

**Knowledge Institute of Technology, Salem**  
**Department of Mechanical Engineering.**

**POWER PLANT ENGINEERING**

**Presented by**

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# Boilers



# Boilers



*Boiler is an apparatus to produce steam. Thermal energy released by combustion of fuel is used to make steam at the desired temperature and pressure.*

The steam produced is used for:

- (i) Producing mechanical work by expanding it in steam engine or steam turbine.*
- (ii) Heating the residential and industrial buildings*
- (iii) Performing certain processes in the sugar mills, chemical and textile industries.*

# Boiler properties:

- (i) Safety. (ii) Accessibility. (iii) Capacity.

- (iv) Efficiency.
- (v) It should be simple in construction.
- (vi) Its initial cost and maintenance cost should be low.
- (vii) The boiler should have no joints exposed to flames.
- (viii) Should be capable of quick starting and loading.

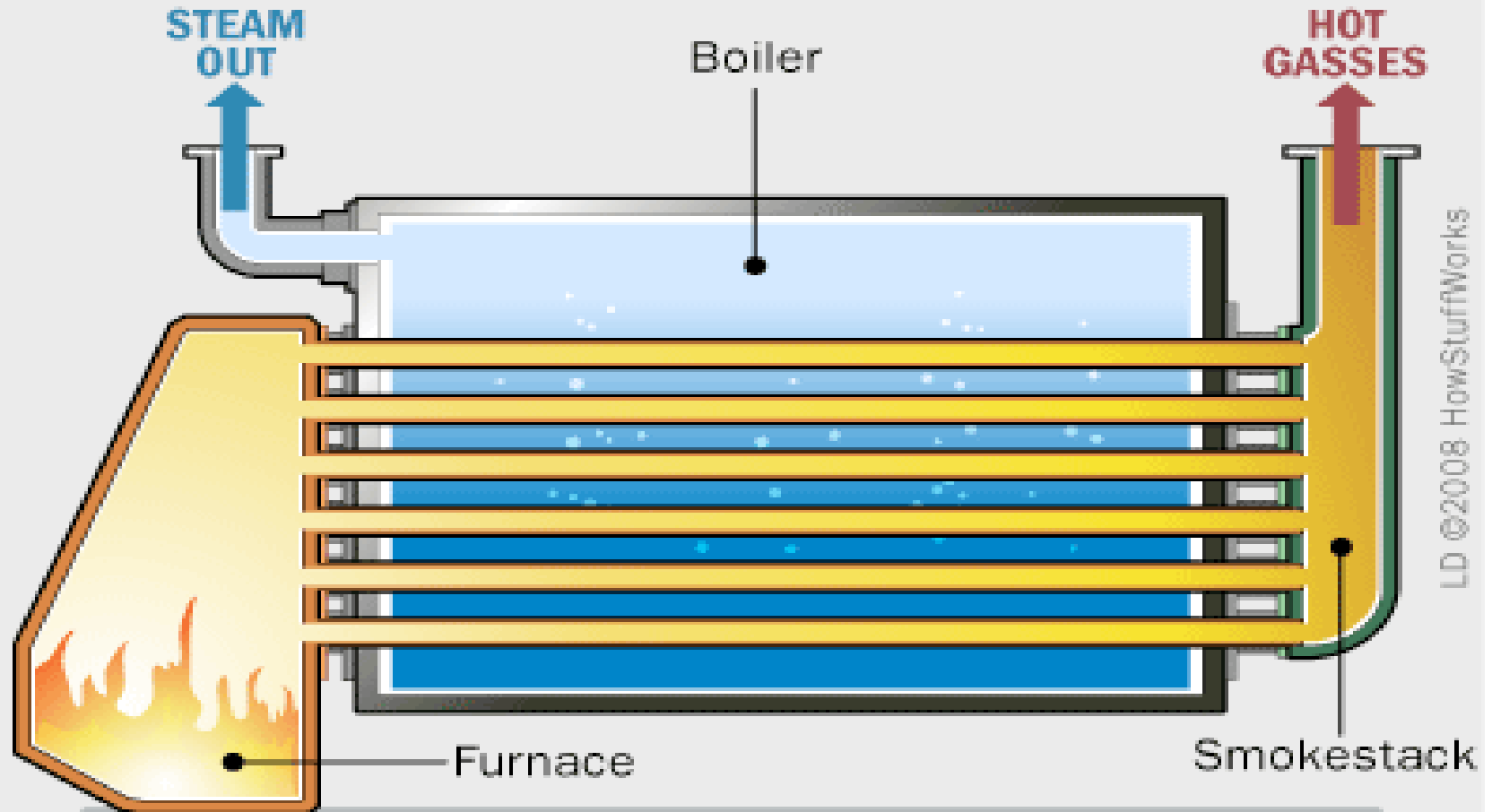
# CLASSIFICATION OF BOILERS

- **According to what flows in the TUBE**
  - 1. Water tube.
  - 2. Fire tube.



# Fire – tube Boilers

How Steam Engines Work Fire-tube Boiler



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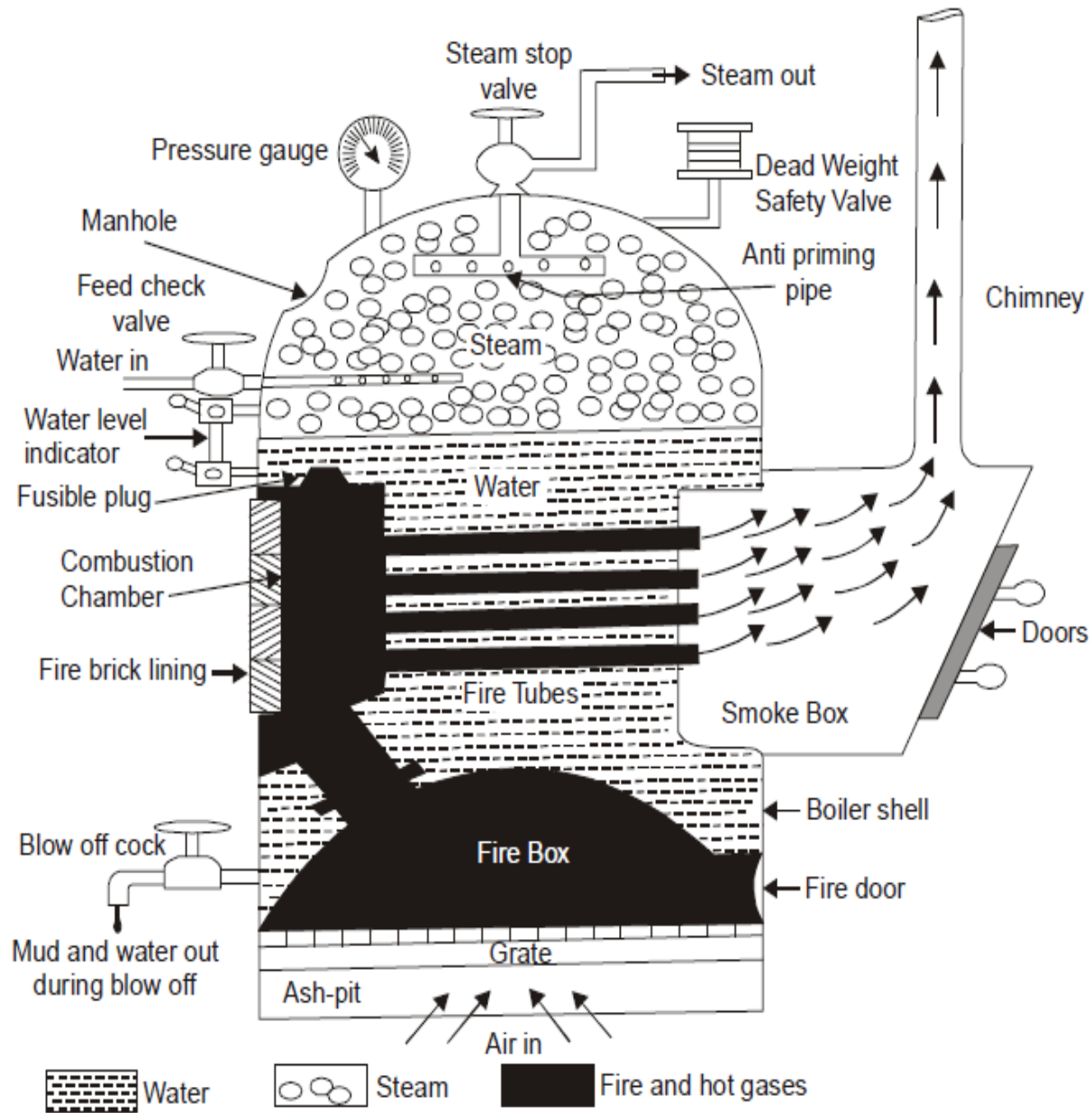
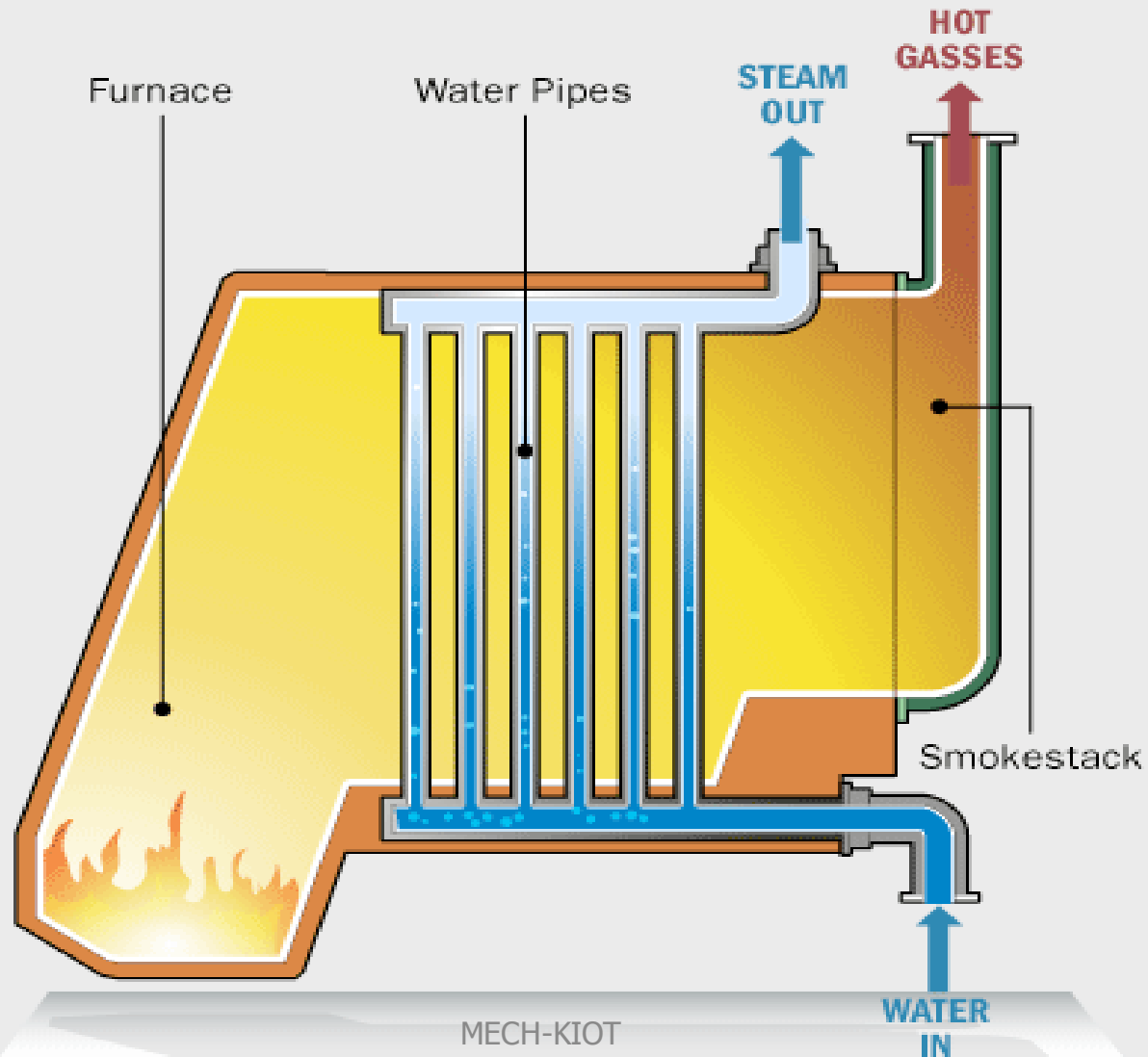


Fig. 5.1 Cochran Boiler.

