ELECTRIC ENERGY GENERATION, UTILISATION & CONSERVATION

UNIT- I

GENERATION

CONVENTIONAL METHODS

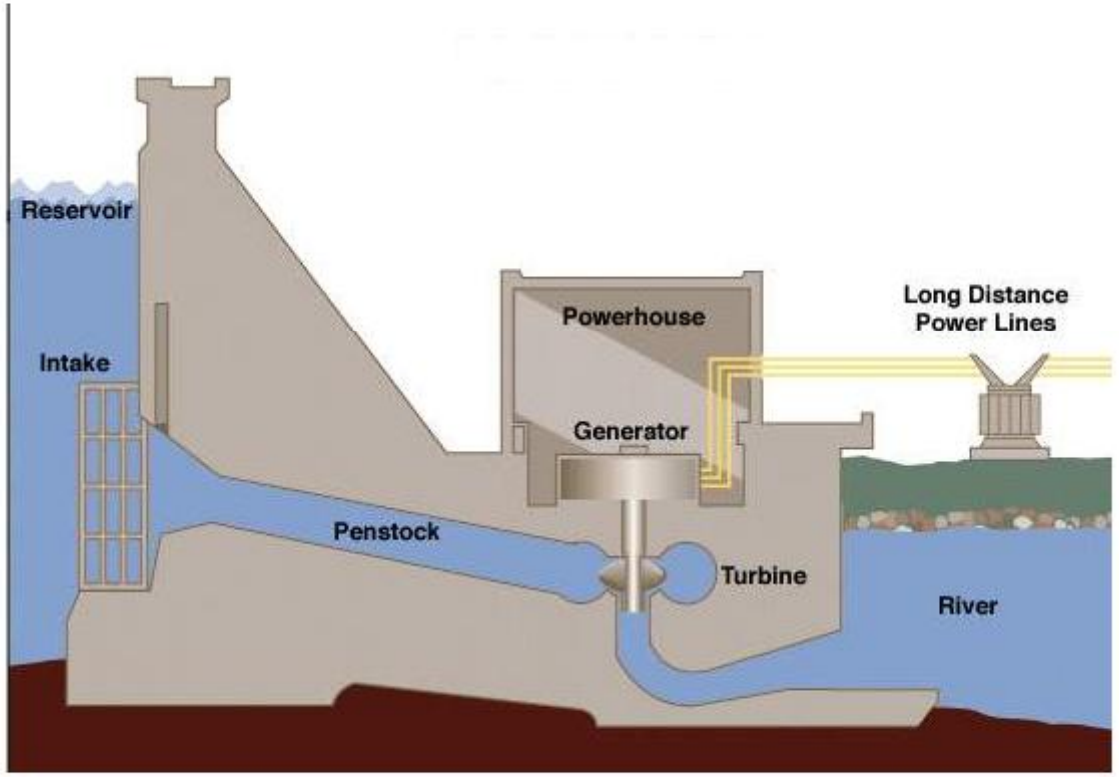
Classifications:

a) Hydro electric power station

b) Steam power station

c) Nuclear power station

HYDRO ELECTRIC POWER PLANT



Parts of Hydro electric power station:

- Reservoir
- Dam
- Surge tank
- Valve house
- Penstock
- Turbine
- Draft tube
- Power house

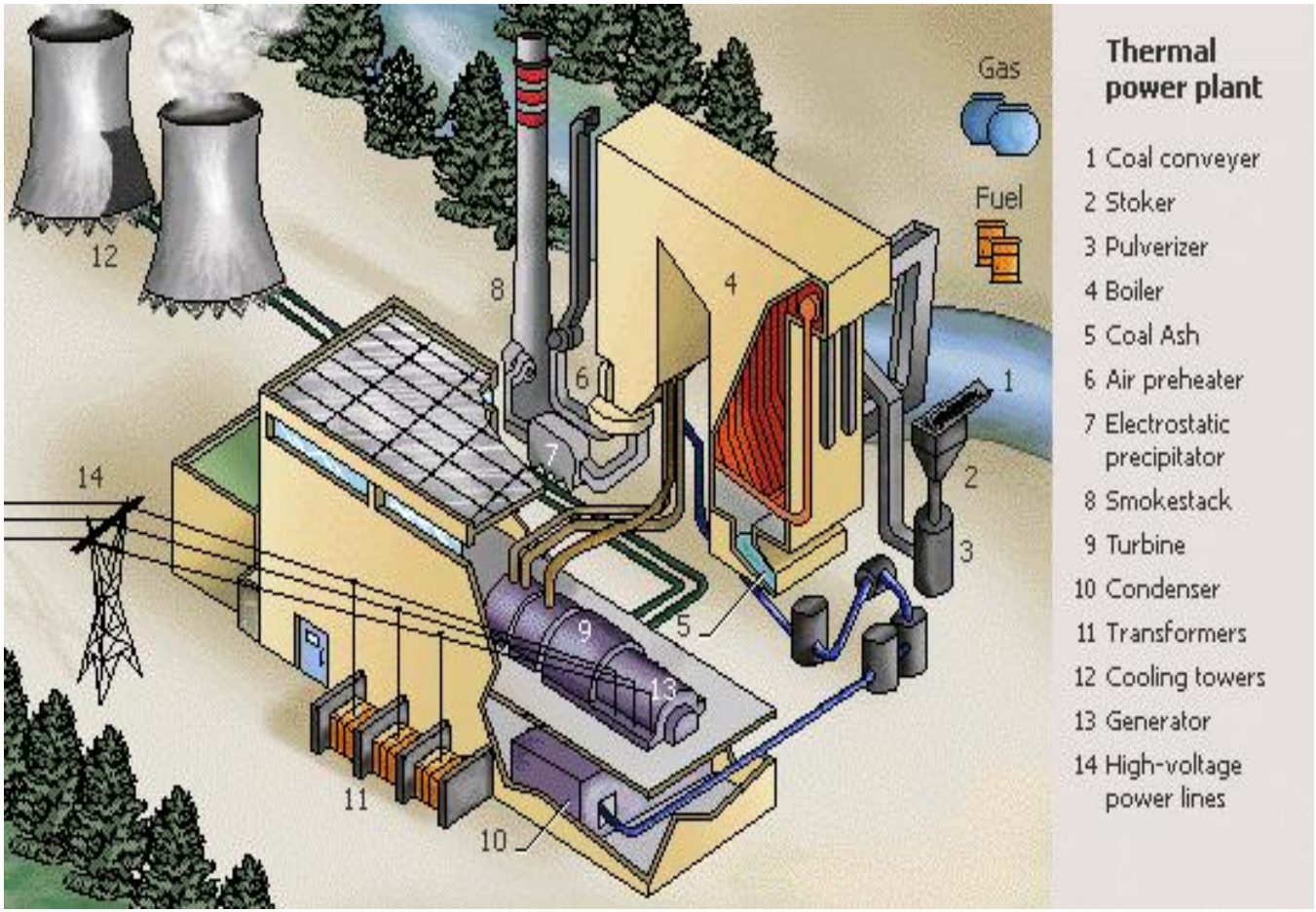
Advantages:

- Water is the cheapest and reliable source
- No fuel transportation problem
- Maintenance cost is low
- Running cost is low
- Life of this plant is more

Disadvantages:

- Long time for erection
- Capital cost of the plant is high
- Cost of transmission lines and losses will be more
- Depends on rain fall

STEAM POWER PLANT



Advantages:

- Fuel is the cheapest source
- Capital cost is low
- Cost of transmission lines and losses will be low

Disadvantages:

- Maintenance cost of the plant is high
- Running cost is high
- Ash handling is difficult
- Air is polluted

Nuclear Power plant

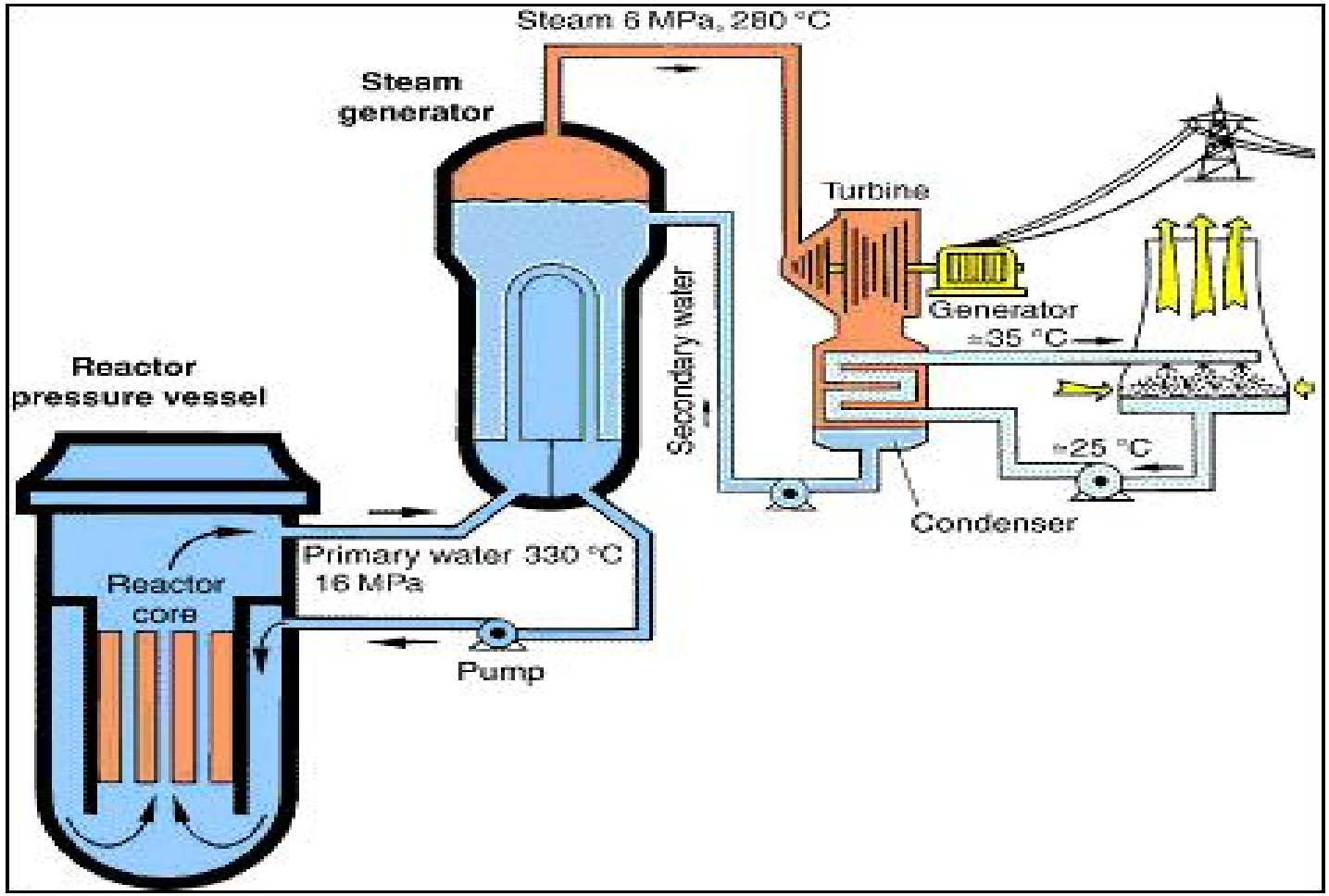
- Energy released from the continuous nuclear fission
- Neutron from U-235 strikes another nucleus and causes to fission.

Main components:

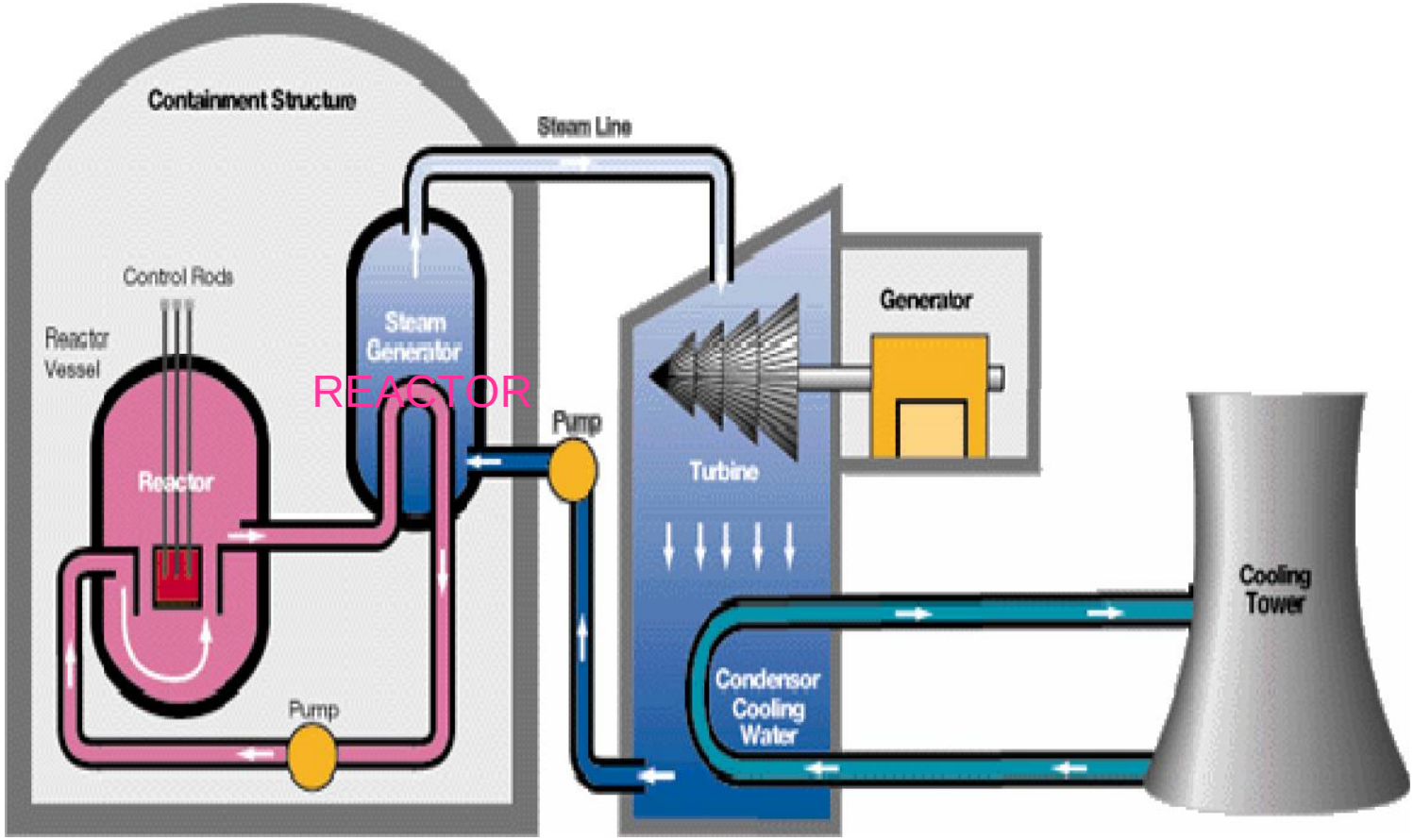
- Fuel : pellets of uranium - rods
- Reactor core : no. of fuel rods
- Moderator : to moderate the neutron velocity (graphite, heavy and light water)

- Coolant : to transfer heat (water, liquid metals)
- Control rods : Neutron absorber (cadmium, boron & hafnium)
- Pressure vessel : to maintain constant pressure.

