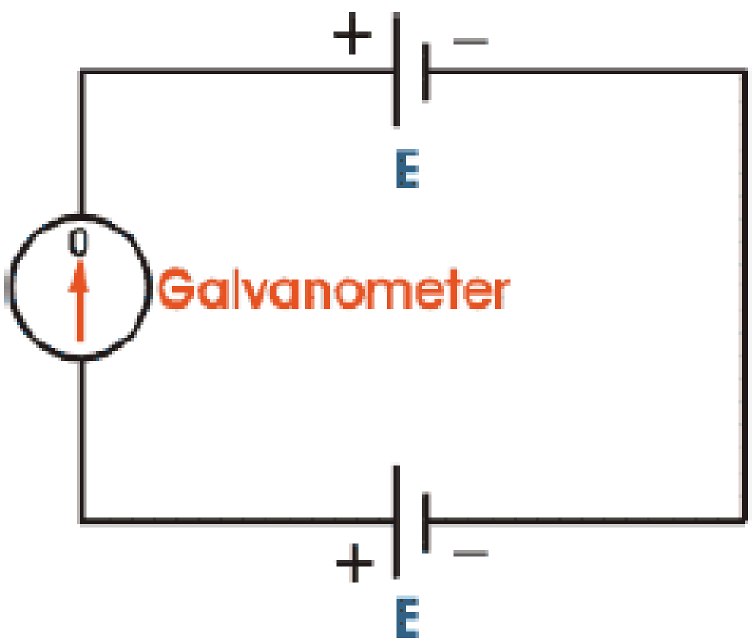
Working Principle of Potentiometer

This is a very basic instrument used for comparing emf two cells and for calibrating ammeter, voltmeter and watt-meter. The basic **working principle of potentiometer** is very very simple. Suppose we have connected two battery in head to head and tale to tale through a galvanometer. That means the positive terminals of both battery are connected together and negative terminals are also connected together through a galvanometer as shown in the figure below



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it is clear that if the voltageof both battery cells is exactly equal, there will be no circulating currentin the circuit and hence the galvanometer shows null deflection. The **working principle of potentiometer** depends upon this phenomenon.

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Now let's think about another circuit, where a battery is connected across a resistor via a switch and a rheostat as shown in the figure below voltage-drop-calculation/ across the resistor. As there is a voltage drop across the resistor, this portion of the circuit can be considered as a voltagesource for other external circuits. That means anything connected across the resistor will get voltage. If the resistor has uniform cross section throughout its length, the electrical resistance per unit length of the resistor is also uniform throughout itslength.

voltage drop per unit length of the resistor is also uniform. Suppose the current through the resistor is i A and resistance per unit length of the resistor is r Ω. Then the voltage appears per unit length across the resistor would be 'ir' ans say it is v volt.

positive terminal of a standard cell is connected to point A on the sliding resistor and negative terminal of the same is connected with a galvanometer. Other end of the galvanometer is in contact with the resistorvia a sliding contact as shown in the figure above. By adjusting this

sliding end, a point like B is found where, there is no current through the galvanometer, hence no deflection of galvanometer.

