PLANAR TRIODE. ✓ TEL 521.

The triode consists essentially of a filament and a circular plate, between and parallel to which, is separately mounted a grid. These are mounted within an evacuated, clear glass bulb, the inside of which has been made electrically conducting to eleminate external electrostatic field effects. The filament is pure tungsten wire mounted on two leads connected to 4 mm sockets in a plastics cap on the neck. Connection to the plate is by a 4mm plug mounted on a plastics top-cap whilst connection to the grid is by a similar plug mounted on one of the plastics side-caps.

This form of construction corresponds with the conventional triode symbol, and provides a simple planar arrangement.

The performance of the triode has been improved by attaching to one of the filament leads a circular disc parallel with the other electrodes to provide a more uniform electric field.

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

Specification. Maxiumum filament voltage 7·5 V.
Optimum plate voltage 500 V.
Typical plate current 0·35 mA.

RECOMMENDED EXPERIMENTS.

The electrical charge produced in the Planar Diode, TEL 520, can be shown to flow unilaterally, but it is not possible to establish with only a filament and plate the direction in which the current is flowing. The introduction of a grid between the filament and plate enables both the direction of flow and the nature of the charge to be determined.

EXPERIMENT 3. (SERIES A) ESTABLISHMENT OF DIRECTION OF FLOW.

Connect the triode into the circuit shown in Figure 1 and with V_a =400 V and V_f = 6·3 V observe the following:-

3.1 When the p.d. between the grid and the filament, Vg, is zero, a current, Iá, of about 0·4 mA flows.

3.2 When the grid is made positive with respect to the filament, the current, Ia, increases considerably.

3.3 Conversely, when the grid is made negative with respect to the filament, the current, Ia, decreases.

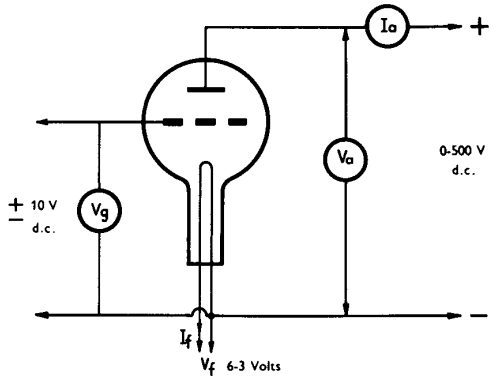


FIGURE 1 CIRCUIT DIAGRAM

Typical results V_g = 400 V and V_f = 6·3 V ; V_g = 0, Ia = 0·4 mA
V_g = +8V, Ia = 0·8 mA
V_g = -8V. Ia = 0·04 mA

The polarity of the grid/filament p.d. either increases or decreases the electric field strength between the electrodes of the triode. If the grid is made negative with respect to the filament, the field strength between grid and plate is increased and between grid and filament decreased.

If the current is due to positive charge from the plate, more current should be drawn off by an increase in field. If the current is due to negative charge from the filament, less current should flow with a decrease in field. The latter however is observed and infers that the current is constituted of negative charge flowing from the filament. This is further corroborated by the evidence of the increase in current with a positive grid polarity.

These experiments establish that negative charges are emitted from a hot filament under the influence of an electric field.

EXPERIMENT 3A. (SERIES A) PRODUCTION OF CATHODE RAYS.

Connect the Triode as shown in Figure 2 so that the grid and filament constitute a diode; a graph, figure 3, of grid current, Ig, against grid voltage, Vg, is typical of a diode characteristic.

