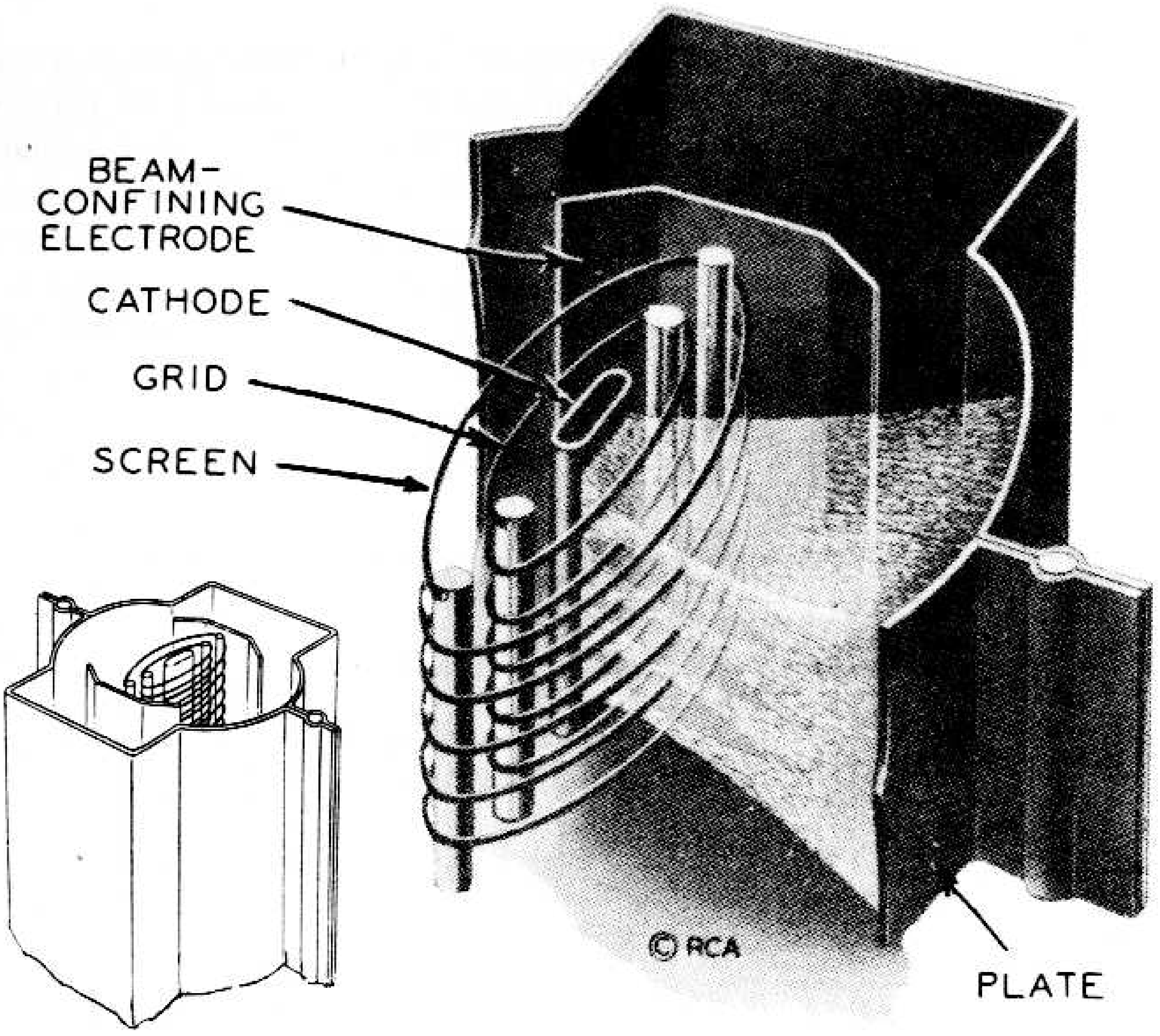
*Sharp cut-off indicates that the plate-current characteristic is as straight as it can be made. A remote cut-off characteristic indicates that the plate current does not become zero until the grid voltage is made very much negative (usually over 30 volts).



ELECTRON BEAM SHEETS FORMED BY GRID WIRES

Fig. 1.6. *Internal structure of type* 6L6 *or* 807 *aligned grid beam power valve* (*diagram by courtesy of R.C.A.*).

(which do not normally require external oscillators) and those of the hexode or heptode "mixer" type which are used with separate oscillators. Pentagrid converters are of two main groups, the first of these being the 6A8 type of construction which incorporates an oscillator grid and oscillator anode ("anode grid") as part of the main cathode stream. The other group comprises the 6SA7, 6BE6 and 1R5 type of construction which has no separate oscillator anode, the screen grid serving a dual purpose. The various types of pentagrid converters are described in detail in Chapter 25.

