SUB :- ELECTRICAL EQUPMENT IN MINES

TOPIC

1. Electrical cables For Mining use.
2. Protective systems including fuses & circcuit Breakers
3. Fundamentals of Transformer (without nomerical Problem.)
4. Industrial Drives- Mining Type
5. Electric Braking Used in Mines.
6. Flame proof & intrinsically safe apparatus.
7. Undergrocond signaling arrangement
8. Sensors & their applications.

Protective Systems

FUSE :-

A short piece of metal inserted in the circuit, which melts when excessive current flows through it & thus break the circuit.

Advantages :-

I) cheapest form of protection.
II) Requires no maintenance.
III) Operation is inherently automatic.
IV) Can break heavy short circuit currents without noise or smoke.
V) Smaller sizes of fuse element impose a current limiting affect under short circuit conditions.
VI) Inverse time current characteristics of fuse make it suitable for over current protection.
VII) Minimum time of operation can be made much shorter than with the circuit breaker.

Disadvantages :-

I) considerable time is lost in rewiring or replacing a fuse after operation.
II) On heavy short circuit discrimination between fuse in series cannot be obtained.
III) Current time characteristic of a fuse cannot always be co-related with that of the protected apparatus.

Characteristics of fuse element :-

I) Low melting point
II) High conductivity.
III) Free from deterioration due to oxidation
IV) Low cost.

Fuse Element Material :-

Commonly used materials -

Lead, tin, Zinc, copper, Silver

Fuse are mainly of 2 type :-

① Low voltage fuse

② High voltage Fuse

① Low Voltage fuse :-

Low voltage fuse are of two type :-

I) Semi. enclosed rewirable fuse. (Kitkat)

II) High Rupturing Capacity (HRC) catridge Fuse.

I) Semi Enclosed Rewirable fuse :-

It consist of a base & fuse carrier.

Advantage

(a) Detachable fuse carrier permits the replacement of fuse element without any danger of coming in contact with live parts.

(b) Cost of replacement is negligible.

Disadvantages

→ Possibility of renewal by the fuse wire of wrong size or by improper material.

→ Fuse has a low breaking capacity & hence can't be used in circuit of high fault level.

→ Fuse element is subjected to deterior at ion due to oxidation through continues heating up element

→ Protective capacity such a fuse is uncertain as it is affected by the ambient conditions.

→ Accurate calibration of the fuse wire is not possible

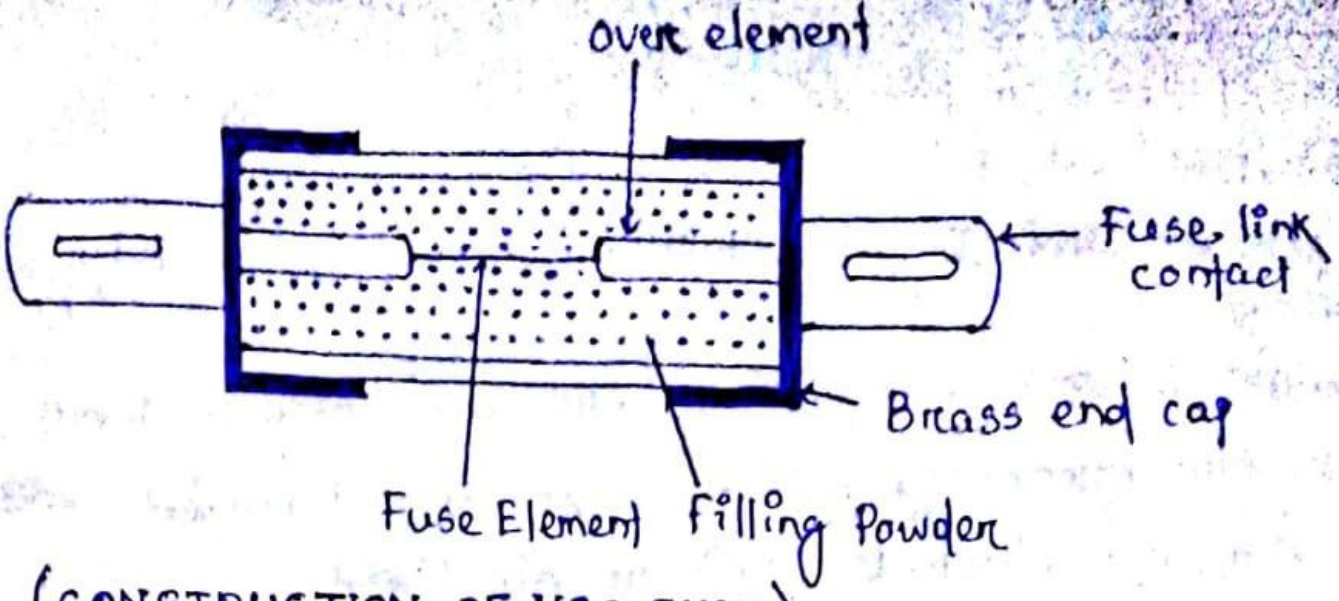
II) High Rupturing Capacity (H.R.C) cartridge fuses :-

→ Primary objection of low & uncertain breaking capacity of Semi-enclosed rewireable fuses is overcome in H.R.C. cartridge fuse.

→ Consist of a heard resisting ceramic body having metal & caps which is wekied silver current carrying element.

→ Space within the body surrounding the element is completely packed with filling powder.

→ Filling material acts as an arc quenching & cooling medium.



(CONSTRUCTION OF HRC FUSE)

Advantages:-

→ Capable of clearing high as well as low fault currents.
→ Donot deteriorate with age.
→ Have a high speed of operation
→ Provide reliable discrimination.
→ Require no maintenance
→ Cheaper than other circuit interrupting devices of equal breaking capacity
→ Permit consistent performance.

Disadvantages

→ Have to replaced after each operation.
→ Produced by the arc may affect the associated switches.

② High Voltage fuse :-

High voltage fuse are of two types:-

I) Liquid type fuse.
II) Metal clad fuse

Circuit Breaker :-

→ Circuit Breakers is a electrical device which can break the electrical contact.

→ It provided protection to electrical power system at a very high voltage.

→ Circuit breaker uses various are quenching medium.

→ The Arc quenching medium can be oil, vacuum, ~~Sulphur~~ Sulfur hexafluoride (SF_6) or air blast.

→ Fuse operates only on load condition but circuit breaker opercate in both no load and on load & faully condition.

→ Based on the ARC quenching medium there are 4 kind of circuit breaker.

i) Oil circuit breaker
ii) Airblast circuit breaker
iii) SF6 circuit breaker
iv) Vacuum circuit breaker.

