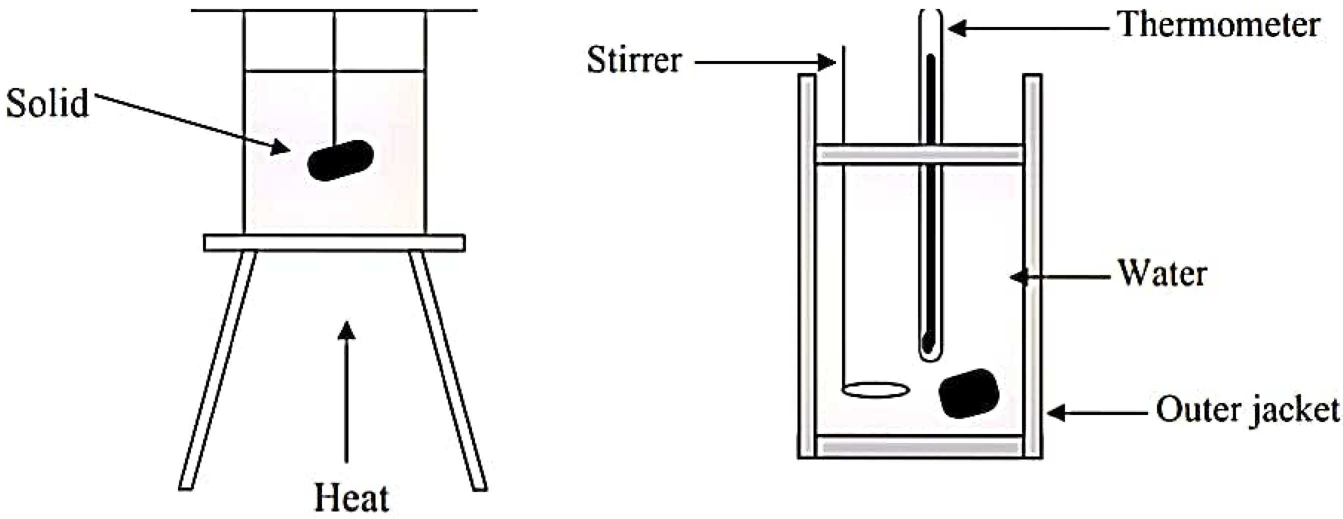



**Figure 1:** Experimental Setup for determining the specific heat capacity of a metal ball.

**Purpose**

To determine the specific heat capacity of a solid by the method of mixtures

# theory

The **heat capacity** C of an object (e.g. metal ball) is the proportionality constant between an amount of heat and the change in temperature that the heat produced in the object. Thus, $Q = C(T_f - T_i)$, where $T_i$ and $T_f$ are the initial and final temperatures of the object. Two objects made of the same material, say marble, will have heat capacities proportional to their masses. It is therefore convenient to define a "heat capacity per unit mass" or specific heat c that refers not to an object but to unit mass of the material of which the object is made and is expressed in joule per kilogram per Kelvin (J $kg^{-1}K^{-1}$). The specific heat capacity equation then becomes $Q = mc(T_f - T_i)$, where m is the mass of the object.

**Equipment/ Materials/ Apparatus**

Y

- Solid (e.g. metal ball) of reasonable size
- Calorimeter with an insulation, outer jacket and stirrer
- Thermometer (reading up to 0.1°C)
- Heater
- Thread
- Sensitive balance
- Beaker

11. Record your observation

**observation**

12. Record your observations

| | | |
|---|---|---|
| i. Mass of solid | $m_1$ | = |
| ii. Mass of empty calorimeter | $m_2$ | = |
| iii. Mass of calorimeter + water | $m_3$ | = |
| iv. Initial temperature of water in calorimeter | $T_i$ | = |
| v. Temperature of the hot solid | 100 °C | = |
| vi. Temperature of mixture | $T_f$ | = |
| vii. Rise in temperature of water and calorimeter | $(T_f - T_i)$ °C | = |
| viii. Fall in temperature of hot solid | $(100 - T_i)$ °C | = |

**calculation**

13. Calculate the specific heat capaci... w:

Let S.H.C of solid = $c$

Also, let S.H.C of calorimeter = $c_1$

And let S.H.C of water = $c_w$

Heat lost by solid = $m_1 c(100 - T_f)$

Heat gained by water = $(m_3 - m_2)c_w(T_f - T_i)$

Heat gained by calorimeter = $m_2 c_1 (T_f - T_i)$

Total heat gained = $(T_f - T_i)[(m_3 - m_2)c_w + m_2 c_1]$

But heat lost = Heat gained

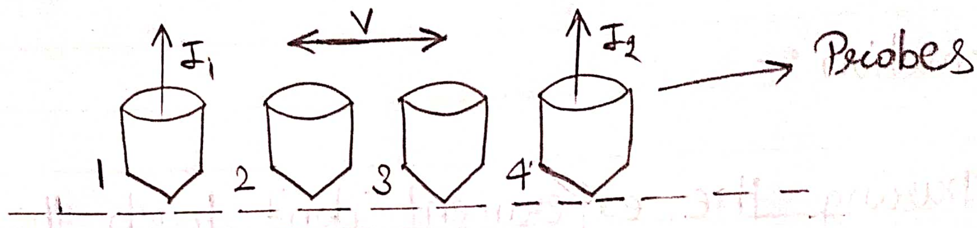
$$m_1 c(100 - T_f) = (T_f - T_i)[(m_3 - m_2)c_w + m_2 c_1]$$

$$c = \frac{(T_f - T_i)[(m_3 - m_2)c_w + m_2 c_1]}{m_1(100 - T_f)}$$

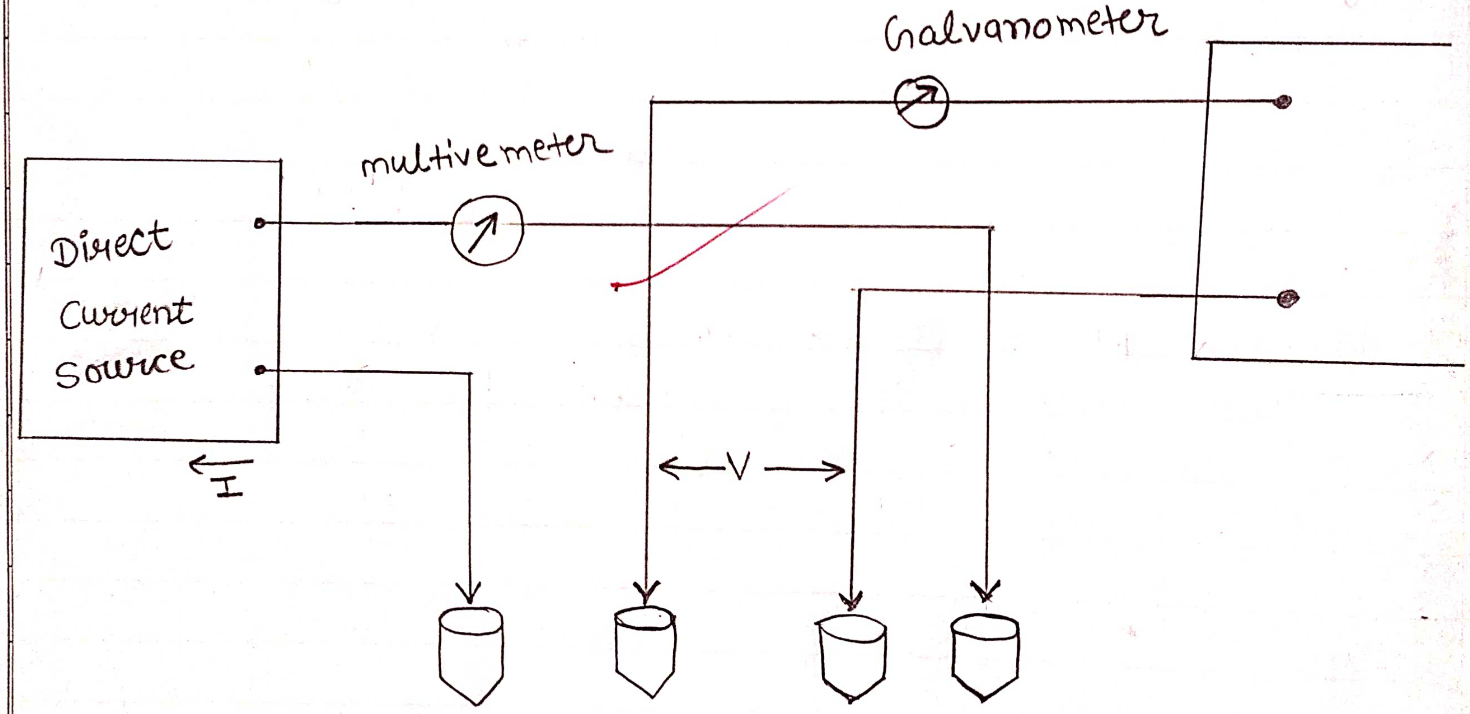


**Conclusion**

The specific heat capacity of the object = .......




method for the four Probe Resistivity




Circuit for resistivity measurement

Object :- To detemine the band gaps of semi-conduator using four Probe method.