SECTION 4 : MAXIMUM RATINGS AND TOLERANCES

(*i*) *Maximum ratings and their interpretation* (*ii*) *Tolerances.*

(i) Maximum ratings and their interpretation

Maximum ratings are of two types—the Absolute Maximum system and the Design Centre system. These are described in detail in Chapter 3 Sect. 1(iv).

(ii) Tolerances

All valves are tested in the factory for a number of characteristics, these usually including plate current, screen current, negative grid current, mutual conductance, noise and microphony, as well as having to pass visual inspection tests for appearance. For methods of testing see Chapter 3. As with any other components such as resistors or capacitors, the characteristics can only be maintained within certain tolerances. For example, a resistor may be bought with a tolerance of plus or minus 10% or 20% ; closer tolerances may be purchased at a higher price.

The subject of tolerances in valve characteristics is covered in detail in Chapter 3 Sect. 2(iii).

Special care should be taken in the screen circuits of beam power amplifiers since in these the screen currents may vary from zero to twice the average figure. Any screen voltage dropping resistor is undesirable with such valves and if the screen is required to be operated at a lower voltage than the plate, it should be supplied from a voltage divider having a bleed current of preferably 5 times the nominal screen current. Alternatively, the screen voltage should be determined for the extreme cases of zero and twice nominal screen current.

