Electrical Machine and Measuring Instruments

→ Construction and working of DC Motor.
→ Construction and working of DC Generator
→ Construction and working of Single (1-ϕ) phase transformer
→ " " " Three (3-ϕ) phase induction Motor
→ " " Alternator / AC generator / Synchronus generator
→ Measuring Instruments
→ Construction and working of digital Multimeter.
permanent magnet moving coil instrument (MI)
→ moving Iron instrument.
→ Measurement of Earth resistance using Megger.
→ Wheatstone Bridge Construction & working.
→ Const & working of Tong tester

* Faraday's laws :-

faraday's 1st law :- $e \propto \frac{d\phi}{dt}$

The induced voltage in a conductor is directly proportional to rate of change of flux.

faraday's 2nd law :-

The magnitude of induced voltage depends on number of turns.

$$e = N\frac{d\phi}{dt}$$

N → No. of turns
e → Induced voltage
$\frac{d\phi}{dt}$ → rate of change of flux

* 1 turn = 2 Conductors.

* Methods to Generate voltage:-

there are two methods. They are

1. Statically induced emf method (Conductor station -ary, flux is alternating (or) ac flux)
2. Dynamically induced emf method (Conductor is rotating under dc flux.

① Example - Transformer.
② Example - DC ~~generator~~ motor, AC motor

* lenz's law:-

The induced emf in a Conductor is opposite to the Cause of producing it. $e = -N \frac{d\phi}{dt}$

2/ * Construction of DC Machine:-

The parts of the DC Machine is divided into two groups. They are 1. Rotating parts
2. Stationary parts

1. Stationary parts :-

* Yoke - it provides mechanical Support to the poles. It provides return path to the magnetic field

* Eye Bolt :- To Carry the machine from one place to another place EYE BOLT is useful

* Foot rest :- To mount the machine on plinth with nut and bolt foot rest is required.

* Terminal Box :- It is mounted on Yoke of the machine. It is used to give & take electric Supply.
* END Covers :- It closes the Both sides of the machine. It provides mechanical Support to the shaft through the bearings.
* Bearings are mounted in end Covers only.
* Brush :- It is made with Carbon material and it is placed in Commitators
* Pole :- It gives the mechanical Support to field the Coil / flux coil.
* Pole shoe :- one end of the pole is fixed to Yoke. other end of the pole 'pole shoes' are placed. the pole shoe provide uniform air gap between Armature Conductors & Pole.

2. Rotating parts :-

* Bearing :- It is mounted in end Covers of the machine. It is made of steel.
→ Shaft is placed through the bearings only.
→ There are two types of Bearings
1. Roller Bearing used for ~~low~~ High Rating machines.
2. Ball Bearings used for low Rating machines

* Armat Shaft :- It is made with stainless steel. It provides mechanical support to Armature and Commitator.
→ Armature & Comitator are mounted on shaft.
* Armature :- In DC machines ~~laboratore~~. laminated Armature core is used. It has no of slots to wound the winding.
* Armature winding :- A Copper wire is placed in the Armature slots is called Armature winding. Emf is induced in this winding only.
* Commitator :- ~~These~~ is mounted of on the shaf to give electric supply to the Armature winding (Motor) or to take the electric supply from the Armature winding Commitator is used.
→ A Commitator works like Invertor in DC- Motor (DC to AC Conversion).
→ Commitator works like Rectifier in case of DC generator. (AC to DC Conversion).
* Working of DC generator:

* Principle :-
whenever rotating Conductor cuts the dc flux or steady state flux then an Emf is induced in the Conductor according to faraday's law of electromagnetic induction.