Apparatus :- Four Probe set up, thermometer, oven, Ge-chip. Conneating wine

formula used -

$$\text{Slope} = \frac{\ln \rho}{1/T} = \frac{E_g}{2K}$$

$$E_g = 2KT \ln \rho$$ where $E_g$ = Energy band gap
$T$ = Temp.
$\rho$ = resistivity
$K$ = Boltzmann's Constant

$$\rho = \frac{\rho_0}{G_7\left(\frac{w}{ws}\right)}$$

$$\boxed{E_g = 2k \times 2.303 \times 10^3 \times \text{Slope}}$$

slope = slope of graph b/w $\log_{10} \rho$ and $10^3/T$

Theory :- The property of bulk material used for the if a brication at transition and other Semiconductor device are essential in determing the Characterctics at the complete device.
Resistivity and left time (at minority Carries) measurments are generally their suctability.

The resistivity in particular may be measurd accurately since it's value is critical in many device.

Four Probe method —
In four probe method four sharp probes are placed on a flate surface at the material to be the outer measurment current is passed through the outer electrod and the flotting potterctial is mesered accruss the linear pairs.

The semiconductor may be consider to the semi co-finite volume to prouent minerity carrier infunction and make good contants the surface on which the probe rest may be mechanically lapped.

Observation :—

(i) Distance b/w probe (S) = 0.200 cm
(ii) Thickness of the crystal (W) = 0.050 cm

Calculation :-

$$\rho = \frac{\rho_0}{G_7(w/s)} \quad \text{where } \rho_0 = \frac{V}{I} \times 2\pi s$$

$I = 5mA = 5 \times 10^{-5}$ Amp

and

$$G_7(w/s) = \frac{2S}{w} \log_e^2 = 5.544$$

distance b/w Probe $S = 2mm = .2cm = 2 \times 10^{-3} m$

Thickness of crystal $w = 0.5 mm = 0.05 cm = 0.5 \times 10^{-3} m$

(1) $\rho_0 = \frac{0.286}{5 \times 10^{-3} \times 100} \times 2 \times 3.14 \times 2 \times 10^{-3} = 0.718$

$\rho = \frac{\rho_0}{G_7(w/s)} = \frac{0.716}{5.544} = 0.129$

(2) $\rho_0 = 0.316 \times 2.512 = 0.793$ $\quad \rho = 0.143$

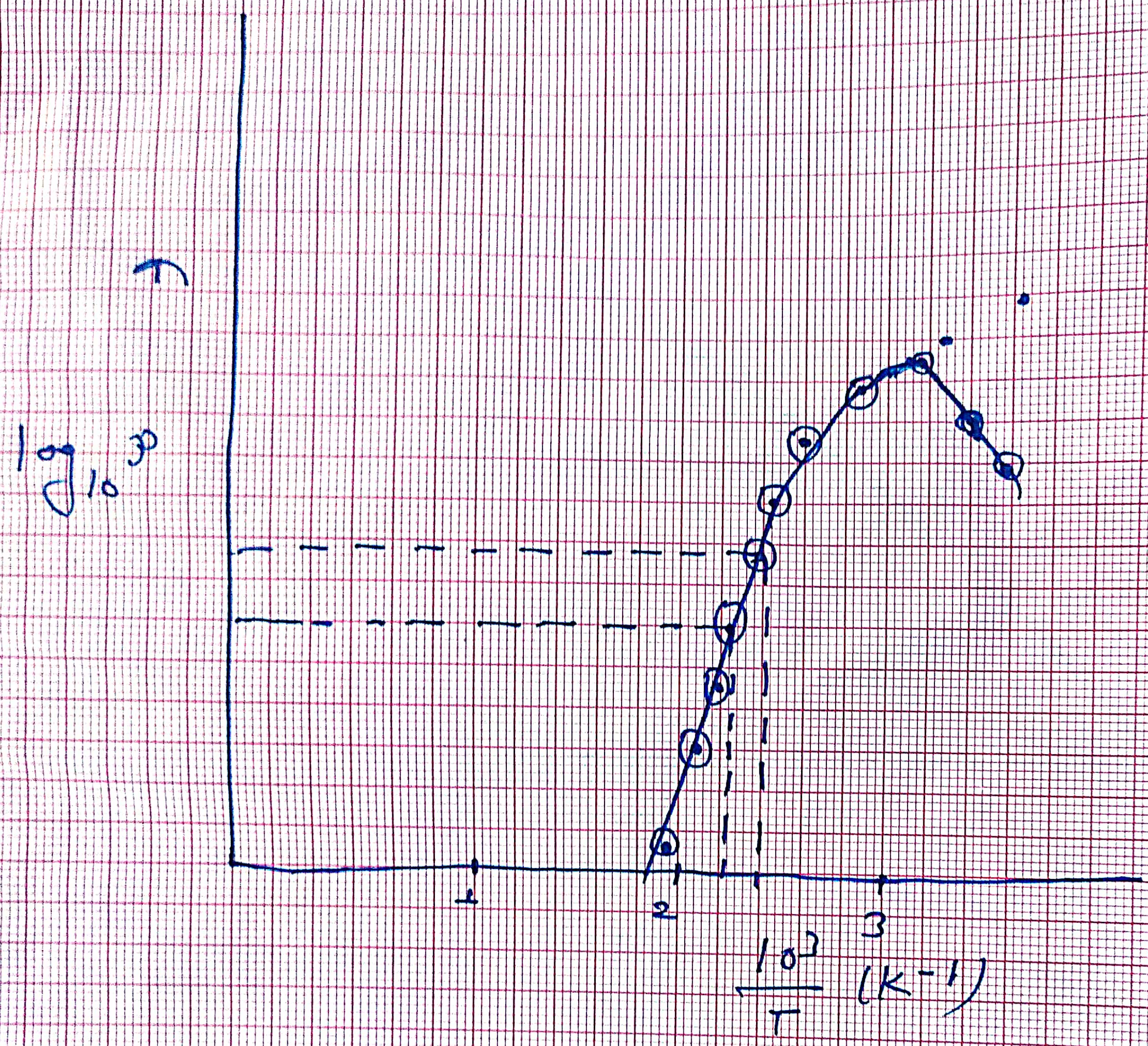
(3) $\rho_0 = 0.344 \times 2.512 = 0.864$ . $\rho = \frac{\rho_0}{G_7(w/s)} = \frac{0.864}{5.554} = 0.156$

(4) $\rho_0 = 0.379 \times 2.512 = 0.952 = \rho = \frac{\rho_0}{G_7(w/s)} = \frac{6.952}{5.554} = 0.179$

(5) $\rho_0 = 0.410 \times 2.512 = 1.03 = \rho = \frac{1.03}{5.544} = .186$

(6) $\rho_0 = 0.437 \times 2.512 = 1.09 = \rho = \frac{1.09}{5.544} = 0.196$

(7) $\rho_0 = 0.461 \times 2.512 = 1.16 = \rho = \frac{1.16}{5.554} = 0.209$



log10 σ
1
2
3
10³/T (K⁻¹)

Result :-

The resistivity of the given semiconductor varies with temp. according to obtained graph.
The energy band gap comes out to be.

$E_g = 1.4103138 \, eV$

| S. No. | Temp °C | Volt V | Temp (T in K) | ρ Ohm-cm | $T^{-1}x10^3$ | $Log_{10}$ ρ |
|---|---|---|---|---|---|---|
| 1. | 30 | 215 | 303 | 9.53 | 3.30 | 0.97 |
| 2 | 40 | 215 | 313 | 9.53 | 3.19 | 0.97 |
| 3. | 50 | 213 | 323 | 9.44 | 3.10 | 0.97 |
| 4. | 60 | 203 | 333 | 9.00 | 3.00 | 0.95 |
| 5. | 70 | 179 | 343 | 7.93 | 2.92 | 0.89 |
| 6. | 80 | 156 | 353 | 6.91 | 2.82 | 0.83 |
| 7. | 90 | 126 | 363 | 5.58 | 2.75 | 0.74 |
| 8. | 100 | 109 | 373 | 4.83 | 2.68 | 0.68 |
| 9. | 110 | 088 | 383 | 3.90 | 2.61 | 0.59 |
| 10. | 120 | 066 | 393 | 2.92 | 2.54 | 0.46 |
| 11. | 130 | 047 | 403 | 2.08 | 2.48 | 0.31 |
| 12. | 140 | 035 | 413 | 1.55 | 2.42 | 0.19 |
| 13. | 150 | 028 | 423 | 1.24 | 2.36 | 0.09 |
| 14. | 160 | 019 | 433 | 0.84 | 2.25 | -0.07 |

