Biogas power plant –

Biogas is a mixture of gases, primarily consisting of methane, carbon dioxide and hydrogen sulphide, produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste, waste water and food waste.
Biogas is produced by anaerobic digestion with anaerobic organisms or methanogens inside an anaerobic digester, biodigester or a bioreactor.

Biogas power plant –

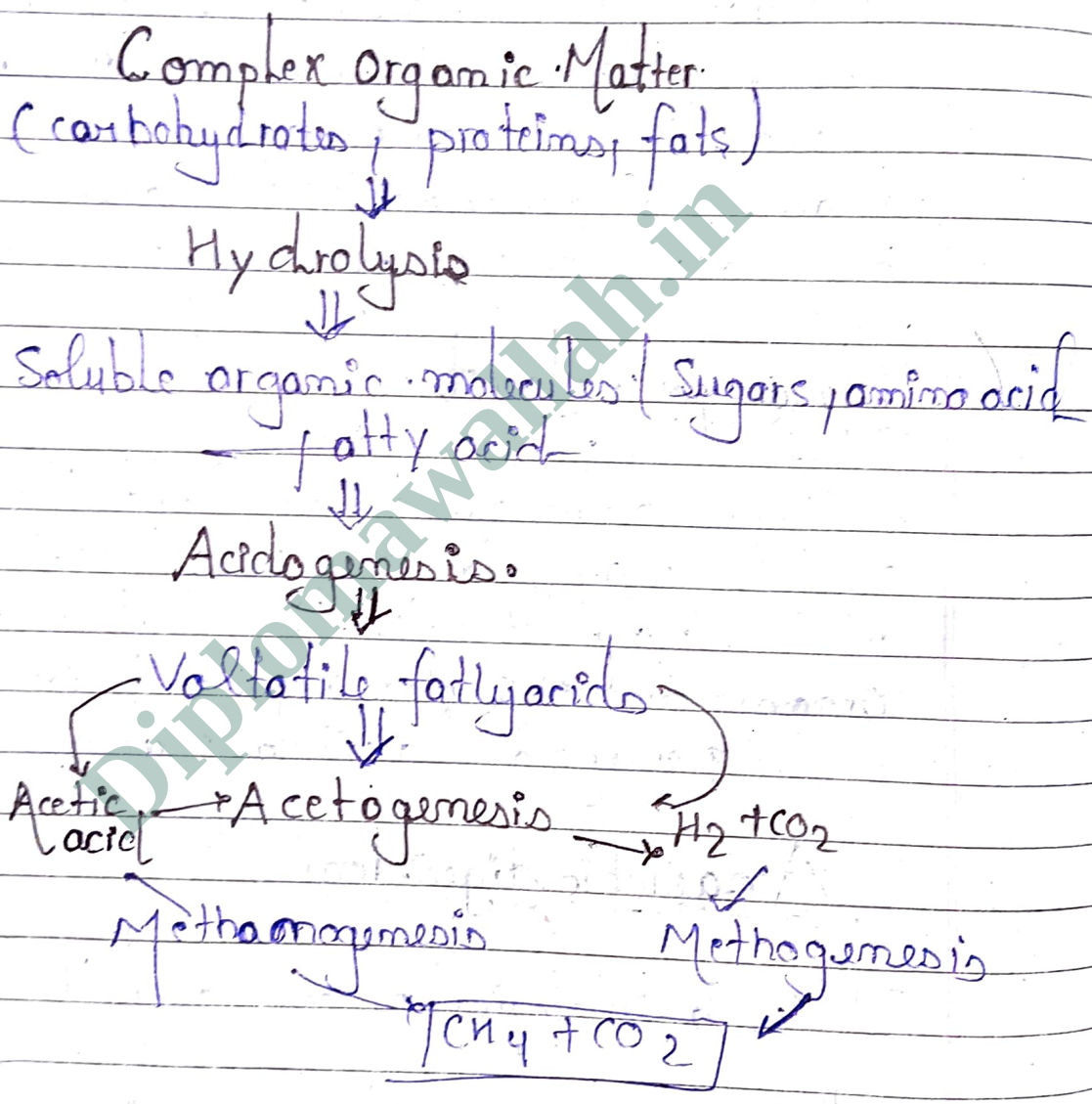
A biogas power plant is a plant that generates electricity and/or heat by utilizing biogas which is produced from the decomposition of organic matter such as agricultural waste, food waste, sewage and animal manure.

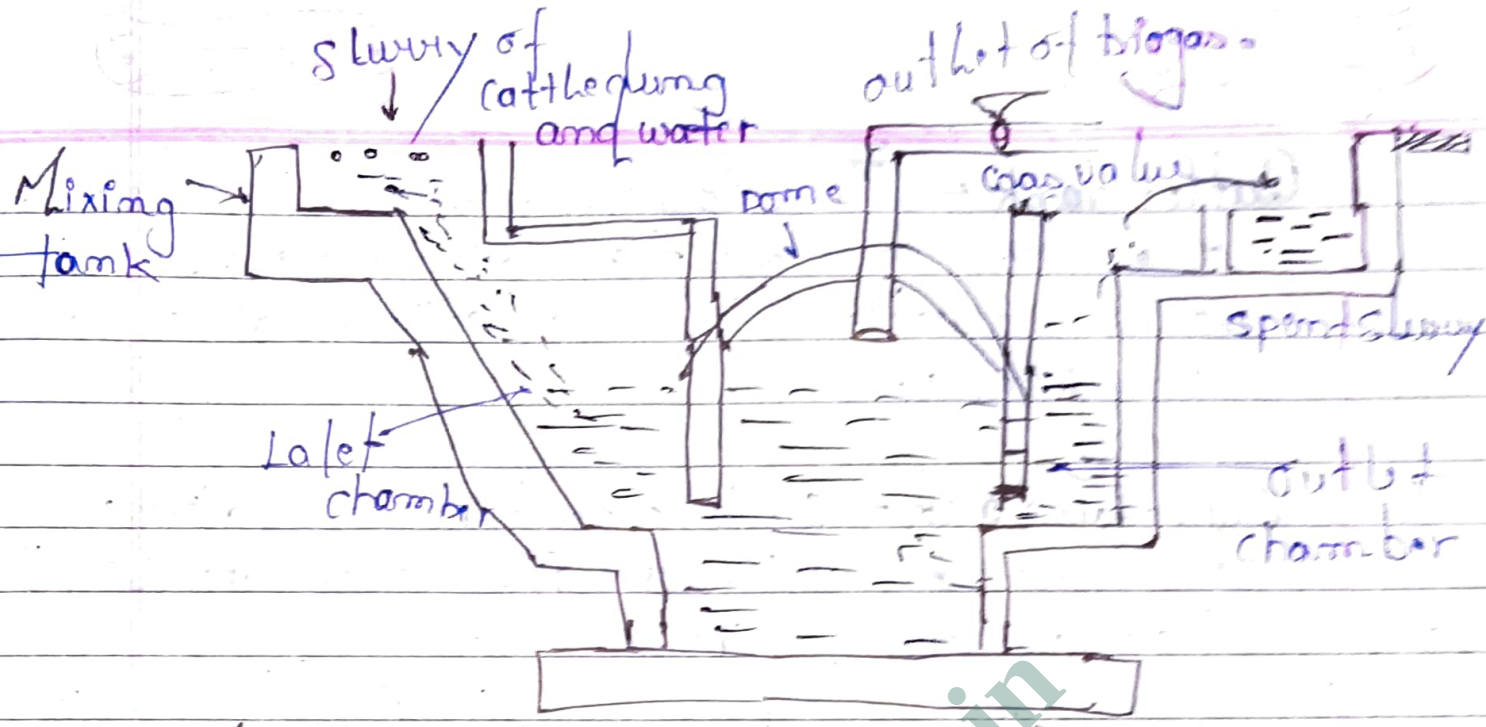
Anaerobic digestion –

It is a biological process and there are 4 stages.

* Hydrolysis – In this stage, bacteria break down organic polymers like carbohydrates into simple sugars so that the next groups of bacteria can further process the materials.

Acidogenesis:- In this stage bacteria called acidogenic bacteria convert the simple sugar and amino acids into carbon dioxide, hydrogen, ammonia and organic acids.





Main parts of biogas

(i) **Mixing tank** – This tank present above the ground where all waste is collected and every thing collected is mixed to be processed further.

(ii) **Inlet chamber** – This basically consists of two parts inlet pipe and storage place where inlet pipe will collect all the waste from mixing chamber.

(iv) **Digester** – These tank present underground so that proper anaerobic conditions can be provided to microbes to grow and produce desired out put. In this tank an outlet pipe is also connected which takes out gas which produce inside.

