EEM

Measurement:-

It is the result of a quantitative comparision between a predetermined valve and an unknown magnitude.

The whole procedure and apparatus required for obtaining the comparision, however must be provable the whole procedure is known as calibration.

Errors in Measurement:-

1. Gross error:- It occurs due to human mistake in reading, recording and also calculating result of measurement.

This error can be avoided by following two aspects:-

(a) while taking the reading and recording the data, care should be taken.

(b) two, three or more readings should be taken for the quantity being measured.

2. Systematic error:-

ⓐ Instrumental error:-

This error is due to misuse of instrument, loading effect of the instrument.

(i) This error may cause the instrument to read too low or too high.

(ii) Some example of such errors are Mechanical friction, pin or pointer, hysterisis of elastic members.

(iii) poor maintenance of instrument, Excessive friction.

(iv) Excessive friction at various parts, lost motion due to necessary clearance at bearing part, teeth etc.

(b) Environmental error:-

This error is due to condition of external to the measuring device (effect of pressure, temperature, humidity, dust, vibration, external magnetic field etc.)

This error can be reduced by:-

* Using the instrument in controlled condition of pressure, temperature, humidity, in which it was originally assembled.
* Make a complete new calibration under the local condition.
* Applying the computed correction to avoid this type of errors.

(c) Observational errors:-

This error is due to carelessness of an operator.

(i) parallax:- This error on account of pointer and scale are not in the same plane.

(ii) Wrong scale reading and wrong recording of data.

(iii) Tendency to read high or low by personal bias.

3) Random error:

This error is small, accidental, independent. The magnitude and direction of this error cannot be predicted from the knowledge of measurement system.

Types of instruments used as Ammeter & voltmeter.

1) PMMI - permanent Magnet Moving iron type instrument

(a) It is most commonly used form of indicating instrument as well as cheapest.

(b) It can be used for both D.C. and a.c. measurement.

(2) PMMC - permanent magnet moving coil type instrument.

There are two types :- (i) Attraction type
(ii) Repulsion type.

Attraction type moving iron instrument:-

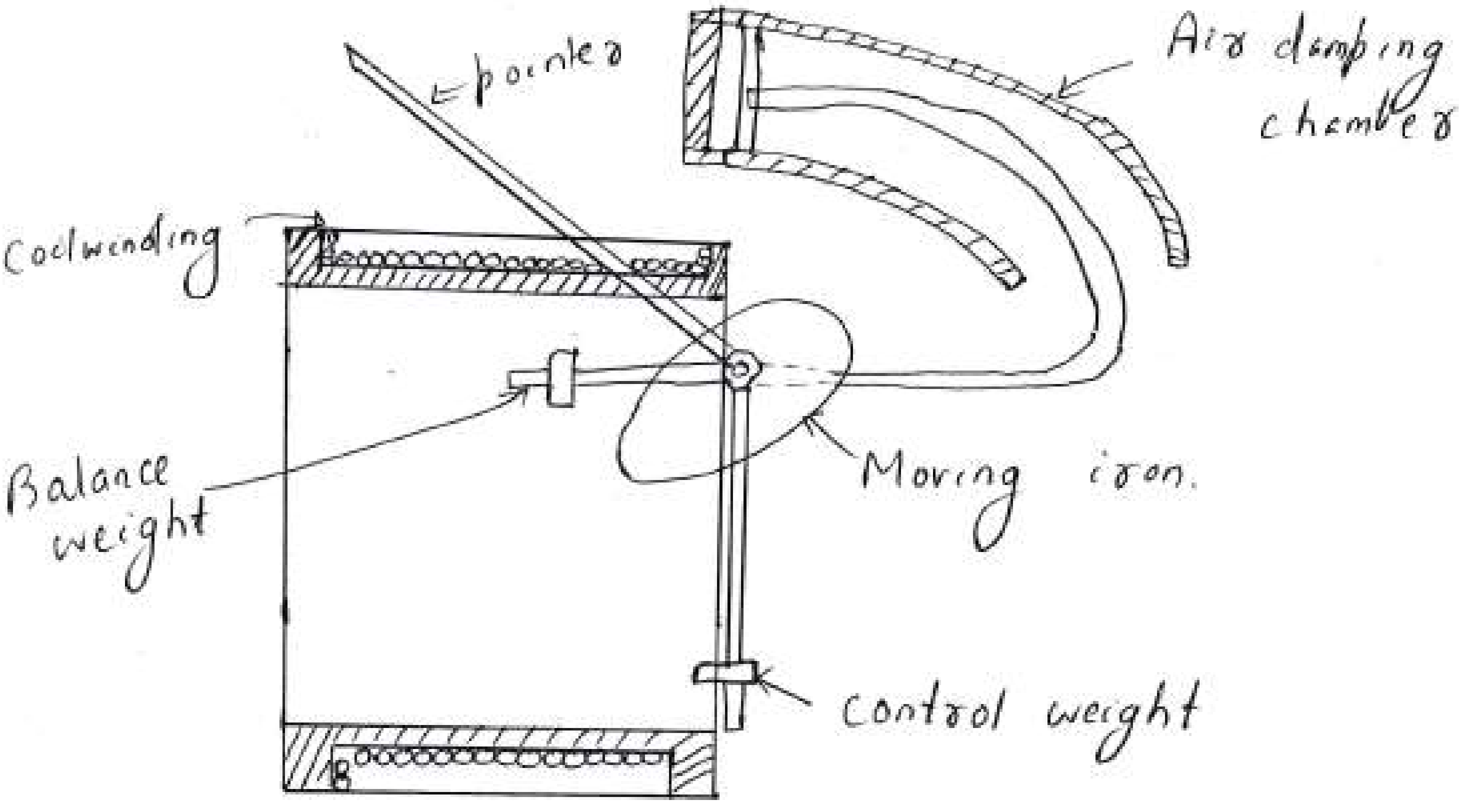


Fig (1)

This figure shows the principle of operation of an attraction type MI instrument. The moving iron is a thin disc of soft iron and is eccentrically pivoted. When a current flows through the coil, the soft iron moves toward the inside the coil, where the field is stronger. Since the pointer is fixed to the spindle carrying the soft iron disc, the former deflects when the latter

Since the magnetic field produced is setup by the current flowing through the coil, the deflection can be calibrated to measure the current.

In this figure, gravity control has been to produce the controlling torque Tc. However present day moving iron instruments invariably use spring control.