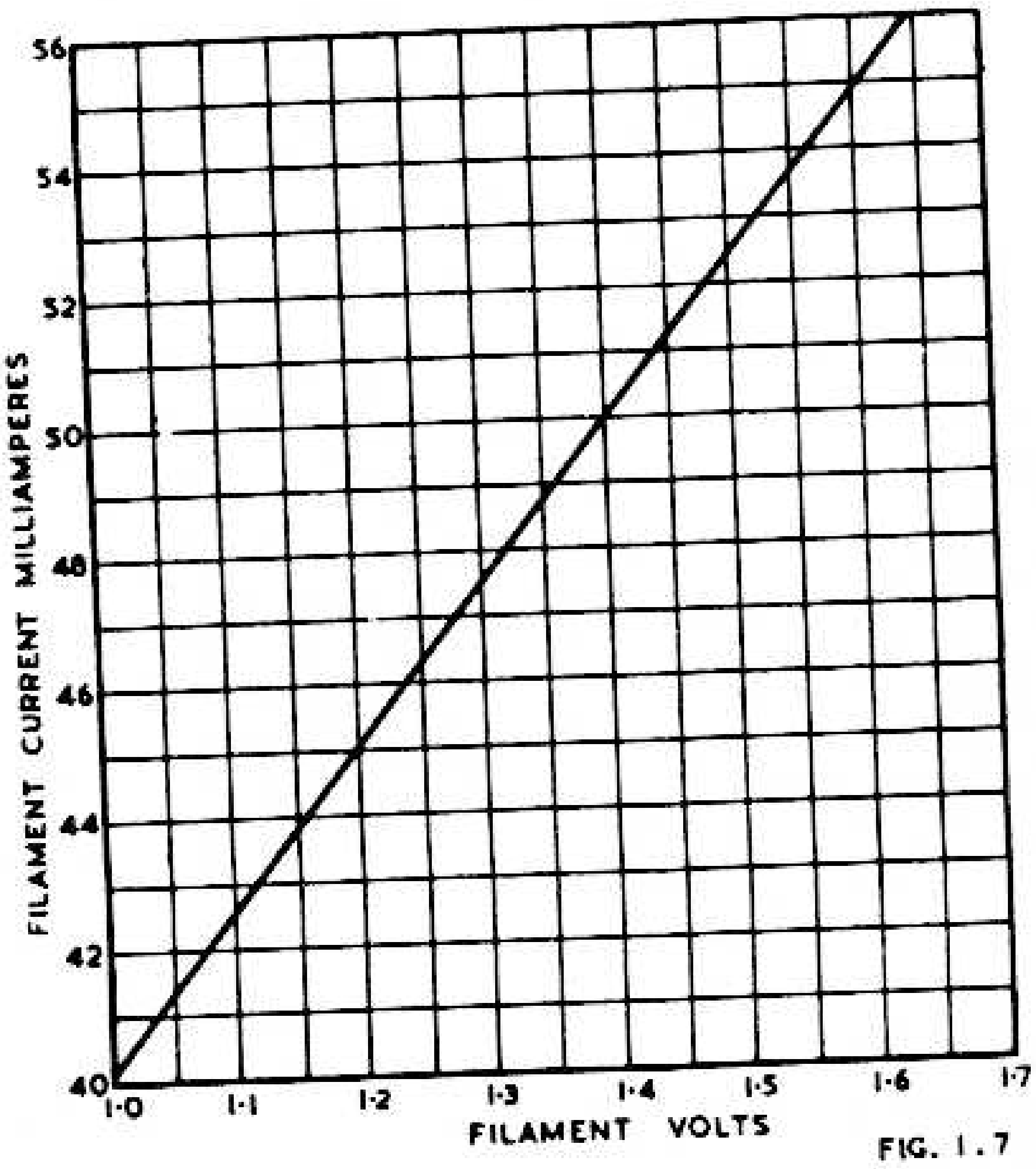


FIG. 1.7

Fig. 1.7. *Filament current versus filament voltage for a valve having a* 1.4 *volt* 50 *milliampere filament.*

The heater voltage should be maintained at an average voltage equal to the recommended voltage, thus leaving a margin of plus or minus 10% for line fluctuations under normal conditions—see Chapter 3 Sect. 1(iv)D. If any wider variation is required, this will involve decreased maximum grid circuit resistance for a higher heater voltage and decreased plate current for lower heater voltage.

SECTION 5 : FILAMENT AND HEATER VOLTAGE/CURRENT CHARACTERISTICS

A valve filament or heater operates at such a temperature that its resistance when hot is much greater than its resistance when cold. The current/voltage characteristic is curved and does not follow Ohm's Law. Two typical examples are Fig. 1.7 for a battery valve and Fig. 35.14 for an indirectly-heated valve. Approximate curves for general use, on a percentage basis, are given in Fig. 1.8 including also dissipation in watts and temperature (Ref. 7). Filament and heater ratings are covered in Chapter 3 Sect. 1.

SECTION 6 : VALVE NUMBERING SYSTEMS

Receiving valves having the American numbering follow two main systems. The first of these is the numerical system, which is the older, and the second the R.M.A. system. Originally various manufacturers produced the same valve under different type numbers such as 135, 235, 335, 435 etc. This was improved upon by dropping the first figure and using only the two latter figures, e.g. 35.

All the more recent American releases follow the R.M.A. system (Ref. 8) of which a typical example is 6A8-GT. In this system the first figure indicates the approximate filament or heater voltage—6 indicates a voltage between 5·6 and 6·6 volts, while 5 indicates a voltage between 4·6 and 5·6 volts ; 1 indicates a voltage in excess of 0 and including 1·6 volts, while 0 indicates a cold cathode. Lock-in types in the 6·3 volt range are given the first figure 7 (this being the " nominal " voltage), but the normal operating voltages remain at 6·3 volts. In the case of tapped filaments or heaters the first figure indicates the total voltage with both sections in series.

The second symbol is a letter which is allotted in sequence commencing with A, except that I and O are not used ; rectifiers follow the sequence backwards commencing at Z. When all the single letters of a group are exhausted, the system then proceeds with two lettters commencing with AB ; combinations of identical letters are not normally used. The single-ended a.c. range has a first letter S while the second letter may be that of the nearest equivalent in the double-ended range—e.g. type 6SK7 is the nearest single-ended equivalent to type 6K7. Another special case is the first letter L which is used for lock-in types in the battery range.

