CHAPTER: 7 (12 MARKS)

ELECTRICAL EQUIPMENT

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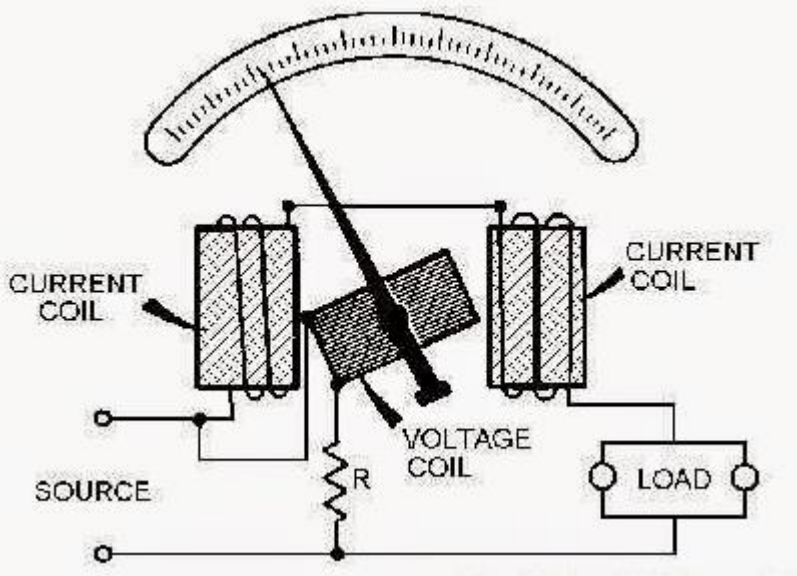
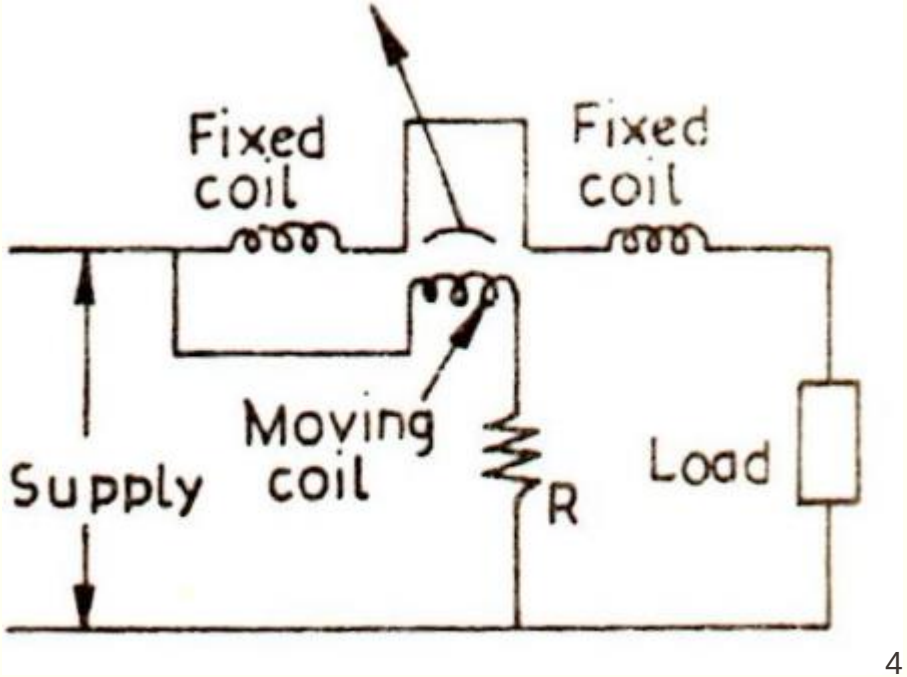
Wattmeter Types

- Electro-dynamometer or Dynamometer type wattmeter
  - Suspended coil torsion-head dynamometer type wattmeter
  - Pivoted coil direct indicating dynamometer type wattmeter
- Induction type wattmeter

Working Principle of Electro-dynamometer type wattmeter

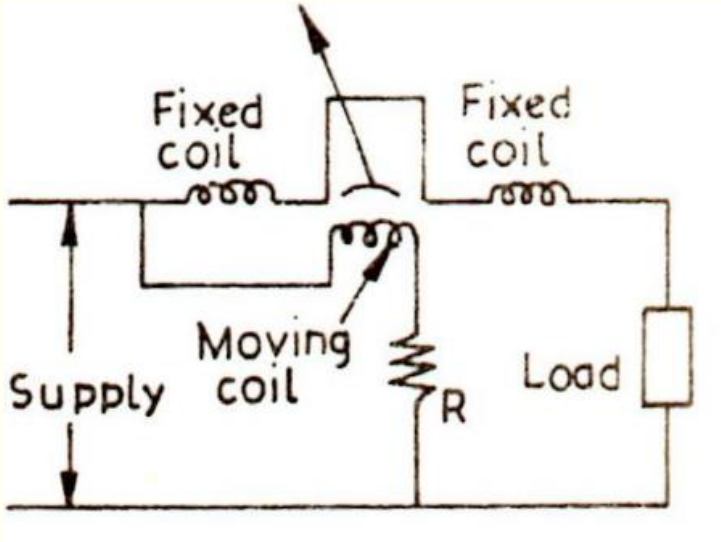
- Operates on the principle that when a current carrying coil is under magnetic field then it experiences a deflecting torque.
- Fixed coil is divided into equal two halves which is connected in series with the load whose power is to be measured.
- Moving coil with series resistance is connected in parallel with supply voltage.