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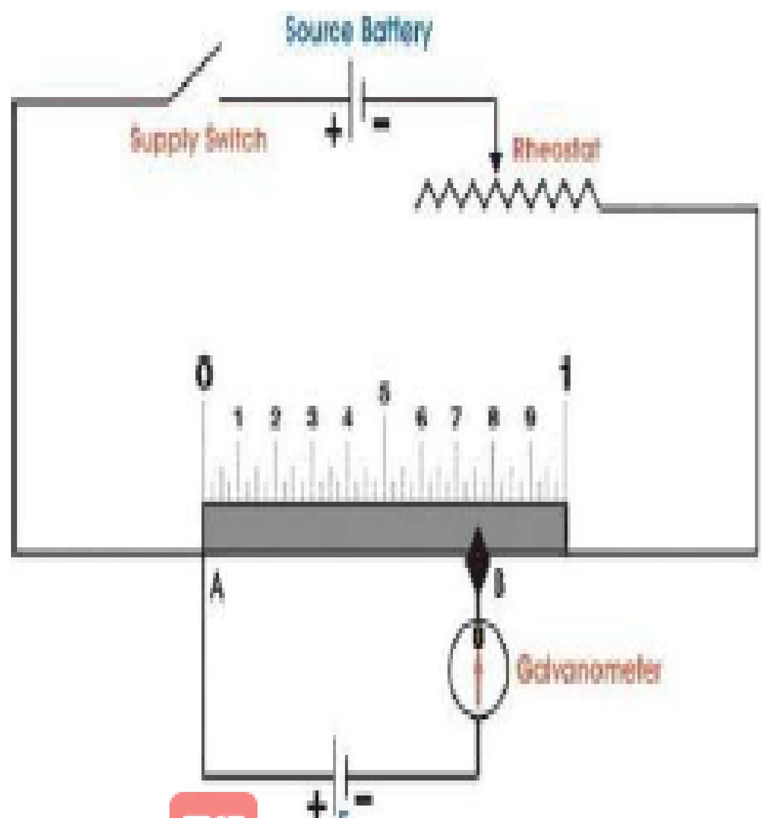
That means emf of the standard cell is just balanced by the voltage-drop-calculation/ appears across AB. Now if the distance between point A and B is L, then it can be written emf of standard cell E = Lv volt. As v (voltage drop per unit length of the sliding resistor) is known and L is measured from the scale attached to the resistor, the value of E i.e. emf of standard cell can also be calculated from the above simple equation very easily.



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DC POTENTIOMETER CAN COMPARE EMFS OF TWO DIFFERENT CELLS

Two cells whose emf's are to be compared are joined as shown in the figure below. The positive terminals of the cells and source battery are joined together. The negative terminals of the cells are joined with the galvanometer in turn through a two way switch. The other end of the galvanometer is connected to a sliding contact on the resistor. Now by adjusting sliding contact on the resistor, it is found that the null deflection of galvanometer comes for first cell at a length of L on the scale and after positioning to way switch to second cell and then by adjusting the sliding contact, it is found that the null deflection of galvanometer comes for that cell at a length of L_1 on the scale.Let's think of the first cell as standard cell and it's emf is E and second cell is unknown cell whose emf is E_1. Now as per above explanation, E = Lv volt and
$L_1 = L_1v$ volt Dividing one equation by other, we get

$$\frac{E_1}{E} = \frac{L_1}{L}$$

As the emf of the standard cell is known, hence emf of the unknown cell can easily be determined.