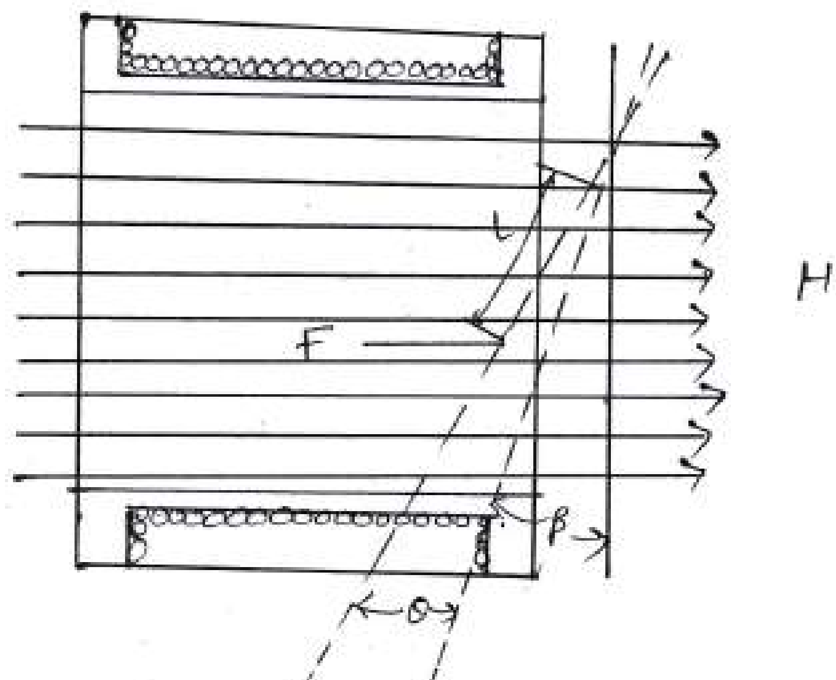


Fig (2)

In this fig.(2) shows the magnetic field inside the coil, due to current I flowing through it. It is assumed that the axis of the disc has eccentricity β

by the coil when in zero position.
Further, it is assumed that disc deflects through an angle θ, when current I flows through the coil. The component of field H producing magnetization of the disc is proportional to $H \cos\{90-(\beta+\theta)\}$ or $H \sin(\beta+\theta)$. Since field H is produced by the current I, the force F on the disc is proportional to $I^2 \sin(\beta+\theta)$.

If it is assumed that this force is acting on the disc at a distance l from the pivot, the deflecting torque T_d is proportional to $l \cos(\beta+\theta)$. As the deflecting torque T_d is dependent on F,

$$T_d \propto I^2 \sin(\beta+\theta) l \cos(\beta+\theta).$$

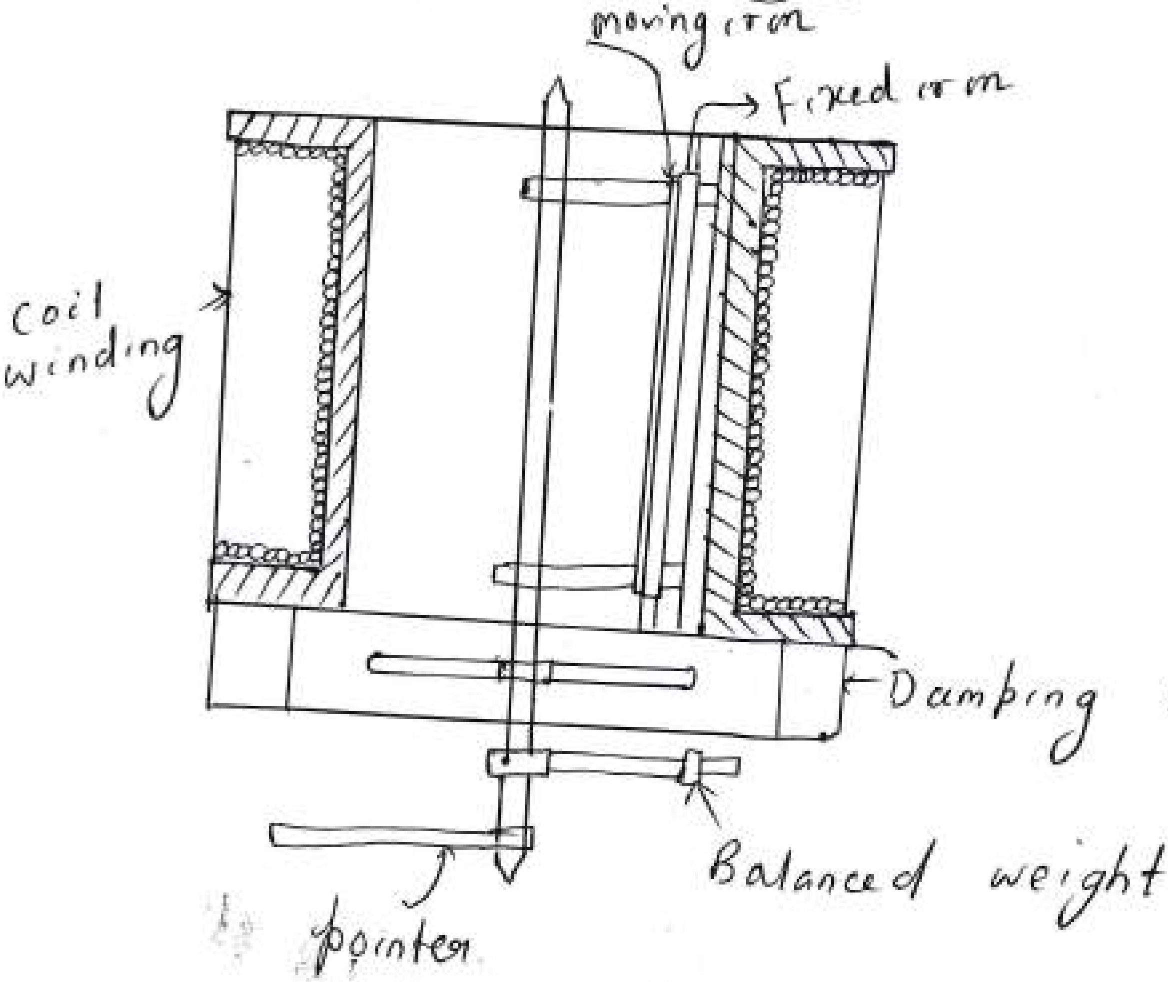
Since l is const.

$$T_d = k I^2 \sin 2(\beta+\theta)$$

The controlling torque $T_c = k'\theta$.
In steady state $T_c = T_d$.

$$k'\theta = k I^2 \sin 2(\beta+\theta)$$

Repulsion type MI (moving iron) instrument:-



This figure shows the sectional view of a repulsion type MI instrument. Two soft iron rods, one fixed and other movable, are placed inside the coil. The movable rod carries a pointer inside the coil, which slides over a calibrated scale. Damping of the pointer is through air friction provided by a light piston moving inside

When current I flows through the coil, the iron rods are similarly magnetized and a force of repulsion is experienced by them. Consequently, the moving soft iron rod moves away from the fixed rod, thereby causing the pointer to deflect.