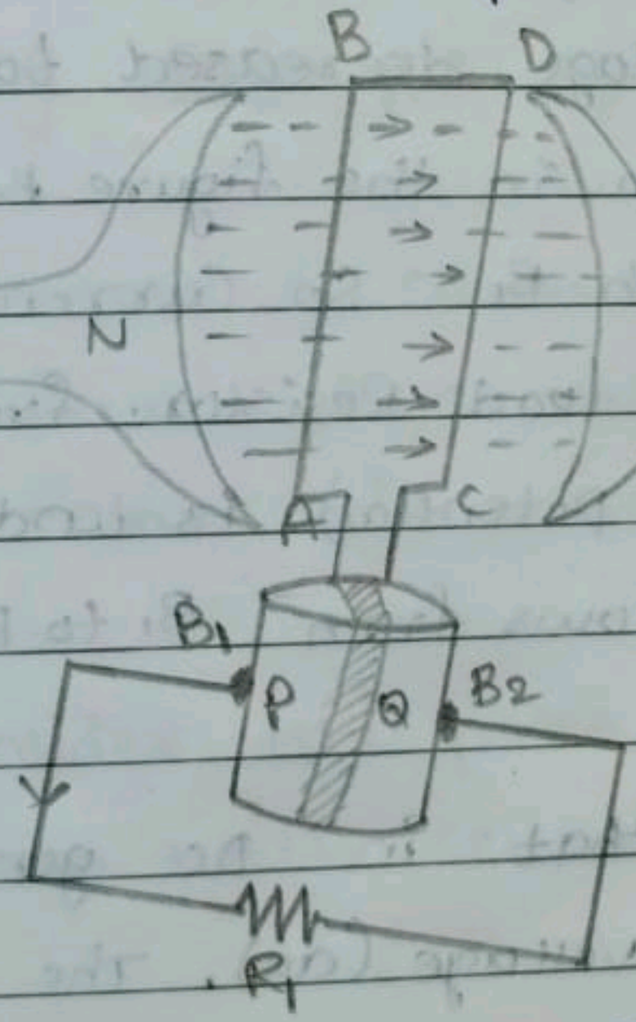
working :-

Consider two permanent magnets with opposite polarity and keep them with certain distance. The flux lines flows from Northpole to Southpole in parallel to the Surface.

In between the poles place a rectangular Copper coil in rightangle to the magnetic field.

finishing end of rectangular coil is Connected to splitring. on the Splitring carbon brushes are placed. Back end of the Carbon brushes are Connected to load.

The below figure a shows the line diagram of DC generator for simple loop operation.



Coil Sides are AB and CD. Coil Side AB is Connected to Splitring part 'P'. The Coil Side CD are Connected to Splitring part 'Q'.

Initially the coil is right angle to the magnetic field so induced Emf is zero. with the help of train prime mover rotate the coil in Counter Clock wise direction. Coil side AB is taken as Reference, Conductor is under north pole. Induced Emf is +ve Conductor is under South pole. Induced Emf is -ve.

The coil side AB is moving under north pole so induced Emf is increasing from 0 to and reached to maximum at 90° [pole centre]. from 90° to 180° Conductor side AB moves away from the pole centre, induced voltage is decreased from maximum to zero. from 180° to 270° induced voltage in side AB is increasing and reached to negative maximum. from 270 to 360° induced voltage decreased to 0 from its -ve Max as shown in the figure B. 0° to 180° split 'P' is under Brush B_1. So Current flows from B_1 to B_2 through load Resistor. from 180° to 360° Split 'Q' within (High potential) is under Brush B_1. So the Current flows from B_1 to B_2 through load Resistor R_L.

We Conclude that in DC generator winding produce alternative voltage (ac). The output voltage is DC as shown in figure B.

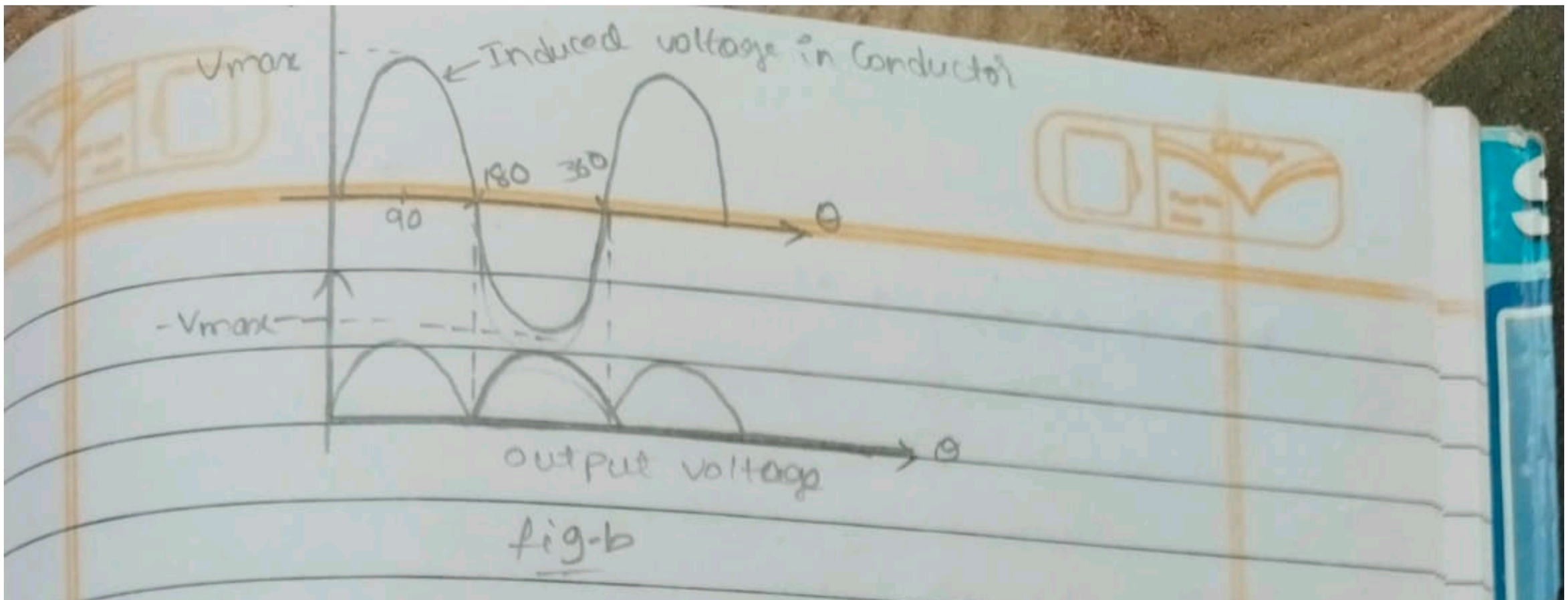


fig-b

* prime mover:-

the device which is used to rotate the rotor of ~~from~~ generator is called prime mover.