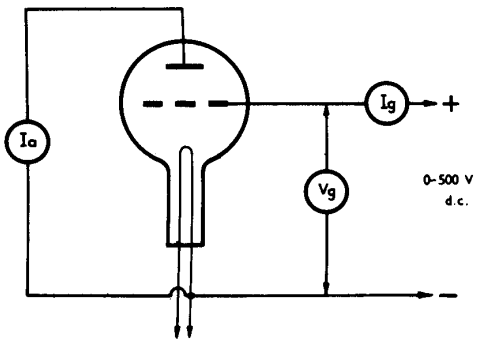


FIGURE 2 INTRODUCTION TO THE DIODE ELECTRON GUN

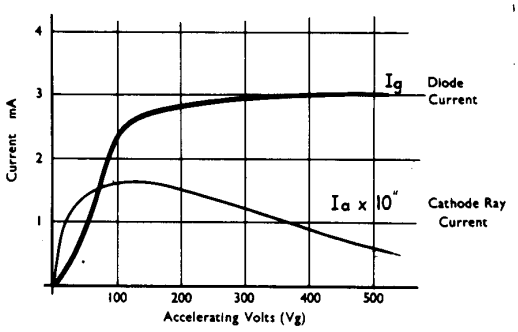


FIGURE 3 DIODE GUN CHARACTERISTIC

The Ia/Vg graph establishes that the negative charges can be accelerated to a velocity sufficient to project them through the grid spaces to the field free region beyond. Observe that the collector current, Ia, is considerable, about 1 mA, and that the current after rising to a maximum decreases with increase in grid voltage Vg, because more charges are attracted to the positive grid.

This simple Diode Electron Gun is applied to project these "cathode"rays" into an experimental zone beyond the positive electrode, where with the Luminescent Tube, TEL 522, a visual method of detection can be demonstrated and the properties of cathode rays investigated, commencing with the Maltese Cross Tube, TEL 523.

EXPERIMENT 19. (SERIES A) APPLICATION OF TRIODE.

Although primarily designed for elementary physics experiments the Planar Triode can be used to demonstrate the application of a triode as an Amplifier and as an Oscillator without the use of elaborate circuits.

As an Amplifier:

Connect the Triode into the circuit shown in Figure 4, using an anode-load resistance, R_L of about 1 megohm (1 watt.). The signal to be amplified, Vg should be applied between the grid and one filament lead; an alternating potential of 0-10 volts at mains frequency is suitable.

The amplification of the applied signal is demonstrated by measuring the alternating p.d. across the anode load, V_L. This is best performed with an oscilloscope where the phase relationship of V_L, Vg and V_a, can be analysed. Typical results are shown in Figure 5, giving the Triode specification.

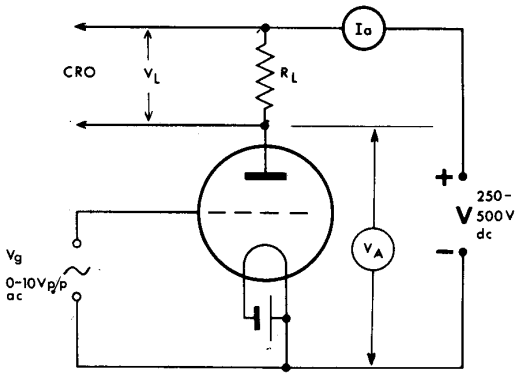


FIGURE 4 TRIODE AS AMPLIFIER

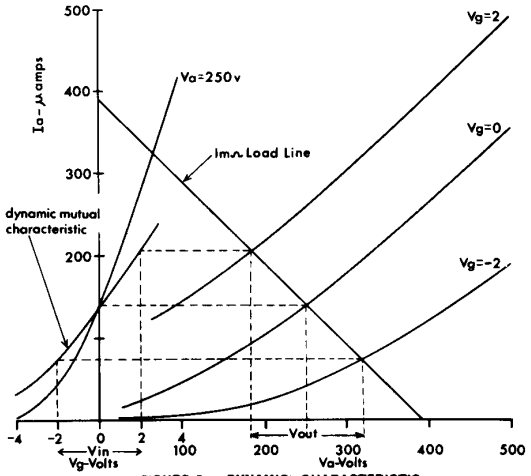


FIGURE 5 – DYNAMIC CHARACTERISTIC

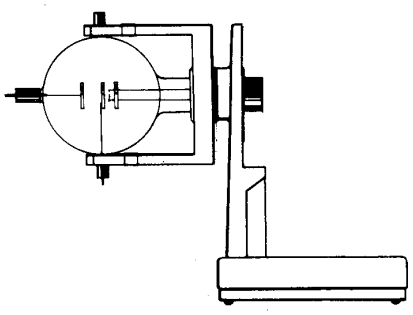
$$\text{Voltage Gain } A = \frac{Vout}{Vin} \simeq 39$$

$$\text{or } A = \frac{\mu R_L}{r_a + R_L} \simeq 39$$

Distortion of an amplified signal can be obtained by increasing the voltage Vg and observing the effect on V_L.