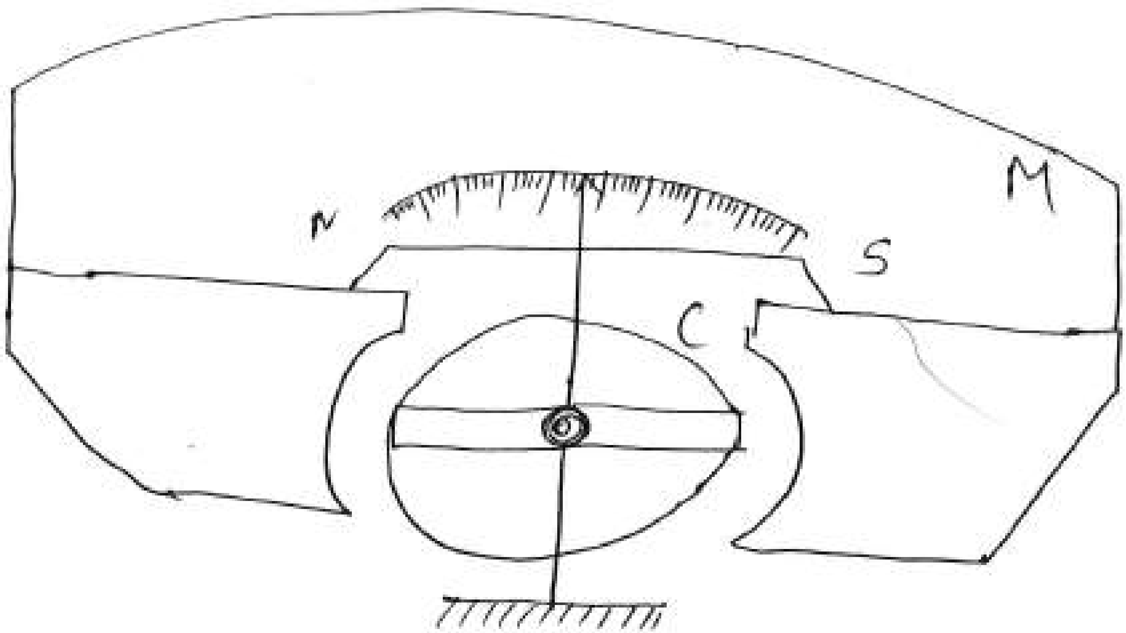
Advantage of moving iron instrument:-

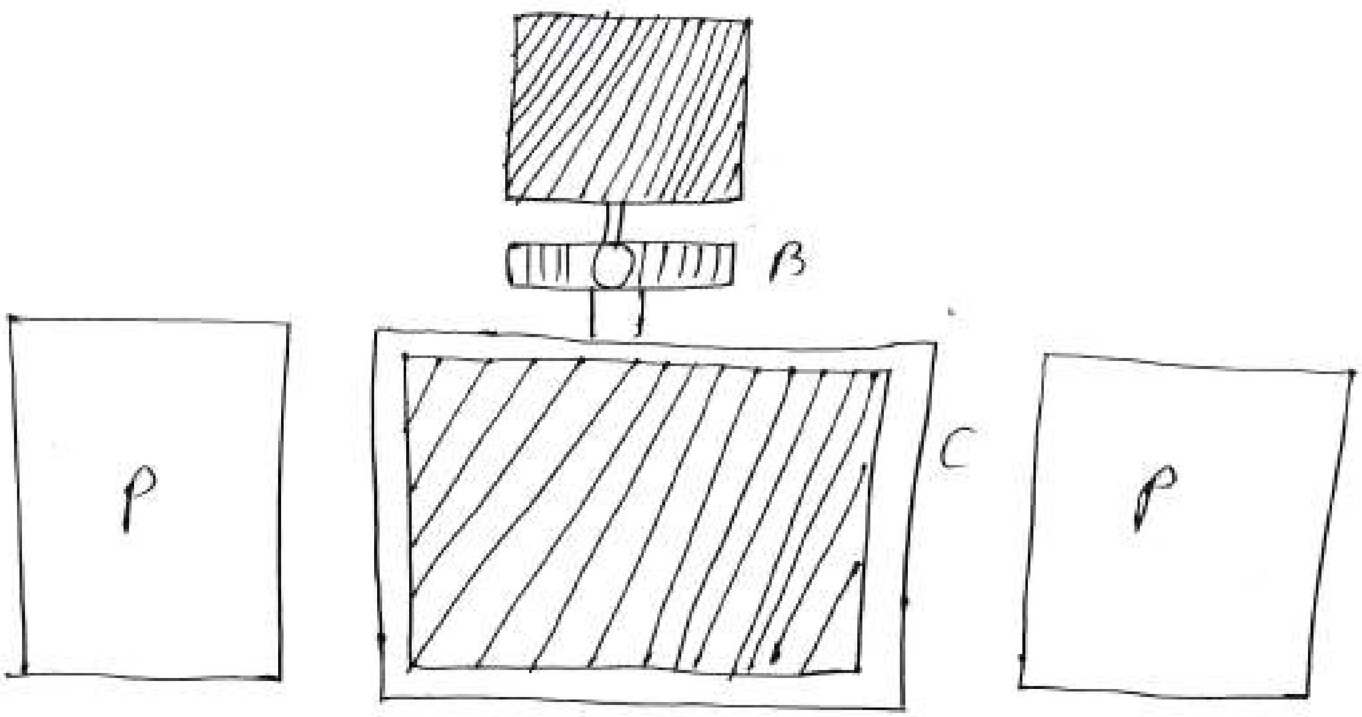
1. It is robust and simple in construction.
2. It can possess high operating torque.
3. It can withstand overload capacity.
4. It is suitable for low frequency and high power circuit.
5. Less friction errors.

Drawback of moving iron instrument:-

1. Scale is not uniform.
2. For low voltage range, power consumption is higher.
3. In case of A.C. measurement change in frequency causes serious error.

Permanent Magnet Moving coil instrument:-





This instrument works on principle that when a current carrying conductor is placed in a magnetic field develops a force which tends to move it

The instrument consists of permanent magnet M and a reactangular coil C which consists of insulated copper wire on light Aluminium frame fitted with pollished steel, resting in jewel bearing. This permanent magnet is made of alnico and soft iron pieces PP which are bored out cylindrically. The function of central core to intensity the magnetic field by reducing the length of air gap across which the magnetic flux has to pass.

When the current is passed through the coil forces are setup on the both side which produce deflection torque Td. If I is the current passing through the coil the force F experienced by each of the side $F = BIl$ N.

B = flux density wb/m²

l = length of coil in m.