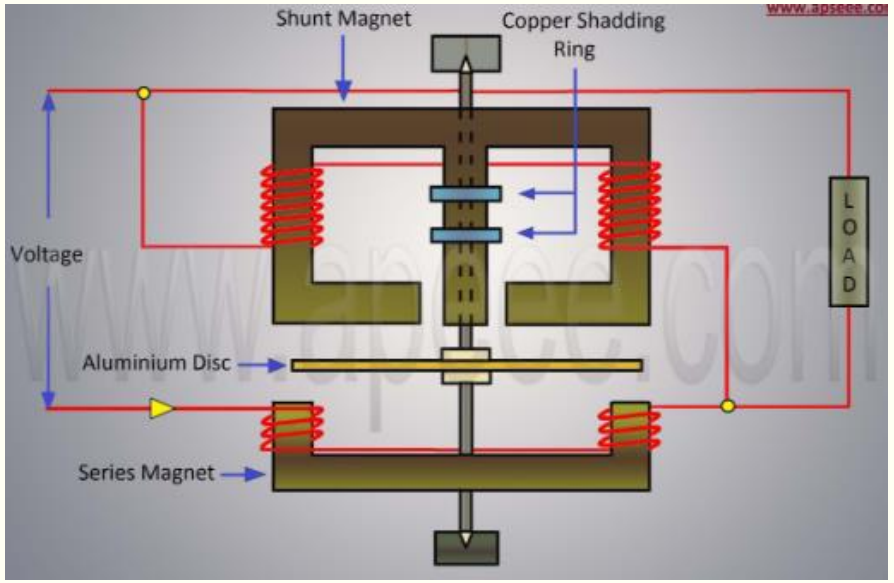
Working Principle of Electro-dynamometer type wattmeter

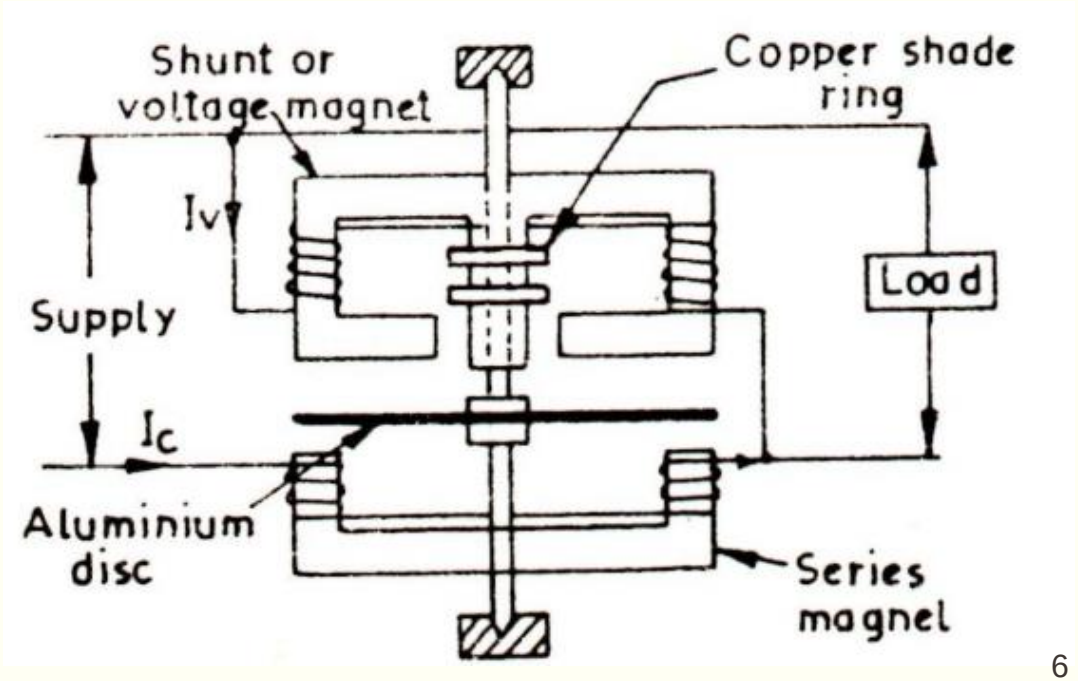
- I1- current through Fixed coils(current coils)
- I2- current through moving coils (voltage coils)
- Flux density is proportional to I1.
- B proportional to I1
- Fixed coils are responsible for producing the required magnetic field.
- When the current flows through moving coil, it experiences the deflecting torque and moves to show deflection.
- Td proportional to B * I2(proportional to V)
- Td proportional to I1 * V and I1 >> I2)
- Td proportional to Power



Working Principle of Induction type wattmeter

- The shunt magnet carries current proportional to the supply voltage and the series magnet carries the load current. The two fluxes produced by the magnets induce eddy currents in the aluminium disc. The interaction between the fluxes and eddy currents produce the deflecting torque on the disc, causing the pointer connected to the moving system to move over the scale.
- Equivalent circuit is almost same as dynamometer type.
- can only be used in AC system.





