Electrical Installation

V.V. Imp

Switchgear The apparatus used for switching, controlling and protecting the electrical circuits and equipment is known as switchgear.

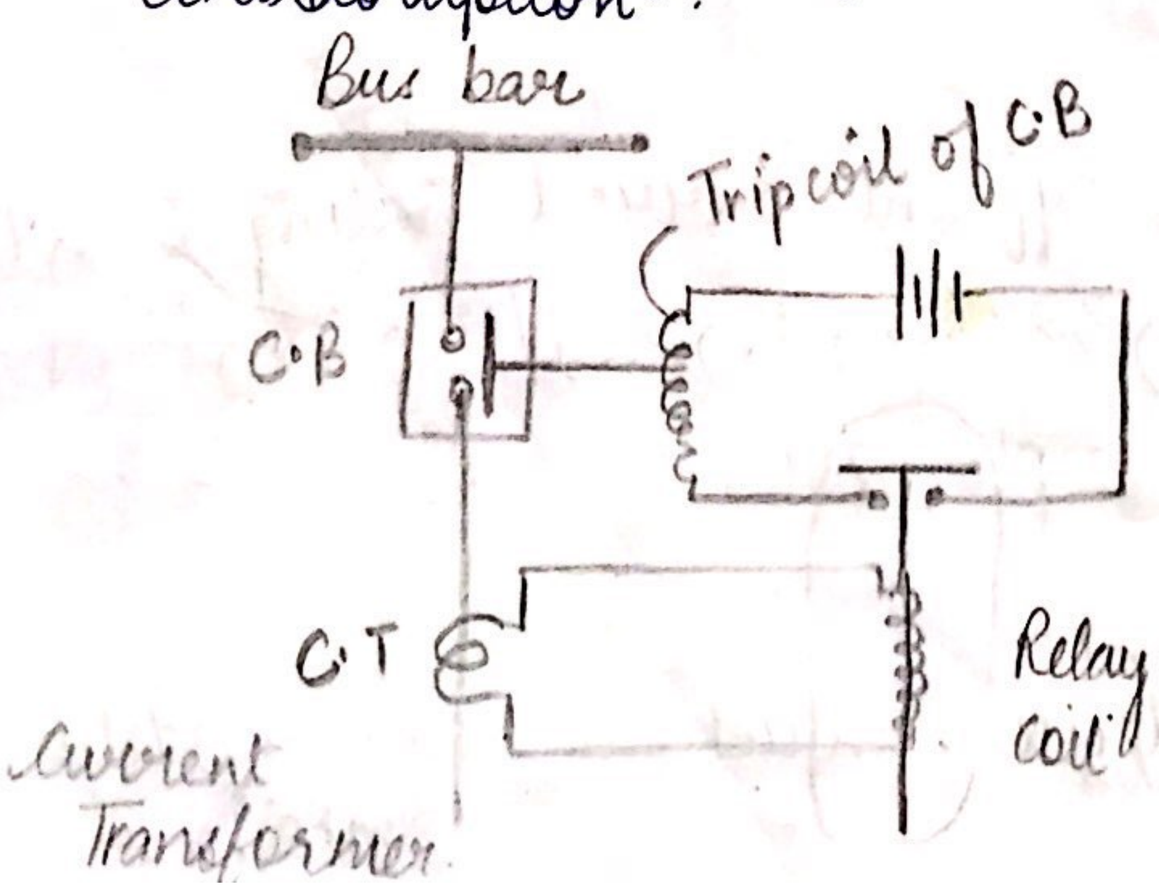
Component of LT switchgear

1. **Switches** A switch is a device which is used to open or close an electrical circuit in a convenient way but it cannot interrupt the fault current.
   a) air break switch b) oil switch. (i. pressure)

2. **Fuses** A fuse is a short piece of wire which melts when excessive current flows through it for sufficient time. It is connected in series with the circuit to be protected. (Round type fuse unit, Kit Kat type/ Rewirable fuse unit, Cartridge type fuse unit, HRC fuse unit, Semiconductor Fuse)

3. **Circuit breaker** A circuit breaker is an equiment which can open or close a circuit under all condition i.e no load, full load and fault condition.
   eg. MCB, ELCB and MCCB

4. **Relay** A relay is a device which detect the fault and supply information to breaker for circuit interruption.



Under normal load emf of sec winding CT is small & current is less to close the relay contacts. This keep trip coil of CB unenergised

eg. Thermal relay, electromagnetic relay

Buchholz relay (X'former)

1. Switch fuse Unit (SFU)

A suitable switch is provided immediately after the meter board to protect the circuit against excessive current. The linked main switch and fuse unit may be provided as one unit or as seperate unit.

Switch fuse is combined unit & known as iron clad switch. 2 types 1. DPIC for controlling 1ϕ 2 wire circuit (240V, 16A)
Double pole Iron clad

2. TPNIC for controlling 3 phase 4 wire circuit. (500V, 32A)
Triple pole neutral Iron clad.

V. Imp Emarks.

2. Miniature Circuit Breaker (MCB)

Imp This is the device that provide protection to the wiring installations and equipment against overcurrent and short circuit faults.

Operation. Thermal operation is achieved with bimetallic strip which deflect when heated by any overcurrents flowing through it. So it release the latch mechanism and cause the contact to open. Inverse time current characteristics result, i.e more the Overload current, shorter time required to operate the MCB. On the occurrence of a short circuit, the rising current energizes the solenoid, operating the plunger to strike the trip lever causing sudden release of latch mechanism which further causes the opening of contacts.

Ratings
These MCB are available with different current rating 0.5, 1, 2, 2.5, 3, 4, 5, 6, 7.5, 10, 16, 20, 25, 32, 35, 40, 63, 100, 128, 160A and voltage rating 240/415V ac upto 220V dc

Uses
It is used to protect the devices such as Air conditioners, refrigerators & computers etc.

3. Earth leakage Circuit breaker (ELCB)

The device which provides the protection against earth leakage.

2 Types

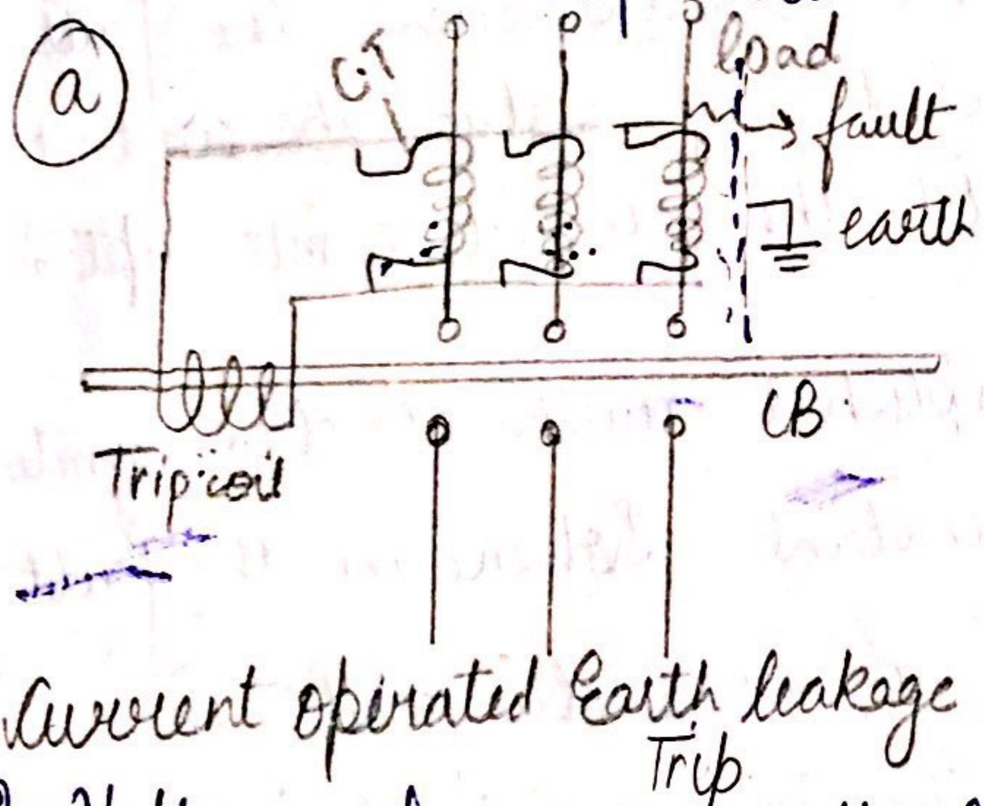
1. Current operated earth leakage C.B.