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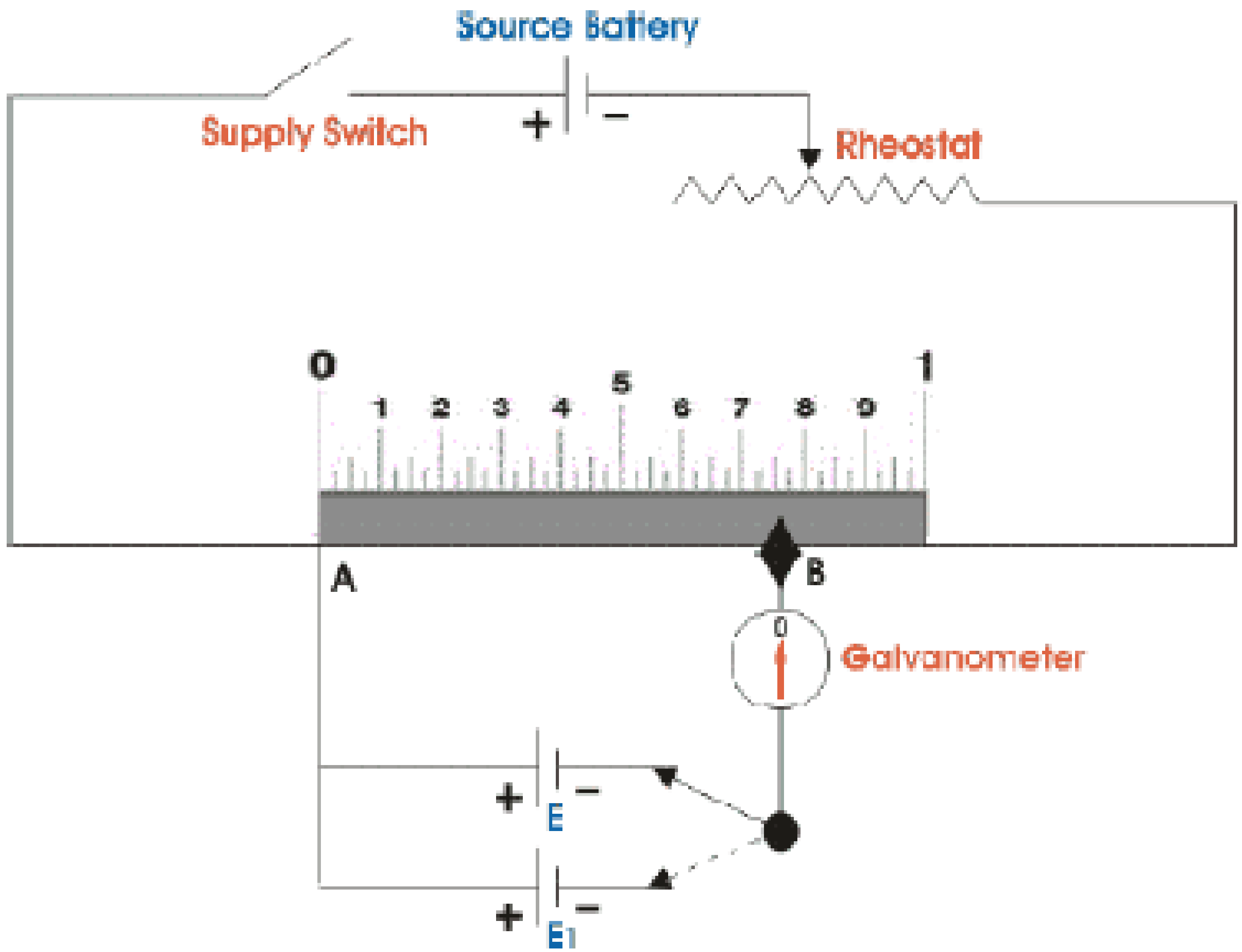

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AC Potentiometer

The Potentiometer is an instrument which measures unknown voltage by balancing it with a known voltage. The known source may be DC or AC. The working phenomenon of DC potentiometer and **AC potentiometer** is same. But there is one major difference between their measurements, DC potentiometer only measures the magnitude of the unknown voltage. Where as, AC potentiometer measures both the magnitude and phase of unknown voltage by comparing it with known reference. There are two types of AC potentiometers:

1. Polar typepotentiometer.
2. Coordinate typepotentiometer.

Polar type Potentiometer

In such type of instruments, two separate scales are used to measure magnitude and phase angle on some reference of the unknown e.m.f. There is a provision on the scale that it could read phase angle up to 3600. It has electrodynamometer type ammeter along with DC potentiometer and phase-shifting transformer which is operated by single phase supply. In phase-shifting transformer, there is a combination of two ring-shaped laminated steel stators connected perpendicularly to each other as shown in the figure. One is directly connected to power supply and the other one is connected in series with variable resistance and capacitor. The function of the series components is to maintain constant AC supply in the potentiometer by doing small adjustments init.