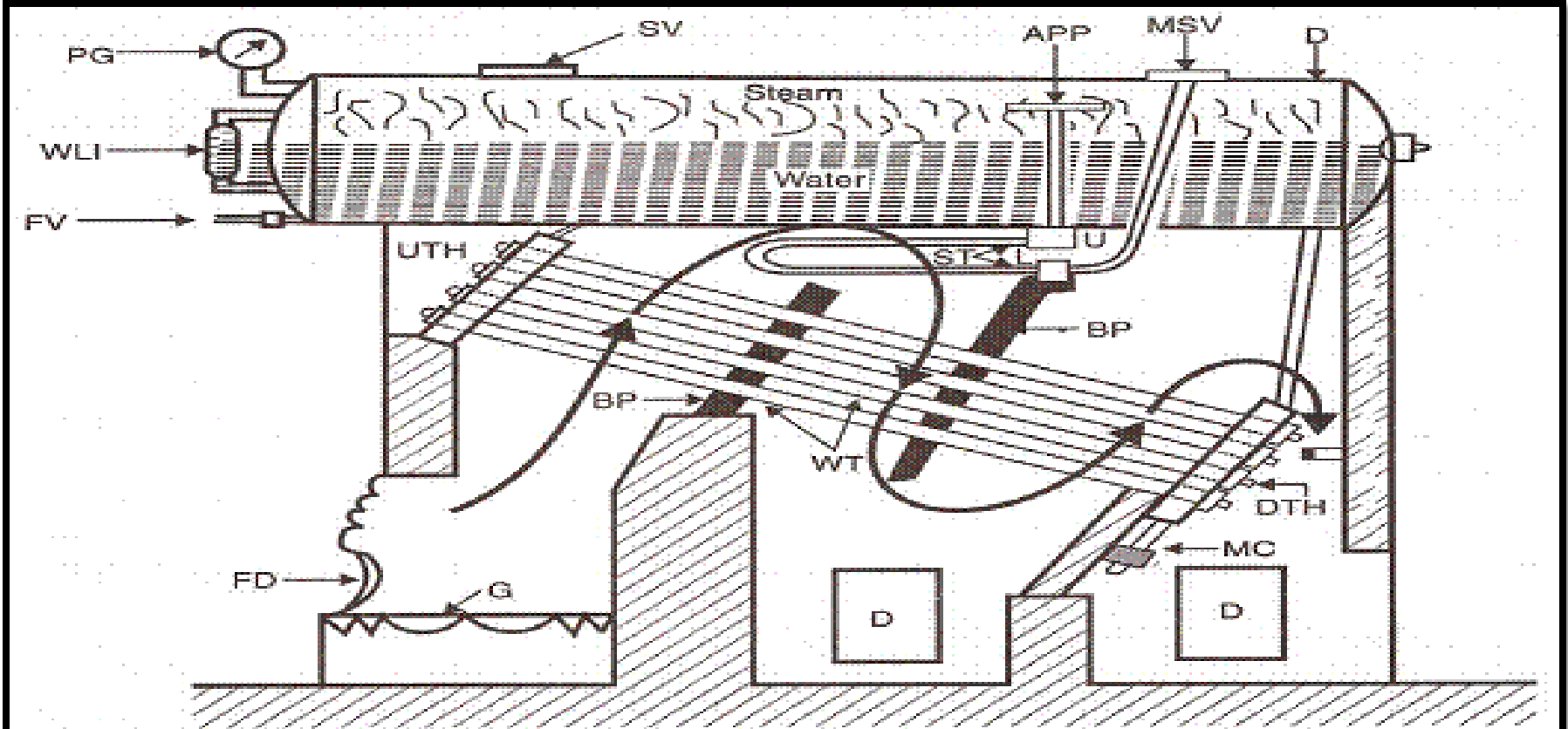
# Water tube boilers

How Steam Engines Work Water-tube Boiler



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# BABCOCK WILCOX BOILER



- D* = Drum
- DTH* = Down take header
- WT* = Water tubes
- BP* = Baffle plates
- D* = Doors
- G* = Grate
- FD* = Fire door
- MC* = Mud collector
- WLI* = Water level indicator

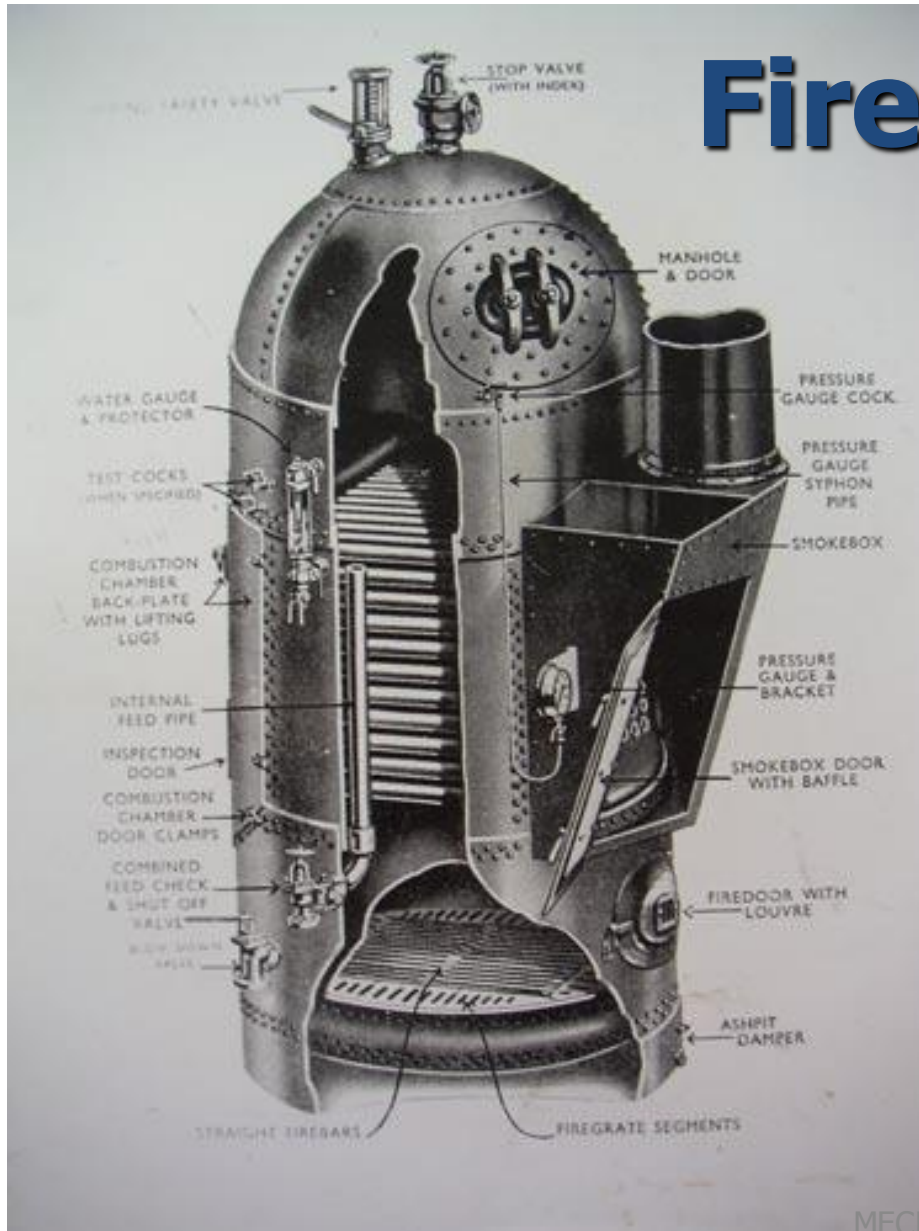
- PG* = Pressure gauge
- ST* = Superheater tubes
- SV* = Safety valve
- MSV* = Main stop valve
- APP* = Antipriming pipe
- L* = Lower junction box
- U* = Upper junction box
- FV* = Feed valve

# Water tube boilers are classified as

- 1. Horizontal straight tube boilers
  - *(a) Longitudinal drum (b) Cross-drum.*
- 2. Bent tube boilers
  - *(a) Two pass (b) Three pass*
- 3. Cyclone fired boilers