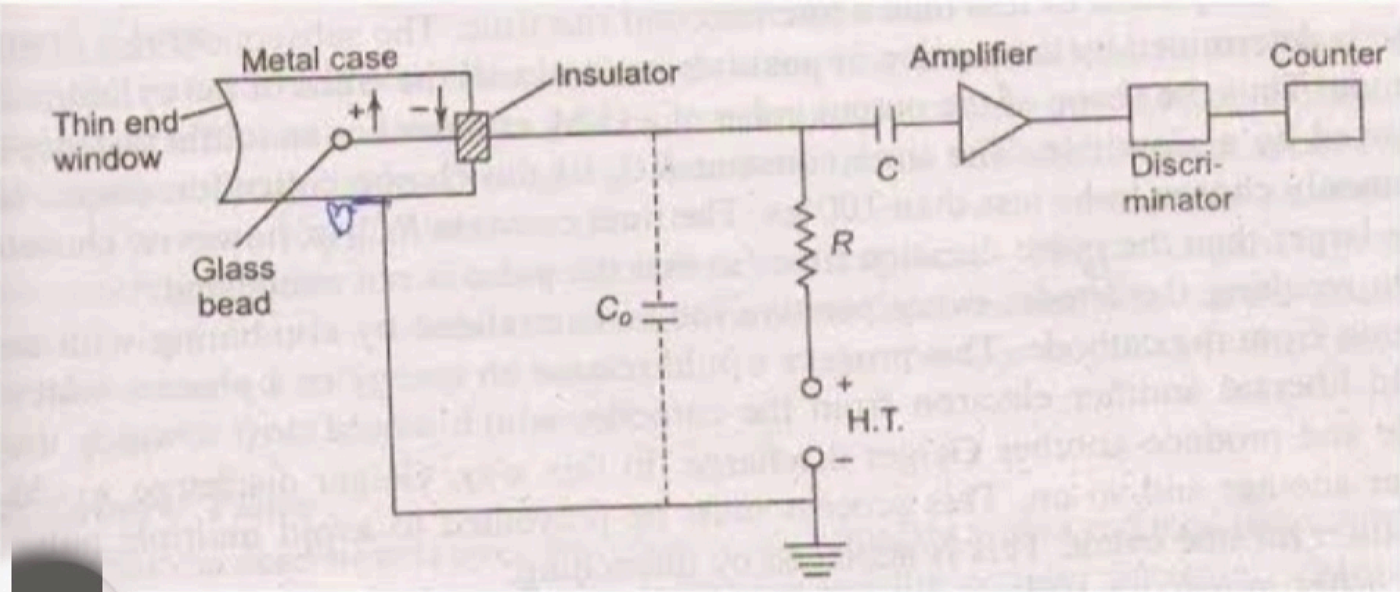



Fig.- GM COUNTER

**Object :-** Study of the charactaristics of a G.M Tube

**Appratus :-** G.M tube, G.M detecter source holder bench, Connecting Cable.

**Theory :-** plateau length (VPL) $= V_2 - V_1$

Operating voltage $V_0 = \frac{V_2 + V_1}{2}$

The slope of the plateau is given by

$$\frac{N_2 - N_1}{N_1} \times \frac{100}{V_2 - V_1} \times 100\,\%$$

**OBservation :-**

| S.NO | Voltage | Counts 30 sec (No) without Source | Count 30 sec with source N | Corrected counts. (N - N₀) |
|---|---|---|---|---|
| 1 | 325 | 0 | 0 | 0 |
| 2 | 350 | 18 | 1370 | 1352 |
| 3 | 375 | 23 | 1627 | 1604 |
| 4 | 400 | 24 | 1631 | 1605 |
| 5 | 425 | 26 | 1635 | 1609 |
| 6 | 450 | 30 | 1641 | 1611 |
| 7 | 475 | 32 | 1647 | 1615 |
| 8 | 500 | 37 | 1655 | 1618 |
| 9 | 525 | 30 | 1681 | 1651 |
| 10 | 550 | 29 | 1685 | 1655 |
| 11 | 575 | 18 | 2645 | 2627 |
| 12 | 600 | 38 | 3300 | 3262 |
| 13. | 625 | 35 | 3322 | 3287 |

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# Calculation :-

$V_1 = 375 \qquad V_2 = 550$ (from graph)

Plateau length $= V_2 - V_1 = 550 - 375$

$= 175\,V$

operating voltage $= \dfrac{V_2 + V_1}{2}$

$= 463.5\,V$

$= 463\,V$

Slope of plateus is given as

$$\frac{N_2 - N_1}{N_1} \times \frac{100}{V_2 - V_1} \times 100\%$$

$$\frac{1656 - 1604}{1604} \times \frac{100}{175} \times 100\%$$

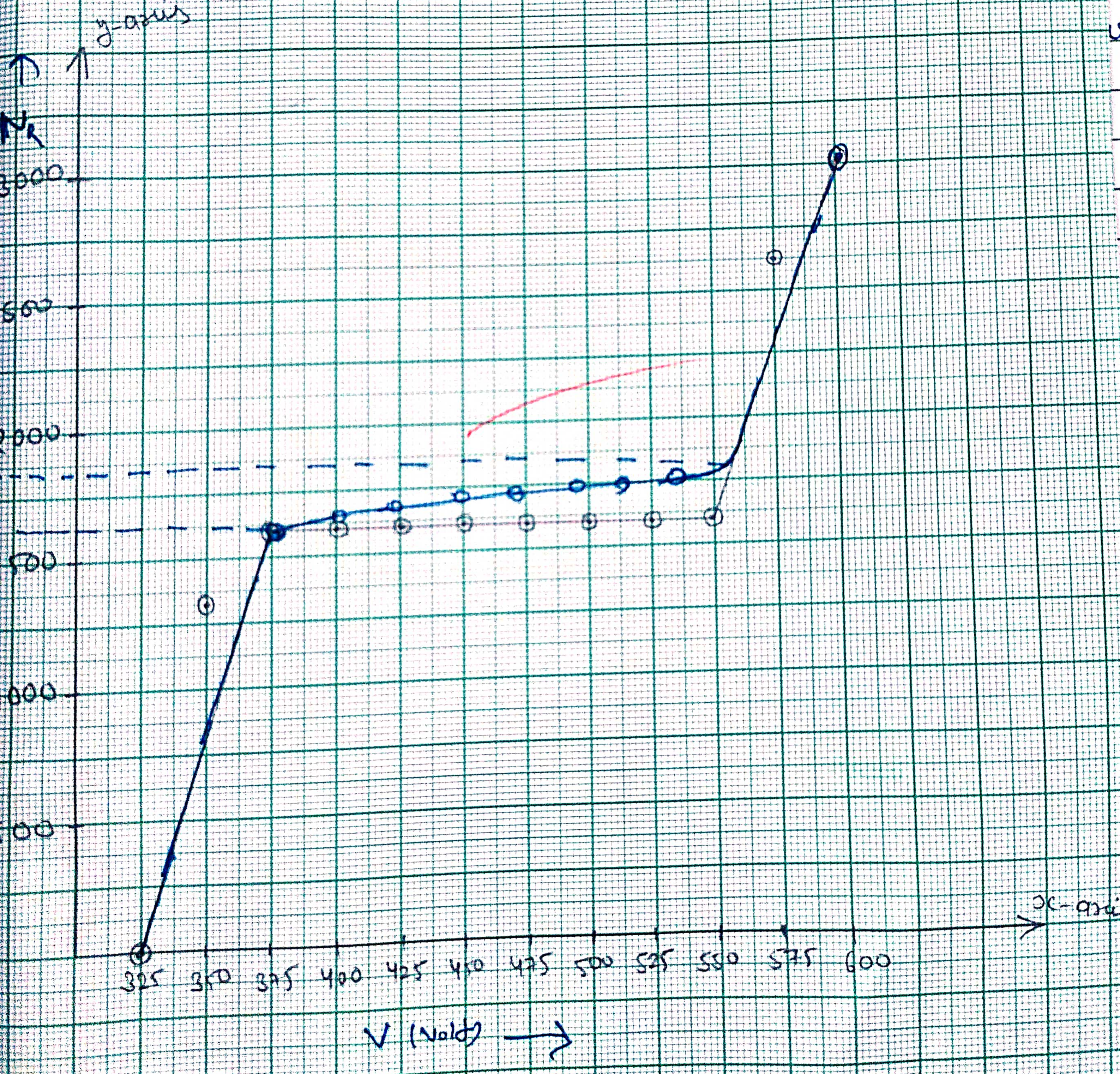
$= 1.85 \times 10^{-4} \times 10^{4}$

$= 1.85\%$

Scale :-

x-axis = 1 unit = 25

y-axis = 2 unit = 500



Result :- The operating voltage (from graph) = 463 V
and Slope of plateus is = 1.85%.

Precaution :-

1. Do not touch wire after power on

2. using placker to get out the source from source holder.

