EXPERIMENT

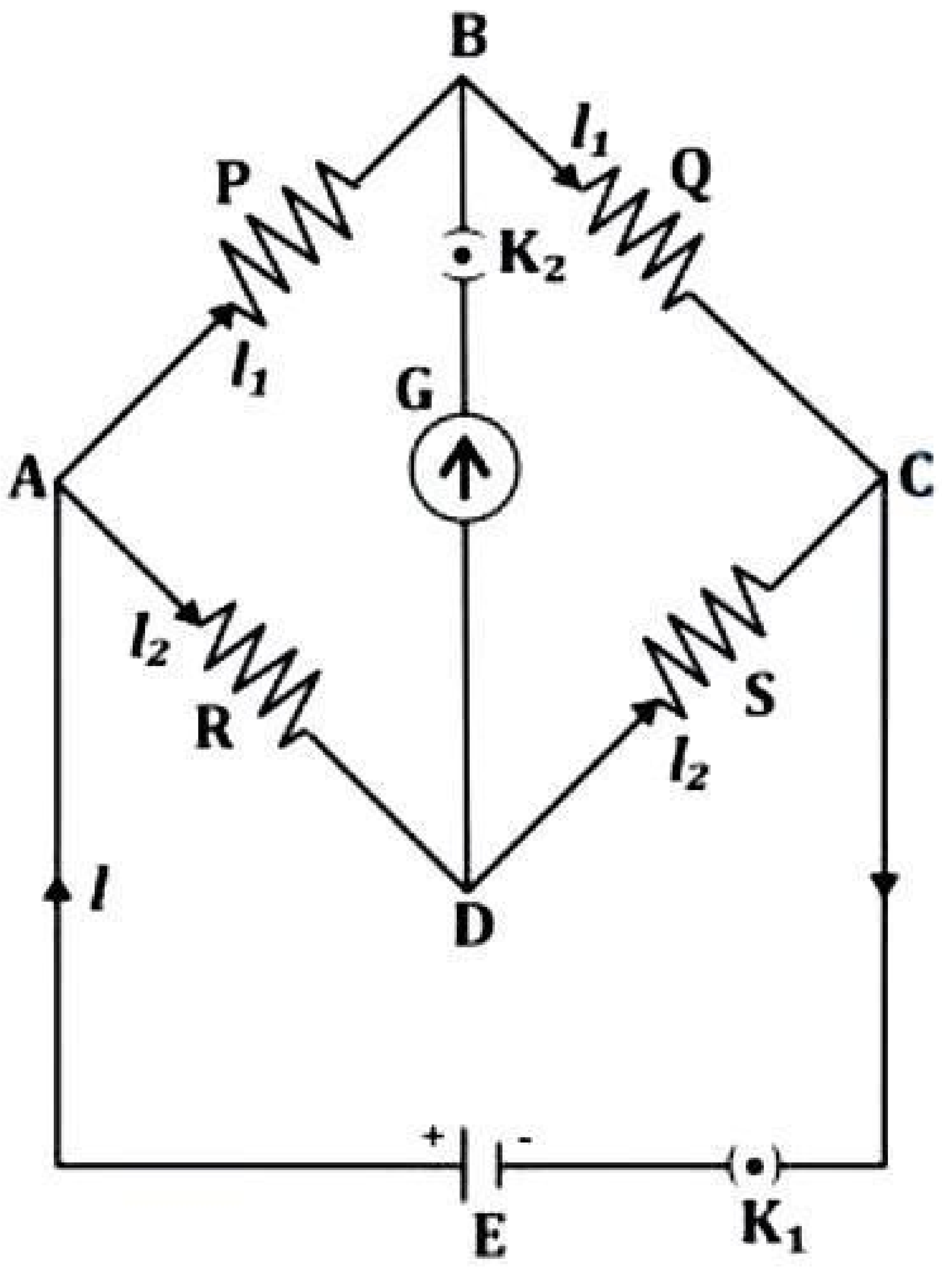
AIM

To find the resistance of a given wire using a meter bridge & hence determine the specific resistance of the material.