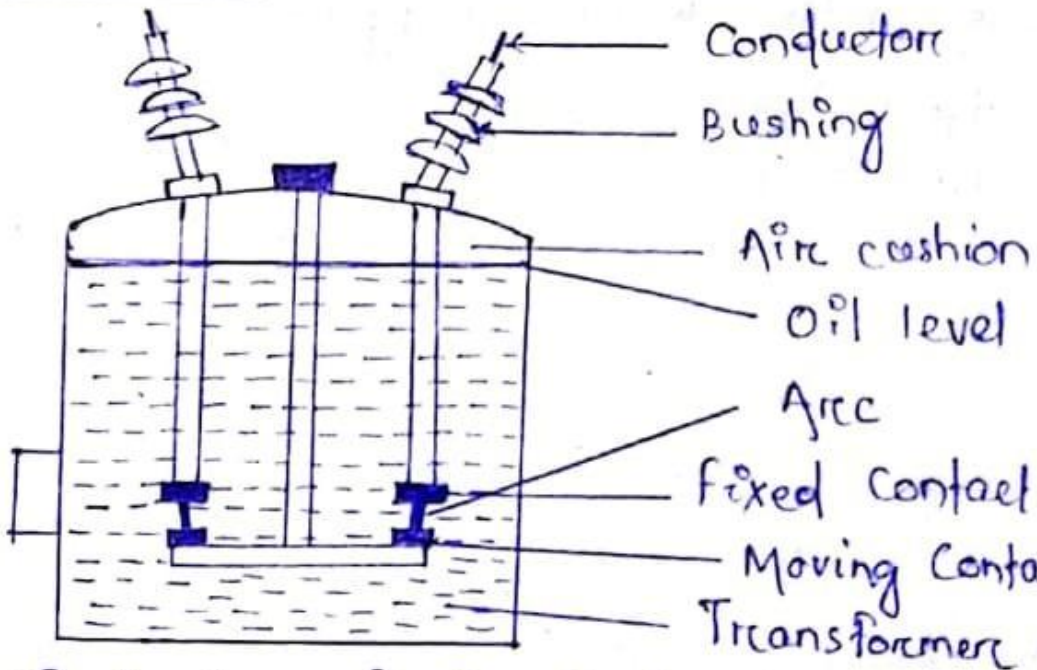
I) Oil circuit breaker :-

→ In oil circuit breaker oil is used as Arc quenching medium.

→ Based on the quantity of oil use there are two kind of circuit breaker.

1- Bulk oil Circuit Breaker (BOCB)
2- Minimum Oil Circuit Breaker (MOCB).

1- Bulk Oil Circuit Breaker



→ It is a very simple type of circuit breaker where fixed contact & moving contact are enclosed in a oil tank.

→ The transformer oil which is present in the oil tank act as an medium of cooling & Arc extinction (ନିଭୁଥିବା).

→ The air cushion provides the space during oil volume expansion.

→ Under faulty condition, the moving contact moves away from fixed contact thus intreps the facth current.

Advantages :-

→ Excellent pulling property of the circuit breaker

→ Simple construction.

Disadvantages :-

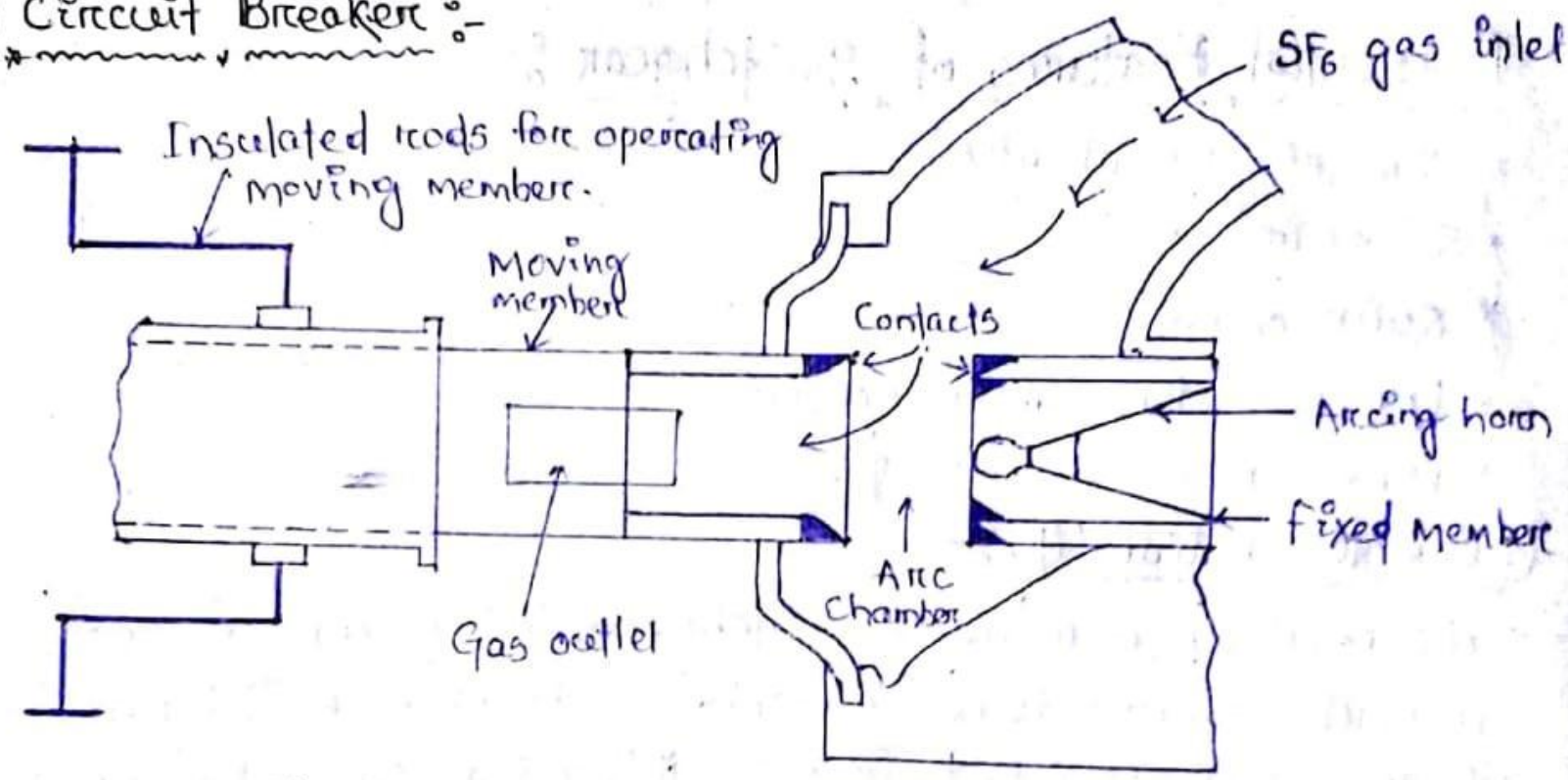
→ There is risk of fire & the oil is inflamable.

