EXPERIMENT 2

OBJECTIVE

To find resistance of a given wire using metre bridge and hence determine the specific resistance of its material.

APPARATUS

A metre bridge (slide wire bridge), a Leclanche cell (Battery eliminator), a galvanometer, a resistance box, a jockey, a one way key, a resistance wire, a screw gauge, a metre scale, a set square, connecting wires and a piece of sand paper.

A Short Description of Metre Bridge

(*a*) *Description*

Slide wire bridge or metre bridge is the practical form of Wheatstone bridge. Usually, P and Q are called ratio arms of fixed resistance, R is an adjustable or variable resistance of known value. S is replaced by an unknown resistance X in Fig. 3.07(*a*) and balance point is obtained at B on the metre bridge wire. Since the bridge uses 1 metre long wire, it is called *metre bridge*. Since a jockey is slided over the wire, it is called a *slide wire bridge*.

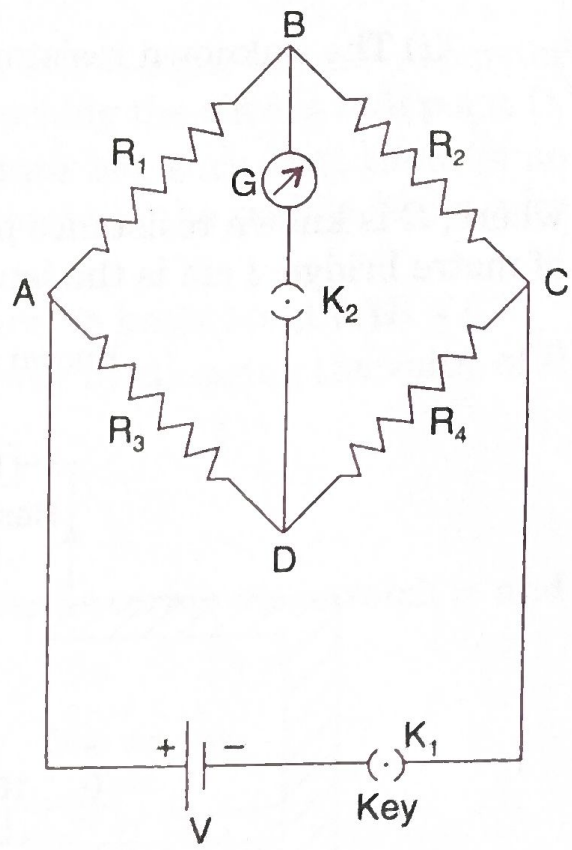

Fig. 3.07. (*a*) Wheatstone's bridge network.

(*b*) *Theory*

(*i*) **For Resistance.** Let AD = l cm, then

$$DC = (100 - l) \text{ cm}.$$

As the metre bridge wire AC has uniform material density and area of cross-section, its resistance is proportional to its length. Hence, AB and BC are the ratio arms and their resistances correspond to resistances P and Q, respectively.

For a balanced Wheatstone bridge, when reading in galvanometer is zero.

$$\frac{R_1}{R_2} = \frac{R_2}{R_4} \qquad ...(1)$$

but, from Fig. 3.07 (*b*)

AB = $R_1 = R$ = resistance from resistance box

BC = X = unknown resistance (R_2)

AD = l = balancing length on meter bridge wire

$= R_3$

$DC = 100 - l = R_4$

$$\frac{R}{X} = \frac{l}{100 - l}$$

$$X = \frac{(100 - l)R}{l} \qquad \text{(working formula for unknown resistance)} \qquad ...(2)$$

(*ii*) **For Specific Resistance.** From resistance formula

$$X = \rho \frac{L}{A} \quad \text{or} \quad \rho = \frac{XA}{L}$$

For a wire of radius r or diameter $D = 2r$

$$A = \pi r^2 = \frac{\pi D^2}{4}$$

Hence,

$$\boxed{\rho = \frac{X\pi D^2}{4L}}$$

CIRCUIT DIAGRAM (*Fig. 3.07 (b)*)

THEORY (*Formula used*)

(*i*) The unknown resistance X is given by

$$X = \frac{(100 - l)}{l} \cdot R$$

where, R is known resistance placed in the left gap and unknown resistance X in the right gap of metre bridge. l cm is the length of metre bridge wire from zero end upto balance point.

