EXPERIMENT (A)

AIM

To verify the laws of combination (series) of resistances using a meter bridge.

MATERIAL REQUIRED

A meter bridge, a Leclanche cell (battery eliminator), a Weston galvanometer, a resistance box, a jockey, two resistance wires or two resistance coils a set square, sandpaper and connecting wires plug key.

THEORY

If given resistances are denoted as R_1 and R_2, the equivalent resistance (Rs) in a series combination is expressed as:

$$R_S = R_1 + R_2$$

For a parallel combination, the equivalent resistance (Rp) is determined by:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$

The Meter Bridge, also known as a slide wire bridge, is a variant of the Wheatstone bridge. It consists of four resistances (P, Q, R, and S) arranged to form quadrilateral ABCD. Opposite junction pairs are connected to a galvanometer and a cell, respectively. When adjusted to eliminate deflection in the galvanometer by pressing key K, the bridge is considered balanced. Under this condition, the equation holds:

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

If three resistances are known, the fourth can be calculated using the above equation. The Wheatstone bridge setup includes gaps AD and CD, representing the left and right-hand gaps, where the unknown resistance S and a resistance box (RB) are connected. A Leclanche cell (E) and a galvanometer (G) are connected across AB and BD. At balance point B on the meter bridge wire, the Wheatstone bridge principle applies:

$$\frac{S}{R} = \frac{P}{Q} = \frac{\text{Resistance of length AB}}{\text{Resistance of length BC}}$$

If the wire has a uniform cross-sectional area and resistance per unit length ρ, then:

