PLANAR DIODE	TEL 520

The DIODE consists essentially of a filament and a circular plate within an evacuated, clear glass bulb, the inside of which has been made electrically conducting to eliminate external electrostatic field effects. The plate and the filament are parallel thus providing a planar construction. The filament is pure tungsten wire mounted on two leads connected to 4 mm dia sockets in a plastics cap on the neck. Connection to the plate is by a 4 mm plug mounted on a plastics top-cap.

The form of construction corresponds with the conventional diode symbol. The performance of the diode however has been improved by attaching to one of the filament leads a circular disc parallel with the plate to provide a more uniform electric field between the electrodes.

The diode can be mounted in the Universal Stand TEL 501.

Specification. Maximum filament voltage 7.5 V
Optimum plate voltage 500 V
Typical plate current 3 mA

RECOMMENDED EXPERIMENTS.

Prior knowledge of the evidence indicating the particulate nature of matter and of electricity, kinetic motion, together with an acquaintance of electro magnetic and electrostatic phenomena, is assumed. As a corollary to the observation that air is ionised by the thermionic effect of an electrically heated filament, the experiment of heating a refractory metal wire in a vacuum suggests itself immediately. This experiment can conveniently be carried out with the Planar Diode TEL 520.

EXPERIMENT 1. (SERIES A) PHENOMENA OF THERMIONIC EFFECT IN VACUUM.

Connect the diode into the circuit of Figure 1 and observe the following:-

1.1. When the filament is cold no current flows between the plate and filament even when the potential difference (p.d.) across these electrodes is increased.

1.2. The resistance of the filament when cold.

1.3. When the filament is hot and with NO p.d. across the electrodes, a current

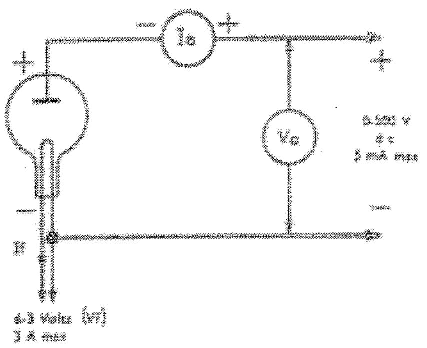

FIGURE 1 CIRCUIT DIAGRAM

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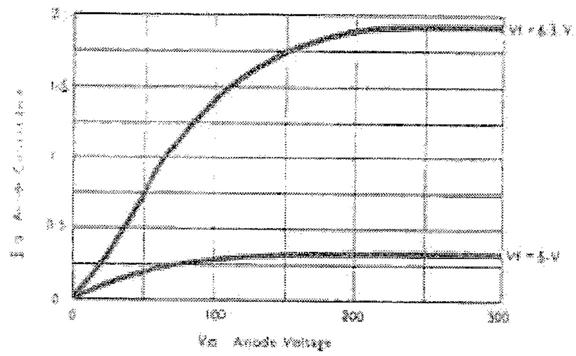

FIGURE 2 DIODE CHARACTERISTIC

of 40 to 60μA flows (the Edison effect)

1.4. This current depends directly on the temperature of the filament (i.e on the voltage which is applied to the filament).

1.5. The resistance of the filament when hot and compare with 1.2.

1.6. For a fixed filament temperature the current across the electrodes increases with the p.d.

1.7. For a fixed p.d, the current across the electrodes depends on the temperature of the filament.

EXPERIMENT 2. (SERIES A) EVIDENCE OF UNILATERAL FLOW.

The d.c. milliameter (Ia) in Figure 1 indicates that the flow of current is either negative charge moving from the filament to the plate or positive charge moving in the reverse direction. Observe that when the polarity of the p.d. is reversed, i.e. when the filament is positive with respect to the plate, no flow of current can be detected.

This experiment only shows that the flow of current in a diode is unilateral; to determine the direction of flow requires an additional electrode i.e. the Triode TEL 521, Experiment 3.

EXPERIMENT 16. (SERIES A) DETERMINATION OF e/m BY MAGNETRON METHOD.

