Potentiometer

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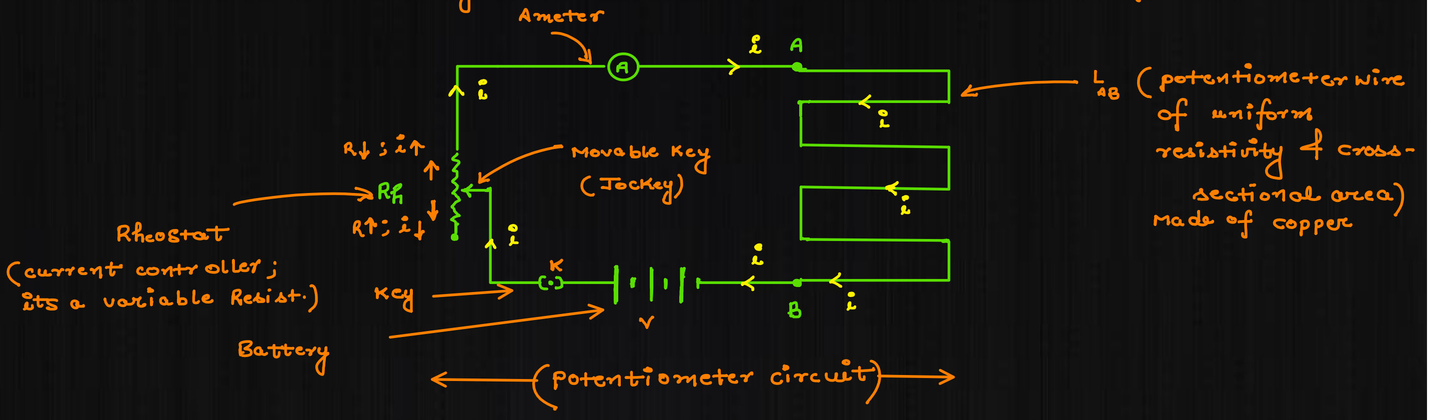
Potentiometer is a device which is used to determine the EMF & internal Resistance of any unknown.

Using this we can also compare the EMFs of two unknown cells.



P.D. b/w the ends of the potentiometer wire :

$$\Delta V_{AB} = i \times R_{AB}$$

$$= i \times \frac{\rho \cdot L_{AB}}{A}$$

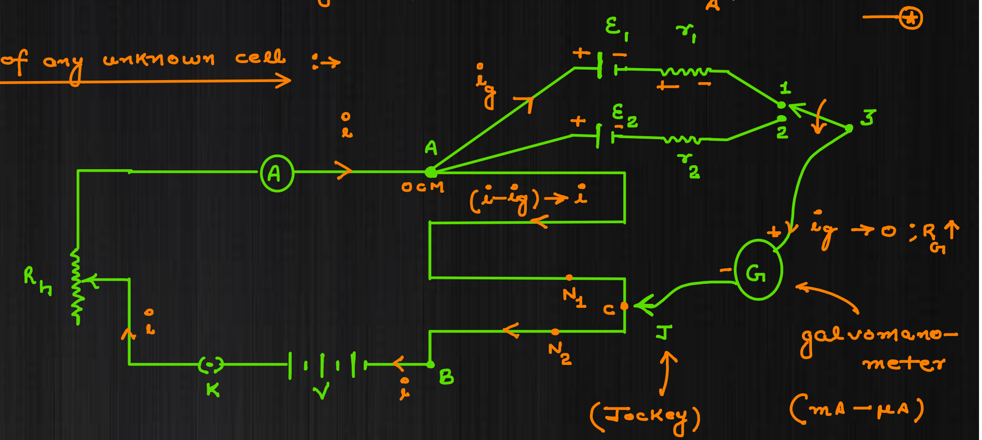
$$\Rightarrow \frac{V_{AB}}{L_{AB}} = \frac{i \times \rho}{A} = \text{const} \qquad \left(\because \begin{array}{l} i = \text{const} \\ \rho = \text{copper} \\ A = \text{const} \end{array} \right)$$

ie; potential Gradient or P.D. per unit length of P.M. wire $= \phi = \left(\frac{i \cdot \rho}{A}\right) =$ const volt/m —⊛

App(I) :→ Determination of EMF of any unknown cell :→

cell 1 $(\varepsilon_1 ; r_1)$ = Known

cell 2 $(\varepsilon_2 ; r_2)$ = unknown



Concept :→ we connect any cell with P.M. & G ; Then we carefully connect the jockey at Diff points of the P.M. wire. Due to this the wire's P.D from A to point of contact becomes equal to the P.D. b/w A to point of contact through cell + G system.

ie; $(\Delta V_{AC})_{wire} = (\Delta V_{AC})_{cell + G}$

$$\Rightarrow (i - i_g) \times R_{AC} = (\varepsilon + i_g \cdot r) + i_g \cdot R_G$$

as we find the null point ; $i_g = 0$

$$i \times R_{AN} = \varepsilon \quad —⊛$$

$$\left\{ i \times \frac{\rho}{A} \right\} \times l_{AN}$$

$$\Rightarrow \frac{V_{AB}}{R_{AB}} \times R_{AN} = \varepsilon$$

$$\Rightarrow \frac{V_{AB}}{\frac{\rho \times l_{AB}}{A}} \times \frac{\rho \times l_{AN}}{A} = \varepsilon$$

$$\Rightarrow \left(\frac{V_{AB}}{l_{AB}}\right) \times l_{AN} = \varepsilon$$

$$\Rightarrow \{\phi \times l_{AN} = \varepsilon\} \quad ; \quad l_{AN} = \text{length of PM}$$

$$\Rightarrow \left(\frac{V_{AB}}{l_{AB}}\right) \times l_{AN} = \varepsilon$$

$$\Rightarrow \boxed{\phi \times l_{AN} = \varepsilon}$$

: l_{AN} = length of PM wire from A to Null point

ie; Balancing Length.