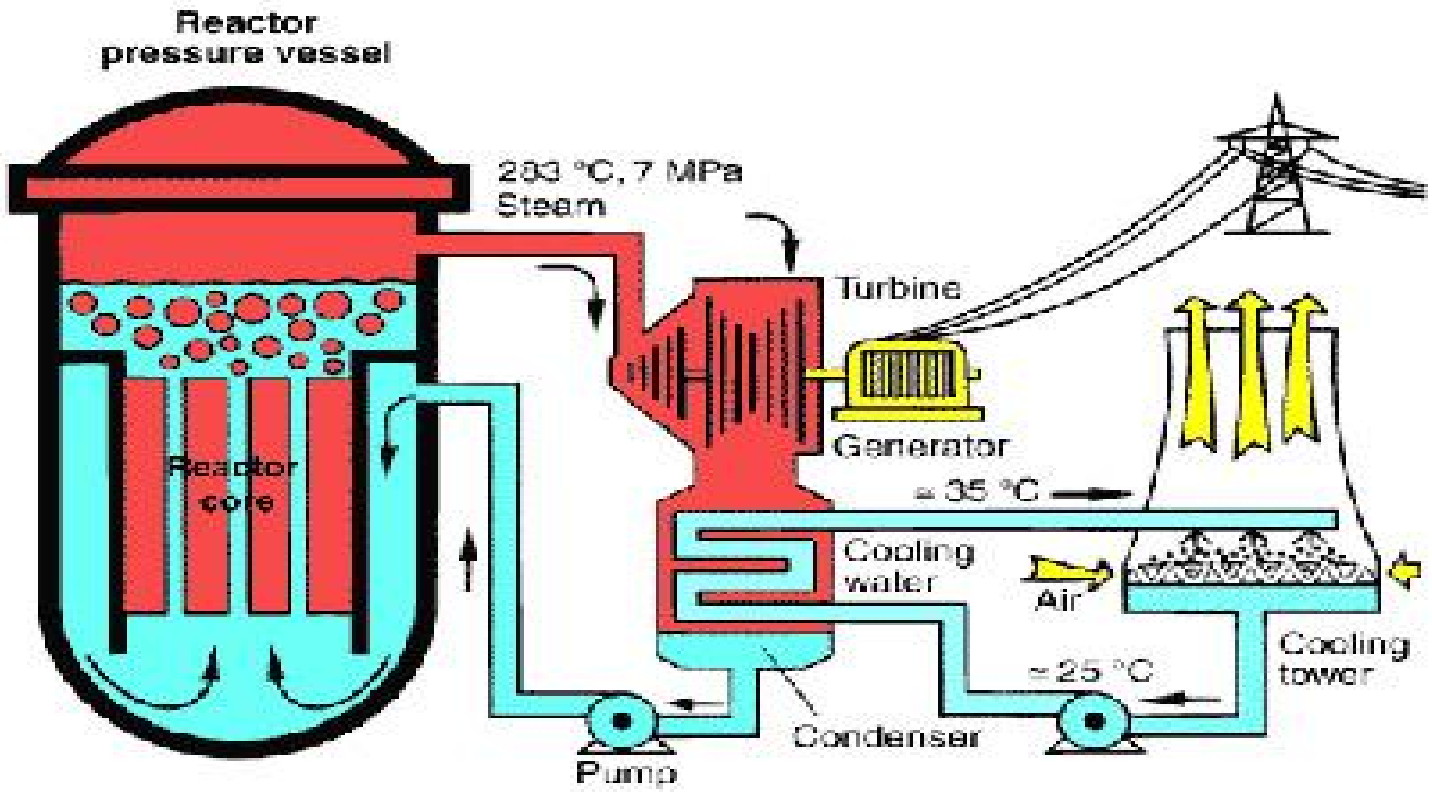
PRESSURIZED WATER REACTOR



PRESSURIZED WATER REACTOR



BOILING WATER REACTOR



Advantages:

- Amount of fuel required is very small
- No fuel transportation problem
- Less space is required
- Located at load centre
- Most economical

Disadvantages:

- Long time for erection
- Capital cost and maintenance cost of the plant are high
- By products are radio active and cause pollution
- Fuel is expensive

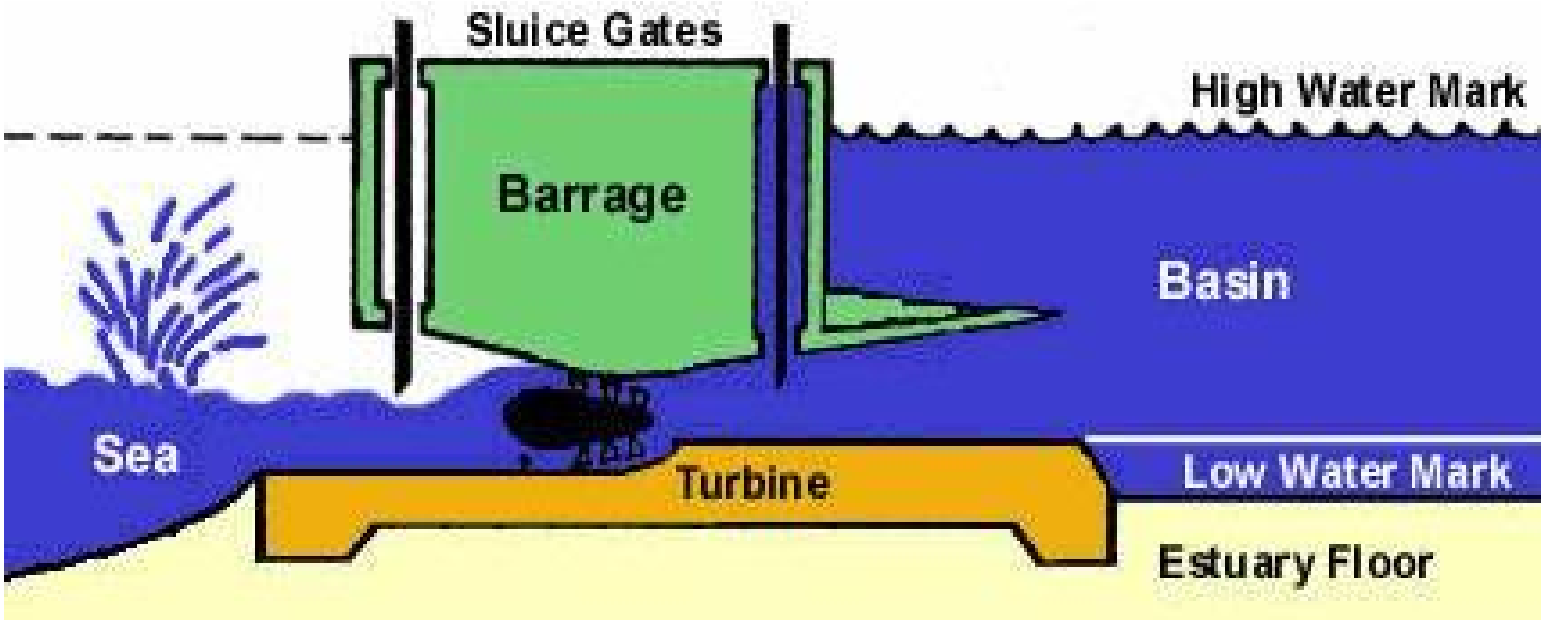
TIDAL POWER PLANT

- It is a rise and fall of water level of sea
- Due to the action of sun and moon on the earth water.

Classifications:

- Single basin arrangement.
- Double basin arrangement.

General scheme of tidal power plant



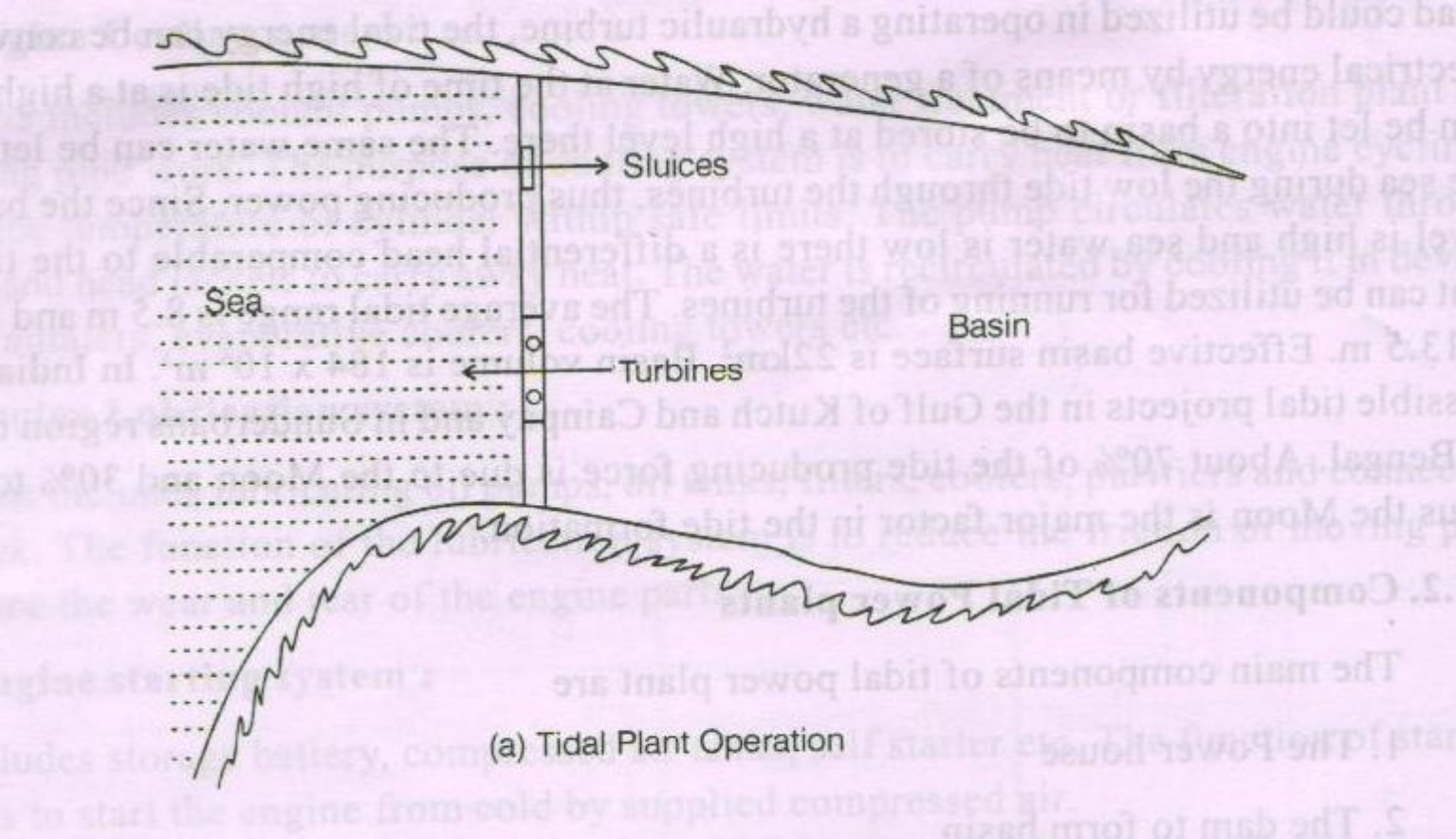
Main components:

a) Power house

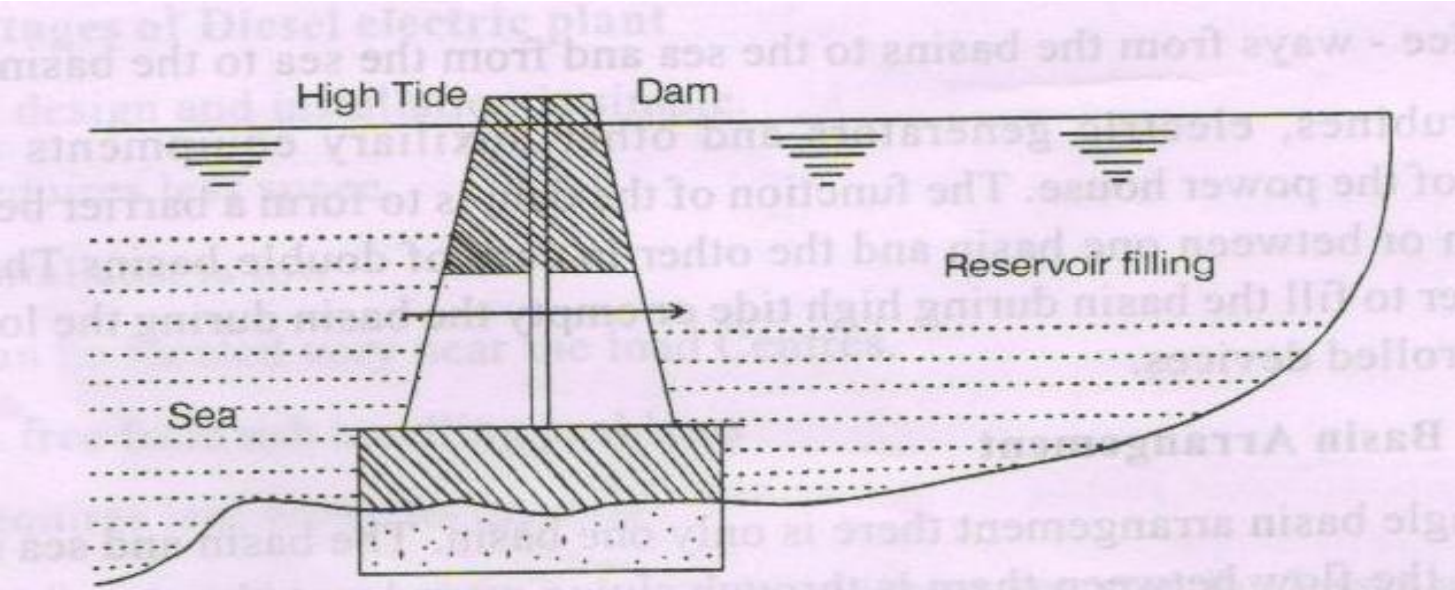
b) Dam to form basin

c) Sluice gates

Operation of single basin arrangement

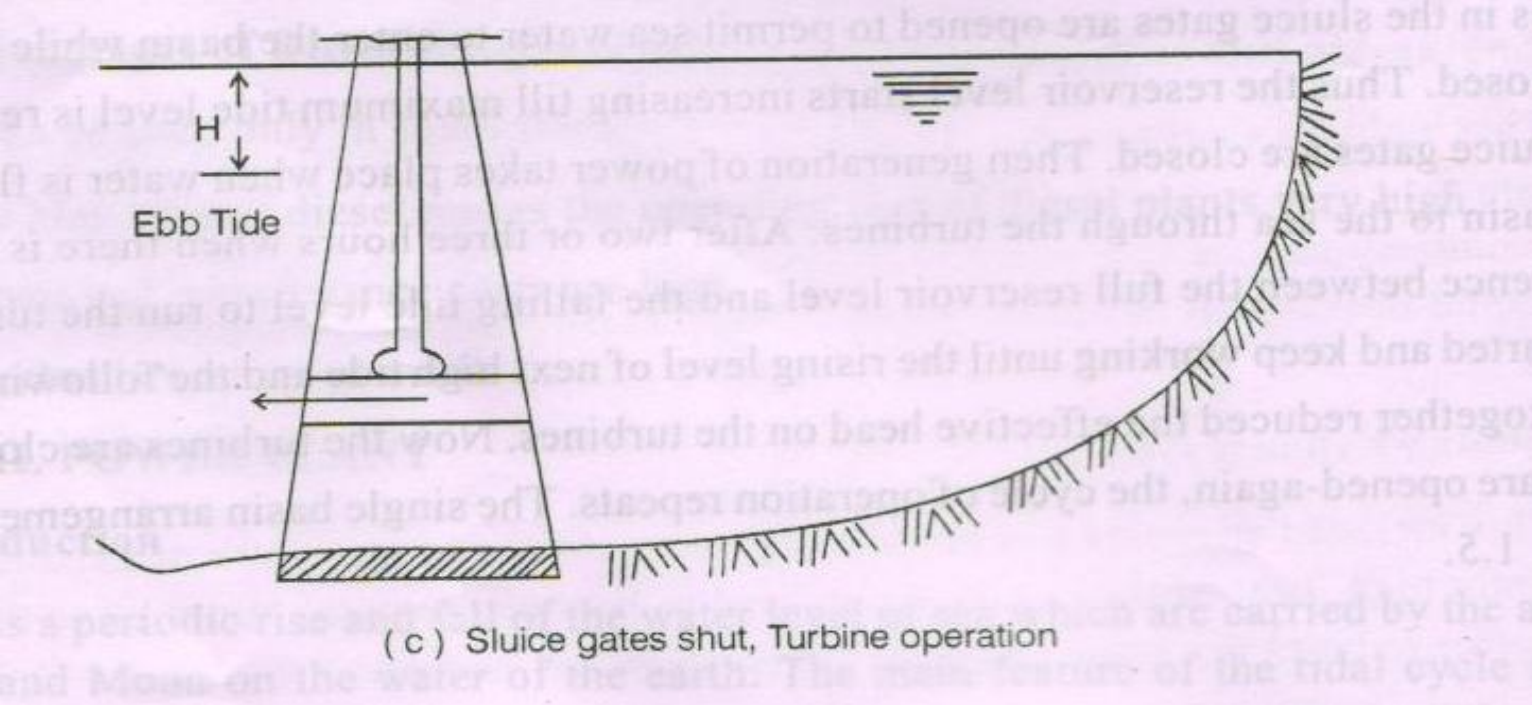


Sluice gates open, Turbines shut off



(b) Sluice gates open, Turbine shut off

Sluice gates shut, Turbine operation



(c) Sluice gates shut, Turbine operation

Advantages:

a) Renewable source of energy

b) Non polluting

c) No transportation problem

d) Cheaper

Disadvantages:

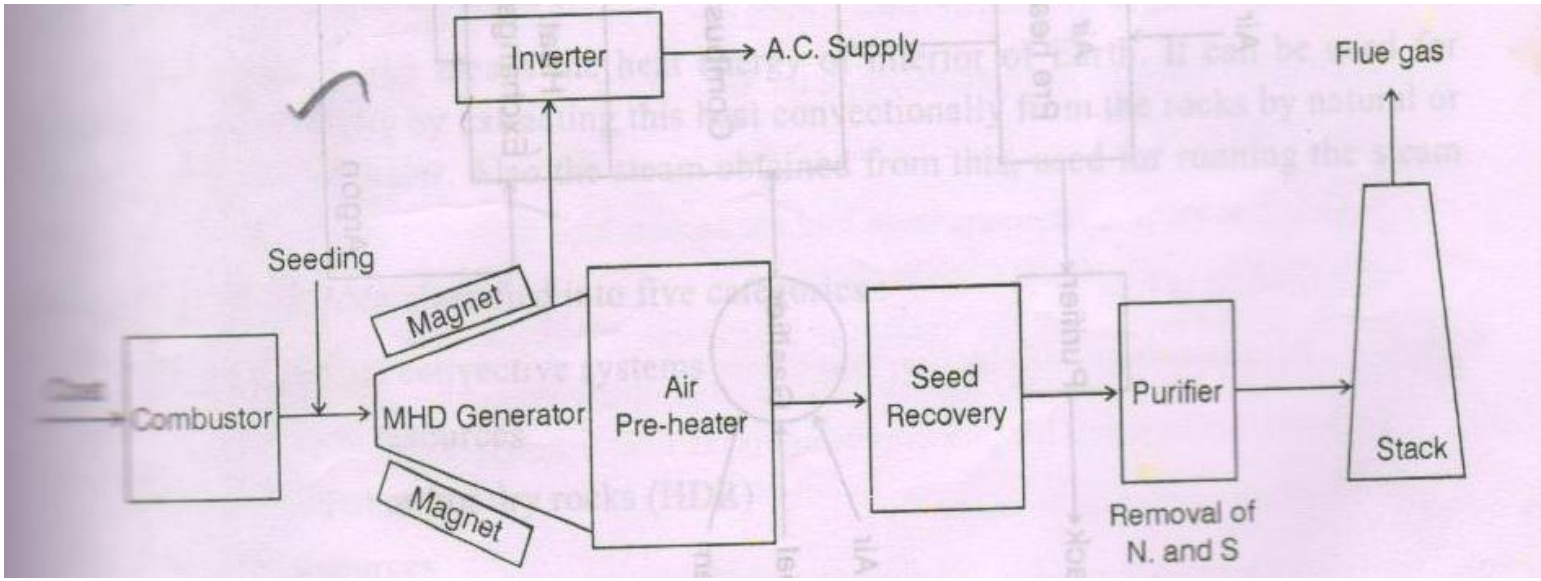
a) Tidal energy is fluctuating in nature

b) Noisy in operation

c) Over all weight is very high

d) Not reliable

MAGNETO HYDRO DYNAMIC GENERATION



Components:

a) Combustor

b) MHD generator

c) Air pre heater

a) Purifier

b) Inverter

c) Seed recovery

d) Stack

ADVANTAGES

- Conversion efficiency is around 50%
- Capital cost is less
- Over all generation is less
- No moving parts
- Closed cycle system produces power, free of pollution

GEOTHERMAL POWER PLANT

- The heat energy of interior of earth.