Energy Meter Types

- Electrolytic Energy Meter
  - Operating principle depends on electrolytic action
- Clock Energy Meter
  - Functions as in clock mechanism
- Motor Energy Meter (operating principle as in electric motor)
  - Mercury Motor meter
  - Commutator Motor Meter
  - Induction Motor Type Energy Meter

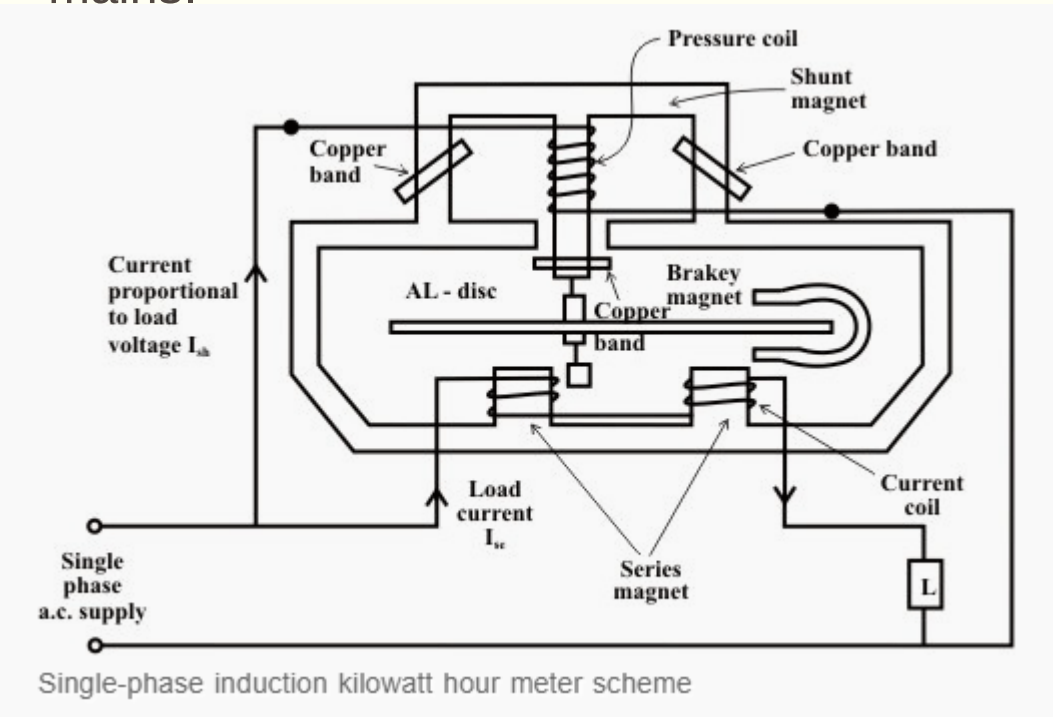
Working Principle of Single phase Induction motor type Energy meter

- Single phase induction type energy meter is also popularly known as ***watt-hour meter***.
- essentially consists of following components:
- Driving System, moving system, braking system, registering system

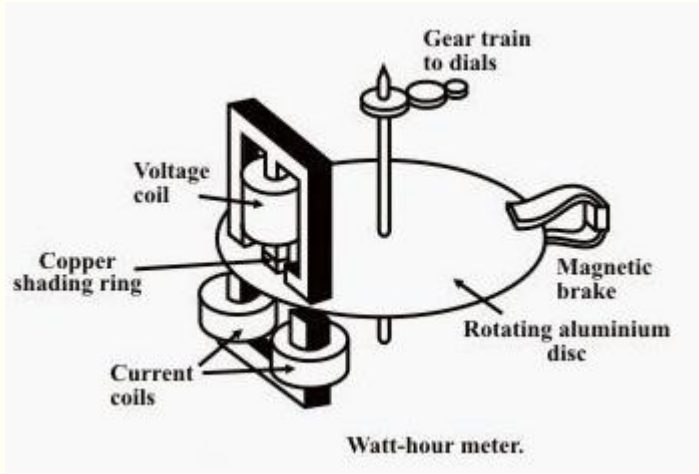
Single-phase induction kilowatt hour meter

Working Principle of Single phase Induction motor type Energy meter – Driving System

- consists of two electromagnets, called ***"shunt" magnet*** and ***"series" magnet***, of laminated construction.
- A coil having large number of turns of fine wire is wound on the middle limb of the shunt magnet.
- This coil is known as "***pressure or voltage***" coil and is connected across the supply mains.