* The drawback in permanent is Ageing effect.

Ageing effect means "losing magnetism". Electro magnets are fullfil the drawback in permanent Magnet.

* If Magnetism is decreased induced voltage decreased.

* Electrical Appliances will not work for low voltages.

* Working principle of DC Motor :-

whenever a current carrying conductor placed in a dc flux it experiences a force. Due to this force Rotor will rotate Continuously in unique direction.

Consider two poles with opposite polarity and place them with certain

* 3-ϕ Induction Motor:

there are two types of induction Motors according to Rotar Construction.

1. Squrrel Cage rotar
2. Slipring rotar

1) Squrrel Cage rotar:-

It is used for low starting torque and high running torque. ex:- All industrial applications

2) Slipring rotar:-

It is used for high starting torque applications ex:- lifts, electric train

* Construction of Squrrel Cage motor is easy, less maintanace, high efficiency, no additional resistors are required.
* Slipring induction motor Connection is difficult, frequent maintanace is required, efficiency is low, additional resistors are required.

(1) & (2) difference

The below figure 'a' shows the squrrel case rotar and figure 'b' shows the slipring rotor.

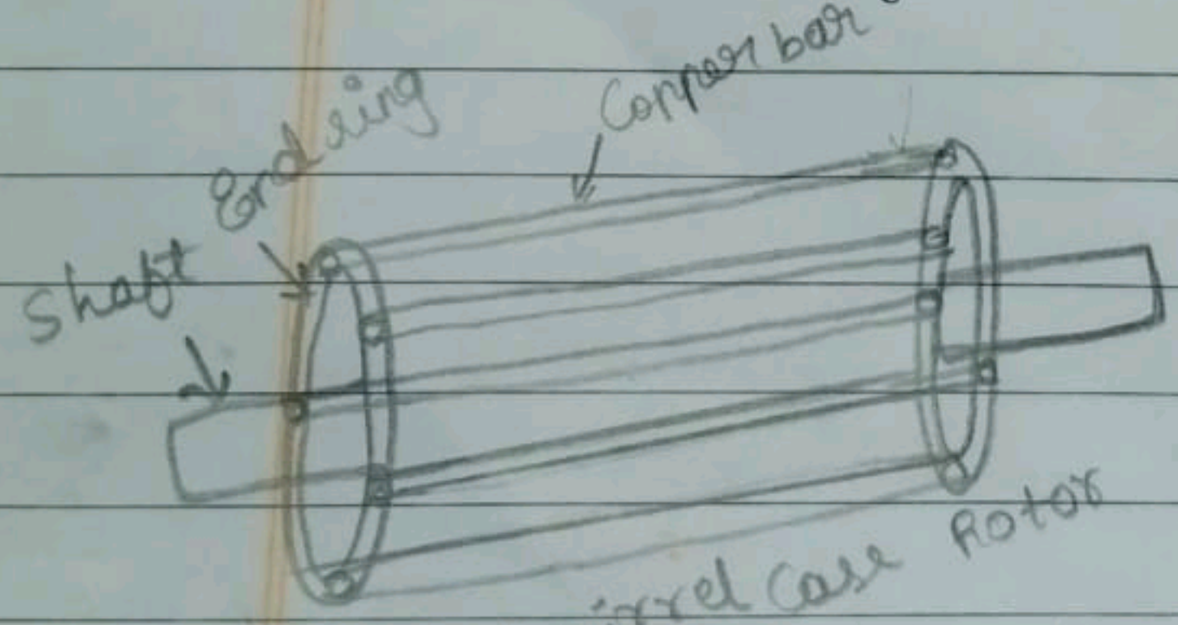


figure - a

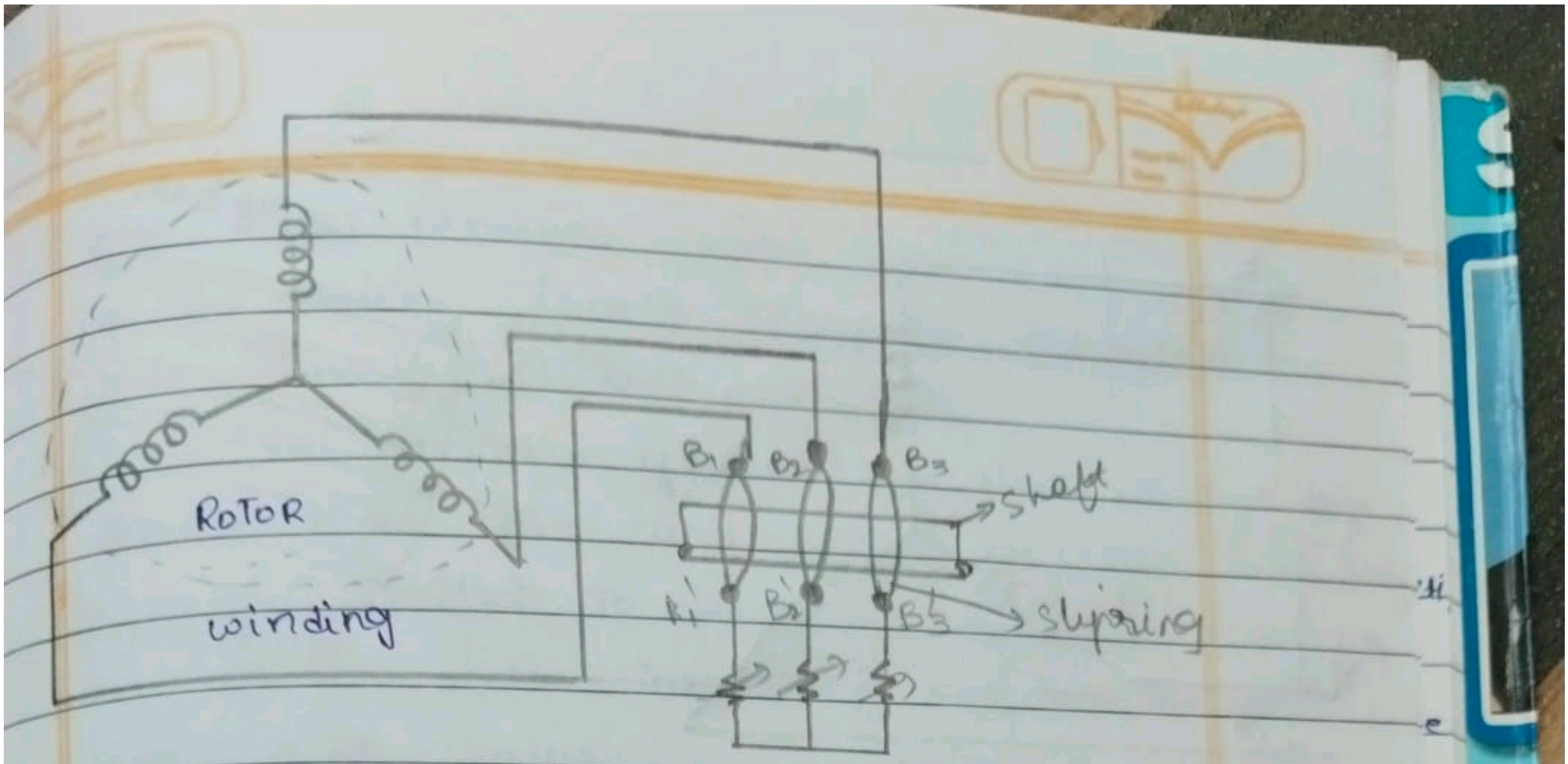


figure-b.

working of 3-phase :-

3-phase induction motor works on electromagnetic indjection principle.

Stator have 3 windings they are connected inside of the stator with a distance of 120° apart. The windings may connected in star form or delta form.

In star form $V_L = \sqrt{3} V_{ph}$

$I_L = I_{ph}$

In delta form. $V_L = V_{ph}$

$I_L = \sqrt{3} I_{ph}$

The Rotors are either squirrel cage or slipring Assume that squirrel cage rotor for analysis. The below figure 'a' shows the line diagram of 3-phase inductor motor. Stator winding is connected in star form and is Connected to a 3-phase AC Supply.

