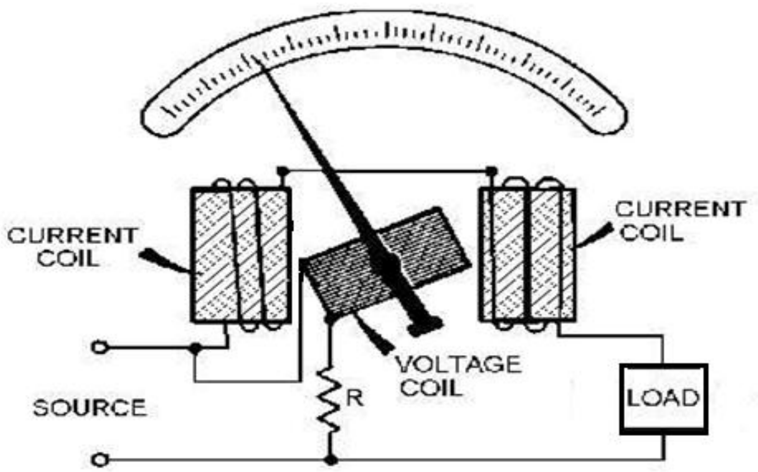
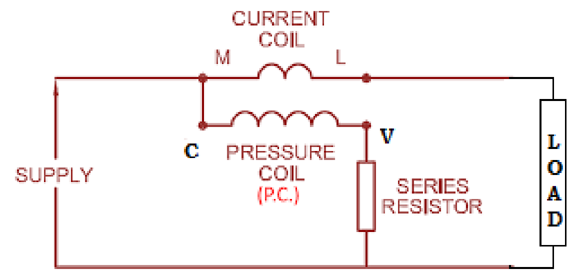
Module II

Measurement of various electrical quantities

Electrodynamometer type wattmeter





- ***Electrodynamometer type wattmeter is an electrical instrument which is used to measure power.***

Construction

- Fixed coil
- Moving coil
- Pointer and scale
- Control spring
- Air friction damping

- The **fixed coils or the field coils** are connected in series with the load and therefore carry the current flowing through the circuit. Hence, they are also called as the **current coils (C.C)** of the wattmeter.
- **moving coil** is connected **across the voltage**, and hence carry a current proportional to the voltage. This coil is also called as the **pressure coil (P.C)** of the wattmeter.
- The control used in these types of instruments is the **spring control**.
- Damping used is the **air friction damping**.
- These types of instruments use **mirror type scales** and **knife edge pointers** and thus helps removing parallax.
- Deflection is **directly proportional to the power** being measured.

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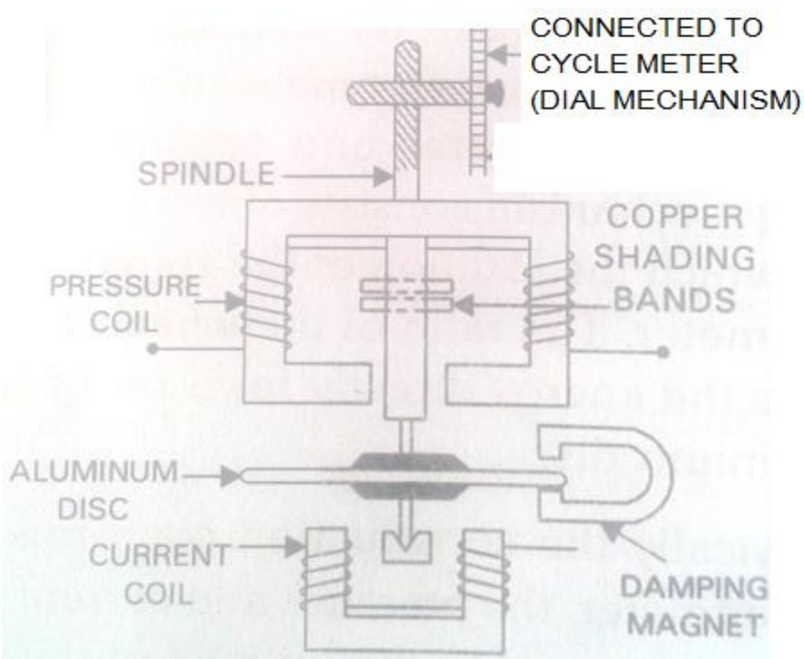
Working