If N = No. of turns; Force $F = NBIl$ N

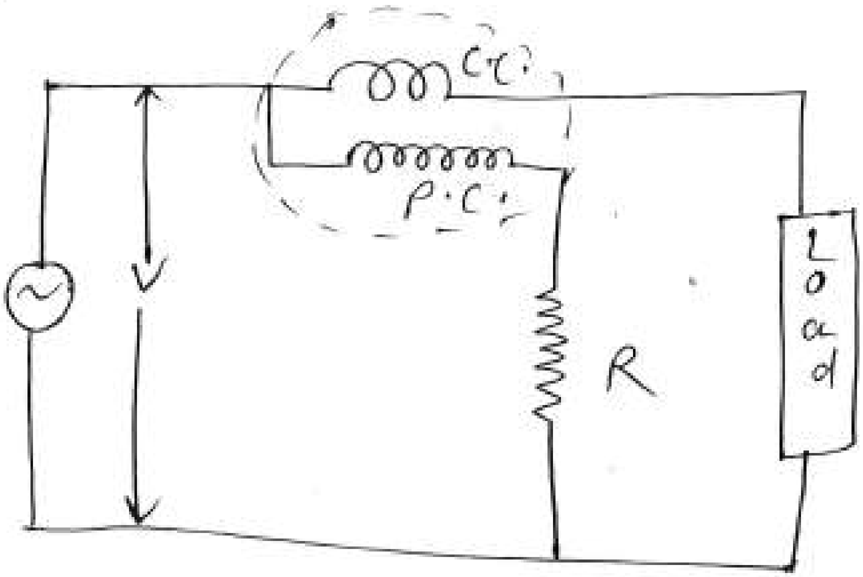
deflecting torque Td = Force x distance

The instrument works on principle that when a current carrying con

Advantages of PMMC instrument:-

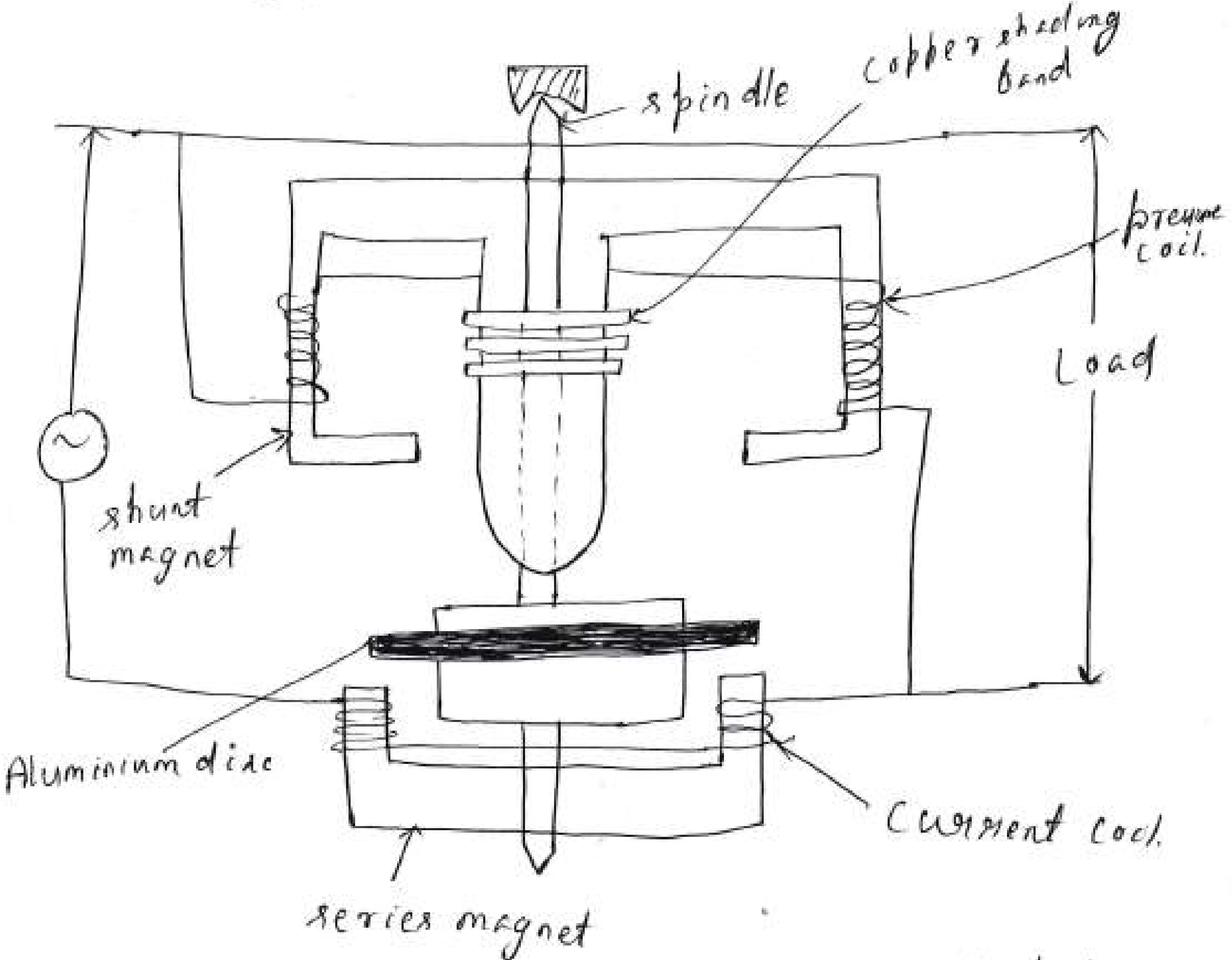
1. low power consumption.
2. Scales are uniform.
3. It has no hysteresis loss.
4. They have very effective and efficient.
5. This range can be extend addition of multiple.

Wattmeter



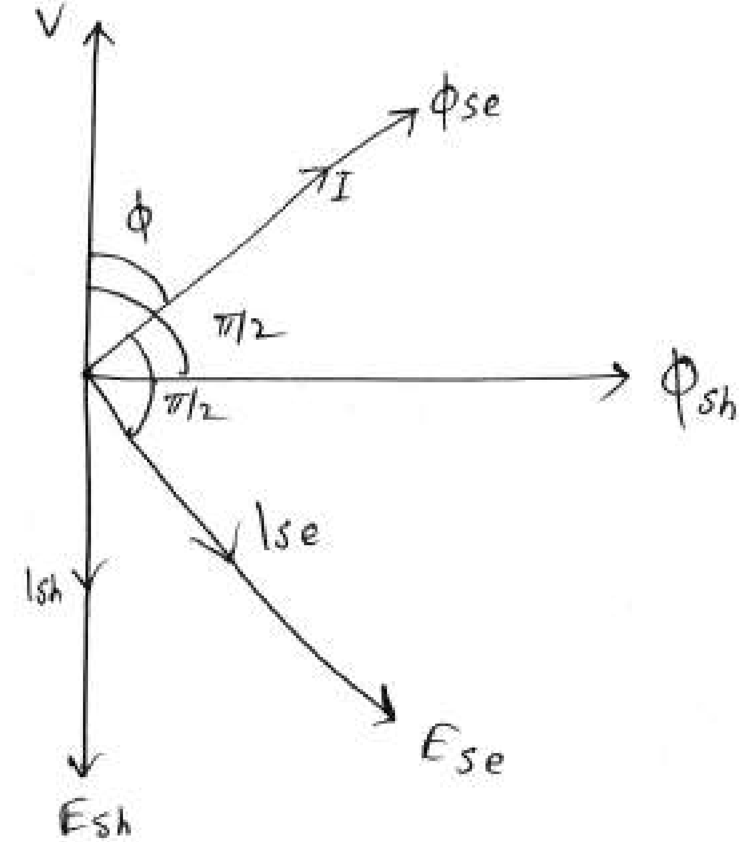
The wattmeter is the combination of an ammeter and voltmeter. Therefore, it consists of two coil known as current coil, and pressure coil. The operating torque is produced due to interaction of fluxes on account of currents in current coil and

Induction type Wattmeter:-



The working principle of Induction instruments is based on the torque produced by a flux, whose magnitude depends on the current or voltage to be measured, and eddy currents which are induced in a metal disc by another flux, whose value again depends on the current, or the voltage to be measured.

The working principle of an induction wattmeter is based on the Induction effect. An induction wattmeter consists of two laminated electromagnets, between which a thin aluminium disc is mounted. The disc is so positioned that the flux from both the magnets cut the ~~flux~~ disc. The winding on one of the magnets, called the pressure coil, is excited by a current proportional to the applied voltage. The other magnet, called series magnet, carries the current coil, and is excited by the load current. The pressure coil electromagnet called shunt magnet is fitted with one or more copper bands. The position of copper bands can be adjusted to make the resultant flux in it lag the applied voltage by precisely 90°. As a result of the flux produced in the two magnets, eddy currents are induced in the aluminium disc. The interaction between the eddy currents and the fluxes produces the deflecting torque.



