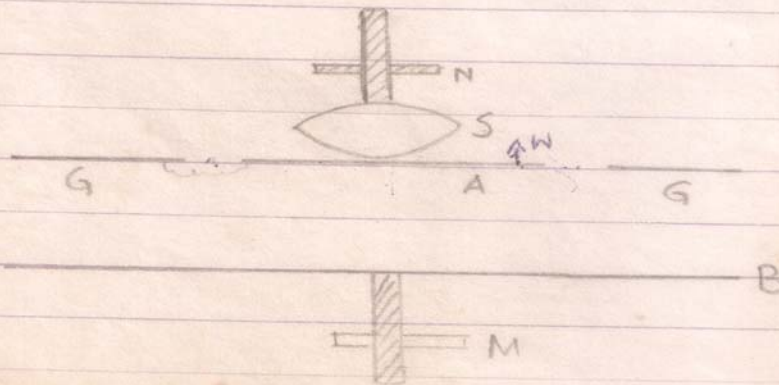




Absolute Electrometer : Attracted disc Electrometer:

Principle: Here the P.d to be measured is placed across the two parallel conducting discs & the force produced in the resultant electrostatic field is measured by direct comparison with known weights. As this P.d is measured in terms of force of attraction and dimensions of the capacitor which can be expressed in terms of fundamental units of mass, length and time, hence it is called an absolute electrometer.

Construction: When a disc is charged, the density of charge is not uniform but is greatest round the edges. This edge effect can be reduced by enclosing the disc by a ring with a small air gap & electrically connected with the charged disc. This is known as guard ring.





The attracted disc 'A' is surrounded by a gilded ring 'GG' which is connected electrically to the disc by a light flexible wire. The effective area of the movable disc is then its actual area, plus half the area of the narrow annular air gap. The moving disc is supported by a spring 'S' which in turn is attached to a micrometer screw M. The lower plate 'B' regarded as fixed during an experiment may also be provided with a micrometer screw M, so that it can be raised or lowered.

A fine cross wire 'W' is attached to the movable disc 'A' so as to enable the zero position of the disc 'A' to be accurately located i.e. the position where A and the gilded ring 'GG' are exactly coplanar.

Theory: Let V_a and V_b represents the potentials of plates A and B respectively.

t = distance of separation between the two plates.

E = Uniform electric intensity between the plates.

$$\therefore E = \frac{V_a - V_b}{t}$$

The plate A will then experience a force $\frac{1}{2} \epsilon_0 E^2$ per unit area of the surface



If A' = Effective area of the plate A

$$F = \frac{1}{2} \epsilon_0 E^2 A' = \frac{1}{2} \epsilon_0 \frac{(V_a - V_b)^2}{t^2} \cdot A'$$

$$\epsilon_0 (V_a - V_b) = t \sqrt{\frac{2F}{\epsilon_0 A'}} \quad \text{--- (1)}$$

Procedure:

- ① At first all the plates A, B and GG are earthed and the plate A is made to lie in the plane of GG.
- ② A small weight 'm' is then placed on the plate A which therefore gets depressed below the plane of GG due to the weighting.
- ③ The plate 'A' is now raised to the level of the plane of GG with the help of screw nut N.
- ④ The small weight 'm' is now removed so that the plate A is pulled up by the spring 'S' and is above the plane of GG. The earth connections of all the plates is now broken.
- ⑤ Now the plate 'A' with the guard ring 'GG' are charged to a constant potential with the help of a machine called Kelvin's Replinsner.
- ⑥ The plate 'B' is then connected to the first of the points, the potential difference between which we want to measure. Then the lower plate B is raised with the help of



micrometer screw 'M' till the upper plate A comes in level with 'GG' and the position of the micrometer screw is read.

Let t_1 is now the separation between the two plates & V_1 is the potential of the lower plate B.

$$V_A - V_1 = t_1 \sqrt{\frac{2mg}{\epsilon_0 A'}} \quad \text{--- (2)}$$

⑦. The plate 'B' is now connected to the second point whose potential is V_2 & the plate B is moved again with the help of micrometer screw 'M' till the plate 'A' comes in level with GG & its position is noted again.