- When current passes through the fixed coil, it set up **magnetic flux in the air gap**.
- The magnetic field produced by it **linked with the moving coil** , it is connected across the supply voltage.
- when a current-carrying conductor is placed in a magnetic field, it is acted upon by **a force** which tends to **deflect the moving system.**
- The movement of moving coil causes the **movement of pointer**.
- The pointer **indicate the magnitude of power**.
- Angle of deflection, $\Theta = V\ I \cos\phi\ dM/d\Theta$

$$\Theta \propto P$$

Single phase induction type energy meter



- ***Induction type energy meter is an electrical instrument which is used to measure Electrical energy in KWH.***

Construction of single phase induction type energy meter

1, Driving system

2, Moving system

3, Braking system

4, Registering system

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1, Driving system

- Consists two electromagnets (ie series and shunt magnet)
- Core of these are silicon steel laminations
- Coil of one electromagnet (series magnet)excited by load current -(current coil)
- Coil of second electromagnet (shunt magnet) is connected across supply -(Pressure coil)
- Copper shading bands used to adjust flux produced by shunt magnet

2, Moving system

- This consists an aluminium disc mounted on light alloy shaft
- This disc is positioned in the air gap between series and shunt magnets

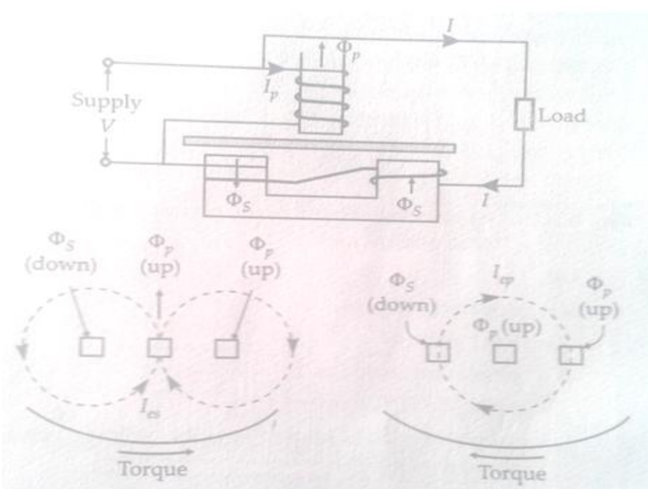
3, Braking system

- A permanent magnet positioned near the edge of aluminium disc forms the braking system

4, Registering system

- Cycle meter records continuously a number which proportional to revolutions of moving system with reduction gears

Working of single phase induction type energy meter



- Current coil produces magnetic field proportional to current and Pressure coil produces magnetic field proportional to voltage.
- These two magnetic fields induce eddy current in the disc.
- Due to the interaction of eddy current and magnetic field, Torque developed on the disc.
- The speed of revolution of disc proportional to electric energy (Kwh)

Classification of resistance

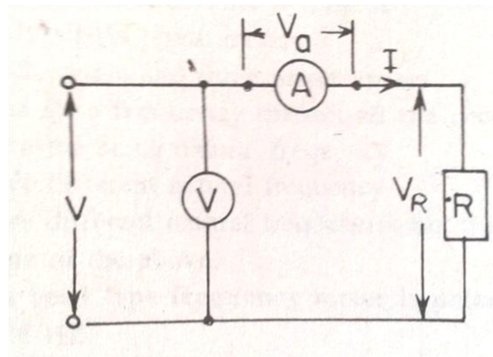
1, low resistance – 0 – 1 ohm

2, Medium resistance – 1 ohm to 100Kohm

3, High resistance – above 100Kohm

Measurement of Resistance

1, By voltmeter ammeter method



- Ammeter connected in series with the resistor
- Voltmeter connected in parallel with resistor.
- The ratio of readings of Voltmeter to ammeter gives the resistance
- R = $\frac{V}{I}$

2, Wheatstone Bridge

It is used in the measurement of **Medium resistance**, and it is an instrument for making comparison measurement and operates upon **a null deflection principle.**