Working principle:-

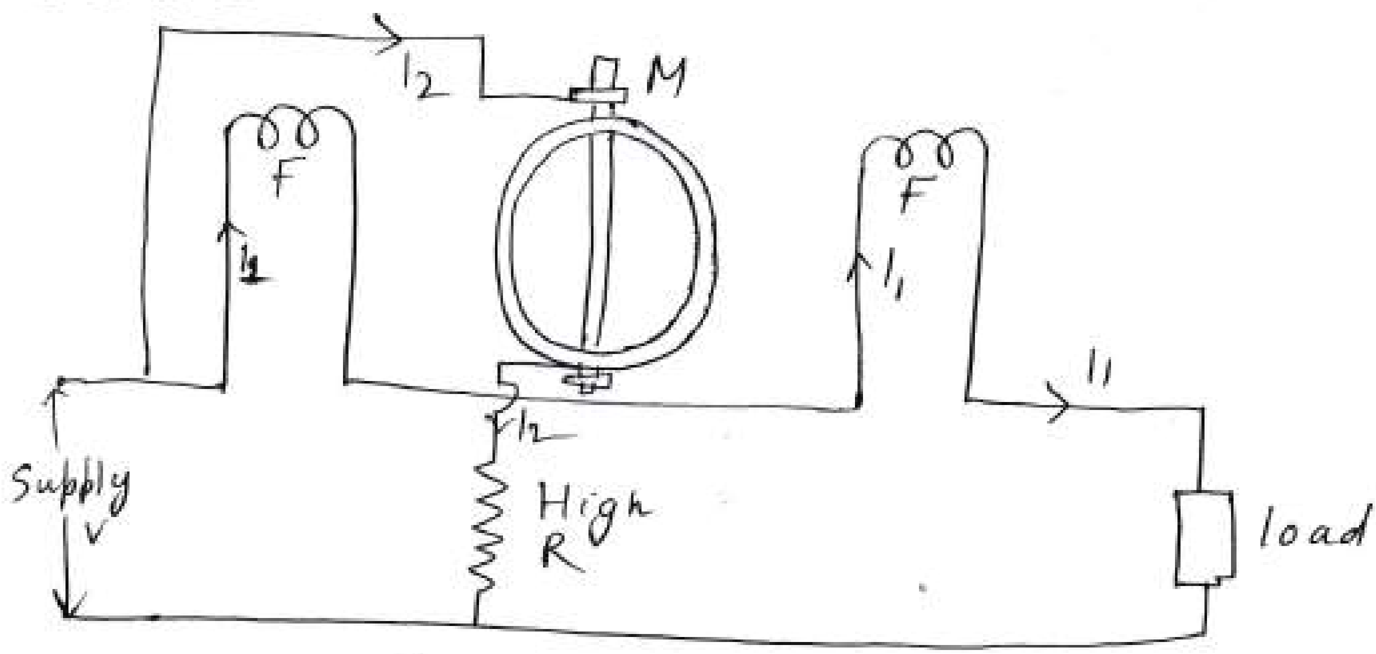
The load current I lags the voltage V by an angle ϕ shown in the figure. The shunt flux ϕ_{sh} lags behind the voltage by $\pi/2$. The series Emf and shunt Emf, E_{se} and E_{sh} induced in the disc due to the flux ϕ_{se} and ϕ_{sh}, they lag behind their response fluxes by $\pi/2$. The current I_{sh} and I_{se} are set up by their induced emf E_{sh} and E_{se} are in phase with their respective emf. Now the two opposite torque given by $\phi_{sh} \times I_{se}$ and $\phi_{se} \times I_{sh}$ will act on the disc. The instantaneous value

$$T_{req} = \phi_{sh} \cdot I_{se} - \phi_{se} \cdot I_{sh}$$

Advantages:-

It is fairly long scale, good damping.

Dynamometer Wattmeter



This figure shows the connection diagram for a dynamometer type wattmeter. The fixed aircored coil is circular in shape and divided into two halves. Both halves are parallel to each other, and the distance between them is adjusted to obtain a uniform magnetic field. It carries main circuit current and is called

The moving coil is centrally pivoted and carries a pointer which moves over a graduated scale. A current that is proportional to the applied voltage is fed to the coil through phosphor-bronze springs M. The moving coil is designated as the voltage coil. These springs also provide the controlling torque. Damping is provided by a piston moving inside an air chamber. R is high resistance connected in series with the moving coil to reduce the phase effect of the inductance of the voltage coil.

Let it be assumed that a direct current I flows in the fixed coils, a magnetic field of B wb/m² is produced, the current I' (which is proportional to the dc voltage V) flows through the moving coil. Then the deflecting Torque Td is proportional to BI'.

But $B \propto I$

and $I' \propto V$

Hence $T_d = KVI$ (product VI is the dc power)

In case of AC quantities,

$$T_d = kvi$$

v and i are instantaneous values of voltage and current, respectively. Due to intertia of moving parts, the reading shown is the average of the mean power. Therefore, the mean value of the deflecting torque $T_{d,mean}$ is given by

$$T_{d,mean} = k \times (\text{average value of instantaneous power } vi)$$

If $v = V_m \sin\theta$, $i = I_m \sin(\theta - \varphi)$ then

$$T_{d,mean} = k\frac{V_m I_m}{2\pi}\int_0^{2\pi} \sin\theta . \sin(\theta - \varphi) . d\theta$$

On simplification $T_{d,mean} = VI\cos\varphi$.

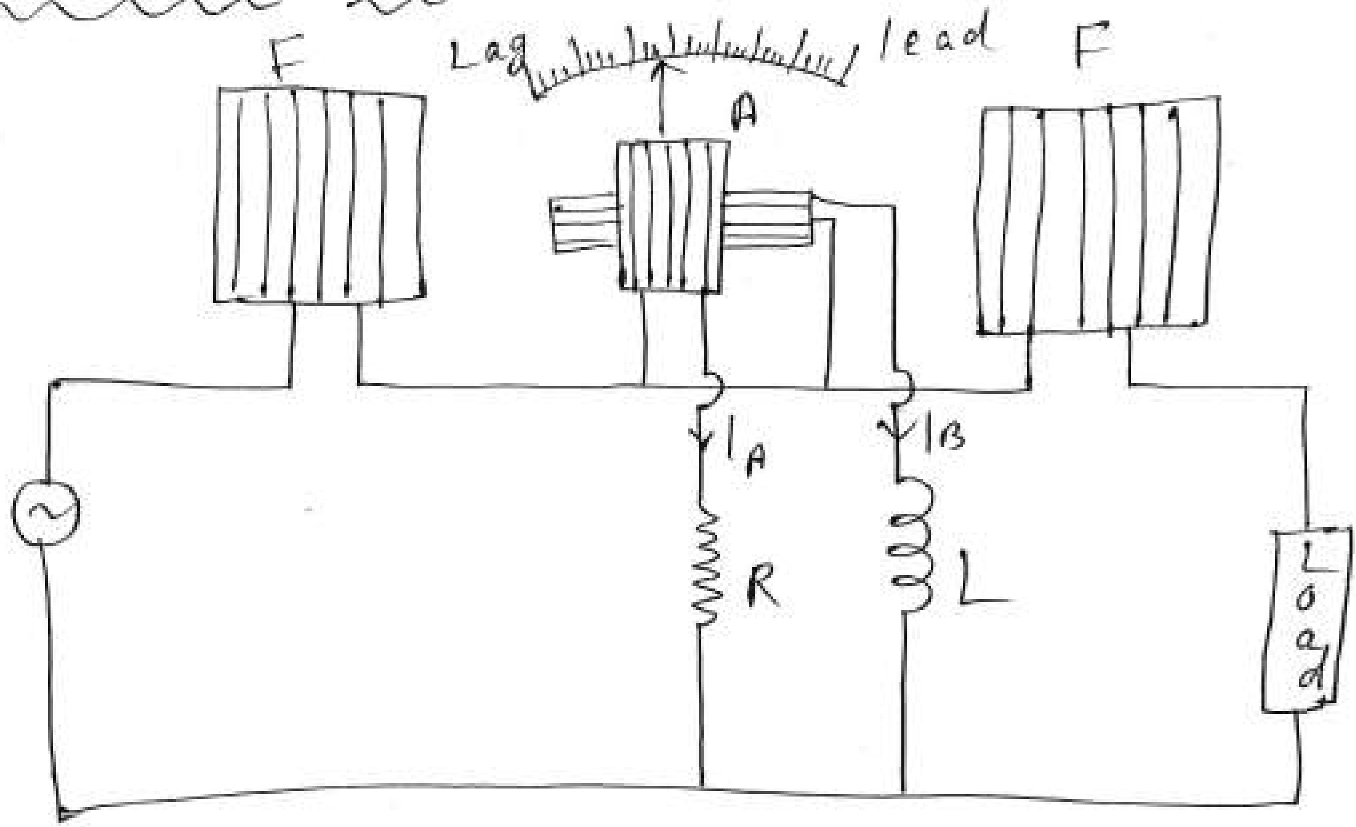
Since a spring control system is used, T_c is proportional to θ, where θ is deflection of the pointer. In steady state,

