Experiment No. 12
Characteristics Of A Triode

Objective:
(a) To study the characteristics of a triode.
(b) To study a simple amplifier circuit.

Apparatus:
A triode mounted on a test board, power supply, a signal generator, two multimeters, a load resistor, a cathode ray oscilloscope.

Theory:
A triode, shown schematically in Fig. 1, is a vacuum tube consisting of 3 electrodes, a cathode C, a grid G and a plate P, sealed in an evacuated envelope. The cathode C is heated by the filament F to give off electrons. The electrons are accelerated towards the plate P which is kept at a high positive potential with respect to the cathode. The grid G is a mesh of wire and it is closer to the cathode than the plate. Thus the voltage on the grid controls the flow of electrons from the cathode to the plate quite effectively.

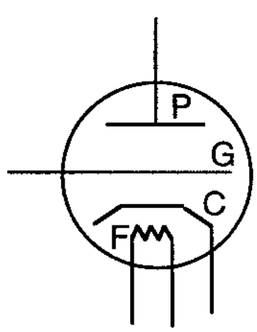

Fig. 1

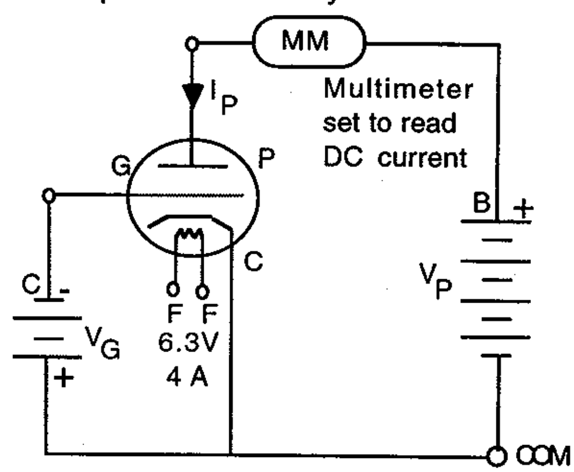

Fig. 2

Consider the triode circuit shown in Fig. 2. By keeping the grid voltage V_G constant, the plate current I_P van be measured for different values of V_P. Then a graph of I_P vs. V_P can be plotted. Three such graphs for 3 different grid voltages are shown in Fig. 3. These curves are known as the plate characteristic curves of the triode. Another type of characteristic curves of a triode are the mutual characteristic curves which are graphs of I_P vs. V_G at constant values of V_P.

Now consider the point A (Fig. 3) for which the plate current, plate voltage and grid voltage are I_{P2}, V_{P1} and V_{G1}, respectively. If the grid voltage is reduced by $(V_{G1} - V_{G2})$ = 2 volt, the plate current is reduced to I_{P2}. By increasing the plate voltage from V_{P1} to V_{P2}, the plate current will be restored to the value I_{P1}. The amplification factor, μ, of a triode at a constant plate current is defined as

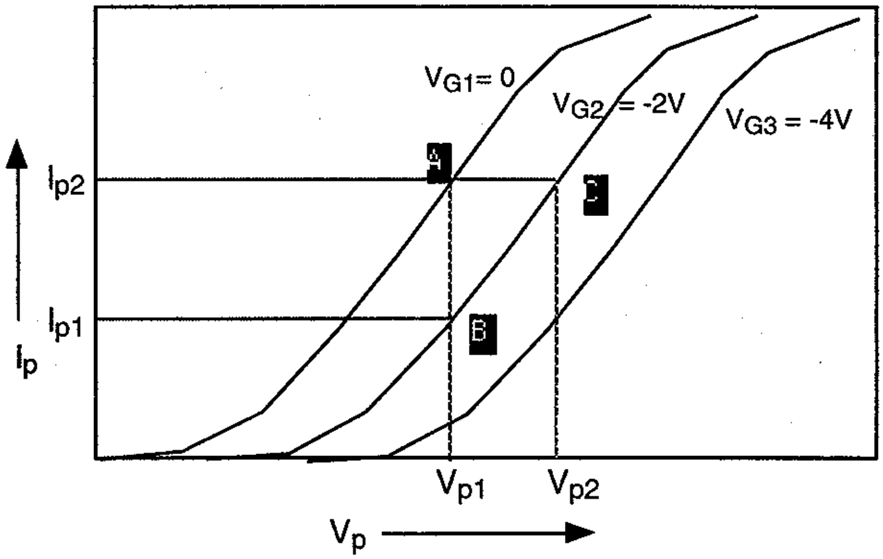

Fig. 3. Plate Characteristics Of A Triode

$$\mu = \left(\frac{V_{P2} - V_{P1}}{V_{G1} - V_{G2}}\right)_i \qquad (1)$$

Another parameter of interest is the triode plate resistance R_P which is defined by

$$R_p = \frac{\Delta V_P}{\Delta I_P} \qquad (2)$$

Here ΔV_P is a small change in V_P,
ΔI_P is a small change in I_P,
and V_G is kept constant.

Thus if ΔV_P (= $V_{P2} - V_{P1}$) and ΔI_P (= $I_{P2} - I_{P1}$) are small (see Fig. 3),

$$R_p = \frac{V_{P2} - V_{P1}}{I_{P2} - I_{P1}} \qquad (3)$$

at the grid voltage V_{G2}.

A simple amplifier circuit is shown in Fig. 4. The sine wave signal V_I from the signal generator is connected in the grid circuit. This signal is displayed on channel A of the cathode ray oscilloscope. A load resistor R_L is connected in the plate circuit and the amplified output signal obtained across R_L is displayed on channel B. The grid bias and plate voltage are suitably adjusted to achieve amplification. If *m* is the amplification factor of the triode, then the input signal V_I will be amplified to mV_I. The the voltage across the total resistance (R_L + R_P) will be mV_I, of which only the fraction

$$\frac{R_L}{R_L + R_P}$$

is obtained across load resistor R_L.

