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SUB- E.M.M.I

sec- C

Chapter-6

Measurement of Resistance

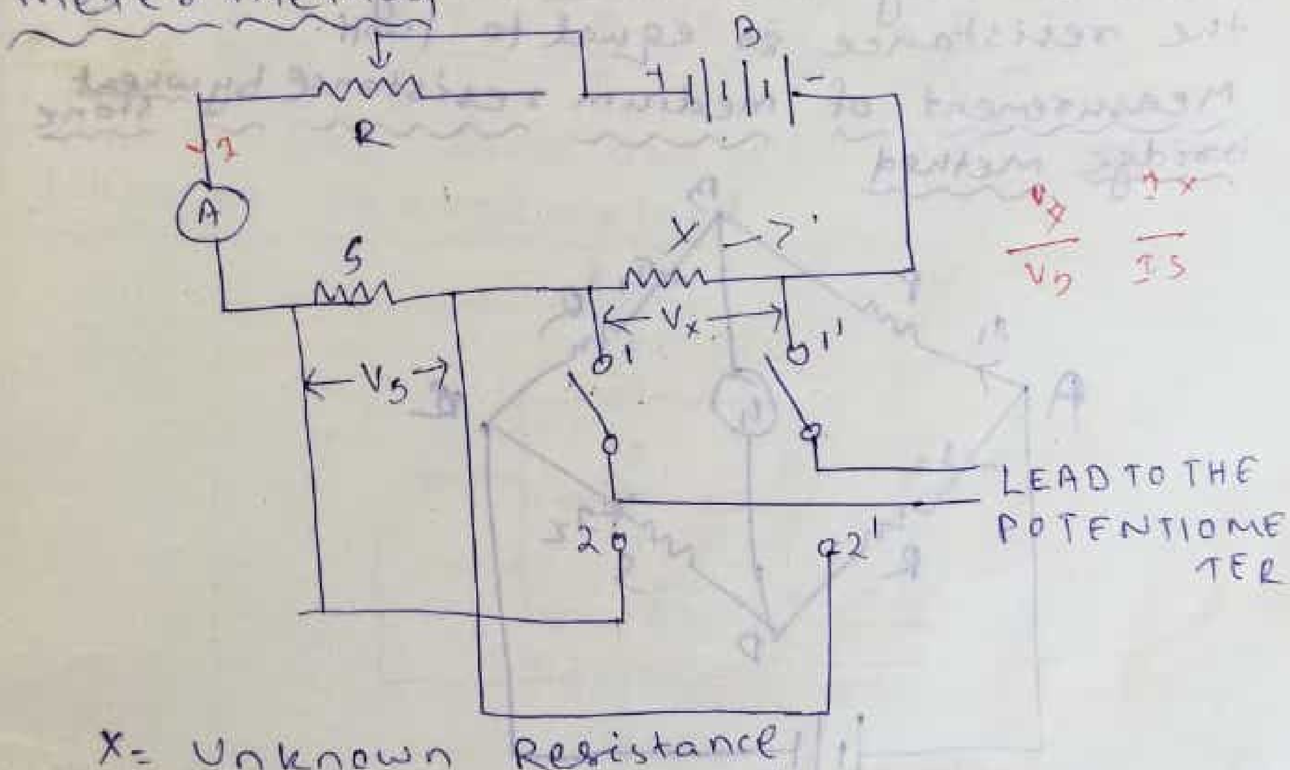
Resistance is classified into 3 types
1. Low 2. High 3 Medium

Low Resistance :- Resistance of 1Ω and under are in this case

Medium Resistance - Resistance ranging from 1Ω to 100 KΩ include in this case.

High Resistance :- (i) Resistance 100 kΩ and above usually termed as high resistance.

Measurement of low resistance by potentio meter method



X = Unknown Resistance
A = Ammeter R = Rheostat
B = voltage S = standard resistor.