Classifications:

- Direct or dry steam PP
- Flash steam
- Binary fluid

Components:

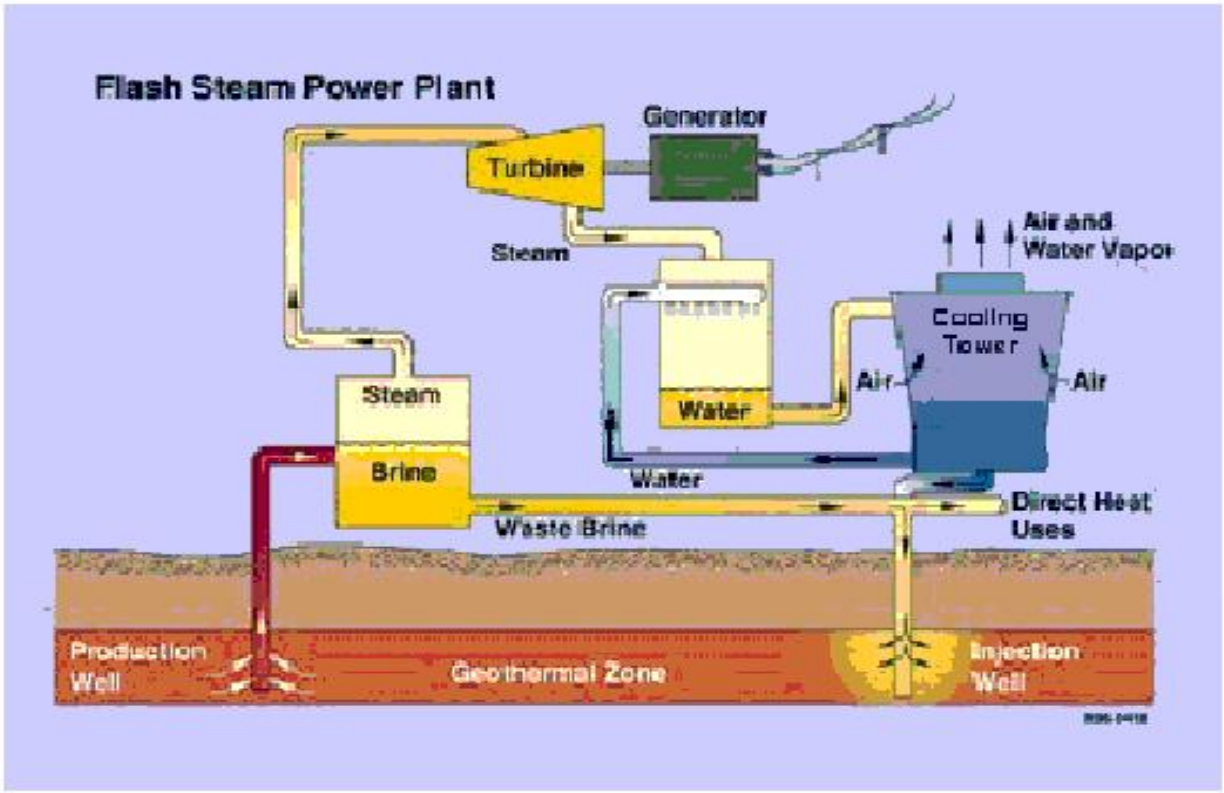
a) Hot brine

b) Turbine

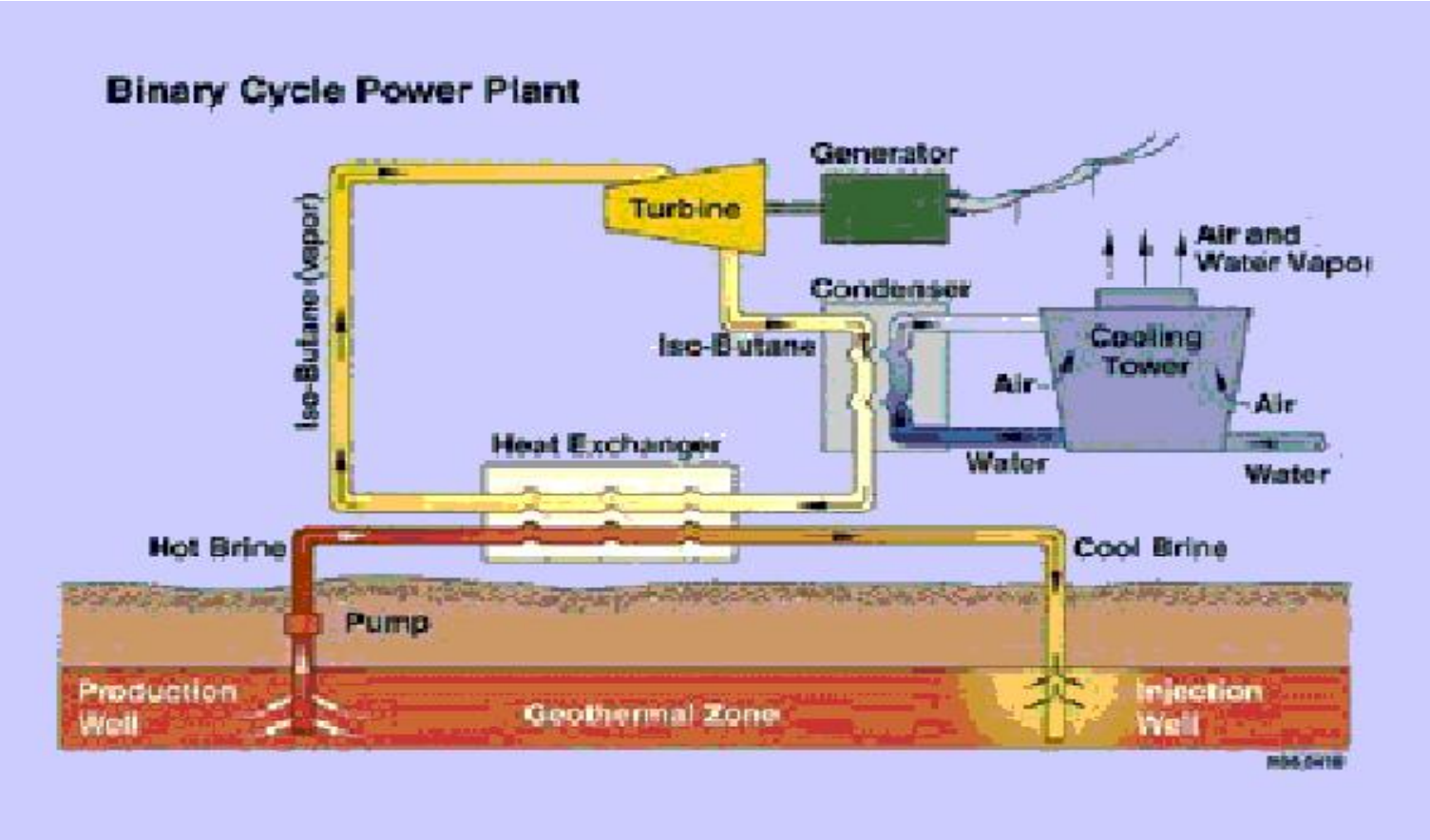
c) Condenser

d) Heat exchanger

FLASH STEAM POWER PLANT



BINARY CYCLE POWER PLANT



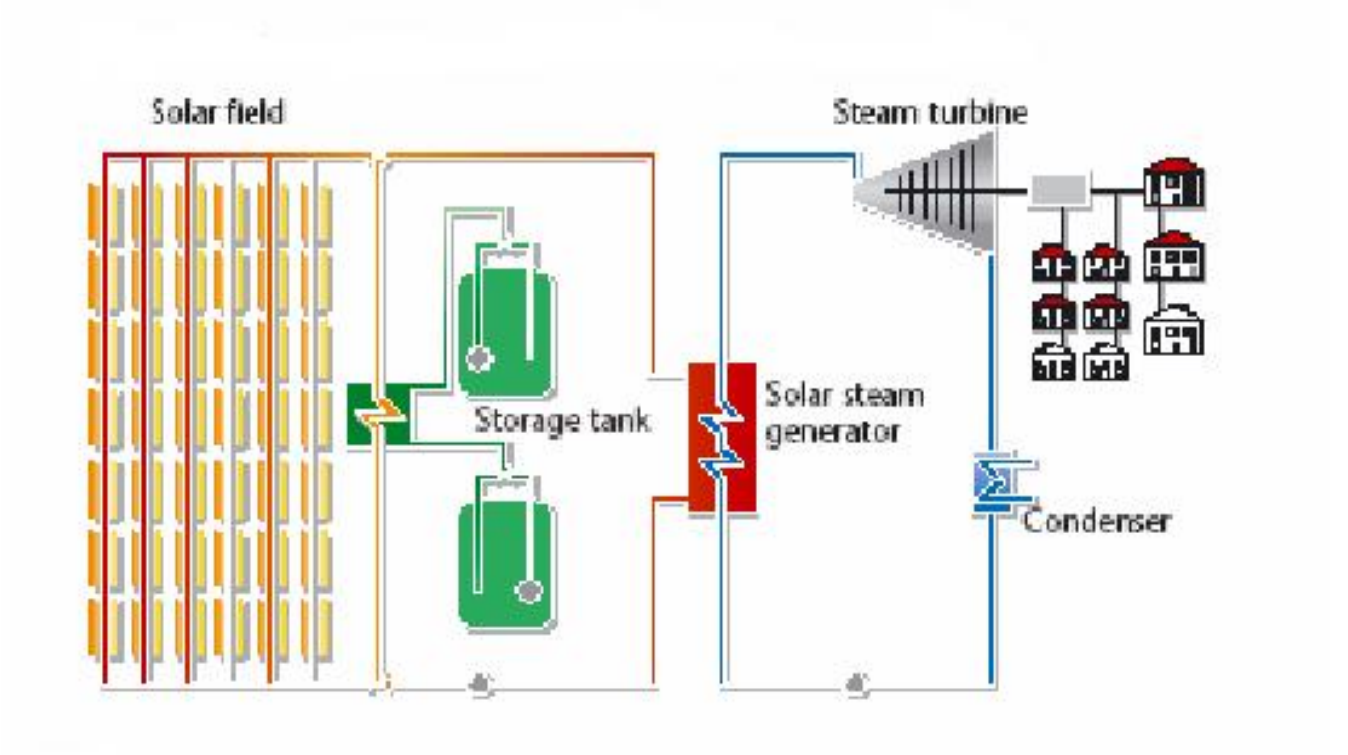
Advantages:

- Versatile in use
- Cheaper
- Highest annual load factor
- Pollution less

Disadvantages:

- Efficiency is low
- Noisy drilling operation
- Need large area

SOLAR POWER PLANT



Sub systems

- Solar energy collection system
- Thermal energy transfer system
- Thermal energy storage system
- Energy conversion system

PARABOLIC THROUGH SYSTEM

Advantages:

- It is free of pollution
- Requires little maintenance
- economical

Disadvantages:

- Available only by day not when sun is cloudy
- Not reliable
- Located at high attitudes
- Initial cost is high.

DISTRIBUTED GENERATION

- The integrated use of small generation units directly connected to the system
- They operate on a renewable fuel such as sun light, wind, gas and biomass

Example of technologies used :

- Micro turbines
- Fuel cells
- Photovoltaic cell
- Internal combustion engines

UNIT II

CONSERVATION

Economics of Generation

- Connected load - sum of continuous ratings of all systems
- Maximum demand - greatest demand of load
- Demand factor - $\frac{\text{Maximum demand}}{\text{Connected load}}$

- Load factor - Average load/Maximum demand
- Diversity factor - Sum of individual Demand / Max.demand
- Capacity factor - Average demand/ plant capacity

Load curve

- Curve showing the load demand
- Very useful in determining the annual requirements for energy

Load duration curve

- Obtained from load curve
- Load elements of load curve are arranged in descending order

Load on the power station:

- Base load - unvarying load occurs the whole day.
- Peak load - various peak demands of load over & above base load

Cost of Electrical Energy

- Fixed cost
- Running cost (or) cost of energy

Fixed cost:

- Cost which is independent of
- maximum demand &units generated
- Capital cost of power plant
- Interest on capital, taxes & insurance

Running cost :

- Depends on only upon the no of units generated
- Cost of fuel
- Maintenance cost
- Operation cost.