Outlet tank :- This tank is required to collect all dead biomass or remaining fragments of input waste. It took out all the waste from the digester.

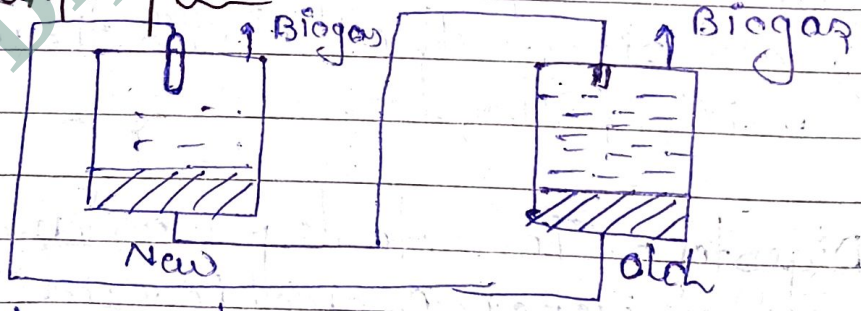
Over flow tank :- outlet chamber open in a small over flow tank where all processed or waste material can be stored.

Classification of Biogas plant

(1) Batch type plant
(2) Continuous type plant

- Floating Gas holder Biogas plant
- fixed Dome Biogas plant.

Batch type plant



Batch type biogas plants are appropriate where daily supplies of raw waste materials are difficults to be obtained. A batch loaded digester is filled to capacity scaled and given sufficient retention time in the digester. After completion of

the digestion, the residue is emptied and filled again. Gas production is uneven because bacterial digestion starts slowly, peaks and then tapers off with growing consumption volatile solids.

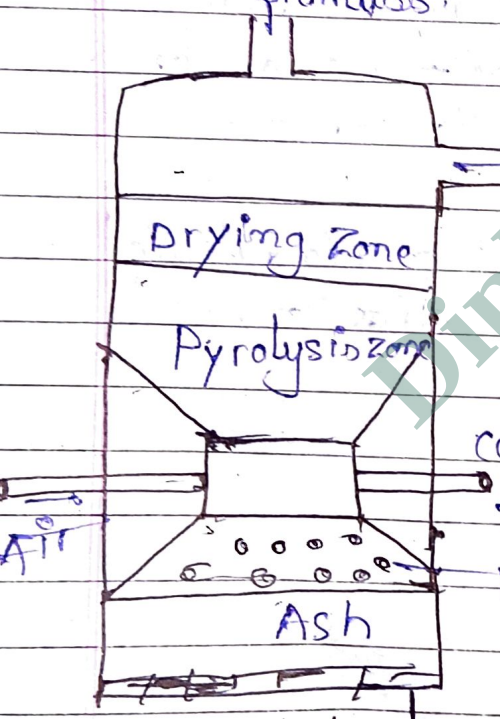
Continuous Type plant:

It continuous type biogas plant, the supply of the gas is continuous and the digester is fed with biomass regulary. Continous biogas plants may be single stage, double stage or multiple process, in the two chambers or digester is called multi stage process.

Retention period:- The period during which the biomass remains in the digester.

GASIFICATION
BIOMASS Power plant.

Gasification is a process that converts organic materials, such as biomass coal, or waste materials, into a gas stream containing carbon monoxide, hydrogen and other gases. The process involves heating the organic material to a high temperature in the presence of a limited amount of oxygen or sometimes in the absence of oxygen, to produce a gas stream rich in carbon monoxide and hydrogen which are referred to a synthesis gas or syngas



Drying Zone – Heating of biomass to remove water at (100 – 150°C).

Pyrolysis zone – Heating of dry biomass without to make bio-char. (200° – 500°C) gives Tar Gases and charcoal.

Combustion Zone

Reduction Zone

Combustion Zone – Adding air to crack and burn tar gases. (800° – 1200°C).

Gives – $H_2O + CO_2$.

Hot reactive charcoal.

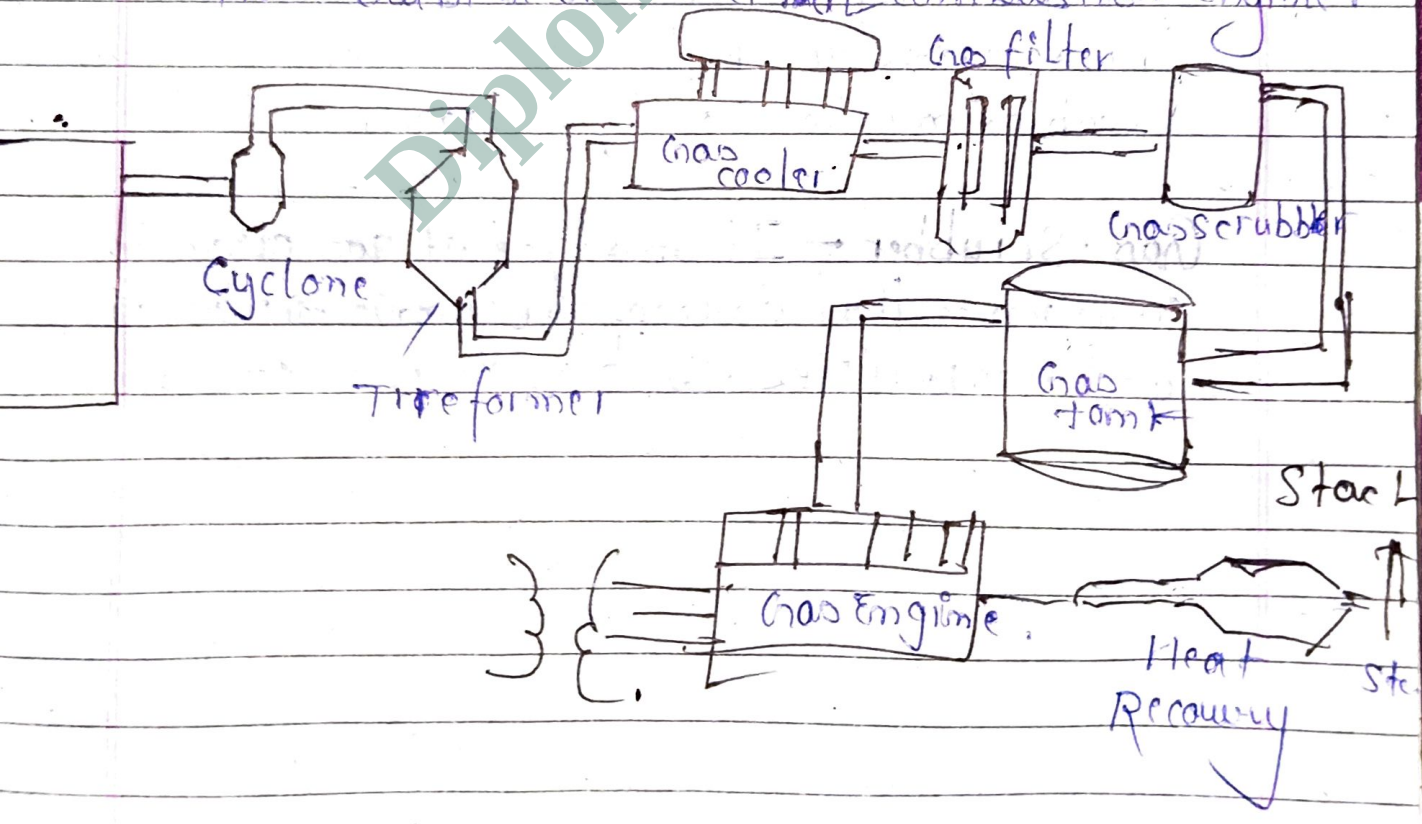
Reduction zone — converting charcoal to syngas. (650-900°C)

$H_2O + C \longrightarrow H_2 + CO$

$CO_2 + C \longrightarrow 2CO$

Biomass Power plant :-

A gasification biomass power plant is a type of power plant that use biomass as its fuel source and converts it into a combustible gas known as "syngas" through a process called gasification. This syngas is then used to generate electricity through a combustion turbine or internal combustion Engine.



Gasifier — heats the biomass in an oxygen-depriived environment to produce a gas called syngas, which consists of carbon monoxide hydrogen, methane, and other combustible gases.

Cyclone → During the gasification process, small particles and ash can be entrained in the syngas stream, which can cause damage. To prevent this cyclone is used to remove the particulate matter by using centrifugal force to seperate the particles from the gas steam.

Tar reformer — It is typically a high-temperature catalytic reactor that use a catalyst to promote the conversion of tars into simpler gases such as methane and hydrogen.