It can be shown that the path of an electron moving in uniform magnetic and electric fields mutually at right angles, is a cycloid. The vertical displacement y of an electron, measured from the emitting surface, is given by $y = mE/eB^2(1 - \cos wt)$ where E is the potential gradient V_a/d, d the separation of filament and plate and B the magnetic flux density.
y will be a maximum when $(1 - \cos wt) = 2$ i.e. when $y = d$.

If the displacement is just less than d, no current will flow to the plate, i.e. the current will be "cut off". By plotting the anode current, Ia, against the field strength, B, for a given set of operating conditions, the anode current will suddenly decrease near the "cut off" point.

$$y_{cut\ off} = d = \frac{2mE}{eB^2} = \frac{2mV_a}{eB^2 d}$$

$$\text{and} \quad \frac{e}{m} = \frac{2V_a}{d^2 B^2}$$

Measurements can be made with the filament at different temperatures and with the diode "saturated" (see experiment 18). The separation of the filament and plate can be measured visually. The magnetic flux, B, can be calculated from the dimensions of the coils and the coil current, I_B (see notes on the Helmholtz coils TEL 502). Details of circuit are given in Figure 3. Typical results are shown in Figure 4.

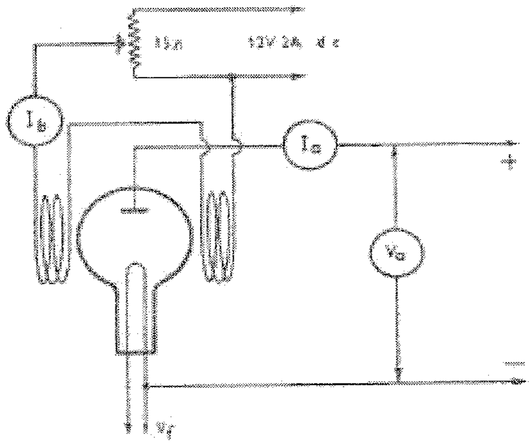

FIGURE 3 MAGNETRON CIRCUIT

In practise the "cut off" is not sharp and is best extrapolated from the point of intersection of tangents drawn to the two parts of the curve; the curve in the "cut off" region is due to emission velocity distribution and to the interference and end effects of the electromagnetic and electrostatic fields.

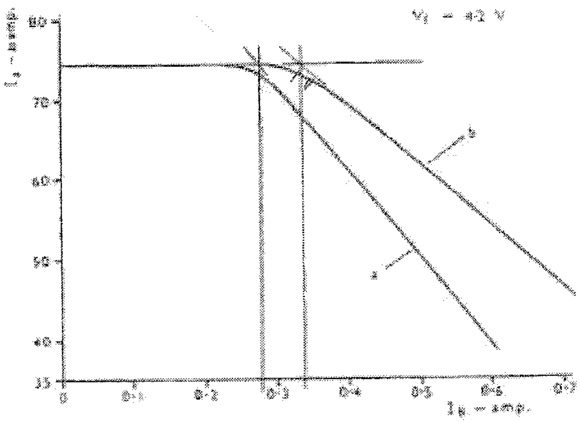

FIGURE 4 MAGNETRON CHARACTERISTIC CURVE

V_a	a 50	b 75	volts
d	0·02	0·02	metres
I_B	0·275	0·335	amps
B TEL. 502	4·23	4·23	$\times 10^{-3} \times I_B$
∴ B	1·18	1·42	$\times 10^{-3}$ Webers
$\frac{e}{m}$	1·80	1·86	$\times 10^{11}$ Coulombs/Kg.

EXPERIMENT 17. (SERIES A) APPLICATION OF DIODE AS RECTIFIER.

In the place of the milliameter in the anode circuit shown in Figure 1 connect a 10k ohm, 1 watt resistor and in place of the DC polarising voltage connect a suitable 250 V a.c. supply.

Investigate the variation of the p.d. across the load-resistor by connecting its ends to the y-plates of an oscilloscope to show the half-wave rectification. Observe that "saturation" of the alternating anode current, Ia, occurs as the amplitude of the a.c. voltage increases.

(continued - Experiment 18)

For various filament temperatures i.e. various values of V_f plot the curves of anode current, I_a, against p.d., V_a.