$$\frac{S}{R} = \frac{\rho(AB)}{\rho(BC)} = \frac{AB}{BC} = \frac{l}{100 - l}$$

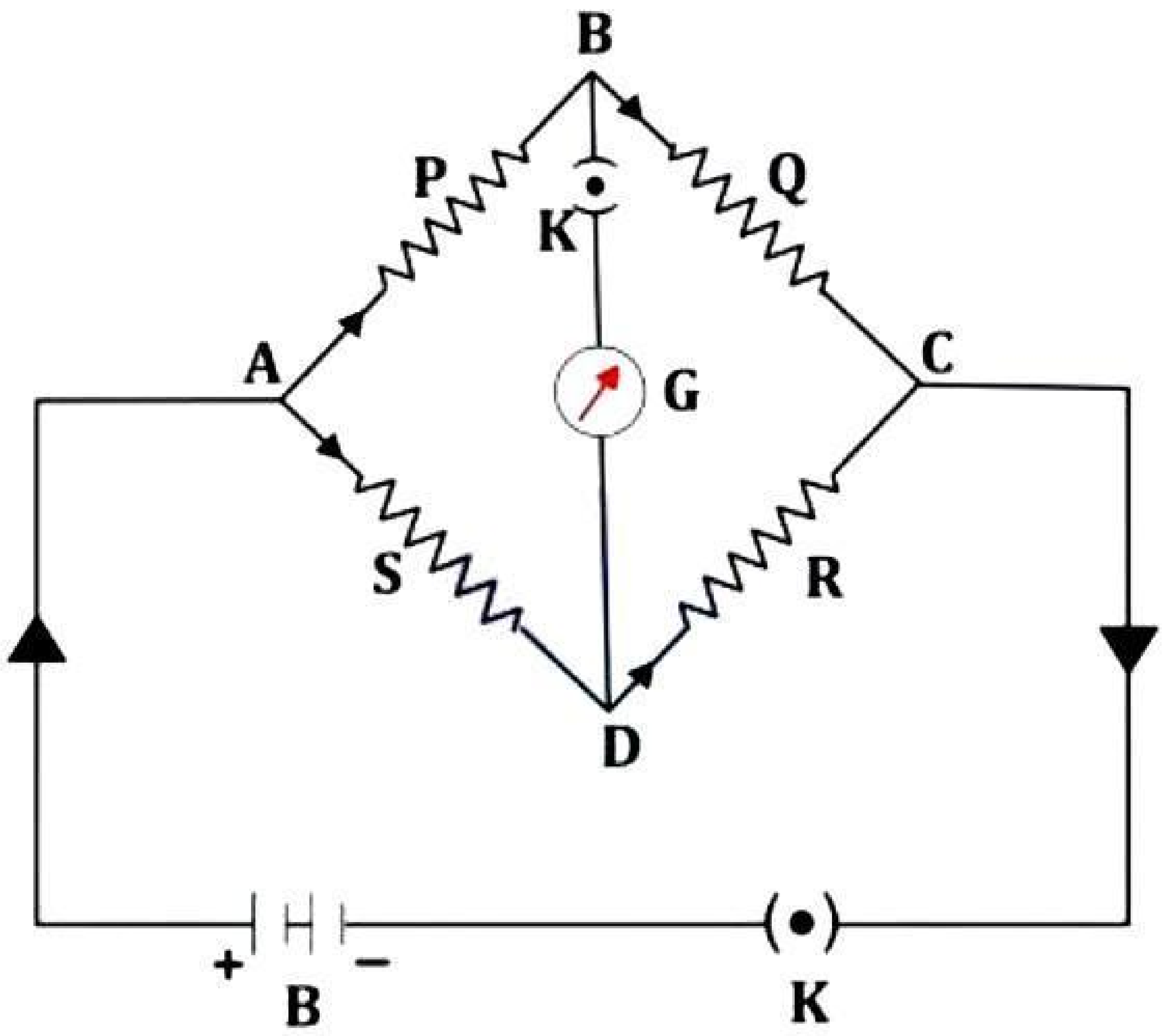


Fig.
Circuit diagram of wheatstone bridge

Where, $AB = l$ is the length from the balanced position on the left side, and $BC = 100 - l$ is the length from the balanced position on the right side.

This yields:

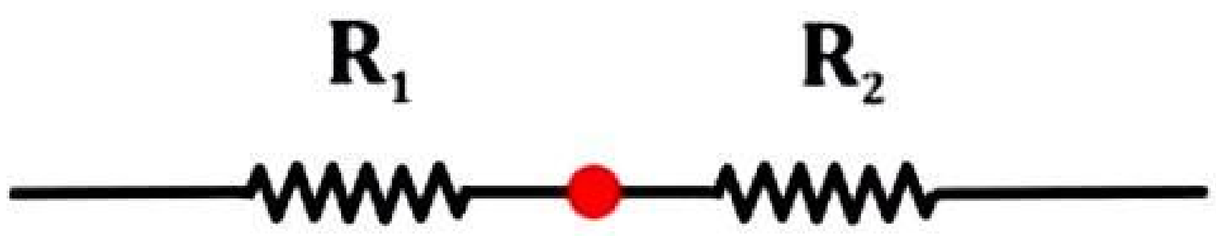
$$S = R\left(\frac{l}{100 - l}\right)$$

For equivalent resistances:

$$R_S = R_1 + R_2 \text{ or } R_p = \frac{R_1 R_2}{R_1 + R_2}$$

PROCEDURE

1. Follow the circuit diagram to establish connections, ensuring that all connections are securely fastened.



Series combination

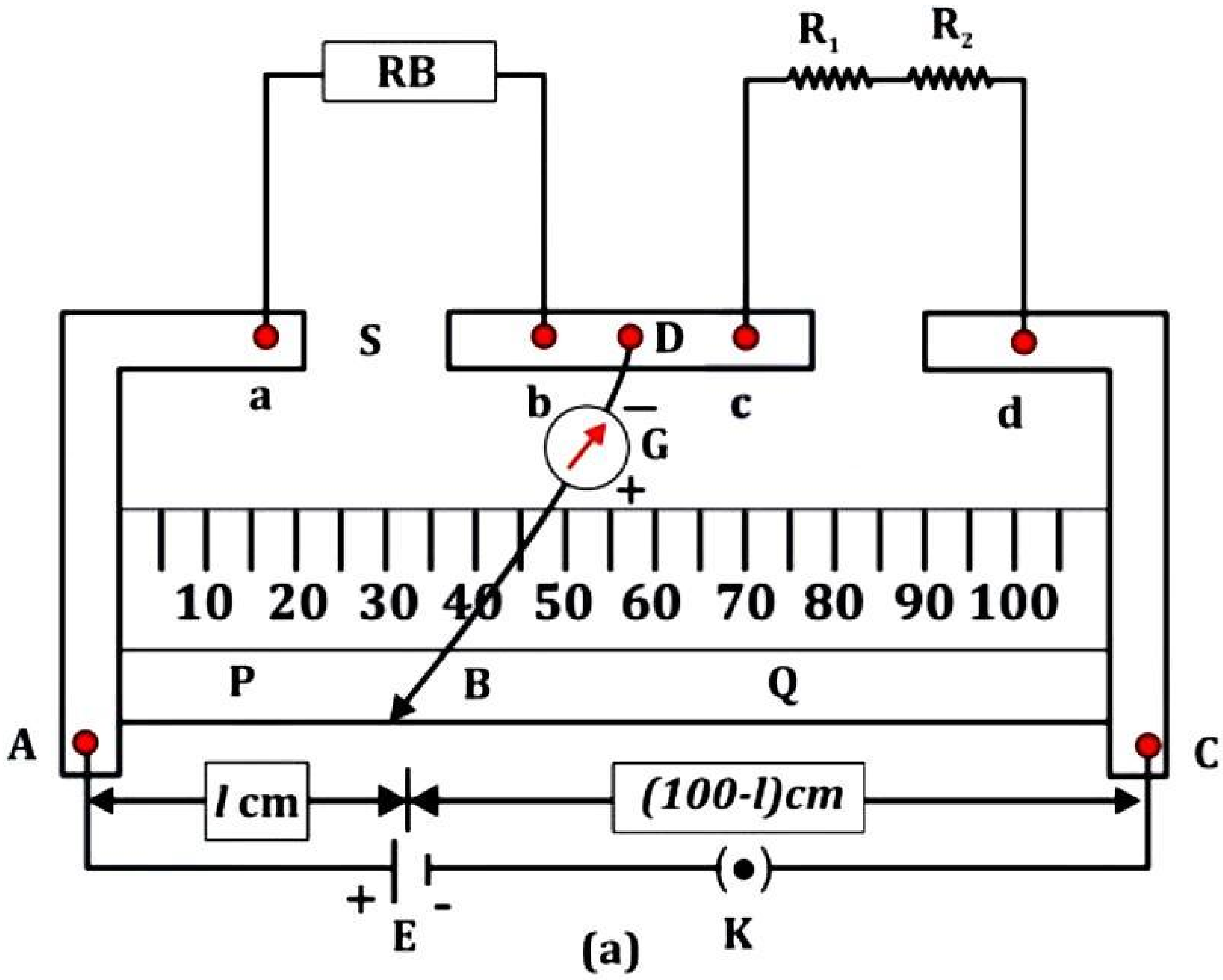


Fig. Circuit diagram for studying the laws of combination by using a metre bridge resistances in (a) series combination

2. Verify the accuracy of the connections by removing the resistance box (RB) and closing plug key K. Proceed to press the jockey at the left extreme end A of the meter bridge wire, noting the deflection direction on the galvanometer. Repeat the process at the right extreme C of the meter bridge wire and mark the deflection direction. If the deflections are opposite, the connections are correct; otherwise, recheck the connections.
3. Place the first resistor with resistance R_1 in the right gap of the meter bridge and RB in the left gap.
4. Adjust the resistance value R from RB to achieve a balance point B approximately at the midpoint of the wire, specifically between the 30 and 60cm marks on the scale.

OBSERVATIONS

1. Record the balance point B on the meter bridge wire with the first resistor positioned in the right gap of the bridge.
2. Document the balance point B on the meter bridge wire with the second resistor placed in the right gap of the bridge.
3. Make note of the balance point B on the meter bridge wire when the series combination of resistors is in the right gap of the meter bridge.
4. Take note of the balance point B on the meter bridge wire when the parallel combination of resistors is situated in the right gap of the meter bridge.

5. Tabulate the readings of all the above-mentioned balance points in a systematic manner, ensuring the inclusion of proper significant figures.

For determination of the equivalent resistance in series combination and parallel combination of resistors.

	Resistance, R from RB (Ω)	Position of the balance point, B (cm)	Length, AB = l (cm)	Length, BC = 100 − l (cm)	$S = R\left(\frac{l}{100-l}\right)$	Mean (Ω)
When the first resistor having resistance R_1 in right gap	2 4		35 22.5	65 77.5	1.125 1.161	1.14
When the second resistor having resistance R_2 in right gap	2 4		24.3 13	75.7 87	0.597 0.631	0.612
When the series combination of resistors having resistance, $R_s = R_1 + R_2$ in right gap.	2 4		48 31.6	52 68.4	1.846 1.847	1.846
When parallel combination of resistors having resistance $R_p = \frac{R_1R_2}{R_1+R_2}$ in right gap	2 4		19.1 10.3	80.9 89.7	0.469 0.459	0.464

CALCULATIONS

1. Derive the equivalent resistance R_s in a series combination from the provided data using Table.
2. Compute the equivalent resistance R in a parallel combination from the data presented in Table.
3. Conduct a comparative analysis between the calculated values of Rs and R with the experimental values utilizing Table.