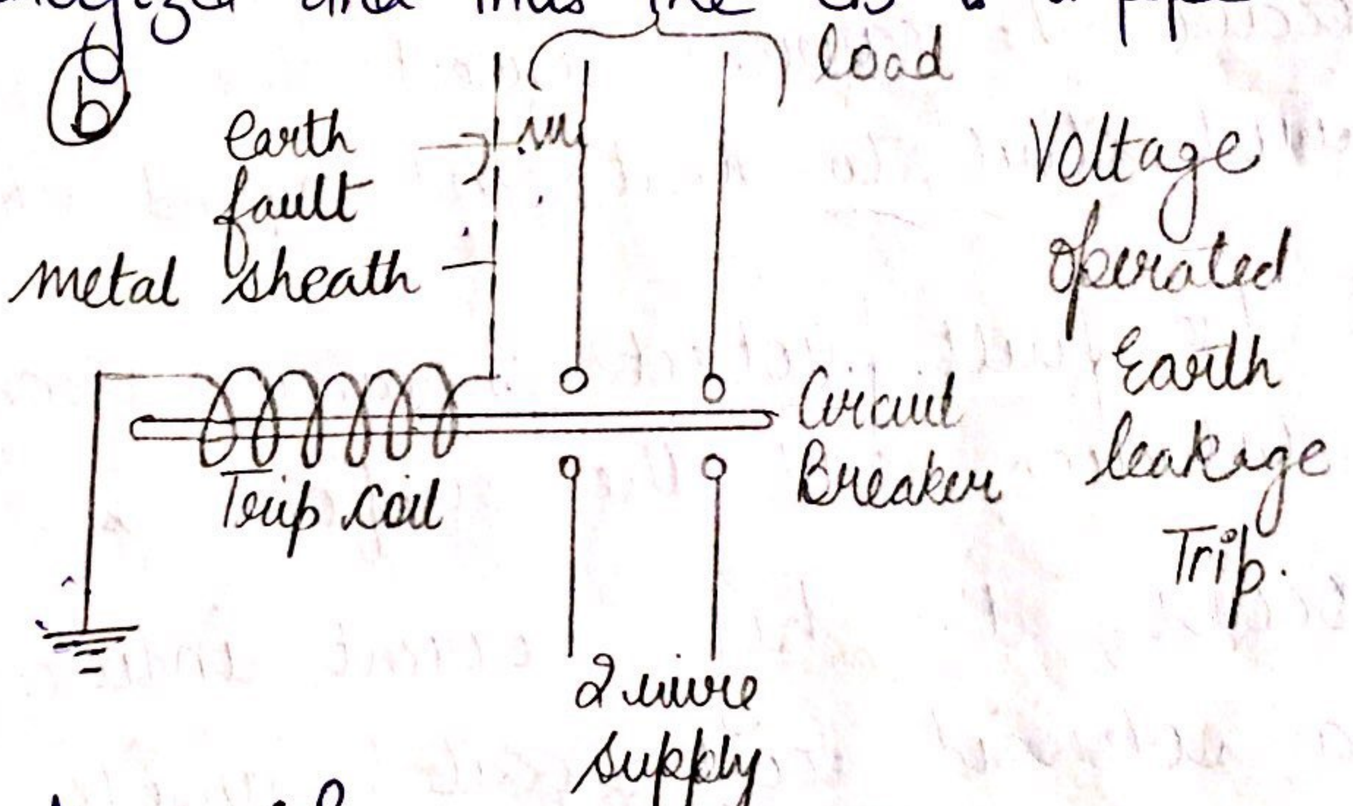
Condition if product of the operating current in A and the earth loop impedance in Ω does not exceed 40 then this type of CB used.

Operation A earth leakage protection is applied to 3ϕ 3 wire s/s.

If there is no earth leakage the sum of all the current in 3 coils of CT = 0 and no current flow through the trip coil.

But in case of any earth leakage, the currents are unbalanced and the trip coil is energized and thus the CB is tripped.





2. Voltage operated earth leakage CB

Suitable when earth loop impedance exceeds the values applicable to current operated earth leakage CB.

Operation An earth leakage trip in 2 wire circuit. When the V b/w the ECC and earth electrode rise to a sufficient value, the trip coil will carry the required current to trip the CB.

ECC (Earth continuity conductor)

A 3rd conductor with Line & neutral in mains distribution s/s bonded to earth.

4. Molded Case Circuit breaker (MCCB)

A molded case CB is a protection device that can be used for wide range of voltages and frequencies of both 50Hz and 60Hz.

Difference b/w MCCB and MCB It have high current rating upto 2500A, and its trip settings are normally adjustable.

Main function
1. Protection against overload
2. Protection against electrical faults.
3. Switching a circuit ON & OFF.

Operation It is based on the same principle used by all types of thermal magnetic C.B.

1. Overload protection is done by means of thermal mechanism It has a bimetallic contact which expands and contracts in response to change in temperature. So whenever the fault occurs the current exceeds the adjusted trip value) the contact will start to heat and expand until the circuit is interrupted.

2. The fault protect is also accomplished with electromagnetic induction, and the response is instent. Whenever the fault occur, the high current induces a magnetic field in a solenoid coil located inside the breaker — this magnetic induction trip contact and current is interrupted.

V. Imp

MCB	MCCB
1. Miniature Circuit breaker with optimum protection facilities of overcurrent only. These are manufactured for fault level of upto 10KA only with operating current 0.5 to 63A. These are used for smaller loads.	Molded Case Circuit breaker with protection facilities of overcurrent, earth fault. Has variable range of 50% to 100% operating current. They can be aimed for remote as well as local operation both. Fault level 16KA to 50KA operating R 25A to 3 larger power requirment.

Types of Wire and Cables

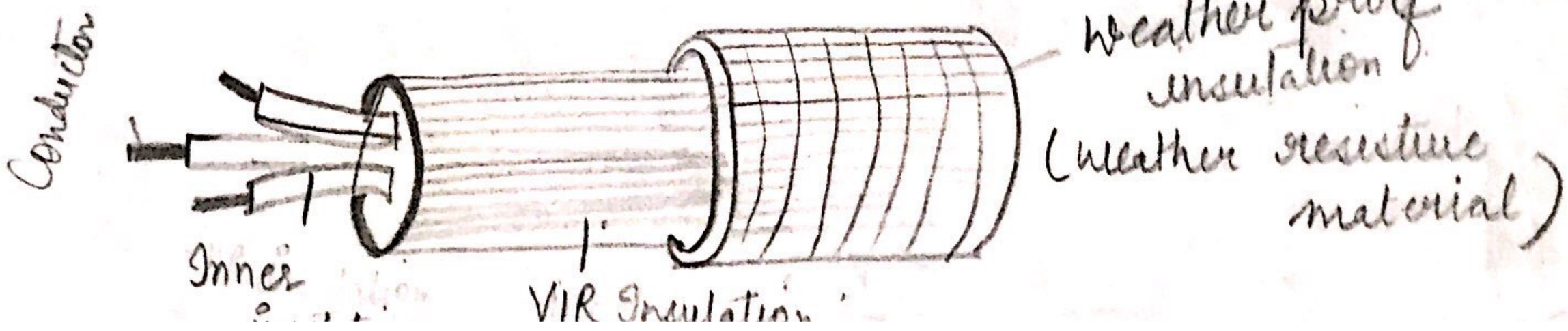
The wires used for internal wiring of building may be divided into groups according to