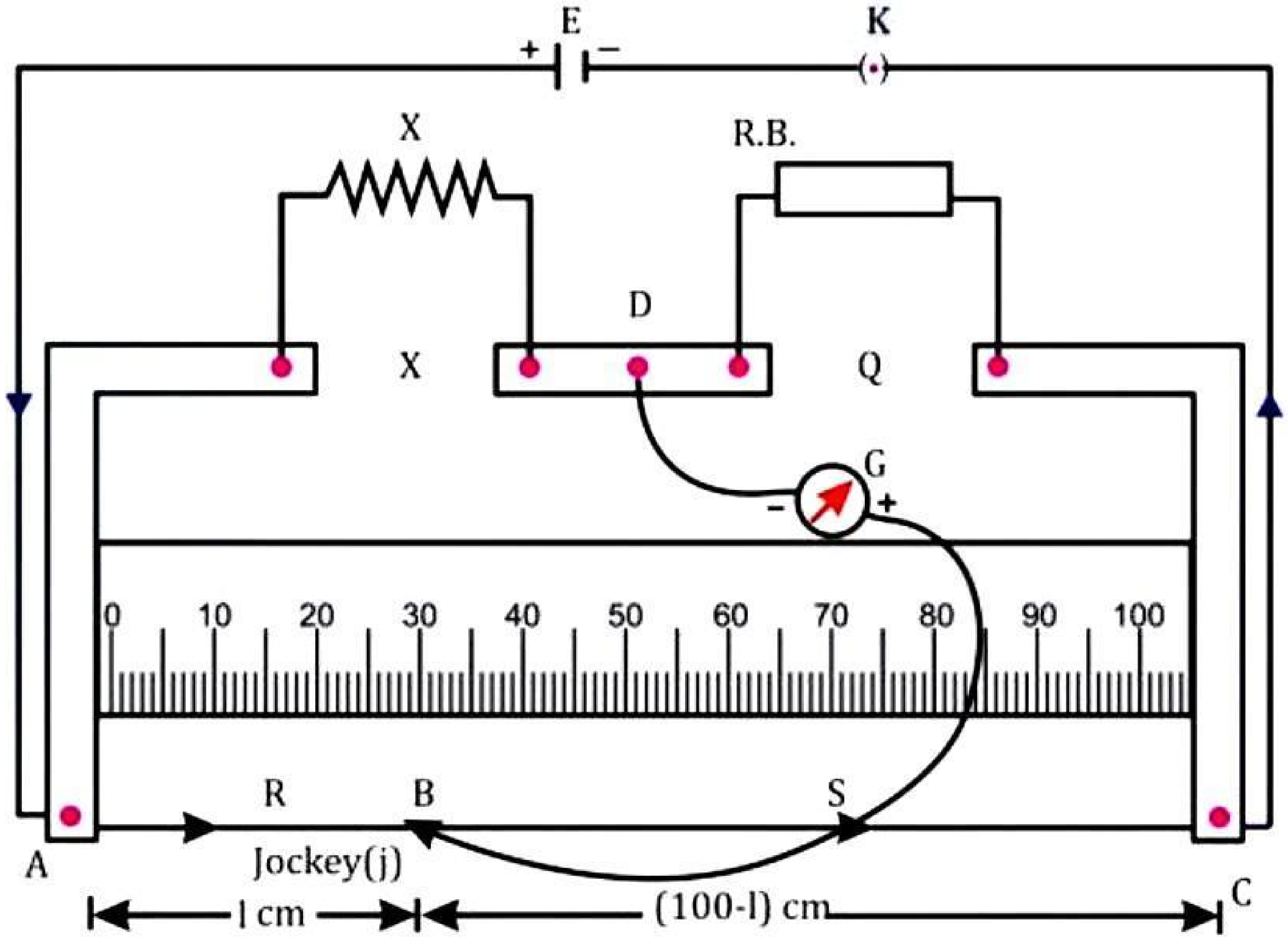
MATERIAL REQUIRED

A meter bridge, a one-meter-long wire of unknown specific resistance, Leclanche cell, a jockey, a key, a sensitive galvanometer, a resistance box, a battery eliminator, connecting wires, sandpaper, a screw gauge, meter scale.