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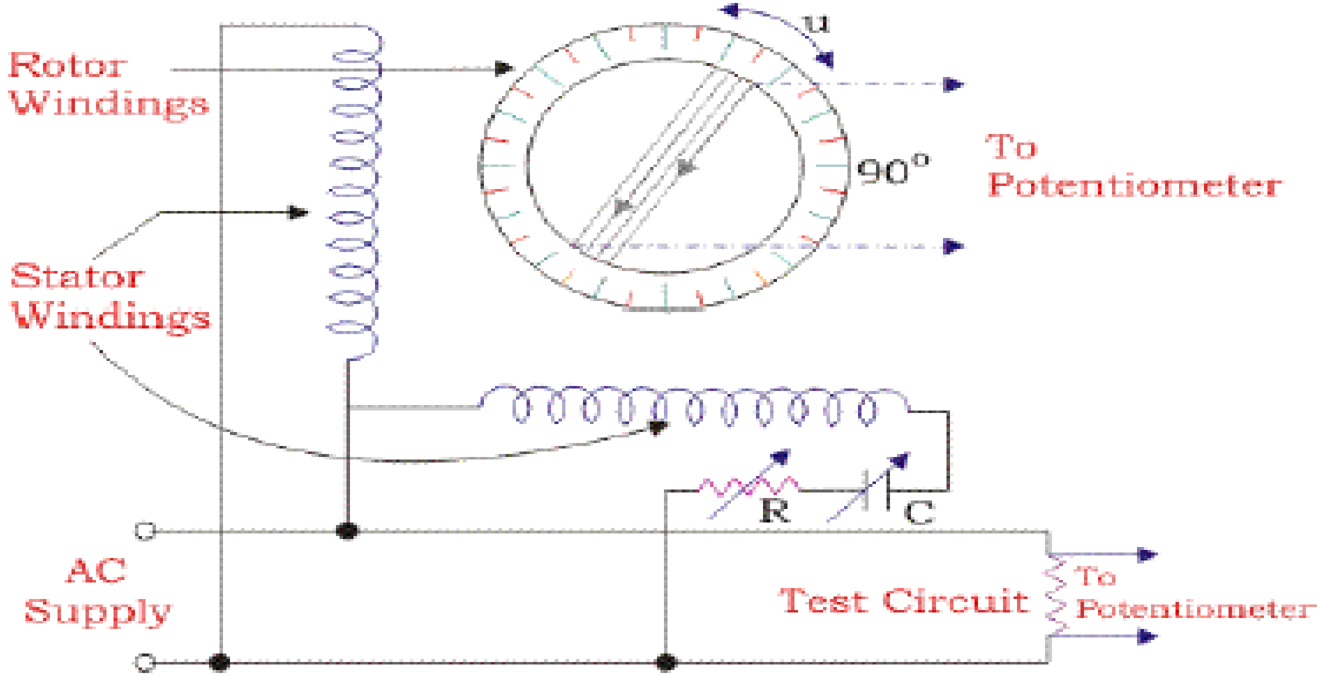
Between the stators, there is laminated rotor having slots and winding which supplies voltage to

the slide-wire circuit of the Potentiometer. When currentstart flowing from stators, the rotating field is developed around the rotor and due to it e.m.f. is induced in the rotor winding. The phase displacement of the rotor emf is equal to rotor movement angle from its original position and it is related to stator supply voltage. The whole arrangement of winding are done in such a way that the magnitude of the induced emf in the rotor may change but it does not affect the phase angle and it can be read on the scale fixed on the top of the instrument.



Polar Type Potentiometer

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The induced emf in rotor winding by stator winding 1 can be expressed as

$$E_1 = K\,I\,sin\omega t\ cos\,\varnothing\ \ldots\ldots\ldots\ldots(1)$$

The induced emf in the rotor winding by the stator winding 2,

$$E_2 = K\,I\,sin(\omega t + 90^o)\ cos(\varnothing + 90^o)$$
$$= -K\,I\,cos\omega t\ sin\varnothing\ \ldots\ldots\ldots\ldots(2)$$

From equation (1) and (2), we get

$$E = K\,I\,(sin\omega t\ cos\varnothing - cos\omega t\ sin\varnothing)$$

Therefore, resultant induced emf in the rotor winding due to two stator winding $E = K\,Isin\,(\omega t - \varnothing)$Where, Ø gives the phaseangle.

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