$$T_d = T_c$$

Hence $\theta \propto VI\cos\varphi$.

This is the actual power in an alternating circuit.

Dynamometer type power factor meter:-

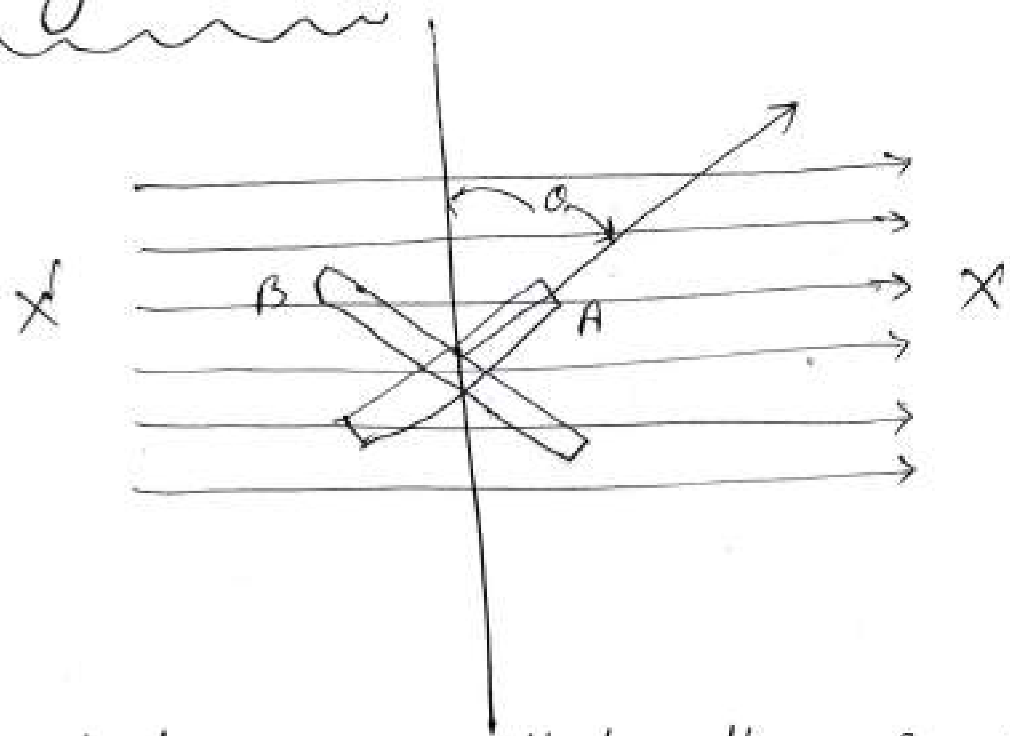


Power factor meter indicates the power factor of a circuit directly, whose readings the power factor may be obtained by dividing the watt supplied by the VA in the circuit.

It consists of fixed coil FF which carries the current of the circuit, under testing. Therefore the magnetic field produced by the coil is proportional to main current. The pressure coil A and B pivoted on a spindle have the moving system. The two coils are connected

The values of R and L are so adjusted that two coils carry same values of current at normal frequency. The current through the coil A in phase with circuit voltage, coil B lag the voltage by an angle δ, which is nearly equal to π/2. The moving coils are made silver or gold ligaments, which are extremely flexible gives a minimum control effect of the moving system.

Working principle:-



Let us assume that the field of two coils are uniform and torque on each coil will be maximum when it is parallel to the field along XX'. When a system power factor angle is ϕ, then the coil A is

The torque on coil A is

$$T_A = KVI\cos\phi \cdot \cos(90° - \theta), \text{ k is const.}$$

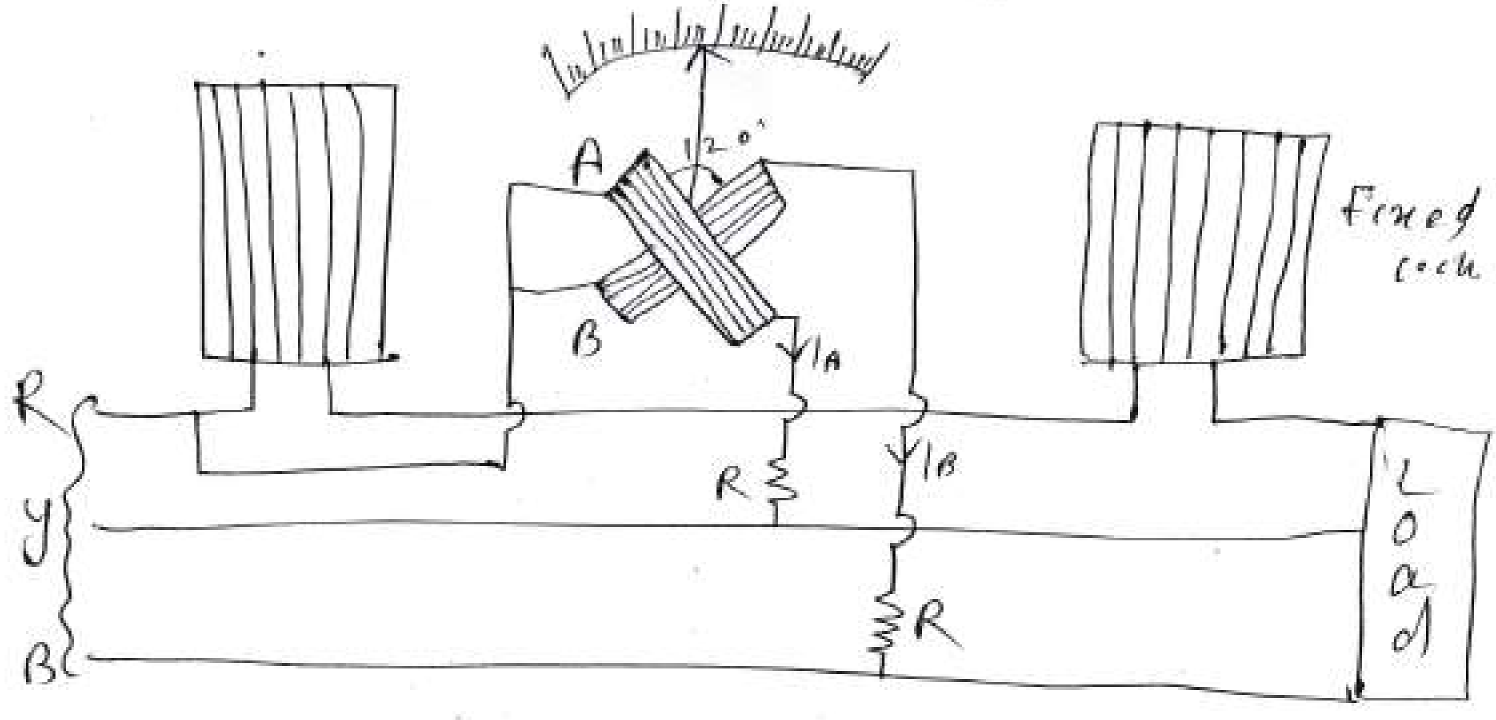
Similarly in coil B current lags the voltage by $\pi/2$, the coil B displaced θ from the maximum torque position. So the torque on coil B is