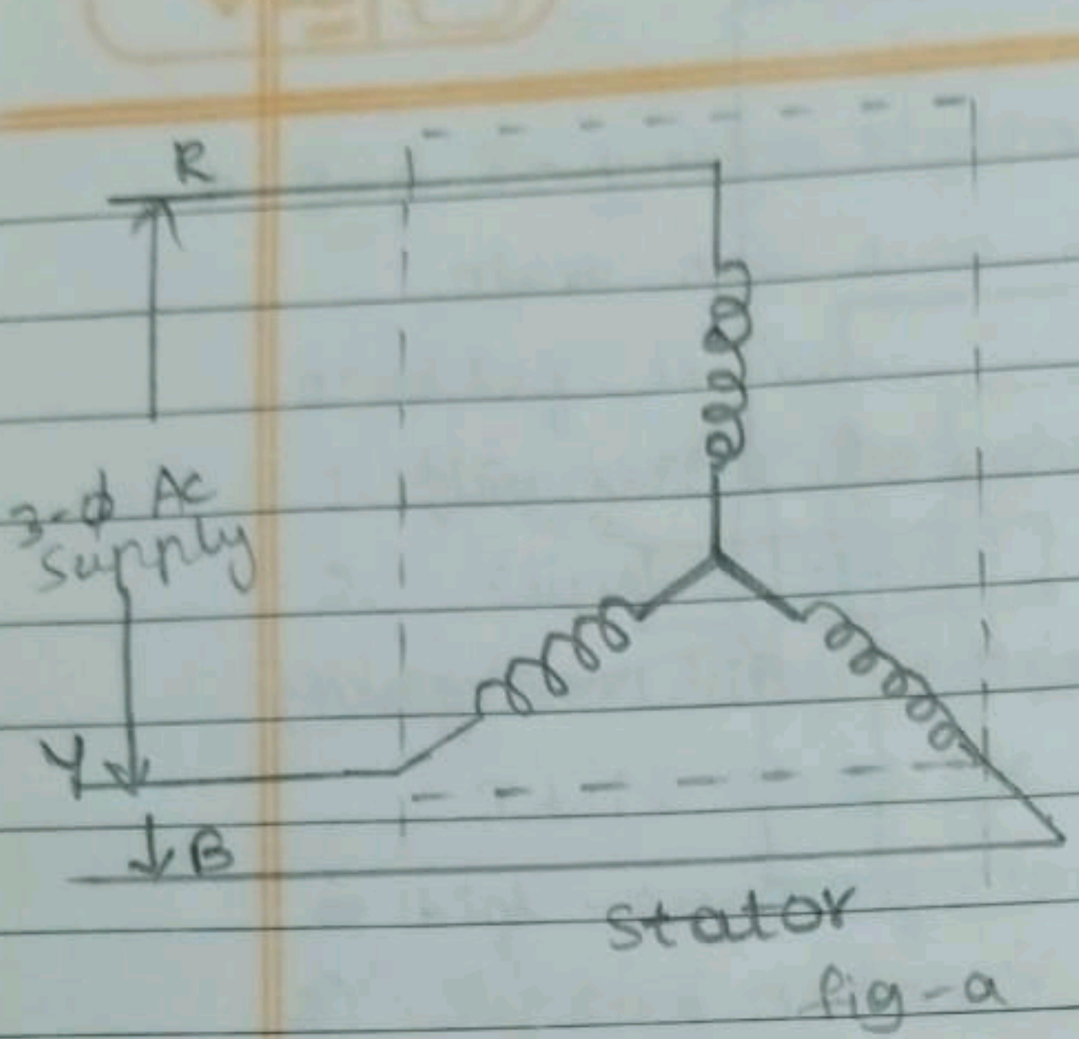
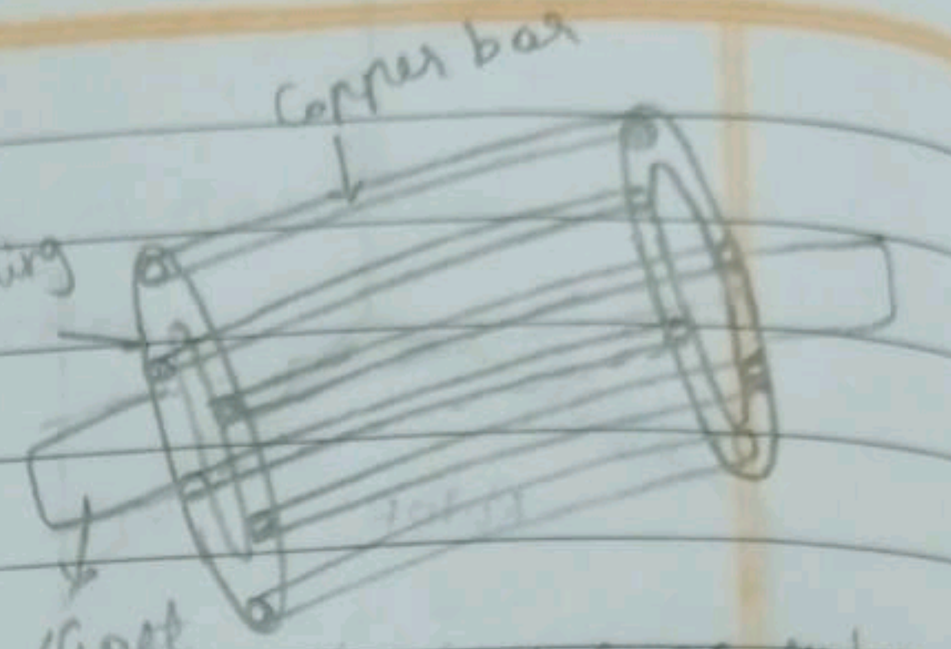


fig-a



Stator is connected to 3-ϕ AC supply produce flux in each phase the resultant flux $\phi_r = 1.5\,\phi_m$

The produced flux in the stator rotating in the air gap between Rotor and stator winding. so the flux is called rotating magnetic flux. (RMF)

The speed of the flux is Synchronous speed.

$$N_s = \frac{120f}{P} \text{ r.p.m}$$

Here f - Supply frequency

P - no. of poles in stator.

