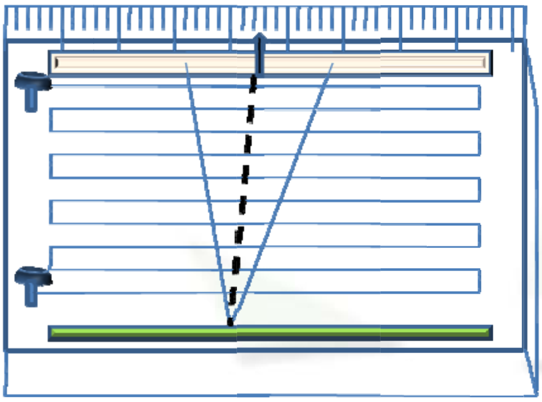
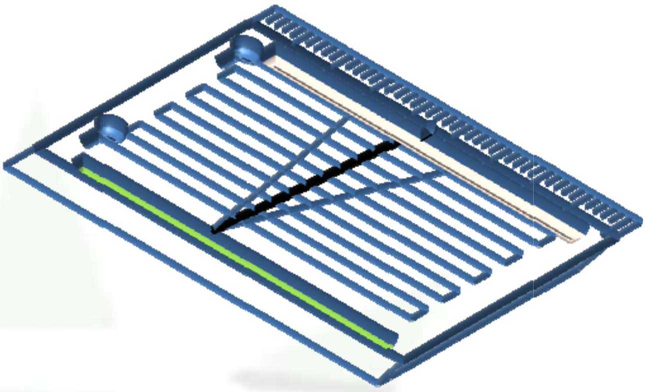
Potentiometers:

It is an instrument used to measure the emf of a cell or a battery. It can also be used to measure potential difference, current, internal resistance of a battery etc.

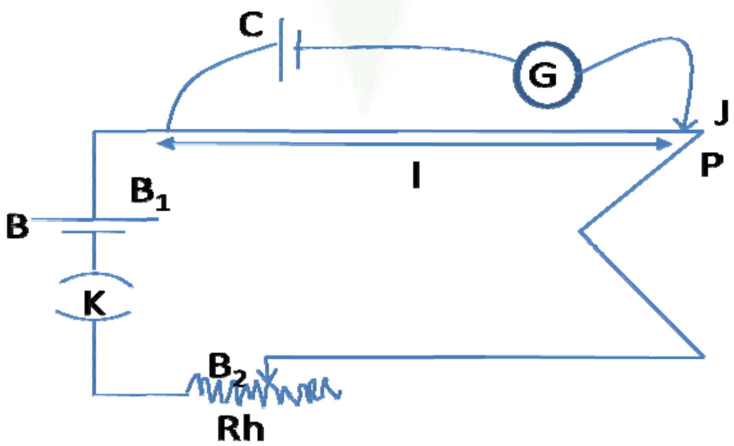




Construction: It consists of a long thin wire of uniform cross section throughout its entire length and having 1000 cm length. This wire is fixed on a wooden board in ten folds each of length100 cm, all parallel to one another as shown. The two free ends of a wire are connected with two terminal screws B1 and B2. Near the 10^{th} wire a brass rod RR parallel to the last wire is fixed on the board with terminal screws at its two ends. By the side of the first wire a groove runs parallel to the first wire on the wooden board. The two legs of the jokey J rest on this groove and the third leg rests on the brass rod RR.

The edge of the wooden board near the first wire is slightly raised, on which a meter scale is fixed. The position of the jokey can be read from the scale.

Theory: A accumulator B of greater than the emf of the test call is connected through a key K and a rheostat across the potentiometer wire B_1 & B_2 there by driving a current through the potentiometer wire and a potential difference is produced across the potentiometer wire. The accumulator B is known as driving cell.



The test cell is connected with its positive terminal of the driving cell and the negative terminal of the test cell is connected through a galvanometer to the jockey J. Let the jokey be passed at the point P, if the emf of the test cell C is greater than the potential difference V_{B1P} then current flows through the galvanometer wire CB_1PGC.

But if $E > V_{B1P}$ current flows along $CGPB_1C$.

If E = VB1P no current flows through the galvanometer and galvanometer shows null deflection.

Let i be the current flowing through the potentiometer wire by the driving cell.

ρ =The resistance per unit length throughout the potentiometer wire.

l= B_1P = the length of the potentiometer wire up to the jockey at null deflection.

Therefore the potential difference across the wire B_1P

$$V_{B1P} = i\rho l$$

E = emf of the test cell.

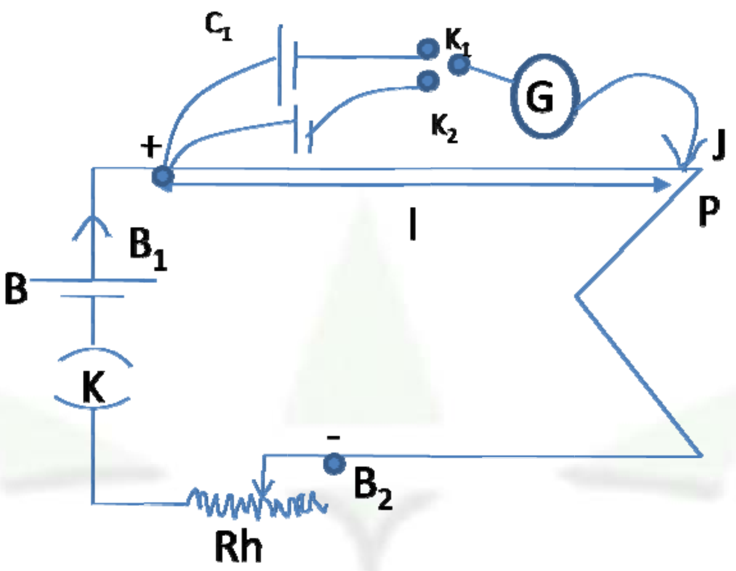
At null deflection $E = i\rho l \longrightarrow (1)$

(A) The current i flowing through the potentiometer wire can be measured by using an ammeter in the potentiometer circuit.