1. Conductor used a) Cu conductor cables b) Al conductor cables
2. Number of cores used a) Single core b) Twin core c) 3 core cables
3. Voltage grading a 250/440V b. 650/1100V (Voltage a conductor can withstend)
4. Type of insulation used:

a. Vulcanized Indian Rubber (VIR) cables 240/415V Cu . cotton tape sheathed
b. Tough rubber sheathed (TRS) cables VIR cable with outer protecting covering of TRS provide additional insolation . corrosion
c. Lead sheathed cables VIR conductor covered with lead sheath provide protect against moisture.
d. Polyvinyl do chloride PVC cables
e. Weather proof cables (outdoor)
f. Flexible cords and cables (consist of wires silk/cotton/plastic covered)
g. Multi strand cables (↑ no. of strands)
h. XLPE cables (Cross linked polyethylene) (↑ current rating, longer life)

* Single wire, may be bare or covered with insulation is called wire while several wires stranded together is called cable.

* PVC insulation is most widely used for covering wire/cables used in internal wire (as it provides better flexibility, has better insuleting qualities, has no chemical effect on metal of wire and gives smaller diameter of cable).



Earthing — equipment grounding
— System grounding

Earthing means connection of neutral point of supply system or the non current carrying parts of electrical apperatus, such as metallic framework, metallic covering of cables etc to the general mass of earth in such a manner that at all times an immediate discharge of electrical energy take place without danges.

Earthing is provided

1. to ensure that no current carrying conductor rise to a potential with respect to general mass of earth than its designed insulation.
2. to avoid electric shock to human beings.
3. to avoid risk of fire due to earth leakage current through unwanted path.

Various method of earthing

1. Strip or wire earthing. (Horizontal buried rocky soil 0.5 depth 25mm × 1.6mm Cu)
2. Rod earthing (12.5mm dia 2.5m l) vertical buried sandy soil
3. pipe earthing (Size depend upon current to be carried & type of soil)
4. plate earthing (dimension 60cm × 60cm × 3mm Cu plate)

The most common and best system of earthing is pipe earthing which is suitable for the same earth & moisture conditions.
(read pipe earthing from)

Batteries

A source of emf (dc) in which chemical energy is converted into electrical energy is called an electric cell. The emf developed and current supplied by single cell is very small i.e only 1.5 V and 0.125 A resp. There are many app. where higher V/I is required. So In order to obtain high V & I no. of cells are connected in series, parallel or series - parallel combination. Such combination of cells is known as batteries.

Types of batteries

1. Primary batteries: Primary batteries can be used only once because the chemical reaction that supply the current is irreversible eg. Voltaic cell, daniel cell, dry cell etc. In these cells during discharging, one of the plates (-ive plate) consumed which cannot be recovered by reversing the direction of flow of current through the cell. Thus chemical action in this case is not reversible and the cells cannot be recharged. This fact makes batteries more expensive so rarely used in commercial applications.

2. Secondary batteries (Storage batteries or accumulators) The batteries can be used, recharged and reused. The chemical reaction that provide current from the battery are readily reversed when current is supplied to the battery eg. lead acid, nickel iron alkaline cell, nickel cadmium alkaline cells.

In these cells no electrode is consumed during discharging however the chemical composition of plates is changed.

reversed the plate and electrolyte regain their origin. composition. So action is reversible and cell can be recha while recharging E.E is converted into chemical energy which is stored in the cell itself ie it is called storage batteries

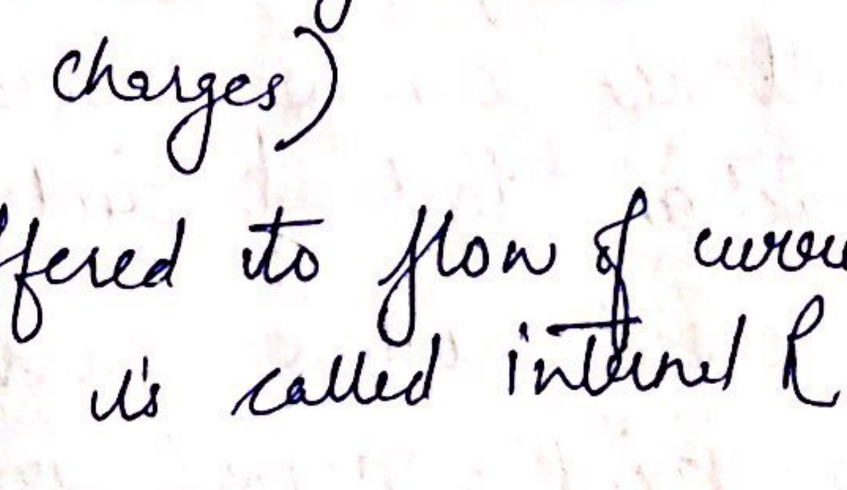
* Usually a no. of cells connected in series placed in single container is called a battery.

Important Characteristics for batteries V. Imp

The 3 important characteristics of an accumulator are.

1. Voltage

a) Emf (electromotive force) of a cell: The energy supplied a cell to one coulomb of charge is called Emf of cell. It is also defined as potential drop b/w the 2 electrode of a cell on open ckt. (E)



b) Terminal Voltage The p.d across the termin of cell at load is known as terminal voltage (V).

When load is applied, it delivers current I to external resistor (R) as show. The p.d across the term reduces to V becoz V.D (IXr) in internal resistance.

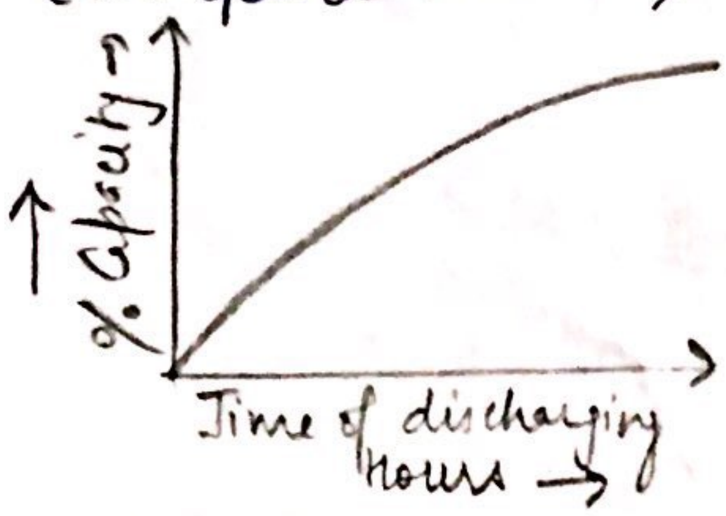
Thus $V = E - IXr$ (if battery discharges.

$V = E + Ir$ if battery charges)

2. Internal resistance of cell The opp. offered to flow of curre by internal composition of cell itself is called intenal R (r).

3. Capacity (Backup) The ability of an accumulator to last & provide current is called the rated output or capacity/bac

So the quantity of electricity which a battery can deliver during single discharge until its terminal Voltage fall to 1.8 Volt is called Capacity of battery. It is expressed in A-H (ampere hours)



Capacity of battery or cell = I_d T_d (discharging)
Current, Time

4. Efficiency of a battery (elementry Calculation for energy consumption)

a. Quantity or (A-H) η The ratio of output A-H during discharging to A-H during charging gives η of batteries

$$\eta_{AH} = \frac{I_d T_d}{I_c T_c}$$

I_d = dis. current
T_d = dis. Time
I_c = charging Current
T_c = charging Time

b. Energy or W-H η The ratio of output Watt-hours during discharging to the input watt hours during charging of battery is called energy / W-H η.

$$\eta_{WH} = \frac{I_d T_d V_d}{I_c T_d V_c}$$

V_d = dis. Voltage.