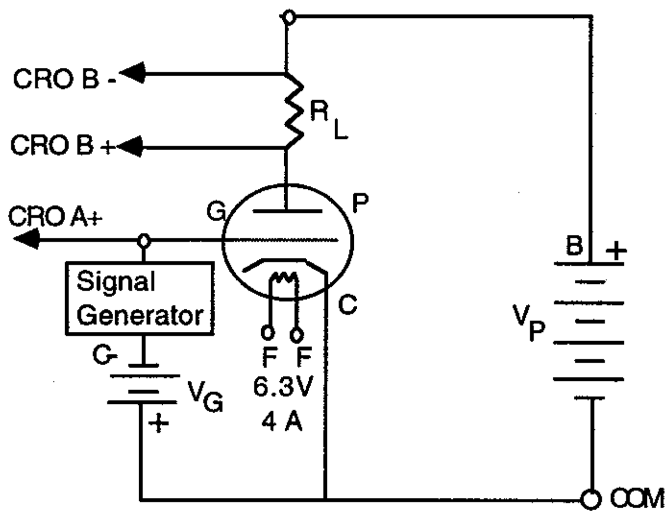

Fig. 4. A Simple Amplifier

Hence the signal V_A, across R_L, is given by

$$V_A = \frac{\mu V_I R_L}{R_L + R_P} \qquad (4)$$

The amplifier gain is defined as

$$\text{gain} = \frac{\mu R_L}{R_L + R_P} \qquad (5)$$

Procedure:

Unit 1: Characteristics Of A Triode:

(a) Make the circuit as shown in Fig. 2. Connect the filament FF to its power supply (6.3V, 4A). Connect the plate to B+ of the power supply and the terminal marked com to the cathode. Connect the grid to C-. Do not include the load resistor in the circuit. Include one multimeter in the circuit to measure the plate current as shown in the figure. The second multimeter will be used to measure DC voltages as described below.

(b) Adjust the second multimeter to read DC volts, connect it to C- and com and adjust the grid bias to -4 volt.

(c) Now connect the second multimeter between B+ and com and adjust the plate voltage to some multiple of 10 such that the plate current (read by the first multimeter) is nearly zero. Record the plate voltage and plate current.

(d) Increase the plate voltage in equal steps (of 10 or 15 volt) and record the plate voltage and plate current each time. Thus measure I_P for about 12 values of V_P.

(e) Repeat the procedure by keeping V_G = -2 volt and 0 volt.

(f) Plot the plate characteristics of the triode (similar to the curves shown in Fig. 3).

Unit 2: Amplifier Circuit:

(f) Measure the load resistance R_L by using the multimeter. Set up the circuit as shown in Fig. 4. Adjust the amplitude of the sine wave of the signal generator to about 2 volt and frequency to about 5000 Hz.

(g) Switch on the oscilloscope. Set MODE to NORM, the vertical coupling (A and B) to AC. The vertical verniers should be in calibrated position. The DISPLAY can be ALT or CHOP. Set the trigger mode to AUTO (it can be changed if necessary) and adjust the trigger level if necessary. Switch on the signal generator. Set the grid bias and plate voltage corresponding to the linear segment (middle portion) of the plate characteristics. Adjust the volt/div (channels A and B) to obtain proper displays on both channels.

(h) Record the data for Unit 2 on the data sheet.

(i) Change V_I, V_P, V_G, etc. slightly to obtain more sets of data.

Note: To achieve $V_g = 0$, connect V_g and the grounded cathode with a black wire.

York College of The City University of New York

Physics II   Name:

Experiment No. 12: Pre-Lab Questionnaire

1. What are plate characteristics of a triode?

2. Describe the function of the grid.

3. What is a convenient way to make V_g zero?

4. In Fig. 4, which shows a simple amplifier circuit, CRO channel A displays ____ and CRO channel B displays ______________________________

Experiment No. 12

Name:

Marks:

Partner:

Remarks:

Section:

Date Submitted:

Title:

Objective:

Theory/Formulas:

DATA SHEET

Observations:

Unit 1: Plate Characteristic Curves:

No.	Plate voltage (V_p)	Plate Current (I_p)		
		V_g = -4 V	V_g = -2 V	V_g = 0
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

Unit 2: Amplifier Circuit:

Load resistance R_L =

Plate voltage = Grid bias =

Volt/Div (A) = Volt/Div (B) =

Peak-to-peak Height (A) = divisions

Peak-to-peak Height (B) = divisions

Effective value of input signal (by multimeter) =

Effective value of amplified signal (by multimeter) =

Calculations:

Unit 1:

Plot the plate characteristics.

Use the middle portions of the curves to fill out the following.

Calculation of μ:

Curve numbers	V_{Gi}	V_{Gj}	V_{pi}	V_{pj}	μ
i=1 & j=2					
i=2 & j=3					
i=1 & j=3					

Calculation of plate resistance, R_p:

Curve number	V_G	I_{pi}	I_{pj}	V_{pi}	V_{pj}	R_p
1						
2						
3						

Unit 2:

From the above table,

μ =

R_p =

R_L =

Theoretical value of gain [Eq. (5)]=

Gain (from oscilloscope readings) =

Gain (from multimeter readings) =

Questions:

1. Define the terms amplification factor, plate resistance and gain.

2. Briefly explain the working of an amplifier circuit.

3. How would you choose the operating voltages (V_p and V_g) for the triode to function as an amplifier? What would happen if the operating voltages in Unit 2 correspond to the beginning of the plate characteristics?

4. In Unit 2, was the output signal distorted? If yes, why?