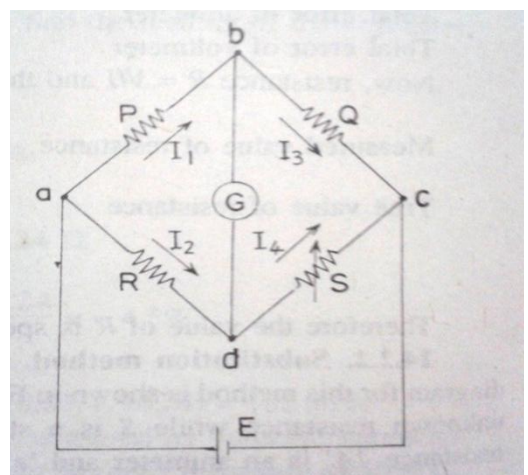


Fig. 14.3. Wheatstone bridge.

at balancing condition Ig = 0, ie galvanometer has null deflection. at that condition,

$$\frac{P}{Q} = \frac{R}{S}$$

$$\mathbf{R} = \frac{P}{Q}S$$

where P,Q and S are resistive arms and R is unknown resistance

Derivation

at balanced condition

Ig = 0

Potential at b and d are same

$I_1P = I_2R$ …………..(1)

$I_3Q = I_4S$…………..(2)

$I_1 = I_3$ & $I_2 = I_4$ (since Ig = 0) so equ.(2) become I1Q = I2S……(3)

equ (1)/(3) $\frac{I1P}{I1Q} = \frac{I2R}{I2S}$

ie. $\frac{P}{Q} = \frac{R}{S}$

$$R = \frac{P}{Q}S$$

$\frac{P}{Q}$ is called Ratio arm & S – adjustable arm

Problem

A regular Wheatstone bridge is used to measure resistance, the bridge has ratio arms 1000ohm and 10 ohms, the adjustable arm has a maximum value of 1000 ohm. a battery of 10V emf and negligible resistance is connected from the junction of ratio arms to the opposite corner. what is the maximum resistance that can be measured by this arrangement.

ans.

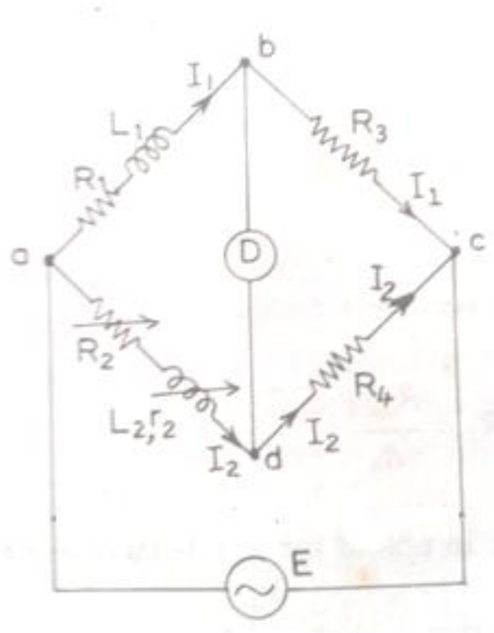
P =1000 ohm, Q = 10 ohm, S = 1000 ohm & V = 10v

at balanced condition

$\frac{P}{Q} = \frac{R}{S}$ R = $\frac{P}{Q}S$ = $\frac{1000}{10}1000$ = 100000 ohm = 100Kohm

Measurement of Inductance by using Maxwell's Bridge

By using this bridge we can find the inductance of a coil.



Where

L_1 – Inductance to be measured (Unknown Inductance),

R_1 – Resistance of Inductor L1

L_2 – Variable inductance (Known),

r_2 – Resistance of Inductor L_2

R_2 – Variable Resistance (Known)

R_3 and R_4 – Resistance

At Balanced Condition , Detector shows zero deflection .

according to AC bridge balancing formula

$Z_1/Z_3 = Z_2/Z_4$ …………..(1)

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where $Z_1 = R_1 + jX_{L2}$

$= R_1 + jwL_2$

$Z_2 = R_2 + jX_{L2}$

$= R_2 + jwL_2$

$Z_3 = R_3$

$Z_4 = R_4$

Substitute Z_1, Z_2, Z_3 & Z_4 in equ. (1)