Tariff

- Different methods of charging consumers are known as tariff
- It should be simple and comprehensible to the public
- It should be uniform

Types of tariff:

- Simple tariff
- Flat rate tariff
- Block rate tariff
- Two part tariff
- Maximum demand tariff
- Power factor tariff

Need for Electrical Energy Conservation

- In order to save the scarce and fast depleting non renewable energy, sources such as coal, gas etc.
- To protect the environment from the pollution caused by them

Effect on Energy Conservation

The energy conservation results in

- Optimal utilization energy
- Prolong the usage of energy available in the earth
- Reduce green house gas emission
- Minimize the global warming

Energy Management

- The judicious and effective use of energy cost to minimize energy cost & to maximize profits.
- Reduce avoidable losses
- Use energy efficient technologies

Energy management strategy

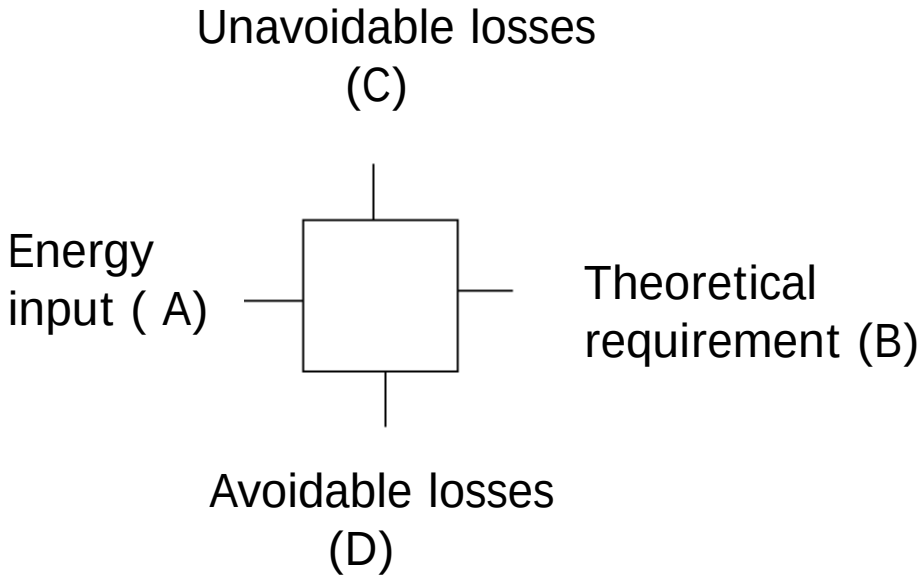
- Appoint Energy Manager
- Conduct Energy Audit
- Formalize an Energy Management Policy Statement
- Conduct Staff Awareness & Training Programme
- Annual report

Energy Auditing

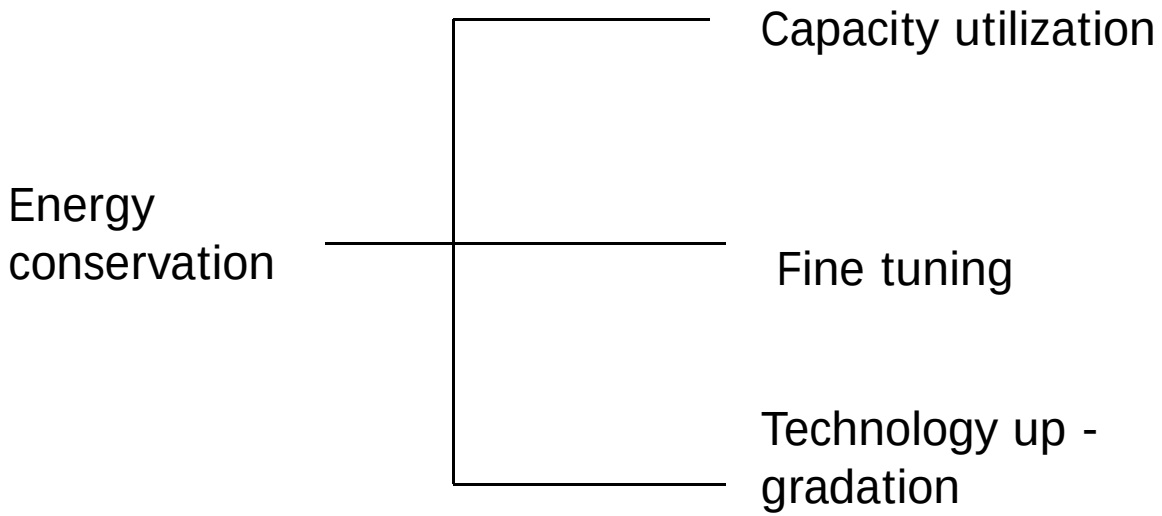
- Key to a systematic approach for decision making area of energy management.
- Quantifies energy usage according to its discrete function
- Verification, Monitoring & Analysis of use of energy including submission of technical report

Energy Audit methodology

- Macro level - methodology



Energy conservation at Macro level



Types of Energy Audit:

- Preliminary Energy Audit
- Detailed Energy Audit

Preliminary Energy Audit

- To establish energy consumption
- To estimate the scope for energy savings
- Identify simple energy saving proposals

Detailed Energy Audit

- Pre Audit phase
- Detailed Audit phase
- Post Audit phase

Economics of power factor improvement

The power factor can be improved by

- Installing static power capacitors
- Operating synchronous motor in over excited
- Installing static VAR compensators

Method of Power factor improvement

- Centralized / group compensation
- Distributed / Individual compensation
- Mixed compensation

POWER QUALITY

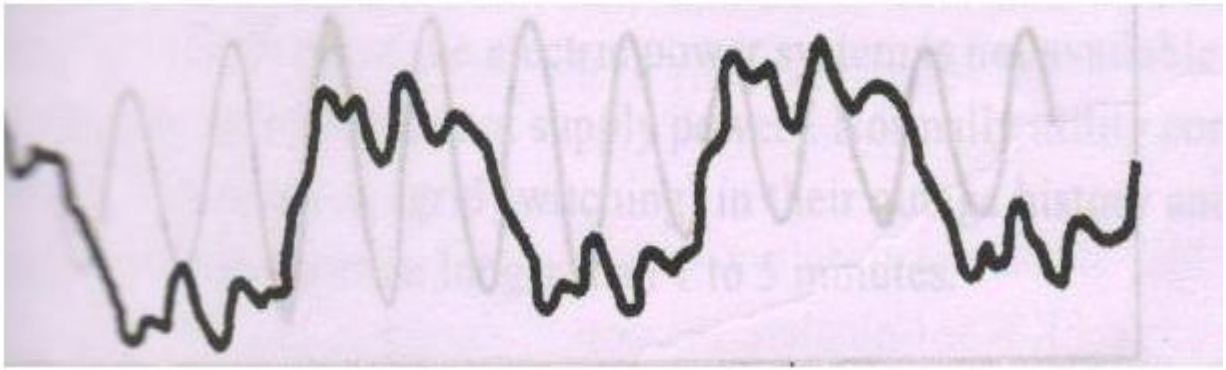
- It means that supply of power within the permitted variation of voltage and frequency and without distortion of sinusoidal wave form in balance condition

Parameters

- Voltage
- Frequency
- Harmonics
- Power supply disturbances (sags, swells, transients, flickers, interrupts outages etc.)

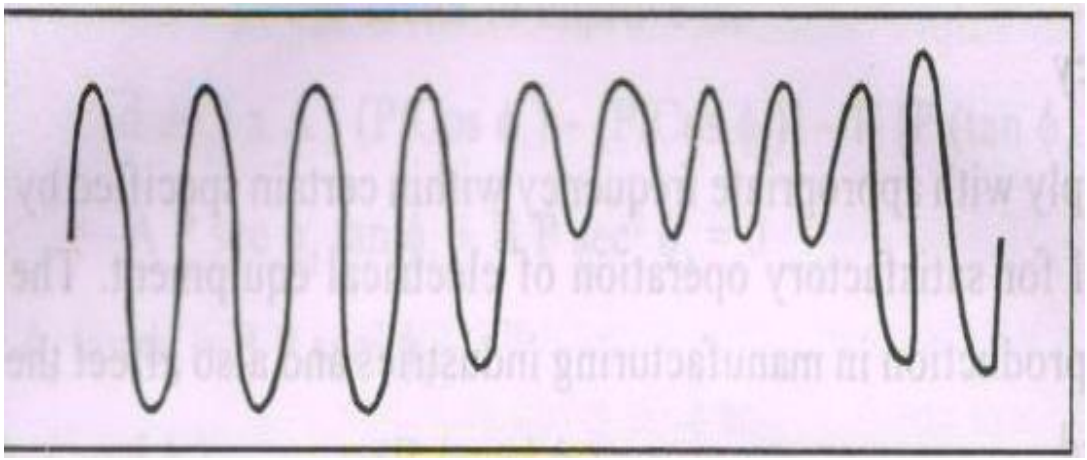
Harmonics :

- Multiples of fundamental frequency.
- Reduced equipment life time & energy efficiency.



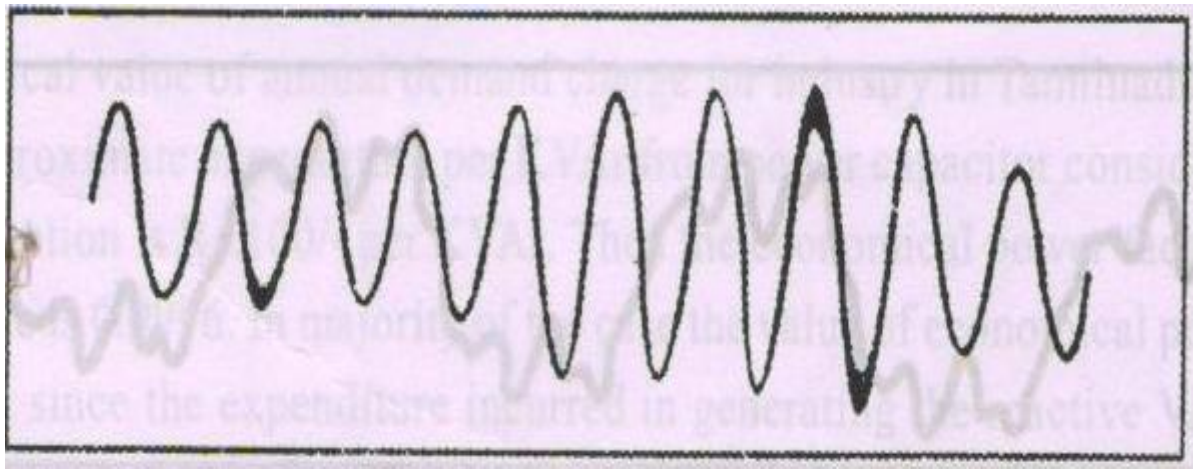
Voltage tags :

- Decreased in rms voltage or current.
- Caused by faults, energy heavy loads



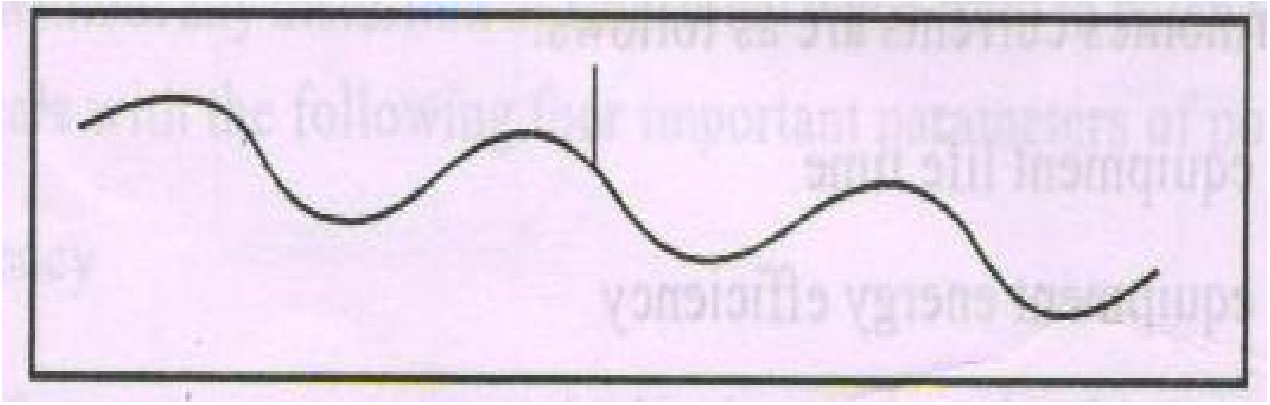
Voltage swells:

- Increased in rms value of voltage or current at the power frequency



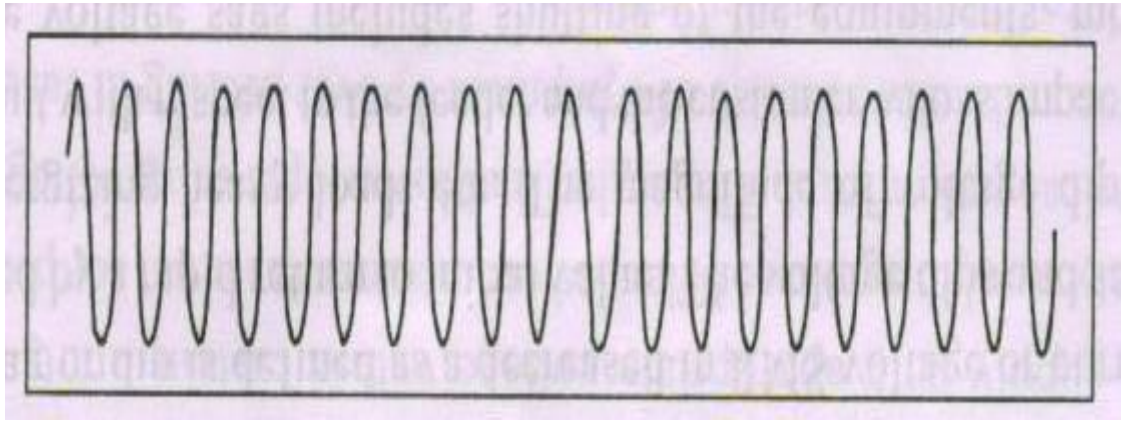
Voltage transients:

- Very short duration over voltages associated with impulses



Flickers:

- Variation of input voltage
- Caused by AC,DC arc furnaces



UNIT III

ILLUMINATION

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Definition of terms

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Laws of Illumination

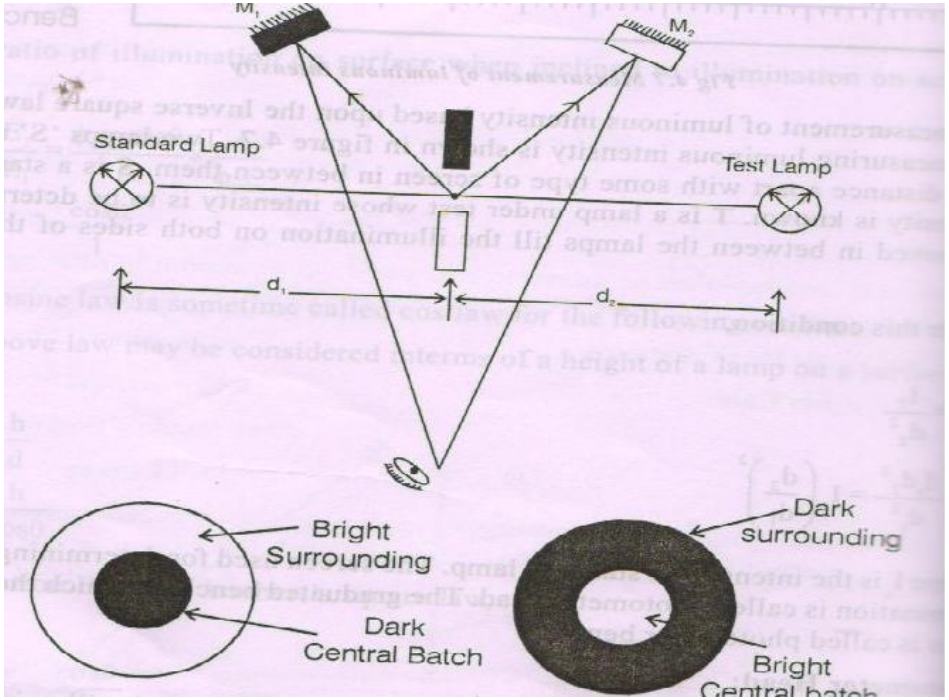
- Inverse Square law
- Lambert's Cosine law

Measurement of Luminous intensity

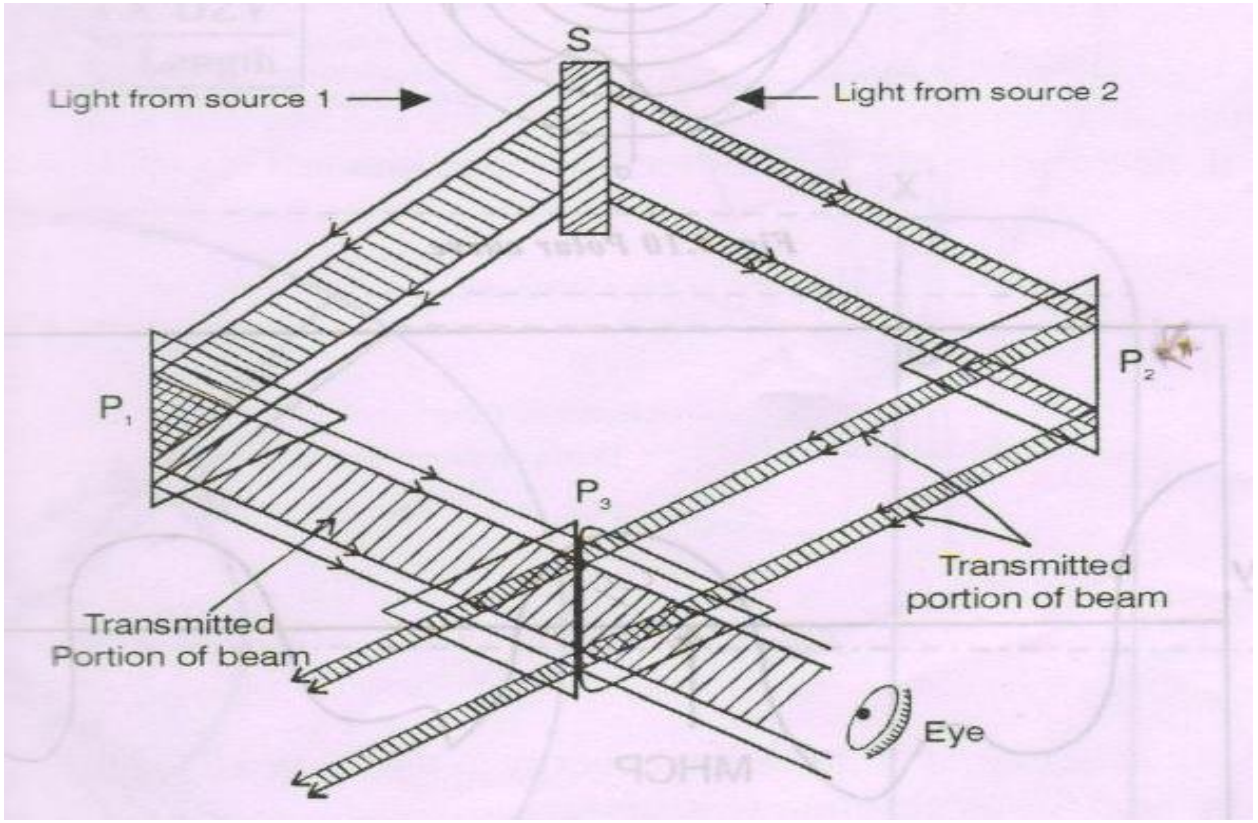
- Bunsen photometer head
- Lummer – Brodhun photometer head
- Flicker photometer head