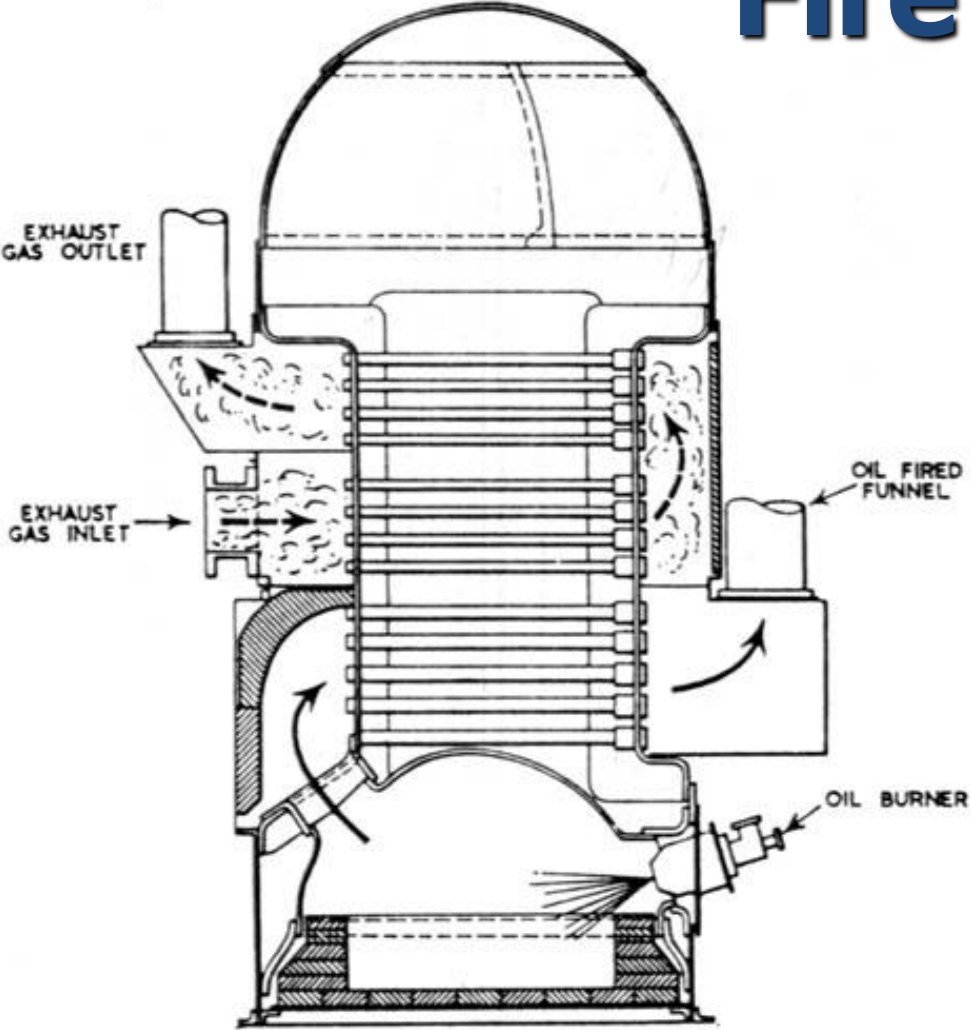
# Fire – tube Boilers

## Cochran Boiler



# Fire – tube Boilers

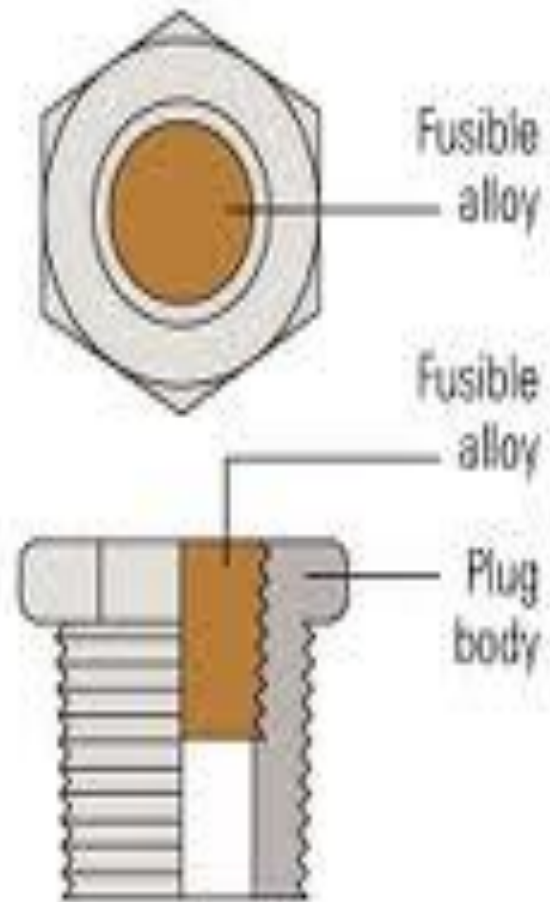
## Cochran Boiler



PATH OF OIL FIRING ———→  
PATH OF EXHAUST GASES - - - - -→

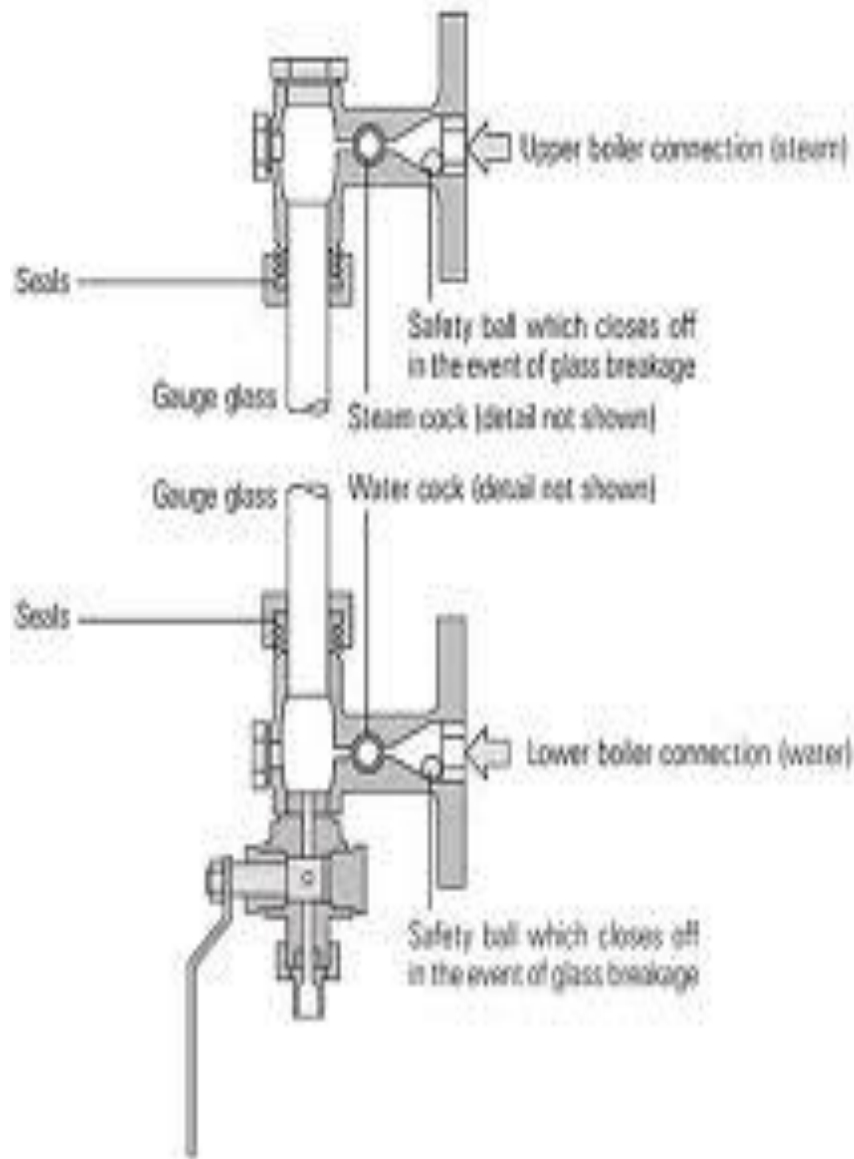
# Main parts .....

Fusible Plug.



# Water Level Indicator.

▪



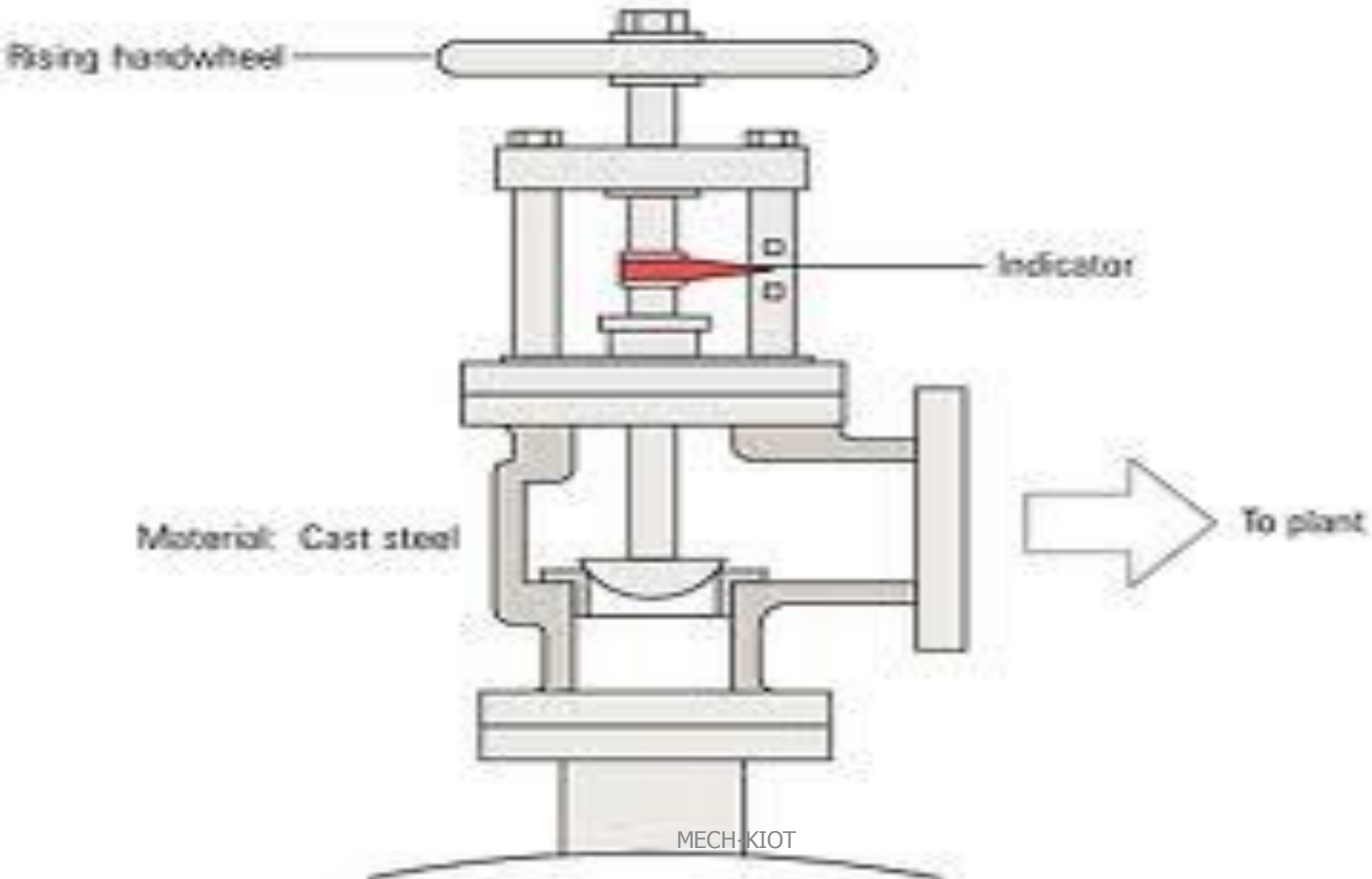
# Pressure Gauge.

This indicates the pressure of the steam in the boiler.



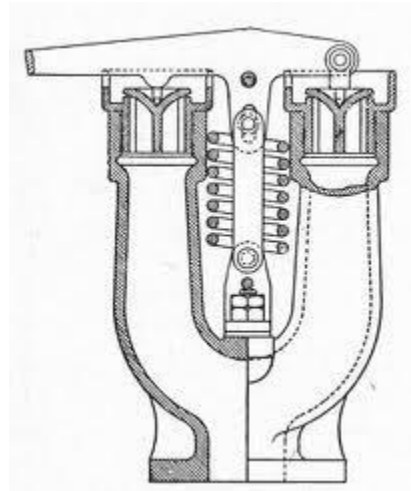
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# Steam Stop Valve.



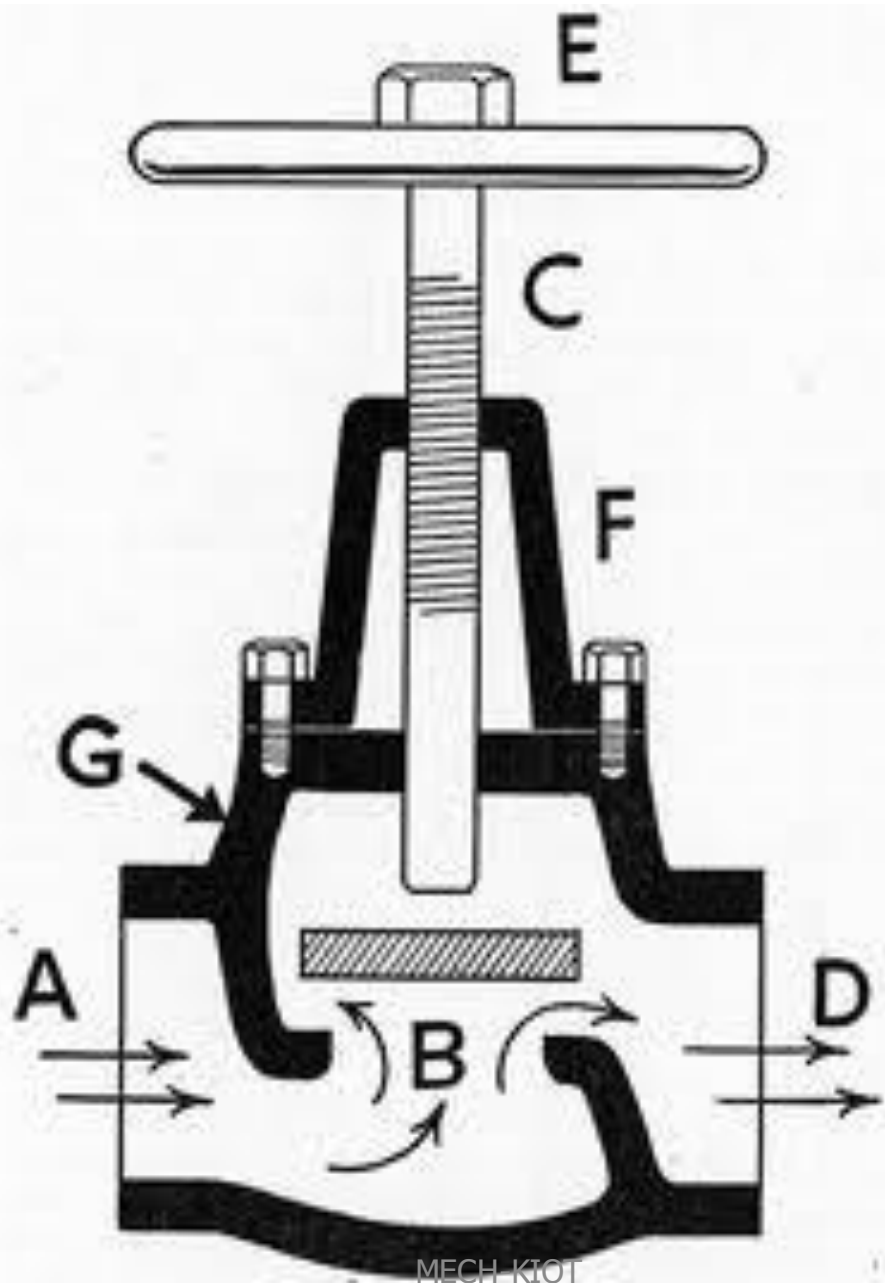
# **Safety Valve.**

**The function of the safety valve is to prevent the increase of steam pressure in the boiler above its design pressure.**

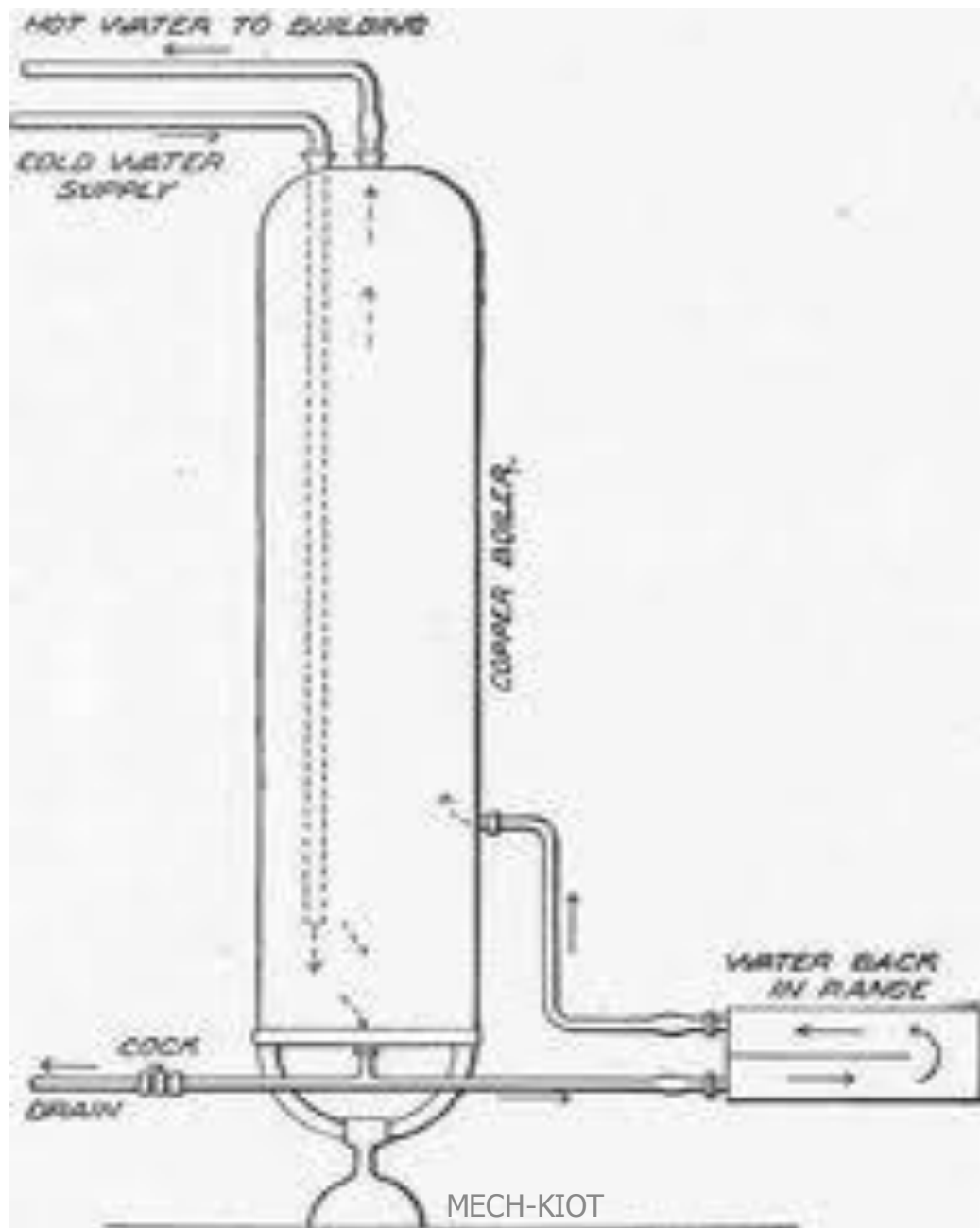


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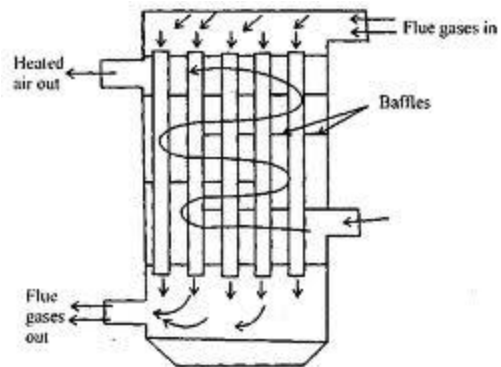
# Feed Check Valve.



