Dr Lawal. ©

Thermionic emission

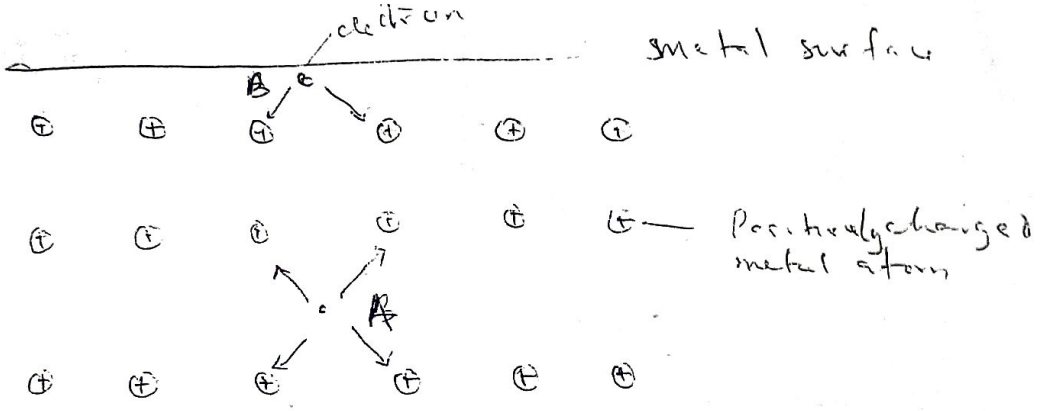
Electron can escape from the surface of a material in various ways, The chief of these are

1. Thermionic emission
2. Photoelectric emission
3. Secondary emission

Thermionic emission is the method often used to obtain a supply of electrons.

In this process, electrons are made to leave the surface of a metal or a metal coated with certain oxides by the application of heat.

The action can be seen to occur in the following way. The atoms in a metal are regularly spaced forming a rigid lattice structure, see fig 1



Every atom has one or more loosely held electrons which, due to the close packing of atoms in a solid are not attached to any particular atom but form an 'electron cloud' belonging to the metal as a whole. The atoms, being short of electrons are positively charged and exert attractive forces on the electrons in the inter-atomic spaces.

At points like A inside the metal, the forces on an electron more or less balance; near the surface at B, an electron trying to escape experiences an

inwards pull due to the absence of atoms above it. The surface act as a barrier which cannot be penetrated by an electron unless its kinetic energy is increased. If the metal is heated to a high temperature, many of the inter-atomic electrons gets sufficient energy to break out.

The energy required by an electron to enable it to escape from the surface of a metal is called the work function ϕ. It depends largely on the nature of the metal. Thermionic emission is analogous to boiling off molecules from the surface of a liquid and the work function can be compared with the specific latent heat of vaporization.

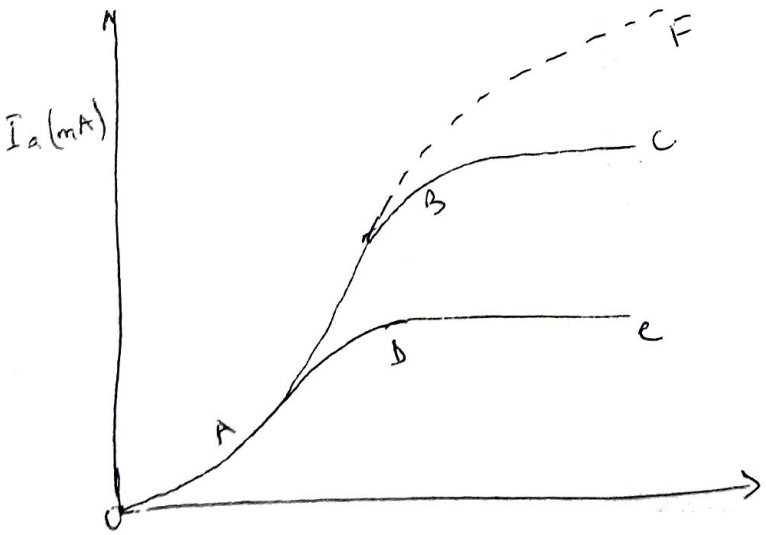
Hot cathode

In many electronic devices, the cathode is heated and acts as the electron-emitter. Such devices are said to have thermionic or 'hot' cathode. The smaller the work function of a metal, the lower the temperature at which it releases electrons, any metal that gives thermionic emission, in most cases, the temperature is to be too near the melting point. Two emitting metals we use for hot cathodes are