DIAGRAM



Wheatstone Bridge



Circuit diagram using metre bridge for determination of specific resistance of a given wire

THEORY

The resistance of a conductor can be found using a Wheatstone's bridge setup, consisting of resistances P, Q, R and S forming a closed quadrilateral ABCD, as illustrated in figure. By connecting A and C with a cell and B and D with a galvanometer, adjusting resistances to achieve no deflection in the galvanometer indicates a balanced Wheatstone's bridge. In the balanced state, $\frac{P}{Q} = \frac{R}{S}$, facilitating the calculation of the fourth resistance when three are known.

The Meter bridge, also known as a slide wire bridge and a type of Wheatstone's bridge, involves gaps AD and CD where resistance box R and unknown resistance S are connected. A Leclanche cell E and a galvanometer G are linked across AC and BD. The balance point is determined by sliding the jockey along wire AC. At balance (point B), adhering to the Wheatstone's bridge equation,

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

For a wire with uniform cross-section and resistance per unit length p, this equation becomes:

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

In the meter bridge, where AC = 100cm = 1m, and AB = 1, BC = 100, the equation simplifies to $\frac{S}{R} = \frac{l}{100-l}$ leading to $S = R\left(\frac{l}{100-l}\right)$. Given known values of R and *l*, the unknown resistance S for the wire specimen can be determined. The resistance S is directly proportional to length l and inversely proportional to the area of cross-section πr^2, expressed as:

$$S \propto \frac{l}{\pi r^2}$$

Introducing a constant of proportionality (k), the relationship becomes $S = k\frac{l}{\pi r^2}$, with $k = S\left(\frac{\pi r^2}{l}\right)$, where r is the radius of the specimen wire and k is the specific resistance of the wire's material.

