Experiment No. 14

Object : *To determine the resistance per unit length of the wire of Carey-Foster's bridge and hence to determine a low resistance with its help.*

Apparatus Required : Carey-Foster's bridge, decimal resistance box, leclanche cell, galvanometer, thick copper strip, plug key, rheostat of nearly 10 ohm, given wire and connection wires.

Description of the Apparatus : The Carey-Foster's bridge is shown in Fig. 51. One metre long wire EF of mangnin (or constantan) of uniform cross-section area is stretched along a metre scale. The wire is connected at both the ends with copper strips. Beside these strips, there is one copper strip B fixed parallel to the metre scale and two L shaped strips A and C at the ends of scale. In between these strips, there are four empty spaces *ab*, *cd*, *ef* and *gh*.

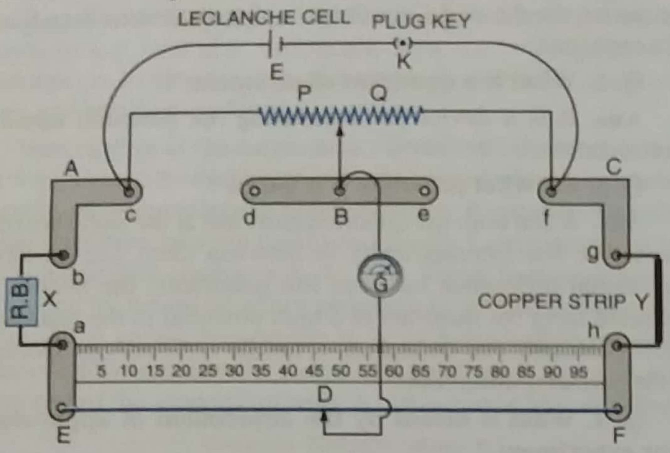

Fig. 51. Carey-Foster's bridge

In one empty space *ab*, a known resistance X; in second empty space *cd* a resistance P; in third empty space *ef*, a resistance Q and in fourth empty space *gh*, the unknown resistance Y are connected. The leclanche cell E and plug key K are connected in between A and C. Between the points B and D, galvanometer G is connected. At point D, contact key is fixed which can move here and there on the wire EF. This key is known as *jockey*. On pressing the jockey, point D gets connected with the galvanometer, otherwise not.

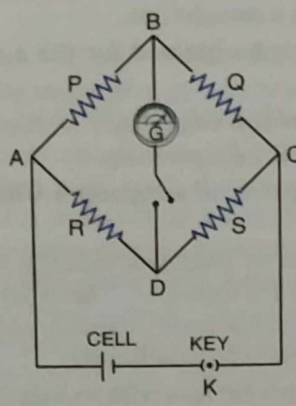

Fig. 52. Wheatstone bridge

Theory : This is based on the principle of Wheatstone bridge. Wheatstone bridge is shown in Fig. 52. On inserting plug in key K and pressing jockey D on Carey Foster's bridge, if there is no deflection in galvanometer then the bridge is in balanced position *i.e.*, the points B and D are at equal potential. In this condition,

$$\frac{P}{Q} = \frac{\text{Resistance between A and D}}{\text{Resistance between D and C}}$$

In the state of zero deflection, if the length of wire ED is l_1 cm, then length of wire DF will be $(100 - l_1)$ cm. If the cross-sectional area of wire is uniform throughout, then resistance per cm length of wire is ρ ohm/cm, and the resistance of wire ED $= l_1 \rho$ and resistance of wire DF $= (100 - l_1)\rho$.

Let the resistance of the strip at the left end be α and at the right end be β, then

$$\frac{P}{Q} = \frac{X + \alpha + l_1\rho}{Y + \beta + (100 - l_1)\rho} \quad \text{...(i)}$$

Now on interchanging the positions of X and Y, let the balancing length obtained on the wire be ED $= l_2$ cm, then DF $= (100 - l_2)$ cm. Then

$$\frac{P}{Q} = \frac{Y + \alpha + l_2\rho}{Y + \beta + (100 - l_2)\rho} \quad \text{...(ii)}$$

From eqns. (i) and (ii),

$$\frac{X + \alpha + l_1\rho}{Y + \beta + (100 - l_1)\rho} = \frac{Y + \alpha + l_2\rho}{X + \beta + (100 - l_2)\rho}$$

Adding 1 on both the sides,

$$\frac{X + Y + \alpha + \beta + 100\,\rho}{Y + \beta + (100 - l_1)\,\rho} = \frac{X + Y + \alpha + \beta + 100\,\rho}{X + \beta + (100 - l_2)\,\rho}$$

Since the numerators of both the sides are equal, hence their denominators will also be equal.