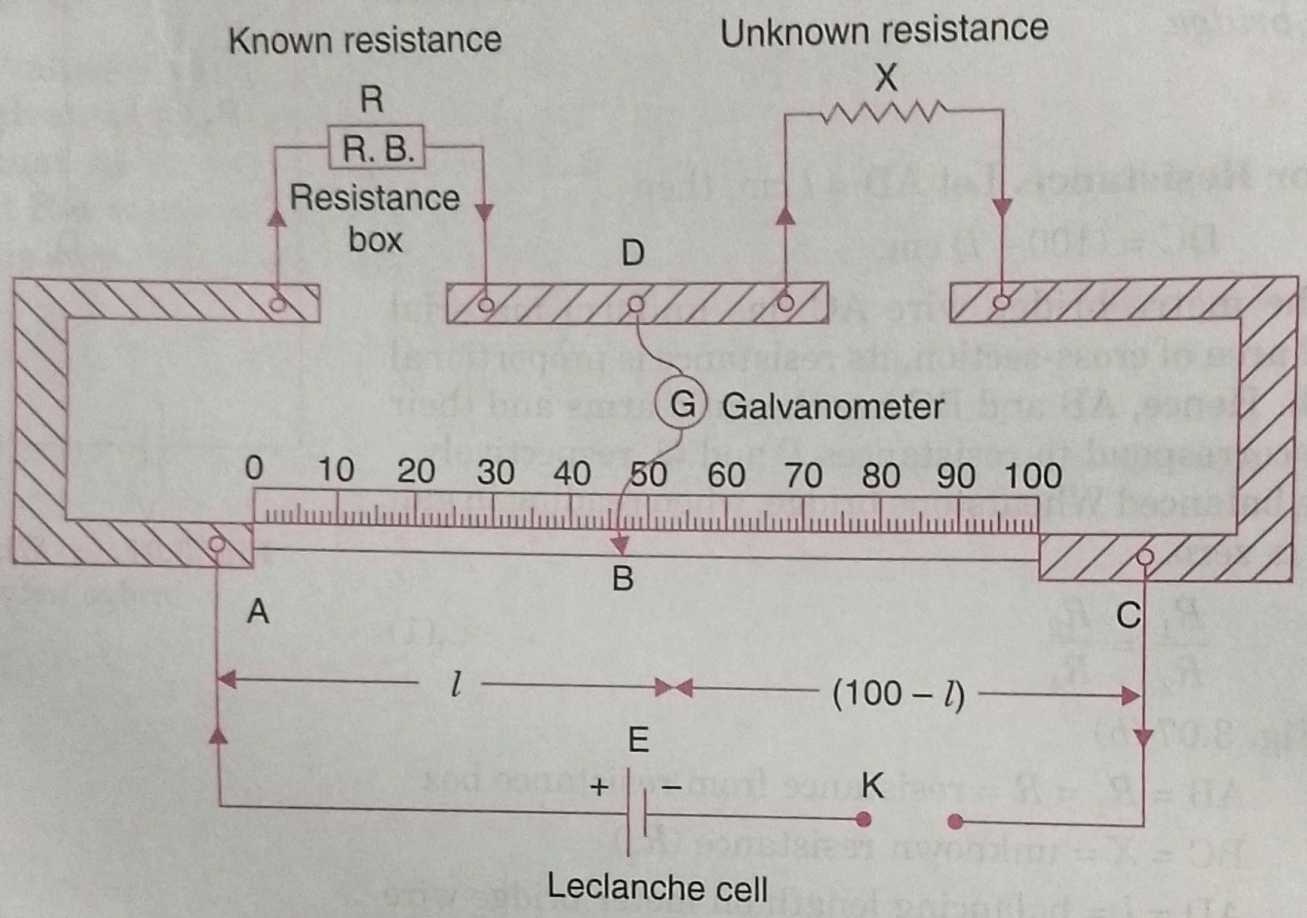

Fig. 3.07. (*b*) Circuit diagram—Metre bridge.

(*ii*) Specific resistance (ρ) of the material of the given wire is given by

$$\rho = \frac{X\pi D^2}{4L}$$

where, L is the length and D is the diameter of the given wire.

PROCEDURE (*Stepwise*)

(*i*) For Resistance

1. Draw the circuit diagram as shown in Fig. 3.07 (*b*) and arrange the apparatus according to the arrangement diagram (Fig. 3.08).
2. Connect the resistance wire whose resistance is to be determined in the right gap between C and B. Take care that no part of the wire forms a loop.
3. Connect resistance box of low range in the left hand gap between A and B.
4. Make all the other connections as shown in the circuit diagram.
5. Take out some resistance (say 2 ohm) from the resistance box, plug the key K.
6. Touch the jockey gently first at left end and then at right end of the bridge wire.