5. Battery ratings.

The standard adopted by both the industry and governm are

1. Ampere hour capacity Rating.
2. Reserve capacity.
3. Cold ratings
4. Cold cranking power ratings.

Elementry Calculation for energy consumption.

Numerical ✱ (write equation) ↑ here.

Numerical A discharge battery is put on charge for $3\frac{1}{2}$ hours at a mean charging voltage of 13.5 V. It is then discharged in 6 hours at a const terminal Voltage 12 V through R ohms. Determine i) R for an AH η 85% ii) watt hour η of battery.

Sol Given $I_c = 5A$ $T_c = 3.5$ $V_c = 13.5\ V$

$T_d = 6$ hours $V_d = 12\ V$

$\eta_{AH} = 85\%$

$= 0.85$

$$\eta_{AH} = \frac{I_d T_d}{I_c T_c}$$

$$I_d = \frac{0.85 \times 5A \times 3.5}{6} = 2.48A$$

$$R = \frac{V_d}{I_d} = \frac{12}{2.48} = \underline{4.48}\ \Omega \quad \underline{4.84}$$

$$\eta_{WH} = \eta_{AH} \times \frac{V_d}{V_c} = 85 \times \frac{12}{13.5} = 75.55\% \quad \underline{\text{Ans}}$$

Power factor improvement (V. Imp)

2nd Power factor improvement can be achieved with the use of either a passive or active input circuit. Passive circuit usually contain a combination of large capacitors, inductors and rectifiers that operate at supply line frequency. Active ckts incorporate some form of high f. switching converter for the power processing with the boost converter being the most popular topology. Since active input circuit operate at a frequency much higher than that of supply line frequency,

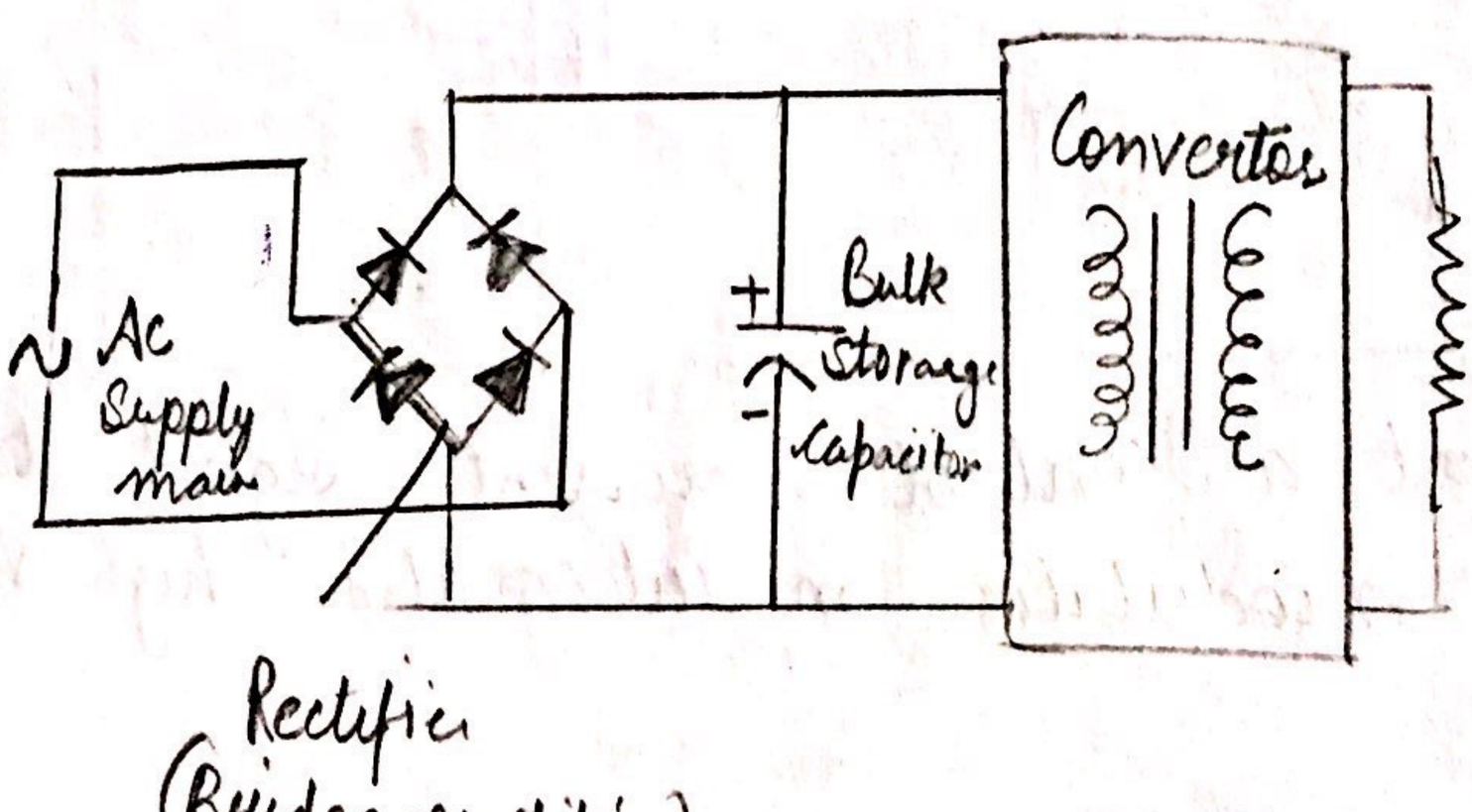
they are smaller in size, light wt. and more efficient than a passive circuit that provide similar ckts (5)

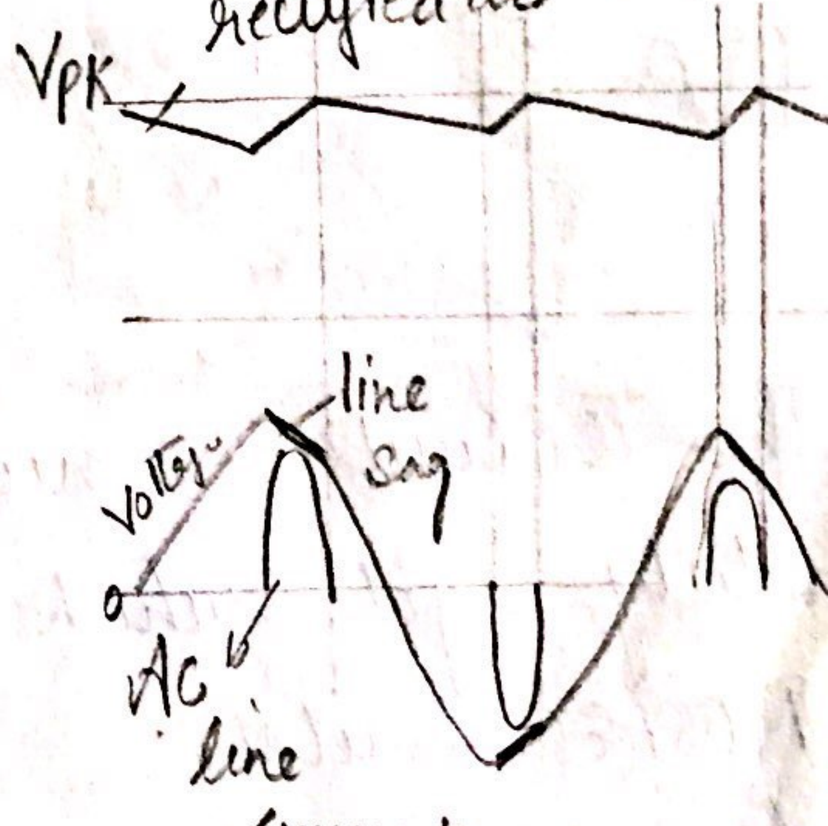
with proper control of the preconverter, almost any complex load can be made to appear resistive to the ac supply line, thus significantly reducing the harmonic current. eg MC3368 active pf controller, TOPS switch

1st

why pf correction is needed?