$$\therefore Y + \beta + (100 - l_1)\,\rho = X + \beta + (100 - l_2)\,\rho$$

or

$$Y = X - (l_2 - l_1)\,\rho \quad \text{...(iii)}$$

If Y = 0, then the resistance per unit length of the wire of Carey-Foster's bridge will be

$$\rho = \frac{X}{(l_2 - l_1)} \text{ ohm/cm} \quad \text{...(iv)}$$

Formula Used : (1) Resistance per unit length of the wire of bridge

$$\rho = \frac{X}{(l_2 - l_1)} \text{ ohm/cm}$$

where l_1 = balancing length on the bridge wire measured from the left end when known resistance X is connected in left gap of the bridge and zero resistance is connected in right gap of the bridge and l_2 = balancing length of the bridge wire measured from the left end on interchanging the positions of X and Y.

(2) Unknown resistance of the given wire $Y = X - (l_2 - l_1)\,\rho$.

where X = known resistance connected in the left gap, Y = the resistance of wire connected in the right gap, l_1 and l_2 respectively are the balancing lengths of the bridge wire measured from the left end, before and after interchanging the positions of X and Y.

Procedure : The experiment is performed in the following two steps:

(1) To determine the resistance per unit length of the bridge wire:

(i) First the circuit is connected as shown in Fig. 51.

(ii) The variable end of the rheostat is adjusted in middle so that both the resistances P and Q are nearly equal.

(iii) Now inserting some resistance X through the resistance box, the jockey D is pressed on the bridge wire and it is slided on it until zero deflection is obtained in the galvanometer. In this position, the distance l_1 of jockey from left end on wire is noted.

(iv) Thereafter the positions of resistance box X and copper strip Y are interchanged and then without changing the resistance in resistance box, again the position of jockey is adjusted on the bridge wire in order to obtain zero deflection in the galvanometer. In this position, the length l_2 of the jockey on the wire from the left end is noted.

(v) Now the experiment is repeated three-four times by changing the resistance X from the resistance box and each time the values of l_1 and l_2 are noted corresponding to the value of X.

(vi) Then using the relation $\rho = \frac{X}{(l_2 - l_1)}$, the value of ρ is calculated for each observation and its mean value is calculated

(2) To determine the resistance of a given wire :

(i) To determine the resistance of a given wire, from the electric circuit shown above in part (1), the copper strip connected in the left gap is withdrawn and in its place the given wire is connected.

(ii) The above steps (ii), (iii), (iv) and (v) in part (1) of the experiment are repeated.

(iii) Now using the relation $Y = X - \rho(l_2 - l_1)$, the value of Y is calculated for each observation and its mean value is obtained.

Observations :

(1) To determine the resistance per unit length of the bridge wire:

S. No.	Resistance connected in resistance box X (in ohm)	Zero deflection position when resistance box is connected		$(l_2 - l_1)$ (in cm)	$\rho = \frac{X}{(l_2 - l_1)}$ (in ohm/cm)
		In left gap l_1 (in cm)	In right gap l_2 (in cm)		
1.					
2.					
3.					
4.					

Mean ρ = ... ohm/cm

(2) For the resistance of a given wire :

S. No.	Resistance connected from the resistance box X (in ohm)	Position of Zero deflection when resistance box is connected		$(l_2 - l_1)$ (in cm)	$Y = X - \rho(l_2 - l_1)$ (in ohm)
		In left gap l_1 (in cm)	In right gap l_2 (in cm)		
1.					
2.					
3.					
4.					

Mean Y = ... ohm

Calculations : (1) For resistance per unit length of bridge wire :

For first observation, ρ = ...
For second observation, ρ = ...
....

Mean ρ = ... ohm/cm

(2) For the resistance of the given wire :

For first observation, $Y = X - \rho(l_2 - l_1)$
For second observation, Y = ...
....

Mean Y = ... ohm.

Result : (i) Resistance per unit length of the Carey-Foster's bridge wire = ... ohm/cm.

(ii) Resistance of the given wire = ... ohm.

Precautions : (1) For greater sensitivity of the bridge, the resistance connected in the four gaps of the bridge should be nearly equal.

(2) Clean the ends of the connecting wires with sand paper before they are used.

(3) Never allow the flow of current in the circuit for a long duration otherwise resistance wire will get heated which in turn increase its resistance. For this, in the circuit insert the plug in key only while taking observation.

(4) Except the resistance introduced in the R.B. box, all other plugs should be firmly tight.

(5) Before pressing the jockey on the bridge wire, plug should be inserted in the plug key attached with the cell so that electric circuit gets completed before the galvanometer gets connected in the circuit.