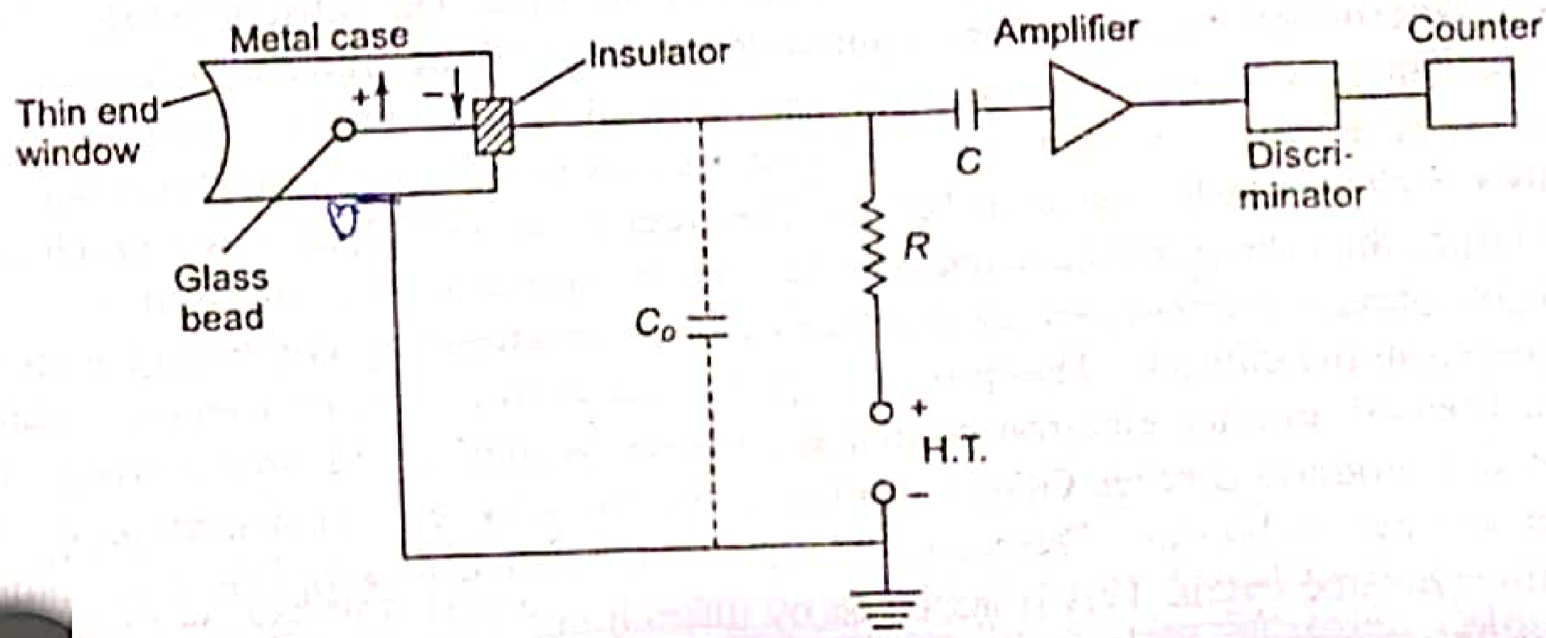



Fig.- GM COUNTER

**Object :-** To verify the inverse square relationship b/w the distance and radiation.

**Appratus :-** Gm Counter, Gm deteater Stand, Gm deteater with conneating cable, A ~~gamma~~ (Beta) Source.

**Theory :-** The inverse square law says is that if we double the distance b/w source and deteater intensity goes down by a factor of four if we triple the distance intensity would decreares by foalr of nine and soon. As a result if we move to distance of a away from the deteator scale of the G.m counter then the intensity of radiation decreases by a facotor.

Product of $c = R \cdot d^2$ is constant

**Observation :-** operating voltage 463 V

Table

| S.No | distance in cm (d) | Counts N is 30 sec | Net Count R (Rate) | in Product | $1/d^2$ (ln $\frac{1}{m^2}$) |
|---|---|---|---|---|---|
| 1 | 2 | 898 | 29.93 | 120 | 2500 |
| 2 | 3 | 665 | 22.57 | 200 | 1100 |
| 3 | 4 | 521 | 17.37 | 248 | 625 |
| 4 | 5 | 417 | 13.9 | 378 | 400 |
| 5 | 6 | 352 | 11.73 | 422 | 278 |
| 6 | 7 | 250 | 8.33 | 408 | 204 |

Calculation

(i) at $d = 2\,cm$

$$\frac{1}{d^2} = \frac{1}{4\times10^{-4}} = 2500 \quad \left(\text{in } \frac{1}{m^2}\right)$$

(ii) at $d = 3$

$$\frac{1}{d^2} = \frac{1}{9\times10^{-4}} = 1100$$

(iii) at $d = 4$; $\frac{1}{16\times10^{-4}} = \frac{1}{d^2} = 625$

(iv) at $d = 5$

$$\frac{1}{d^2} = \frac{1}{25\times10^{-4}} = 400$$

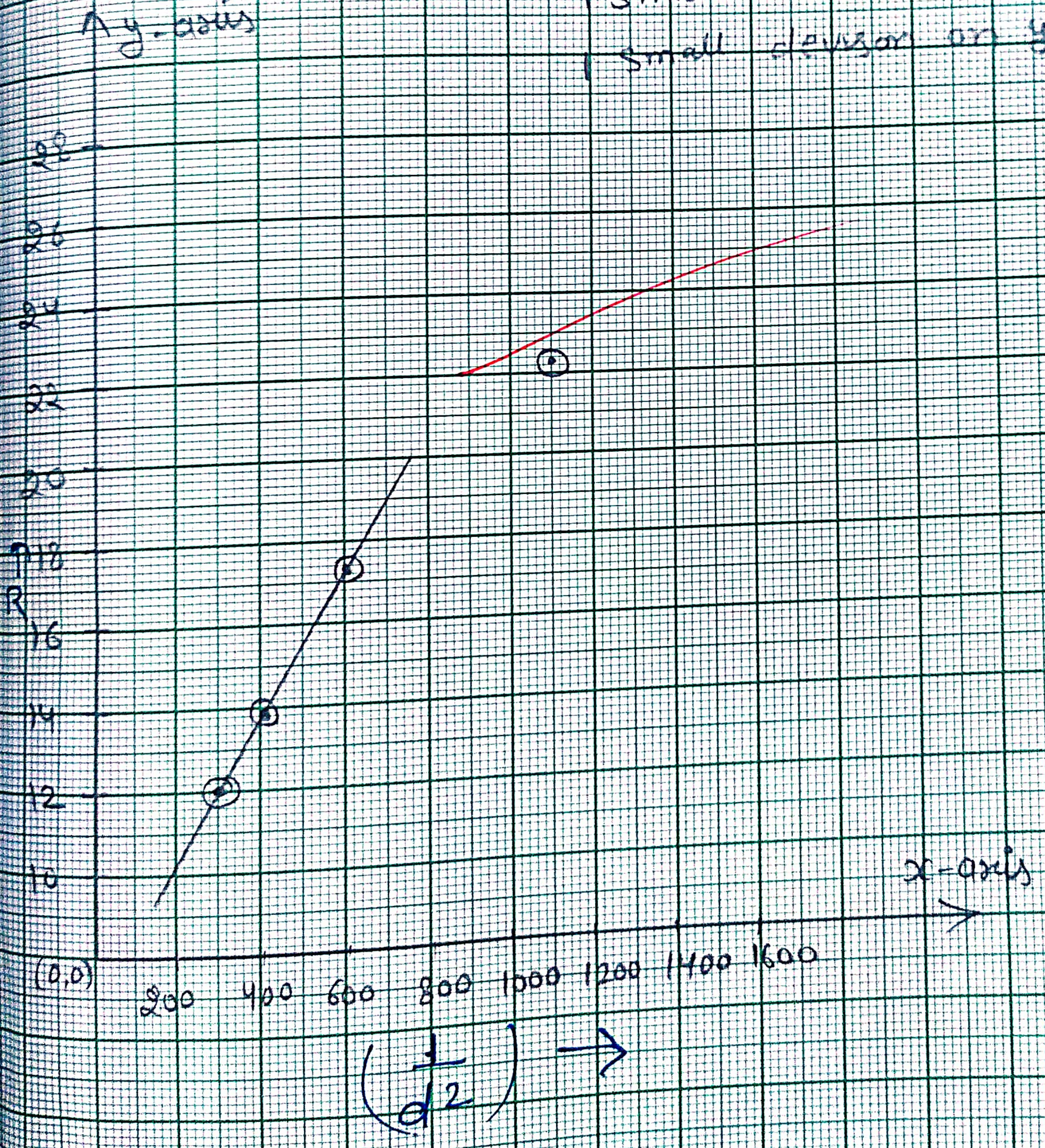
(v) at $d = 6$

$$\frac{1}{d^2} = \frac{1}{36\times10^{-4}} = 278$$

Scale :-

Small devison on x-axis = 20

small devison on y-axis = 0.2



No.

Result :- plot a graph of net rate (R) as distance (d) and product of ($C = Rd^2$) transformation $1/d^2$ shown in table.

Pracaution :-

(i) Do not touch the detector wire of for power cuppel is one.