The simple rectifying circuit draws pwf power from the ac supply main when the instantaneous ac voltage exceed the capacitor voltage. This occur near the supply line voltage peak and result in high current spike as shown in fig since power is only drawn near the supply line V peaks, the resulting spike of current are extremely non sinusoidal with a high current of harmonics. This result in poor power factor condition where apparent input power is much higher than the true power. This reason that pf correction is required in power supplie





(1) MC 3366: An active pf controller whose function is to boost preconverter in off line power supply line appy has low power & high density also low power dissipation.

It features a (1) watchdog timer, (2) one quadrant multiplier (to initiate output switching. (to force line current to follow the instantaneous voltage)

(3) detector (to ensure critical conduction of operation)

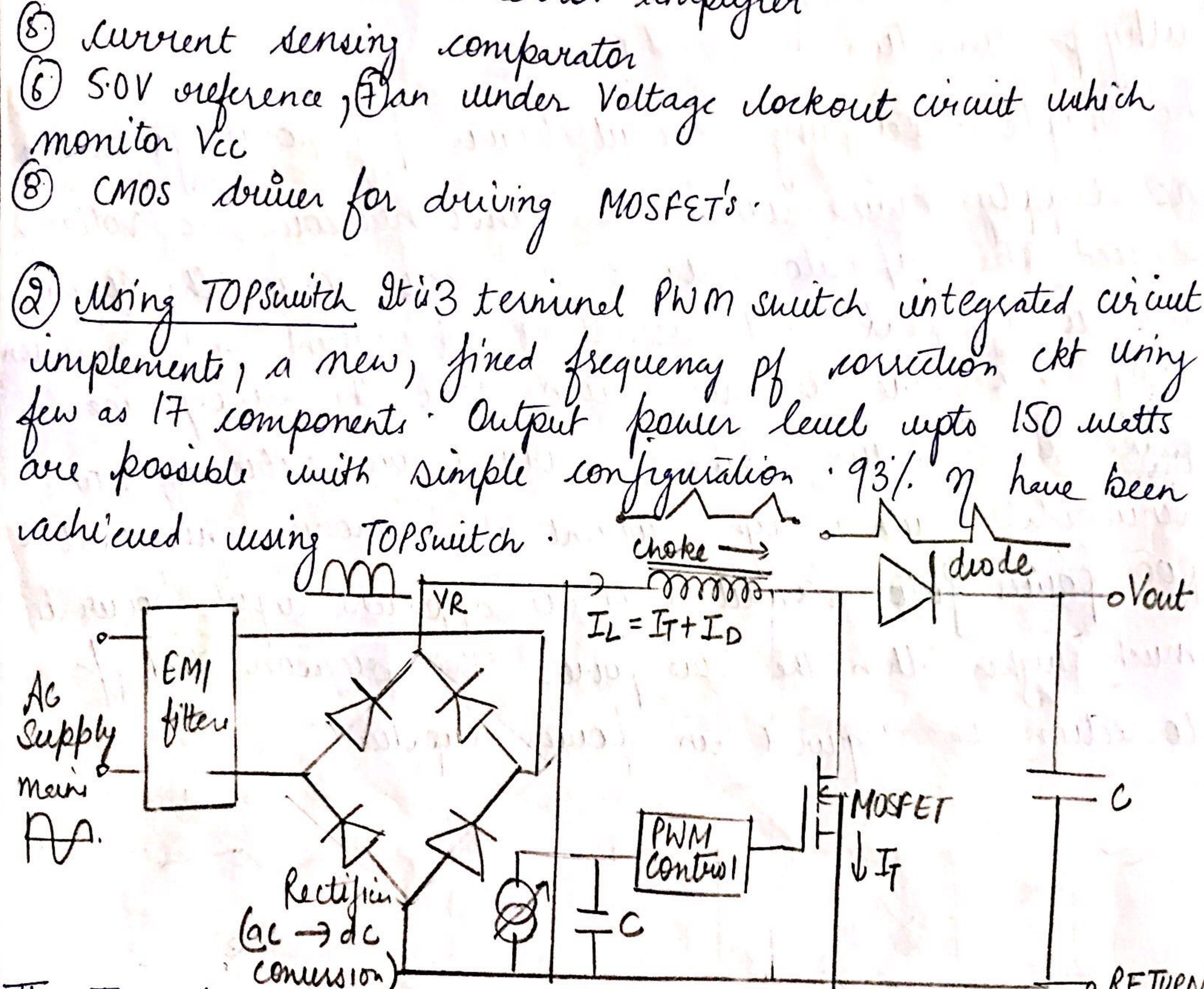
(4) A transconductance error amplifier

(5) current sensing comparator

(6) 5.0V reference, (7) an under Voltage lockout circuit which monitor Vcc

(8) CMOS driver for driving MOSFET's.

(2) Using TOPSwitch It is 3 terminal PWM switch integrated circuit implements, a new, fixed frequency pf correction ckt using few as 17 components. Output power level upto 150 watts are possible with simple configuration. 93% η have been achieved using TOPSwitch.



The TOP Switch convert a control current signal to a duty cycle which modulates an integrated high voltage MOSFET switch.

fig shows a simplified ckt which produces a dc voltage

of higher than the peak of full wave rectified ac supply voltage proper control of TP switch duty cycle over line freq. period generates a filtered sinusoidal input current waveform that is in phase with input voltage waveform.

Construction/Characteristics/ merits & demerits / App of

1. Nickel cadmium cells.

It was developed by Swedish scientist Waldemar Junger in 1899.

Const. Anode $Ni(OH)_4$ Cathode Cd (cadmium)
electrolyte — KOH (potassium hydroxide) of specific gravity

Its const. is similar to nickel iron cell with the difference that its extreme plates are tine moreover the plates are electrically connected to the container.

Chemical action during discharging. Diagram (last page)

At cathode $Cd + 2OH \rightarrow Cd(OH)_2$
At anode $Ni(OH)_4 + 2K \rightarrow 2KOH + Ni(OH)_2$

no change in specific gravity of electrolyte.

Recharging At anode $Ni(OH)_2 + KOH \rightarrow Ni(OH)_4$
cathode $Cd(OH)_2 + 2K \rightarrow 2KOH + Cd$

regain their original composition.

Characteristics 1) emf :- fully charge. 1.4 V which decreases to 1.3 rapidly.
2. $\eta = 80\%$ AH and 65% WH
3. Internal resistance very low, less than lead acid cell.

advantages very long life nearly 20 years) can be stored in any condition as there is no change in specific gravity and these cells can be charged for short period.

disadvantages 1. Very costly 2. low average emf therefore more cells are required for particular voltage.

2. Nickel Iron alkaline cell/ batteries

Also known as Edison cell, developed by American Scientist Thomson edison in 1909.

Const. Consist of 2 plates :- Anode & cathode. The active material of anode is $Ni(OH)_4$ and cathode is fe (iron) when fully charged. These plate immersed in electrolyte KOH. A small quantity of LiOH (Lithium hydrate) is also added to electrolyte which Res the capacity and life of cell. The specific gravity is 1.2 and the container made of nickel plated iron to which negative plates are connected

Diagram (last page)

Working

When cell is fully charge its positive plate $Ni(OH_4)$ and -ive plate fe. KOH is electrolyte is dissociated into K^+ and OH^- ions

Discharging $fe + 2OH \Rightarrow feOH_2$ cathode

$Ni(OH)_4 + 2K \rightarrow 2KOH + Ni(OH)_2$ anode

recharging $fe \cdot Ni(OH)_2 + 2OH \rightarrow Ni(OH)_4$

$fe(OH)_2 + 2K \rightarrow fe + 2KOH$

When cell is put on charging the OH^- ions moves toward anode and potassium ions move toward cathode.