We get

$R_1 = \frac{R3}{R4}(R2 + r2)$ and $\mathbf{L_1 = \frac{R3}{R4} L2}$

Measurement of Capacitance by using Schering Bridge

It is used to measure capacitance of capacitor

it consists,

C1 – Capacitance to be measured

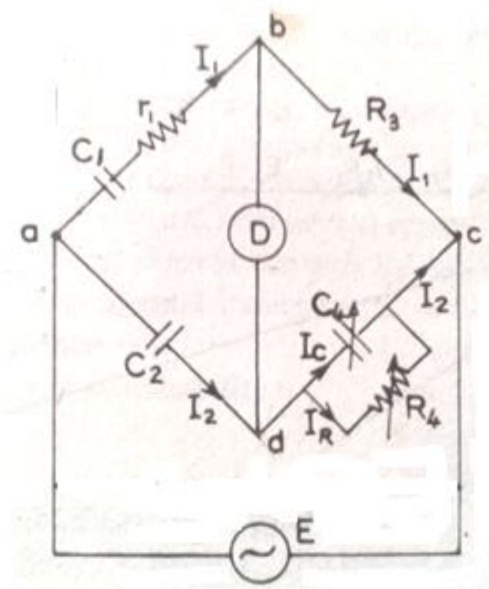
r1 – resistance of the capacitor C1

C2 – Known fixed capacitance

R3 – Standard fixed resistance

R4 – Variable resistance

C4 – Variable capacitor



Under balanced condition, Detector shows zero deflection

$$\mathbf{C1 = \frac{R4}{R3} C2}$$

$r1 = R3\frac{C4}{C3}$

Location of cable fault

1, Murray loop test

2, Varley loop test

these two tests are used to find the location where earth fault or short circuit fault occur in underground cables.

Murray loop test

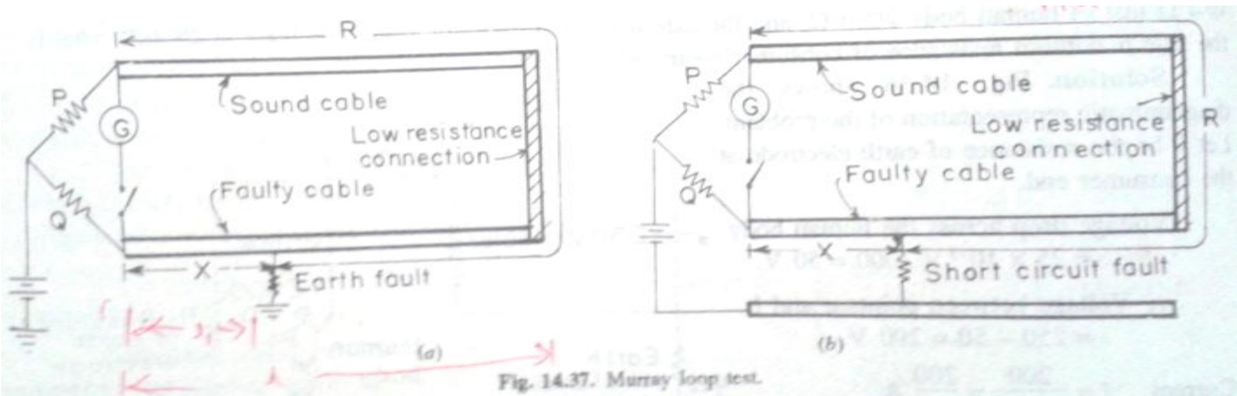


Fig. 14.37. Murray loop test.

it consists P/Q ratio arms , Battery source and galvanometer

$$\frac{P}{Q} = \frac{R}{X}$$

$$\frac{P}{Q} + 1 = \frac{R}{X} + 1$$

$$\frac{P+Q}{Q} = \frac{R+X}{X}$$

$$X = (R+X) * \frac{Q}{P+Q}$$

since $X = l1r$ and $R + X = 2lr$, where r = resistance per unit length

$$l1r = 2lr * \frac{Q}{P+Q}$$

$$\boldsymbol{fault\ length\ l1 = 2l * \frac{Q}{P+Q}}$$

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