Let t_2 = separation between the two plates.

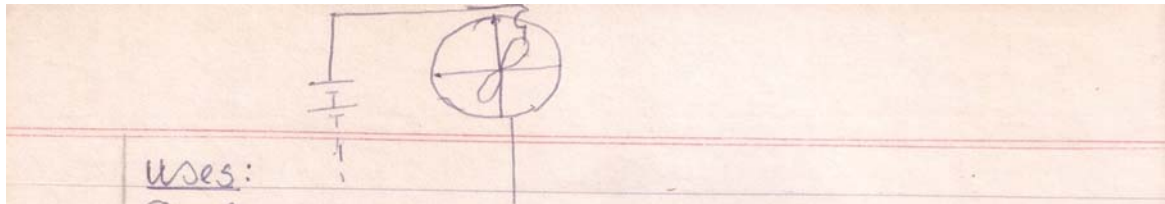
$$V_A - V_2 = t_2 \sqrt{\frac{2mg}{\epsilon_0 A'}} \quad \text{--- (3)}$$

Substituting (3) from (2):

$$V_2 - V_1 = (t_2 - t_1) \sqrt{\frac{2mg}{\epsilon_0 A'}} \quad \text{--- (4)}$$

$(t_2 - t_1)$ can be obtained from the difference of the two micrometer readings.

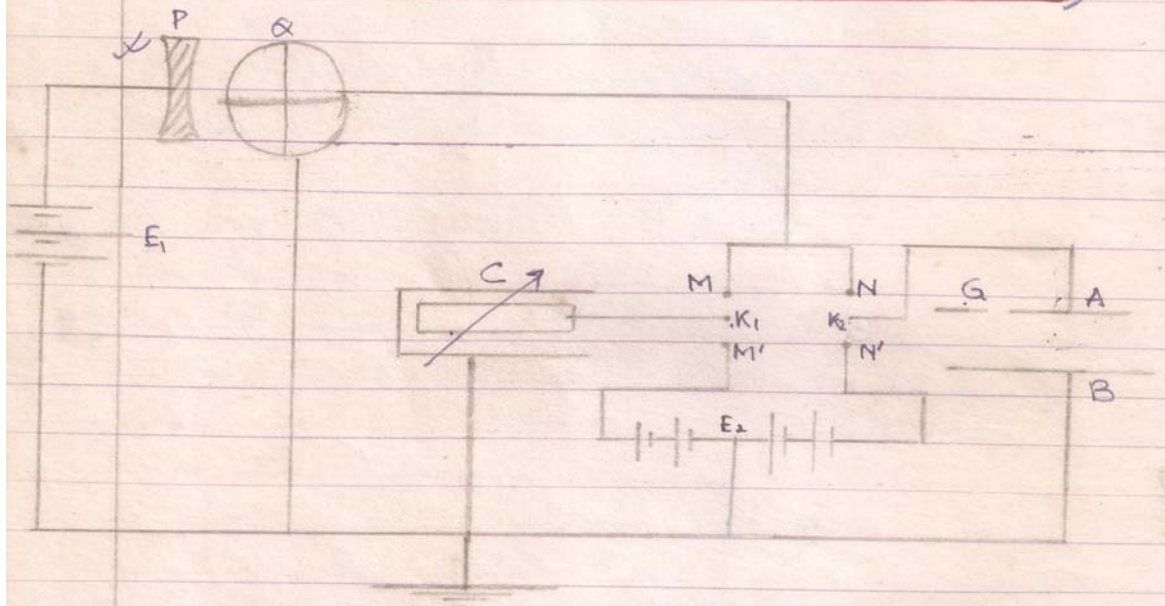
The main disadvantage of this instrument is its lack of sensitivity. For P.d's of a few hundred volts the attractive force is small unless the discs are very close together.



Uses:

①. Since the resistance of a voltmeter has a finite value it always draws some current from the circuit in which it is connected and therefore shows less values of P.d. On the other hand the attracted disc electrometer is an air condenser having infinite resistance and hence measures the actual P.d.