Electrical characteristics

1. emf of fully charged cell is 1.4V which decreases to 1.3V rapidly however the avg emf is 1.2V which decreases to 1.0V when fully discharge.
2. internal R is high nealy 5 times to that of lead acid cell.
3. A-H η is 80% & W-H η is 60%

Advantages 1. longer life
2. KOH is not harmful if spilled away.
3. lower weight nearly half of lead acid cell.
4. can withstand higher temperature.

Disadvantages 1. higher cost nearly double
2. lower efficiencies.

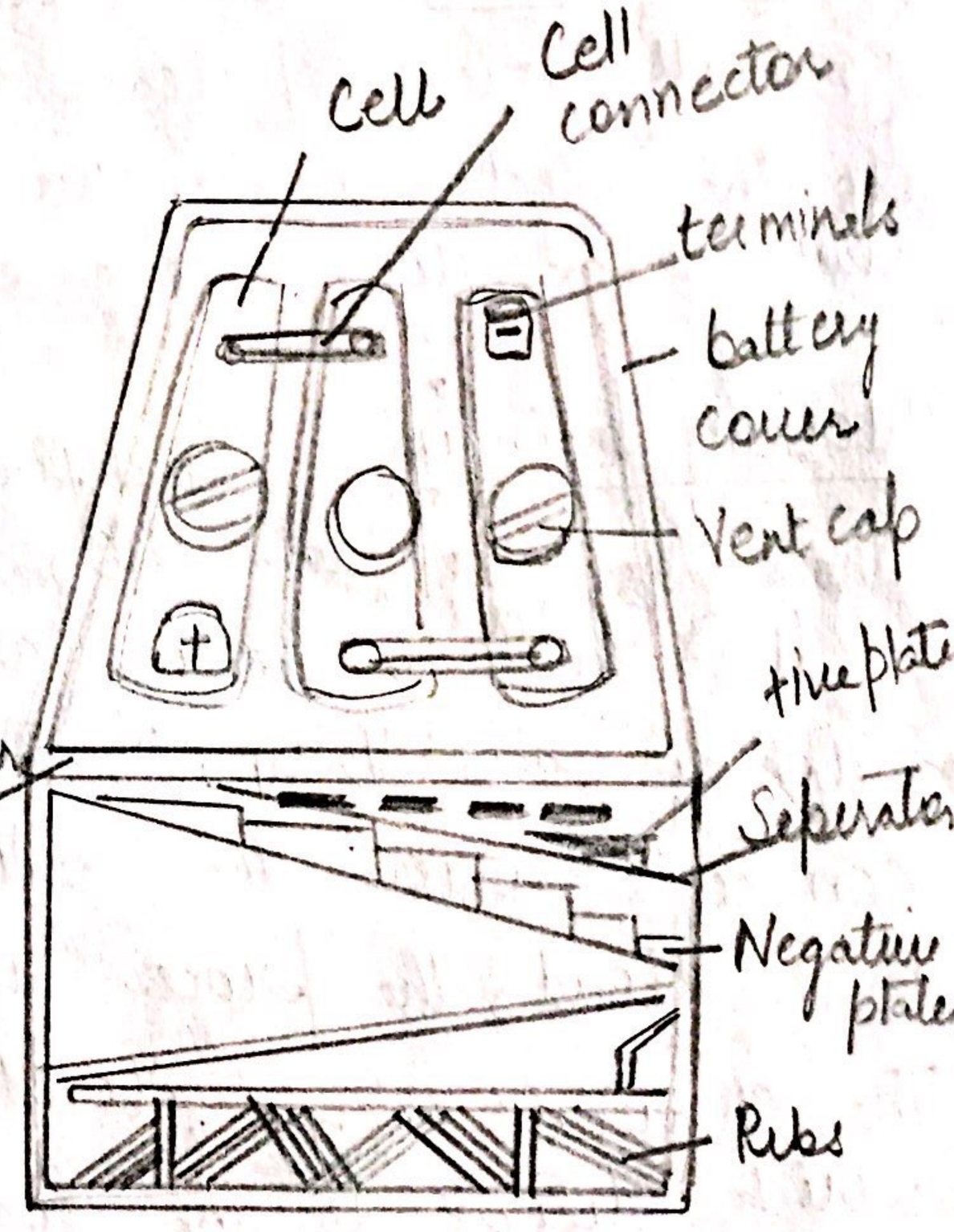
lead acid batteries.

The important parts of batteries

1. **Containes**
Outer body, made up of hard rubber or plastic and is sealed at top to prevent spilling of electrolyte.

2. **plates**
Alloys of lead antinomy sheet covered with lead peroxide & spongy lead forming +ive and -ive plates respectively are used as electrodes.

3. **Seperator**
To reduce internal resistance of cell and to save the space the plates are placed close 2 each other



they are separated by rubber sheet (non conducting material)

4. Electrolyte H_2SO_4 is used as an electrolyte in lead acid batteries. This added its water in such a proportion that with fully charged battery its specific gravity is about 1.28 to 1.29.

5. Battery cover each cell is covered with molded hard rubber and sealed with an acid resistant material.

6. Vent caps it has hole that allow the free exit of gases formed in the cell during charging. It's can be easily removed for adding water.

7. Inter cell connector cells are connected in series with a lead alloy link (in one container)

8. Cell terminals Each cell has 2 terminals which are generally made of lead as it does not corrode due to the electrolyte. The tive terminal of the battery is marked with red colour or tive sign.

Working principle

When the tive plate (PbO_2 (lead peroxide) – chocolate brown colour and –ive plate of (Pb) spongy lead – grey in colour are immersed in a dilute sulphuric acid (H_2SO_4) of specific gravity 1.28 and load is connected across the cell, it start delivering current to the load, the process is called discharging of cell. The chemical energy stored in cell is converted into EE. which delived to the load.

Chemical action during discharging

At cathode SO_4^{--} (Sulfate) $- 2e \rightarrow SO_4$ (radical)

At anode $Pb + SO_4 \rightarrow PbSO_4$ (lead sulfate)
(Grey colour) whitish colour

Explain these Chemical reaction as follows

At anode $2H^+ + 2e \rightarrow 2H$

$PbO_2 + 2H \rightarrow PbO + H_2O$
Chocolate brown

$PbO + H_2SO_4 \rightarrow PbSO_4 + H_2O$
(Sulfuric acid) whitish colour.

Eg Hydrogen gas liberated at anode acts chemically with anode material PbO_2 and reduces to PbO which further reacts with H_2SO_4 forming $PbSO_4$)

Chemical action during recharging.