$$T_B = KVI\sin\phi \cdot \cos\theta, \text{ where k is const.}$$

For balanced condition

$$\boxed{T_A = T_B \text{ and } \theta = \phi}$$

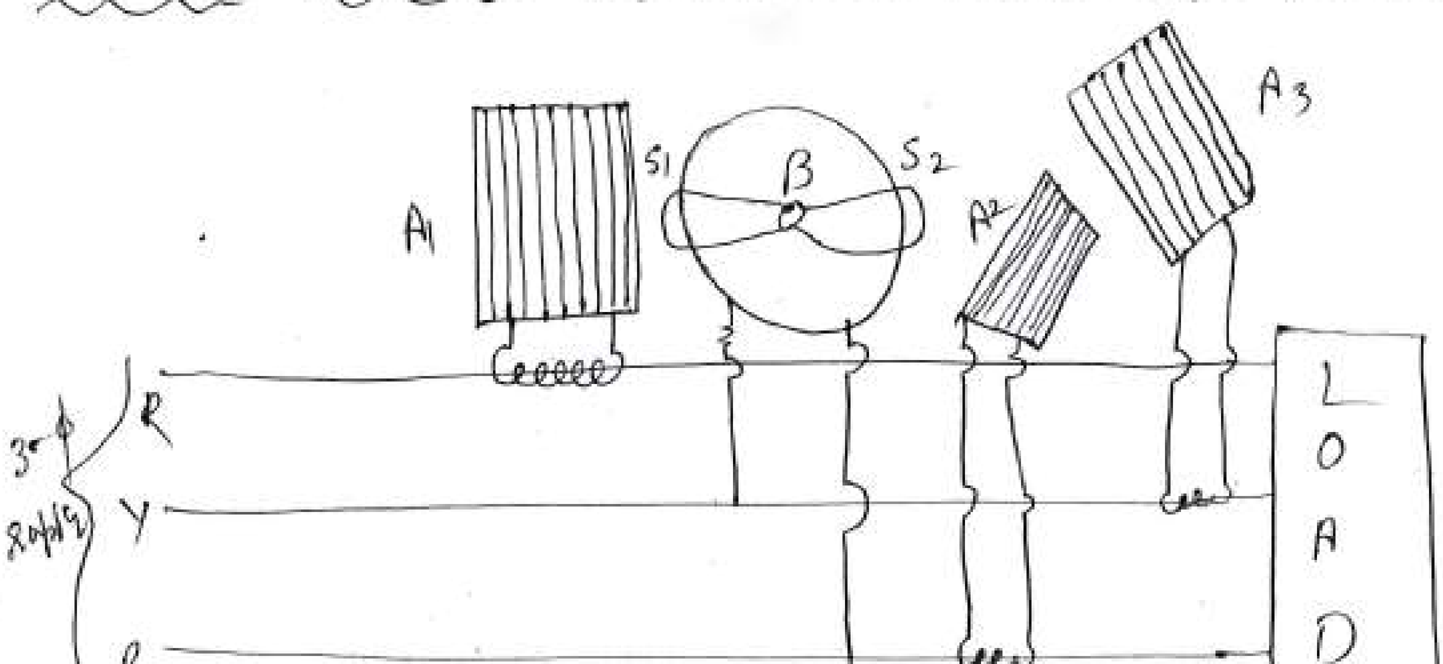
Dynamometer type power factor meter for balanced three phase load:-



In this instrument the two moving coils are fixed to 120° apart. The fixed coil FF connected in R and carrying the current in the line. There is no necessity for phase splitting. Since the required phase displacement between the current of the moving coils obtained from the supply.

The moving coils are 120° apart, the angle which the pointer is displaced from the unity power factor position is equal to phase angle of the circuit. This meter gives indication independent of frequency and waveform. This type of instrument is more accurate than moving iron type instrument.

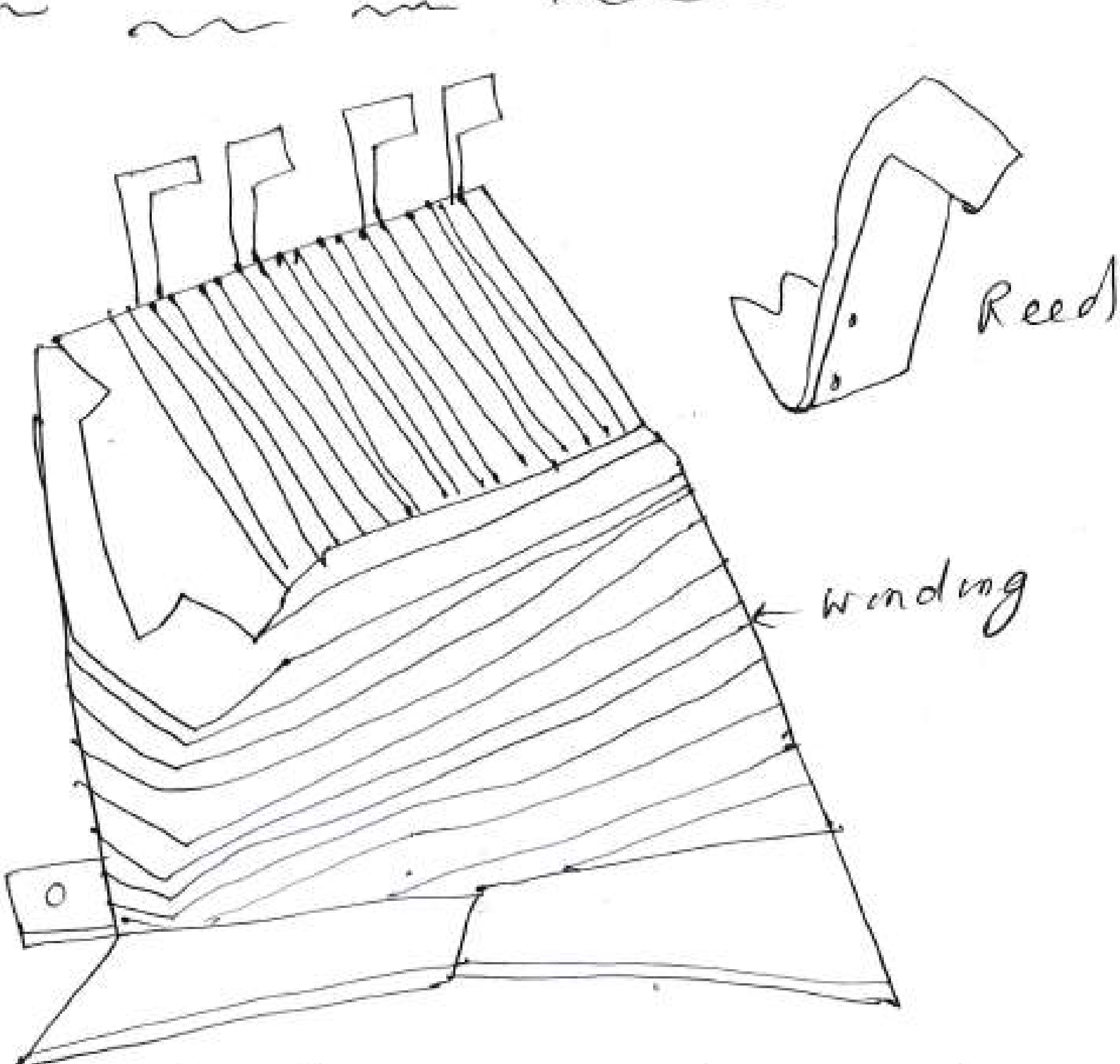
Moving irontype powerfactor meter for threephase