Note that the current passed by the diode eventually rises to an approximately steady value which is known as the "saturation" current. Note that the "saturation" current is very dependent on the temperature of the filament.

Typical characteristics are shown in Figure 2.

The use of a pure tungsten filament rather than the more modern thoriated or indirectly heated cathodes, ensures that the phenomenon of saturation is evident.

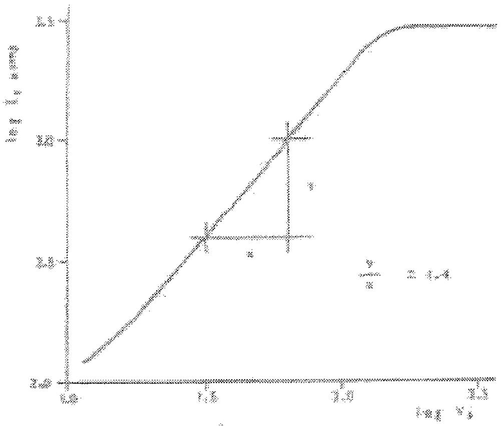

FIGURE 5 3/2 POWER LAW

Child and Langmuir, assuming zero emission velocity and also zero electric force at the cathode surface, used Poisson's equation to establish that

$$I_a = K\,V_a^{3/2}$$

hence $\log I_a = 1 \cdot 5 \log V_a + \log k$.

where the constant k is a factor of the geometry of the system, which in this instance is planar.

In figure 5, log I_a is plotted against log V_a and the slope of the unsaturated part of the curve shows a close approximation to the Three Halves Power Law.

(NOTE: For advanced pupils having a knowledge of the Richardson – Dushman equation and Stefan's Law, the temperature of the filament may be estimated from the measurements of its resistance when cold and when hot, experiments 1.2. and 1.5.).

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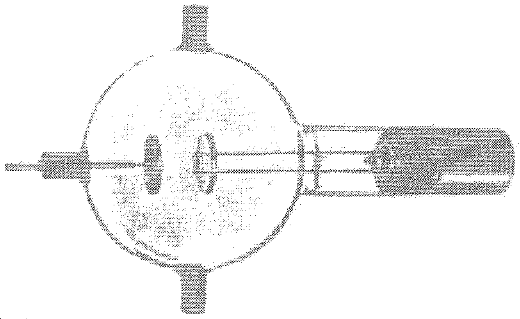

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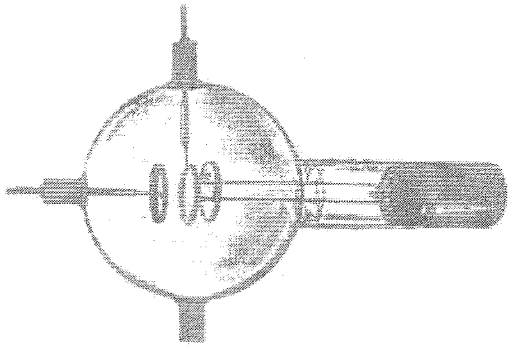

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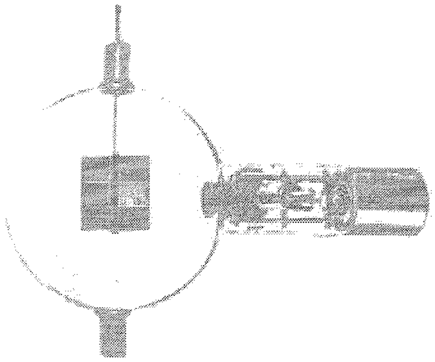

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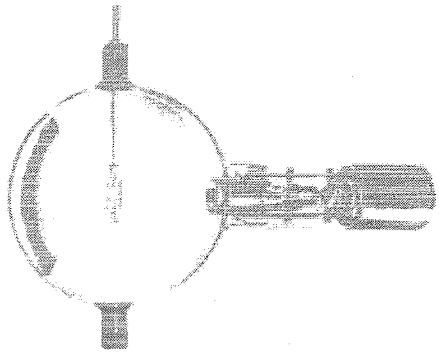

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