Bunsen photometer head

- $I_t = I_s (d_2 / d_1)^2$



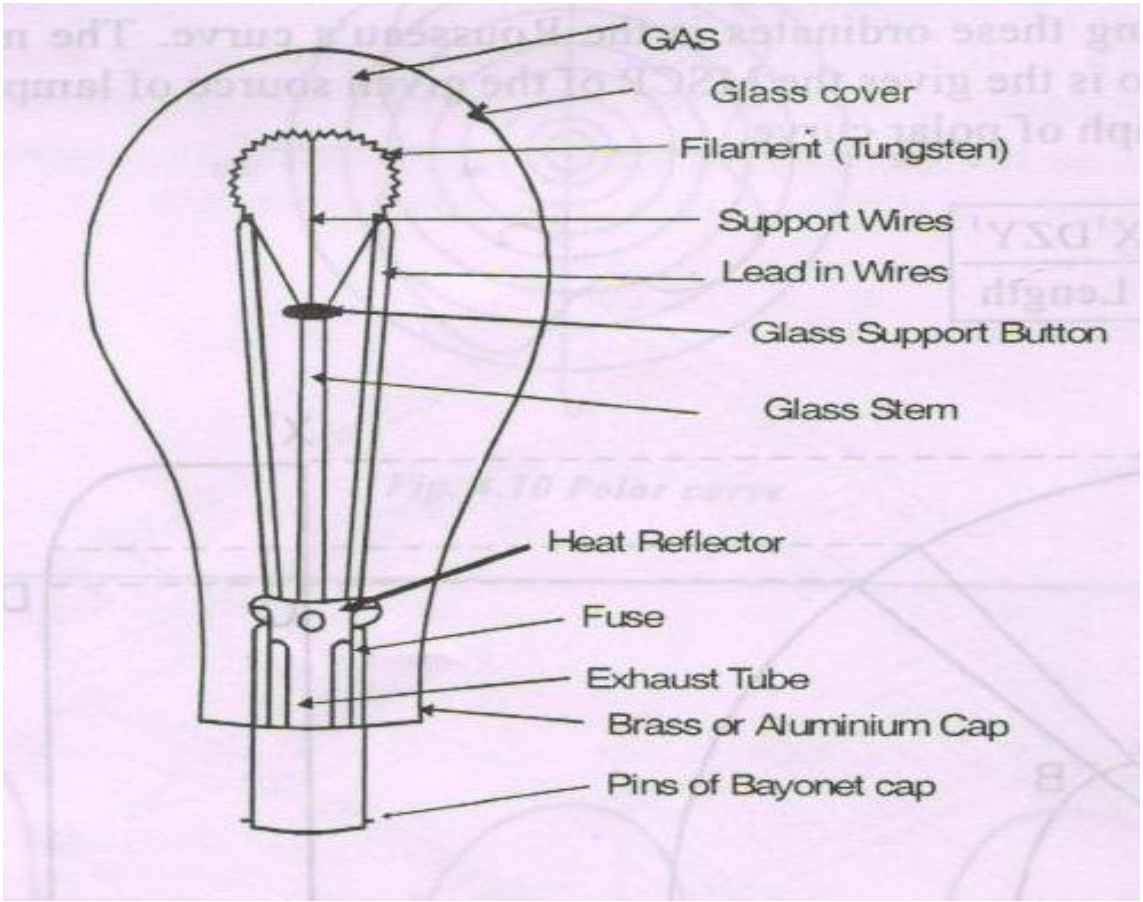
Lummer – Brodhun photometer head



Types of Lamp

- Filament Lamp (GLS)
- Tungsten Halogen Lamp

Filament Lamp (GLS)



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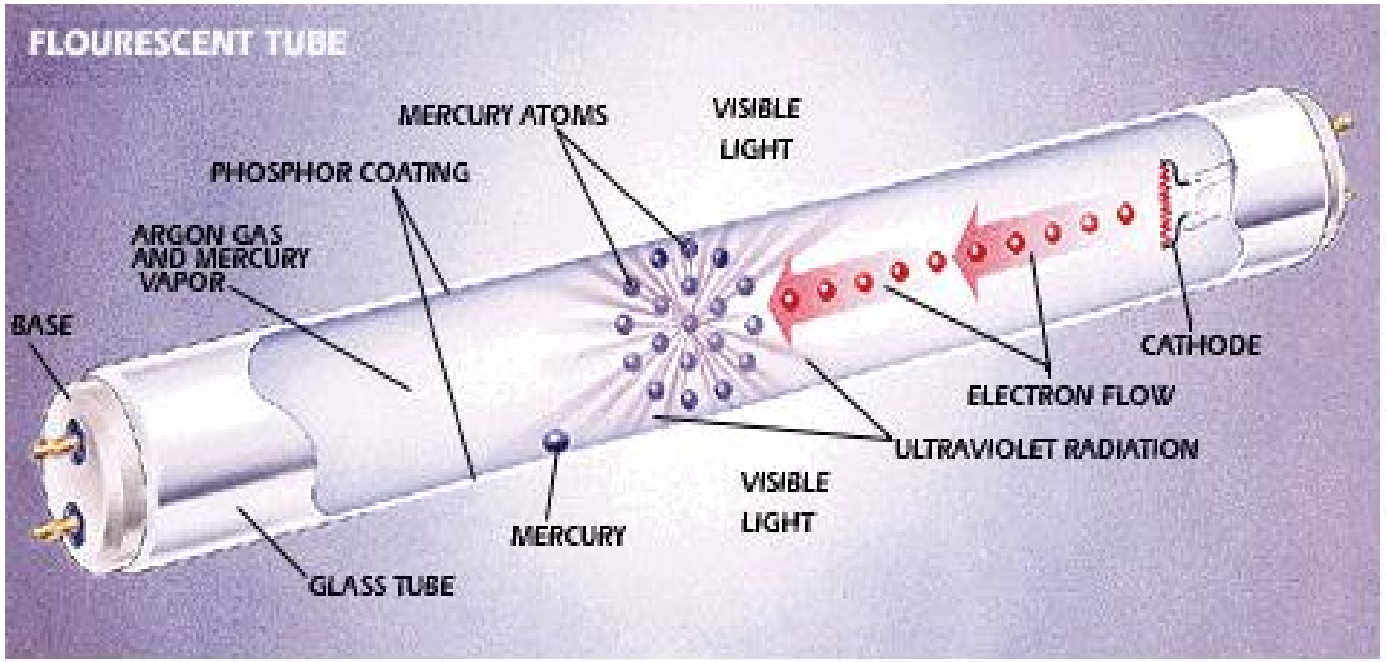
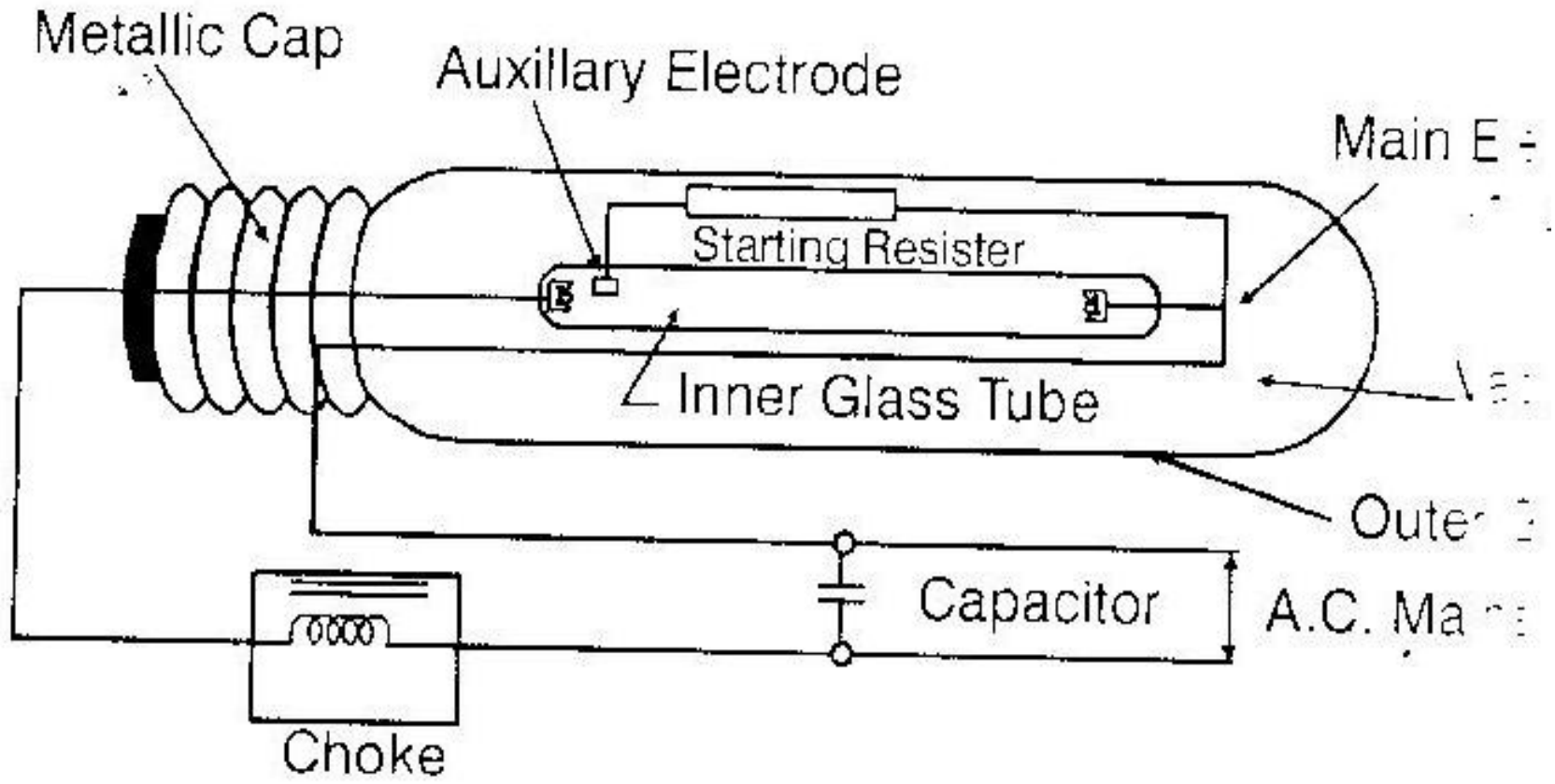
Fluorescent Lamp



High Pressure Mercury Vapour Lamp



Types of Lighting

- Direct lighting
- semi direct
- Indirect
- Semi indirect

HEATING

- When electric current passes through a medium, heat is produced

- $H = I^2 Rt$ Joules

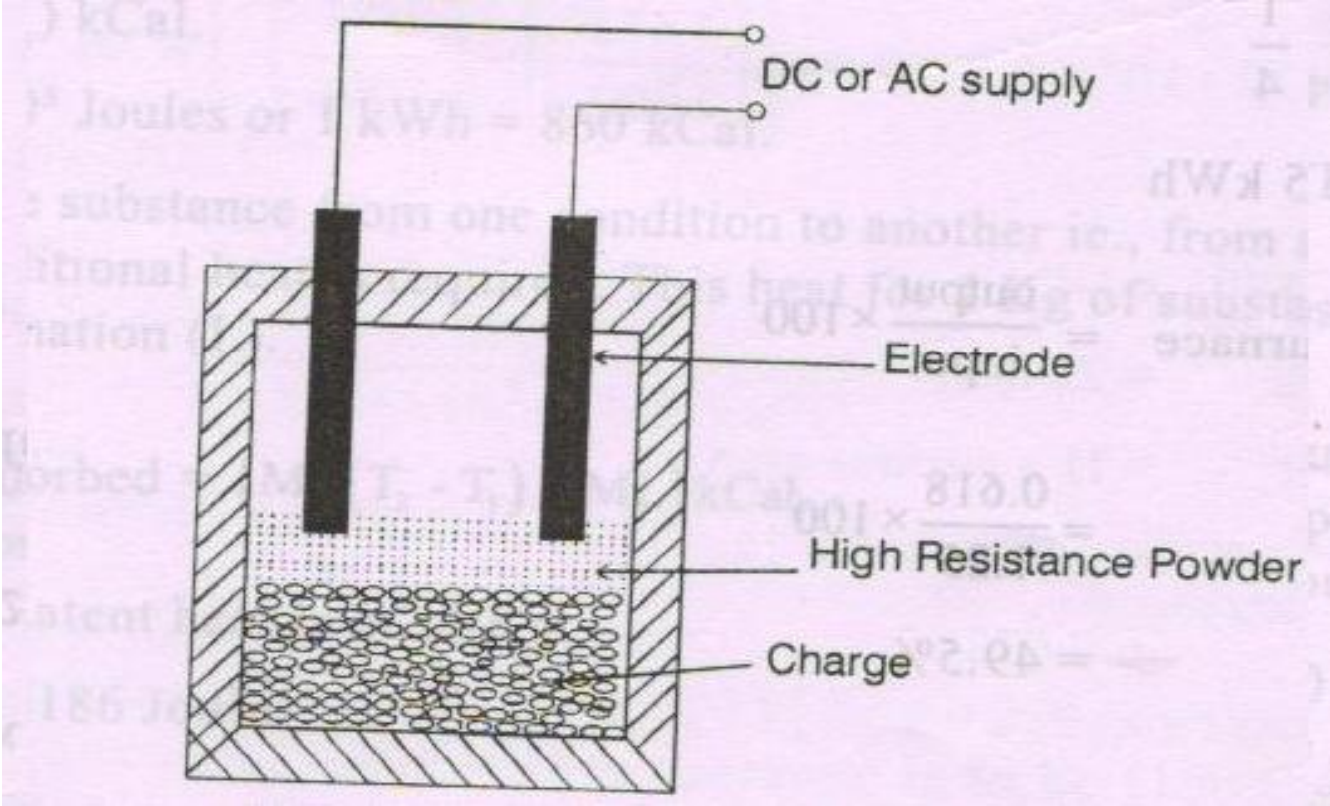
Properties of heating materials

- High specific resistance
- High melting point
- Freedom from oxidation
- Small temperature coefficient

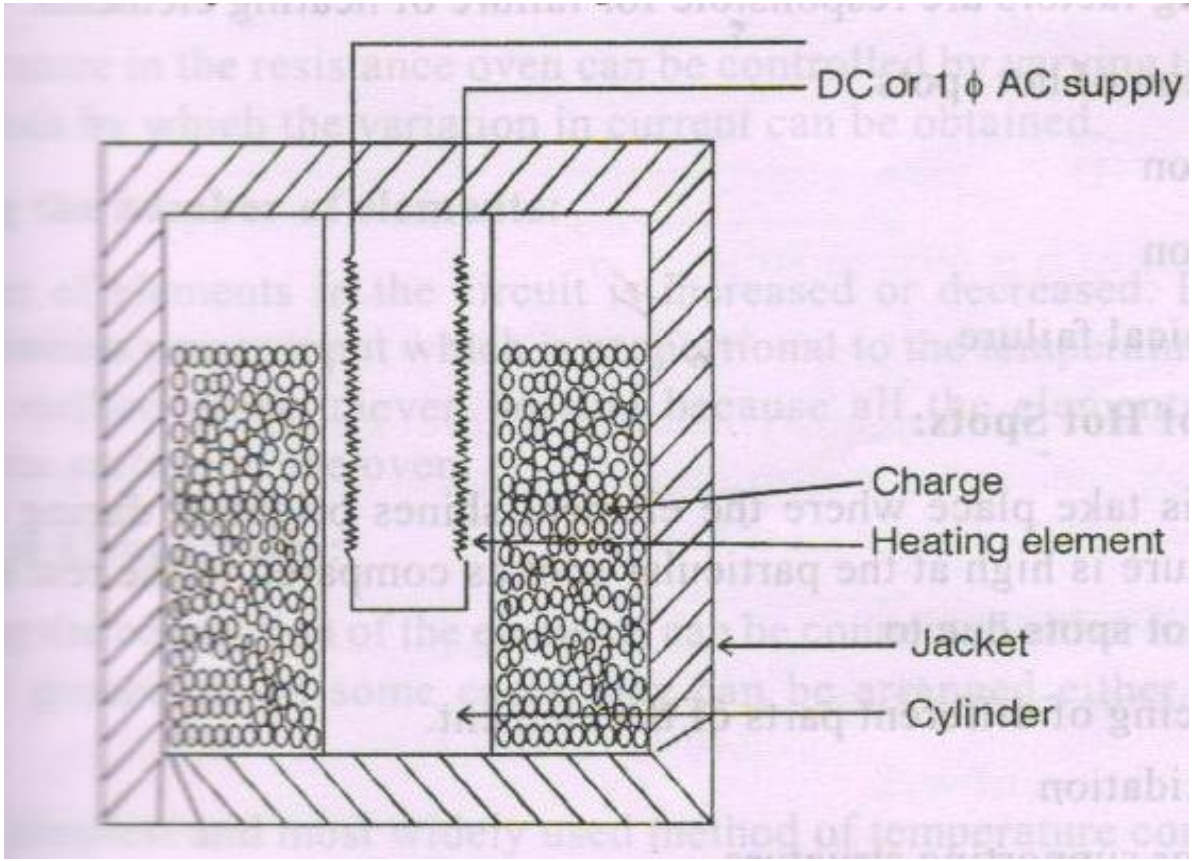
Types of Heating

- Resistance heating
  - a) Direct
  - b) Indirect
- Induction heating
  - a) Direct
  - b) Indirect
- Dielectric heating
- Arc heating

