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EXPERIMENT NO. 11

NAME OF EXPERIMENT: TO VERIFY THE LAW OF SERIES AND PARALLEL RESISTANCE USING P.O. BOX

APPARATUS REQUIRED

1. P.O. Box
2. Galvanometer
3. Resistance wire
4. Connecting wire
5. Leclanche cell

THEORY

When resistance are joined in series, the equivalent resistance R is given by

$$R_s = R_1 + R_2$$

Where, R_1 and R_2 are specific resistance.

When resistance are in parallel, the equivalent resistance R is given by,

$$R_p = \frac{R_1 \times R_2}{R_1 + R_2}$$

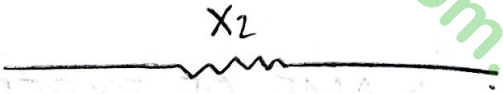
Wheatstone bridge principle states that if P, Q, R and X be four resistance, X being unknown resistance connected, 'G' a moving coil galvanometer, E a ~~lecla~~ leclanche cell then for null deflection of galvanometer,

$$\frac{P}{Q} = \frac{X}{R}$$

$$\therefore \boxed{X = \frac{P}{Q} \times R}$$

(i)

(ii)



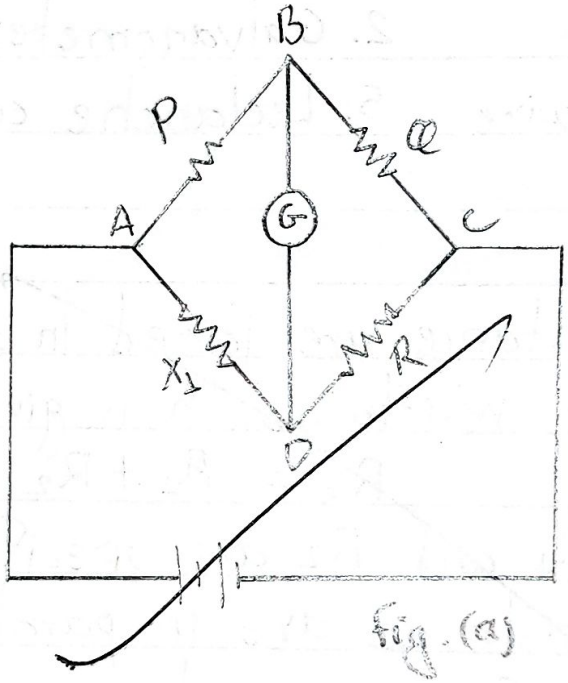


fig. (a)

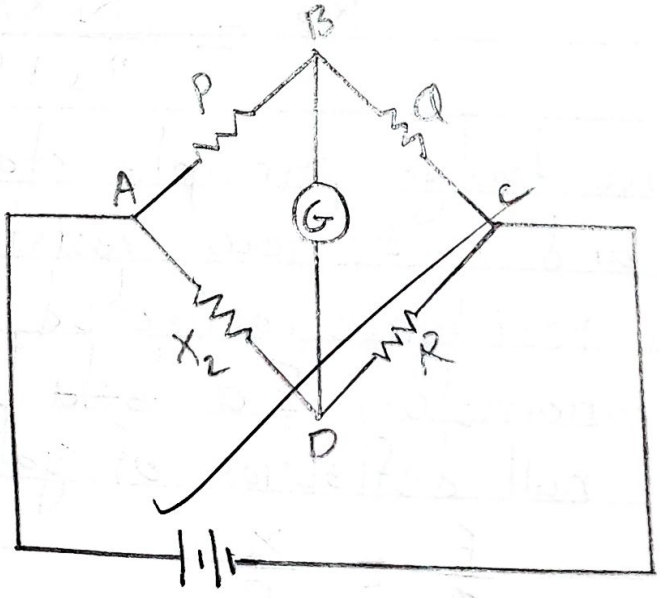
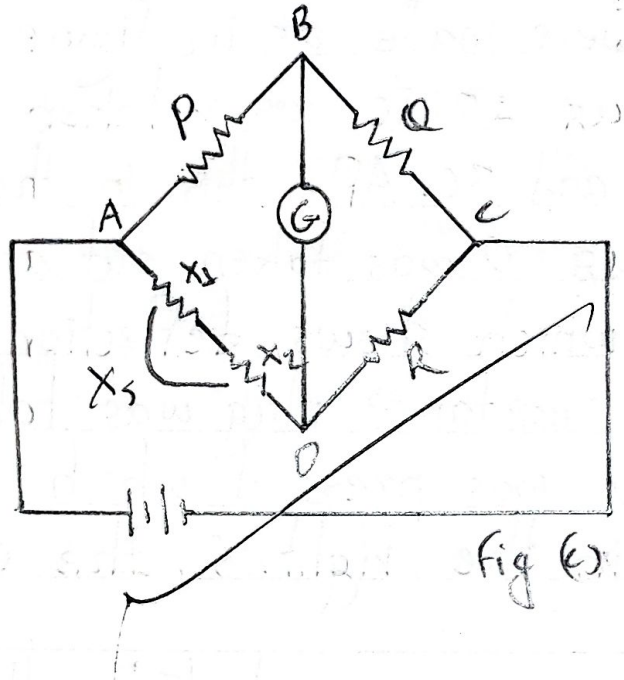


