EXPERIMENT – 7

Aim of the experiment: To determine the emf and internal resistance of a cell using a stretched wire potentiometer.

Apparatus required: Stretched wire potentiometer, jockey, galvanometer, Power source, Cell (Leclanché), Standard cell (1), rheostat, plug and key (x4), resistance box, connecting wires

Theory: This experiment is based on the principle of balancing an unknown emf against a known and adjustable potential difference.

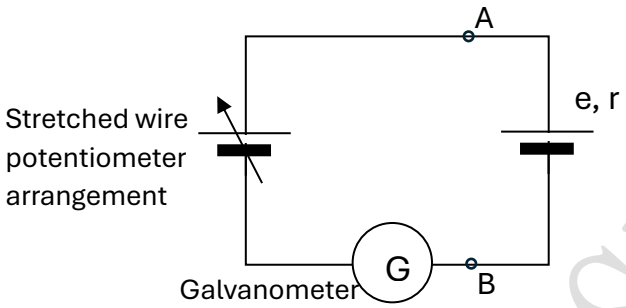

Figure - 1

A potential gradient is created across a stretched wire potentiometer with the help of a battery $\mathcal{E}$ and a rheostat Rh. The gradient has a value ir where r is the resistance per unit length of the potentiometer wire and i is the current through it. The current i and hence the gradient is controllable by the rheostat (Rh). The potential difference between points A & B depends on the length l of the segment AB and the potential gradient. The unknown emf is balanced against this potential difference and in the balanced condition there will be no current through the galvanometer.