→ There is chance of explosion.

→ This is avoided for U/G coal mines.

→ Regular maintenance is required.

SF6 Circuit Breaker :-



→ In SF6 circuit breaker SF_6 is used as an Arc quenching medium.

→ SF6 has insulation property 2 to 3 times of air. It is non-explosive in nature.

Construction :-

→ The SF6 circuit breaker contains a close chamber in which fixed contact & moving contact are there.

→ Before fault the fixed contact & the moving contact are kept intact.

→ During fault the fixed contact & the moving contact are separated from each other & the SF6 is flown from SF6 reserver thus the Arc is quenched.

→ There is recycle mechanism inside the SF6 circuit breaker which makes it possible to recycle SF6.

Advantages :-

→ It is non explosive in nature that's why it is used in coal mine
→ There is provision for recycling that's why the coast of operation is very less.
→ Less maintenance
→ Less noisy operation.
→ No arching product.

Disadvantages :-

→ SF6 is very much coastly.
→ It require auxiliary device to recycle the SF6 that's why it is more bulky.

Essential Features of Switchgear :-

* Complete reliability
* Discrimination.
* Quick operation
* Provision for manual control.
* Provision for instruments.

① Complete reliability :-

→ The need for a reliable switchgear has become of paramount importance. This is not surprising because switchgear is added to the power system to improve the reliability. when fault occurs on any part of the power system, the switchgear must operate to isolate the faulty section from the remainder circuit.

② Absolutely certain Discrimination :-

→ When fault occurs on any section of the power system, the switchgear must be able to discriminate between the faulty section & the healthy section.

③ Quick operation :-

→ The switchgear must operate quickly so that no damage is done to generators, transformers & other equipment by the short circuit currents.

④ Provision for manual control :-

A switchgear must have provision for manual control in case the electrical for electronics control fails, the necessary operation can be carried out through manual control.

⑤ Provision for Instruments :-

→ There must be provision for instruments which may be required. These may be in the form of Ammeter or Voltmeter.

RELAY :-

→ Relays are a remote control electrical switch that can be switched using low current to control to high current load.

→ Relay is a sensing device which detects any abnormality in the system & with the help of tripping coil it activate the circuit breaker thus breaking the circuit for protection of the system.

Types of Relay :-

(I) Instantaneous Relay :-

→ The relay which operate instantaneously having no time relay is known as instantaneous relay.

(II) Inverse time Relay :-

→ The relay having Inverse time characteristic is known as inverse relay.

(III) Definite Time Lag Relay :-

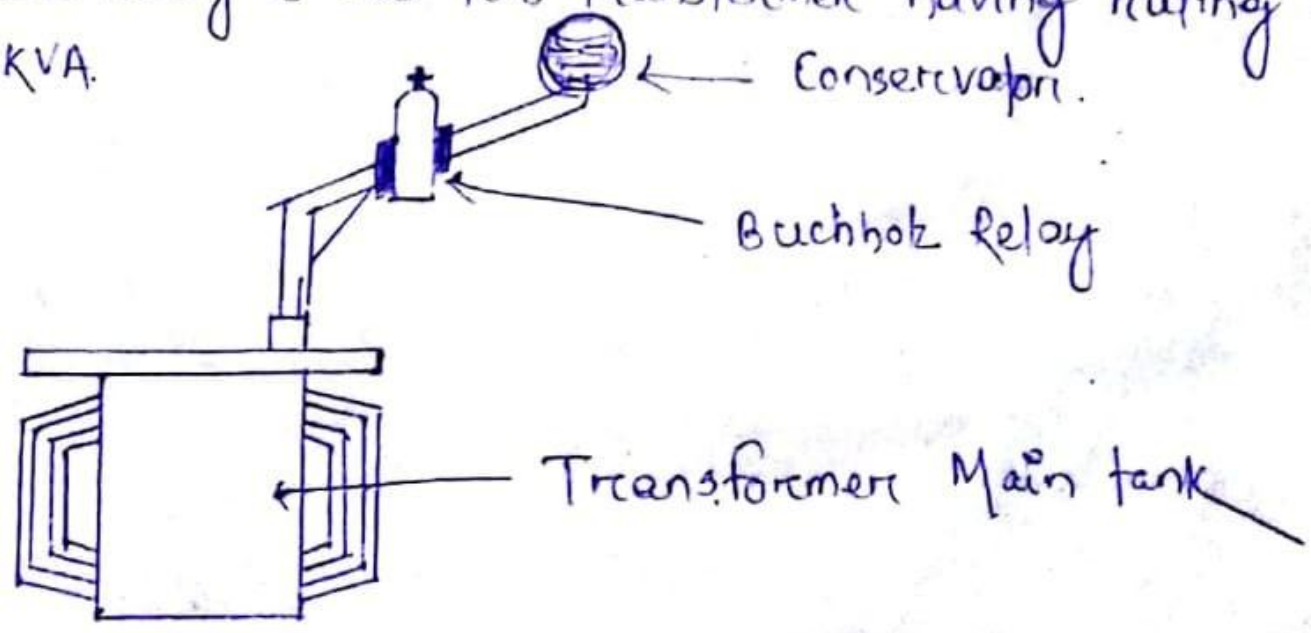
→ The relay has a definite time forced in operation.