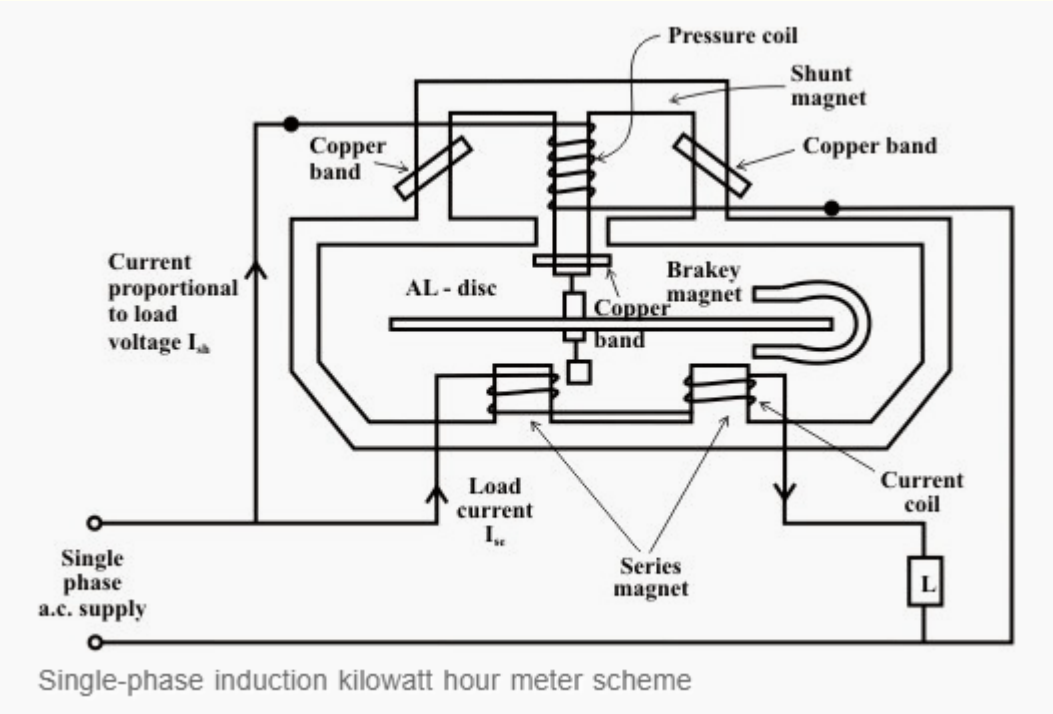
Single-phase induction kilowatt hour meter scheme



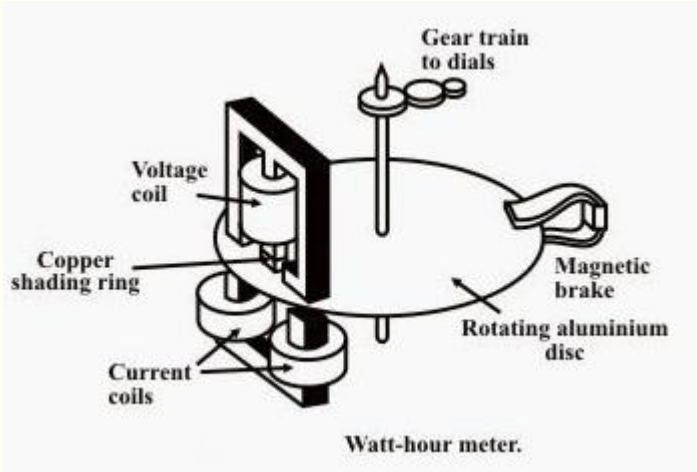
Watt-hour meter.

Working Principle of Single phase Induction motor type Energy meter – Driving System

- The series electromagnet is energized by a coil, known as ***"current" coil*** which is connected in series with the load so that it carry the load current.
- The flux produced by this magnet is proportional to, and in phase with the load current.



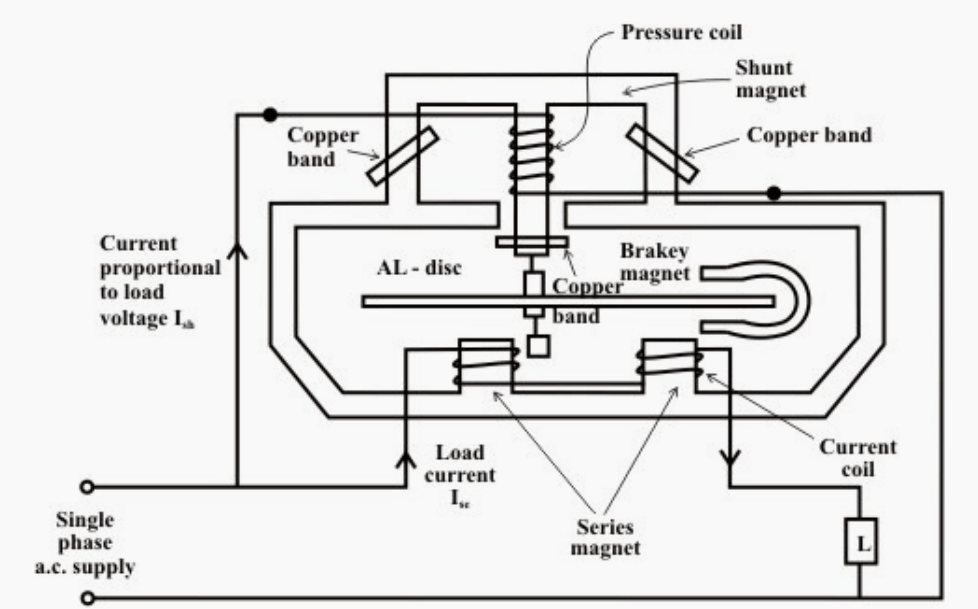
Single-phase induction kilowatt hour meter scheme