RESULT

The resultant equivalent resistance in a series combination of resistors with resistance values- $R_1 = 1.142\ \Omega$ and $R_2 = 0.6122\ \Omega$ is $R_s = 1.8462\ \Omega$.

PRECAUTIONS

1. The connections should be neat, clean, and tight.
2. Thick copper wires should be used for the connections after removing the insulation near their ends by rubbing them with sandpaper.
3. Voltmeter and ammeter should be of proper range.
4. A low-resistance rheostat should be used.

5. The key should be inserted only while taking observations to avoid heating of resistance (otherwise its resistance will increase).

SOURCES OF ERROR

1. The temperature of the surroundings may change during the experiment.
2. A wire may be of the non-uniform area of the cross-section.
3. The error arises due to the end resistance of copper wires.

VIVA- VOCE

Q 1. What is a metre bridge?

Ans. A metre bridge, also called a slide wire bridge, is an instrument that works on the principle Wheat stone bridge. A meter bridge is used in finding the unknown resistance of a conductor as that of in a Wheatstone bridge.

Q 2. How do you find the equivalent resistance of the series combination of resistance?

Ans. In series combination, the same current passes through each resistor in the chain and the total resistance R_T is given by the equation,

$$R_T = R_1 + R_2 + R_3 + \dots\dots R_n$$

Q 3. What is Wheatstone bridge?

Ans. A Wheatstone bridge is a particular type of electrical circuit that is used in measuring the unknown electrical resistance of the circuit by balancing the two legs of the bridge circuit, where the unknown component includes one of its legs.

Q 4. What is the use of a metre bridge?

Ans. To measure the resistance precisely for a resistor, a metre bridge is used.

Q 5. Which principle is followed by the metre bridge for its working?

Ans. The principle of the Wheatstone bridge is followed by a metre bridge for its efficient working.

Q 6. Which material wire is used in a metre bridge?

Ans. The materials such as nichrome, constantan or manganin are used in making the wire of a metre bridge because these materials have a high value of resistance, and the coefficient of the temperature of their resistances is low.

Q 7. What is the case when the metre bridge is in a more sensitive condition?

Ans. The metre bridge circuit will be very sensitive when all four resistors have the same resistance values.

Q 8. What is the balanced condition of a Wheatstone bridge?

Ans. When no current flows through the galvanometer, the Wheatstone bridge is said to be in a balanced condition. By adjusting the known resistance and variable resistance, this condition can be achieved.

Q 9. What is the working principle of a Wheatstone bridge?

Ans. It is the principle of null deflection which is responsible for the working of a Wheatstone bridge, i.e. no current flows through the circuit, and the ratio of their resistances are equal.

EXPERIMENT (B)

AIM

To verify the laws of combination (parallel) of resistances using a meter bridge.

MATERIAL REQUIRED

A meter bridge, a lead accumulator, a rheostat, a plug key, a galvanometer, a jockey, three standard resistance coils of different values (say 1Ω, 2Ω, 3Ω), a resistance box, (0 – 100Ω) and a piece of sandpaper.