(B) The resistance of the entire potentiometer wire can be measured by a P.O box and dividing it by 1000 we get ρ

Thus knowing i, ρ, l we can calculate E.

Uses of Potentiometer: (1) To compare the emf of two cells



If K1 is closed (K_2 is open) balance point is found by using C_1

$$E_1 = i\rho l_1$$

If K1 is opened and K2 is closed by measuring C_2 balance point is found

$$E_2 = i\rho l_2$$

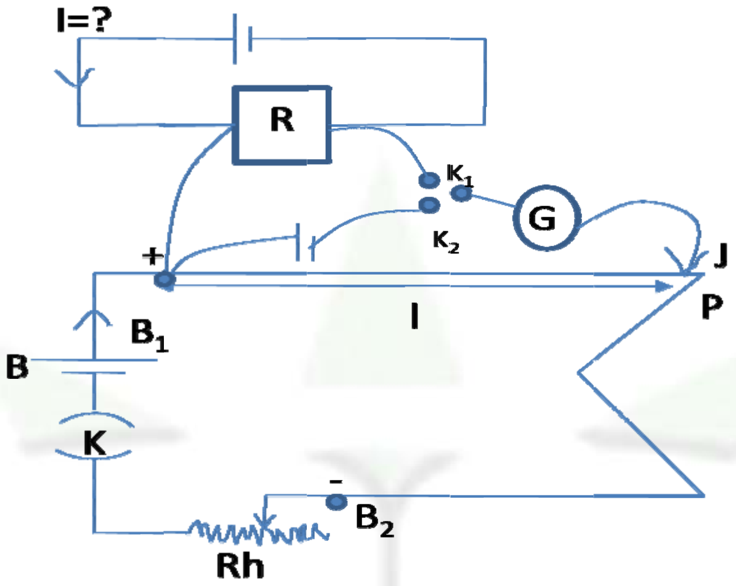
$$\frac{E_1}{E_2} = \frac{i\rho l_1}{i\rho l_2} = \frac{l_1}{l_2} \rightarrow (1)$$

Let C_2 be the standard cell i.e. A cell whose emf accurately known

(e.g. Cadmium cell E_2=1.0183 Volt)

$$E_1 = \frac{l_1}{l_2} E_2 \rightarrow \text{Thus emf of the test cell } C_1 \text{ can be calculated.}$$

(2) Measurement of current by using potentiometer



Let V = P.D across the standard resistance R

$V = IR \rightarrow (1)$

(i) Closing K_1 (K_2 open) balance point is found

$V = i\rho l_1 \rightarrow (2)$

(ii) K_1 is opened, closing K_2 using the standard cadmimum cell C balance point is found.

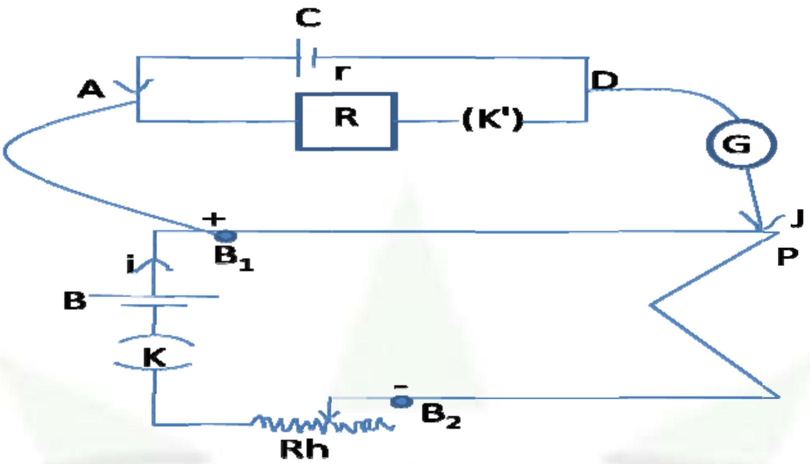
emf of the standard cell $E = i\rho l_2 \rightarrow (3)$

$$\frac{V}{E} = \frac{i\rho l_1}{i\rho l_2} = \frac{l_1}{l_2}$$

$$\frac{IR}{E} = \frac{l_1}{l_2}$$

$$I = \frac{E}{R}\frac{l_1}{l_2}$$

(3) To measure the internal resistance of a cell by using a potentiometer



(1) Key K' is kept open no current flows through R i.e. The circuit of the test cell is an open circuit. The balance point is found by using the test cell C.

$$\text{The emf of the test cell } E = i\rho l_1 \rightarrow (1)$$

(2) The Key K' is closed a current flows through the circuit of the test cell producing a potential difference across AD

$$V = IR = \left(\frac{E}{R+r}\right)R \rightarrow (2)$$

Using the potential difference the balance point is found

$$V = i\rho l_2 \rightarrow (3)$$

Dividing equation (1) by equation(3)

$$\frac{E}{V} = \frac{i\rho l_1}{i\rho l_2} = \frac{l_1}{l_2}$$

$$\frac{E}{\left(\frac{E}{R+r}\right)R} = \frac{l_1}{l_2}$$

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