EXPERIMENT 4

AIM : To find the capacitance of a capacitor using flashing and quenching of a neon lamp.

APPRATUS USED : A capacitor of unknown capacitance, capacitors of known capacitance (say 0.1, 0.2, 0.5 µF), a neon flashing lamp, a resistance of about 1 meg ohm, regulated D.C. power supply capable of giving upto 150 volts and 5 keys.

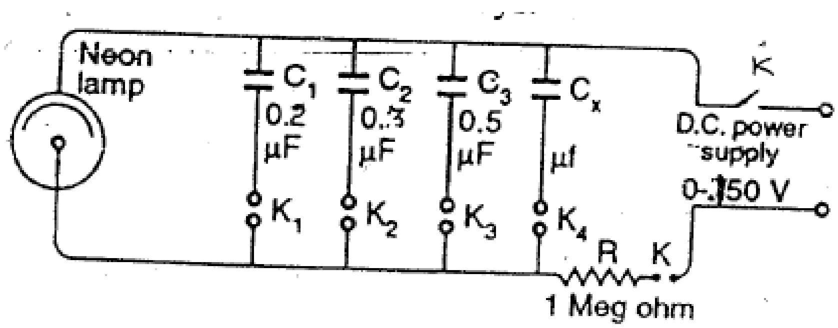


Figure (1)

Note : Neon lamps intended to be connected direct to H.T. have a ballast resistor of about 2000 ohm sealed into the cap to limit the current. This must be removed for this experiment. Alternatively small neon flash bulbs without any resistor sealed in are available from radio dealers.

THEORY :

Flashing and quenching of a neon bulb. A neon bulb is placed in parallel with a capacitor and connected to D.C. supply which can be continuously increased from 0 to 150 volt through a high resistance of about 1 meg. Ohm. The voltage is slowly increased to a value say V_1 when the lamp flashes and begins to glow. As soon as the neon lamp flashes, it becomes conducting and the capacitor begins to discharge through it. It continues to do so until the extinction (or quenching) potential V_2 is reached when the neon lamp ceases to glow and stops conducting. The capacitor then again beings to charge till the flashing potential V_1 is reached when again the lamp flashes and begins to glow. The process is repeated, During the time the capacitor is charging the neon lamp does not glow. In other words, the total time t between two consecutive flashes is equal to the time taken by the voltage first to fall from the flashing potential V_1 to quenching potential V_2 (discharge) and then to rise from V2 to V1 (charging). This flashing and quenching time can be determined by noting the time taken by the lamp to produce say 20 consecutive flashes and quenches.

If t_1 is the time taken by the capacitor voltage to fall from V_1 to V_2 and t_2 is the time taken by the voltage to rise from V_2 to V_1, then

$$V_2 = V_1 e^{-t_1/CR}$$

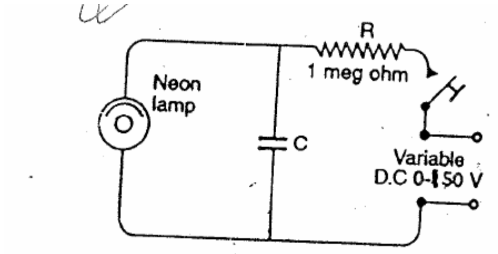
Or

$$t_1 = -CR \log_e \frac{V_2}{V_1}$$

And $$V_2 = V_1\left(1 - e^{-t_2/CR}\right)$$

Or $$t_2 = -CR\log_e\left(1 - \frac{V_2}{V_1}\right)$$

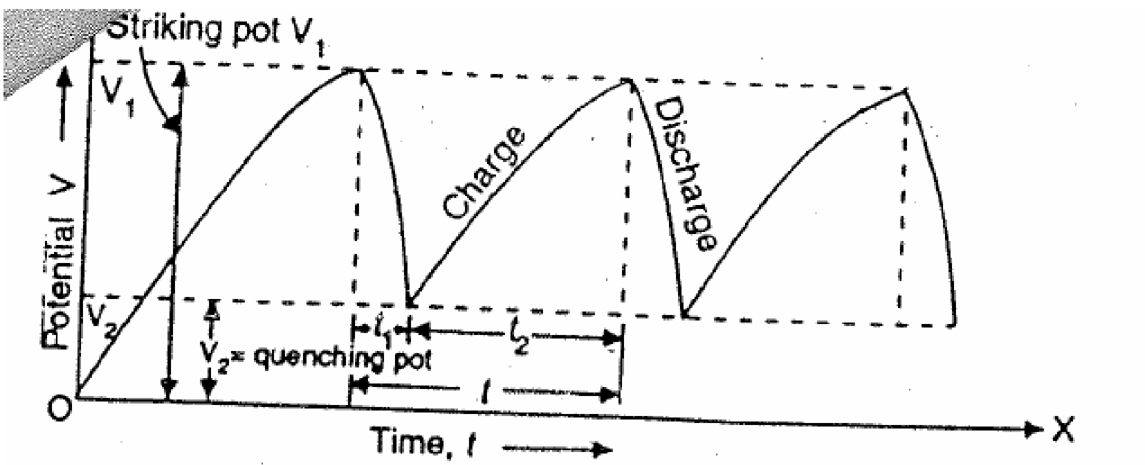
$\therefore$ $$t = t_1 + t_2 = C\left[-R\log_e\frac{V_2}{V_1} - R\log_e\left(1 - \frac{V_2}{V_1}\right)\right]$$