Gas Scrubber — It is a type of gas cleaning equipment that is used to remove acidic gases and impurities such as sulphur compounds.

Advantages:-

1. fuel flexibility: Gasification power plant can use a wide range of solid fuels.

2 High Efficency: higher efficiencies compared to traditional combustion based power plant, which can result in lower fuel consumption and Emissions.

3. Reduced Emmision.

4. Syngas utilization:- The syngas produced is used for a variety of applications, including electricity generation, chemical production and as a feedstock for liquid fuel production.

Disadvantage:

-> High capital investement.

2 complexity.

-> Dependence on fuel quality.

Solar PV power plant.

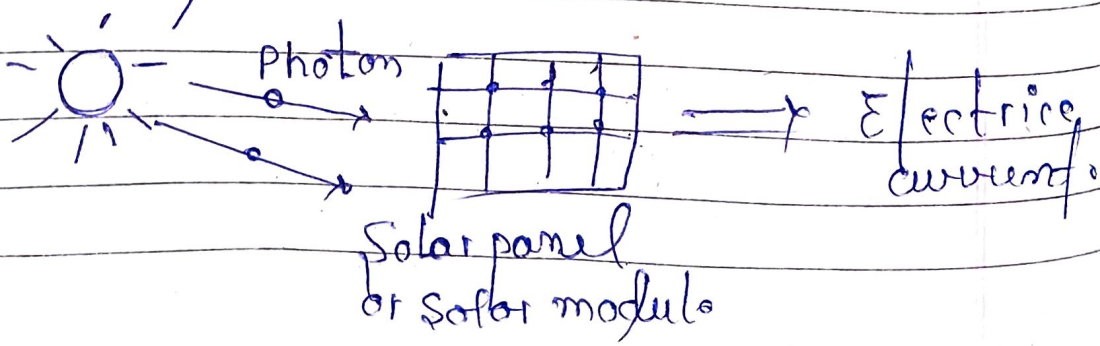
Solar power plant use the Sun's rays to produce electricity. Photovoltaic plants and solar thermal systems are most commonly used solar technologies today

There are two types of solar power plants. They are differentiated depending on how the energy from the Sun is converted into Electricity.

1) Solar photovoltaic power plant.
2) Solar thermal power plant.

Solar photovoltaic power plant

A photovoltaic cell, commonly called a solar cell or PV cell is a technology used to convert solar Energy directly into Electricity. A photovoltaic Effect, which cause them to absorb the photons and release Electrons. The Electrons are captured in the form of an electric current in other words, Electricity.



Solar thermal plant:-

A solar thermal plant is generates heats by concentrating the sun's energy that is turn builds steam that helps to feed a turbine and generator to produce Electricity.

1. Parabolic troughts.
2. Solar power tower.
3. Solar pond.

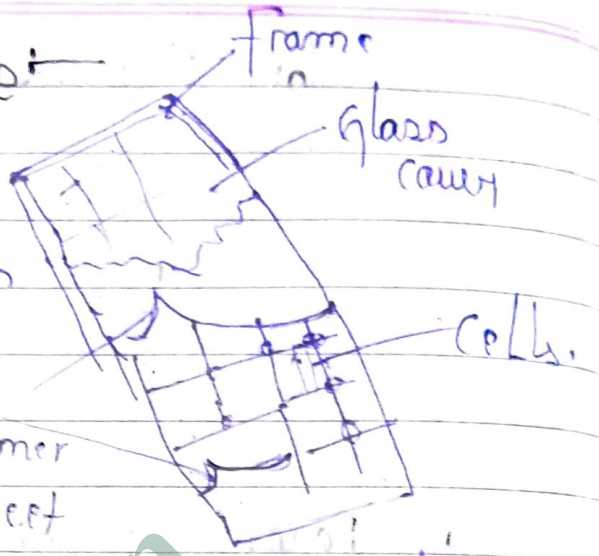
Solar cell / PV cell.

A solar cell is a semiconductor (P-N junction diode) device that converts electromagnetic radiation reaching us from the sun to Electrical Energy The current generate D.C. The p.d of S.C is about 0.5 to 0.6 volt and hence described number of such cells to be connected in series to achieve 14 to 18 volts.

Solar panels:- Solar panel or solar module is basically an arry of series and parallel connected solar cells.

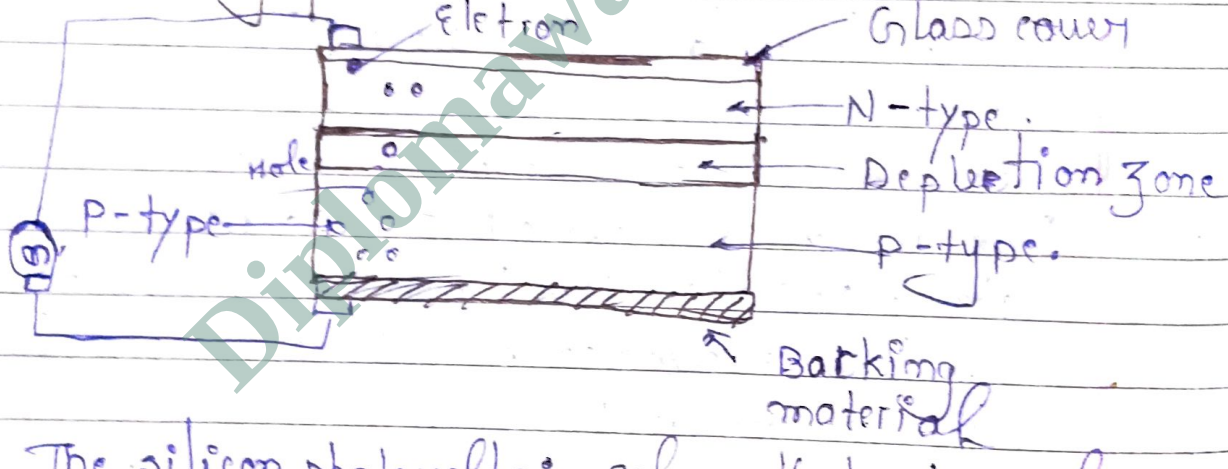
Solar array:- Solar panels are connected together to create a solar array