- **Blow-off Cock.**



- Air Pre-heater



*Fig. Tubular Type Air Preheater*

# Boiler performance

- 1) Evaporative capacity

can be expressed in terms of:

a) kg of steam/hr

b) kg of hour/hr/m<sup>2</sup> of heating surface

c) kg of steam/kg of fuel fired

# Boiler efficiency

- Ratio of heat actually utilized in the generator to the heat supplied by the fuel.

$$\text{Efficiency} = m_w(h - h_f) / C$$

Where C is the calorific value

# **TURBINES: Machines to extract fluid power from flowing fluids**

**Steam  
Turbine**

**Water  
Turbines**

**Wind  
Turbines**

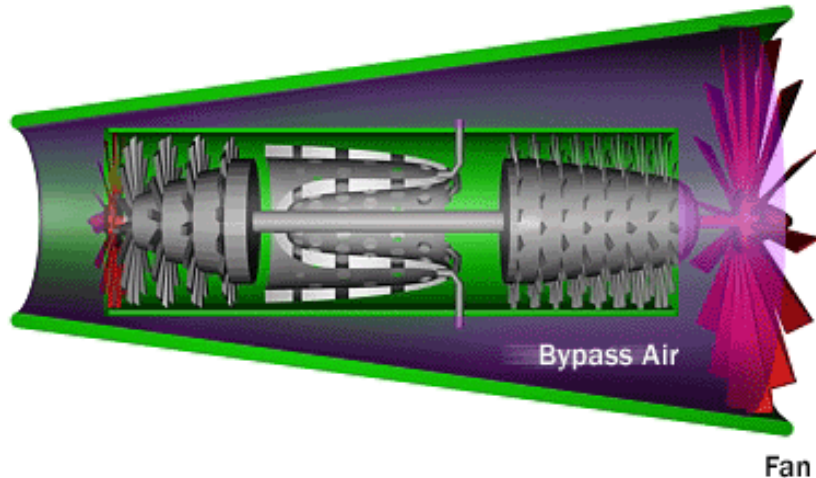
**Gas  
Turbines**

- High Pressure, High Temperature gas
- Generated inside the engine
- Expands through a specially designed TURBINE

**Aircraft Engines  
Power Generation**

# **GAS TURBINES**

# PRINCIPLE OF OPERATION



- Intake
  - Slow down incoming air
  - Remove distortions
- Compressor
  - Dynamically Compress air
- Combustor
  - Heat addition through chemical reaction
- Turbine
  - Run the compressor
- Nozzle/ Free Turbine
  - Generation of thrust power/shaft power

# Advantages and Disadvantages

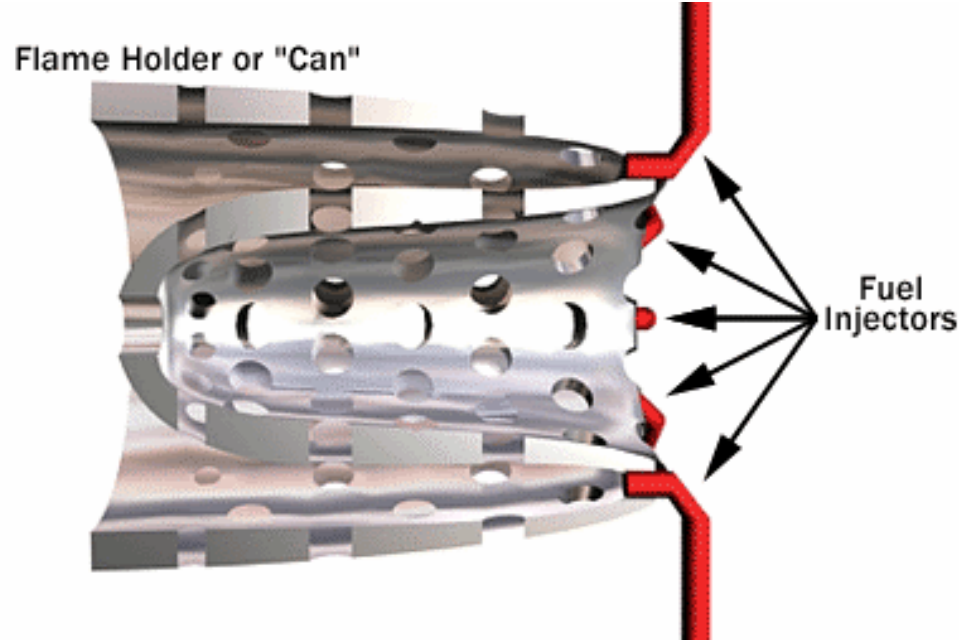
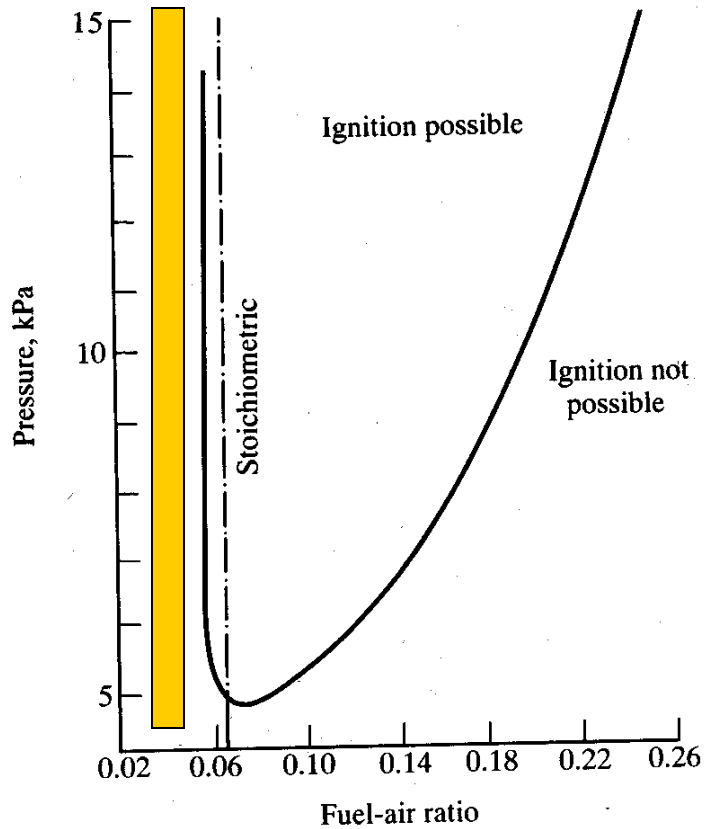
- Great **power-to-weight ratio** compared to reciprocating engines.
- **Smaller** than their reciprocating counterparts of the same power.
- **Lower emission levels**

- **Expensive:**
  - high speeds and high operating temperatures
  - designing and manufacturing gas turbines is a tough problem from both the engineering and materials standpoint
- Tend to use **more fuel** when they are idling
- They prefer a **constant rather than a fluctuating load.**

# Needs for Future Gas Turbines

- Power Generation
  - Fuel Economy
  - Low Emissions
  - Alternative fuels
- Military Aircrafts
  - High Thrust
  - Low Weight
- Commercial Aircrafts
  - Low emissions
  - High Thrust
  - Low Weight
  - Fuel Economy

# Gas Turbine Combustion

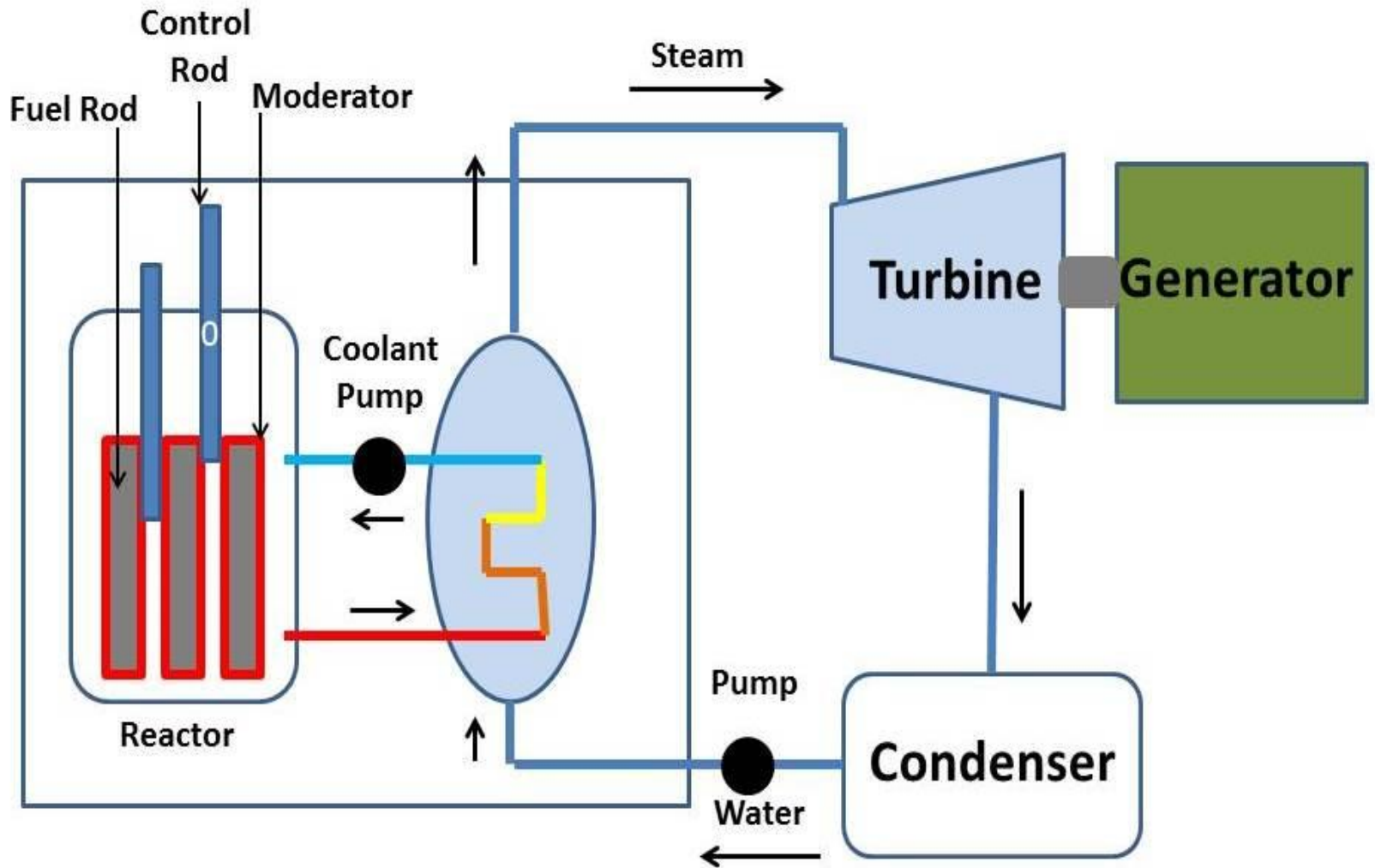


# NUCLEAR POWER PLANT

- Basics of Nuclear Engineering
- Layout and Subsystems of Nuclear Power Plants , working of Nuclear Reactors:
- Boiling Water Reactor(BWR)
- Pressurized Water Reactor(PWR)
- CANada Deuterium- Uranium reactor(CANDU)
- Breeder, Gas Cooled and Liquid Metal Cooled Reactors.
- Safety measures for nuclear power plants.