② Determination of relative permittivity i.e. dielectric constants of solid: Hopkinson's method (using attracted disc electrometer):-



C = Cylindrical Condenser the inner cylinder can be slided, the outer cylinder being earthed.

AB An attracted disc electrometer, the lower plate B is earthed & plate A is connected to K_2 .



E_2 = The middle point of E_2 is earthed so that the ends M' & N' are at P.d.s $+V$ and $-V$ w.r to each.

Q = Quadrant Electrometer of which the needle is charged.

Procedure: ① K_1 and K_2 are connected to M' & N' so that inner cylinder of C is charged $+ve$ and A is charged $(-ve)$.

② When K_1 and K_2 are connected to M and N . If the Capacities of C and A are equal then equal and opposite charges will neutralize and no deflection would be obtained in the "Quadrant Electrometer". But if there is an excess of one kind of charge and that Condenser has a greater Capacity which is connected to the Quadrants from which the needle moves, C is adjusted till no deflection is obtained.

③. A parallel sided Slab of suitable size of the solid whose 'K' is to be determined is placed in the lower plate B of the Guard ring Capacitor, thus increasing its Capacitance. By keeping C fixed to its previous adjustment the plate B is lowered till there is again no deflection on making contact K_1 & K_2 first below then above.



Calculation:

x = distance through which B is lowered.
 t = thickness of the dielectric slab.
 d = separation between A & B in case of no deflection without the dielectric slab.
 A = effective area of the Guard ring Capacitor.

Capacity of A without dielectric = $\frac{\epsilon_0 A}{d}$

In null deflection : $\frac{\epsilon_0 A}{d} = C$ — (1)

where C = Capacity of cylindrical condenser.

When the dielectric slab is introduced

Capacity of A = $\frac{\epsilon_0 A}{\left[d+x - t \left(\frac{\epsilon_r - 1}{\epsilon_r} \right) \right]} = C$ — (2)

from (1) and (2) :-

$\frac{\epsilon_0 A}{d} = \frac{\epsilon_0 A}{\left(d+x \right) - t \left(\frac{\epsilon_r - 1}{\epsilon_r} \right)}$ $\epsilon_r = k$

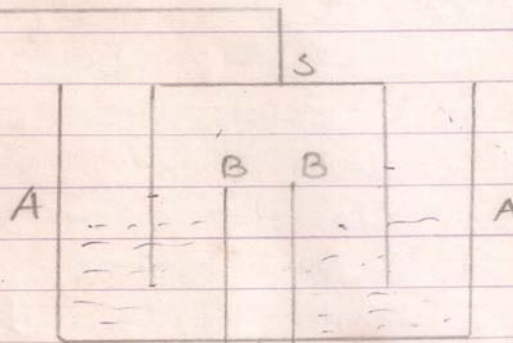
or $d = (d+x) - t \left(\frac{k-1}{k} \right)$

or $x = t \left(1 - \frac{1}{k} \right)$

or $t - x = \frac{t}{k}$ or $k = \frac{t}{(t-x)}$



(b) S.I.C of liquid : Hopkinson's method:



A special cylindrical Condenser consists of double cylinder in which an insulated metallic cylinder 'S' could be hung is used. which takes the place of Guard ring Capacitor 'A' in the fig. of Case (a) C is adjusted for no deflection when cylindrical Condenser contain only air and the length of 'S' is measured. Then 'S' is filled with liquid Capacity will change & 'S' is again adjusted for null deflection and length of 'S' is again measured.

Let a & b = radii of outer & inner cylinder of S.

l_1 and l_2 = lengths of the inner cylinder inside and outside outer cylinder of S.

$$\text{Capacity of S in first case } C_1 = \frac{2\pi\epsilon_0 l_1}{\log_e \frac{b}{a}} = \text{Capacity of C}$$

$$\text{Capacity of S in second case : } C_2 = \frac{2\pi\epsilon_0 \epsilon_r l_2}{\log_e \frac{b}{a}} = \text{Capacity of C}$$

$$K = \epsilon_r = \frac{l_1}{l_2}$$