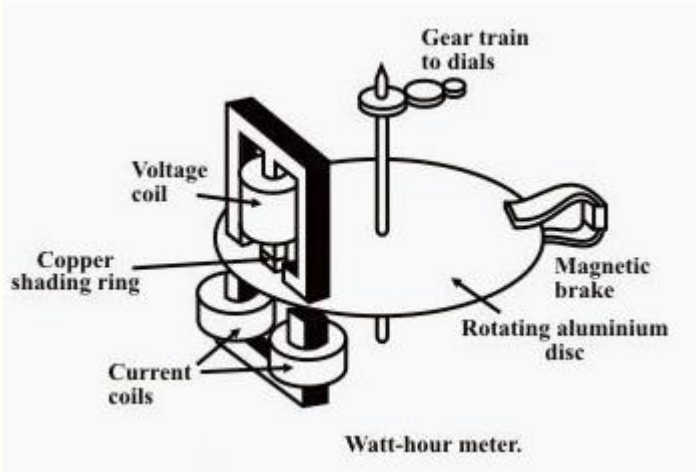
Watt-hour meter.

Working Principle of Single phase Induction motor type Energy meter – Moving System

- consists of a light rotating aluminium disk mounted on a vertical spindle or shaft.
- The shaft that supports the aluminium disk is connected by a gear arrangement to the clock mechanism on the front of the meter to provide information that consumed energy by the load.
- The time varying (sinusoidal) fluxes produced by shunt and series magnet induce eddy currents in the aluminium disc.
- The number of rotations of the disk is therefore proportional to the energy consumed by the load in a certain time interval and is commonly measured in ***kilowatt-hours (Kwh)***.



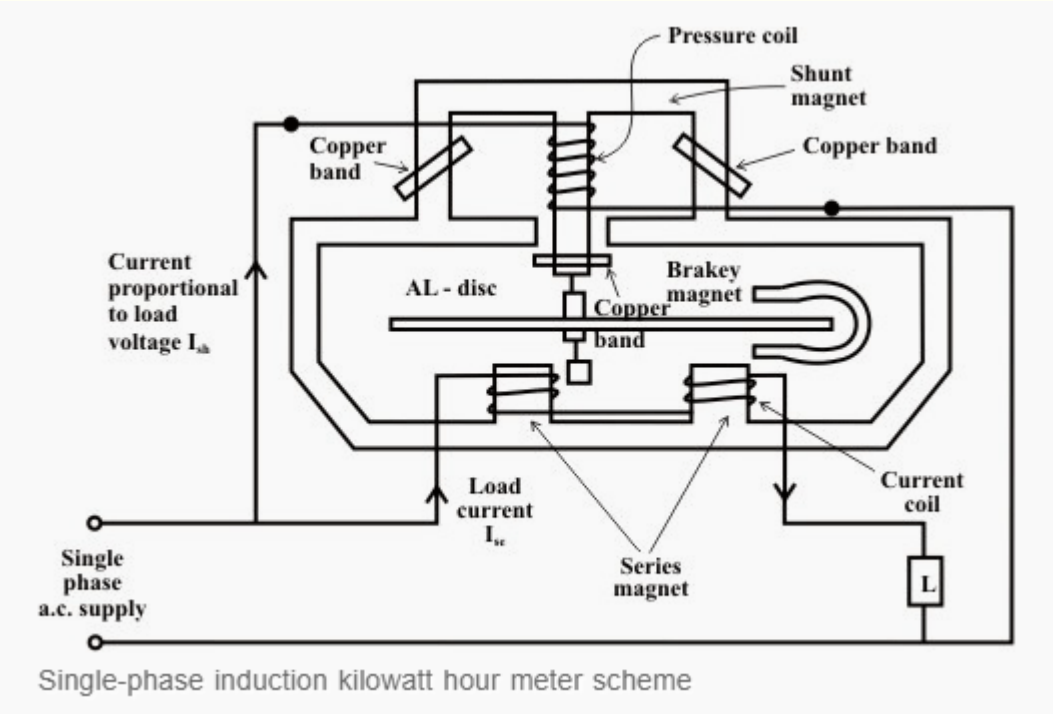
Single-phase induction kilowatt hour meter scheme



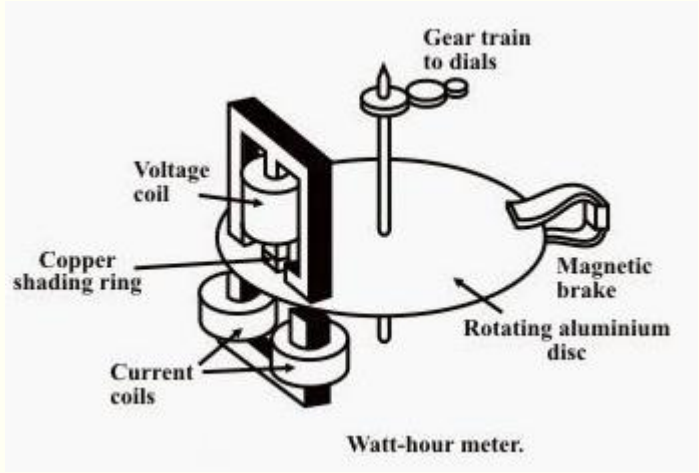
Watt-hour meter.

Working Principle of Single phase Induction motor type Energy meter – Braking System

- Damping of the disk is provided by a ***small permanent magnet***, located diametrically opposite to the a.c magnets.
- The movement of rotating disc through the magnetic field crossing the air gap sets up eddy currents in the disc that reacts with the magnetic field and exerts a braking torque to control the rotating disc.