# NUCLEAR POWER PLANT

- A nuclear power plant or nuclear power station is a thermal power station in which the heat source is a nuclear reactor.
- As it is typical of thermal power stations, heat is used to generate steam that drives a steam turbine connected to a generator that produces electricity.
- At end of 2017, the WNPR(world nuclear performance report) there are 449 nuclear power reactors in operation operating in 31 countries.

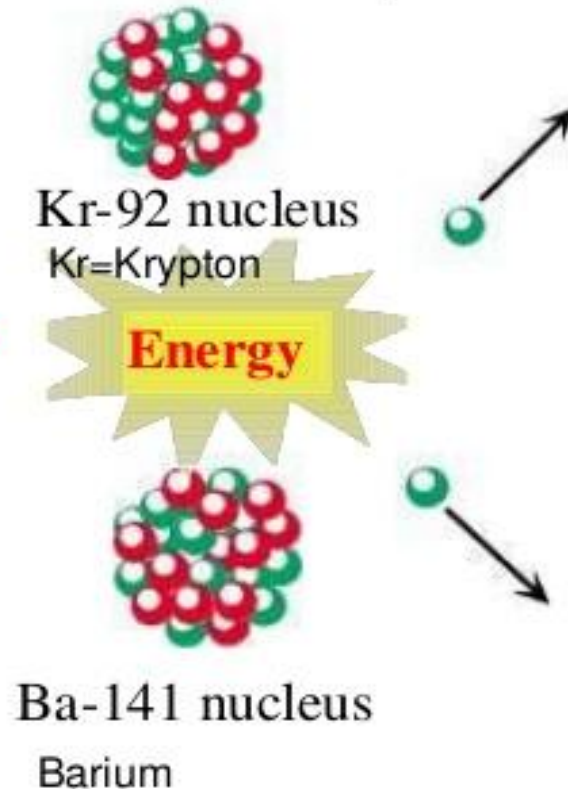
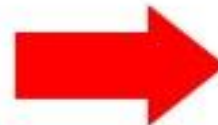
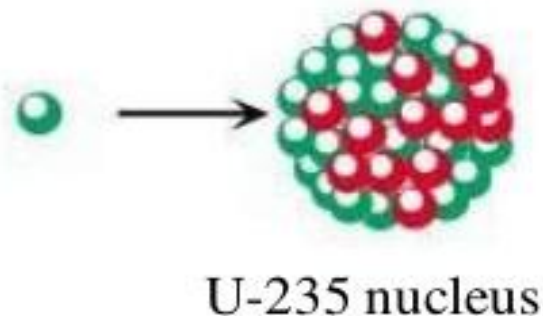


# Nuclear Power Plant

# Nuclear Fission

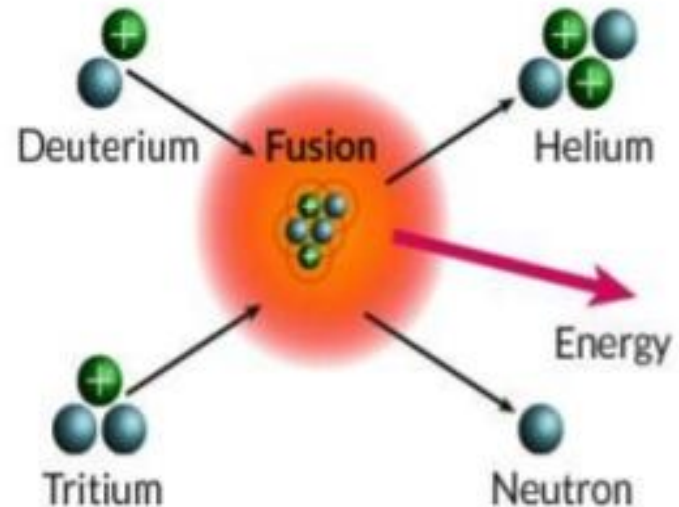
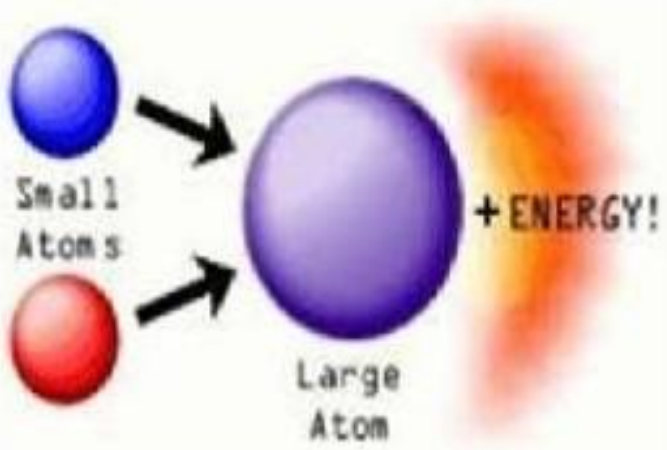
- Nuclear Fission is the splitting of a heavy, unstable nucleus such as  $U^{233}$ ,  $U^{235}$ ,  $PU^{239}$  into two lighter nuclei.

 proton  
 neutron

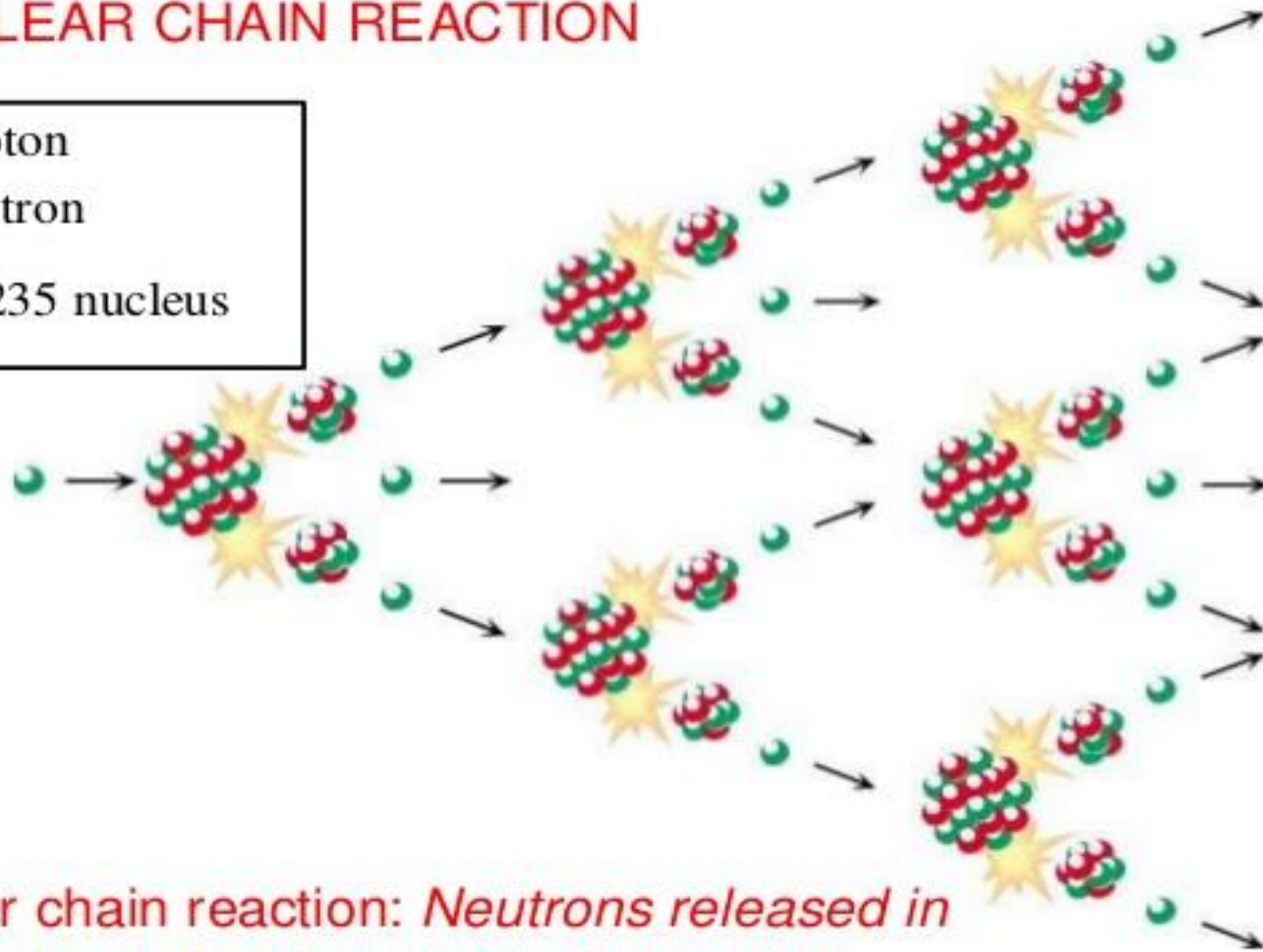
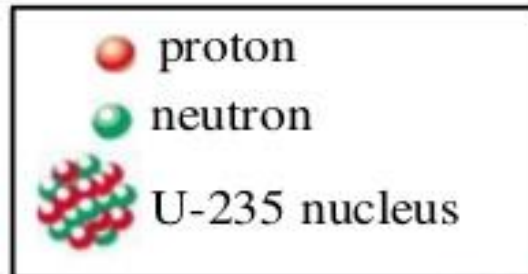


# Nuclear Fusion

- Fusion is the process where two lighter nuclei combine together
- In both process, vast amounts of energy will be released



# NUCLEAR CHAIN REACTION



Nuclear chain reaction: *Neutrons released in fission* trigger the fissions of other nuclei

## NR Working Principle

- ✚  $U^{235}$  splits into two fragments ( $Ba^{141}$  &  $K^{92}$ ) of approximately equal size.
- ✚ About 2.5 neutrons are released, 1 neutron is used to sustain the chain reaction. 0.9 neutrons is absorbed by  $U^{238}$  and becomes  $Pu^{239}$ . The remaining 0.6 neutrons escapes from the reactor.
- ✚ The neutrons produced move at a very high velocity of  $1.5 \times 10^7$  m/sec and fission other nucleus of  $U^{235}$ . Thus fission process and release of neutrons take place continuously throughout the remaining material.
- ✚ A large amount of energy (200 Million electron volts, Mev) is produced.

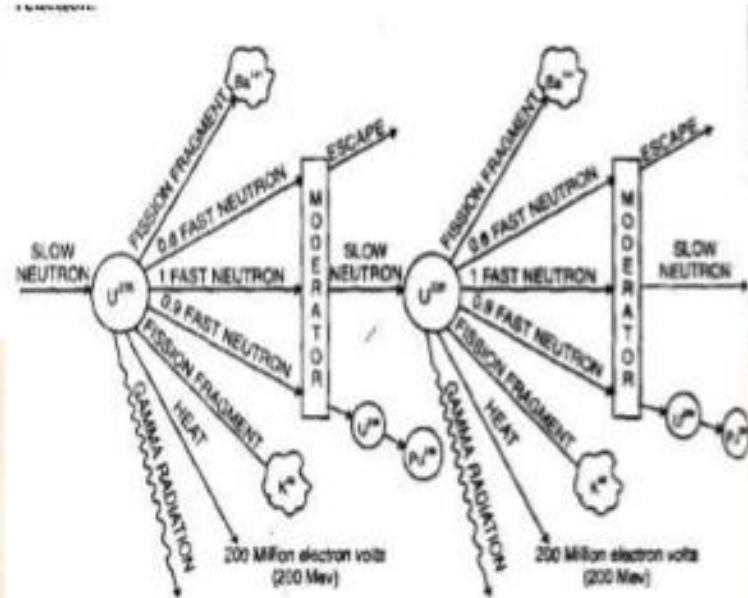


Fig. 3.7: CONTROLLED CHAIN REACTION IN A NUCLEAR REACTOR

Note : Moderators are provided to slow down the neutrons from the high velocities but not to absorb them.