A rotating field is set up by the three coils A_1, A_2 & A_3, which are supplied from three phase line through current transformer. The coil B is placed at the centre of the system which is connected in series with resistance across two lines of the supply. Inside the coil B, there is a iron rod, with sector shaped, piece S_1 and S_2 at the ends. Damping vane and pointer also attached through the coil B.

The moving iron carries alternating flux. Its rotation depends upon relative phase of the current in coil B, which is practically in phase with the voltage, and the current in coil A. The deflection of the moving system is approximately equal to angle of phase displacement between current and voltage in three phase circuit

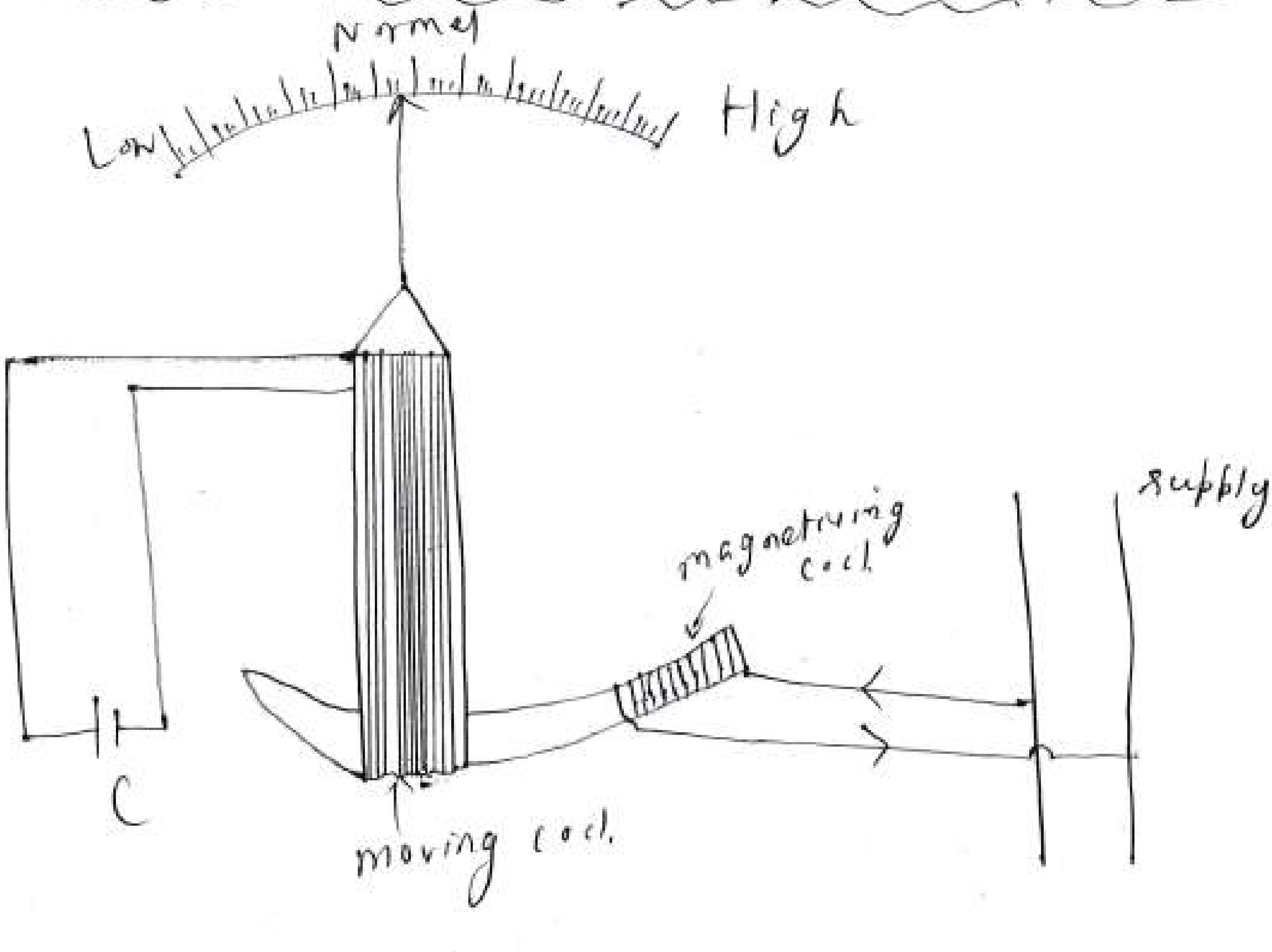
Mechanical resonance type frequency meter:-



The frequency meter works on the principle of mechanical resonance of thin flat steel reeds arranged along side and closed to an electromagnet. That is why this frequency meter is known as Vibrating Reed type frequency meter. The electromagnet has laminated core and its coil is connected in series with the resistance

The reeds are fixed at the bottom end and free at the top end. When the instrument is connected across the supply which frequency is to be measured, an alternating flux is setup in the core due to this alternating flux an attractive force is experienced

Electrical Resonance type frequency meter:-



It consists of a laminated iron core A magnetising coil mounted at one end of the iron core. A moving coil pointer is attached to it and pivoted so that it can move freely over the iron core. The moving coil is connected across the capacitor C and fixed coil is connected across the supply, whose frequency is to be measured. When the magnetising coil is connected across the supply, current I flows through it and flux is setup in the iron core and emf is induced in the moving coil. The current in the moving coil may be lagging or leading the induced emf depending upon whether circuit is inductive or capacitive.