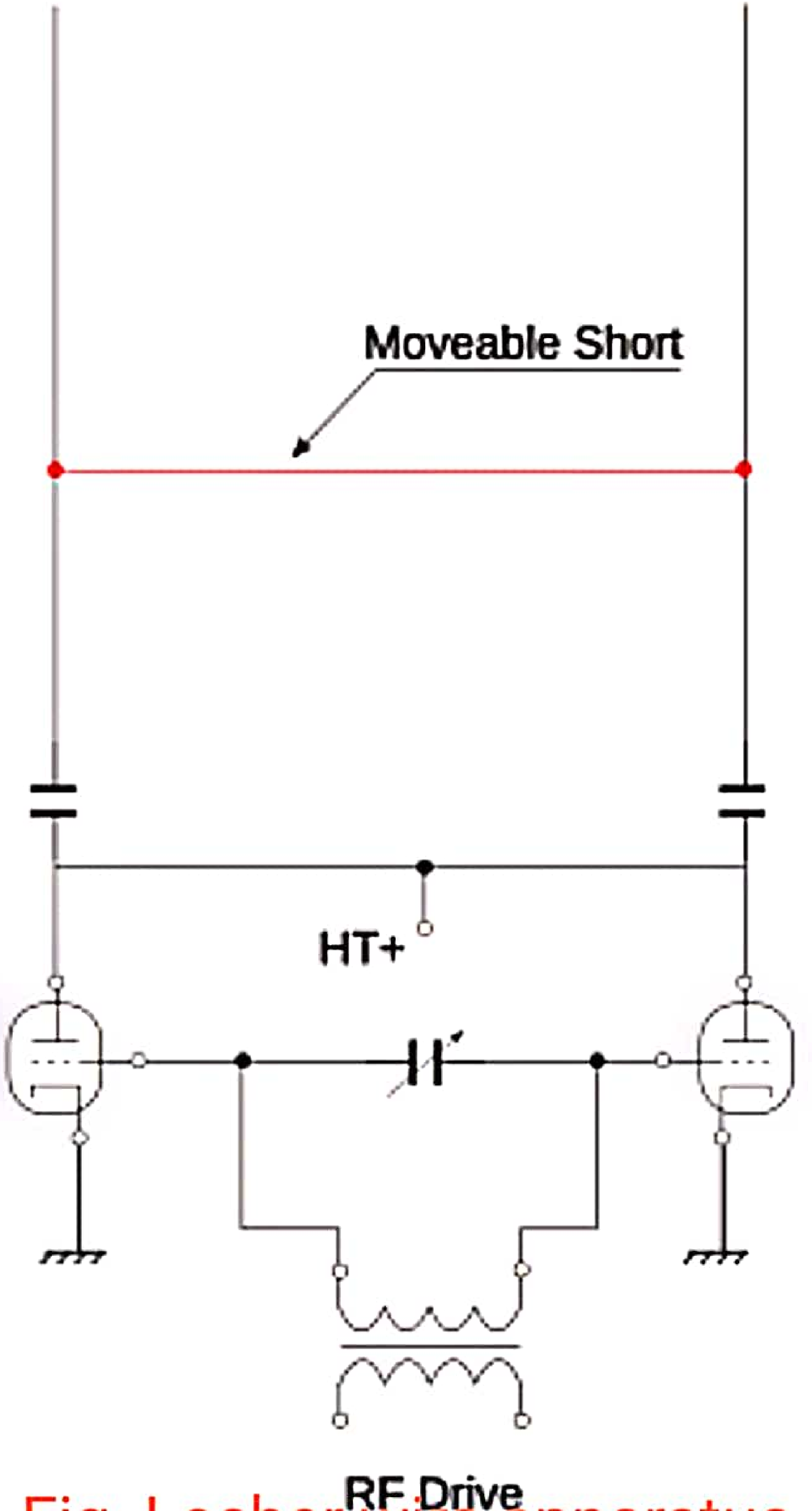



Fig. Lecher wire apparatus

**Object :-** To determine dielectric constant of a Speciman (Liquid) at high frequency by Lacher wires.

**Apparatus :-** Lecher wire, Deteater, Condenses wooden Scall, VHF Oscillator.

**Theory :-** A high frequency Power oscillator is induativity coupled to a pair of parellel Conducting wires called Lacher wires. The of incident and refleated wave from the therminating ends of wine from standing waves. The field strength is maxima at nodes and minima at antinodes however if a capiator is connected across the fermi heating ends of lines then the position's of nodes and anti-nodes change as a result of change in h.c of the lacher lines such a change occurs on immersing the capiator in dielectric speciman the value of di-electric speciman the value of di-eletric constant at Ultra high frequency is determines on the basis

Experimental set up is a tuned guid- tuned anode oscillator with proper feedback through grid anode capacity.

$$E = \frac{\lambda_d^2 - \lambda_o^2}{\lambda_a^2 - \lambda_o^2}$$

where $\lambda_o$ is the wavelength of standing wave on lecher lines with lines in air only $\lambda_o$ is the wave length of standing wave on Leacher lines with air Capacitor at the temprature ends.

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$\lambda_d$ is the waves length of stending wave on the Lecher lines with terminating end capictor immersed in the dielectric specimain.

Observation Table

| S.No | without test capicitor | | | with air capicitor | | | with di-electric cap. | | |
|---|---|---|---|---|---|---|---|---|---|
| | max. position | $\frac{d_o}{2}$ | d | max position | $\frac{d_o}{2}$ | $d_o$ | max position | $\frac{d_o}{2}$ | $d_o$ |
| | 12 | 14 | | 10 | 18 | 33X2 | 6 | 46 | 88 |
| | 26 | 28 | 20X2 | 28 | 46 | =66 | 52 | 42 | |
| | 54 | 18 | =40 | 74 | | | 94 | | |
| | 72 | | | | | | | | |

Calculation :-

$$E = \frac{d_d^2 - d_o^2}{d_a^2 - d_o^2}$$

$$= \frac{(88)^2 - (40)^2}{(66)^2 - (40)^2}$$

$$= \frac{7744 - 1600}{4356 - 1600}$$

$$= \frac{6144}{2756}$$

$$= \boxed{2.22}$$

Result :-

di-electric constant of Liquid - 2.22

Precautions:-

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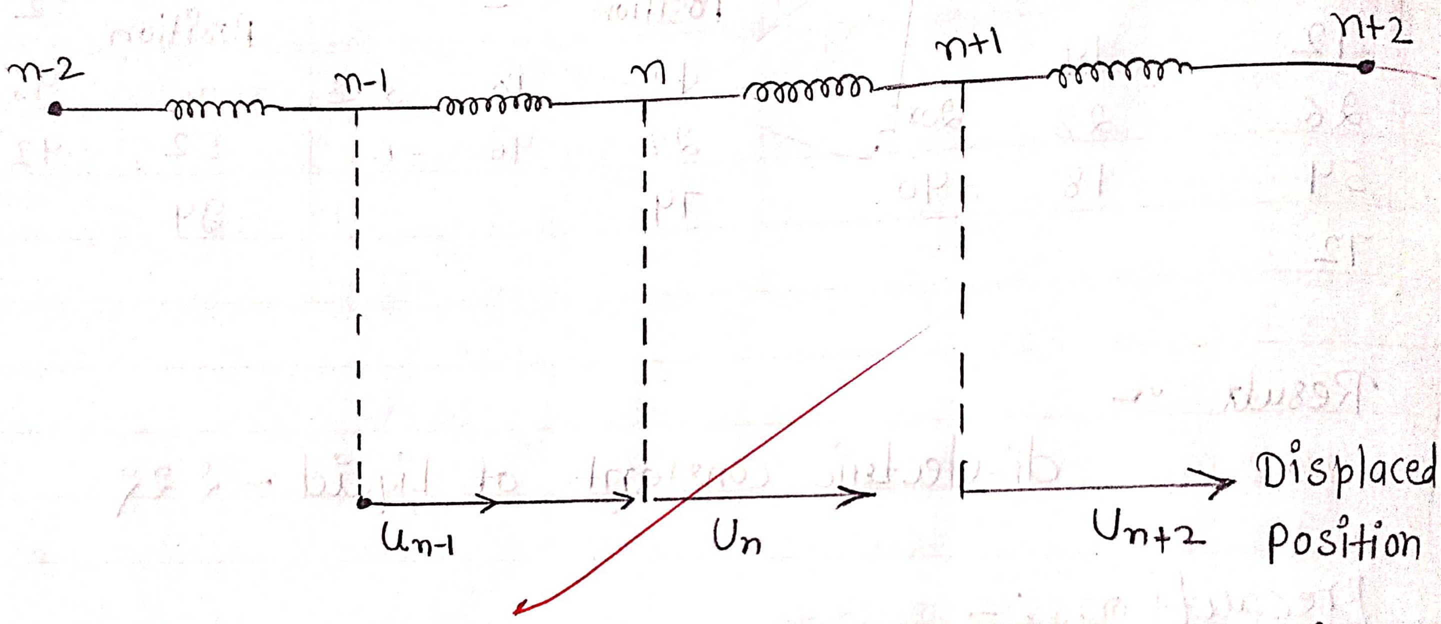
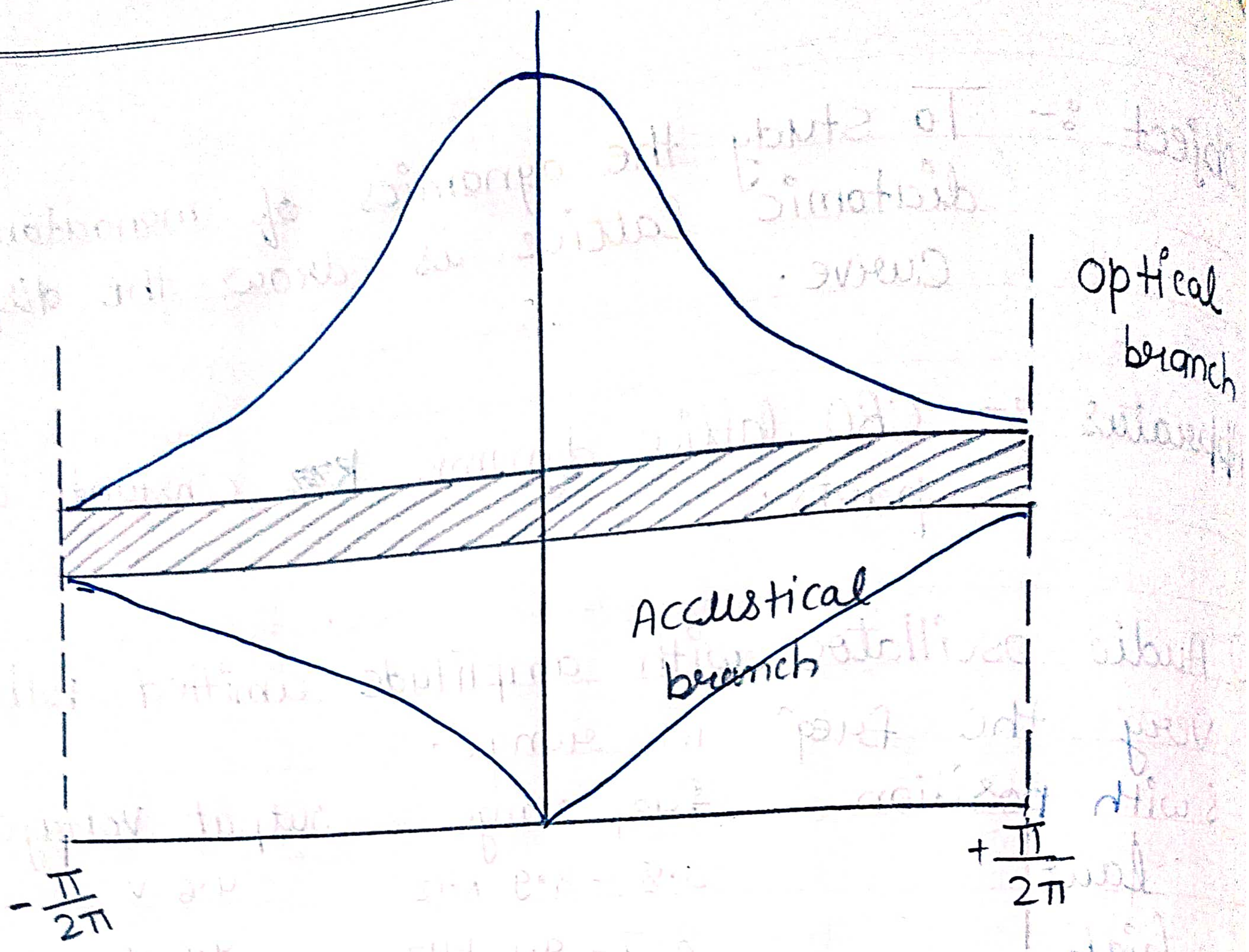