Construction of Solar panels:-

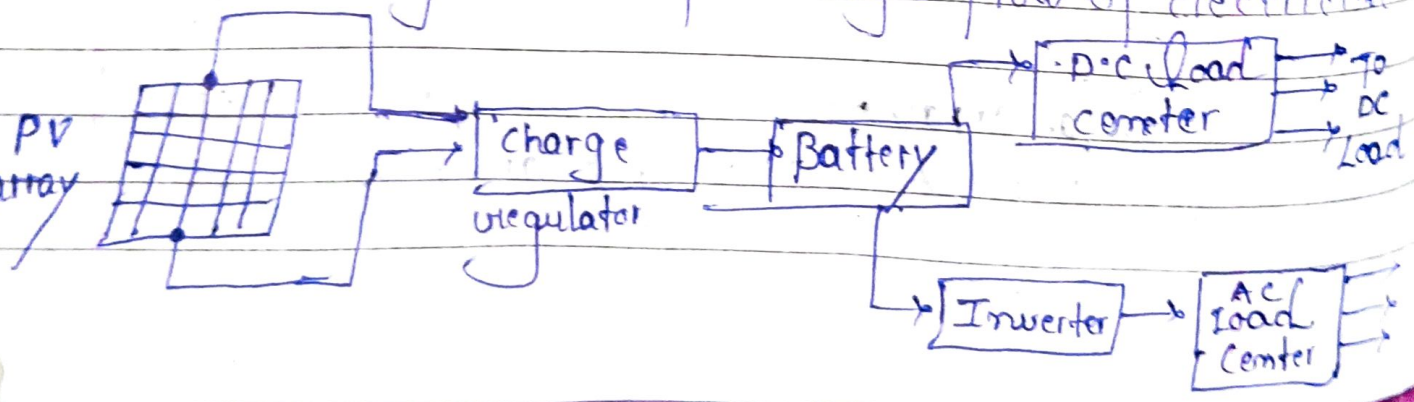


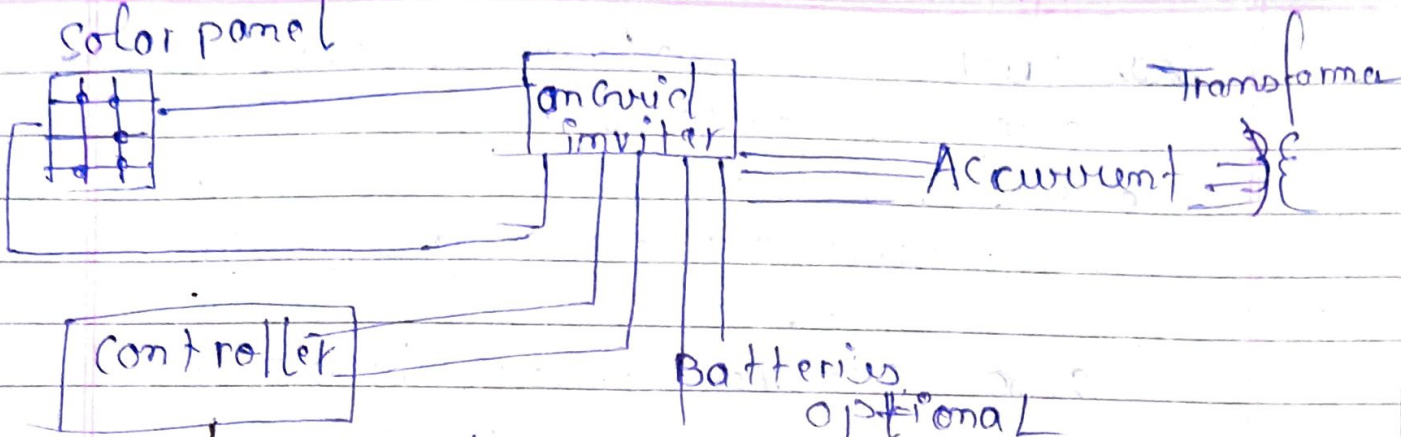
A standard solar panel consists of a layer of silicon cells a, metal frame, a glass casing, polymer sheet, backing material and various wiring to allow current to flow from the silicons cells.

Working of solar cell



1. The silicon photovoltaic solar cell absorbs solar radiation.
2. When the Sun's ray interact with silicon cell Electron begin to move, creating a flow of Electricity





command and control signals for electricity production from panels.

Advantages:-

- PV panels provide clean-green.
- Solar energy is energy supplied by nature it is thus free.
- solar energy can be made available almost anywhere there is sunlight.
- operating and maintenance cost for PV panels and considered to be low.

Disadvantage:-

- As in all renewable energy source, not shining at night but also during day time there may be cloudy or rainy weather.
- Solar energy panel require additional equipment to convert DC to AC inverter to be used on power network.

Ac load.

Gas turbine power plant.

Gas turbine power plant in which the prime mover is a gas turbine which is a combustion engine. The gas turbine produced mechanical energy. Then this energy drives a generator that produces Electrical Energy.

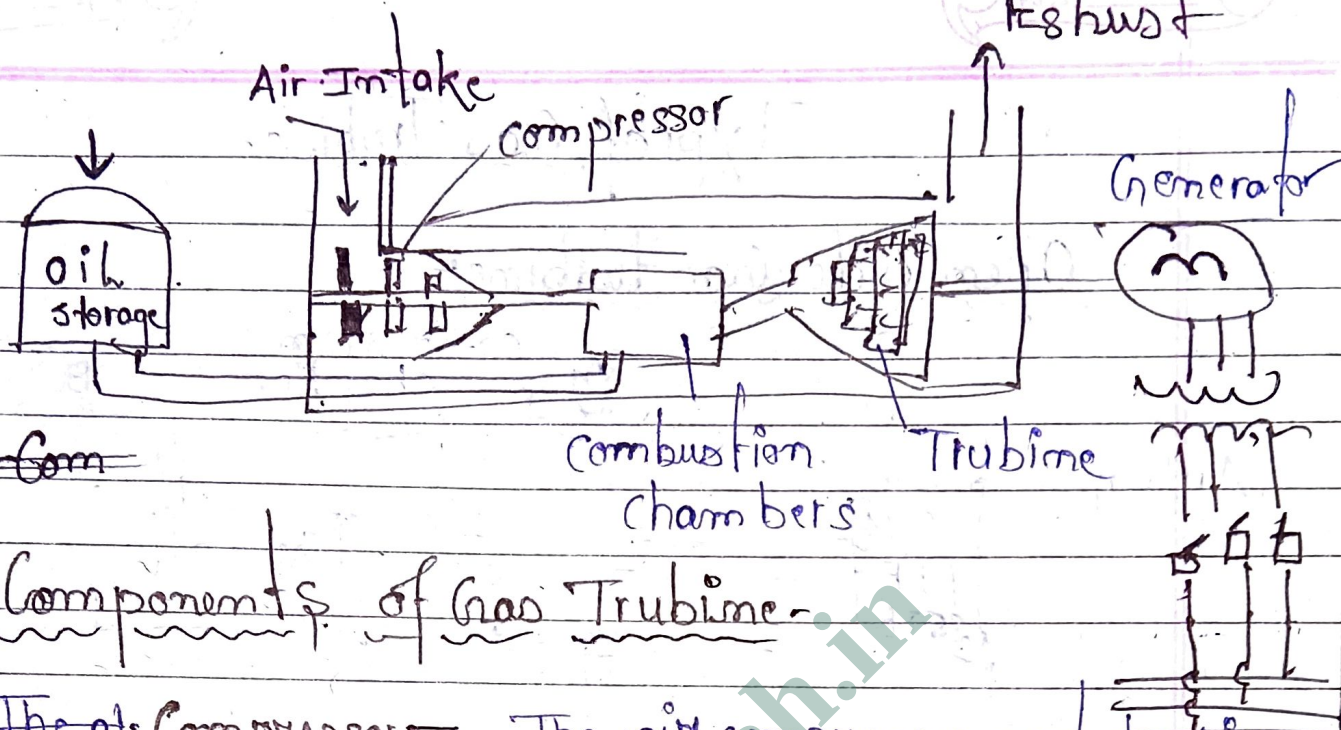
Overall efficiency of Gas turbine - 35%

Application of Gas turbine -

- In power plant.
- To drive aviation system of all kind of aircraft.
- To drive locomotive and marine ship.
- To drive auxiliaries like compressors, blowers and pumps.

Gas turbine

Gas turbines are a type of internal combustion (IC) engine in which burning of an air fuel mixture produces hot gases that spin a turbine to produce power.



Components of Gas Turbine-

~~The of~~ Compressor- The air compressor and ~~turbine~~ are mounted at either end on common horizontal axle (shaft), with the combustion chamber between them.

Combustion chamber-

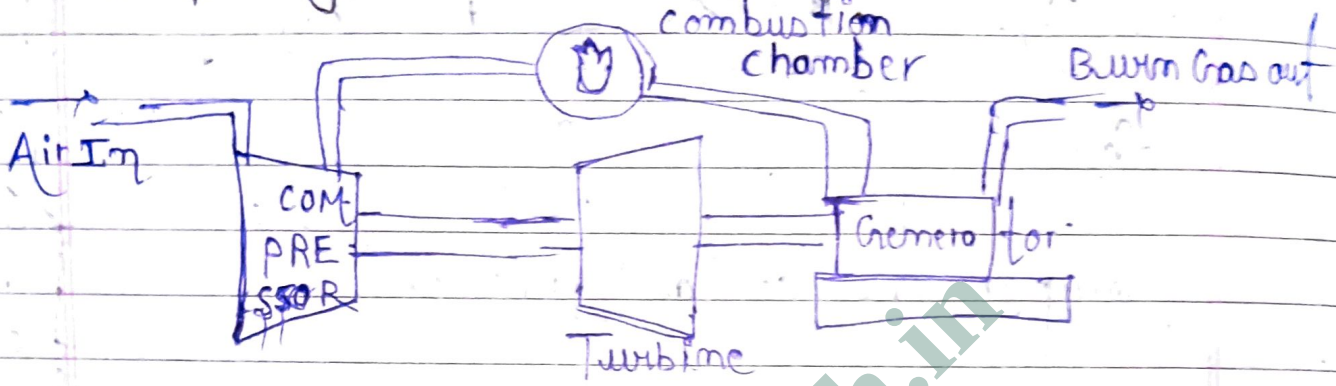
In the combustion chamber the compressed air combines with fuel and resulting mixture in burnt.