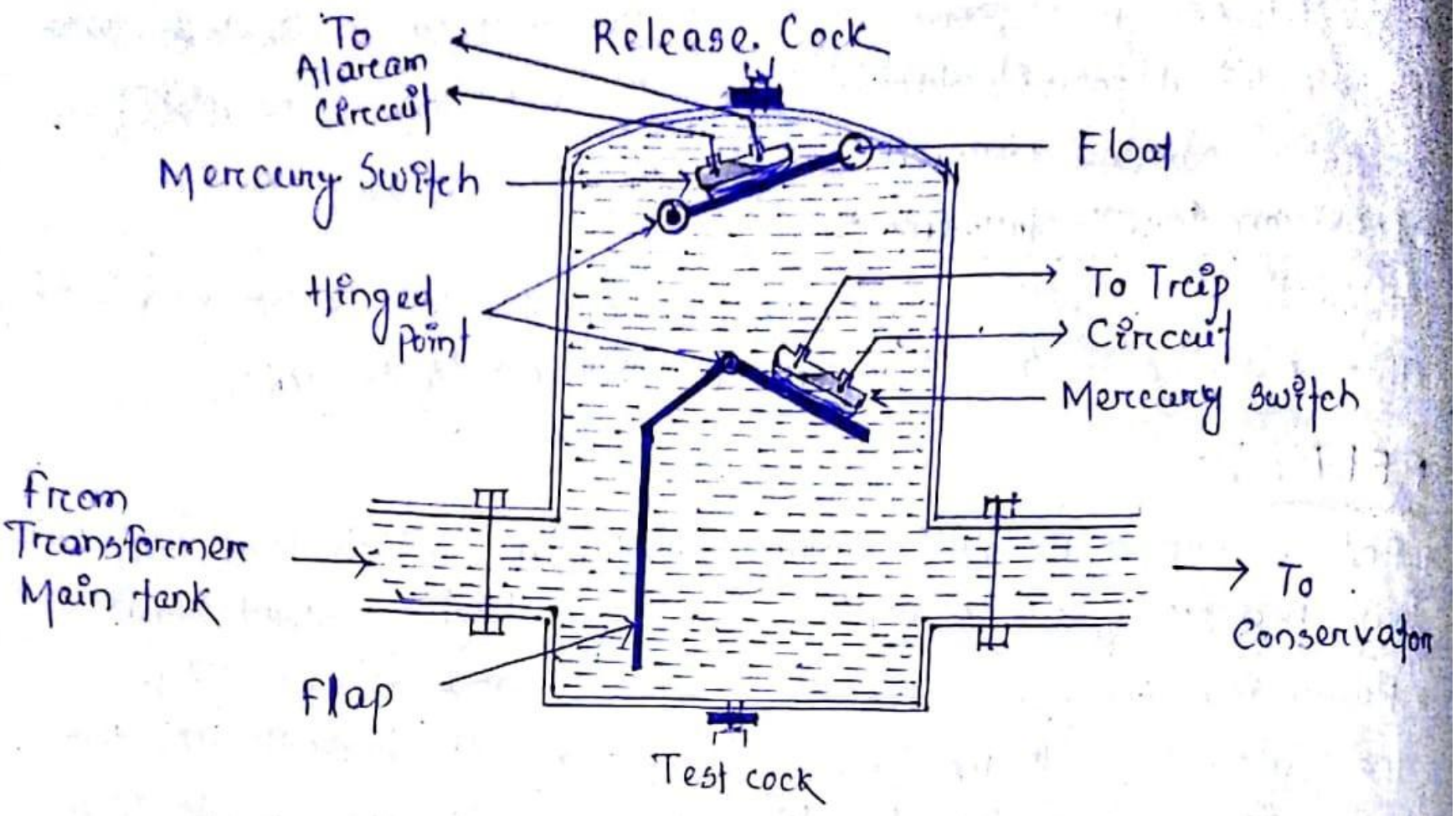
(IV) Buchholz Relay :-

→ It is use for protection of slowly developing fault as well as major fault.

→ It is connected between main tank & conservator.

→ Buchholz relay is use for transformer having rating more than 500 KVA.





(Working Principle of Buchholz Relay)

Construction :-

→ It is a close chamber filled with oil having two mercury switch.

→ When the fault is minimum the upper mercury switch operate & it give raises to Alaram. As the Alaram circuit get activated

→ When the fault is major fault it produces very high quantity of hydrogen gas which operate both copper & lower mercury switch.

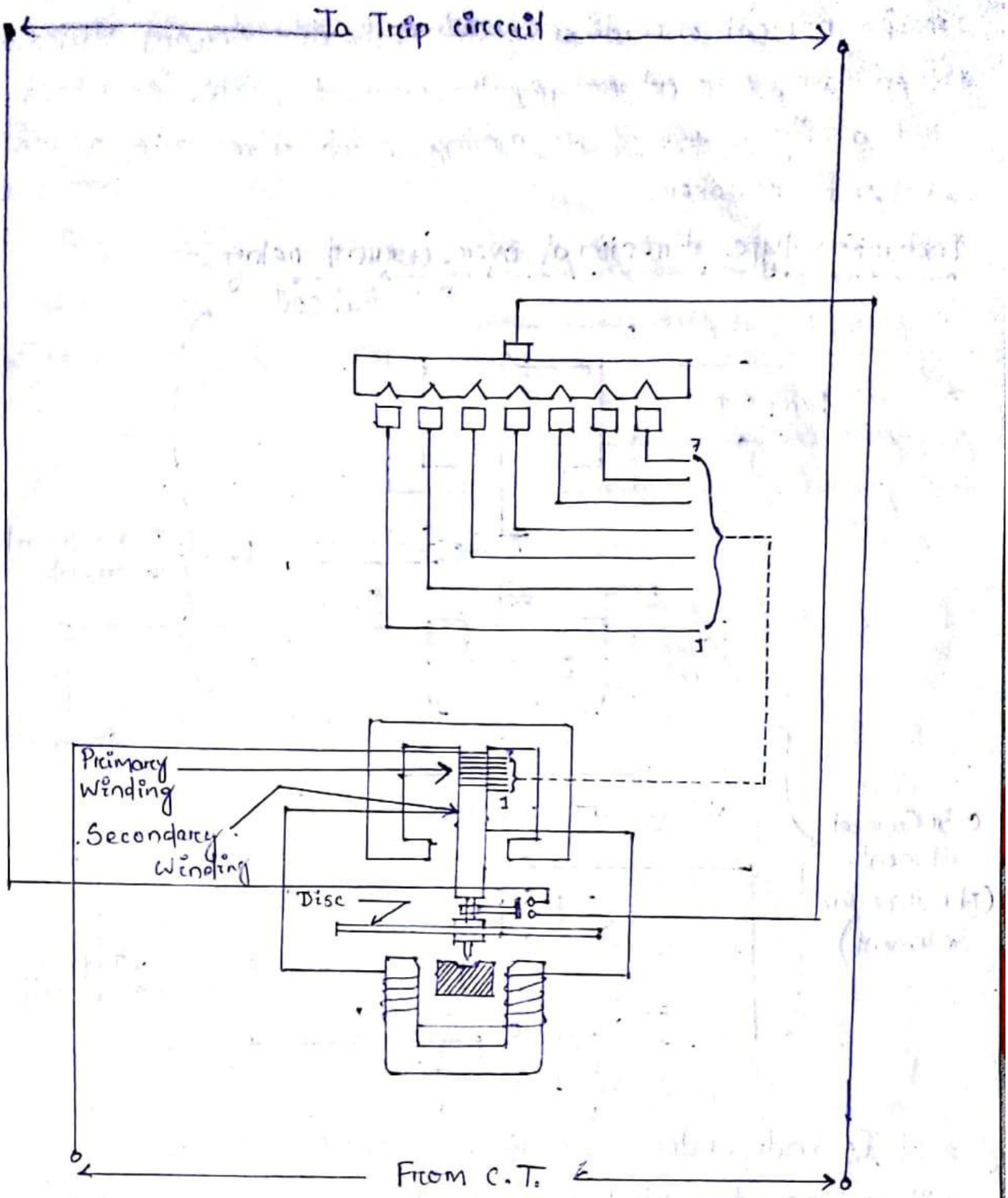
Advantage

→ It is good for both major & miner fault.