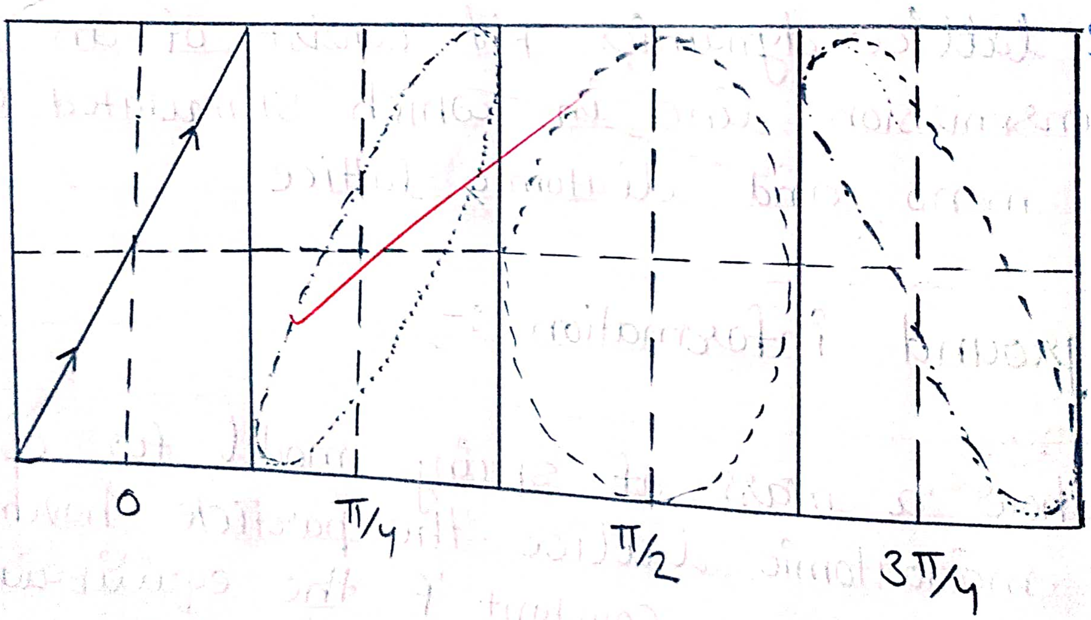

Fig – one dimensional linear monoatomic lattice

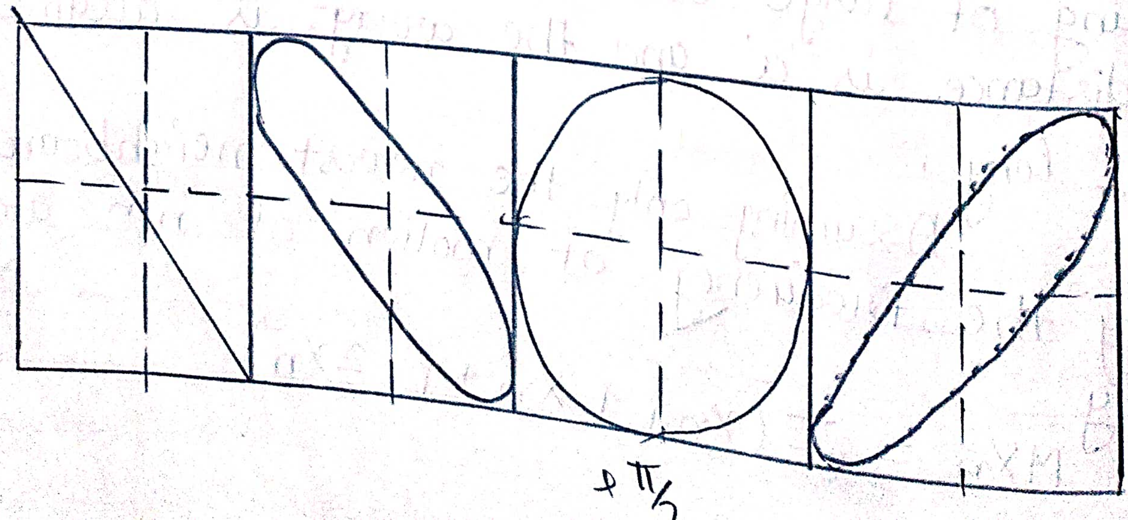
a = lattice constant

K = force constant

m = mass of atom


optical branch
Accustical branch
$-\frac{\pi}{2\pi}$
$+\frac{\pi}{2\pi}$


0
$\pi/4$
$\pi/2$
$3\pi/4$


$+\pi/2$

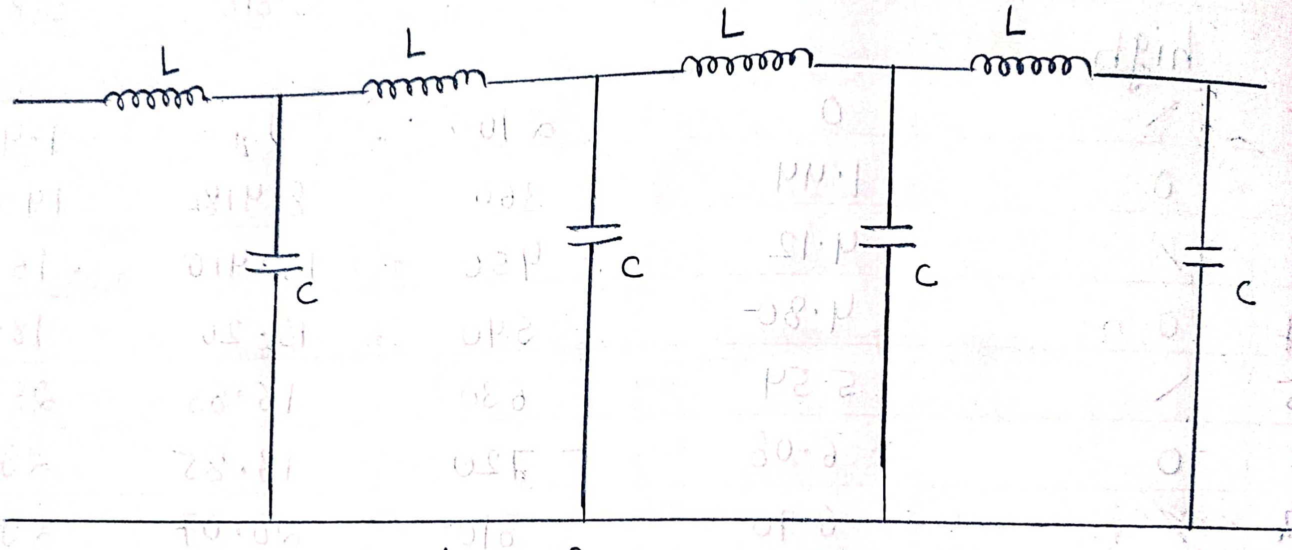
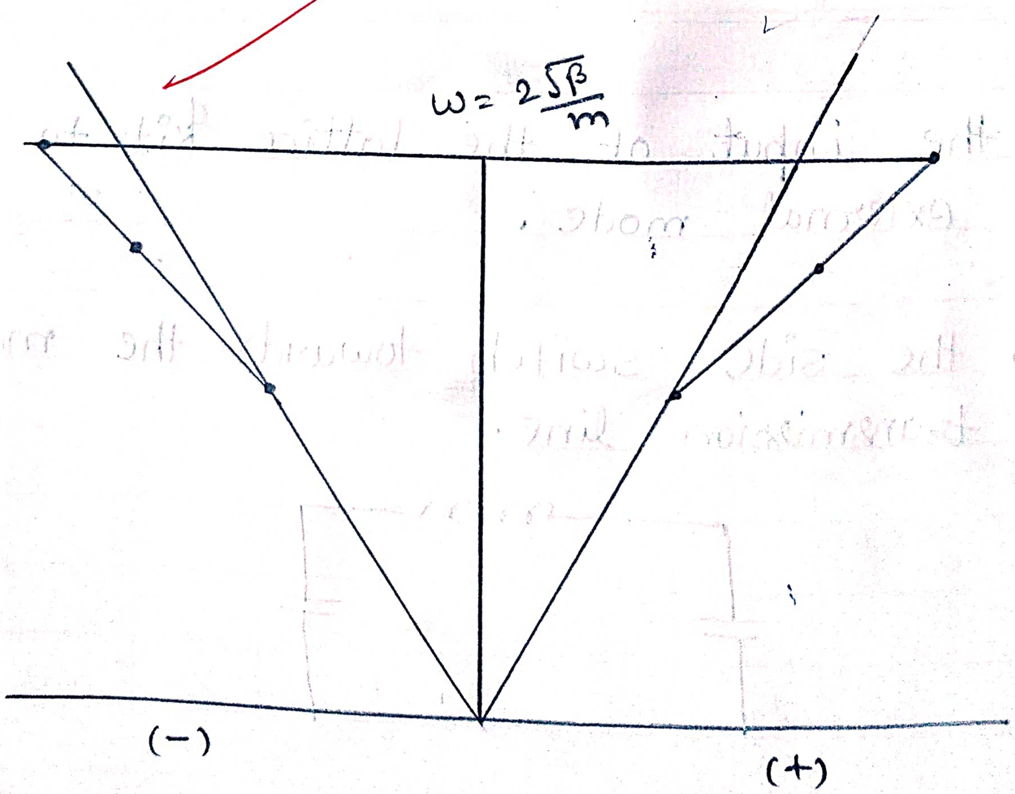



fig :- electrical analog of linear monoatomic




The graph b/w ω & K

**Object :-** To study the dynamics of monoatomic & diatomic lattice is drow the dispersion curve.

**Appratus :-** CRO, lattice dynamic constant of following parts.

① Audio oscillator with amplitude limitted following to very the freq$^n$ in range.
& with position

| position | freq$^n$ range | output voltage |
|---|---|---|
| law | 0.8 – 8.9 KHz | 4.6 V |
| high | 8.7 – 9.1 KHz | 4.6 V |

② The lattice dynamics kid consist of an electrical transmission line in which stimulated one dimensional mono and diatomic lattice

**Back ground information :-**

fig(a) show a mass of spring model for a one dimensinal monoatomic lattice. the particle havemols connected by spring of large constant 'f' the equilibrium distance b/w distance is 'a' and the array is attumed by inqinity long.
Assuming only the nearest neighboarking inequlity the frequency of motion of nth atom is given by

$$MX_n = I(X_{n-1} + X_{n+1} - 2X_n)$$

which solved when the angular frequeny given

$$\omega^2 = \frac{4f}{M} \sin^2\left(\frac{Ka}{2}\right)$$

$$= \frac{2f}{M}(1-\cos\theta)$$

Phase change per unit cell freq

$$V_{max} = \frac{\omega_{max}}{2} = \frac{1}{\pi}\sqrt{\frac{F}{m}}$$

The eleatrical analoge of the mono atomic lattice is shown in the fig ⑥ the dispersion of the circuit is.

$$\omega^2 = \frac{2}{LC}(1-\cos\theta)$$

The diatomic lattice with alternautive mass 'm' & 'M' shown in the fig. can be simulated by transmission line.

(Mecenical) $\omega^2 = f\left[\frac{1}{m} + \frac{1}{M}\right] \pm \left[f\left(\frac{1}{m} + \frac{1}{M}\right)^2 - \frac{4\sin^2\theta}{Mm}\right]^{1/2}$

(eleatrical) $\omega^2 = \left[\frac{1}{L}\left(\frac{1}{C_0} + \frac{1}{C_1}\right)\right] \pm \left[\frac{1}{L}\left(\frac{1}{C} + \frac{1}{C_1}\right)^2 - \frac{4\sin^2\theta}{CC_1}\right]^{1/2}$