At anode $SO_4^{2-} - 2e \rightarrow SO_4$ (radical)

$SO_4 + H_2O \rightarrow H_2SO_4 + O$

$PbSO_4 + O + H_2O \rightarrow PbO_2 + H_2SO_4$

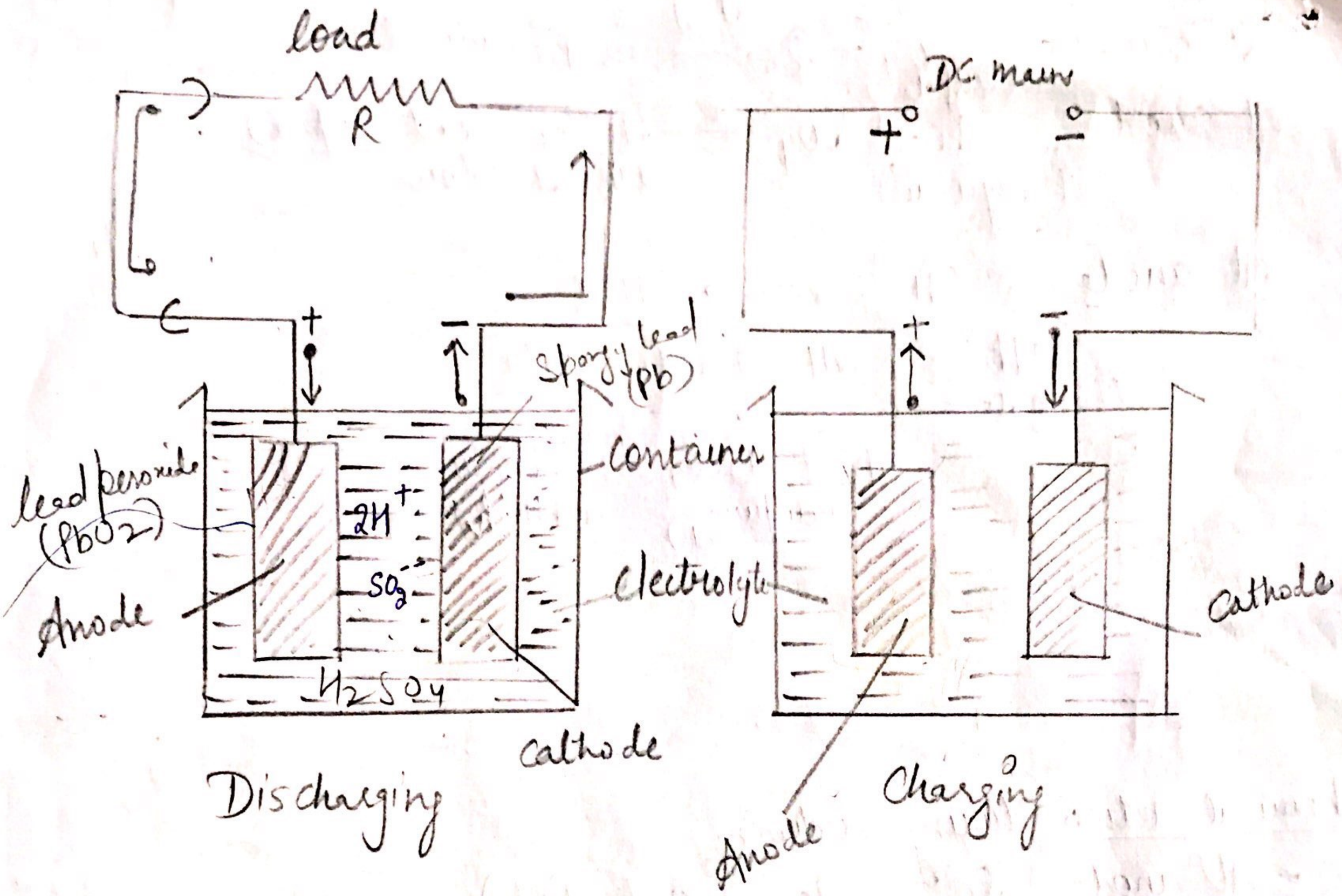
At Cathode $2H^+ + 2e \rightarrow 2H$

$PbSO_4 + 2H \rightarrow Pb + H_2SO_4$.

Here. Electrical energy is converted in Chemical energy

The average life of a lead acid battery is 2 to 4 years

Application 1. Used in automobiles for starting & lighting.
2. for lighting on steam and diesel railway trains
3. Used at telephone exchange.
4. Used for lighting purpose in remote areas.
5. Used at generating station & Substation for operation of protective devices and for emergency lighting.



Nickel Iron Alkaline cell

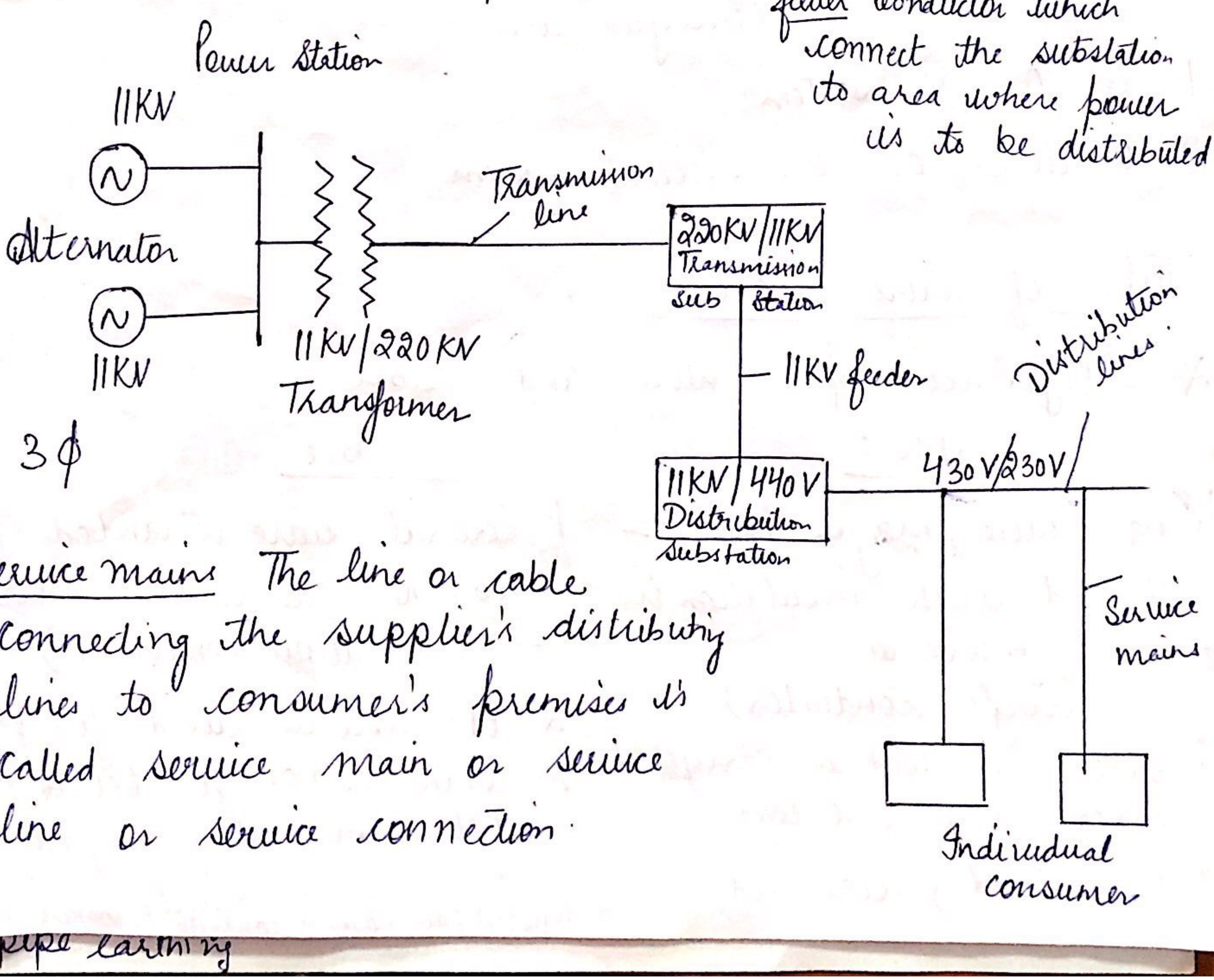
Nickel Cadmium cell

CHS Electrical Installation

Transmission lines Power is transmitted from generating station to the utility centre by the means of transmission lines.

Distributed lines from the utility centre power is distributed through distributors / distribution lines. The consumers are provided power supply by tapping connection from distribution lines.

electric power sls



feeder conductor which connect the substation to area where power is to be distributed

Service mains The line or cable connecting the supplier's distributing lines to consumer's premises it's called service main or service line or service connection.

pipe earthing

An electrical supply s/s consist of 3 principal components the power station, transmission line and distribution system. Electric power is produced at power station which are located at favourable places, generally quite away from consumer. It is then transmitted over large distance to load centre with the help of conductors known as transmission line. finally, it is distributed to large number of small and big consumer through distribution network.