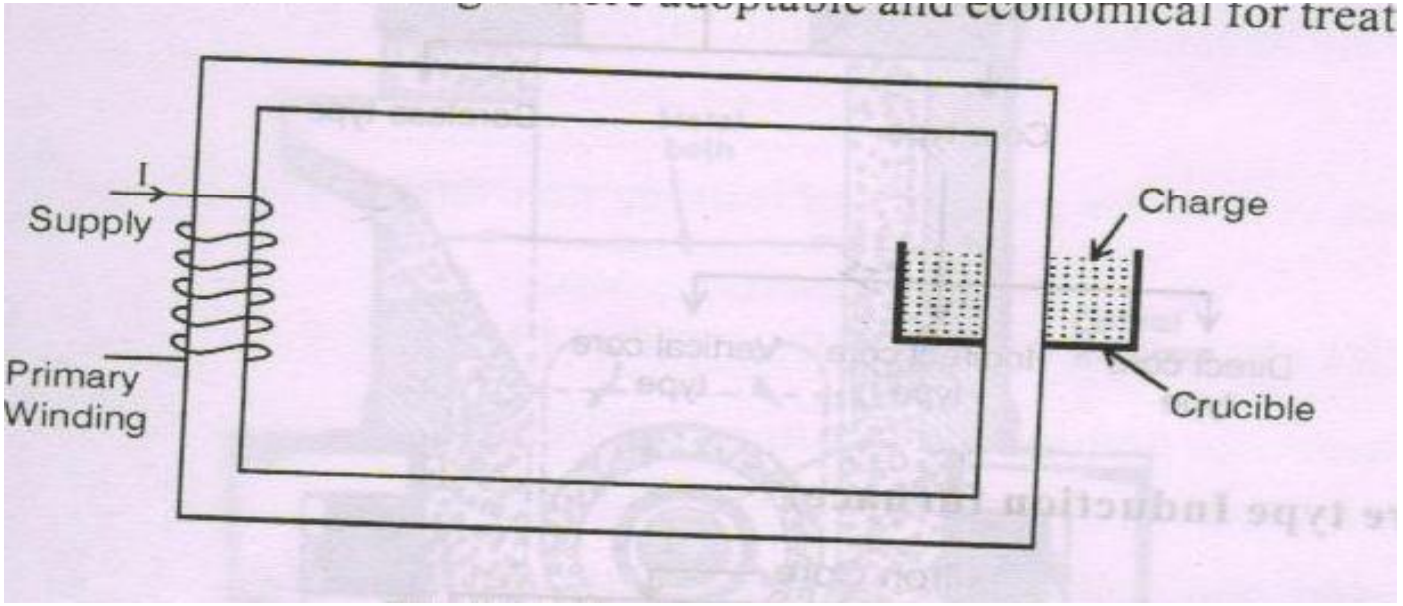
Direct resistance heating



Indirect resistance heating



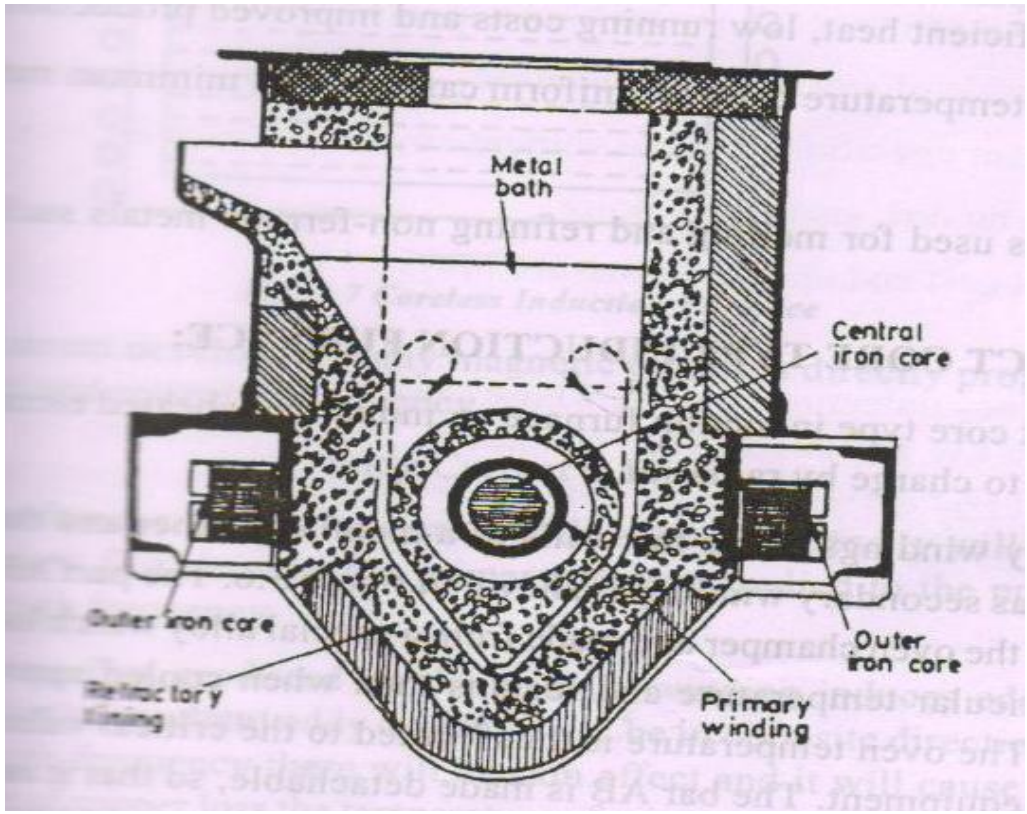
Induction heating



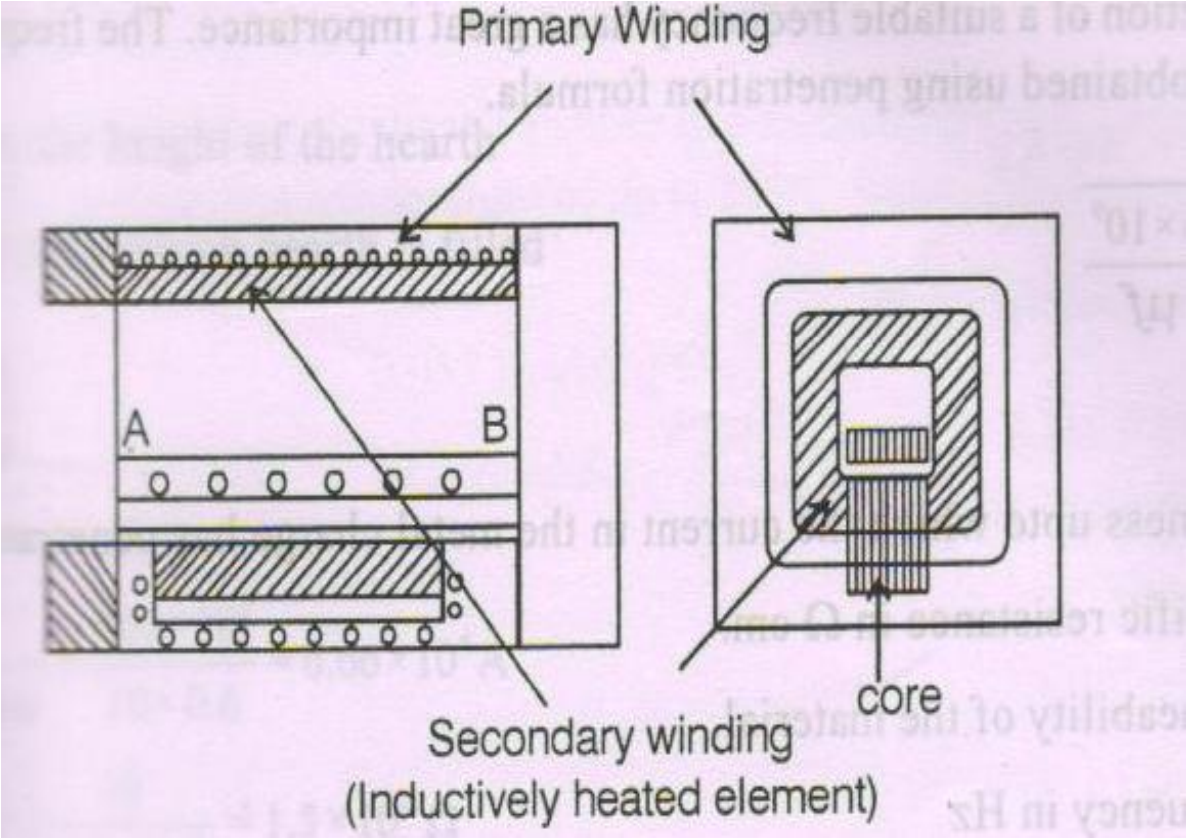
Types of Induction furnaces

- Core type
  - a) Direct
  - b) Indirect
  - c) Vertical
- Coreless type

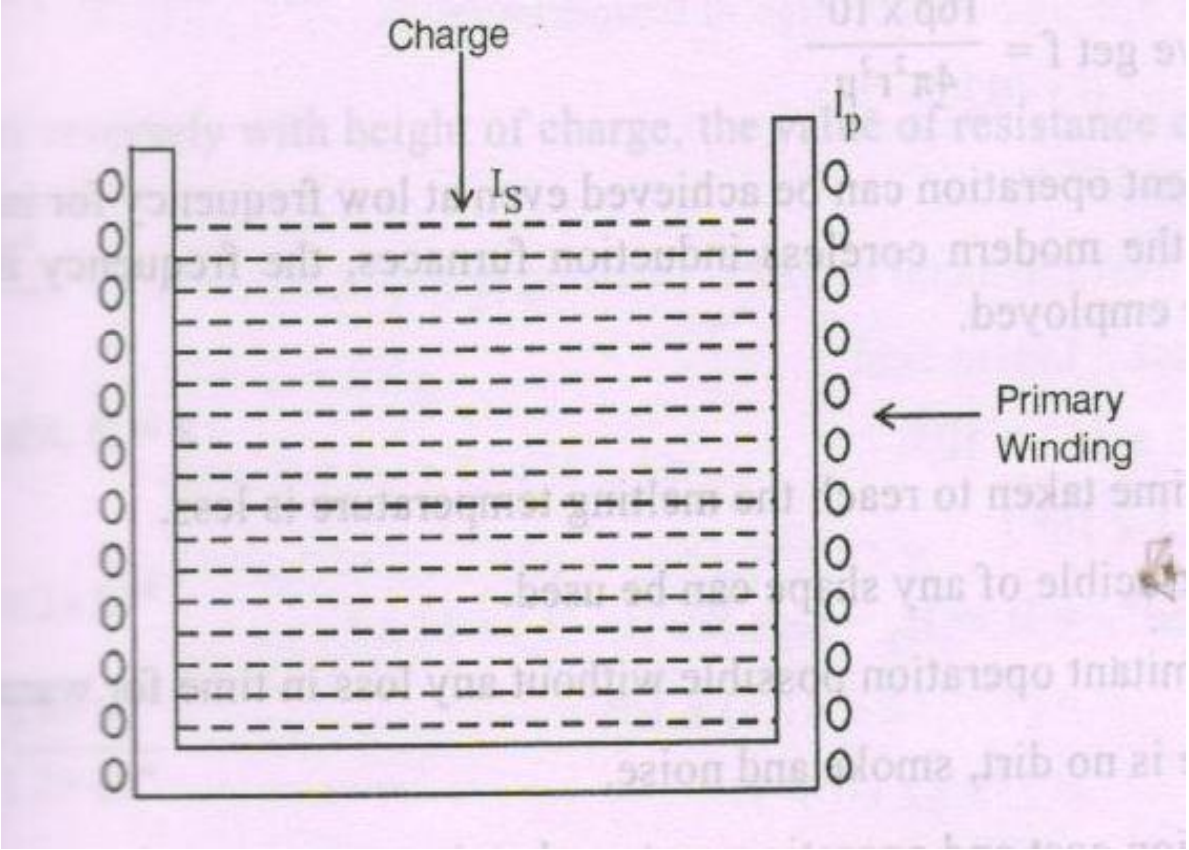
Vertical type Induction furnace



Indirect type Induction furnace



Coreless type Induction furnace



UNIT V

ELECTRIC TRACTION

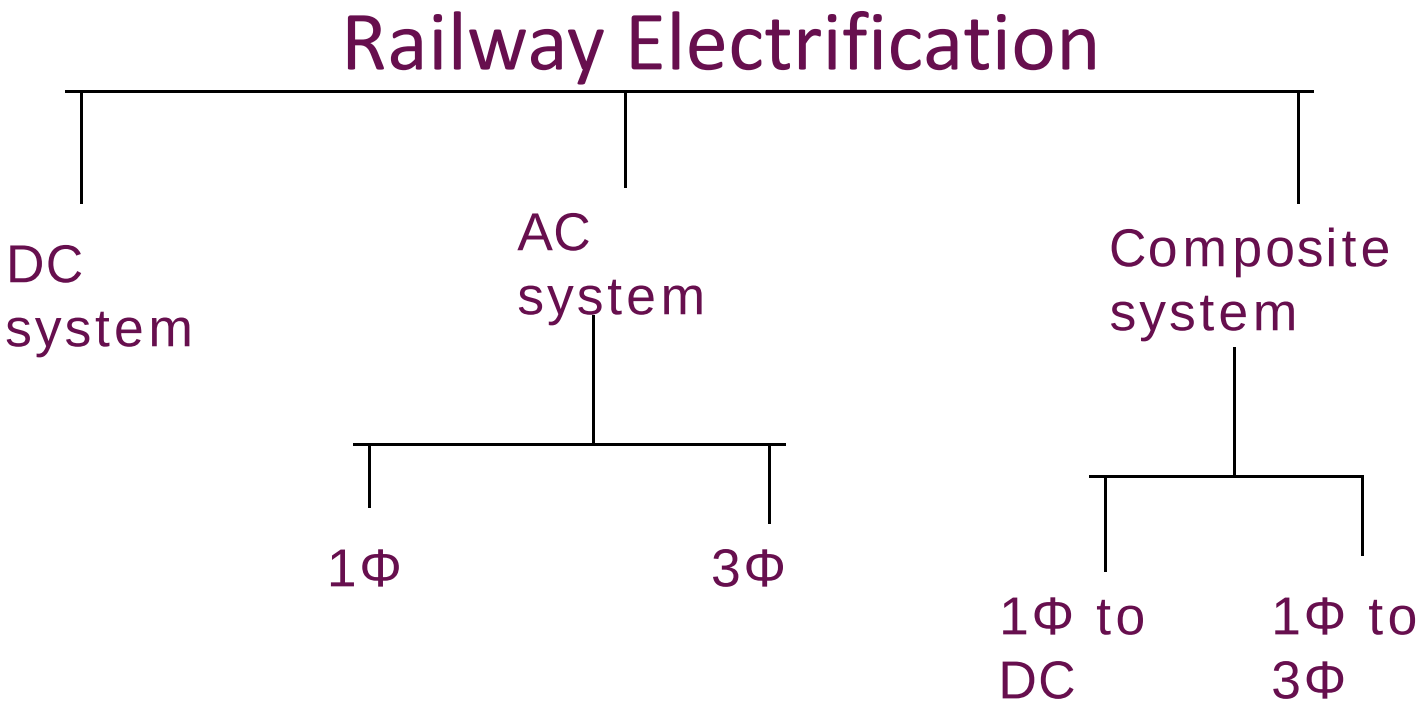
INTRODUCTION

- Locomotion in which driving force is obtained from motors
- Driving equipment should be capable of overloads for short periods
- Maximum tractive effort should be exerted at starting
- Wear should be minimum

Advantages :