Turbine-

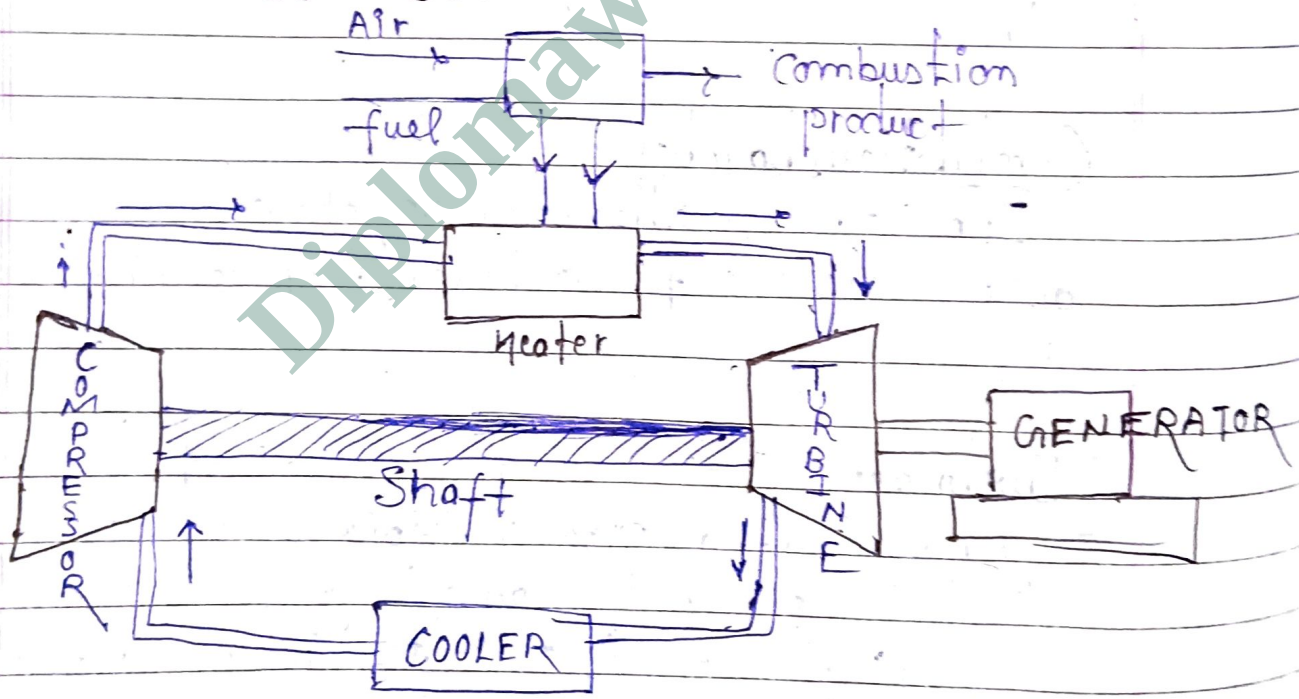
The burning gas expands rapidly and rush into the turbine, where they cause the turbine wheels to rotate. The shaft of the turbine is coupled to a generator to drive it.

Type of Gas Turbine.