Electrical Supply s/s can be classified into

1. Ac or DC system.
2. Overhead or underground system

line used to transmit electrical energy.

Types of wire & cables

* Difference b/w wire and cable

wire	cable
1. Single wire, may be bare or covered with insulation is called wire too. (Single conductor)	1. Several wire stranded together is called cable. (multiple conductor)
2. A wire is used to carry electricity, to bear mechanical loads.	2. A cable is used for power transmission for ~~telecommunication~~ telecommunication signals or to carry electricity
3. Types Solid, Standard	3. Twisted pair, multi conductor, coaxial cable

Fuse.

A fuse is a short piece of metal, inserted in the circuit which melts when excessive current flows through it and thus breaks the circuit.

Low voltage fuse

Semi enclosed rewireable fuse, HRC cartridge fuse (High rupturing capacity)

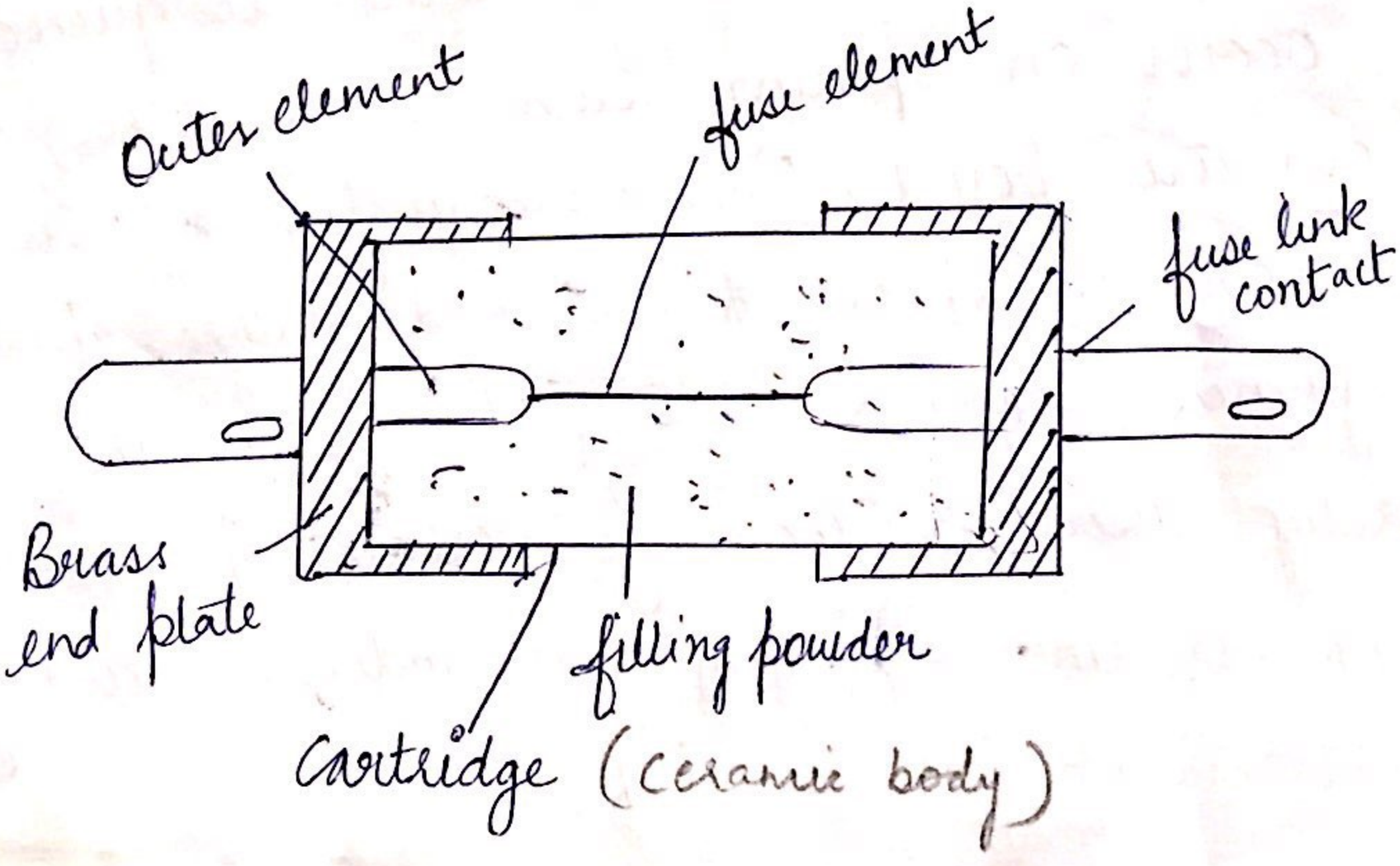
High Voltage fuses

Cartridge type, liquid type, metal clad fuses.

V. Imp

High Rupturing capacity cartridge fuse

It consist of a heat resisting ceramic body having metal end caps to which welded silver current-carrying element. The space within the body surrounding the element is completely packed with filling powder. The filling material may be chalk, plaster of pairs or marble dust acts as arc quenching and cooling medium.
∴ carries normal current with overheating.



when a fault occurs, the current increases and the fuse element melts before the fault current reaches its first peak. The heat produced in the process vapourises the ~~metal~~ melted silver element. The chemical reaction b/w the silver vapours and the filling powder results in formation of a high resistance substance which helps in quenching the arc.

Advantage 1. High speed of operation.
2. longer life & require no maintenance.
3. They are cheaper than other circuit interrupting devices of equal breaking capacity.

Disadvantages 1. They have to replaced after each operation.
2. Heat produced by the arc may affect the associated switches.

Switch Air break switch These switch are designed to open a ckt under load. In order to quench the arc that occur on opening such as switch, special arcing horn are provided (where arc is formed). As switch opens these horns are spread farther moved and farther apart. The arc is lengthened, cooled & interrupted. Air break switches are generally used outdoor for circuits of medium capacity such as line supplying an industrial load from a main transmission line or feeder.

Earthing Or Grounding

The process of connecting the metallic frame (i.e non current carrying part) of electrical equipment or some electrical part of system (eg neutral point in a ster connected system, one conductor of the secondary of transform etc) to earth / soil is called grounding Or earthing.

Advantage

If grounding is done systematically in the line of the power system, it prevent accidents and damage to the equipment of power s/s and at the same time continuity of supply can be maintained.

Grounding / earthing may be classified as

1. Equipment grounding: The process of connecting non current carrying metal part of electrical equipment to earth.
2. System grounding The process of connecting some electrical part of the power system to earth.

* Neutral Grounding The process of connecting neutral point of 3 phase system to earth either directly or through some circuit element (eg resistance, reactance etc) is called neutral grounding.

Various method of earthing are

1. Strip or wire earthing.
2. Rod earthing.
3. Pipe earthing
4. plate earthing.

Pipe earthing: The most common and best m/s of earthing as compared to other systems suitable for same earth and moisture condition.

A galvanised steel and perforated pipe of approved length and diameter is placed upright in permanently wet soil. Size of pipe depend upon current to be carried and type of soil. Usually dia = 40 mm and $l = 2.5$ m for ordinary soil or greater length in case of dry & rocky soil. depth = 3.75 m at which pipe is buried. The pipe at bottom is surrounding with broken pieces of charcoal for a distance about 15 cm around pipe. Alternate layer of coke and salt are used to increase the effective area of earth and decrease the earth resistance respectively.

Another pipe $d = 19$ mm $l = 1.25$ m is connected to the top of pipe. As in summer season the moisture in the soil decreases which cause increase in earth resistance. So concrete work is done to keep the water arrangment accessible to have effective earth, 3/4 buckets of water are put through funnel (dia = 19 mm) connected to pipe.