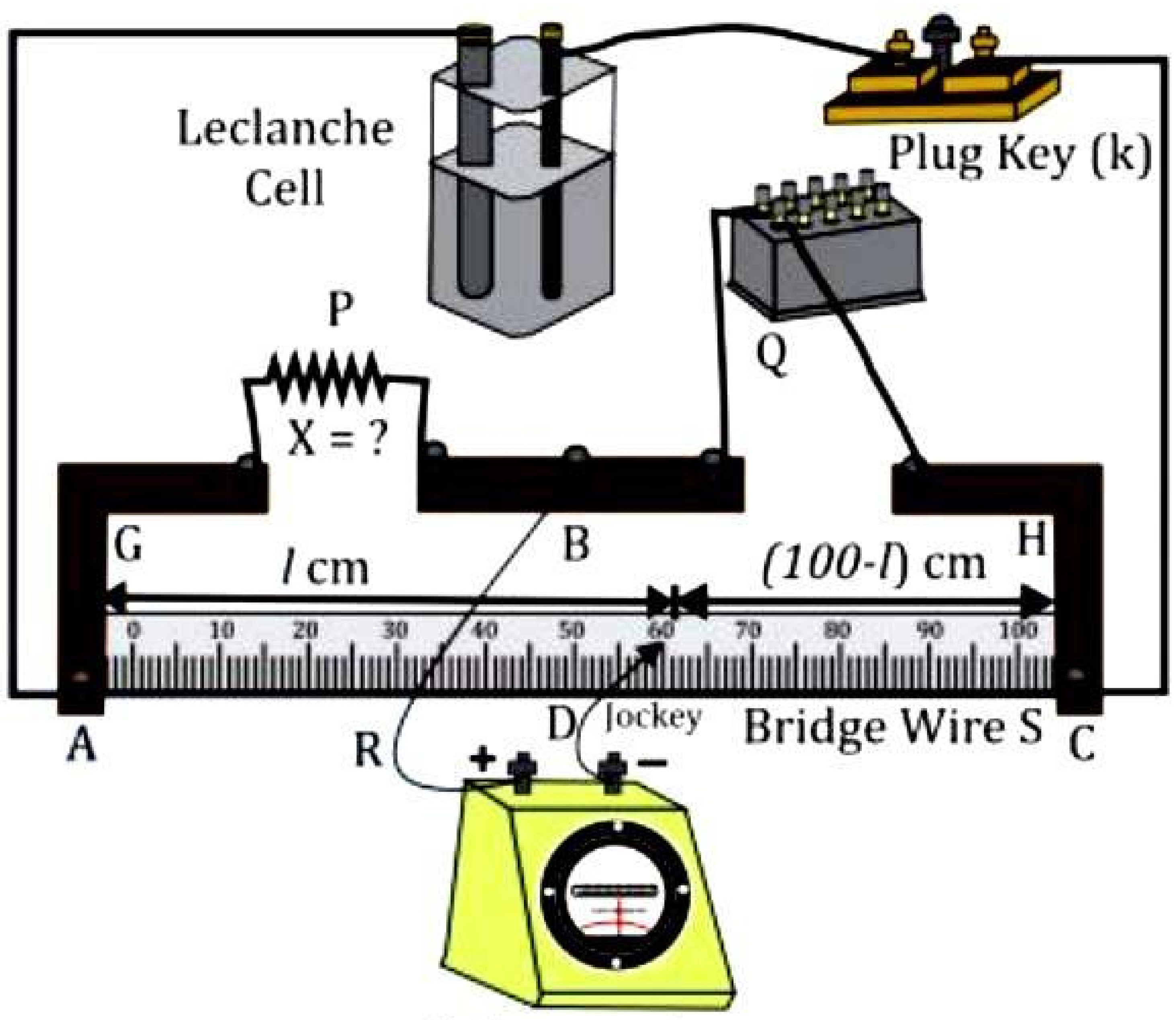


Fig. Assembly diagram using a metre bridge for determination of measuring resistance of the given wire

PROCEDURE

1. Follow the connections outlined in the above given figure and ensure that all connections are securely tightened.
2. Verify the accuracy of the connections by removing a resistance plug from the resistance box, closing the key, and pressing the jockey at end A of the wire.
3. Observe the galvanometer deflection and note its direction.
4. Repeat the process at end C of the wire and observe the galvanometer deflection.
5. If the deflections are in opposite directions, the connections are correct; otherwise, recheck the connections.
6. Adjust the resistance value (R) from the resistance box to achieve a balance point approximately at the midpoint of the wire AC, between the 30 and 60cm marks on the scale. Record the jockey's position.
7. Interchange the positions of S and R in the gaps and again note the jockey's position.
8. Repeat the experiment four times, varying the values of R.
9. Use a meter scale to measure the length (*l*) of the resistance wire.
10. Utilize a screw gauge to measure the diameter of the resistance wire.

OBSERVATIONS

1. The specimen wire's length, denoted as *l* _____ is cm.

2. The screw gauge's least count is _____ cm.
3. The screw gauge's zero error is _______ cm.
4. Record the balanced point of the bridge based on the jockey's position in tabular form.
5. Document the diameter and consequently the radius (r) of the specimen wire in tabular form.

For determining the resistance of the specimen wire.

No. of observations	Resistance, R from R.B. (Ω)	When the specimen wire of resistance S is in the left gap				
		Position of the balance point, B (cm)	Length (l), AB = l (cm)	Length, BC = 100 – l (cm)	$S_1 = R\left(\frac{l}{100-l}\right)$ (Ω)	Mean, S_1 (Ω)
1.						
2.						
3.						
4.						
5.						

For determining the resistance of the specimen wire.

No. of observations	Resistance, R from R.B. (Ω)	When the specimen wire of resistance S is in the right gap				
		Position of the balance point, B (cm)	Length (l), AB = l (cm)	Length, BC = 100 – l (cm)	$S_2 = R\left(\frac{l}{100-l}\right)$ (Ω)	Mean, S_2(Ω)
1.						
2.						
3.						
4.						
5.						