# Nuclear Reactor



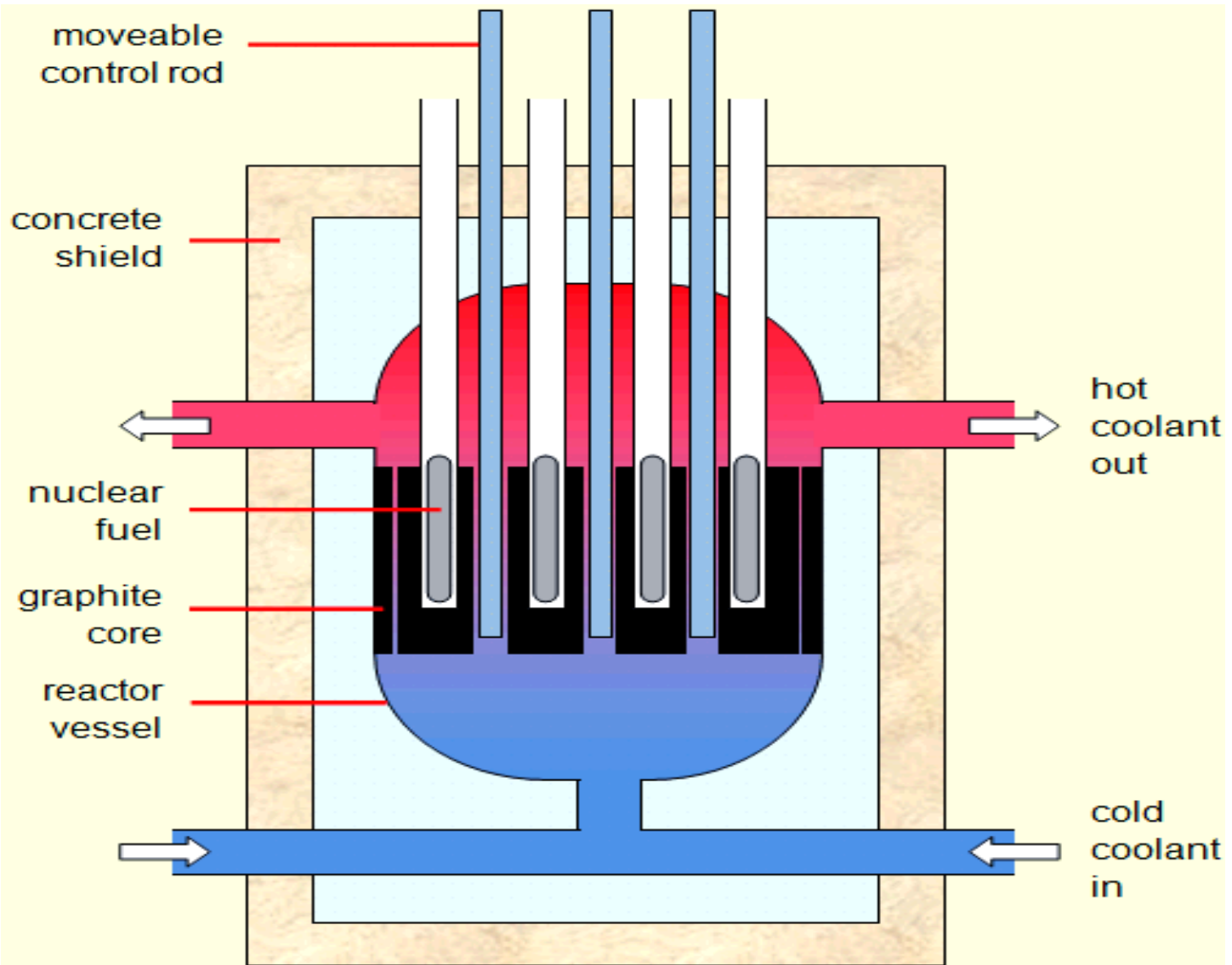
A nuclear reactor is an apparatus in which nuclear fission is produced in the form of a controlled self-sustaining chain reaction.

In other words, it is a controlled chain-reacting system supplying nuclear energy.

It may be looked upon as a sort of nuclear furnace which burns fuels like  $U^{235}$ ,  $U^{233}$  or  $Pu^{239}$  and, in turn, produces many useful products like heat, neutrons and radioisotopes.

**Nuclear Reactors are classified according to the chain reacting system, use, coolants, fuel material etc.**

# NUCLEAR REACTOR



### Based on the type of Reaction

- Nuclear Fission
- Nuclear Fusion
- Radioactive decay

### Based on Coolant used

- Pressurized Water Reactor (PWR)
- Boiling water reactor (BWR)
- Liquid metal cooled reactor
- Gas cooled reactors
- Molten Salt Reactor (MSR)

## Nuclear Reactors

### Based on Moderator Material

- Graphite moderated reactors
- Water moderated reactors
- Light element moderated reactors
- Organically moderated reactors

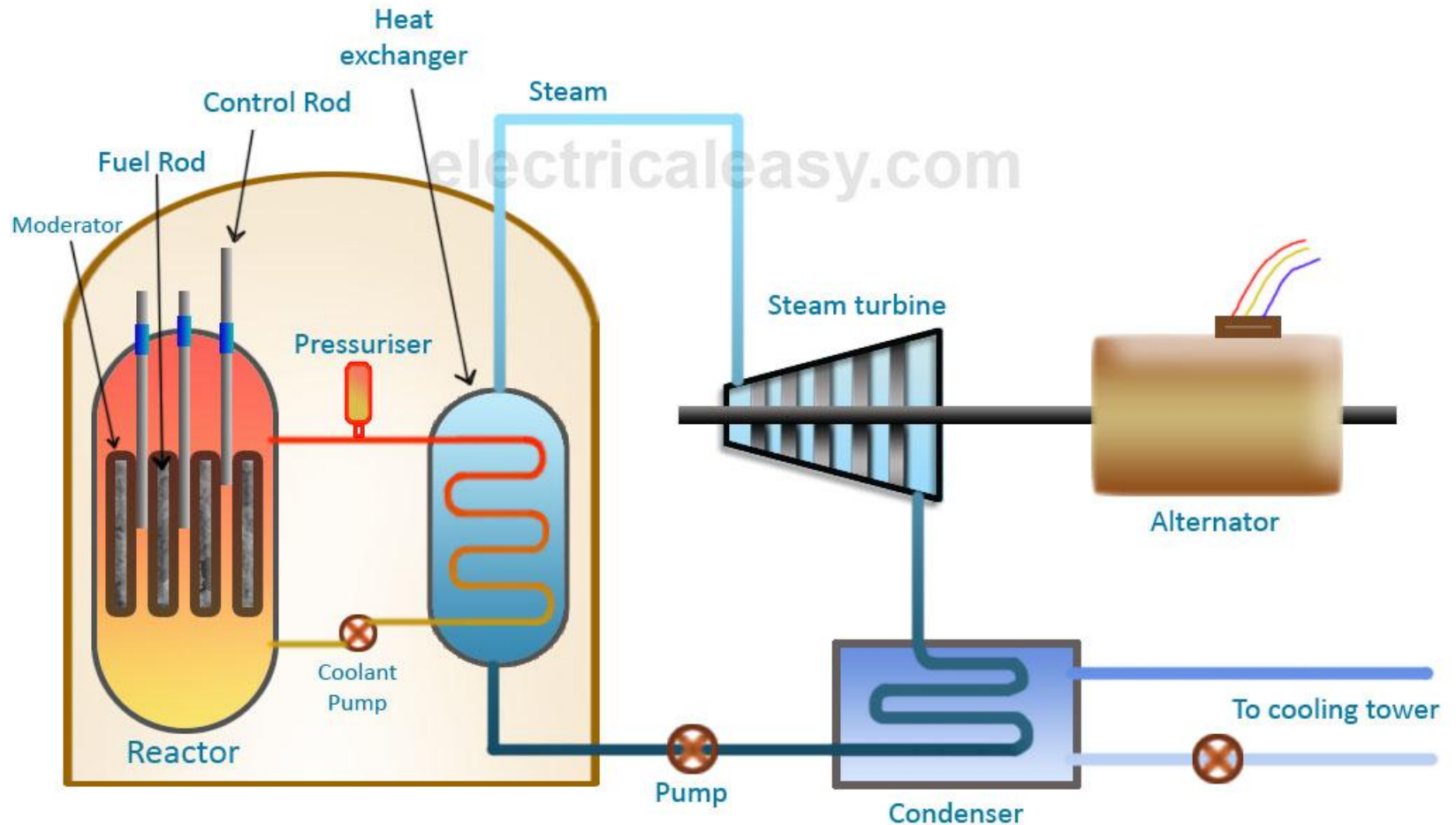
### Classification by use

- Electricity
- Propulsion
- Other uses of heat
- Transmutation of element (Breeder Reactors)
- Research reactor

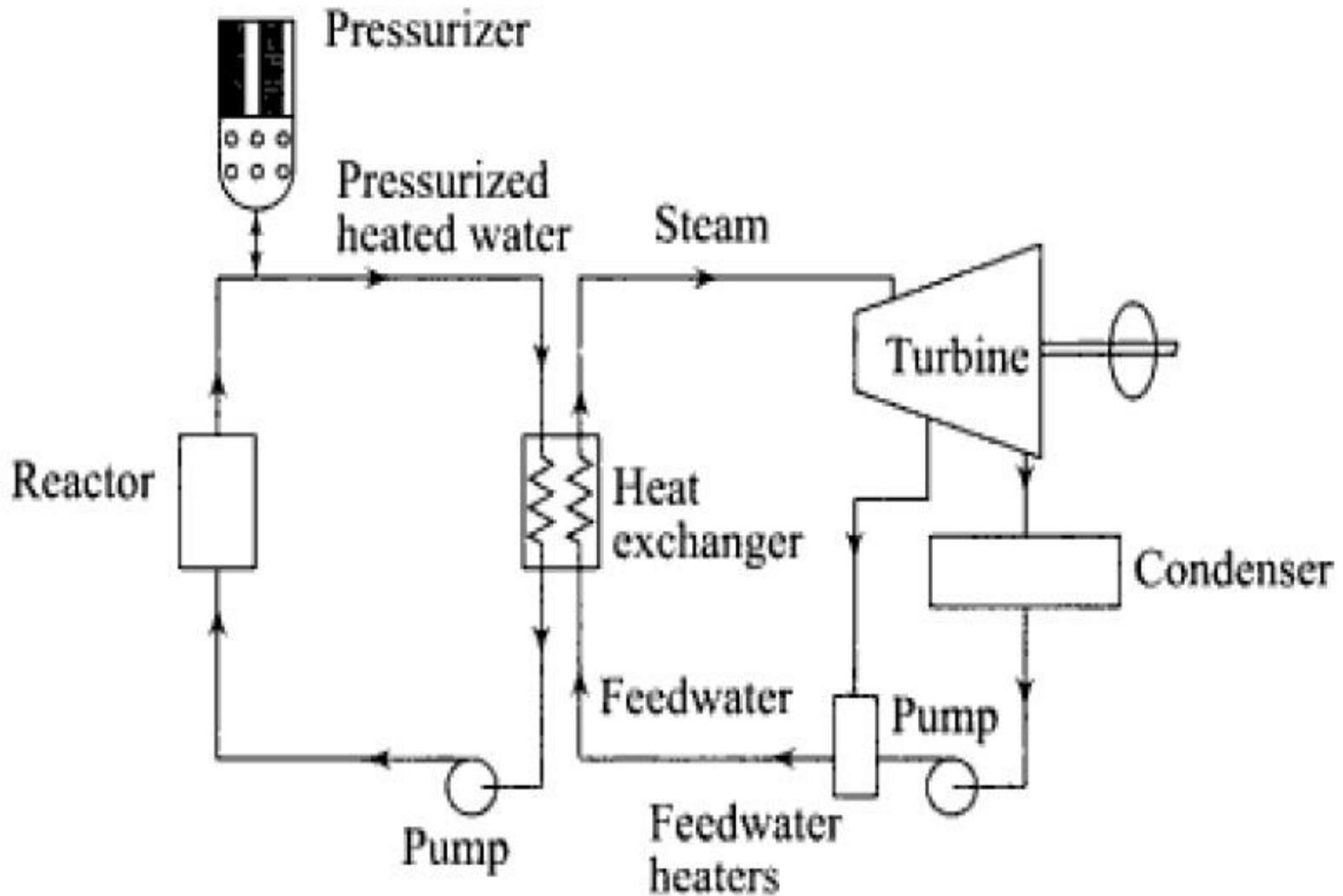
# Types of Nuclear Reactors

- Pressurized Water Reactor(PWR)
- Boiling Water Reactor(BWR)
- CANada Deuterium- Uranium reactor(CANDU)
- Fast Breeder Reactors
- Gas Cooled Reactors
- Liquid Metal Cooled Reactors.