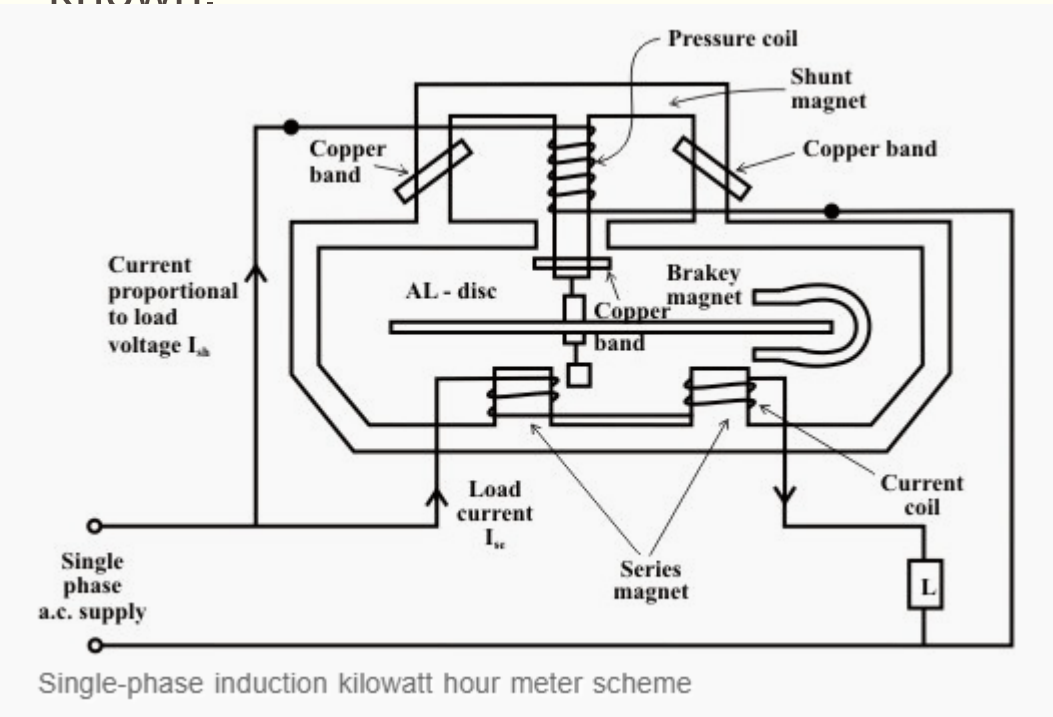
Single-phase induction kilowatt hour meter scheme



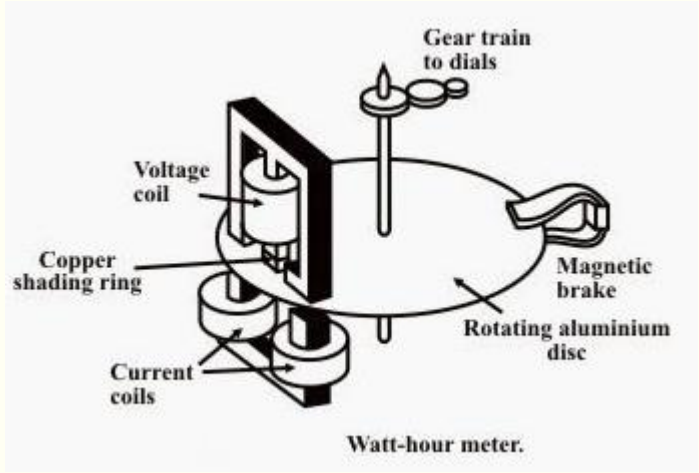
Watt-hour meter.

Working Principle of Single phase Induction motor type Energy meter – Registering System

- The registering or counting system essentially consists of gear train, driven by pinion gear on the disc shaft, which turns pointers that indicate on dials the number of times the disc has turned.
- The energy meter thus determines and adds together or integrates all the ***instantaneous power values*** so that total energy used over a period is thus known.



Single-phase induction kilowatt hour meter scheme



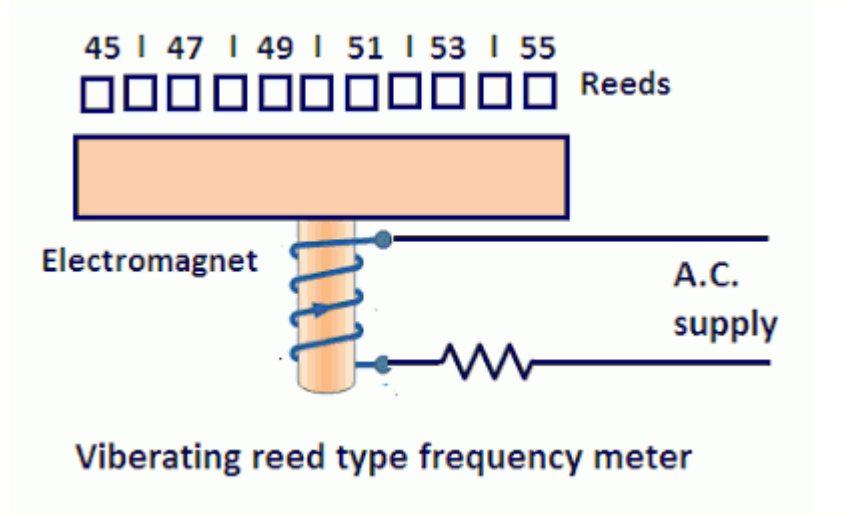
Watt-hour meter.