There are two frequency $\omega_+$ & $\omega_-$ corresponding to a particalar value of wave vector K, $V_+$ is called optical branch $V_-$ is called accustical brach.

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## Experimental produqe :-

1. Although the lattice dynamic kit to audio oscillator & plug in the power freq$^n$.

| S.NO | CRO Pattern | Dial reding | Q | hQ | ν (KHz) obs. | ν (KHz) Cal. |
|---|---|---|---|---|---|---|
| 1. | / | 0 | 0 | 0 | 0 | 0 |
| 2. | 0 | 8·34 | 9 | 90 | 3·27 | 3·64 |
| 3. | \ | 9·34 | 18 | 180 | 5·11 | 7·24 |
| 4. | High | | | | | |
| 1. | / | 0·00 | 27 | 270 | 0 | 10·80 |
| 2. | 0 | 4·25 | 36 | 360 | 11·38 | 14·35 |
| 3. | \ | 5·27 | 45 | 450 | 13·85 | 17·77 |
| 4. | 0 | 6·47 | 54 | 540 | 17·46 | 21·08 |
| 5. | / | 7·37 | 63 | 630 | 24·76 | 24·66 |
| 6. | 0 | 7·62 | 72 | 720 | 27·59 | 29·29 |
| 7 | \ | 7·80 | 81 | 810 | 29·26 | 30·16 |
| 8 | 0 | 8·19 | 90 | 900 | 31·35 | 32·64 |
| 9 | / | 8·35 | 99 | 990 | 33·50 | 30·31 |
| 10 | 0 | 8·32 | 108 | 1080 | 34-06 | 37·89 |

Table :-

For diatomic

$L = 1.0\ mH$ $C = 0.047\ \mu F$ $C_1 = 0.1\ \mu F$

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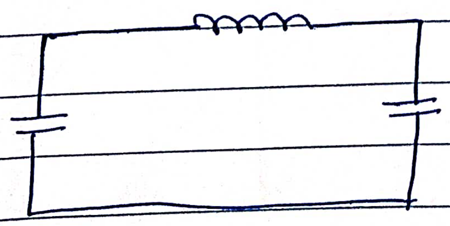
| S.No | CRO Pattern | Dial Reading | $\theta$ | Frequency Cal. | Frequency obs. |
|---|---|---|---|---|---|
| 1 | / | 0 | 0 | 0 | — |
| 2 | 0 | 7·31 | 90 | 2·418 | 2·9 |
| 3 | \ | 8·66 | 180 | 3·318 | 5·8 |
| 4 | high | | | | |
| 1 | \ | 0 | 270 | 0 | 1·4 |
| 2 | 0 | 1·44 | 360 | 8·418 | 14·0 |
| 3 | / | 4·12 | 450 | 15·410 | 16·5 |
| 4 | 0 | 4·80 | 540 | 15·20 | 18·0 |
| 5 | \ | 5·54 | 630 | 16·83 | 28·5 |
| 6 | 0 | 6·08 | 720 | 18·85 | 29·5 |
| 7 | / | 6·70 | 810 | 20·07 | 29·5 |
| 8 | 0 | 7·70 | 900 | 27·59 | 33·0 |

(II) Feed the input of the lattice kit to CRO. the on the external mode.

(III) Swich the side switch towards the monoatomic side the transmission line.



(iv) Starting with the lowest freq$^n$ very with the frequency of the audio oscillator diatomic the freqhency b/w.

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input and output voltage

(v) Represent the observel & calculated value of $\nu$ as a freq^n of a conneated on the agerment b/w the theoritical & practicale.

