

EXPERIMENT 3: Measurement of unknown resistance using Carey-Foster's Bridge

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1 Aim of experiment

We are going to determine the value of an unknown resistance using a meter-bridge and then make further accurate measurements using Carey Foster bridge to take into account the specific resistivity (ρ) of the bridge wire. Finally measuring the radius and length of the unknown resistance we can determine the specific resistivity of the material given.

2 Apparatus required

- a) An unknown resistance
- b) A known resistance (variable)
- c) A galvanometer
- d) A very high resistance of the order of 15000Ω to protect the galvanometer.
- e) A dry cell
- f) A plug key
- g) A meter bridge with jockey
- h) A sorting plate
- i) A copper strip

3 Theory of Experiment

Brief discussion and relevant formulae:

The Meter Bridge is a device for measurement of resistance using the principle of Wheatstone Network. AB is a uniform wire 100 cm (1m) long, stretched in two segments of 50 cms. AA' , BB' , CC' , DE are thick metal strips which have zero resistance. $A'D$ and BE are gaps in which resistances to be compared are connected. The dry cell is connected through a plug key between A' and B' . A pivoted galvanometer is connected between the

central terminal (F) and sliding contact J through a high resistance. With a standard resistance in R the position of jockey is found for which the current in the galvanometer is zero. Then,

$$\frac{X}{R} = \frac{\text{Resistance of } AJ}{\text{Resistance of } JB} = \frac{l}{100 - l} \quad (1)$$

Using the bridge one can calculate the resistance of the wire from which the specific resistance ρ of the material of wire can be obtained.

The Carey-Foster Bridge is a modified form of meter bridge. The shorting plate DE is removed so that we get four gaps AD, DC, CE, EB in which resistances can be connected. Two equal resistances P and Q can be connected in gaps DC and CE suppose an unknown resistance and a known resistance are connected in gaps AD and EB . Let the balance point be found at J ($AJ = l$)

Let the resistance per cm of the bridge wire be ρ . The contact resistance in DJ and JE be α and β . Then

$$\frac{P}{Q} = \frac{X + \alpha + l\rho}{R + \beta + (100 - l)\rho} \quad (2)$$

If, X and R are interchanged the balance point shifts to J' , ($AJ = l'$)

$$\frac{P}{Q} = \frac{R + \alpha + l'\rho}{X + \beta + (100 - l')\rho} \quad (3)$$

then,

$$\frac{P + Q}{Q} = \frac{X + R + (\alpha + \beta) + 100\rho}{X + \beta + (100 - l')\rho} = \frac{X + R + (\alpha + \beta) + 100\rho}{X + \beta + (100 - l)\rho} \quad (4)$$

Hence,

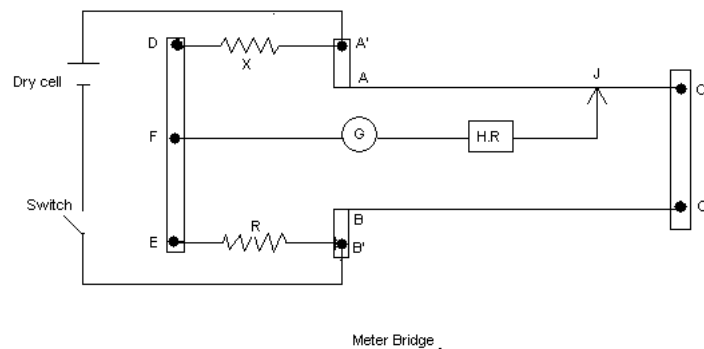
$$X = R + (l - l')\rho$$

To determine ρ , connect a thick copper strip (of zero resistance) in place of the unknown resistance X . Determine l and l' as before. So,

$$\rho = \frac{R}{l - l'} \quad (5)$$

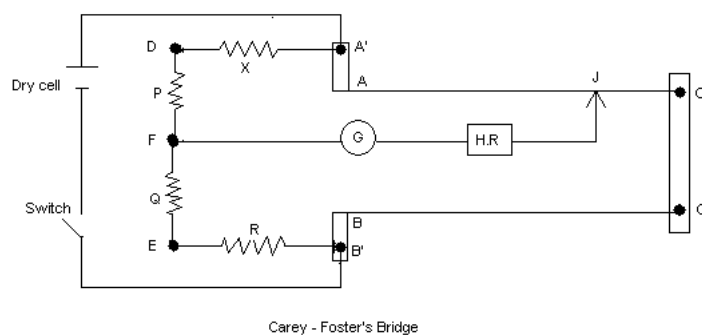
4 Procedure

We first construct the circuit as shown in figure



Now, we try to find a spot such that the Galvanometer shows no deflection. We note the length at that point. We take a number of such readings by varying the rheostat (R). Now, we reverse the position of the variable and unknown resistance and again take readings. Thus, we get two sets of readings. We can get a crude measure of the unknown resistance using the readings. However, it must be kept in mind that during the experiment, the bridge wire also had contributed to the resistance which we had not taken into account. To take care of that, we now take help of the Carey Foster's bridge. We remove the sorting plate and thus obtain two more gaps where we put two more variable resistances, namely P and Q .

The circuit looks as follows:



We set $P = Q$ and find the balance point. We again take two sets of readings of the balance point. Finally, to determine the specific resistivity ρ of the wire, we use a copper strip by making the assumption that copper has infinite resistance. In this case also, we take two sets of reading, one with

resistances in proper positions and one in reversed position. From these two sets, we can calculate ρ . Using this value of ρ we can determine from the formula a roughly accurate value of X i.e the unknown resistance.

5 Calculations

5.1 Mesurement of approx. resistance using Meter Bridge

S.No.	Resis. Ω	Null point cm	Resis. Ω
1	1.2	40.6	0.820
2	1.1	42.3	0.806
3	1	45.2	0.825
4	0.9	47	0.798
5	0.8	50.2	0.802
6	0.7	53.2	0.796
7	0.6	57.5	0.812

So, the mean resistance R is = 0.808 Ω

Also, the length of the wire is = 24 cm

Diameter of wire = 0.52 mm

Thus, the specific resistivity of the material comes out to be
= $7.14 \times 10^{-6} \Omega/cm$

5.2 Determination of ρ of bridge wire using Carey-Foster's bridge

S.No.	$R\Omega$	l	l'	$l-l'$	$\rho \Omega/cm$
1	0.1	51.5	48.3	3.2	0.031
2	0.09	51.2	48.6	2.6	0.035
3	0.07	50.9	48.5	2.4	0.029
4	0.05	50.1	48.6	1.5	0.033

So, the mean ρ is = 0.032 Ω/cm

5.3 Determination of unknown resistance using Carey Foster's bridge

S.No.	$R\Omega$	l cm	l' cm	$(l' - l)cm$	$X\Omega$
1	0.5	47	52.9	5.9	0.688
2	0.6	47.9	51.3	3.4	0.709
3	0.7	49.4	49.8	0.4	0.713
4	0.8	51.1	48	-3.1	0.700
5	0.9	52.9	46.4	-6.5	0.692

So, the mean resistance is = 0.700 Ω

6 Result

So, the mean resistance = 0.700Ω

7 Discussions

1) During the experiment, due to Joule heating, temperature of the wire increases. Hence, the resistance doesnot remain constant, it changes. So, to get more accurate readings, the circuit should be broken and the wire should be given time to cool down.

2) For, minimum error, the ratio $\frac{l}{100-l} \rightarrow 1$. Hence, for this condition, $l \rightarrow 50$. So, we should take readings near 50cm in order to reduce the error.

8 Error Analysis