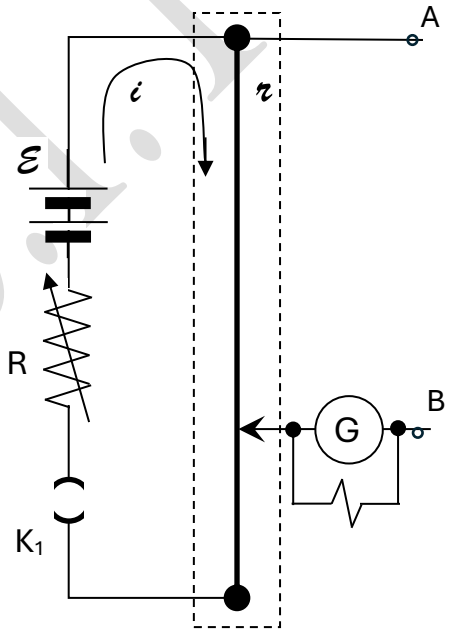

Figure - 2

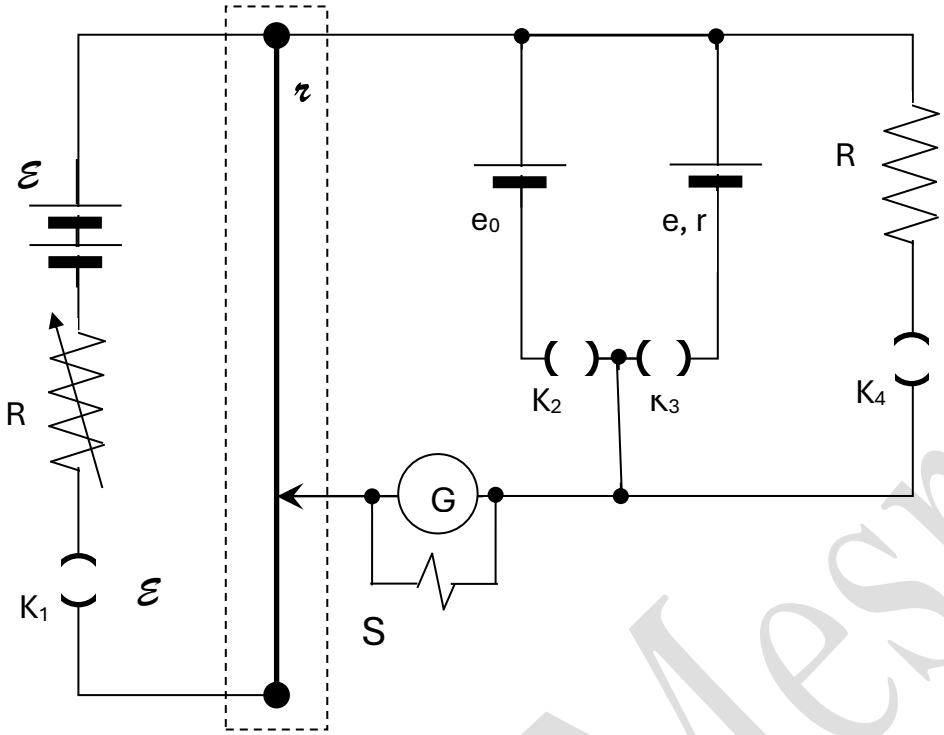

Figure – 3

Assume, e_0 (= 1.0183V) be the emf of the Weston-Cadmium standard cell; e be the emf of the cell under investigation (e.g., Leclanché cell) and r be its internal resistance

When the emf e_0 of a standard cell is balanced against the potentiometer for a particular length
l_1 of its wire then we can write,

$$e_0 = i\boldsymbol{r}l_1 \quad (1)$$

Similarly, for a Leclanché cell that is balanced against a wire length l_2, we can write,

$$e = i\boldsymbol{r}l_2 \quad (2)$$

and, when a Leclanché cell is balanced against a wire length l_3 while powering a standard resistor R, we can write,

$$V = i\boldsymbol{r}l_3 \quad (3)$$

Using equations (1) and (2) we get

$$e = \left(\frac{l_2}{l_1}\right) e_0 \quad (4)$$

and using equations (1) and (3) we have

$$V = \left(\frac{l_3}{l_1}\right) e_0 \quad (5)$$

We know that,

$$V = e - Ir \quad (6)$$

also,

$$V = IR \quad (7)$$

therefore, using equations (6) and (7) we have,

$$V = e - \frac{V}{R} r \quad (8)$$

or we may write,

$$r = \left(\frac{e}{V} - 1\right) R \quad (9)$$

Hence, using equations (4), (5) and (9) it is possible to determine e and r of the Leclanché cell.

Procedure and Precautions:

1. Make an arrangement as shown in fig-3.
2. *Key K_1 must remain closed for the entire duration of the experiment as this would stabilize the circuit thermally*
3. *A shunt must be used across the galvanometer to avoid a possible damage. As the user gets closer to the balance point the value of the shunt may be gradually increased in order to get appreciable deflection near the balance point.*
4. *If you are using an actual standard cell like, Weston-Cadmium cell, then you need to be very careful not to draw any current from that cell.*
5. Use an adjustable resistance box as galvanometer shunt (S) and choose a value around 10 ohm.
6. Adjust the rheostat sliding contact somewhere midway.
7. Close keys K_1 & K_3.
8. *Note that K_2 and K_3 must never be closed simultaneously.*
9. Contact the jockey alternately at points A and C and ensure that the galvanometer deflections in the two cases are in opposite sense. If not, adjust the rheostat and repeat this process.
10. *Jockey should be held vertical and should not be made to slide onto the potentiometer wire.*
11. Close key K_1 and K_2 (K_3 and K_4 open).
12. Get an approximate balance point on the potentiometer wire. Now, gradually increase the value of shunt to make the galvanometer more sensitive and re-position the jockey to get closer to the balance point. Finally, remove one of the connections of the shunt and get the precise balance point.
13. Enter this observation in the table under l_1.
14. Open K_2 and close K_3.

15. Once again connect the shunt, make its value low (~10ohm) and repeat the process [7] to obtain a balance point.
16. Enter this observation under l_2.
17. Now close key K_4 and make R = 30 ohm and repeat the process [10].
18. Enter your observation under l_3.
19. Repeat [6] thru [13] four times to obtain a set of five readings for potential gradient 1.
20. Open all the keys.
21. Calculate the values e, V and r using their respective relations with l1, l2 and l3.

Observations:

S. No.	Balancing lengths		
	l_1 (cm)	l_2 (cm)	l_3 (cm)
1			
2			
3			
4			
5			
Average			

Calculations:

	Average
e ($=\frac{l_2}{l_1}e_0$)	
V ($=\frac{l_3}{l_1}e_0$)	
r ($=\left(\frac{e}{V}-1\right)R$)	

Result & discussion:

The emf and internal resistance of the cell under test is determined with fair accuracy and precision (and is also confirmed using a DMM).

Emf = _____ V

and its internal resistance r = _____ Ω

the maximum emf of a Leclanche cell is _____ V, and its internal resistance may lie in the range of 1 Ω to 50 Ω or even higher, depending upon the condition of the cell.