(1) Tungsten. This metal has a work function of 4.5 eV and operates at the rather high temperature of 2200°C, it has white heat, its melting point is about 3300°C. A large emission is possible and it is used chiefly in high-power radio transmitting valves.

anode voltage. The L.T can be a.c or d.c and ies from 1.4 Volts for a battery type valve to 6.3 Volts more for a mains-type valve. The H.T must be d.c. d variable up to 100 or 200 Volts according to the valve. The anode current I_a is measured by a milliammeter and the anode voltage V_a by a voltmeter. The filament is connected to H.T negative to provide a complete circuit for the anode current

To obtain the characteristic curve, V_a is increased by steps and the corresponding values of I_a recorded. If the results are plotted, a curve is obtained similar to OABC as in the diagram below



characteristic curve graph

It can be explained as follows. When V_a is zero, the electrons emitted by the filament tends to ~~cluster~~ cluster round it since their emission velocities are small.

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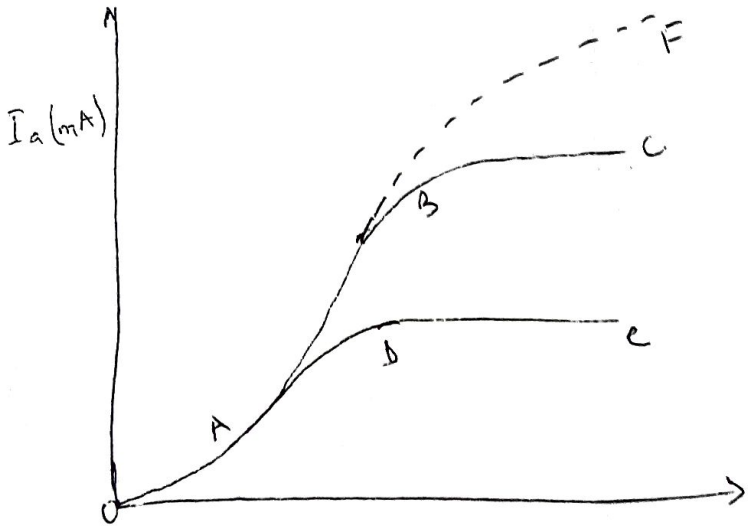

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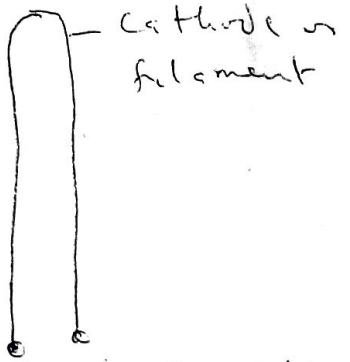
oxide-coated valves saturate less abruptly due to the emission depending on the electric field at the cathode surface as well as ~~the~~ on the cathode temperature. They follow a curve similar to CF in the characteristic curve graph

OXIDE-COATED METALS. A mixture of the oxides of
ium and strontium has a work function of approximately
eV and give copious emission at 750°C i.e. dull
red heat. Most thermionic devices employ this type of
emitter.

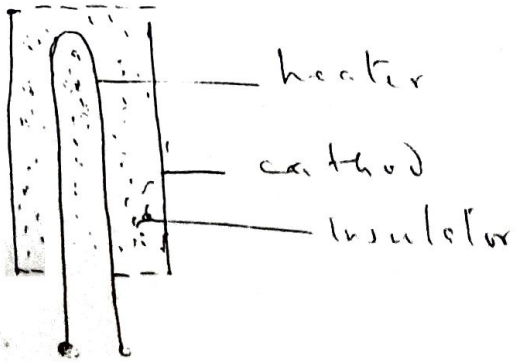
The cathodes are heated electrically either directly
or indirectly.