7. Note the deflections in the galvanometer. If the galvanometer shows deflections in opposite directions, the connections are correct. If the deflection is one side only, then there is some fault in the circuit. Check or seek help of your teacher and rectify the fault.
8. Move **(slide)** the jockey gently along the wire from left to right till galvanometer gives no deflection. The point where the jockey is touching the wire is null point D.
9. Choose an appropriate value of R from the resistance box such that there is no deflection in the galvanometer when the jockey is nearly in the middle of the wire (*i.e.*, between 45 cm to 55 cm).
10. Note position of point D (with the help of a set square) to know length AB = l.
11. Take at least four sets of observations in the same way by changing the value of R in steps.
12. Record your observations as given in table 1.

(*ii*) **For Specific Resistance**

13. Cut the resistance wire at the points where it leaves the terminals, stretch it and find its length by using a metre scale.

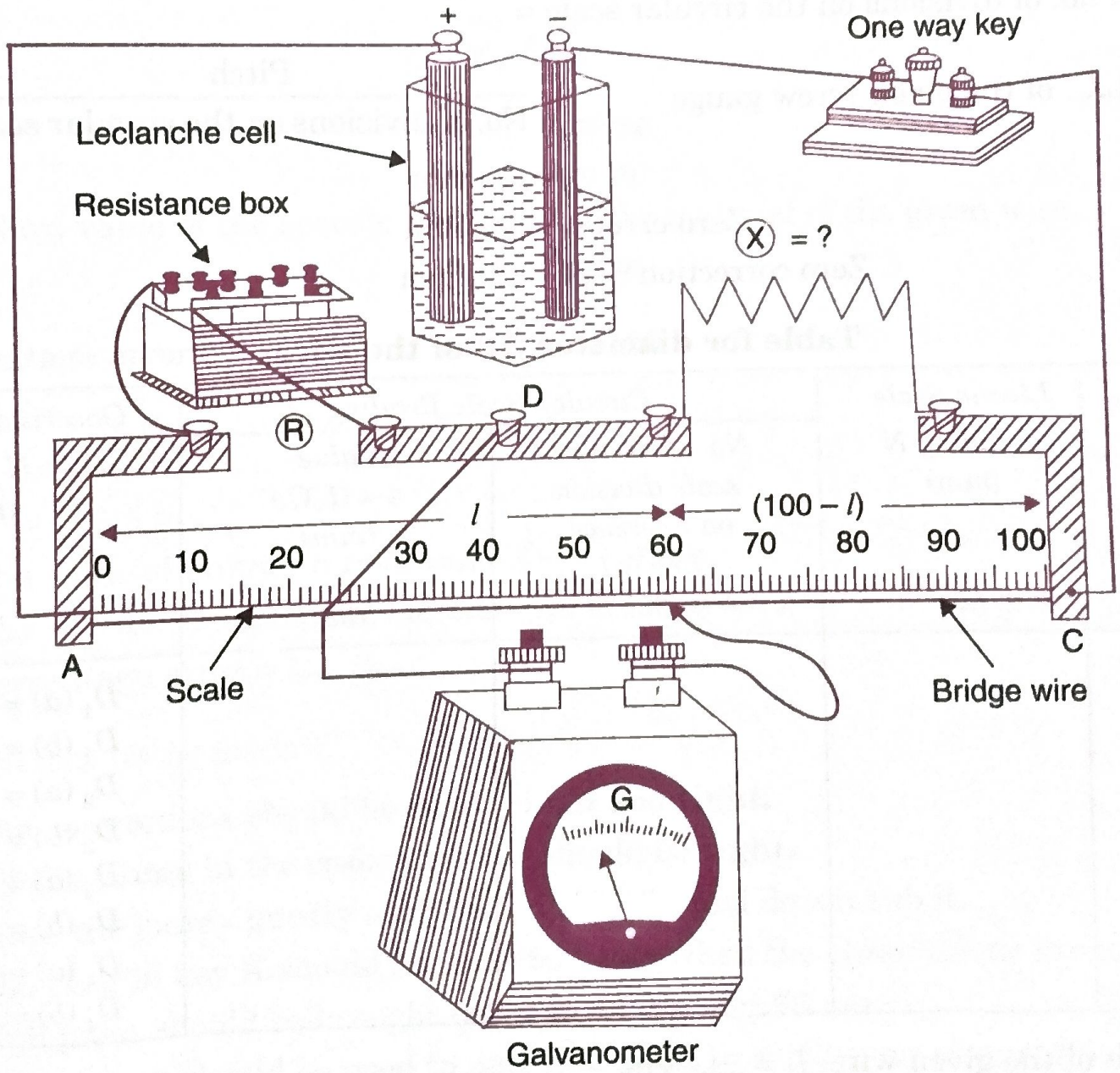

Fig. 3.08. Arrangement diagram.