(i) X, A, S, R are connected in series with a low voltage high current supply source. The Rheostat is used for controlling the magnitude of current into the circuit

(ii) Double pole double throw switch is used in the circuit. When it is in position 1 and 1', it connects with X (unknown resistance). When it ~~connects~~ moves to position 2, 2 it connects to the the standard resistance connects to the circuit

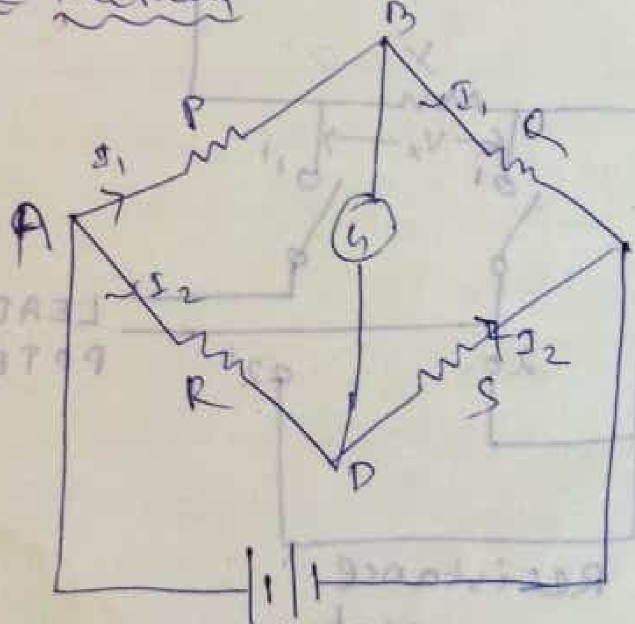
When it is in position 1 and 1'
then $V_x = I \cdot x$
When it is in position 2 and 2'
$V_s = I \cdot S$
So we can write

$$\frac{V_x}{V_s} = \frac{I \cdot x}{I \cdot S} \Rightarrow \frac{V_x}{V_s} = \frac{x}{S}$$

$$\Rightarrow x = S \cdot \frac{V_x}{V_s}$$

So from this we known the value of x, which is known as unknown resistance.
The magnitude of the current is adjusted in such a way that the voltage drop across the resistance is equal to 1 volt.

Measurement of medium resistance by wheat stone bridge method



(i) It is used for measurement of medium resistance. It has four resistive arms P, Q, R and S and one galvanometer.
(ii) ~~The P, Q, R ratio~~ We know the value of P, Q and
P, Q are ratio arm, S = standard Resist.
Here, we have to find out the value of R.

(iii) The bridge is said to be balanced, when the potential difference across the galvanometer is 0, that means there is no current flows through.

(iv) That means I_1 flows through P and Q and I_2 flows through R and S. Here $V_B = V_D$.

So from this condition, we write.

$$V_{AB} = V_{AD}$$

$$\Rightarrow I_1 P = I_2 R \quad \text{—— (1)}$$

and we can write.

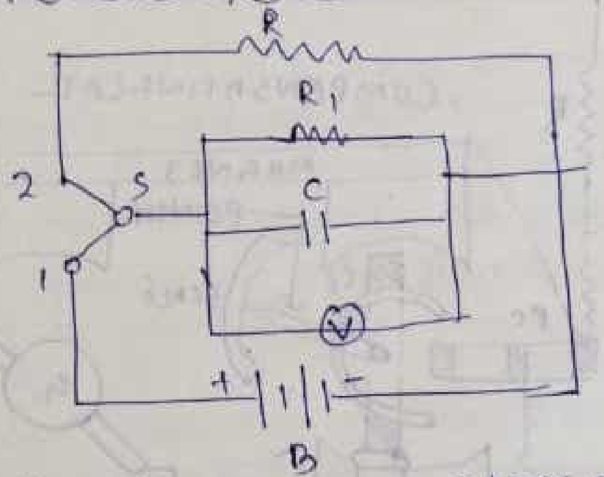
$$V_{BC} = V_{CD} \Rightarrow I_1 Q = I_2 S \quad \text{—— (2)}$$

Divide eqn (1) by eqn (2)

$$\frac{I_1 P}{I_1 Q} = \frac{I_2 R}{I_2 S} \Rightarrow \frac{P}{Q} = \frac{R}{S} \Rightarrow R = \frac{P}{Q} S$$

Hence we find out the unknown value.