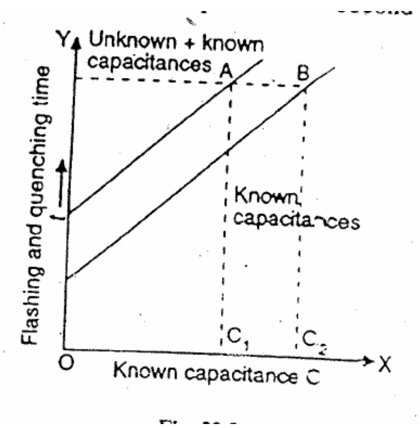
$\therefore$

As R, V_2 and V_1 have constant fixed values, the function within brackets is a constant., Let it be = k

$\therefore$ t = kC



Determination of capacitance. To find the value of an unkwown capacitance a second graph is plotted by noting the flashing and quenching time for the sum of the unknown capacitance and each of the unkwnon capacitances. The two graphs are parallel straight lines as shown. To calculate the value of the unknown capacitance draw a straight line AB parallel to X-axis corresponding to any value of flashing and quenching time cutting the two graphs at A and B respectively. If C_1 and C_2 are the values of the known capacitances corresponding to the points A and B respectively C_x the unknown capacitance and C_s the stray capacitance of the circuit then.



Total capacitance corresponding to point A

$= C_s + C_1 + C_x$

And total capacitance corresponding to point B

$= C_x + C_2$

Since the flashing and quenching time for both is the same

$K(C_s + C_1 + C_x) = k\,(C_x + C_2)$

Or $\quad Cx = C_2 – C_1$

PROCEDURE :

1. Draw a diagram showing the scheme of connections as in Figure (1) and make connections accordingly.

2. Connect the capacitance C_1 in the circuit by putting in the key K_1. Put in the key K and increase the power supply voltage slowly till the neon lamp just begins to flash. As it is connected in parallel.

Remove the key K to disconnect the power supply. Put in the key K_4 so that the capacitors C_1 and C_x (of unknown capacitance) are connected in parallel and total capacitance is equal to their sum $C_1 + C_x$. Again put in the key K (see that the power supply voltage remains constant). Note the time of 20 flashes. Remove the keys K, K_4 and K_1.

3. Repeat the experiment with capacitors C_2 alone and $(C_2 + C_x)$; C_3 alone and $(C_3 + C_x)$. Now put in the keys K_1 and K_2 so that the total capacitance $(C_1 + C_2)$ is in the circuit. Repeat the experiment with $(C_1 + C_2)$ and then with $[(C_1 + C_2)+C_x]$. Similarly repeat the experiment with $(C_1 + C_3)$ and $[(C_1 + C_3)+C_x]$, $(C_1 + C_2 + C_3)$ and $[(C_1 + C_2 + C_3)+C_x]$

OBSERVATION :

1 Sl.No.	2 Known Capacitance	3 Time for 20 Flashes without C_x	4 Flashing and Quenching time t	5 Time for 20 Flashes with C_x	6 Flashing and Quenching time t
	C_1 = **C_2 =** **C_3 =** $C_1 + C_2$ = $C_1 + C_3$ = $C_1 + C_2 + C_3$				

4. Plot two graphs (i) between values of capacitance in column 2 taken along X-axis and flashing and quenching time t in column 4 (without unknown capacitance) and (ii) between values of capacitance in column 2 and quenching and flashing time t in column 6 (with unknown capacitance) taken along the Y-axis. For three different values of flashing and quenching time draw three straight lines. Parallel to X-axis cutting the two graphs at A and B, C and D, and E and F respectively.

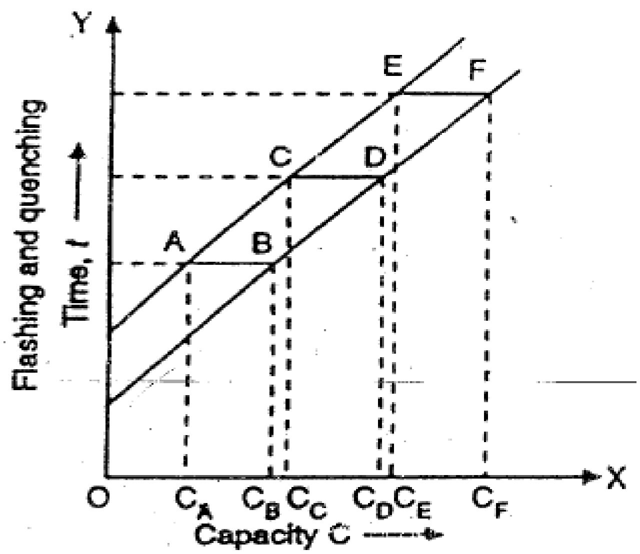


Figure (2)

The unknown capacitance

$C_x = AB = C_B – C_A$

$= CD = C_D - C_C$

$= EF = C_F – C_E$

Mean $C_x = \mu F$

PRECAUTIONS

1. The voltage from the D.C. power supply should remain constant throughout the experiment.

2. The resistor sealed in the cap of the neon lamp should be removed before using it for the experiment, otherwise a bulb without resistor should be used.

SPACE FOR STUDENTS WORK AREA