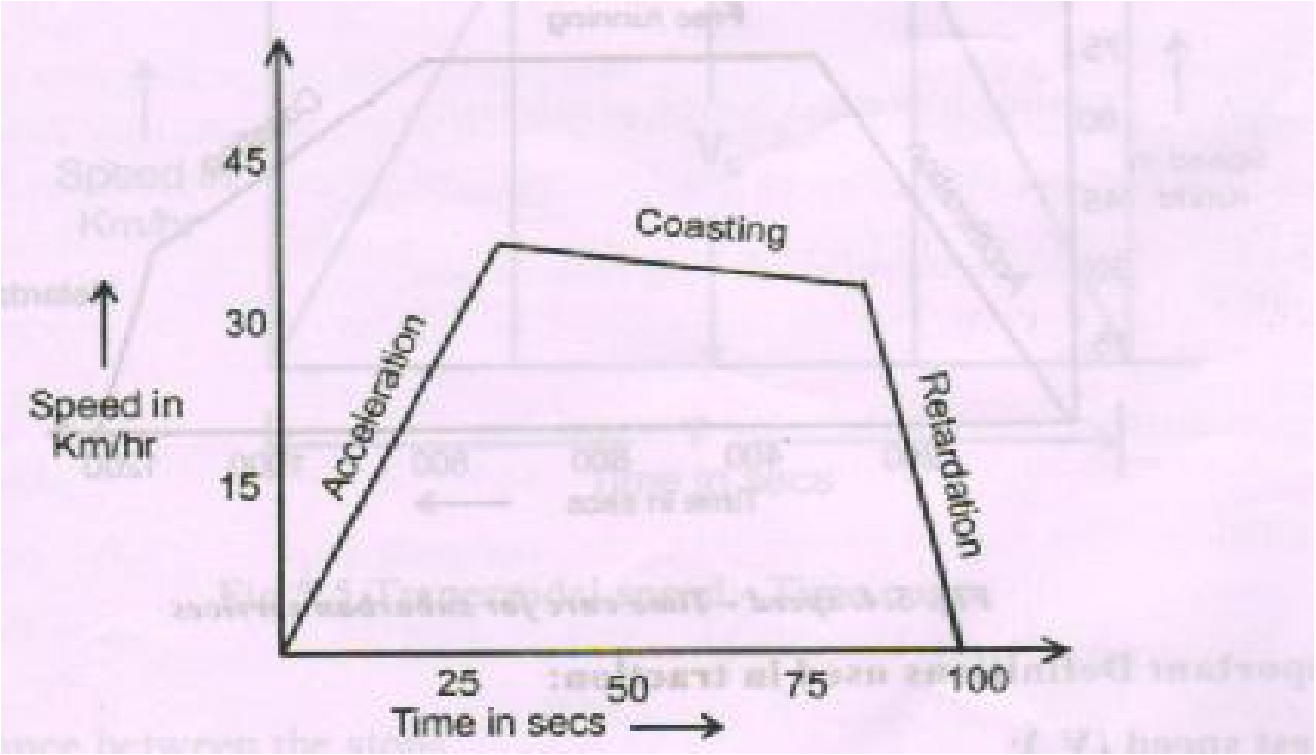
- Cheapest method
- Free from smoke and flue gas
- Very high starting torque
- Smooth and rapid acceleration and braking
- Adhesion coefficient is better
- Great passenger carrying capacity

Classifications :



Speed – Time curve

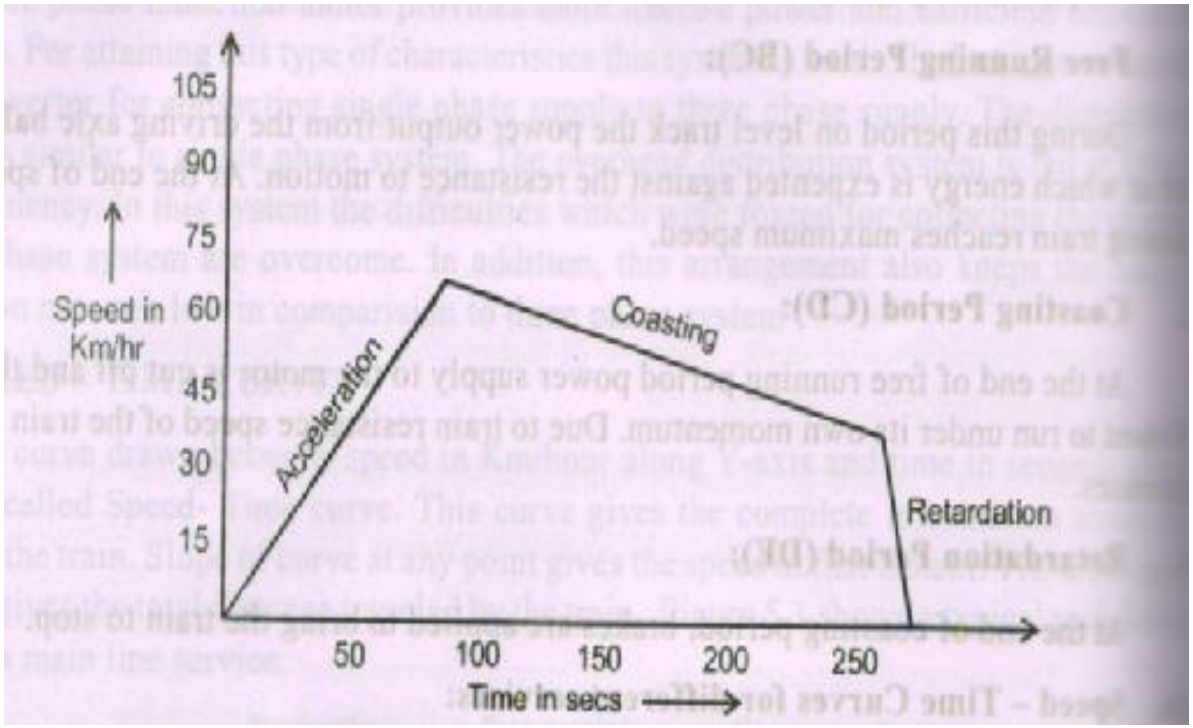
- Sub urban service



It consists of

- Acceleration period
- Free run period
- Coasting period
- Braking period

Main line service



Important terms

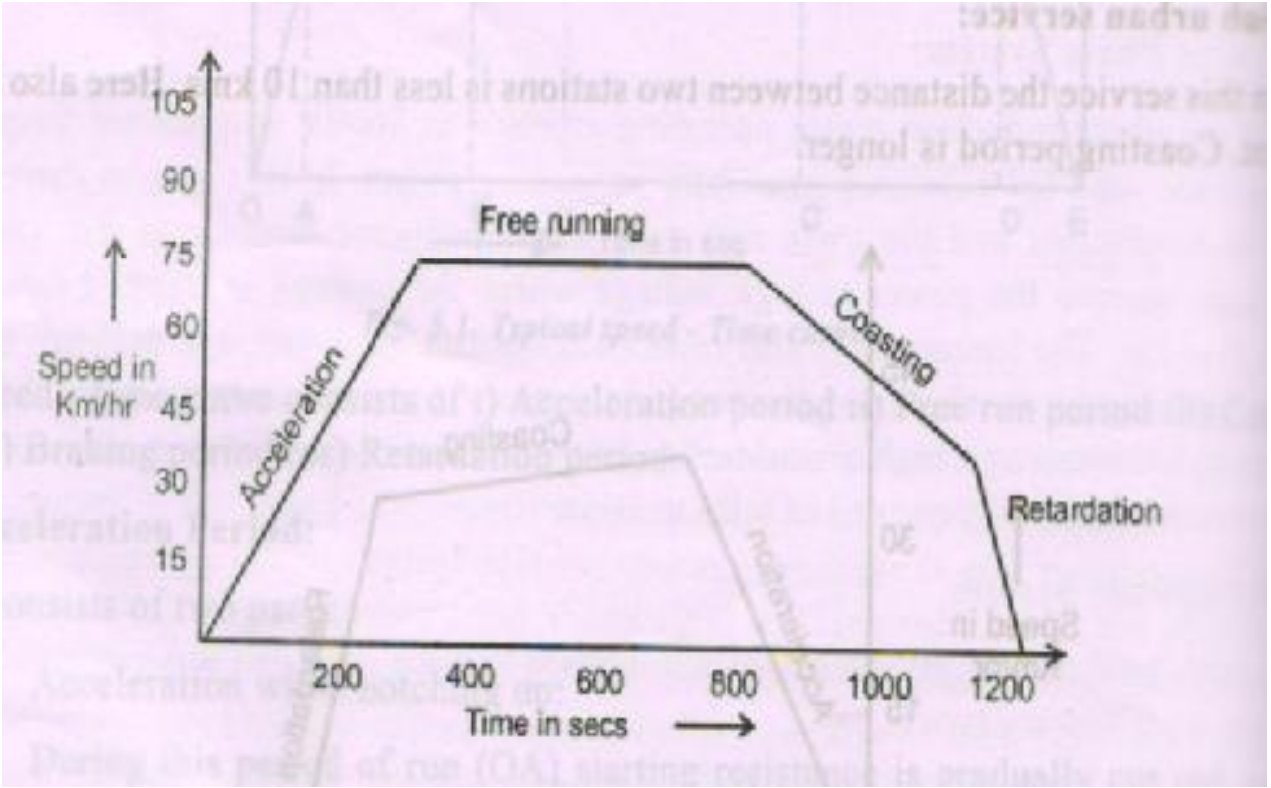
- Creset speed (Vc)

  - maximum speed attained by train during run

- Average speed (Va)

  - $\frac{\text{Distance between stops in km}}{\text{Actual time of run in hour}}$

Urban service



- Tractive effort is transferred to driving wheel
- Tractive torque and effort is given by

$$T = \frac{Fd'}{2}$$

$$F = \frac{2T}{d'}$$

d = diameter of gear wheel in metres

Tractive effort for propulsion of a train

- component needed to provide acceleration
- component needed to overcome train resistance
- component needed to overcome gradients

Factors affecting specific energy consumption

- Distance between the stops
- Maximum speed
- Weight of the train
- Train resistance
- Acceleration and retardation

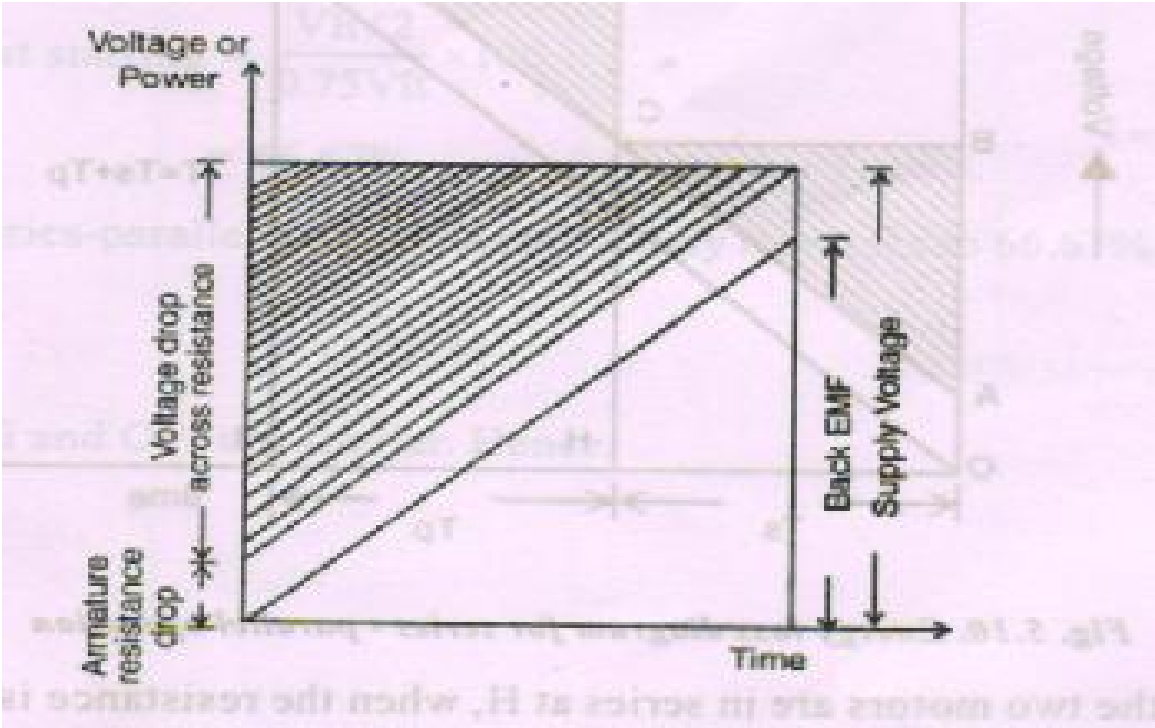
Teaction motor control

- DC series motor control
- Series – parallel control of DC series motor

DC series motor control

- At the time of starting, no back emf, so motor speed is high.
- to limit the current, starting resistance is added.
- Some energy is wasted in resistance

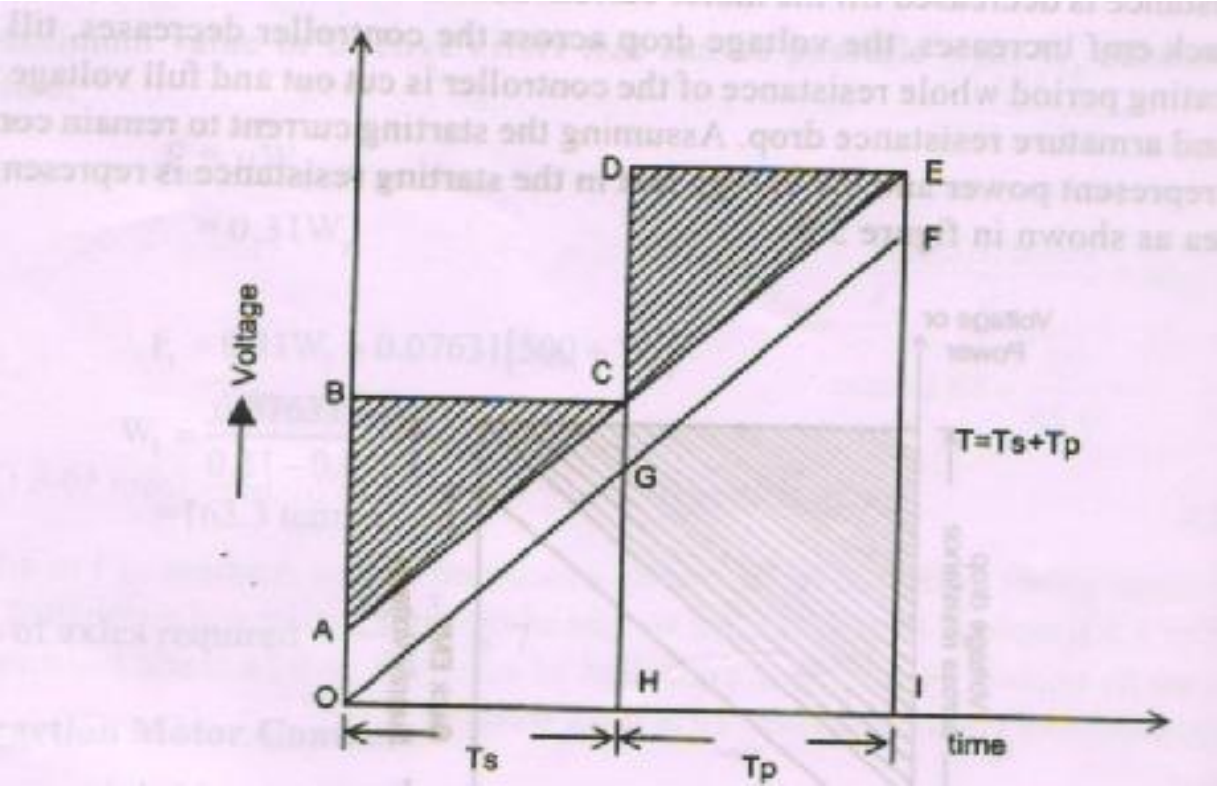
Energy loss diagram



Series – parallel control

- two motors are used
- at starting they are connected in series
- for full speed , they are connected in parallel
- Energy loss is minimum