Loss of charge method



(i) In the circuit. C is capacitor of known capacitance. V is voltmeter, R_1 = total leakage resistance. and R = resistance to be measured.

(ii) In this method capacitor first charged by battery, when we put switch to stud 1 it allows discharge through R and R_1 by putting switch to stud 2. The time taken for P.d fall from V_1 to V_2

(iii) Let the equ. resistance of R_1 and R are connected in parallel be R'

$i = -\frac{dq}{dt} = -C\frac{dv}{dt}$ — (1) also $i = \frac{V}{R'}$ — (2)

Comparing two expⁿ

$$\frac{V}{R'} = -C\frac{dv}{dt} \Rightarrow \frac{dv}{V} = -\frac{dt}{CR'}$$

$$\int_{V_1}^{V_2}\frac{dv}{V} = \int_0^t -\frac{dt}{CR'} \Rightarrow \left[\log V\right]_{V_1}^{V_2} = \left[-\frac{t}{CR'}\right]_0^t$$

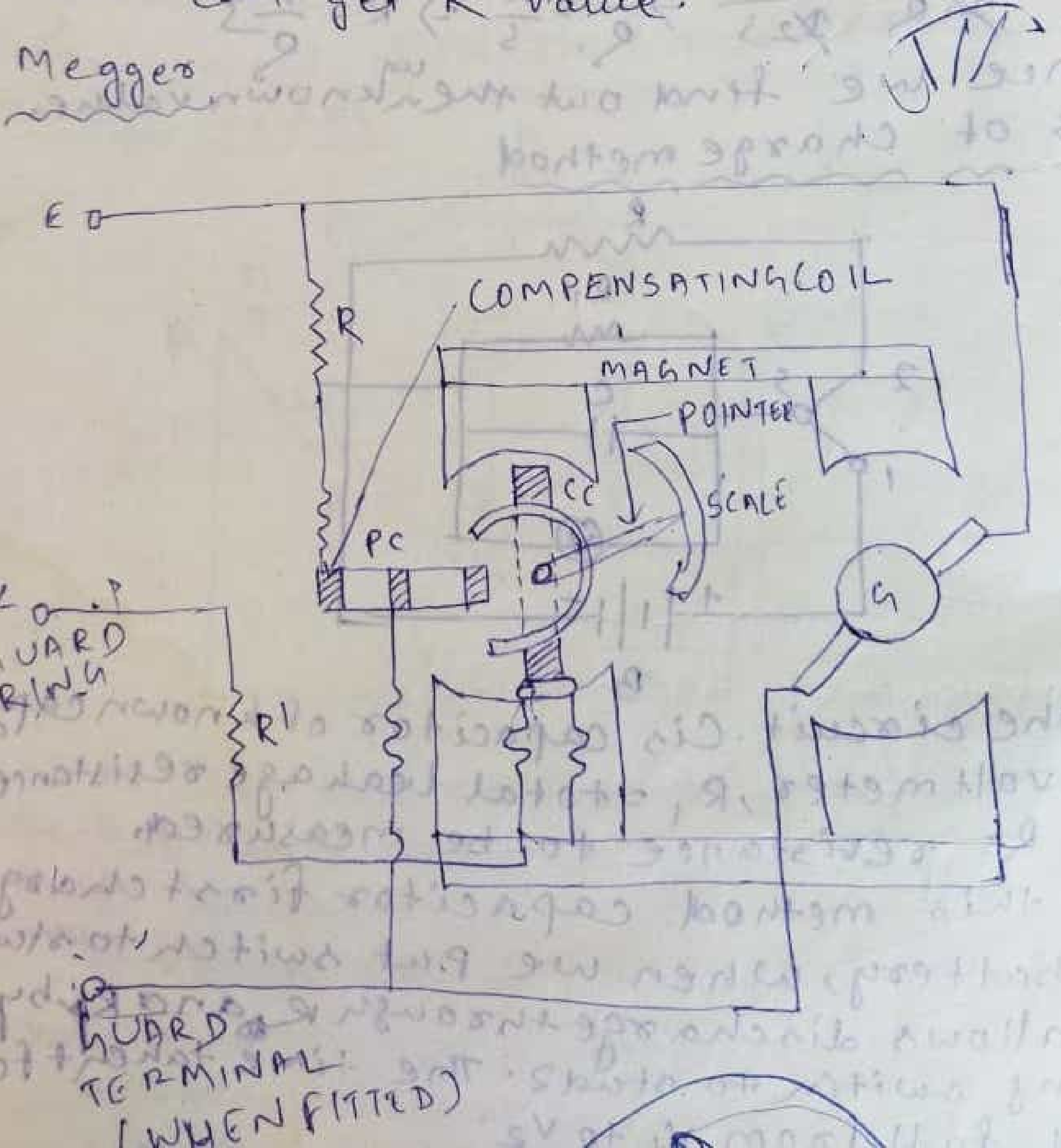
$$\Rightarrow \log\frac{V_2}{V_1} = -\frac{t}{CR'} \Rightarrow V_2 = V_1 e^{-t/CR'}$$

