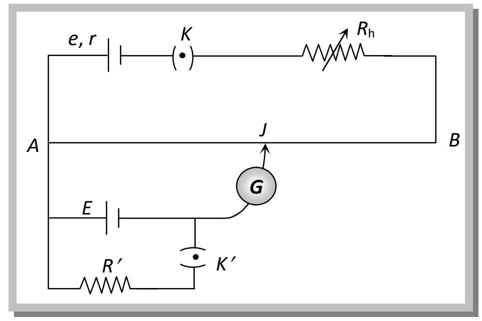
Application of Potentiometer.

(1) To determine the internal resistance of a primary cell

(i) Initially in secondary circuit key K' remains open and balancing length (l_1) is obtained. Since cell E is in open circuit so its emf balances on length l_1 i.e. $E = xl_1$ ……. (i)

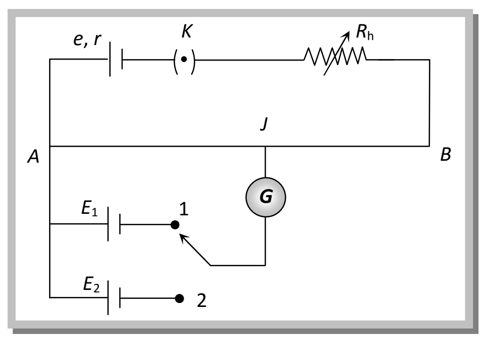


(ii) Now key K′ is closed so cell E comes in closed circuit. If the process is repeated again then potential difference V balances on length l_2 i.e. $V = xl_2$ ……. (ii)

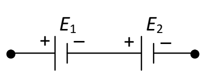
(iii) By using formula internal resistance $r = \left(\frac{E}{V} - 1\right).R'$

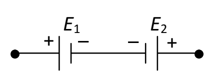
$$r = \left(\frac{l_1 - l_2}{l_2}\right).R'$$

(2) Comparison of emf's of two cell: Let l_1 and l_2 be the balancing lengths with the cells E_1 and E_2 respectively then $E_1 = xl_1$ and $E_2 = xl_2$ $\Rightarrow \frac{E_1}{E_2} = \frac{l_1}{l_2}$



Note: Let $E_1 > E_2$ and both are connected in series. If balancing length is l_1 when cell assist each other and it is l_2 when they oppose each other as shown then:

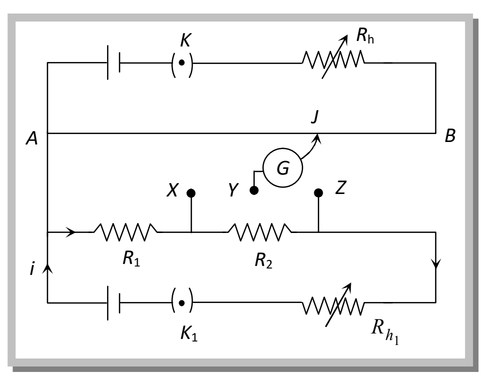




$(E_1 + E_2) = xl_1$ $\qquad$ $(E_1 - E_2) = xl_2$

$\Rightarrow \quad \frac{E_1 + E_2}{E_1 - E_2} = \frac{l_1}{l_2}$ or $\frac{E_1}{E_2} = \frac{l_1 + l_2}{l_1 - l_2}$

(3) Comparison of resistances : Let the balancing length for resistance R_1 (when XY is connected) is l_1 and let balancing length for resistance $R_1 + R_2$ (when YZ is connected) is l_2.

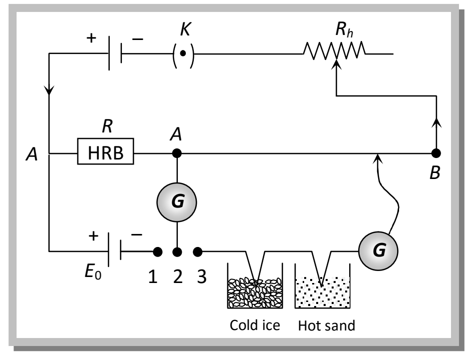


Then $iR_1 = xl_1$ and $i(R_1 + R_2) = xl_2$

$\Rightarrow \quad \frac{R_2}{R_1} = \frac{l_2 - l_1}{l_1}$

(4) To determine thermo emf

(i) The value of thermo-emf in a thermocouple for ordinary temperature difference is very low (10–6 volt). For this the potential gradient x must be also very low (10–4 V/m). Hence a high resistance (R) is connected in series with the potentiometer wire in order to reduce current.



(ii) The potential difference across R must be equal to the emf of standard cell i.e. iR = E0 $\therefore i = \frac{E_0}{R}$

(iii) The small thermo emf produced in the thermocouple e = xl

(iv) $x = i\rho = \frac{iR}{L}$ $\therefore e = \frac{iRl}{L}$ where L = length of potentiometer wire, ρ = resistance per unit length, l = balancing length for e

(5) To calibrate ammeter and voltmeter

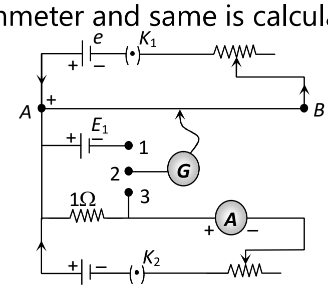
Calibration of ammeter

(i) If p.d. across 1Ω resistance is measured by potentiometer, then current through this (indirectly measured) is thus known or if R is known then i = V/R can be found.

(ii) Circuit and method

(a) Standardization is required and per formed as already described earlier. (x = E0/l0)

(b) The current through R or 1Ω coil is measured by the connected ammeter and same is calculated by potentiometer by finding a balancing length as described below.



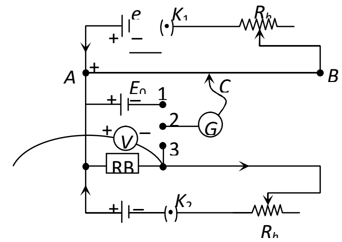
Let i' current flows through 1Ω resistance giving p.d. as $V' = i'(1) = xl_1$ where l1 is the balancing length. So error can be found as [i (measured by ammeter) $\Delta i' = i - i'\left[= xl_1 = \left(\frac{E_0}{l_0}\right)l_1\right]$

Calibration of voltmeter

(i) Practical voltmeters are not ideal, because these do not have infinite resistance. The error of such practical voltmeter can be found by comparing the voltmeter reading with calculated value of p.d. by potentiometer.

(ii) Circuit and procedure

(a) Standardization: If l0 is balancing length for E0 the emf of standard cell by connecting 1 and 2 of bi-directional key, then x = E0/l0.



(b) The balancing length l1 for unknown potential difference V′ is given by (by closing 2 and 3) $V' = xl_1 = (E_0 / l_0)l_1$.

If the voltmeter reading is V then the error will be (V – V′) which may be +ve, – ve or zero.

Concepts

In case of zero deflection in the galvanometer current flows in the primary circuit of the potentiometer, not in the galvanometer circuit.

A potentiometer can act as an ideal voltmeter.