DIAGRAM

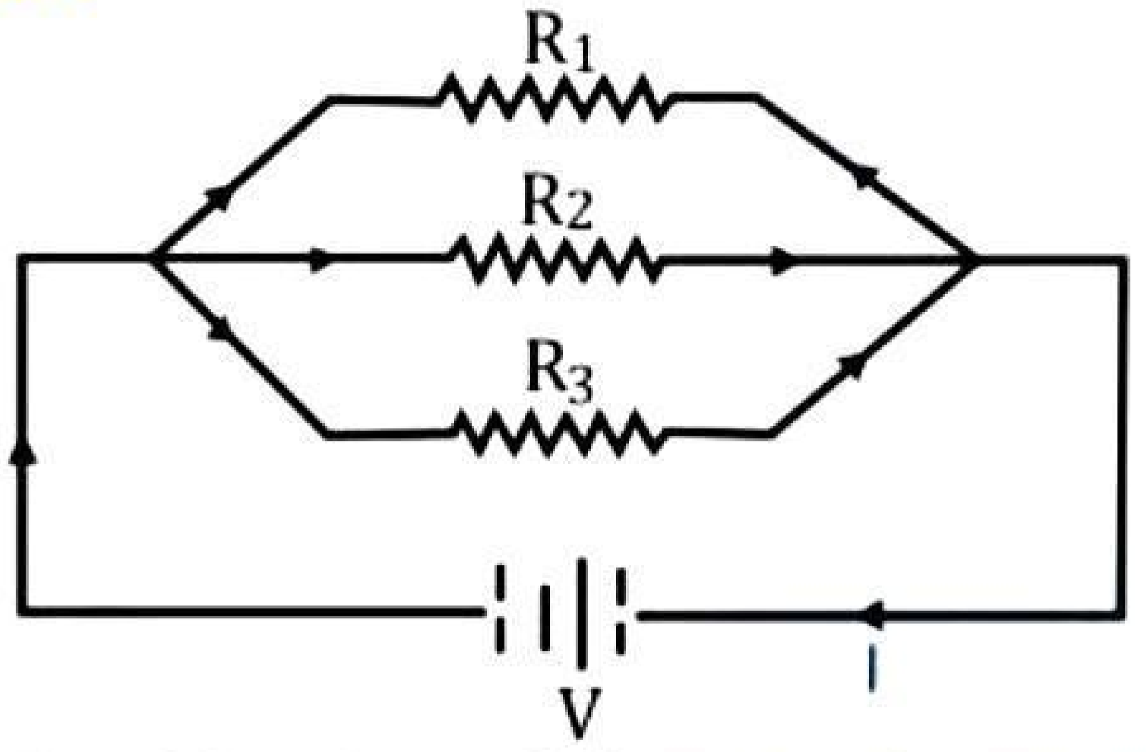


Fig. Combination of three resistor parallel

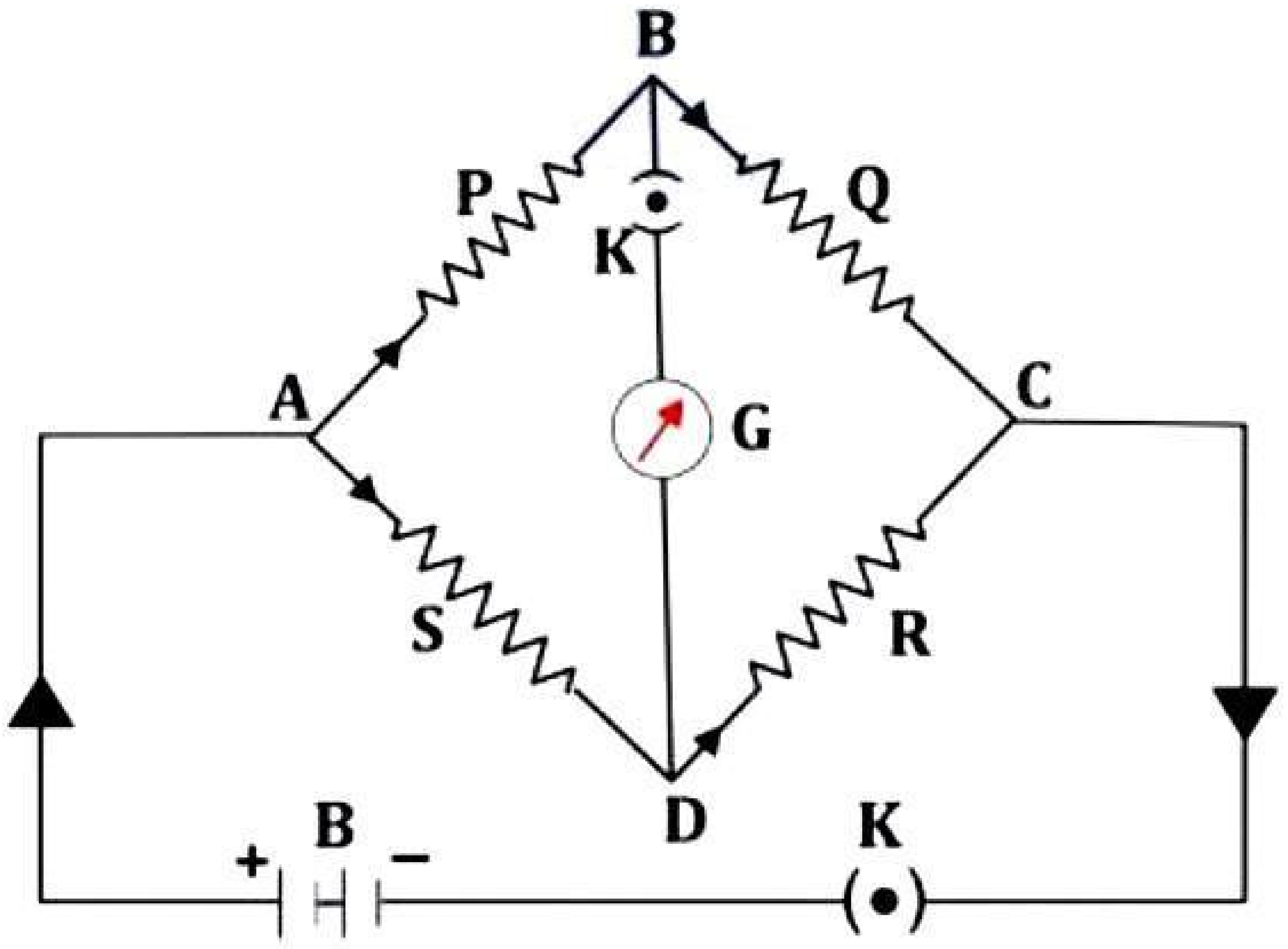


Fig. Circuit diagram of wheatstone bridge

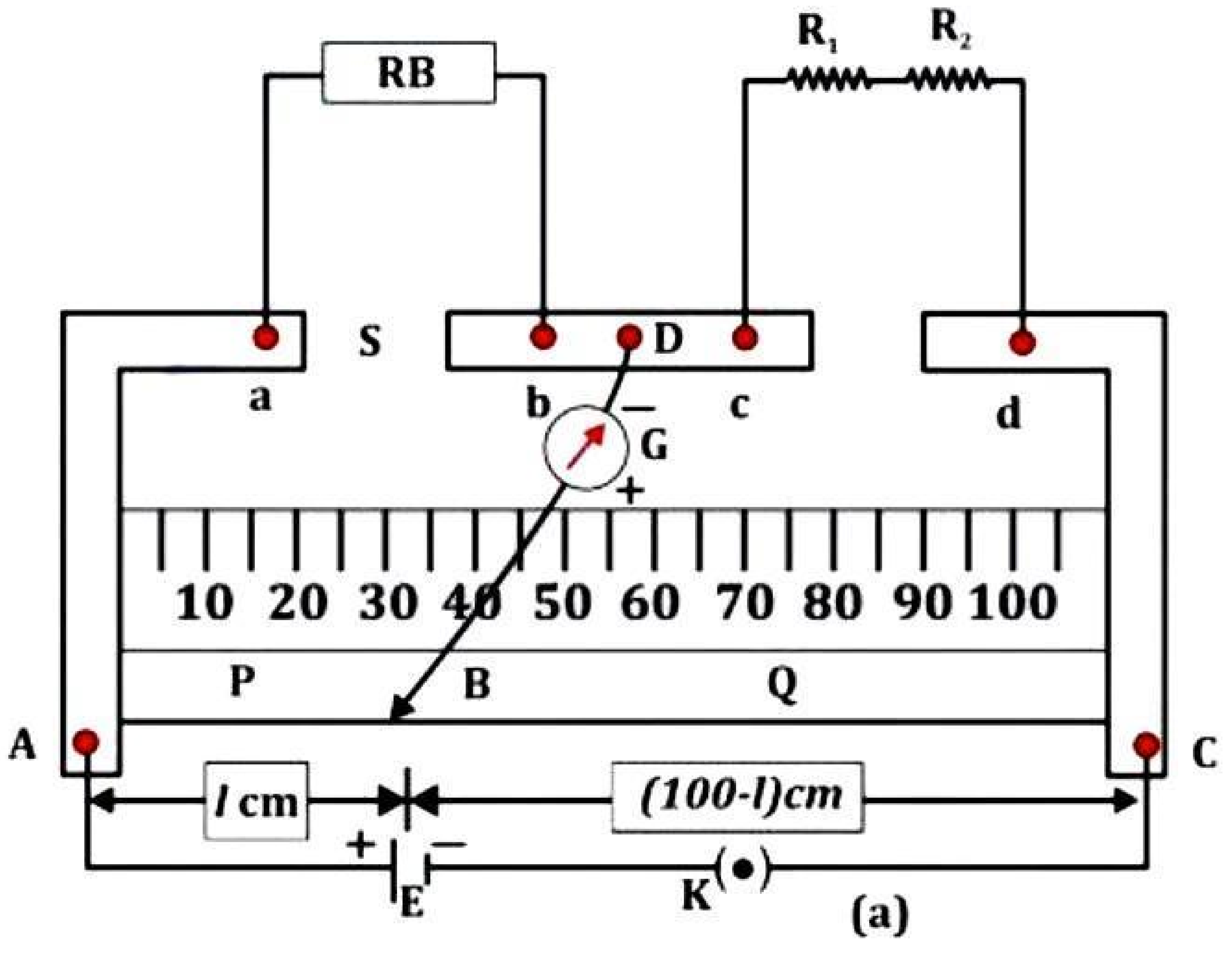


Fig. Circuit diagram for studying the laws of combination by using a metre bridge resistances in (a) series combination

THEORY

Same as in Experiment - 3(A).

PROCEDURE

The 4 steps are the same as in the Experiment - 3(A).

1. Substitute the initial resistor in the right gap of the meter bridge with the second resistor, which has a resistance of R_2. Proceed to identify the balance point B using the procedure outlined in step (4) (As per the previous experiment).
2. Exchange the second resistor in the right gap of the meter bridge. Create a series combination by linking one end of the first resistor to one end of the second resistor. Connect this series combination of resistors to the right gap of the meter bridge. Then, follow step (4) (As per the previous experiment) to ascertain the balance point B on the meter bridge wire.