Disadvantage

→ Very Costly.

Induction over current relay :-



→ The above fig. shows diagram of a Induction type over current relay which is non-directional.

→ If the current exceed the pre-determine value then the trip is propagated towards the circuit breaker.

Constructional details :-

→ It consist of two electromagnet winded by two type of winding. Primary winding & secondary winding in between these two a dics is placed.

→ The primary of the electromagnet connected to the secondary of the CT (Current Transformer)

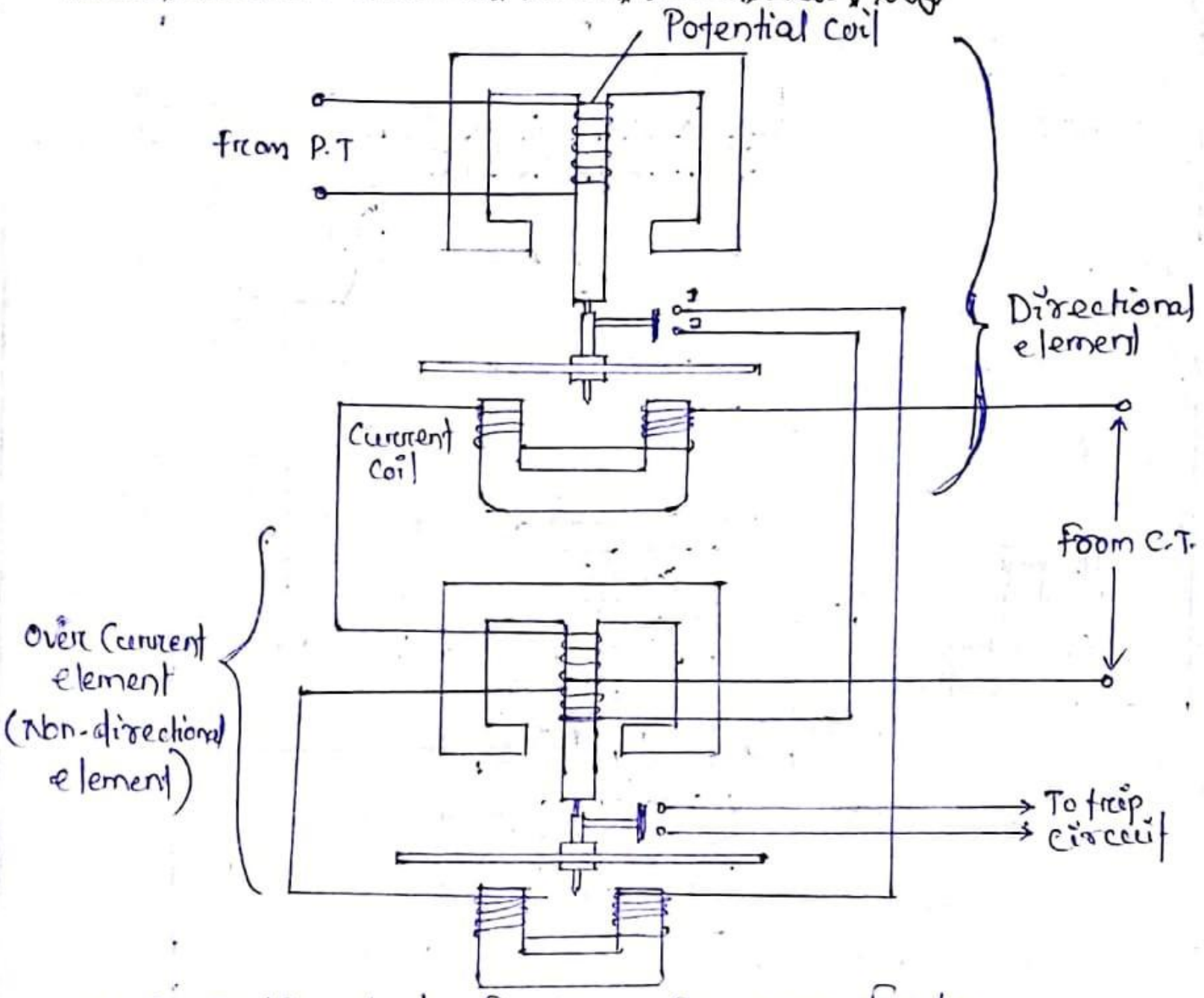
→ The controling ~~force~~ torque is provided by a spiral spring.

Operation :-

→ The driving torque is due to the principle of induction under normal operating condition the dics remain stationary.

→ When fault current occurs the current value increases the rating value & this starts moving, which gives trip signal to circuit breaker.

Induction type directional over current relay :-



→ It is indipendent of voltage & power factor.

→ There are two kind of element -

(i) Directional element

(ii) Nondirectional element.

(i) Directional element :-

→ It is an directional element through which the power flows in specific direction.

(ii) Non-directional element :-

→ It is an over current element whose construction is same as induction type over current relay.

Operation

(I) Normal operating condition :-

→ The power flows in normal direction. Therefore the directional power relay doesn't operate thereby tripping the over current element all energized.