Frequency Meter Types

- Mechanical Resonance Type
- Electrical Resonance Type
- Weston Type
- Ratio-meter Type
- Saturable Core Type

Working Principle of Mechanical Resonance Type (Vibration Read Type) Frequency Meter

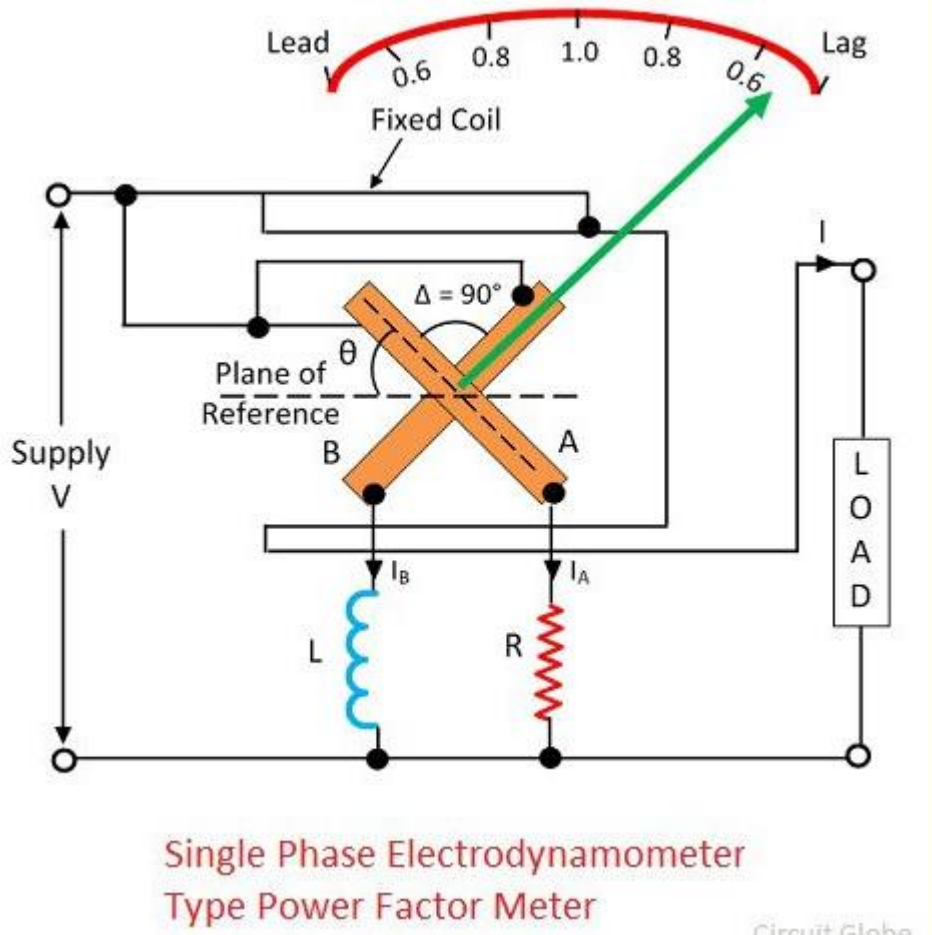
- A vibrating reed frequency meter consists of a number of thin steel strips called reeds.
- These reeds are placed in a row alongside and close to an electromagnet.
- The electromagnet consists of thin laminations and a coil is wound around it as shown in fig.
- The coil is connected in series with a resistance across the supply whose frequency is to be measured.
- The reeds are arranged in ascending order of natural frequency. The difference in frequency is usually 1Hz. Thus the natural frequency of first reed may be 45 Hz, of the second 46 Hz, of the next 47 Hz and so on of the last may be 55 Hz.
- When meter is connected to measure frequency, all the reeds tend to vibrate but the reed whose natural frequency is twice the frequency of supply will vibrate most.