fig. (b)

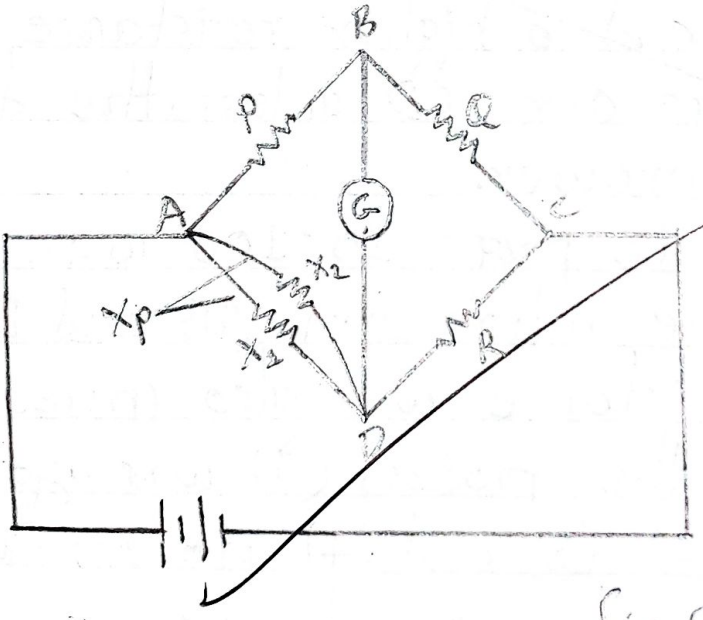
PROCEDURE

1. A circuit diagram was drawn and ~~continuous~~ connections were made as in figure.
2. Resistance plug 10:10 were taken out from the ratio arm AB and BC. After this, in the third arm CD, resistance plug 0 was taken out and battery key was pressed which shows deflection in the left. Likewise, ∞ resistance plug was taken out and battery key was pressed which shows the deflection in the right. So, the circuit was right.
3. This operation was repeated by alternating taking out a low and a higher resistance plug from the resistance arm CD unless the deflection becomes narrower.
4. Next, resistance plugs 10:100 were taken out from the ratios arm AB and BC and the value of resistance was also increased by 14 times and the process (3) was again repeated.
5. The above (2), (3) and (4) process were repeated for other circuits too.
6. Observed deflection and direction were noted in the table.