As an Oscillator:

Reverse the Jaws in the stand and lock in position using the special retaining '0' ring provided with each Triode. Connect up the circuit shown in Figure 6, using Helmholtz Coils, TEL 502 (mounted in the normal manner in the locating sockets) to provide positive feedback.



Oscillation may be demonstrated using a miniature mains-type indicator neon or an oscilloscope.

The frequency of oscillation is approx. 40 - 60 Kc/s.

The neon leads should be interconnected using a small loop and this simple detector should be placed close to the coils.

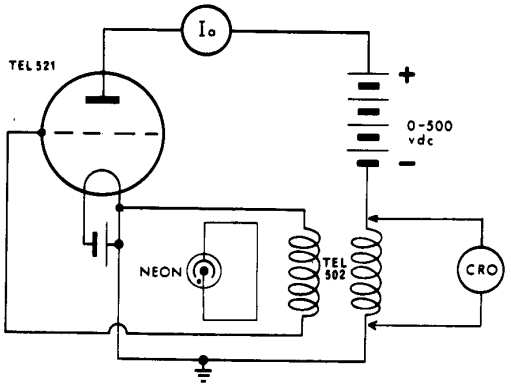


FIGURE 6 TRIODE AS OSCILLATOR

Rotate one of the coils to illustrate that the occurrence and amplitude of the oscillations depends on the relative position of the two coils; vary V_a from 100 to 500 volts and observe that the amplitude of the oscillations does not increase in direct proportion to V_a.

Modulation of the oscillations is apparent if the filament is heated from an a.c. supply or if V_a has an a.c. component, due for example to inadequate smoothing of the d.c. supply.

Shunt the coils with 0·01 and 0·02 mfd capacitors to illustrate the variation of frequency with capacitance for a given inductance.

The above experiments are simple but spectacular methods of demonstrating the basic properties of amplifiers and oscillators.

EXPERIMENT 20. (SERIES A) CHARACTERISTIC CURVES

The important 'electronic' property of a multi-electrode valve is the mutual effect of potential differences between the electrodes; this is best represented graphically. The systematic investigation of I_a, Vg and V_a in the circuit of Figure 1 gives the Static Characteristics as shown in Figure 7.

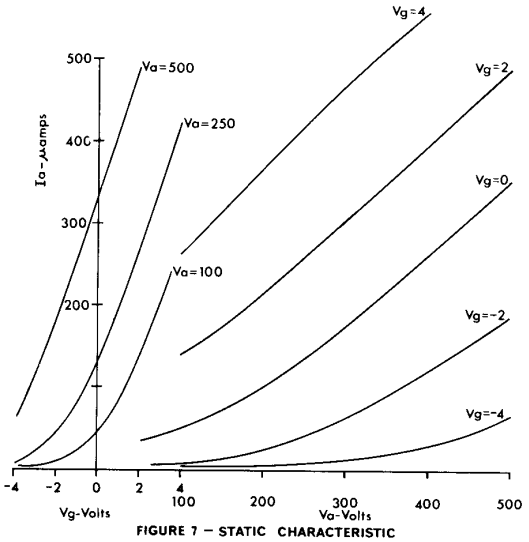


FIGURE 7 – STATIC CHARACTERISTIC

Tabulate measurements of I_a against V_a with Vg fixed, the Anode Characteristic and against Vg with V_a fixed, the Mutual Characteristic

$$r_a = \frac{\Delta V_a}{\Delta I_a} \simeq 1{\cdot}1\ M\Omega$$

$$g_m = \frac{\Delta I_a}{\Delta V_g} \simeq 75\ \mu A/volt.$$

$$\mu = \frac{\Delta V_a}{\Delta V_g} \simeq 82$$