14. Measure the diameter of the wire at least at four places, in two mutually perpendicular directions at each place with the help of screw gauge.
15. Record your observations as given in tables.

OBSERVATIONS

1. Table for length (l) and unknown resistance (X)

Serial No. of Obs. (1)	*Resistance from the resistance box* R *(ohm)* (2)	*Length AB = l (cm)* (3)	*Length BC = (100 – l) (cm)* (4)	*Unknown resistance* $X = R\,\frac{(100-l)}{l}$ *(ohm)* (5)
1.	.....	.....	.....	.....
2.	.....	.....	.....	.....
3.	.....	.....	.....	.....
4.	.....	.....	.....	.....

2. Least count of the screw gauge

Pitch of screw gauge = ... mm

Total no. of divisions on the circular scale = ...

$$\therefore \quad \text{L.C. of the given screw gauge} = \frac{\text{Pitch}}{\text{No. of divisions on the circular scale}}$$

$$= \text{..... mm}$$

Zero error e = ... mm

Zero correction ($-e$) = ... mm

3. Table for diameter (D) of the wire

Serial No. of Obs. (1)	*Linear Scale Reading N (mm)* (2)	*Circular Scale Reading*		*Observed diameter* $D_0 = N + n \times L.C.$ *(mm)* (4)
		No. of circular scale division on reference line (n) (3a)	*Value* $n \times (L.C.)$ *(mm)* (3b)	
1. (a) O				D_1 (a) =
(b) O				D_1 (b) =
2. (a) O				D_2 (a) =
(b) O				D_2 (b) =
3. (a) O				D_3 (a) =
(b) O				D_3 (b) =
4. (a) O				D_4 (a) =
(b) O				D_4 (b) =

Length of the given wire, L = ... cm.

CALCULATIONS

1. Calculation for X

1. From position of D, find l cm and write in column 3 of Table 1.
2. Find length $(100 - l)$ cm and write in column 4.
3. Calculate X and write in column 5.

$$\text{Mean } X = \frac{X_1 + X_2 + X_3 + X_4}{4} = \ldots\ldots \text{ ohm}$$

2. Calculation for D

$$\text{Mean observed diameter} = \frac{D_1(a) + D_2(b) + \ldots\ldots + D_4(a) + D_4(b)}{8}$$

$$= \ldots\ldots \text{ mm}$$

$$\text{Corrected diameter, } D = \ldots\ldots \text{ mm}$$

$$= \ldots\ldots \text{ cm.}$$

3. Calculation for Specific Resistance

Specific resistance of the material of the given wire,

$$\rho = X \cdot \frac{\pi D^2}{4L}$$

$$= \ldots\ldots \text{ ohm-cm}$$

$$= \ldots\ldots \text{ ohm-m}$$

Standard value of the specific resistance of the material of the given wire,

$$\rho_0 = \ldots\ldots \text{ ohm-m}$$

$$\text{Percentage error} = \frac{\rho \sim \rho_0}{\rho_0} \times 100$$

$$= \ldots\ldots \%.$$

RESULT

1. The value of unknown resistance X = ... ohm.
2. The specific resistance of the material of the given wire = ... ohm m.
3. Percentage error = ... %.

PRECAUTIONS (*to be taken*)

1. The connections should be **neat, clean** and **tight.**
2. All the **plugs** in the resistance box should be **tight.**
3. Move the jockey **gently** over the bridge wire and do not rub it.
4. The plug in key K should be **inserted** only when the observations are to be taken.
5. Null point should be brought between **45 cm** and **55 cm.**
6. **Set square** should be used to note null point to avoid error of **parallax.**
7. At one place, diameter of wire should be measured in **two** mutually perpendicular directions.
8. The wire should not make a **loop.**

SOURCES OF ERROR

1. The instrument screws may be **loose.**
2. The **plugs** may not be **clean.**
3. The wire may not have **uniform thickness.**
4. The screw gauge may have **faults** like *back lash error* and *wrong pitch.*

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