The RMF cuts the rotor then an EMf is induced in the Rotor according to faraday's law of electromagnetic induction. we know that the Rotor is at closed path.

So the induced Emf ↓ circulate in the Rotor

↓

Produce current

then flux produced in the Rotor.

The Rotor flux is in opposite direction to the stator flux. (r.m.f).

Due to interaction of stator and Rotor fluxes force develop on the rotor. and rotor will rotate Continuously in unique direction. To change the direction of rotation of an induction motor interchange any two supply terminals at stator

* Alternator:-

It is also Called AC generator or Synchronous generator.

Electrical equipment works for a Constant frequency to generate Constant frequency we should run the generator at Constant speed of Synchronous speed.

$$N_S = \frac{120 \cdot f}{P}$$

So AC generator

In the stator of an alternator there are 3 windings in its inner periphery. the 3 windings are Connected in either Star or delta form. the angle of displacement b/w each winding is 120° apart.

The windings are

In delta Connection $V_L = V_{ph}$, $I_L = I_{ph}$

In star Connection $I_L = I_{ph}$, $V_L = \sqrt{3} V_{ph}$

the phase terminals are named as red, yellow and blue. Black is used for neutral.

There are two types of Rotors in an alternator

1. Salient pole Rotor
2. Cylindrical Rotor

Salient pole Rotor diameter is high and runs at low speed. (Hydro plant). Cylindrical Rotor diameter is less and runs at high speed. (Steam plants)

** * A DC supply is given to the Rotor winding then it makes north and South poles.

The Rotor Rotates with the help of prime mover at synchronous speed.

while Rotating the Rotor flux cuts the stator winding alternatively. Then Emf are induced in the stator winding the generated Emf is given to the loads.

The below figure shows the schematic diagram of 3-ϕ Alternator.