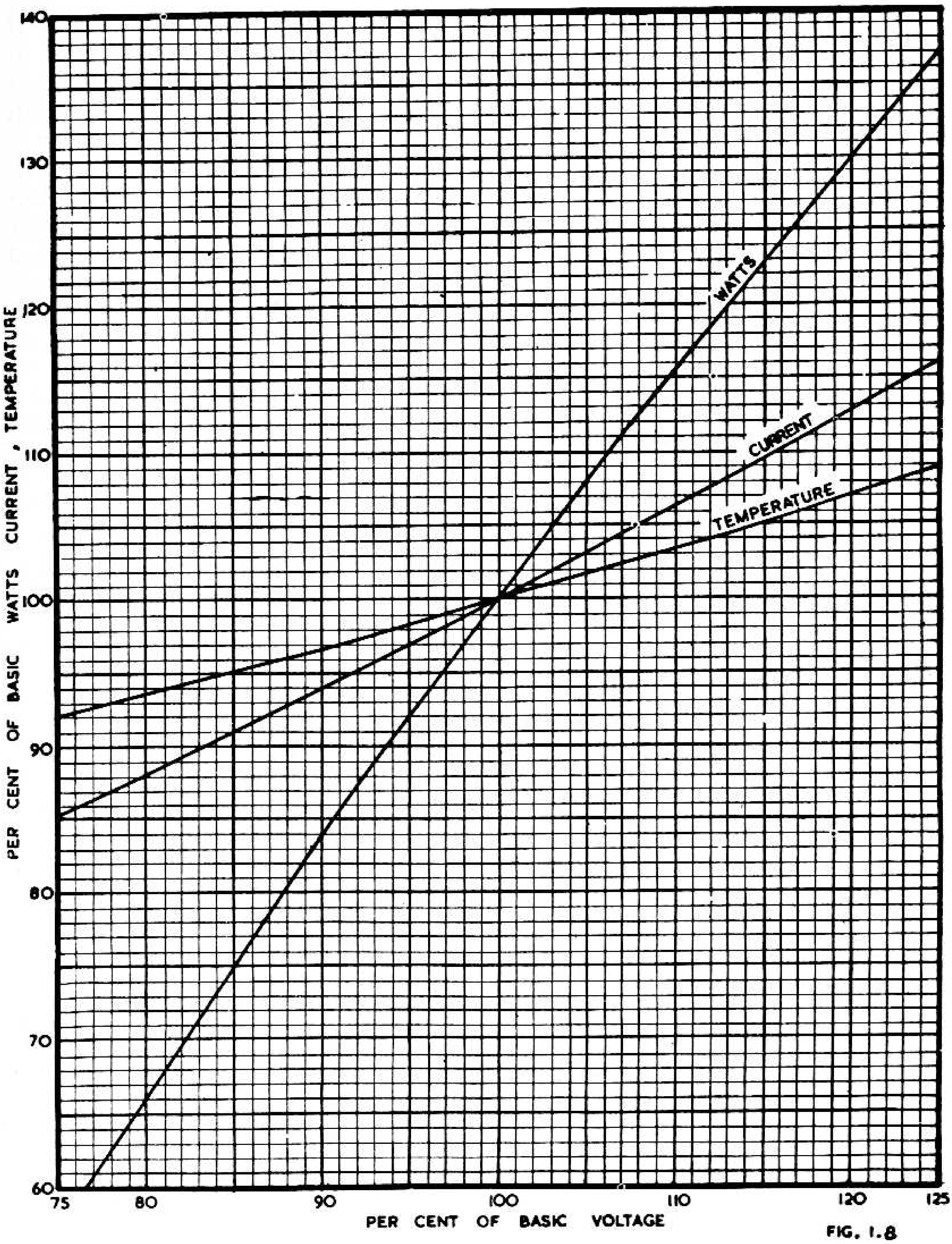


FIG. 1.8

Fig. 1.8. *Filament or heater current, dissipation and temperature plotted against filament or heater voltage, per cent (Ref.* 7).

The final figure denotes the number of "useful elements" brought out to an external connection.

The envelope of a metal valve, the metal base of a lock-in valve, and internal shielding having its separate and exclusive terminal(s) are counted as useful elements. A filament or heater counts as one useful element, except that a tapped filament or heater of two or more sections of unequal rated section voltages or currents counts as two useful elements. An octal-based glass valve having *n* useful elements exclusive of those connected to Pin No. 1 is counted as having $n + 1$ useful elements. Elements connected to terminals identified as "internal connection, do not use" do not count as useful elements. Combinations of one or more elements connected to the same terminal or terminals are counted as one useful element. For example a directly heated triode with a non-octal base is denoted by 3; an indirectly-heated triode, with a non-octal base is designated by 4; a directly-heated tetrode with a non-octal base is designated by 4. A pentode with the suppressor internally connected to filament or cathode is numbered as a tetrode. A metal envelope or octal-based glass triode with an indirectly-heated cathode is designated by 5, a tetrode (or pentode with the suppressor internally connected) by 6, and a triode-hexode converter usually by 8.

The suffix after the hyphen denotes the type of construction used. In general, metal valves, lock-in types and miniature types have no suffixes, but octal-based glass valves types are given the suffix G for the larger glass bulb or GT for the smaller parallel-sided T9 bulb. The letter M indicates a metal-coated glass envelope and octal base. X indicates a "low loss" base composed of material having a loss factor of 0·035 maximum (determination of loss factor to be in accordance with ASTM Designation D-150-41T). The letter Y indicates an intermediate-loss base composed of material having a loss factor of 0·1 maximum. The letter W indicates a military type. The letters, A,B,C,D,E and F assigned in that order indicate a later and modified version which can be substituted for any previous version but not vice versa.

SECTION 7 : REFERENCES*

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Additional references will be found in the Supplement commencing on page 1475.

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*For abbreviations of titles of periodicals and references to periodicals see pages 1367-1369.