Observations for determining the diameter of the given specimen wire:

No. of observations	Main scale reading, s(cm)	Circular scale div. coinciding, n	Observed diameter, d = s + n(LC)(cm)	Mean, d(cm)
1.				
2.				
3.				
4.				
5.				
6.				
7.				

CALCULATIONS

1. The average resistance of the specimen wire, denoted as S, is calculated as the mean of S_1 and S_2:

$$S = \frac{S_1 + S_2}{2} = \cdots \Omega$$

2. The specimen wire's radius, represented by r, is determined as half of its diameter (d):

$$r = \frac{d}{2} = \cdots \text{cm}$$

3. The specific resistance (k) of the specimen wire is determined using the values of S, r, and l in the equation:

$$k = S\left(\frac{\pi r^2}{l}\right) = \cdots \Omega cm$$

RESULTS

1. The resistance of the provided wire is S = ⋯ cm.

2. The material specific resistance of the provided wire is k = ⋯ cm.

PRECAUTIONS

1. The connections must be tight and clean.
2. The resistance box should be checked for tight connections so that unknown resistance does not creep in.
3. The jockey should gently slide on the wire. It should never be rubbed or hard pressed on the wire.
4. The balance point should be obtained almost in the centre of the wire.
5. The wire should not have kinks or turns in it.
6. Backlash errors in screw gauge must be avoided. The thickness of the wire should be measured in mutually perpendicular directions at four equally spaced points of the wire.
7. The key should immediately be taken out if readings are not being taken.

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 cross-section.
3. The error arises due to the end resistances of copper wires.
4. Backlash errors while measuring the thickness of wire using a screw gauge may arise.

VIVA- VOCE

Q 1. Why is the meter bridge not suitable for measuring very high/very low resistances?

Ans. For measuring high/low resistances, all resistances should be comparably high/low. Moreover, in the case of low resistances, the end resistances and resistance of connecting wires become comparable to the unknown resistance and introduce errors in the result.

Q 2. Does the accuracy with which the null point can be determined depend on the sensitivity of the galvanometer also?

Ans. Yes, it does.

Q 3. Can you demonstrate this point?

Ans. Yes, sir, actually the null point is not a sharp point on the wire, there is a small distance through which the jockey has to be moved to cause just a perceptible deflection of the galvanometer. This distance depends on the sensitivity of the galvanometer and affects the accuracy of our measurement.

Q 4. How can the error due to this be minimized?

Ans. Increasing the voltage between A and C will increase the current and we will be able to see perceptible deflection over a short distance.

Q 5. If length l, may be read with an accuracy of ± 0.1 cm, what will be the uncertainty introduced in the result?

Ans. ± 0.4 cm.

Q 6. If the main circuit remains on all the times, will it affect the position of the null point significantly Explain.

Ans. Yes, Because basically, we compare voltages across ratio arms and $V \propto R \propto I$. As R increases with temperature l will be affected.

Q 7. If the bridge wire length is not exactly 100 cm how will you modify your calculations to get the best possible value of unknown resistance?

OR

The scale attached to the wire may not indicate the exact length.

Ans. If the zero of the scale does not coincide with the starting point of the scale, correct the value of l as $l' = l \pm x$, where l is the position of a null point on the scale and x is the zero-error reading. (i.e., the difference between the starting point of the wire and zero on the scale). Then read the position of the C end of the wire on the scale, let it be l. Then $\frac{l}{L-l} = \frac{X}{R}$ will give us a value of x with the least error.

Q 8. If the meter bridge wire is not of a uniform area of cross-section or uniform density, how will it affect the observations?

Ans. This will add to a systematic instrumental error in locating null points.

Q 9. What can you do to minimize the error?

Ans. We will repeat the experiment by interchanging the positions of known and unknown resistances in their gaps and then finding the mean of the resistance values of unknown resistance obtained in the two cases.

Q 10. If the same experiment is performed with AC = 50 cm wire instead of 1 m, what changes would be there in the result?

Ans. The accuracy of results will be considerably reduced as the longer the length of the wire, the greater will be the accuracy.