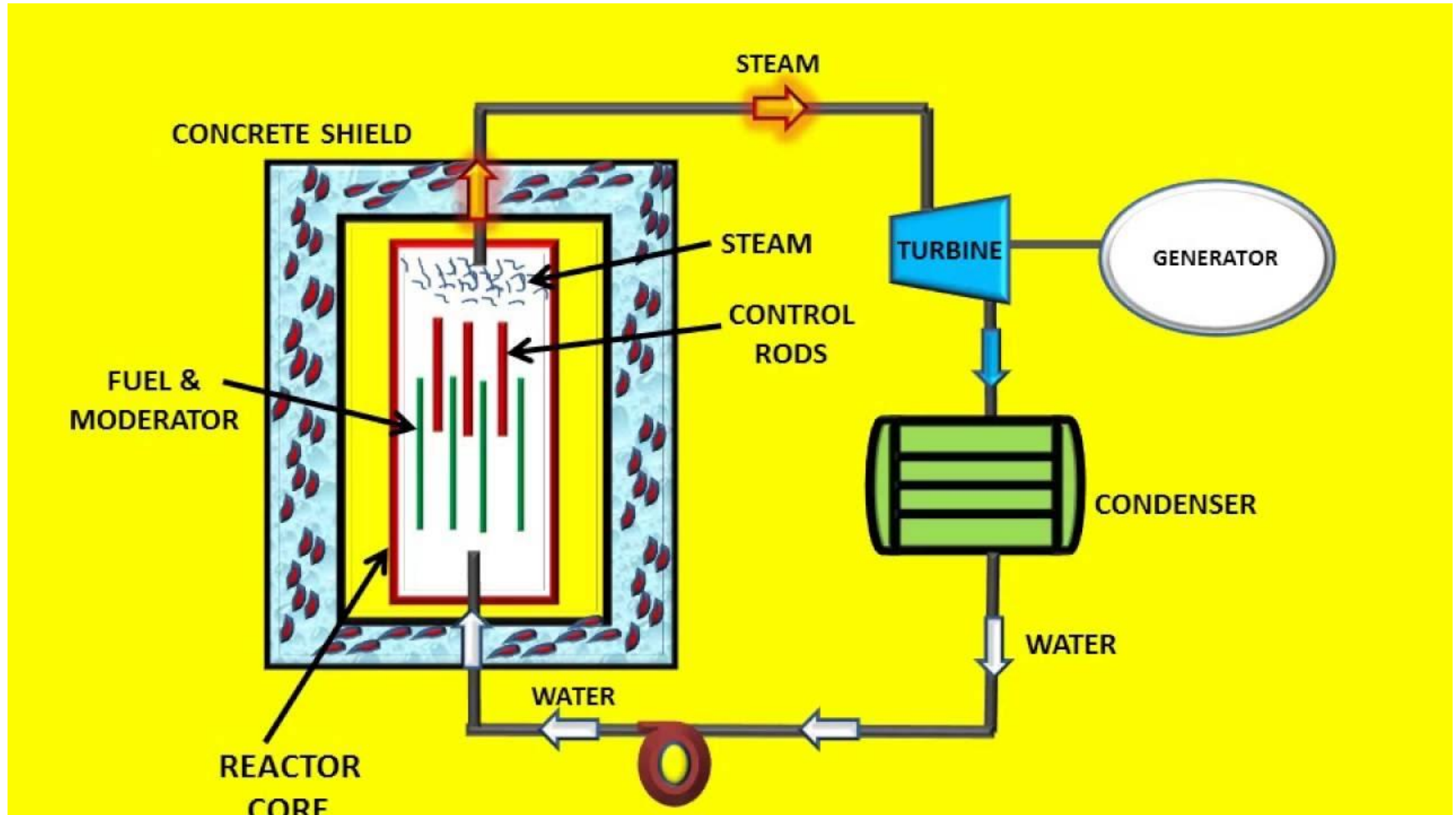
# Pressurized Water Reactor(PWR)



# Pressurized Water Reactor(PWR)

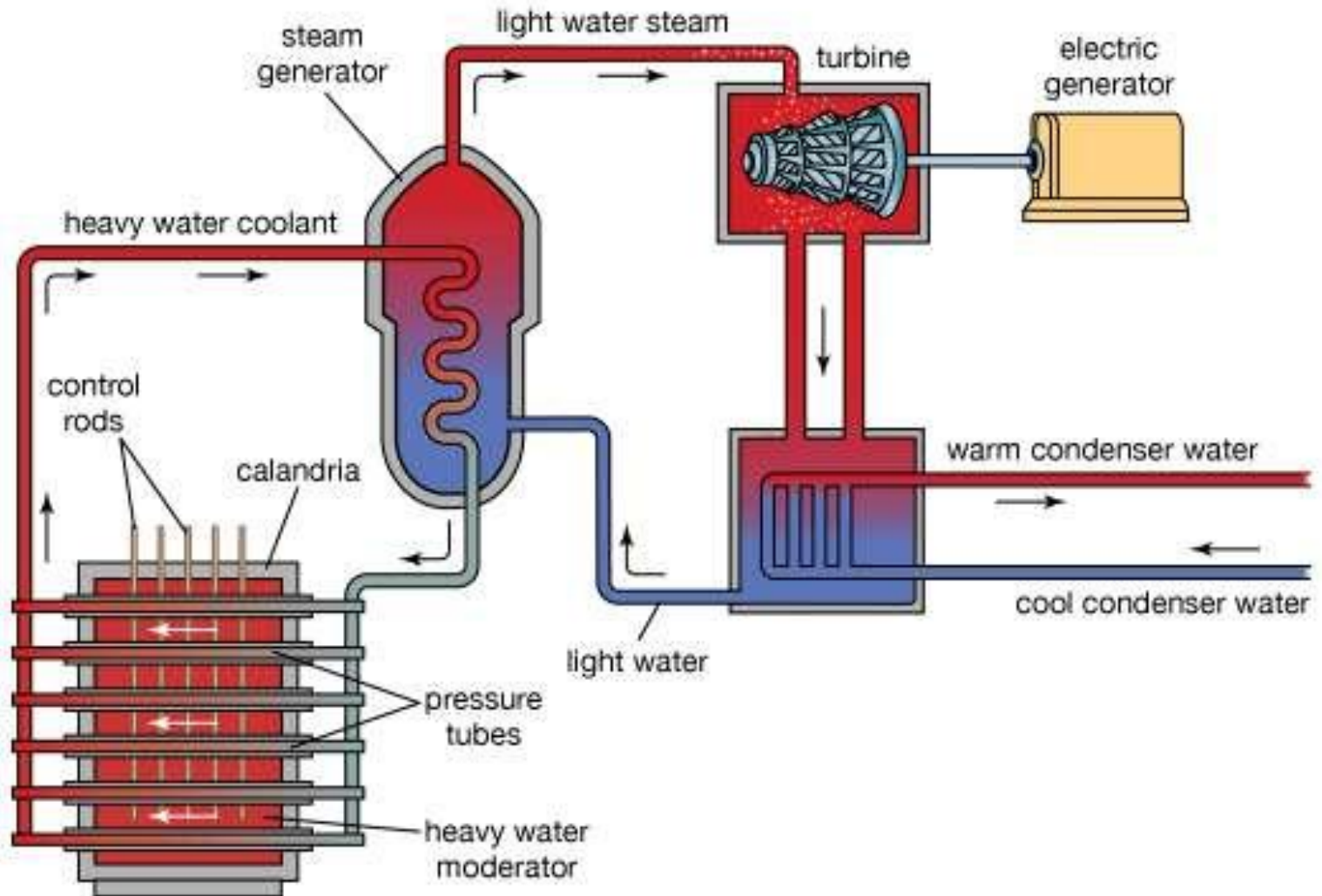


# Boiling Water Reactor(BWR)



# CANada Deuterium- Uranium reactor(CANDU)

Canada Deuterium Uranium (CANDU) reactor



# Breeder Reactor

- If fission is initiated with  $U^{235}$  it not only gives off heat but also free neutrons.
- Under certain conditions if  $U^{238}$  is placed in the reactor these free electrons may convert  $U^{238}$  into plutonium.
- This process is known as breeding. These reactors are therefore known for their better utilization.

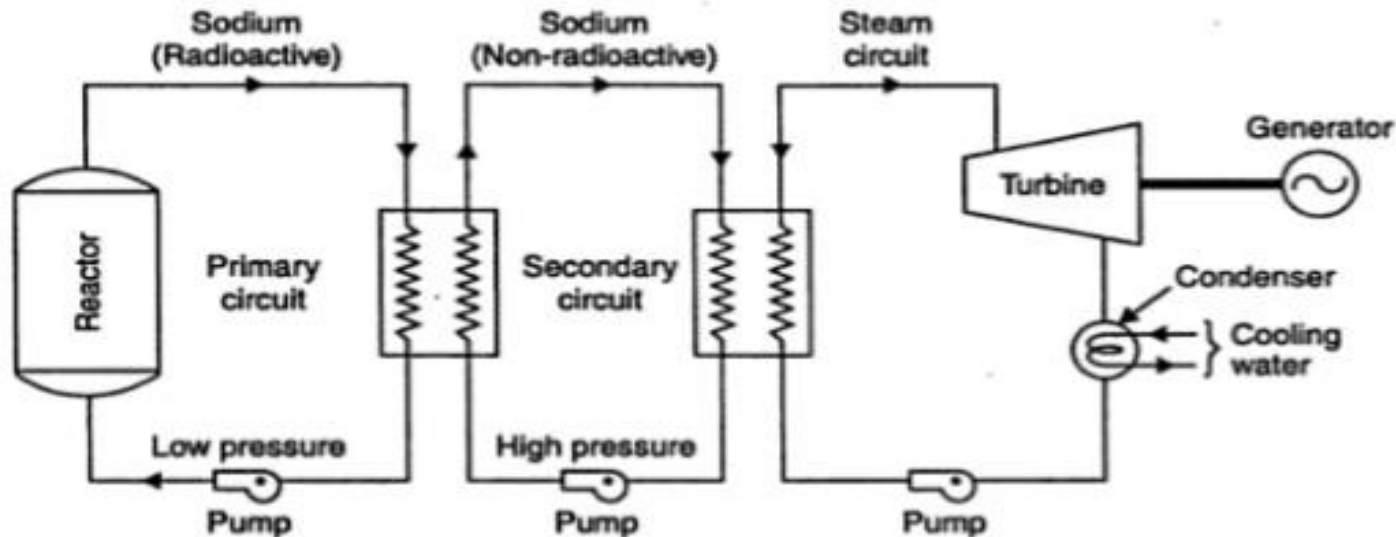


Fig. 6.17. Breeder reactor.

# Gas Cooled Reactors

## GAS COOLED REACTORS

- Uses **graphite** as a neutron **moderator** and **carbon dioxide** as **coolant**
- The GCR was able to use **natural uranium** as fuel.
- Two main types of GCR:-
  1. Magnox reactors developed by United Kingdom.
  2. UNGG (Uranium Naturel Graphite Gaz) reactors developed by France.
- The main difference between these two types is in the fuel cladding (shielding) material.
- Both types used fuel cladding materials that were unsuitable for medium term storage under water, making reprocessing an essential part of the nuclear fuel cycle.

# GAS Cooled Reactor

- it features a fast-neutron spectrum and closed fuel cycle for efficient conversion of fertile uranium and management of actinides.
- The reference reactor design is a helium-cooled system operating with an outlet temperature of 850 °C using a direct Brayton cycle gas turbine for high thermal efficiency.
- Several fuel forms are being considered for their potential to operate at very high temperatures and to ensure an excellent retention of fission products: composite ceramic fuel, advanced fuel particles, or ceramic clad elements of actinide compounds.
- Core configurations are being considered based on pin- or plate-based fuel assemblies or prismatic blocks, which allows for better coolant circulation than traditional fuel assemblies.

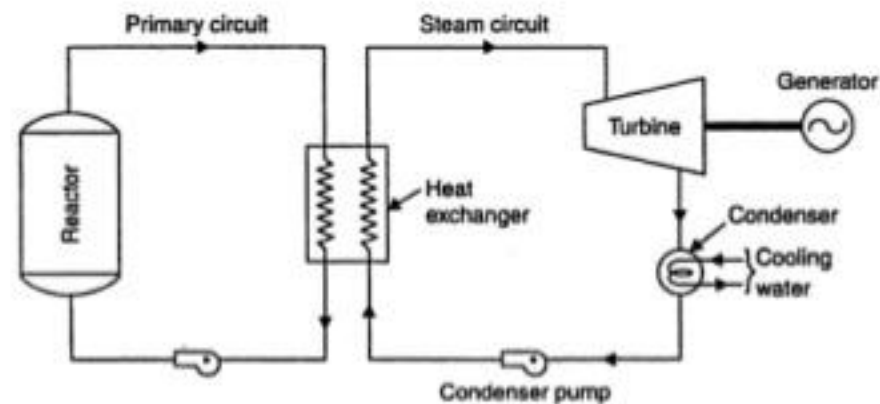


Fig. 6.15. Gas-cooled reactor.



# Nuclear Plant Site Selection

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- Proximity to load center
- Population distribution
- Land Use: not agricultural
- Meteorology: wind direction
- Geology: bearing capacity of soil
- Seismology: low seismic activity
- Hydrology: Near a water source

## WHAT IS SOLAR ENERGY?

SOLAR ENERGY RADIANT LIGHT AND HEAT FROM THE SUN IS HARNESSSED USING A RANGE OF EVER-EVOLVING TECHNOLOGIES.

SUCH AS SOLAR HEATING, SOLAR PHOTOVOLTAICS, SOLAR THERMAL ELECTRICITY SOLAR ARCHITECTURE AND ARTIFICAL PHOTOSYNTHESIS.

# BASIC PRINCIPLE OF SOLAR ENERGY

- Solar radiation is reduced in intensity in the atmosphere by dust, clouds, haze and fog.
- The radiation strikes a solid or liquid, it is absorbed and transformed into heat energy.
- The heat energy is collected in a fluid generally water.
- This energy can be used in a solar heater or drier or can be used in a collector is used to collect or parabolic concentrated the solar energy.

# Working of solar power plant

**Photovoltaic Electricity** – This method uses photovoltaic cells that absorb the direct sunlight just like the solar cells you see on some calculators.

**Solar-Thermal Electricity** – This also uses a solar collector: it has a mirrored surface that reflects the sunlight onto a receiver that heats up a liquid. This heated liquid is used to make steam that produces electricity.