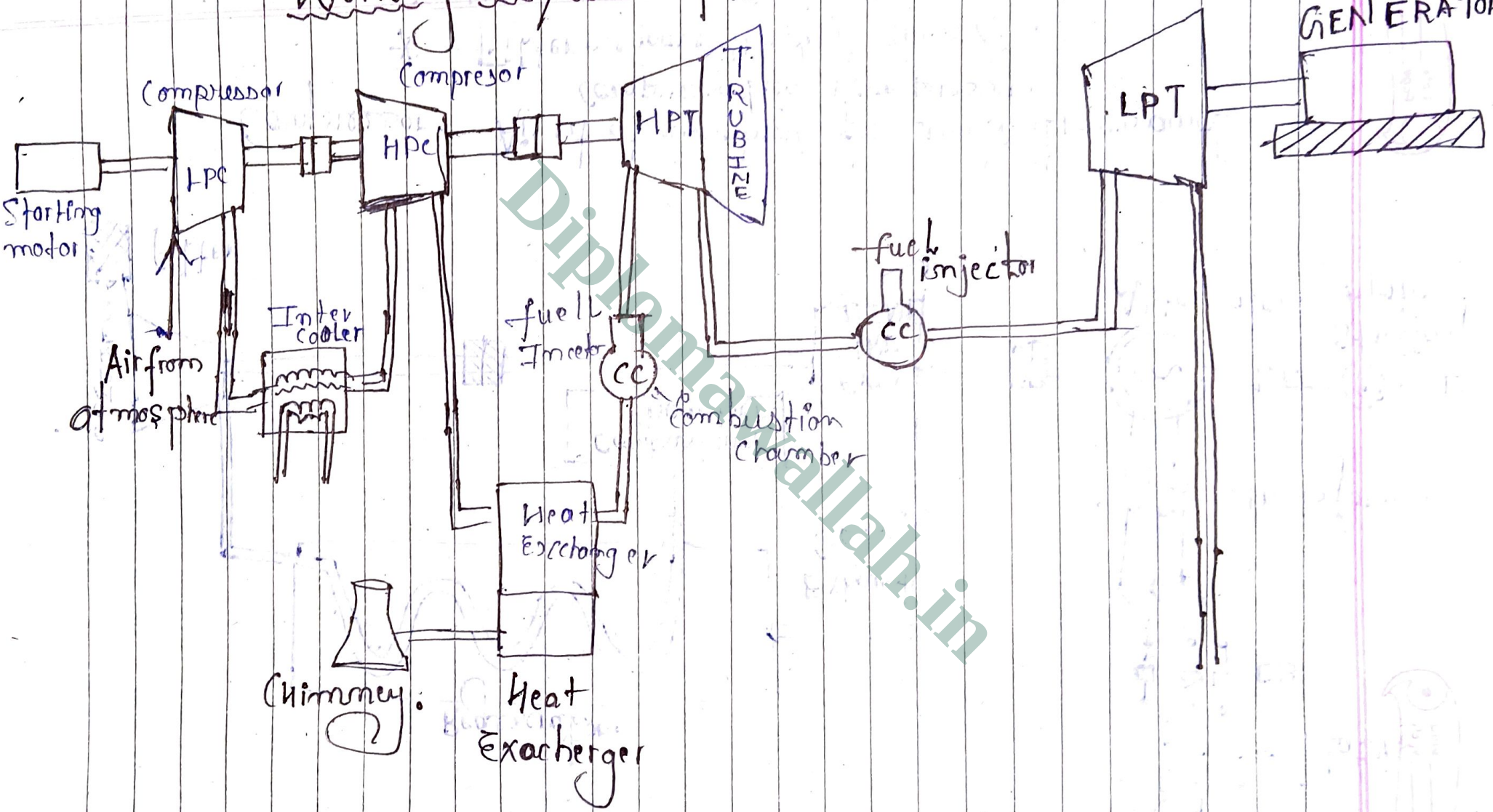
Open cycle Gas turbine

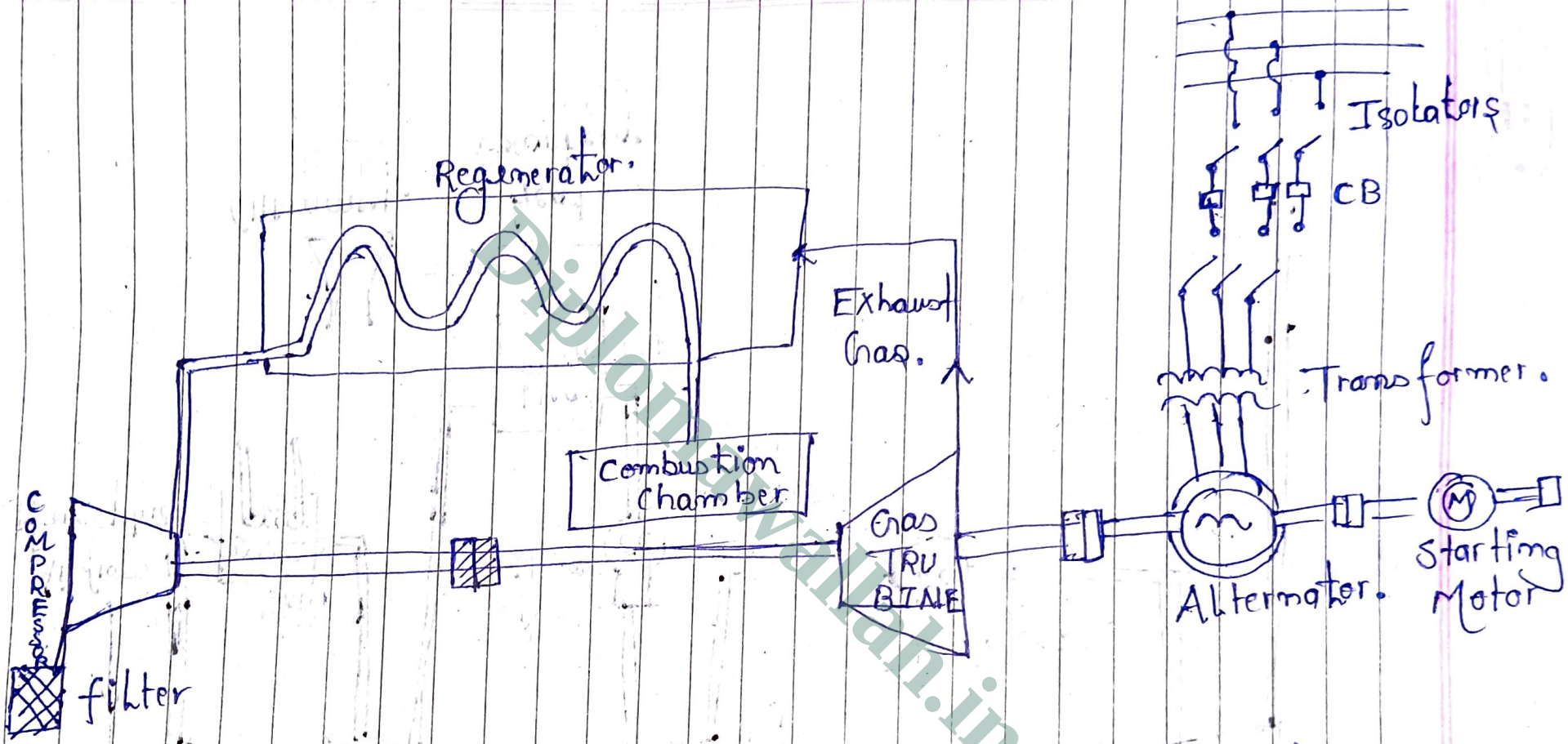


Closed Gas Turbine



Working Layout of Gas Turbine





Compressor — Air at atmospheric pressure is drown and compressed in a compressor.

* — Filter remove the dust from Air.

* — High-pressure air from the compressor is then fed to the Generator.

Regenerator - is used for preheating the compressed air.

→ It consists of a network of tubes. The compressed air from the compresser is passed through these tubes.

→ The hot exhust gas from the gas turbine is passed over these tubes to pre-heat the compressed air.

→ The pre-heated compressed air is fed to the combustion chamber.

Combustion chamber.

→ Pureheated compressed air from the regenerator is fed into the combustion chamber.

→ Oil or natural gas is also injected into the combustion camber at high pressure.

→ The oil mixes with compressed air and undergoes combustion.

Gas Turbine -

→ Gase while passing over the turbine blade expand and cause the turbine blades to rotate.

Starting motor.

→ compressor, turbine and alletor are all mounted on the same shaft.

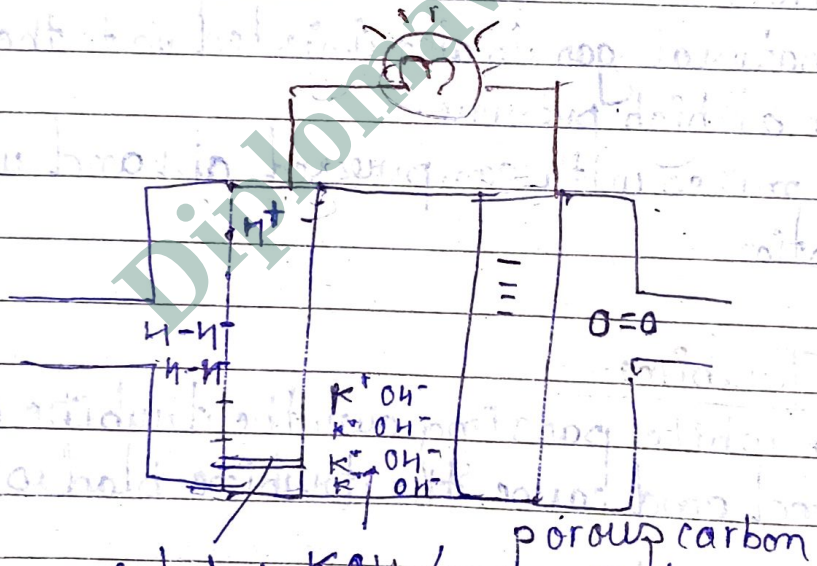
→ Before stating the turbine, the compressor has to be started. for this purpose, a staring motor is used.

Fuel cell

any thing that produces Energy from combustion reaction.

Type of fuel cell

- Alkalice fuel cell (H_2-O_2)
- phosphoric acid fuel cell (PAFC)
- Molten carbohydrate fuel cell
- Solid oxide fuel cell
- Proton Exchange membrance fuel cell
- Direct methanol fuelcells.
- Microbial / biological fuelcell.



Oxidation:- (Pt, Pd, CaO)

$$2H_2 \longrightarrow 4H^+ + 4e^-$$

$$4H^+ + 4OH^- \longrightarrow 4H_2O$$

$$2H_2 + 4OH^- \longrightarrow 4H_2O + 4e^-$$

=)

Reduction reaction.

$$2H_2O + O_2 + 4e^- \longrightarrow 4OH^-$$

Overall reaction from the both

$$2H_2 + O_2 \longrightarrow 2H_2O$$

→ This cell is used in application to moon
→ They do not release any harmful molecules.
→ Reverse osmosis process is used to obtained water.
→ Efficency 60% to 70%.

Working of fuel cells.

→ Fuel cell mainly use hydrogen as fuel.
→ It consists of two electrodes namely anode and cathode with an electrolyte between them.
→ The hydrogen fuel is supplied to the anode and oxygen is supplied to the cathode.
→ At the anode the hydrogen atom is split into positively charged H^+ ions and negatively charged electrons.

$$2H_2 \longrightarrow 4H^+ + 4e^-$$

→ The electron from the anode flow to the cathode through an external circuit producing direct current electricity.

→ The positive H^+ ions travel through electrolyte to reach cathode.
→ In the cathode the H^+ ions combine with electrons and oxygen atom to form water. The water formed at the cathode is the by-product of the fuel cell.

$$4H^+ + 4e^- + O_2 \rightarrow 2H_2O.$$

→ Each fuel cell generates an average DC voltage of about 0.7V
→ Several cells are connected in series-parallel combination to increase the current and voltage.

Classification of fuel cells.

a) Phosphoric Acid fuel cell (PAFC)
b) Alkaline fuel cell (AFC)
c) Polymer Electrolytic Membrane fuel cell (PEMFC)
d) Molten Carbonate Fuel cell (MCFC)
e) Solid oxide fuel cell (SOFC)

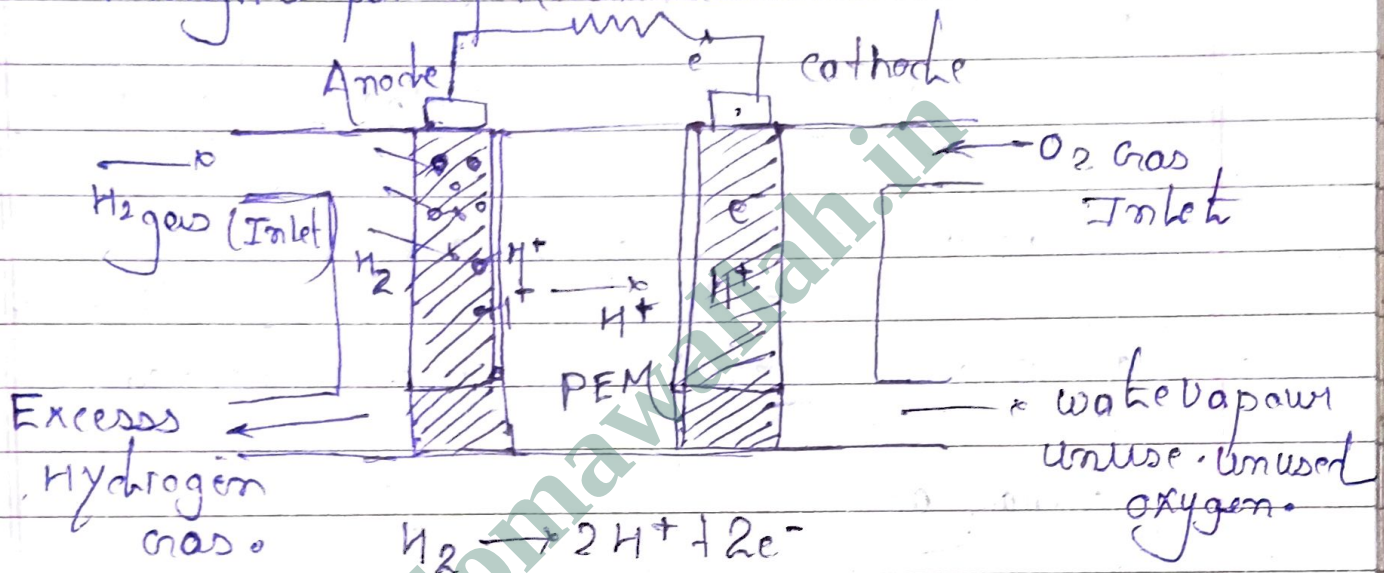
Application of fuel cells.