(II) Under short-circuit condition :-

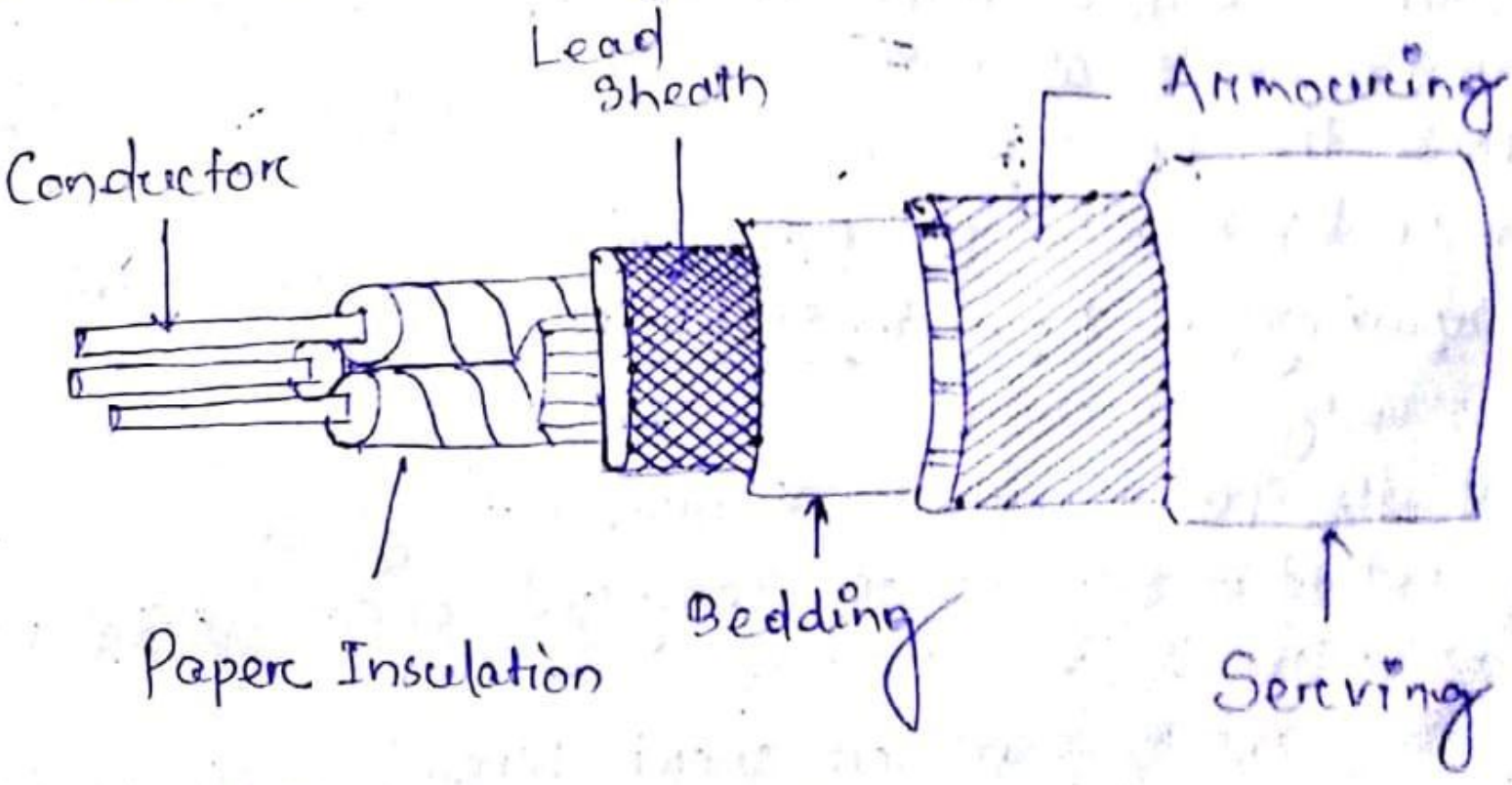
→ Power flows in reverse direction hence the directional element operate & finally the disc rotate which send trip signal to the circuit breaker.

→ This type of relay is direction specific. Therefore it is known as directional relay.

Underground Cables :-

→ Since the lods having the trends towards growing density. This requires the better appearance, rugged construction, greater service reliability & Increased safety. An underground cable essentially consists of one or more conductors covered with suitable insulation & surrounded by a protecting cover.

→ The interference (हस्तक्षेप) from external disturbances like storm, lightning, ice, trees etc should be reduced to archiver trouble free service. The cable may be buried directly in the ground. or may be installed in ducts buried in the ground.



Laying of Underground Cable :-

→ The reliability of underground cable network depends to a considerable extent upon proper laying.

→ There are three main method of laying u/g cables.

(a) Direct laying
(b) Draw in system
(c) Solid system.

(a) Direct Laying :-

→ This method is cheap & simple & is most likely to be used in practice.

→ A trench of about 1.5 meter deep & 45 c.m. wide is dug.

→ A cable is been laid inside the trench & is covered with concrete material or bricks in order to protect in term mechanical injury. This gives the best heat dissipating conditions beneath the earth.

→ It is clean & safe method.

Disadvantages of Direct Laying :-

→ Localization of fault is difficult.

→ It can be costlier in congested areas where excavation is expensive & inconvenient.

→ The maintenance cost is high.

(b) Draw in System :-

→ In this condrelt or duct of concreate is laid in ground with main holes at suitable positions. ~~from main hole~~ along the cable route.

→ The cables are then pulled into positions from main holes.

Disadvantages of Draw in System :-

→ It is very high initial cost.

→ Heat dissipation conditions are not good.

→ This method is suitable for congested areas where excavation is expensive & inconvenient.

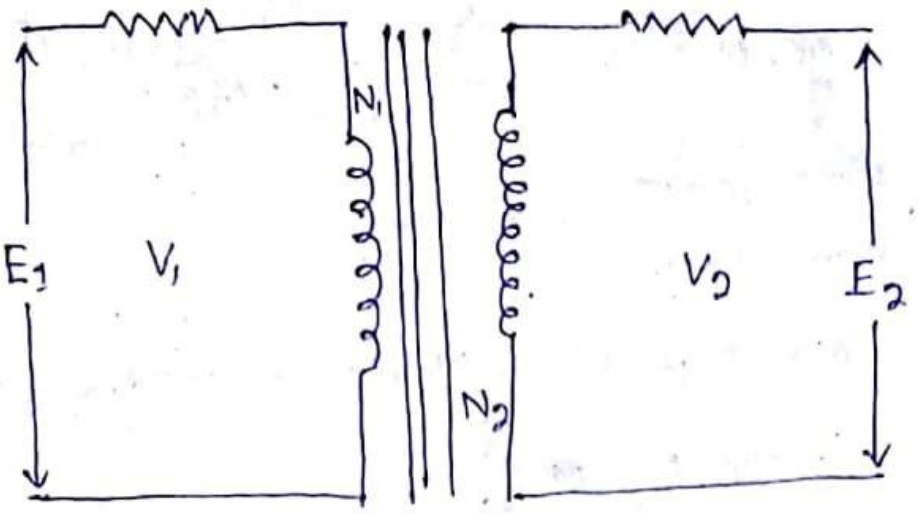
→ This is generally used for short lengths cable route, such as in work hole load crossing where frequent digging is costlier & impossible.

TRANSFORMER

→ Transformer is an electrical device which convert electrical energy from one end to other end without being electrically connected.

→ It is based on the principle of induction.

→ It is two terminal - (I) Primary
(II) Secondary



→ Transformer is a core over which winding are winded to form primary & secondary winding.

→ The primary voltage is E_1 & the secondary voltage is E_2 & N_1 is the no. of winding in the primary & N_2 is the no. of winding in the secondary.