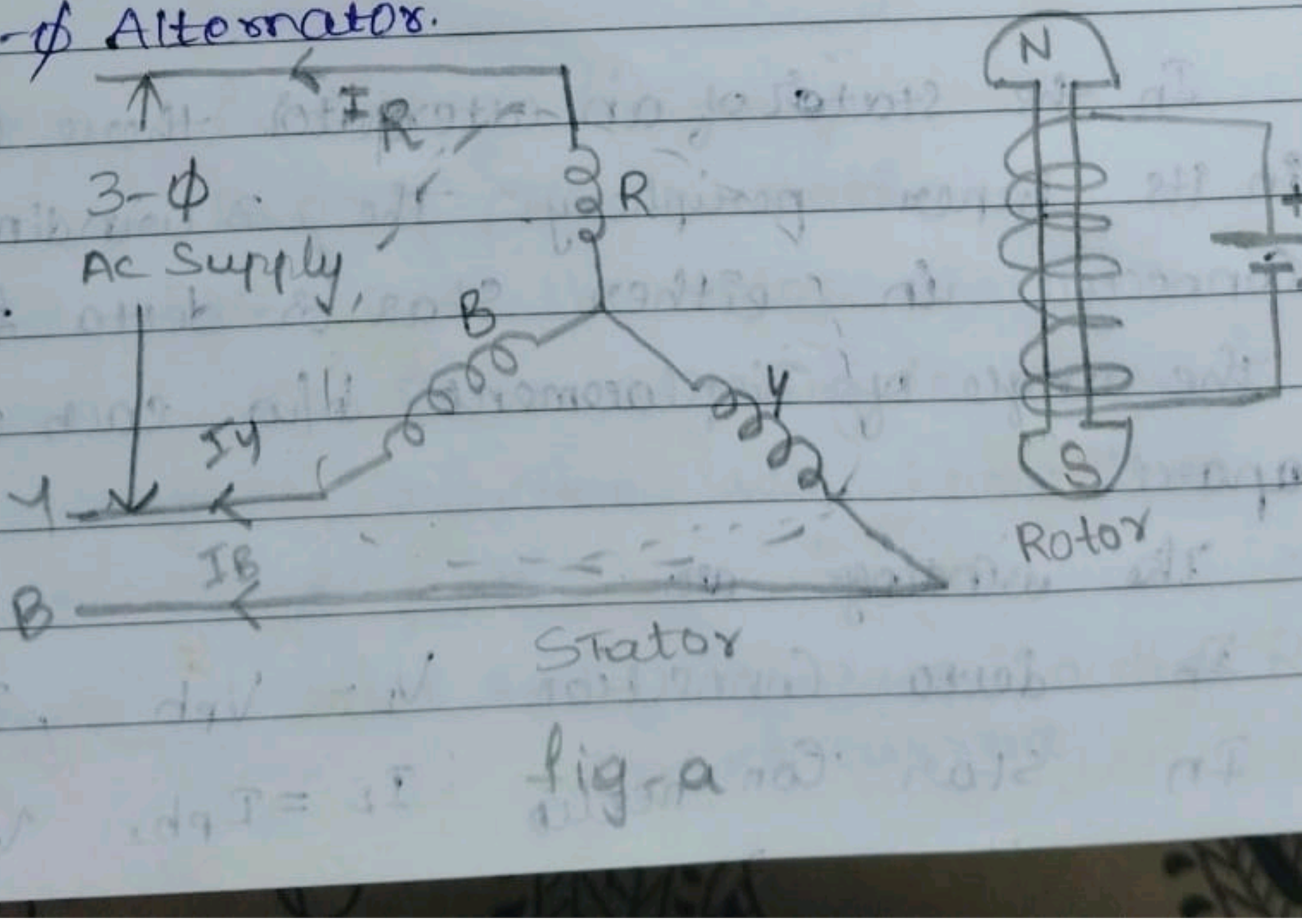
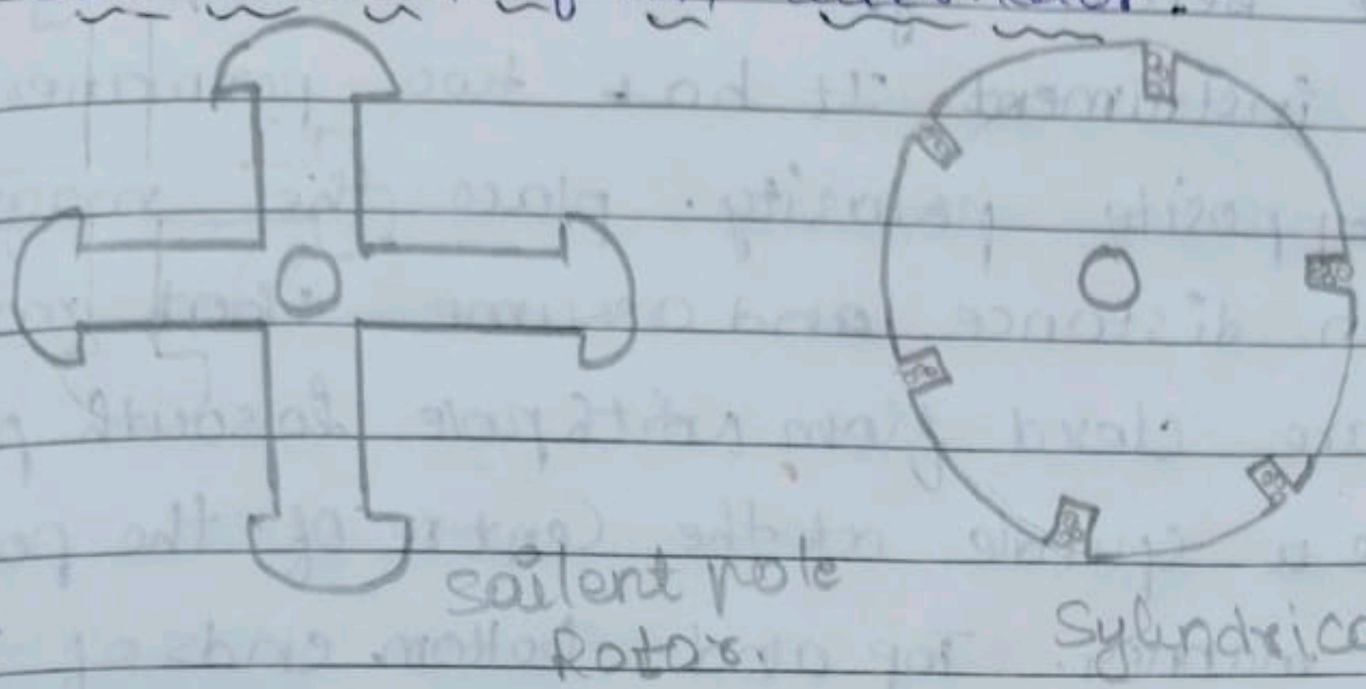


fig-a

* Construction of an alternator :-



According to rotor Construction Alternators are 2types 1. Sailent pole Alternator

2. Cylindrical pole Rotor Alternator.

Stator Contains Armature winding togeneeate in its inner periphary / insideof sator.

The stator windings are wrounded 120° apart there are 3. windings named as : R, Y and B.

Sailent pole Rotor is used for Hydro power plants and Cylindrical pole Rotor is used for thermal powerplants & steam powerplants.

the Running Speed of cylindrical Rotor is very high and no. of poles are low. whereas in salient pole diameter is high no. of poles is high number and running speed is low.