From above we can get R' value and we know the value of R_1. So we can get

$$\frac{1}{R} = \frac{1}{R'} - \frac{1}{R_1}$$

we can get R value.

Megger



(i) It is used for the measurement ... resistance and insulation resistance. It consists of dc generator and a true ohmmeter. Permanent magnet provide the field for both the generator and the ohm meter.

(ii) Moving element of ohmmeter consists of 3 coils known as current coil, pressure coil and compensating coil.

(iii) Current (deflecting) coil is connected in series with 'R' between one generator terminal and the test terminal marked 'L'. R' protects the current coil in case the test terminals are short circuited and also controls the range of the instrument.

(iv) Pressure coil is in series with compensating coil and protection resistance R is connected across the generator terminals. Compensating coil is provided to obtain better scale proportion.

Working:- (i) When the test terminal is open, no current flows through deflecting coil. The pressure coil governs the motion of moving element causing it to move to its extreme counter clockwise position. The pointer on the scale indicated by the pointer, is marked infinite resistance.

(ii) When the test terminals L and E short circuited. The current flowing through current coil is large enough to produce enough torque to overcome the counter clockwise torque of pressure coil. This moves the pointer to its extreme clockwise position. It is marked as zero resistance.

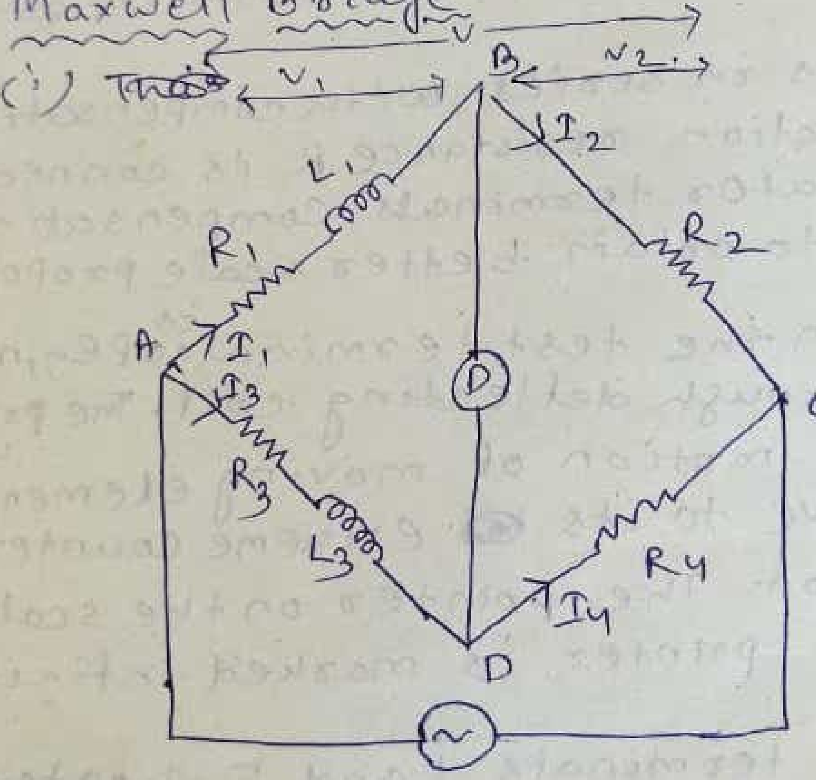
(iii) When a resistance under test is connected betn test terminals L and E. The opposing torque coils balance each other. So that the pointer comes to rest and some point on the scale.