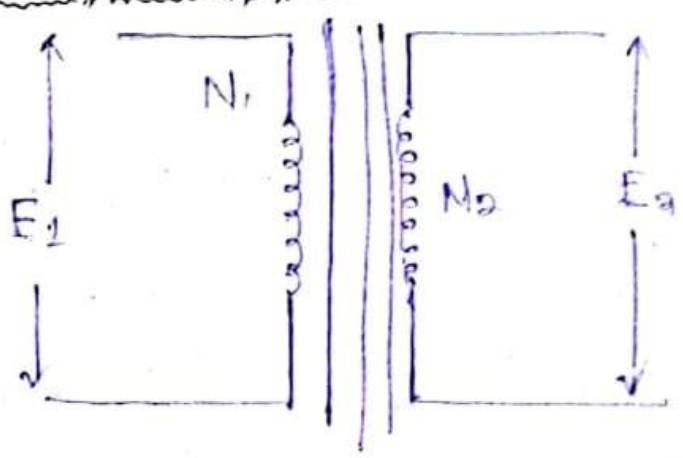
$$\frac{E_1}{E_2} = \frac{N_1}{N_2}$$

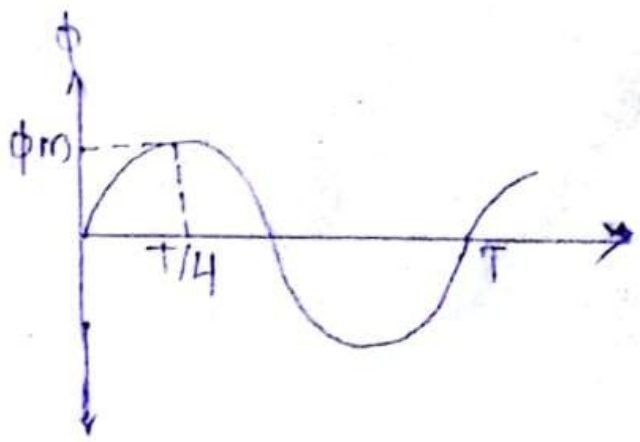
→ There are two kind of transformer - (I) Step up
(II) Step down.

→ Depending on the ratio of no. of winding, If $K<1$ then the transformer is a step up transformer. When $K>1$ then it is known as step down transformer.

→ Transformer transfer electrical energy without any deviation in frequency & power.

Transformer Equation :-





N_1 = No. of terns in the primary winding

N_2 = No. of terns in the secondary winding

ϕ_m = maximum Flux in the core.

f = Frequency = $\frac{1}{T}$

As shown in the Fig. the flux raises sinusoidally to its maximum value in 1 quarter of cycle. $(\frac{P}{4})$

P = Time period of sine wave.

average rate of change of flux = $\frac{\phi_m}{T/4} = \frac{\phi_m}{1/4f} = 4f\phi_m$.

form Factor = $\frac{\text{rms value}}{\text{avg. value}} = 1.11$

$\Rightarrow$ rms avg. changes = $1.11 \times 4f\phi_m = 4.44f\phi_m$

For single no. of turn $E = \frac{d\phi}{dt}$

For N no. of turn $E_1 = \frac{Nd\phi}{dt}$

For primary side $E_1 = N_1 \times 4.44 f\phi_m$ ——— ①

$E_2 = N_2 \times 4.44 f\phi_m$ ——— ②

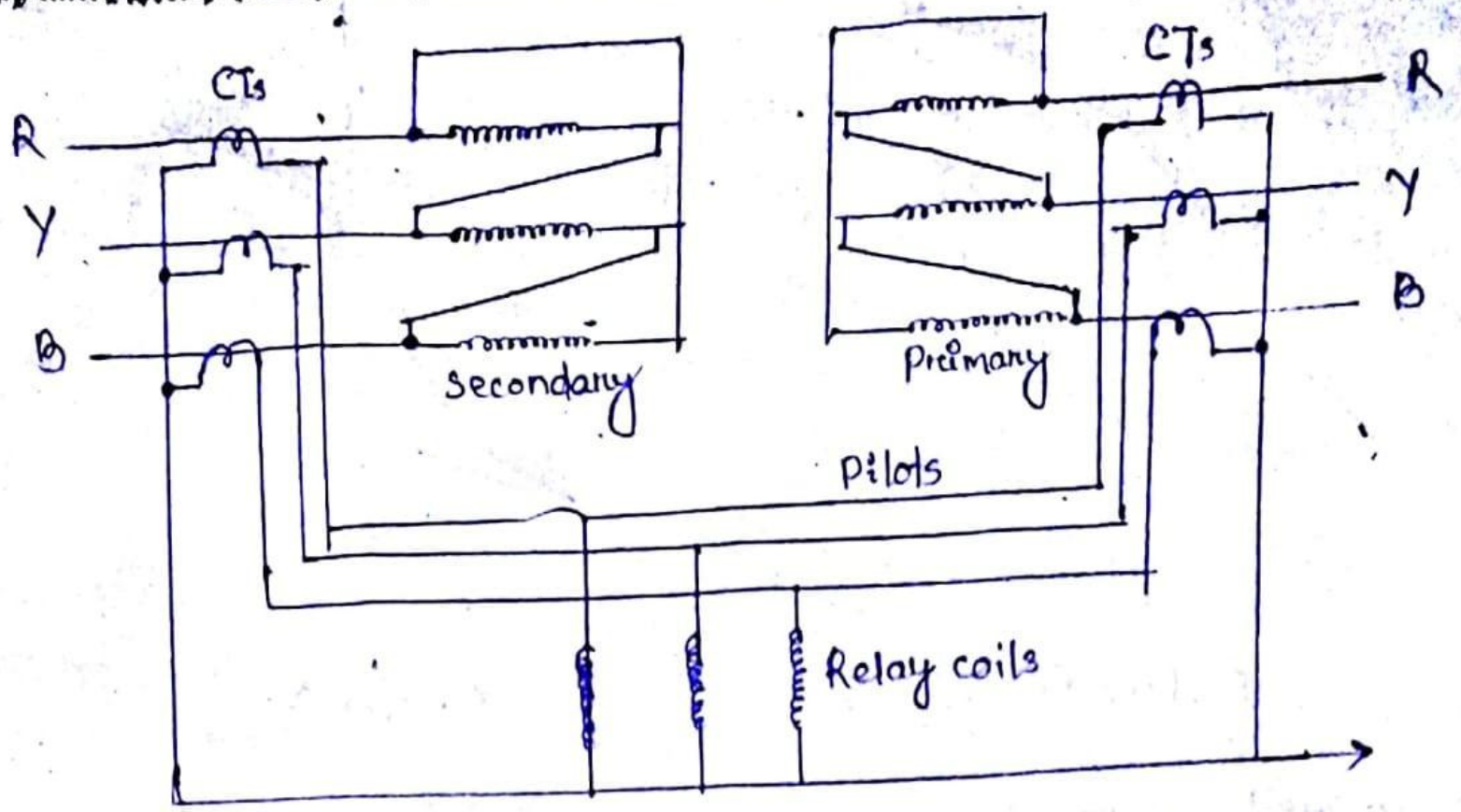
by dividing eqn ① & ②

$$\frac{E_1}{E_2} = \frac{4.44 f\phi_m N_1}{4.44 f\phi_m N_2} = \frac{N_1}{N_2}$$

→ If $\frac{E_1}{E_2}$ is <1 then it is a step-up transformer.

→ If $\frac{E_1}{E_2}$ is >1 then it is a step down transformer.