# Component used in PV System

➤ **Solar Panel**

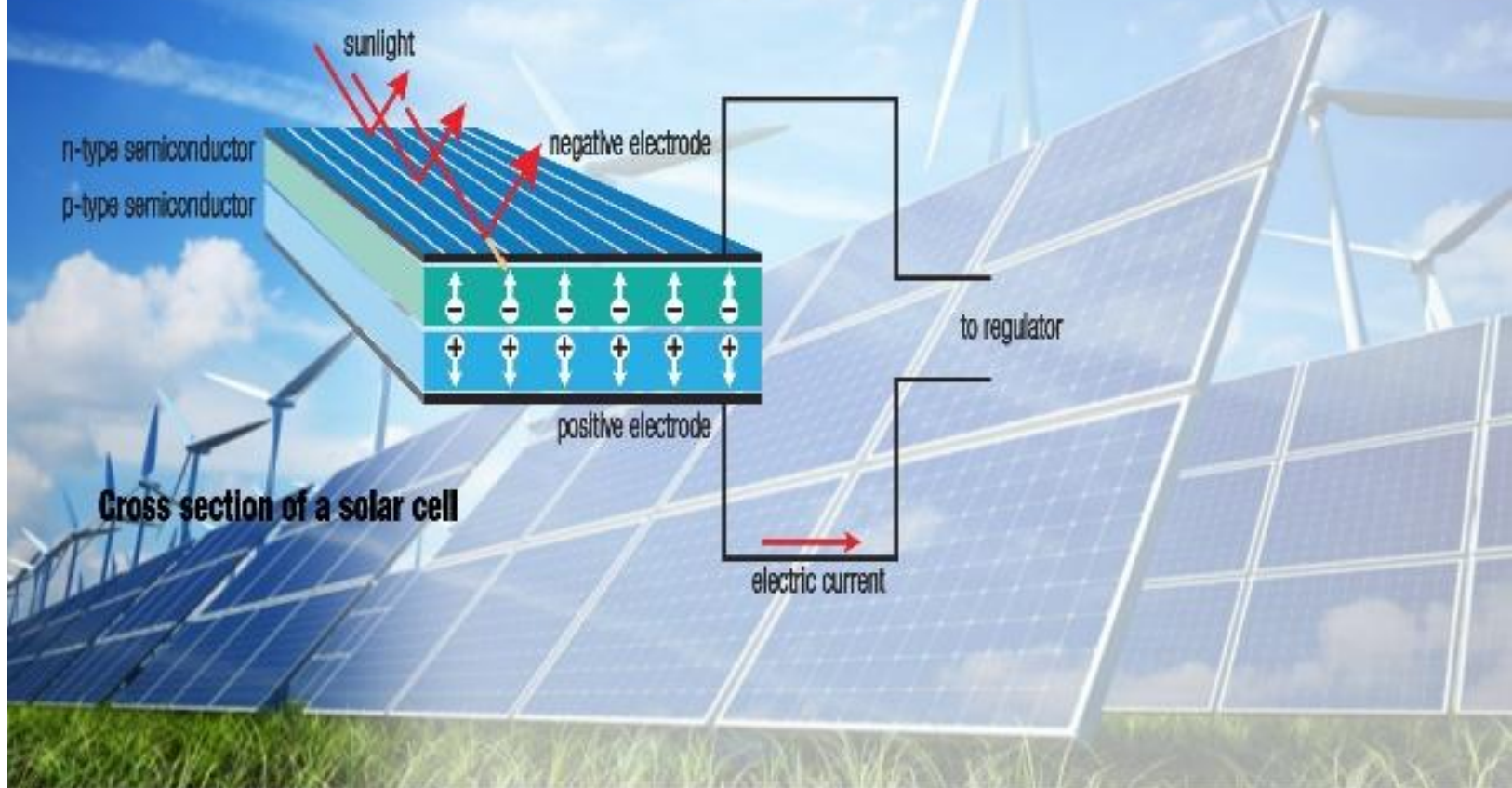
➤ **Controller**

➤ **Battery**

➤ **Inverter**

# 1. Solar panel :

they are need to convert the solar energy into Electrical energy.



## 2. Batteries :

batteries are use for to store energy offline(DC). If we direct use to any load it works but on the time like night there no sun light in this time if we connect the load to active we need this.



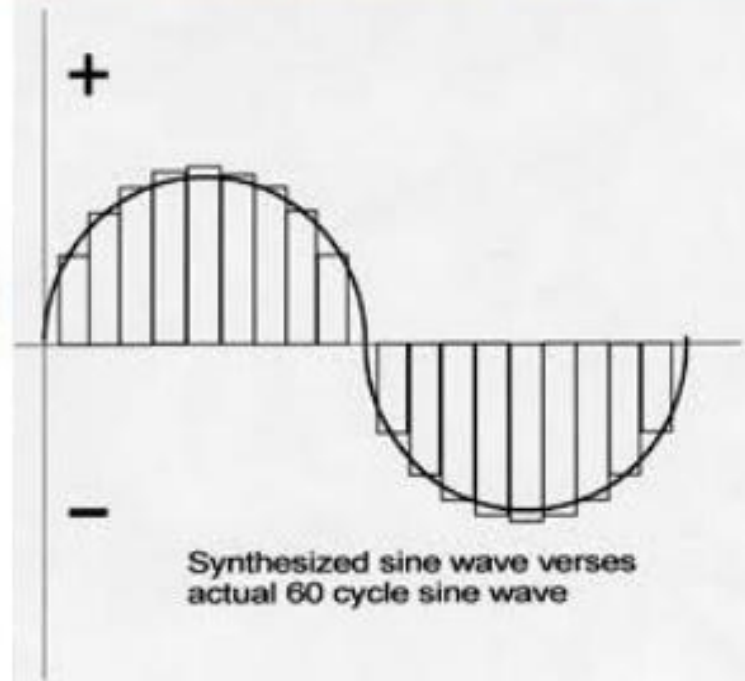
### 3. Controller :

charge controller is a one type of Voltage controller to charge the batteries and keep away cell from over charging.



## 4. Power inverter:

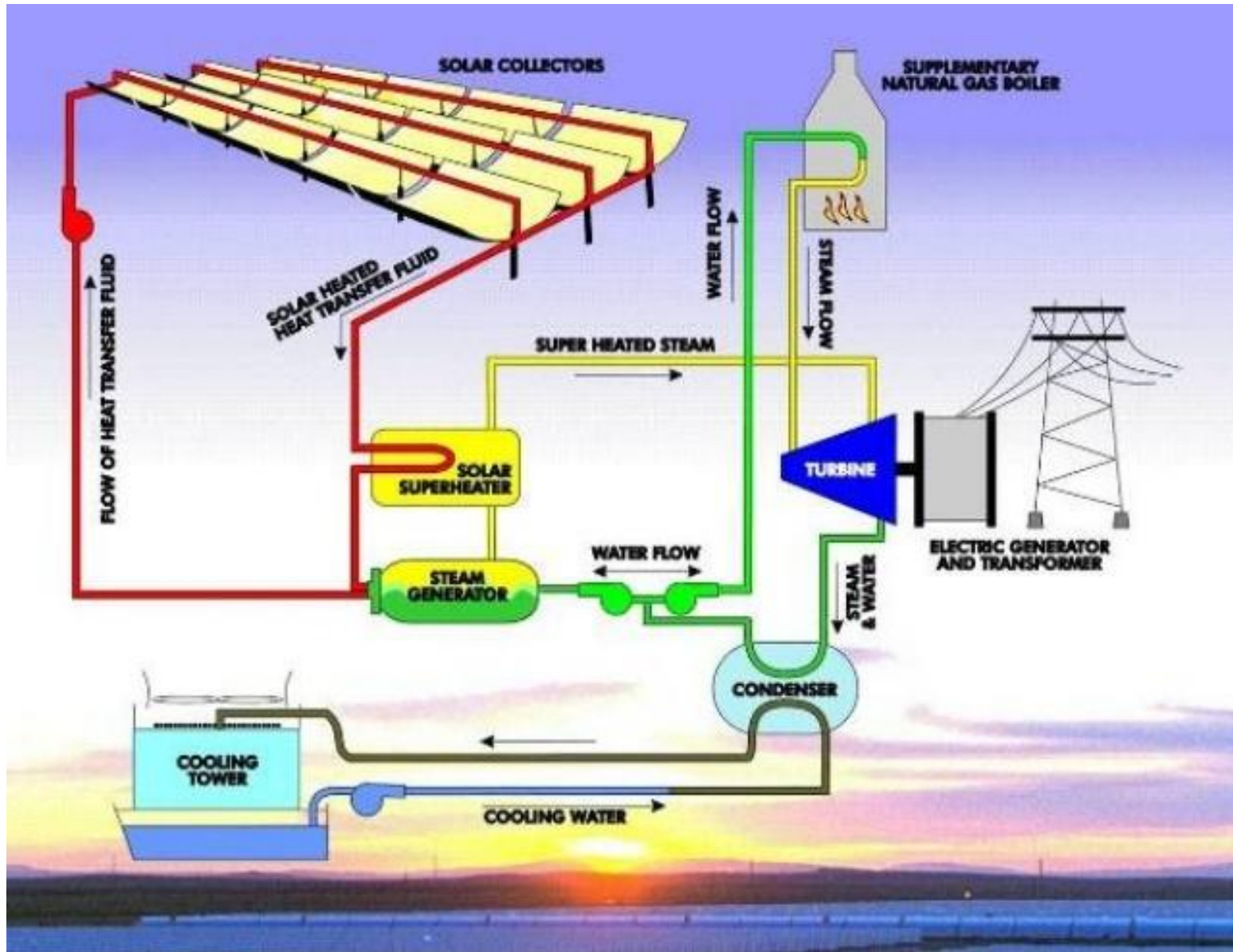
it is one type of converter.it is convert the Dc to the 230 volt AC as per need of application



# SOLAR-THERMAL ELECTRICITY



- Solar collectors capture and concentrate sunlight to heat a synthetic oil called terminal, which then heats water to create steam.
- The steam is piped to an onsite turbine-generator to produce electricity, which is then transmitted over power lines. On cloudy days, the plant has a supplementary natural gas boiler.
- The plant can burn natural gas to heat the water, creating steam to generate electricity.



# TYPES OF ELECTRICITY TARIFF

- Simple tariff
- Flat rate tariff
- Block rate tariff
- Two part tariff
- Maximum demand tariff
- power factor tariff
- Three part tariff

# **SIMPLE TARIFF**

- When there is a fixed rate per unit of energy consumed, it is called a simple tariff or uniform rate tariff.

## **ADVANTAGES:**

- This is the most simplest of all tariff.
- In this type, the price charged per unit is constant.
- It means, the price will not vary with increase or decrease in number of units used.

# DISADVANTAGES

- The cost per unit delivered is high.
- There is no discrimination among various types of consumers.

## APPLICATION:

- Generally applied to tube wells used for irrigation purposes.

# FLAT RATE TARIFF

- When different types of consumers are charged at different uniform per unit rates, it is said to be Flat rate Tariff.
- In this type, the consumers are grouped into different classes.
- Each class is charged at different uniform rate.
- The different classes of consumers may be taken into account of their diversity and load factors.
- Since this type of tariff varies according to the way of supply used, separate meters are required for lighting load, power load etc.

## **Advantages:**

- More fair to different consumers.
- Simple calculations.

## **Disadvantages :**

- A particular consumer is charged at a particular rate. But there are no incentives for the consumer.
- Since different rates are decided according to different loads, separate meters need to be installed for different loads such as light loads, power loads, etc. This makes the whole arrangement complicated and expensive.
- All the consumers in a particular “category” are charged at the same rates. However, it is fairer if the consumers that utilize more energy be charged at lower fixed rates.
- **Application**  
Generally applied to domestic consumers.

# BLOCK RATE TARIFF

- When a given block of energy is charged at a specified rate and the succeeding blocks of energy are charged at progressively at reduced rates, it is called a block rate tariff.

## **Advantages:**

- Only 1 energy meter is required.
- Incentives are provided for the consumers due to reduced rates. Hence consumers use more energy. This improves load factor and reduces cost of generation.

## **Disadvantages:**

- If a consumer does not consume any energy in a particular month, the supplier does not charge any money even though the connection provided to the consumer has its own costs.

## **Application:**

Generally applied to residential and small commercial consumers.

# TWO-PART TARIFF

- When the rate of electrical energy is charged on the basis of maximum demand of the consumer and the units consumed, it is called a two-part tariff.
- Total Charges = Tk. (  $a$  kW +  $b$  kWh ) Where,
- $a$  = fixed charge (interest, labour cost, transmission cost etc.)
- $b$  = charge per kW of maximum demand
- This type of tariff is mostly applicable to industrial consumers who have appreciable maximum demand

## **Advantages:**

- If a consumer does not consume any energy in a particular month, the supplier will get the return equal to the fixed charges.

## **Disadvantages :**

- Even if a consumer does not use any electricity, he has to pay the fixed charges regularly.
- The maximum demand of the consumer is not determined. Hence, there is error of assessment of max demand and hence conflict between the supplier and the consumer.

## **Application :**

Generally applied to industrial consumers with appreciable max demand.

# MAXIMUM DEMAND TARIFF

- It is similar to two-part tariff.
- The only difference is the maximum demand of the consumer is calculated by installing a maximum demand meter at his premises.
- This type of tariff is mostly applied to the bulk consumers.

## **Application**

Generally applied to large industrial consumers.

# POWER FACTOR TARIFF

- The tariff in which the power factor of the consumers is taken into account is known as power factor tariff.

# THREE-PART TARIFF

- When the total charge to be made from the consumer is split into three parts viz., fixed charge, semi-fixed charge and running charge, it is known as a three-part tariff.
  - Total Charge = Tk.  $(a + b \text{ kW} + c \text{ kWh})$
  - Where,
    - a = fixed charge (interest, labour cost, transmission cost etc.).
    - b = charge per kW of maximum demand.
    - c = charge per kWh of energy consumed.
- This type of tariff is generally applied to big consumers.

## **Application :**

This type of tariff is generally applied to big consumers