In the direct heating, a current is passed through the
cathode itself, which is in the form of a wire or filament
made of tungsten or tungsten coated with oxide mixture



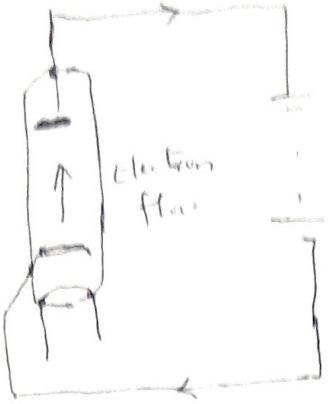
directly heated cathod

Indirect heating is possible with oxide-coated cathodes



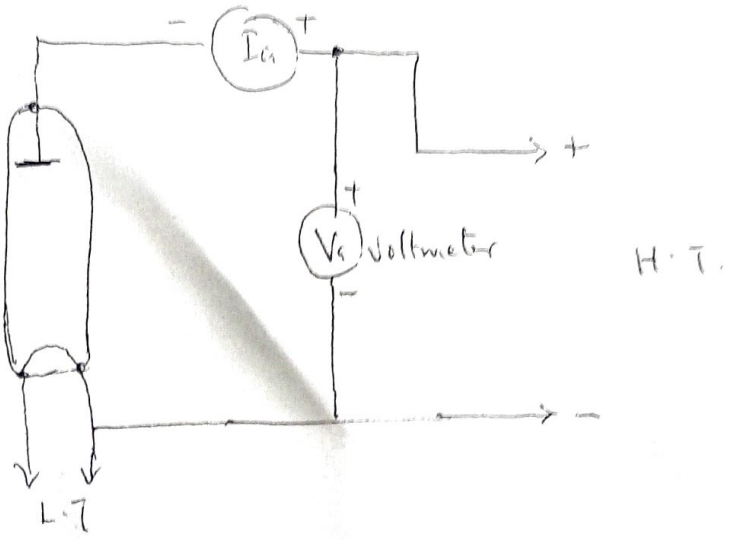
Indirect heated cathode

Here the cathode consist of a thin hollow nickel
tube on which the oxide is sprayed. The cathode
is heated by passing a current through the fine
tungsten wire, called the heater, inside the tube



characteristics of a diode valve

characteristic curves show how the anode current depends on the anode voltage ie. the p.d between the anode and cathode and may be determine experimentally for a directly heated diode using the circuit diagram below



As with most valve circuits, two voltages are required — a low tension or L.T supply to maintain heating current through the filament and a high Tension dd or H.T supply to provide

anode voltage. The L.T can be a.c or d.c and ies from 1.4 Volts for a battery type valve to 6.3 Volts more for a mains-type valve. The H.T must be d.c. d variable up to 100 or 200 Volts according to the valve

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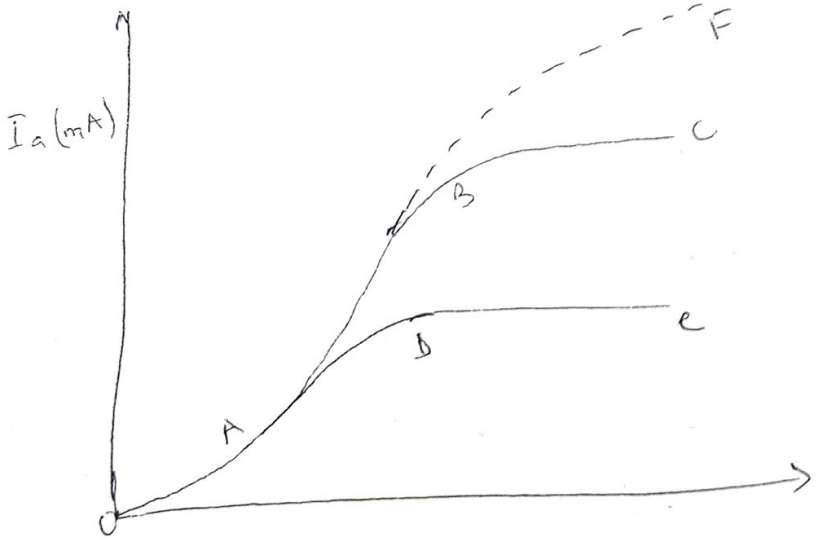

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