for the known cell :→

$$\varepsilon_1 = \phi \times l_{AN_1} \quad \text{— (1)}$$

or

$$\varepsilon_1 = \phi \times l_1$$

l_{AN_1} or l_1 is the length of P.M. wire from 0 cm. to the null point.

ie; Balancing Length of cell 1

for the unknown cell :→

$$\varepsilon_2 = \phi \times l_{AN_2}$$

or — (2)

$$\varepsilon_2 = \phi \times l_2$$

l_{AN_2} or l_2 is the Length of P.M. wire from 0cm. to the null point

ie; Balancing Length of cell 2

eqn (2)/(1)

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$$

EMF of the unknown cell

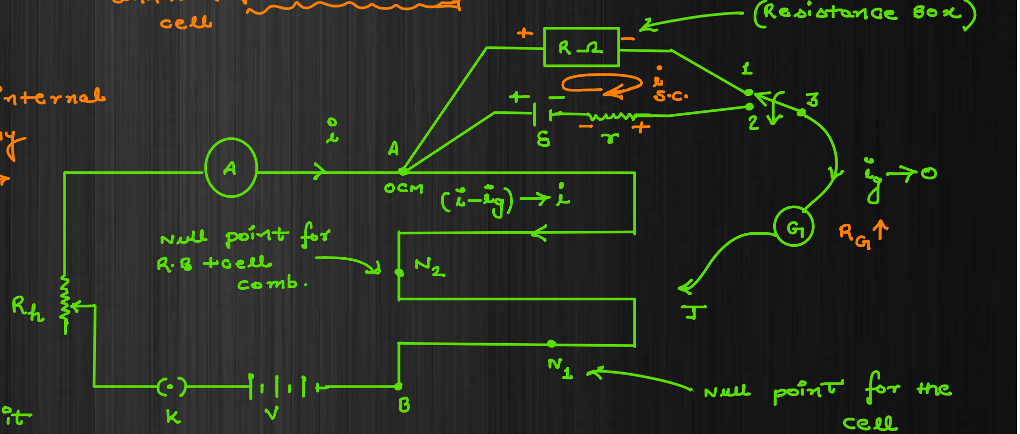
$$\boxed{\varepsilon_2 = \varepsilon_1 \times \frac{l_2}{l_1}}$$

if ε_1 & ε_2 both are unknown

comparision of the EMF

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_2}{l_1}$$

App (2) :→ Determination of internal Resistance of any unknown cell :→



first we connect the G with the cell only & find the Null point for it

$$\Rightarrow \varepsilon = \phi \times l_{AN_1}$$

or

$$\Rightarrow \varepsilon = \phi \times l_1 \quad \text{— (1)}$$

$l_{AN_2} = l_2$; Balancing Length of cell alone

Then we connect the R.B, cell & G together & find the Null point for this combination.

∵ no current comes out from secondary circuit through the G after we found Null point.

∴ we can say no current was gone in the sec. from the primary circuit.

Hence current in the P.M. wire again becomes const. ie; i Amp. & a short circuit current flows b/w R.B. & the cell

$$i_{sc} = \left(\frac{\varepsilon}{R + r}\right) \quad \text{— (2)}$$

∵ G shows no difflection after we found the null point ie $i_g \to 0$

$$\therefore \Delta V_G = i_g \times R_G \to 0$$

$$\Rightarrow V_{N_2} = V_1 = V_2 = V_3$$

$$\Rightarrow \Delta V_{cell} = \Delta V_{R.B} = (\Delta V_{wire})_{AN_2}$$

$$\Rightarrow (\varepsilon - i_{s.c.} \times r) = i_{sc} \times R = \phi \times l_{AN_2} \quad \text{— (*)}$$

from eqn (2)

$l_{AN_2} = l_2$ ie Balancing

$\Rightarrow$ S.C. SC AN_2

$l_{AN_2} = l_2$ ie Balancing Length of (cell + R.B.)

$i_{SO} = \dfrac{\varepsilon}{(R+r)}$

from eqn (2)

$$\frac{\varepsilon \cdot R}{(R+r)} = \varphi \times l_2 \quad \text{--- (3)}$$

eqn (3)/(1)

$$\Rightarrow \frac{R}{(R+r)} = \frac{l_2}{l_1}$$

$$\Rightarrow R \cdot l_1 = R \cdot l_2 + r \cdot l_2$$

$$\Rightarrow r \cdot l_2 = R \cdot (l_1 - l_2)$$

internal Resistance of the unknown cell.

$$\Rightarrow \boxed{r = R \cdot \left(\frac{l_1}{l_2} - 1\right)} \quad \text{--- (*)}$$

Note: → Here $l_1 > l_2$, ie Balancing length of the cell alone must be greater than the Balancing Length for (cell + R.B.) combination.