(v) Guard ring is provided to shunt the le[akage] current over the test terminals.

Operation:- The resistance under test is connected between the test terminals (L...). The generator handle is then steadily turned at uniform speed. A type of slipping ... is attached to the handle. The turning of handle must be kept up until the pointer gi[ves] a steady reading. The larger the capacitance of the object under test longer it will give a steady reading.

Maxwell Bridge

(i)



(i) It is used to measure the medium resistance

L_4 = Unknown self inductance.

L_3 = known variable inductance.

R_3 = constant

R_2, R_4 = Pure resistance.

D = detector

when the bridge is balanced, the current flowing through detector D is zero.

$I_1 = I_2$, $I_3 = I_4$

PD across arm AB = PD across arm AD = V_1

$\Rightarrow I_1 Z_1 = I_3 Z_3 = V_1$

$\Rightarrow I_1 (R_1 + j\omega L_1) = I_3 (R_3 + j\omega L_3) = V_1$ —— (1)

PD across BC = PD across CD = V_2

$\Rightarrow I_2 R_2 = I_4 R_4 = V_2$ —— (2)

We know $I_1 = I_2$, $I_3 = I_4$

$\Rightarrow I_1 R_2 = I_3 R_4$ —— (3)

Dividing eqn (3) with eqn (1)

$$\frac{I_1 (R_1 + j\omega L_1)}{I_1 R_2} = \frac{I_3 (R_3 + j\omega L_3)}{I_3 R_4}$$

$$\Rightarrow \frac{R_1 + j\omega L_1}{R_2} = \frac{R_3 + j\omega L_3}{R_4}$$

$$\Rightarrow \frac{R_1}{R_2} + \frac{j\omega L_1}{R_2} = \frac{R_3}{R_4} + \frac{j\omega L_3}{R_4}$$

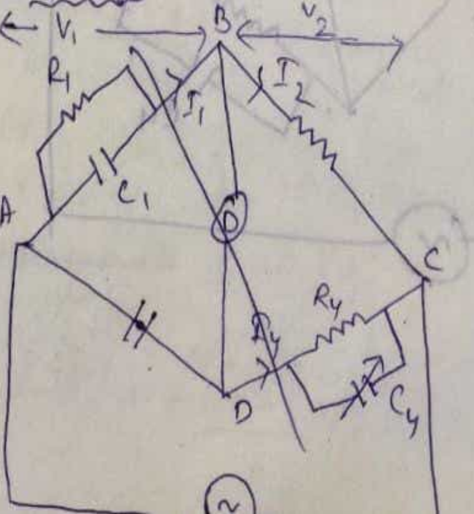
Equating imaginary side.

$$\frac{j\omega L_1}{R_2} = \frac{j\omega L_3}{R_4}$$

$$\Rightarrow L_1 = \frac{R_2 L_3}{R_4}$$

Value of self inductance L_1 can be determined.

Schering Bridge



It is used to measure capacitance.

C_1 = Unknown capacitor

C_3 = Standard capacitor

C_4 = variable capacitor

R_2, R_4 = known non inductive resistor

R_3 = variable resistor

$Z_1 = R_1 - j/\omega C_1$, $Z_2 = R_2$, $Z_3 = -j/\omega C_3$

$Z_4 = \frac{R_4}{1+j\omega C_4 R_4}$

We know that

When bridge is balanced

$Z_1 Z_4 = Z_2 Z_3$

$$Z_4 = R_4 \parallel C_4$$

$$= \frac{1}{\frac{1}{R_4} + \frac{1}{1/j\omega C_4}} = \frac{1}{\frac{1}{R_4} + j\omega C_4}$$