(vi) findout the max. frequency of transmission & Compare with theoritical value of $\hbar \sqrt{f/m}$

Diatomic lattice -

(i) E up the side switch on the lattice dynamic kit towards to $C_1 = 0.0147$ uf

(ii) Repet the procedure outline for the mono atomic lattice note the existance of energy gap

## Calculation :-

① for monoatomic Lattice

$$\omega^2 = \frac{2}{LC}(1-\cos\theta)$$

then $\nu = \frac{1}{2\pi}\sqrt{\frac{2}{LC}(1-\cos\theta)}$

$$\nu = 32.84\sqrt{1-\cos\theta} \text{ KHz}$$

(i) at $\theta = 90^\circ$  $\nu = 32.84\sqrt{1-\cos 90^\circ}$

$\nu = 3.64$ KHZ

(ii) at $\theta = 180^\circ$  $\nu = 32.84\sqrt{1-\cos 180}$

$\nu = 7.2$ MHZ

② for diatomic lattice

$$\omega^2 = \frac{1}{L}\left[\frac{1}{C}+\frac{1}{C_1}\right] + \frac{1}{L}\left(\frac{1}{C}+\frac{1}{C_1}\right]^2 - \frac{4\sin^2\theta}{LC_1}$$

$$\omega^2 = \frac{1}{2\pi}\sqrt{\frac{1}{L}\left(\frac{1}{C}+\frac{1}{C_1}\right) + \frac{1}{L}\left(\frac{1}{C}+\frac{1}{C_1}\right)^2 - \frac{4\sin^2\theta}{CC_1}}$$

Similarly from eqn ② calculate freqn diff. angle.

Result :-

(i) for monoatomic lattice dispertion curve b/w freq$^n$ Calculated and observed a phase difference $\alpha$ is almost same for theratical and optical value.

(ii) for diatomic lattice vibration curve consist of two branch optical which is uper part is the accuesical branch. the difference b/w these parts

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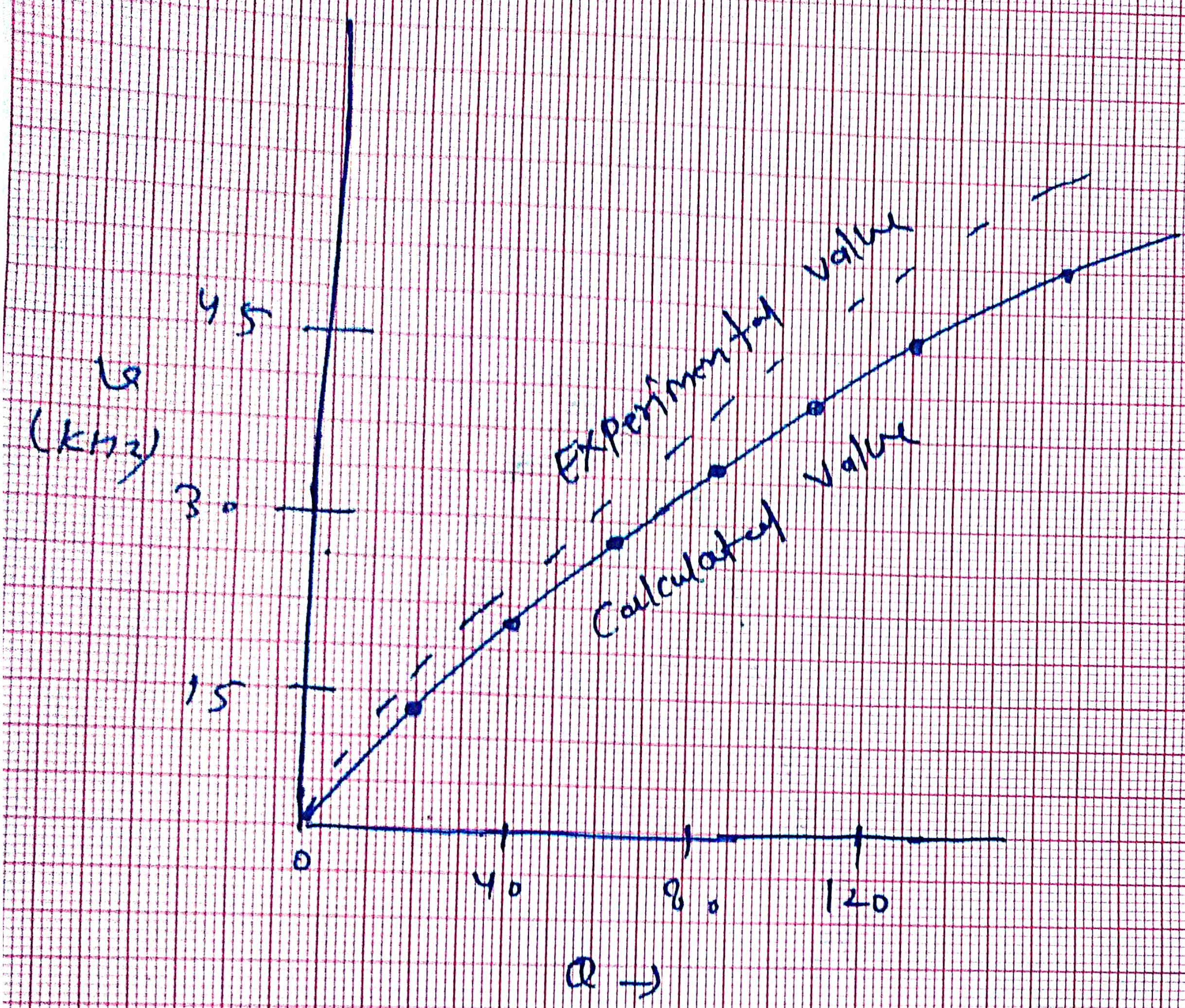
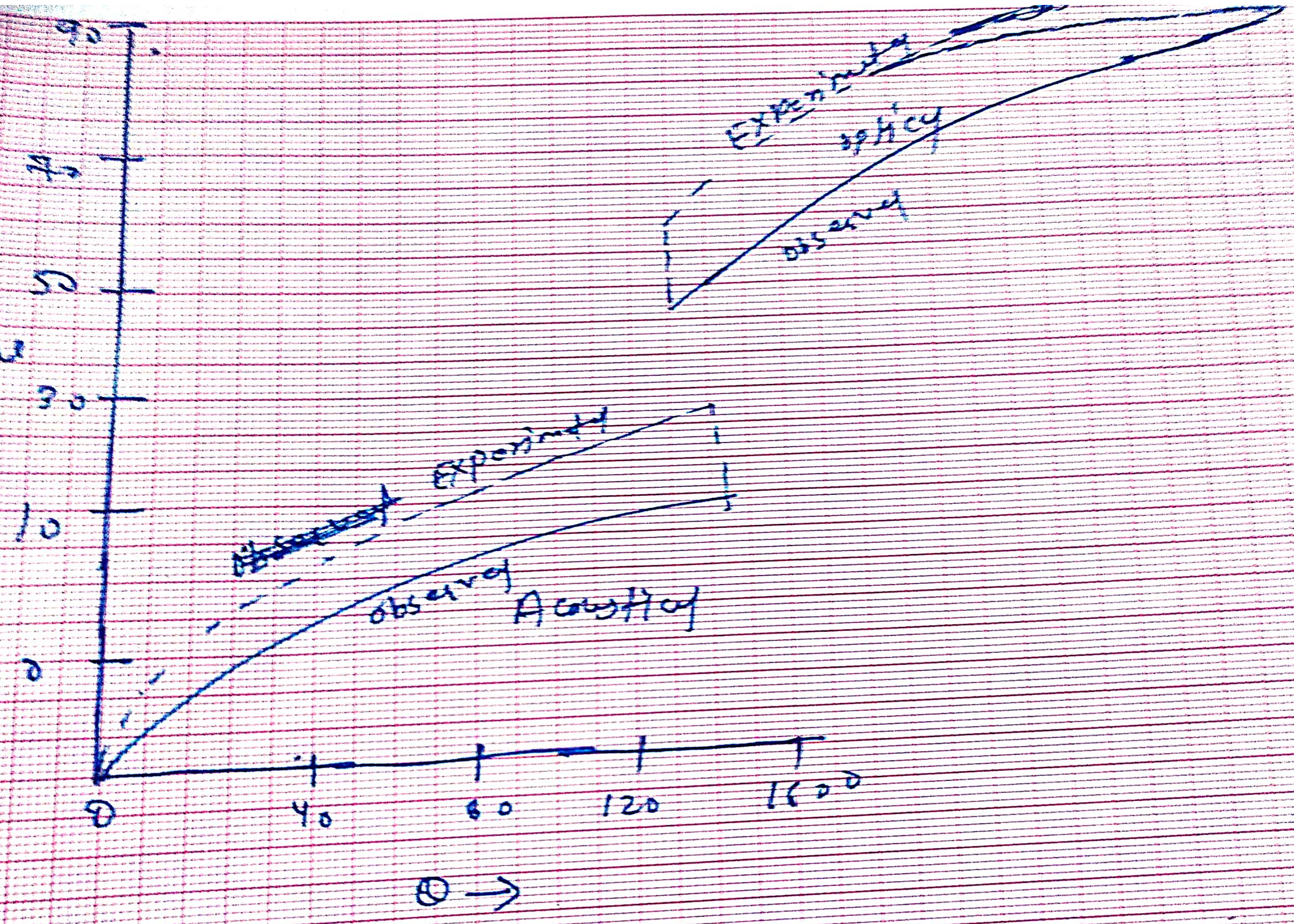
are branchless towards as forbidden frequency gap the graph for experiment & theroritical value is almost same.

26/11/24

... monoatomic Brans





Experimental
observed
Accuracy
Efficiency