$X_s = ?$

fig (i)



$X_p = ?$

fig. (ii)

OBSERVATION TABLE

For X_1

No. of Obs.	Ratio arms P : Q	Resistance in 3rd arm	Galvanometer deflection	Inference about unknown resistance
1.	10 : 10	0	Too left	Value of X_1 lies between 0 and 1.
		∞	Too right	
		1	Too right	
2.	10 : 100	1	Too left	Value of X_1 lies between 0.4 and 0.5
		4	Slow left (5 divs)	
		5	Slow right (29 divs)	

Change in deflection (5+29) = 1 Ω

Or, 1 Ω = 34 division

$\therefore \frac{1}{34}\ \Omega = 1$ div

$\therefore R_1 = 4\ \Omega + 5$ div

$= 4\ \Omega + 5 \times \frac{1}{34}\ \Omega$

$= (4 + 0.147)\ \Omega$

$= 4.147\ \Omega$

For X_2

No. of Obs	Ratio arms P : Q	Resistance in 3rd arm	Galvanometer deflection	Inference about unknown resistance
1.	10 : 10	0	Too left	Value of X_2 lies between 0 and 1.
		∞	Too right	
		1	Too right	

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2.	10:100	1	Too left	Value of X_2 lies
		3	Slow left (16 div)	between 0.3 and
		4	Slow right (25 div)	0.4

Change in deflection (16+25) div = 1 Ω

or, 1 Ω = 41 divisions

or, $\frac{1}{41}$ Ω = 1 div

$\therefore R_2 = 3\,\Omega + 16 \text{ div}$

$= 3\,\Omega + 16 \times \frac{1}{41}\,\Omega$

$= 3\,\Omega + 0.39\,\Omega$

$= 3.39\,\Omega$

When two resistors X_1 and X_2 are connected in series.

For X series,

No. of Obs.	Ratio arms P:Q	Resistance in 3rd arm	Galvanometer deflection	Inference about unknown resistance
1.	10:10	0	Too left	Value of X_s lies
		∞	Too right	between 0 and
		1	Too right	1
2.	10:100	1	Too left	Value of X_s lies
		7	Slow left (17 div)	between 0.7 and
		8	Slow right (14 div)	0.8

Change in deflection (17+14) divs = 1 Ω

or, 1 Ω = 31 divisions

or, $\frac{1}{31}$ Ω = 1 division

$\therefore R = 7\Omega + 17 \text{ divisions}$

$= 7\Omega + 17 \times \frac{1}{31}\Omega$

$= 7.548\Omega$

CALCULATION

For Table (i)

$R = 4.147\Omega$

We know at balanced condition,

$$\frac{P}{Q} = \frac{X_1}{R}$$

or, $$\frac{10}{100} = \frac{X_1}{4.147}$$

or, $$X_1 = \frac{10}{100} \times 4.147$$

$\therefore X_1 = 0.4147\Omega$

For Table (ii)

$R = 3.39\Omega$

We know at balanced condition

$$\frac{P}{Q} = \frac{X_2}{R}$$

or, $$\frac{10}{100} = \frac{X_2}{3.39}$$

or, $$X_2 = \frac{10}{100} \times 3.39$$

$\therefore X_2 = 0.339\ \Omega$

For Table (iii), if connected in series

$R = 7.548\ \Omega$

We know at balanced condition

$$\frac{P}{Q} = \frac{X_S}{R}$$

or, $\frac{10}{100} = \frac{X_S}{7.548}$

$\therefore X_S = 0.7548\ \Omega$

For series

$R_{observed} = R_1 + R_2$

$= (4.147 + 3.39)\ \Omega$

$= 7.537\ \Omega$ 0.7537

$R_{calculated} = 7.548\ \Omega$ 0.7532

OBSERVATION TABLE

S.N.	Resistance (R_1)	Resistance (R_2)	$R = R_1 + R_2$ (series)	
			Observed	Calculated
1.	4.147 Ω	339 Ω	7537 Ω	7.548 Ω
	0.4147	0.339	0.7537	0.7548

RESULT

Hence, the resistance was calculated and compared with the observed and verified.

PRECAUTION

1. Calculation should be done accurately.
2. P.O. Box should be used properly.
3. Reading of galvanometer should be taken accurately.