$$\Rightarrow \frac{R_4}{1 + j\omega C_4 R_4}$$

$5 \times 3 = 6 \times 7$

$\rightarrow 5 \times 3 = 4 \times 6 \times 7$

We know when bridge is balanced

$$Z_1 Z_4 = Z_2 Z_3$$

$$\Rightarrow \left(R_1 - j/\omega C_1\right)\left(\frac{R_4}{1+j\omega C_4 R_4}\right) = \frac{-jR_2}{\omega C_3}$$

$$\Rightarrow \left(R_1 - j/\omega C_1\right) R_4 = \frac{-jR_2}{\omega C_3}\left(1 + j\omega C_4 R_4\right)$$

$$\Rightarrow R_1 R_4 - \frac{jR_4}{\omega C_1} = \frac{-jR_2}{\omega C_3} + \frac{R_2 C_4 R_4}{C_3}$$

Equating imaginary term

$$\frac{-jR_4}{\omega C_1} = \frac{-jR_2}{\omega C_3}$$

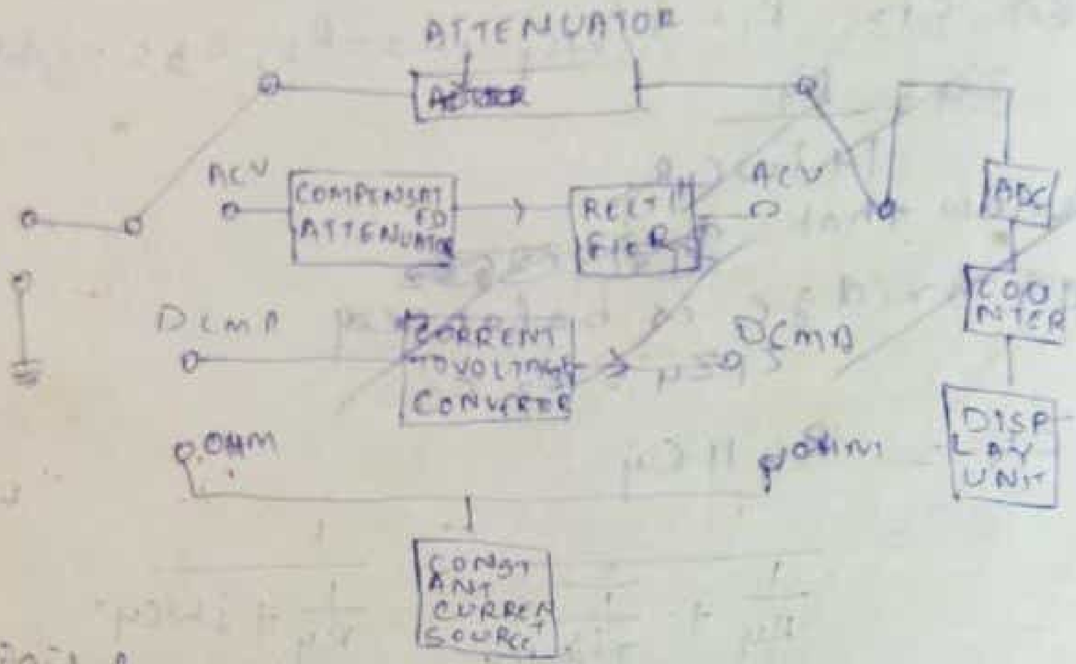
$$\Rightarrow C_1 = \frac{C_3 R_4}{R_2}$$

Equating Real term:

$$R_1 R/_4 = \frac{R_2 C_4 R/_4}{R_3}$$

$$\Rightarrow R_1 = \frac{R_2 C_4}{R_3}$$

Digital multimeter



(i) Digital multimeter is basically a digital voltmeter it is used for voltage, current (dc or ac) and resistance.

(ii) For measurement of ac voltage the input voltage is converted into DC voltage by rectifier. A compensated attenuator is employed. For both AC and DC measurement same attenuator is used.

(iii) For measurement of resistance, a constant current, depending on the range supplied from a battery or constant current is passed through the resistance under measurement and the voltage developed across it. The resistance value is displayed in ...

(iv) For measurement of current an known current is passed through the precision resistor and the voltage across it is developed and measured. Current value is displayed in mA.