Viberating reed type frequency meter

Power Factor Meter

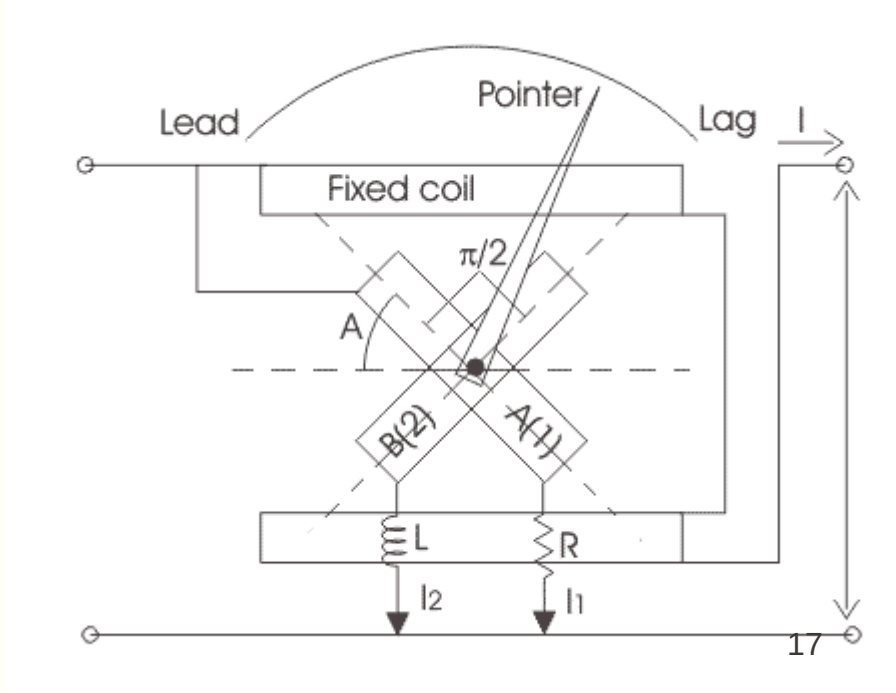
- Power factor cos ϕ = P/VI
- Types:
  - Electro-dynamometer type
    - single phase
    - three phase
  - Moving iron type



Single Phase Electrodynamometer Type Power Factor Meter

Working Principle of Single Phase Electrodynamometer type Power Factor Meter

- pressure coil is split into two parts one is purely inductive another is purely resistive as shown in the diagram by resistor and inductor.
- At present the reference plane is making an angle A with coil 1.
- the angle between both the coils 1 and 2 is 90^{o}.
- Thus the coil 2 is making an angle (90^{o} + A) with the reference plane.
- during measurement of power factor the values of R and L are adjusted such that R = wL so that both coils carry equal magnitude of current.
- the current passing through the coil 2 is lags by 90^{o} with reference to current in coil 1 as coil 2 path is highly inductive in nature.
- Now there are two deflecting torques one is acting on the coil 1 and another is acting on the coil 2.

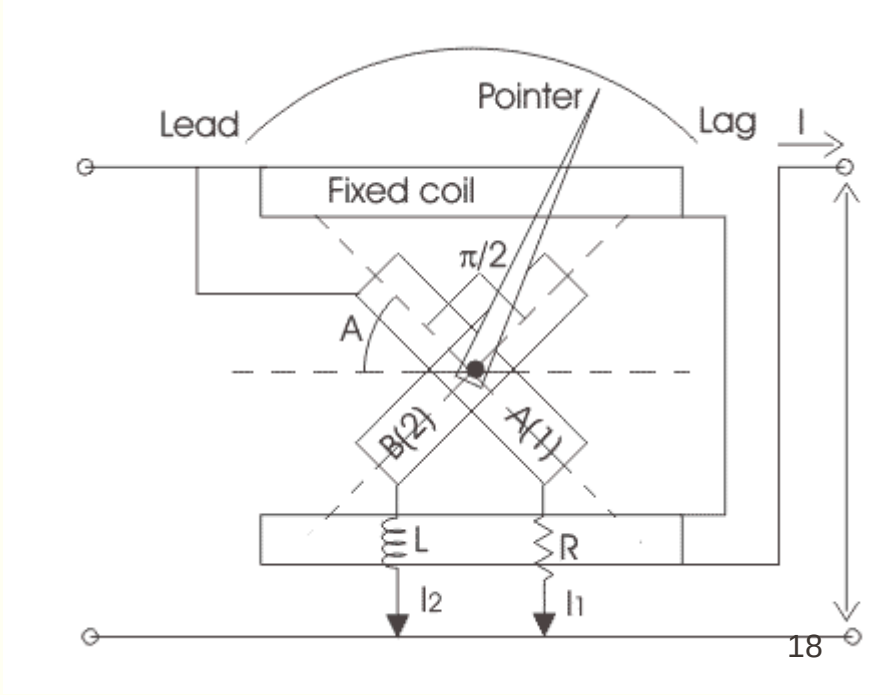


Working Principle of Single Phase Electrodynamometer type Power Factor Meter

- The coil winding are arranged such that the two torques produced, are opposite to each other and therefore pointer will take a position where the two torques are equal.
- deflecting torque for coil 1- T1 = KVIM cos ϕ sinA

  Where M is the maximum value of mutual inductance between the two coils, A is the angular deflection of the plane of reference.

- Now the mathematical expression for the deflecting torque for coil 2 is- T2 = KVIM cos (90-ϕ) sin(90+A)
- T2 = KVIM cosA sin ϕ
- equilibrium we have both the torque as equal thus on equating T_1=T_2
- Therefore ϕ = A.
- deflection angle is the measure of phase angle of the given circuit



Instrument Transformer

- Current Transformer
- Voltage Transformer

Instrument Transformer

- You will need the measuring instruments having higher range to measure high current and voltage, which literally mean huge instruments. Or there's another way, using the transformation property of AC currents and voltages, you can transform the voltage or current down with a transformer whose turns ratio is accurately known, then measuring the stepped down magnitude with a normal range instrument. The original magnitude can be determined by just multiplying the result with the transformation ratio. Such specially constructed transformers with accurate turns ratio are called as **Instrument transformers**.
- Current Transformer (CT): generally used to **measure currents of high magnitude**.
- Voltage/Potential Transformer (PT) : generally used to **measure voltages of high magnitude**.

Thank You!