→ Used in central power generation.
→ Used as residential power source of 5 to 70kW
→ Used as Emergency power supplies in hospitals.
→ Used to power Electric vehicles for road and rail transports.

**

Fuel cell.

It is an Electrochemical cell that converts chemical Energy of a fuel (Generally hydrogen) and oxdizing agent (Generally oxygen) into Electricity through a pair of Redox reaction.



$H_2 \rightarrow 2H^+ + 2e^-$

Polymer Electrolyte membrane
Proton Exchange Membrane.

H^+ ions passes from PEM and reaches at cathode. Electron are not passes from PEM because PEM made of plastic. they reach the cathode by External conductor. They after H^+ ions, Electron and oxygen are combine and form water vapour.

Anode Side Oxidation reaction.

$H_2 \rightarrow 2H^+ + 2e^-$

~~HVDC~~

Edison Vs Tesla → father of Electrical Science.

Cathode Side reaction.

$\frac{1}{2}O_2 + 2H^+ + 2e^- \longrightarrow H_2O$.

Net Reaction Redox Reaction

$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$ + Electricity + Heat.

Generally it generates about 0.7 V one cell. Therefore hundreds of fuel cells are stacked together to fulfill the Requirements.

Advantage:-

→ Eco friendly power generation.
→ No pollution occurs during power generation we get water & heat as by-product. Here water may be very useful in space application or where water is required.
→ Efficiency upto 60%.

Disadvantage-

→ It is difficult to extract the Hydrogen.
→ Its transportation is difficult & costaly Hydrogen is highly flammable
→ Cost of catalyst such as platinium or Iridium is very high

Type of Fuel cell—

(i) Proton Exchang membrane fuel cell
(ii) Solid oxide fuel cell
(iii) Alkaline fuel cell (KOH / NaOH)
(iv) Phosphoric Acid fuel cell

Applications—

→ fuel cell vehicles (FCVs) including Car buses truck.
→ In portable power for devices
→ In back up power applications
→ In stationary power Generation to generate Small or Bulk amount of Electricity

Alkali fuel cell.

Anode

$$H_2 + 2OH^- \longrightarrow 2H_2O + 2e^-$$

Cathode

$$\frac{1}{2}O_2 + 2e^- + 2OH^- \longrightarrow 2H_2O$$

$$H_2 + \frac{1}{2}O_2 \longrightarrow H_2O + \text{Electricity} + \text{Heat}$$

Sub station-

Electrical substation are the interface between parts of distribution grid and transmission system.

The electrical power is generated at a power ~~sta~~ generating ~~sat~~ stations which which is located far away from the consumer's load.

But it is important to note that power is generated at a low voltage, transmitted at a higher voltage, and distributed at a lower voltage again. This voltage variation is for many technical and economic reasons. for changing this voltage many locations in the power system, an arrangement of various electrical equipment is used which is known as a substation.

A substation is a systemic arrangement of electrical equipment like transformers, circuit breakers, isolators, and more, which is designed and developed to change some electrical parameters like current voltage, frequency, etc.

Power transformers-

The main purpose of the power transformer is to step-up the transmission voltage at the Generation unit & step down the transmission voltage at the distribution unit. Generally for rating up to

10 MVA (Mega Volt Ampere) oil Immersed, naturally cooled and 3-phase transformer are used. Similarly for more than 10 MVA, air blast cooled transformers are used.

Instrument transformer—

The main purpose of an instrument transformer is to decrease high current as well as voltage for a secure & realistic value.

Voltage transformer— This transformer can be define as it is an instrument transformer used for changing the voltage from as superior value to the minor value.

→ Used for measurement of voltage.
→ used for protective relay.

Current transformer— is an electrical device and the main function of this is to change the value of current from the superior value to the minor value. This type of transformer is applicable in meter, control apparatus and paralled by AC instruments.

$$\frac{I_S}{I_P} = \frac{N_P}{N_S} \quad \therefore N_S > N_P$$

$$I_S < I_P$$

Lightning Arrester. This is the first component in an Electrical substation, and the main function of these component is to protect the components of the substation from passing high voltage as well as stops the amplitudes and duration of the flow of current. The light arrestor components are connected among the earth as well as line which mean parallel to the components under ~~of~~ defence at the Electrical Substation.

Circuit Breaker. This ~~System~~ is a type of Electrical switch used to open or close the circuits when an error arises in the system. When an error happen in the system, then the relay transmits the single to the circuit-breaker & ~~Therefore~~ their parts are move seperately.

Buss Bar. It is a kind of current carring conductor where many connections are made.

Isolator in Substation. The isolator is one type of Electrical switch, used to isolate the circuit whenever the flow of current has been disrupted. These switches are named as disconnected switches and it works under a non-load conditions.

Batteries — In large power station or substations the operation of lighting, relay system or control circuits are powered by batteries

Switchyard — The switchyard is the inter-connector among the transmission as well as generation & equal voltage is maintained in this device.

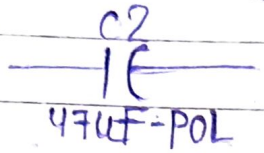
Relay — The ~~re~~ the main role of the this system in the substation is it guards the grid component against the ~~regu~~ irregular conditions like faults. This is one type of detecting device, used to decect and determine the fault location, and then sends the signal to the circuit breaker.

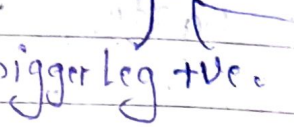
Capacitor Bank — improve the power factor condation or controle the voltage.

This device is inbuit with capacitors that are connected either in series or else parallel. The main function of this is to store the Electrical Energy in Electrical charge form. This bank draws primary current which amplifies the ~~po~~ pf of the system. it acts as source for reactive power.

Electronic Components

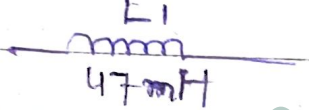
Capacitor





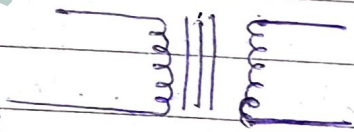
A capacitor is a basic electronic component that stores electrical energy in the form of an electronic charge.

Inductors



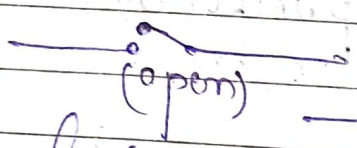
* An inductor is also a fundamental electronic component sometimes referred to as a coil.
The inductor stores electrical energy in the form of an electromagnetic field.

Transformers.



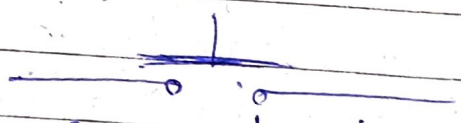
* A transformer basically two or more coils where electromagnetic interact.

Switches

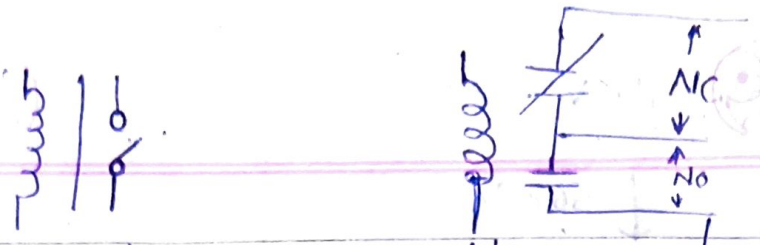


* A switches help on and off the flow of current through the circuit.

Single-pole single-throw



Push button (normally open)



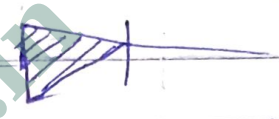
Relay.

are electromagnetically operated switches.

→ They are used extensively in electrical system especially industrial system.

→ Relays are used for motor control circuits, circuits to protect workers, ~~which~~ switching circuits and power switching.

Transistor and Diodes

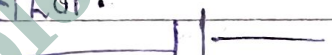


→ Diode are solid state devices or semiconductor.

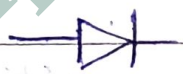
→ Used in Amplifier, computers and industrial controls and used in inverter.