Differential Protection of transformer :-



(Merz-Price protection scheme)

Principle

→ Merz price protection scheme is employed for differential protection of transformer.

→ Under normal operating condition the incoming current must be equal to outgoing current.

→ Under fault condition the incoming current is not equal to the outgoing current hence according to the arrangement the difference in the current energised the relay coil which send trip signal to circuit breaker.

→ It is use for earth as well as phase fault.

Losses of transformer :-

→ There are two kind of losses in a transformer

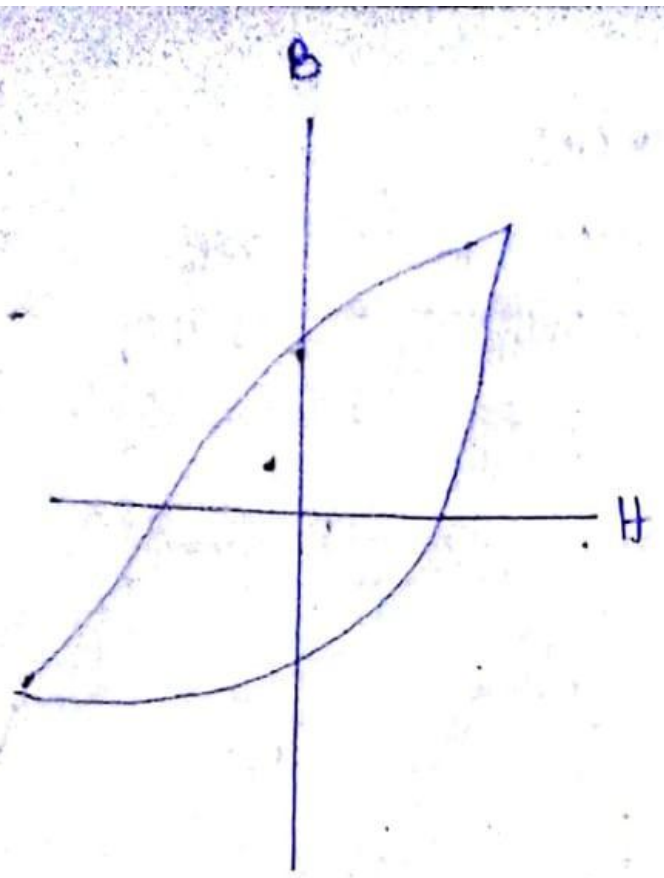
(i) Iron loss
(ii) Copper loss

→ Iron loss is of 2 types-

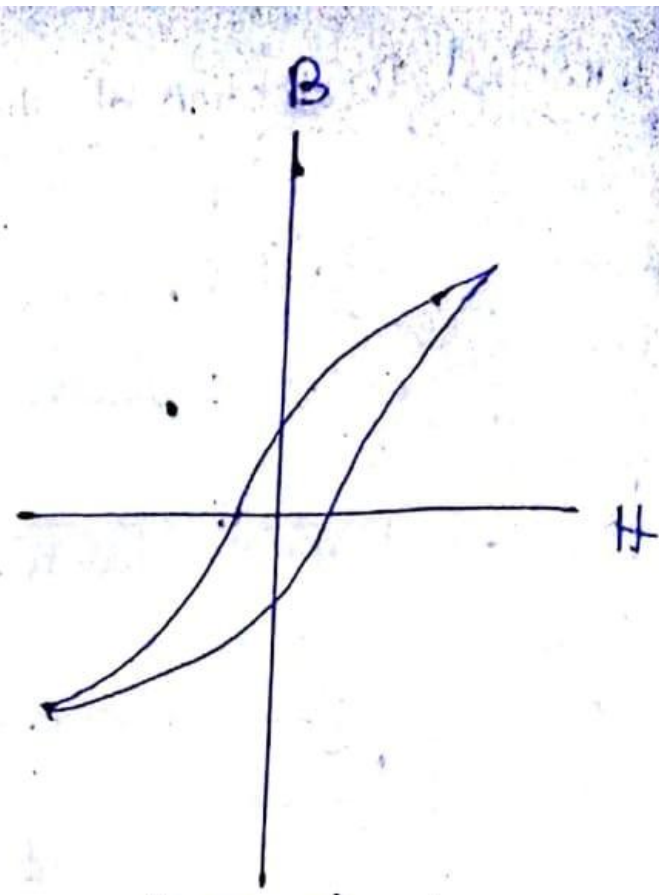
(a) Hysteresis loss
(b) Eddy Current loss

(a) Hysteresis Loss

→ It is due to reversal of magnetisation of transformer core subjected to alternating nature of magnetising force the hysteresis loss is proportional to the area of hysteresis loop for B-H curve



(Iron)



(Silicon)

→ To reduce the hysteresis loss material which has less area in the B-H curve is choosen.

(b) Eddy Current Loss :-

→ Eddy current Loss takes place due to circulating current in close loop that occurs in the core the power loss caused can be reduce by means of a process known as lamination.

→ where thin material are insulated in between will result for less eddy current loss.

(ii) Copper Loss :-

→ There are many conductor present inside transformer, when current flows $h = \frac{I^2}{RT}$ amount of heat is loss, This is known as copper loss.

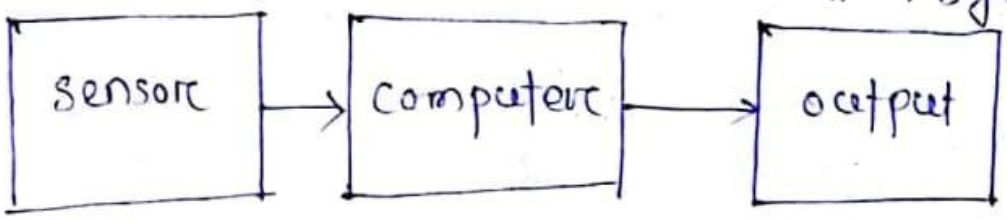
Sensors And Their Applications

→ Sensor is a device which senses different type of input & convert it into a suitable output. It is a kind of device which convert signal of one energy to another.

→ There are different kind of sensors -

(i) Temperature Sensor
(ii) Smoke, Gas & Alcohol sensor
(iii) Light sensor
(iv) Proximity sensor
(v) Color sensor
(vi) Touch sensor
(vii) Humidity sensor
(viii) heart beat sensor etc.....

→ Sensor is a main part of close door control system



→ The sensor senses like position, height, speed, location.

→ The sensor gives the signal to the computer & the computer process all the pre-design data.

→ There are 2 type of sensor -

(i) Active sensor
(ii) Passive sensor

(i) Active Sensor

→ The sensor which is external energy.

(ii) Passive Sensor

→ The sensor which don't detect the external energy is known as passive sensor.

→ Another type of classification -

(i) Analog
(ii) Digital

→ When the sensor, where the output is always electrical quantity is known as transducer.