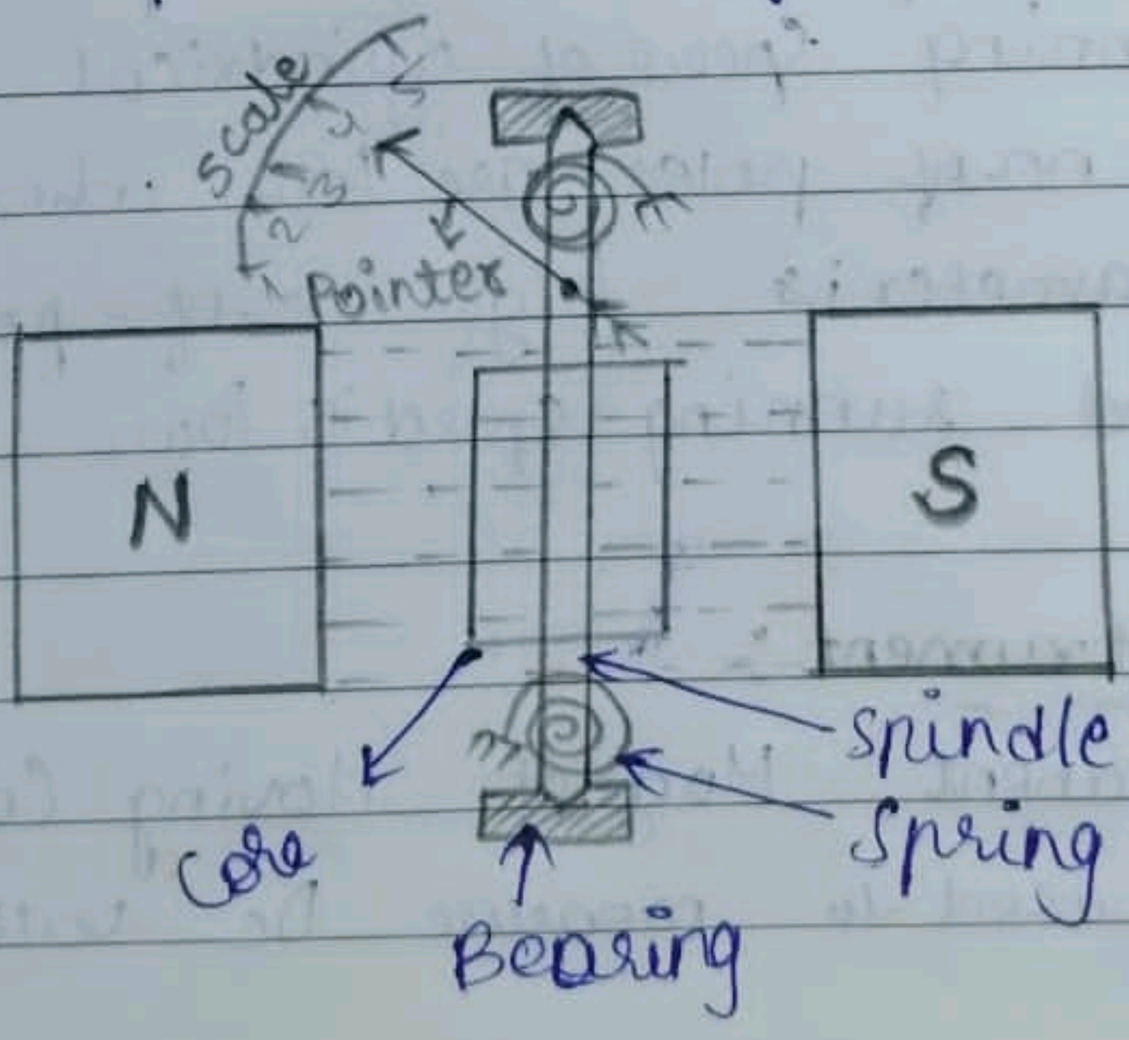
* PMMC Instrument :-

PMMC → Permanent Magnet Moving Coil Instrument.

It is used to measure Dc voltage and Dc current.

The below figure shows the line diagram of PMMC instrument. It has two permanent magnets with opposite polarity. place the magnet with certain distance and assume that magnetic field lines are closed from north pole to south pole.

place a spindle at the centre of the poles in vertical manner. Top and bottom ends of the spindle bearings are provided for free rotation. on the spindle a pointer is connected to indicate the measured value on the scale. In MC moving coil instruments uniformly distributed scale is preferred ($I \propto \theta$ angle) on the spindle there is a rectangular iron core to wound the Copper wire. the Copper wire is Connected to measuring terminals. in Ammeter the terminals are Connected in Series to the line. In case of voltmeter the terminals are Connected across positive and negative terminals.



the Coil produce the flux and interact with main pole flux. As a result deflection torque is obtained. Due to deflection torque the spindle is rotating from 0 value. the springs provides controlling torque in opposite direction to the deflection torque. The pointer is oscillating at the final reading. to observe the oscillations we provide damping torque. The damping torque is obtained in three methods

1. Air friction damping
2. Oil friction damping
3. Eddy Curry damping