3. Substituting the series combination of resistors in the right gap of the meter bridge, create a parallel combination by linking one end of each resistor to a shared point. Connect this parallel combination of resistors to the right gap of the meter bridge. Proceed to establish the balance point B on the meter bridge wire by adhering to step (4) (As per the previous experiment).

OBSERVATIONS

Same as in Experiment - 3(A).

CALCULATIONS

Same as in Experiment - 3(A).

RESULT

As per the experiment - 3(A).

The obtained equivalent resistance in a parallel combination of resistors with resistance values $R_1 = 1.142$ and $R_2 = 0.6120$ is $Rp = 0.4642$.

PRECAUTIONS

Same as in Experiment No. 3(A)

SOURCES OF ERROR

Same as in Experiment No. 3(A)

VIVA- VOCE

Q 1. Give one example of each of:

(i) Series combinations of resistors

(ii) Parallel combinations of resistors

Ans. (i) The decorative series of small bulbs we use in Deepawali uses bulbs in series.

(ii) In household circuits, we connect various appliances in parallel.

Q 2. Do you connect the fuse in series with the appliance or parallel to it? Why?

Ans. In series. So that heavy current before damaging the appliance may blow off the fuse.

Q 3. If resistance r is connected in series R, will the reading of the ammeter increase or decrease?

Ans. The reading in the ammeter will decrease as the net resistance in the circuit increases.

Q 4. If resistance r is connected in parallel R, will the reading of the ammeter increase or decrease?

Ans. Ammeter reading will increase as the total resistance will become less than r and R.

Q 5. Why does the resistance increase in a series combination?

Ans. Because the charge carriers now have to cross long distances.

Q 6. Why does the resistance decrease in parallel combination?

Ans. Because a broader cross-section is available to the charge carriers for their propagation.

Q 7. If two bulbs are connected to the same supply in series, will they glow brighter? Why?

Ans. No, they will glow with less brightness. Because in series connection resistance will increase current will get reduced and hence less heat/light will be produced per second.

Q 8. A bulb is marked 220 V, 100 W. What does this imply?

Ans. This implies that the bulb will glow with maximum brightness at 220 volts and then it will consume 100 J of energy per second.

Q 9. Does this mean that 220 V, 100 W is a fixed specification for the bulb?

Ans. You can put the bulb to any voltage but then it will draw current and consume power accordingly.