Energy loss diagram



Series – parallel starting methods

- Shunt or short circuit transition method
- Bridge transition method

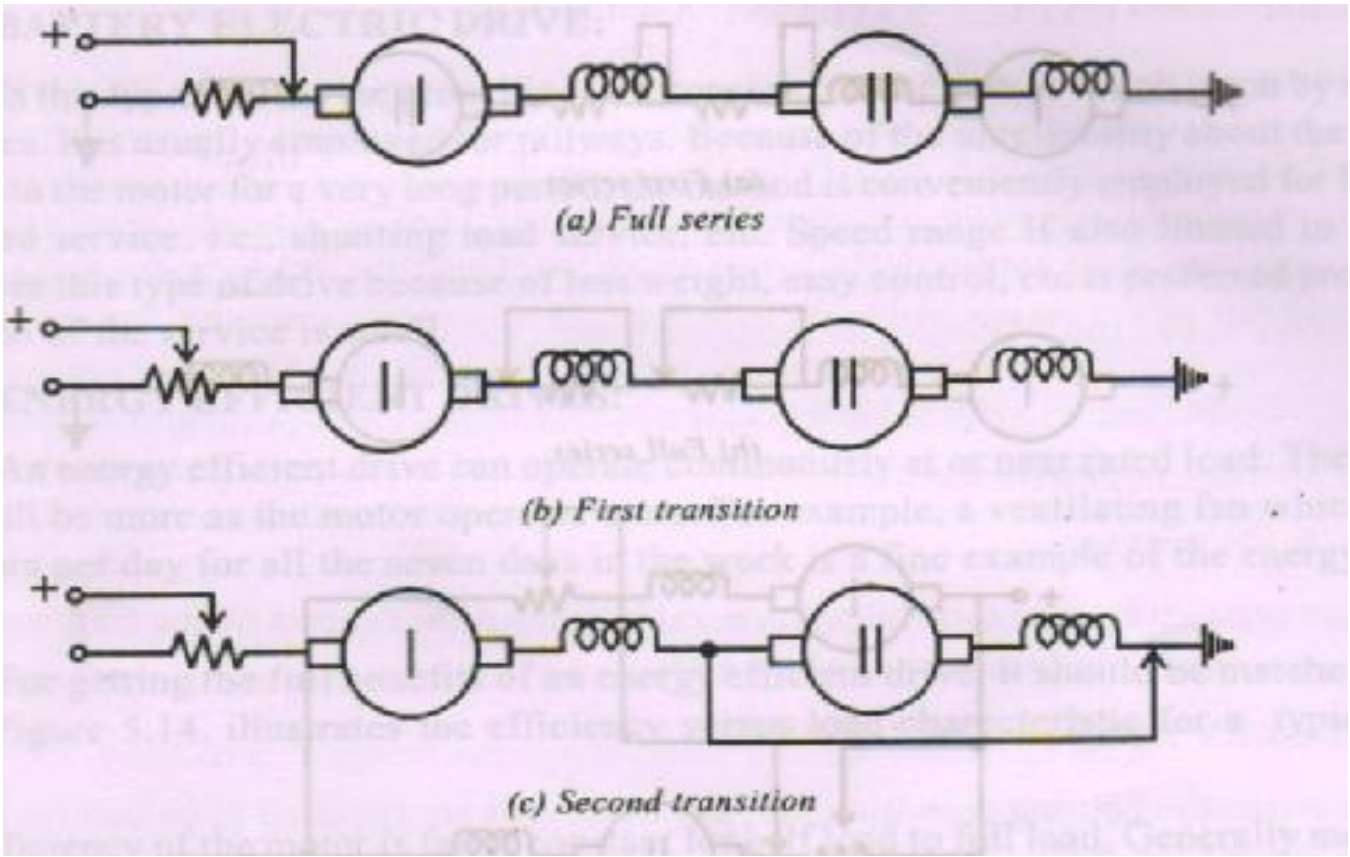
Shunt transition methods

- Full series
- first transition
- Second transition
- Third transition
- First parallel
- full parallel

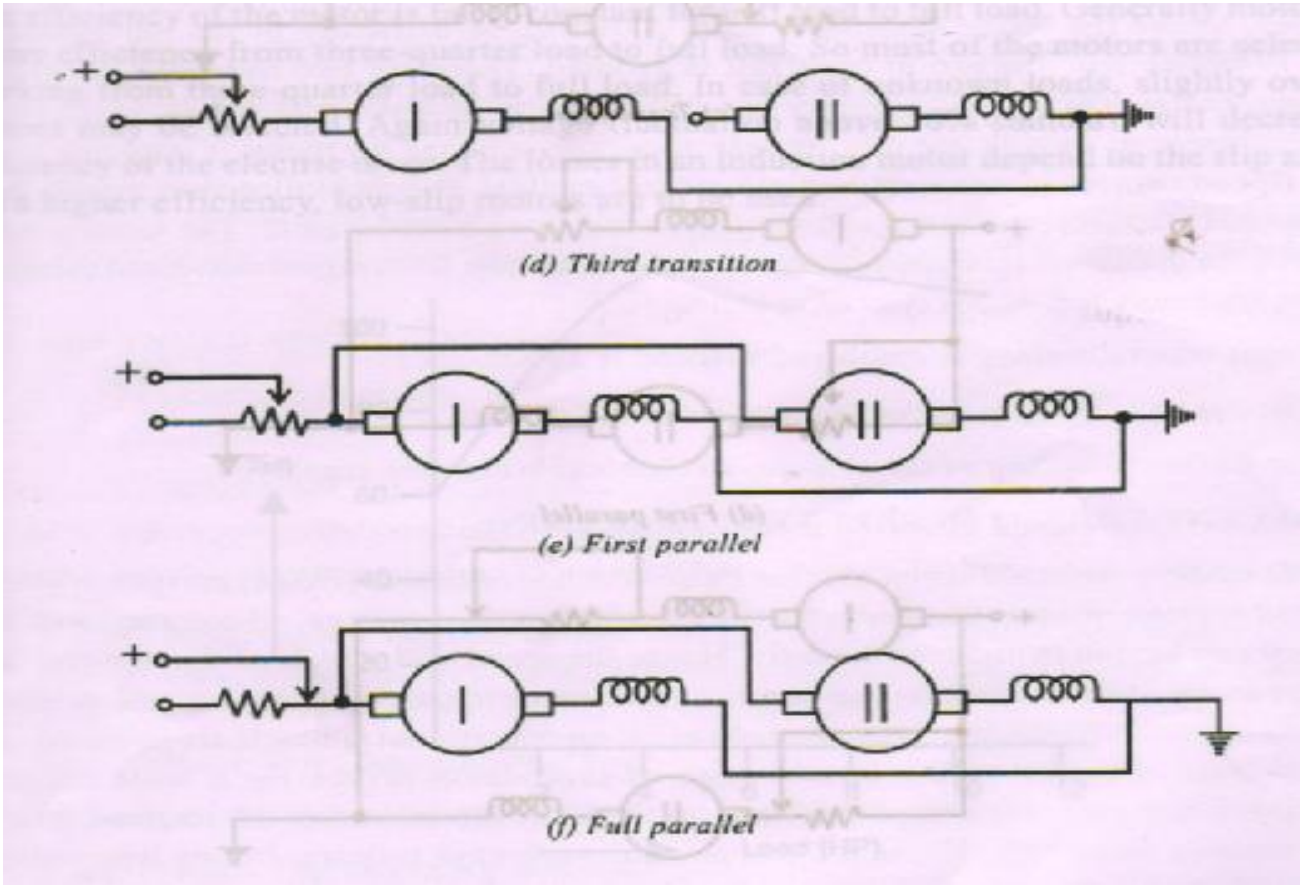
Bridge transition method

- first series
- Full series
- Transition
- first parallel
- full parallel

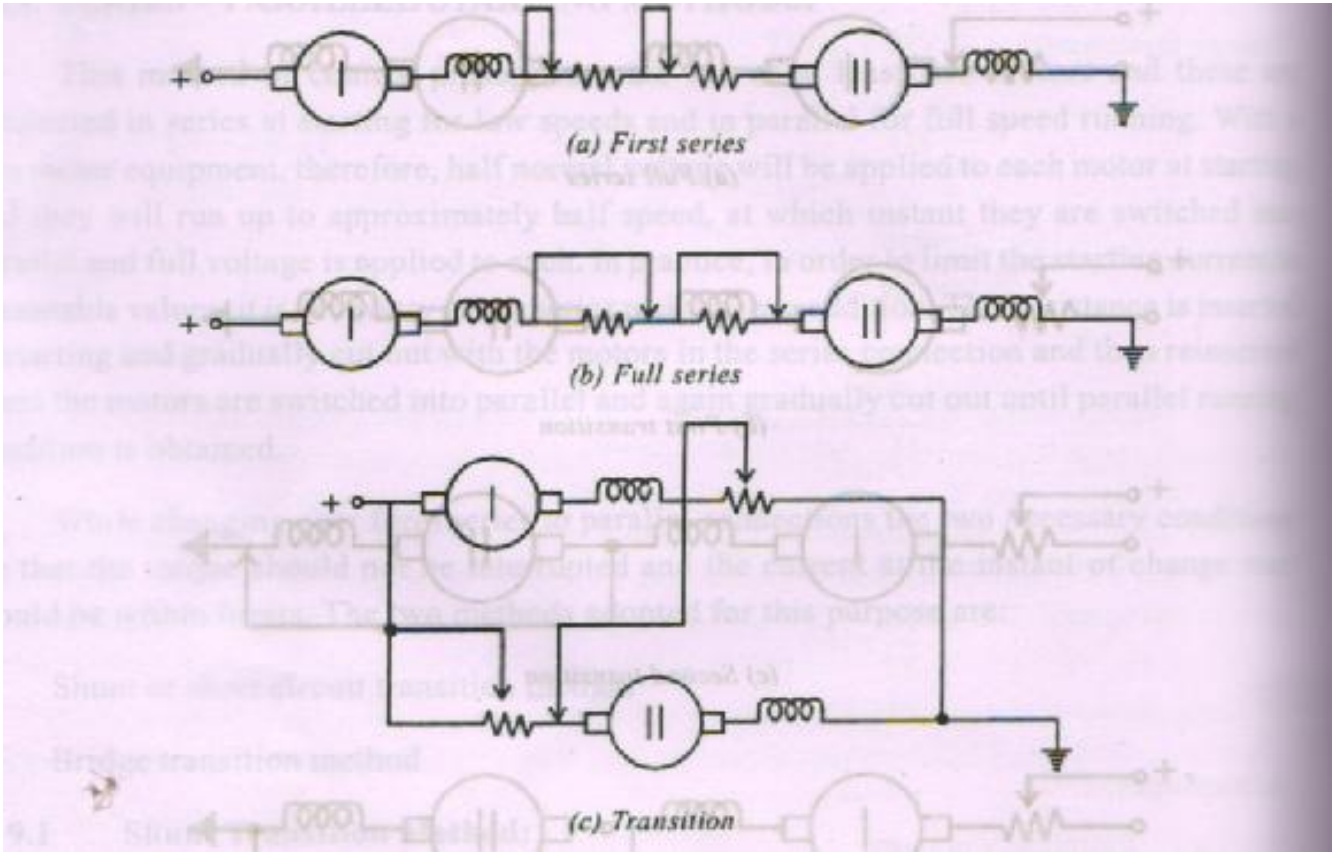
Full series, first transition and Second transition



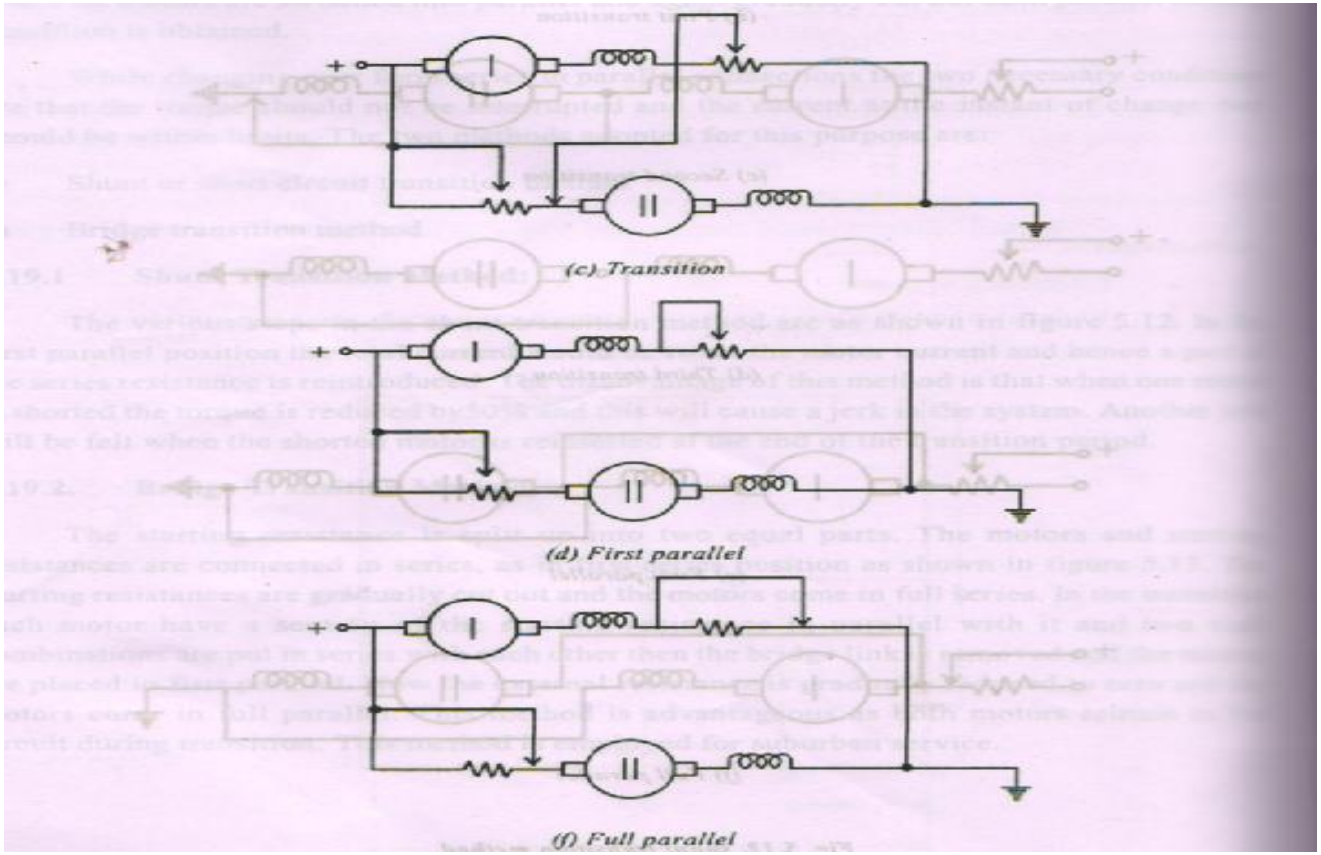
Third transition, First parallel& full parallel



Bridge transition method



Third transition, First parallel& full parallel



Recent trends in electric traction

- PWM technique is applied
- PWM AC drives used in subways, rail cars, trolley buses, diesel electric and electric locomotives.
- GTOs are user in PWM inverter technology
- Microprocessors unit controls firing pulses to the GTOs

Advanced speed control

- Tap changer control
- Thyristor control
- Chopper control
- Microprocessor control

Tap changer control

- Variable voltage control without losses
- Low voltage tap changing method

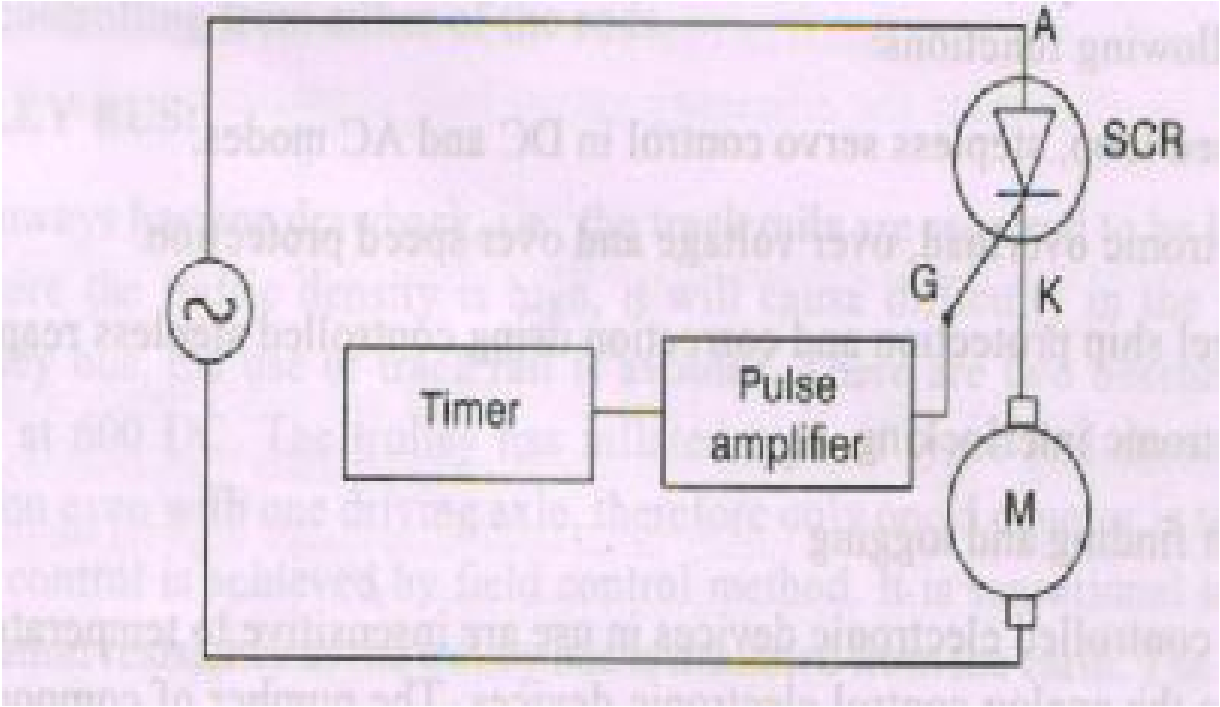
  - by keeping the number of turns primary turns and changing the secondary turns
- High voltage tap changing method

  - keeping turn ration constant and applying variable voltage

Thyristor control

- Magnitude of DC voltage is decided by average of the positive half cycles allowed to pass through the rectifiers
- by allowing positive half cycles
- by not allowing certain portion of positive half cycles

Diagram



Chopper control

- Pulse Width Modulation

  - time period constant with variation in Ton & Toff

Microprocessor control