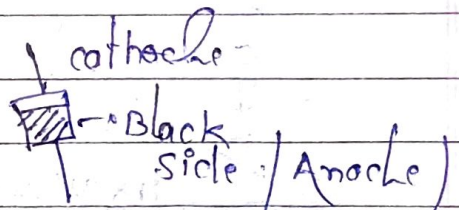
→ protective devices and switches.

01 Ceramic Capacitor.

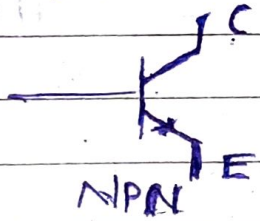


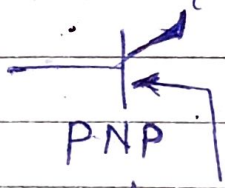
02 Diode





03 Transistor



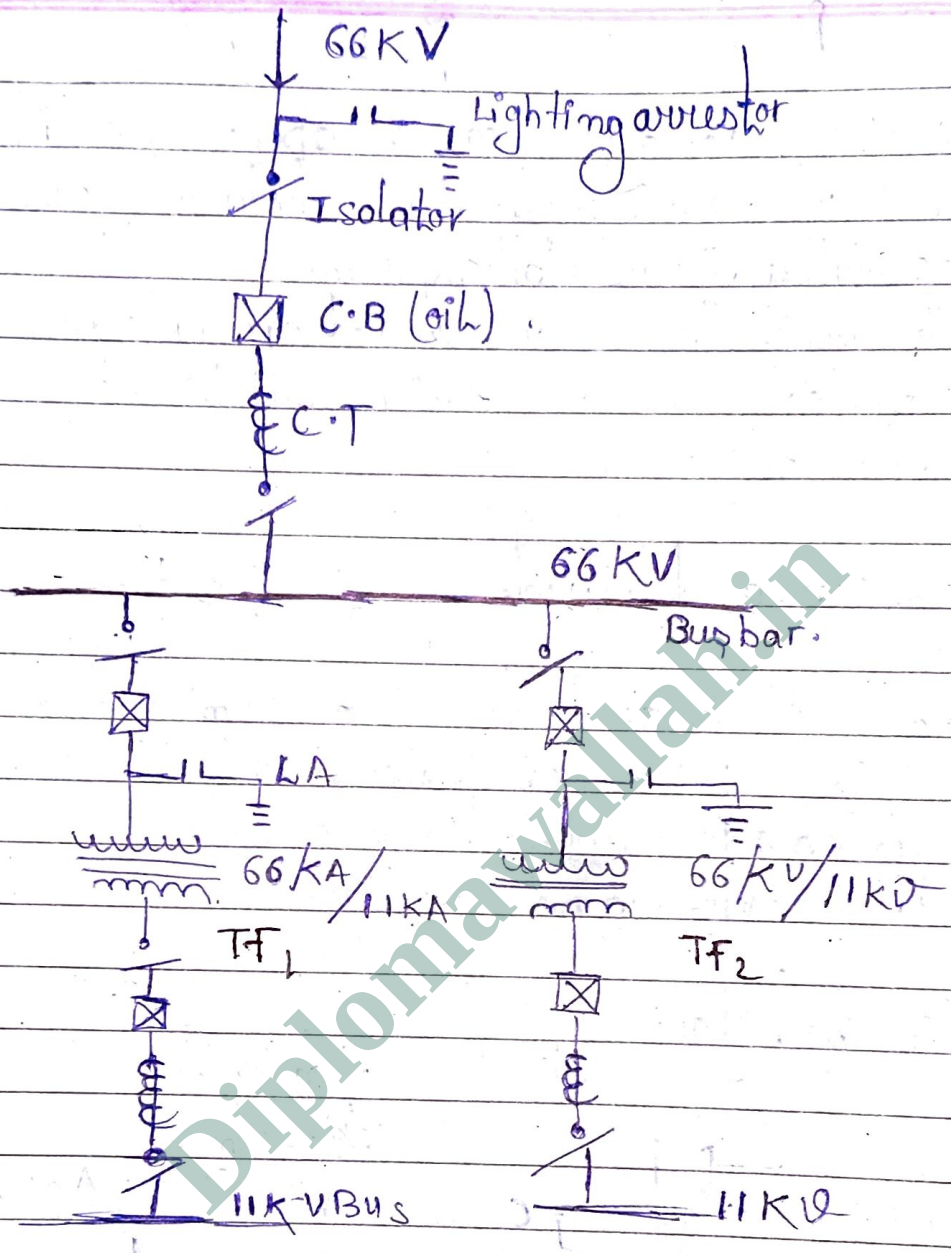


Used to convert low signal into high signal

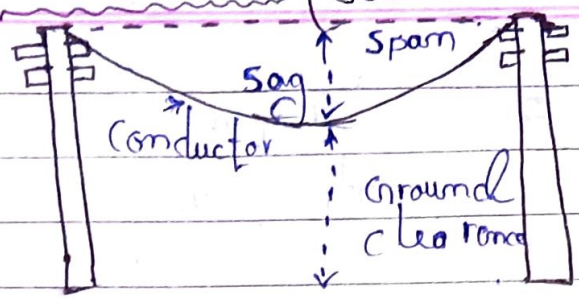
04 Voltage Regulator

Used in circuit may you want constant voltage in circuit.

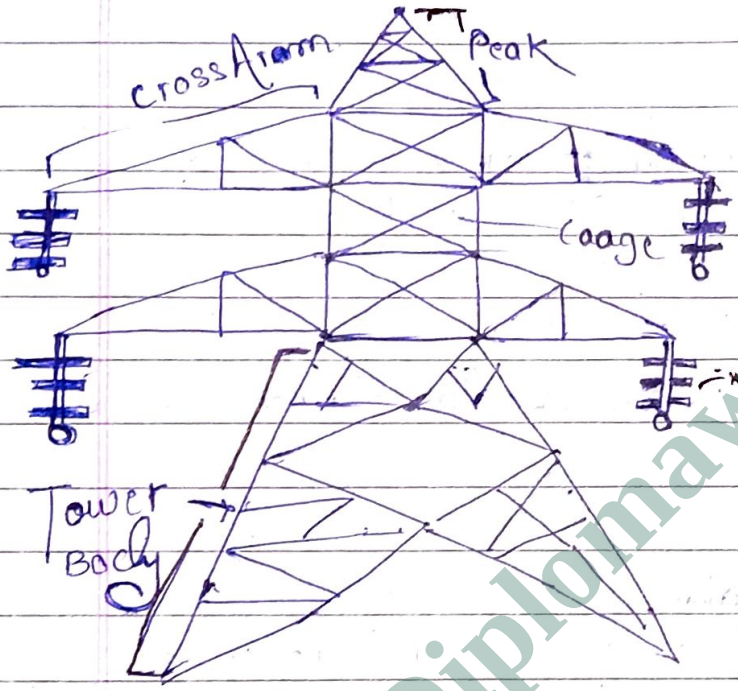
66/11KV Substion



Transmission Line Distribution

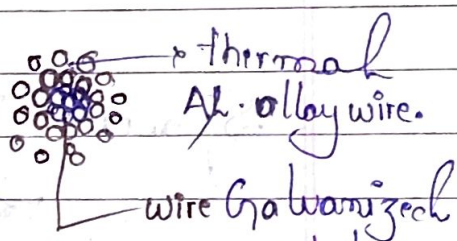


Transmission tower



ACSR cable

Aluminium Conductor steel Reinforced.



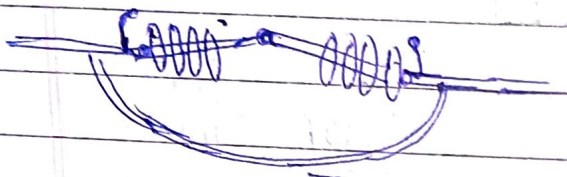
Galvanzied steel core
→ High-quality steel to increase strength.

Aluminium 1350 series –
Quality aluminium to ensure the transmission performance.

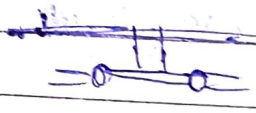
Topmost Earth wire – Optical Ground wire (OPGW)
→ used for communication purpose.

Touch potential
Step potential.

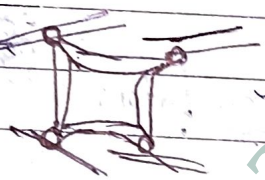
by pass or trans for of extra charge in atmosphere.



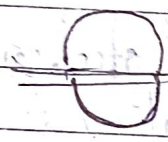
It help in connection between two wire.



Stockbridge damper.
absorbition vibration.

Spacer 

It provide the space between conductor.



Aerial markerball
used to visualization of conductor.

Guarding wire.