UNIT II

DIESEL CYCLE POWER PLANTS

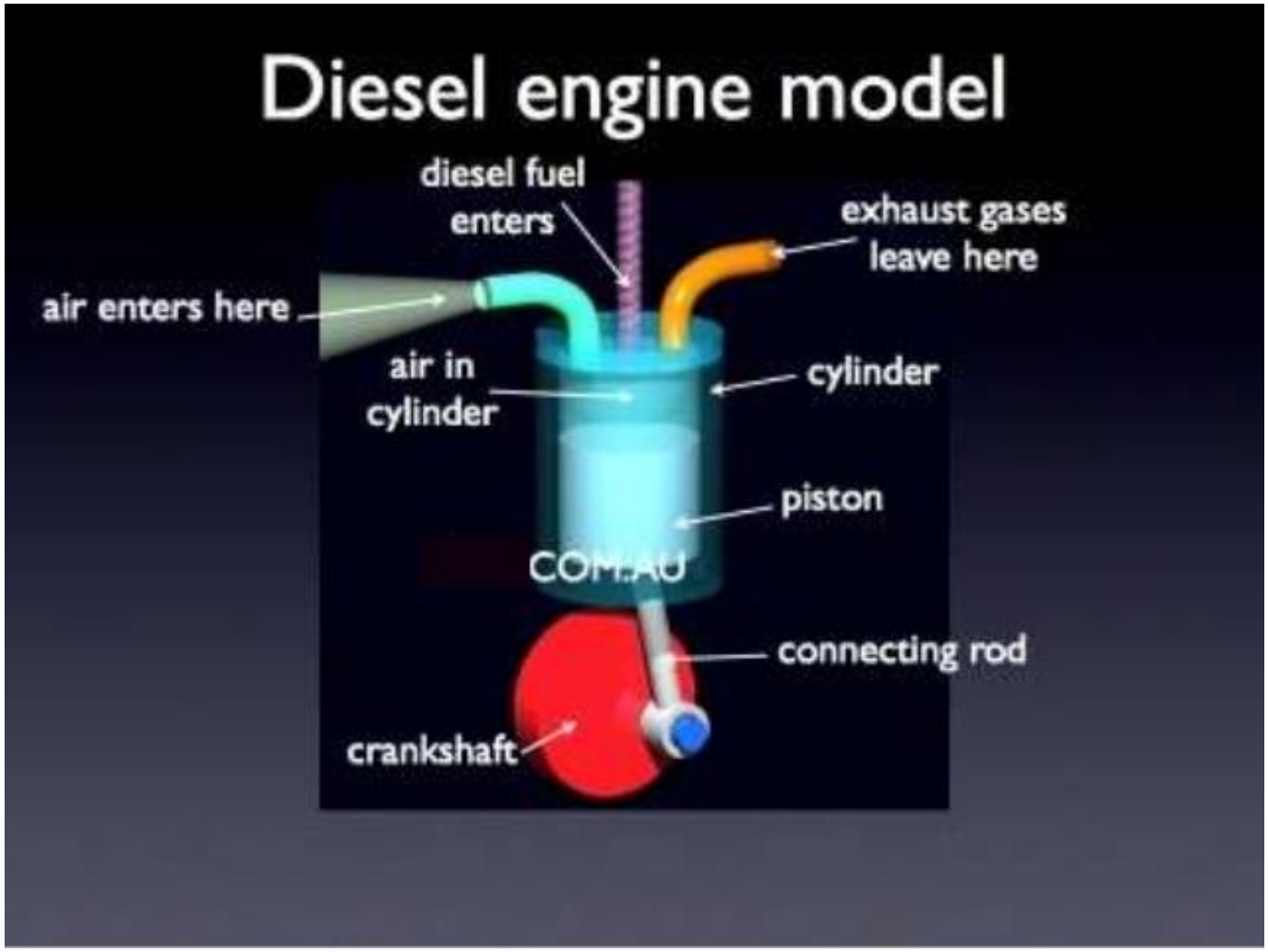
Power plant engineering
Diesel power plant

➢ INTRODUCTION:

- A generating station in which **diesel engine** is used as the prime mover for the generation of electrical energy is known as **diesel power station**
- Diesel power plants produce power in the range of 2 to 50 MW.
- They are used as standby sets for continuity of supply such as hospitals, telephone exchanges, radio stations, cinema theatres and industries.
- They are suitable for mobile power generation and widely used in railways , submarine & ships.

Applications of diesel power plant

- They are used as central station for small or medium power supplies.
- They can be used as stand-by plants to hydro-electric power plants and steam power plants for emergency services.
- They can be used as peak load plants in combinations with thermal or hydro-plants.
- They are quite suitable for mobile power generation and are widely used in transportation systems such as automobiles, railways, air planes and ships.
- Now-a-days power cut has become a regular feature for industries. The only solution to tide over this difficulty is to install diesel generating sets.


Diesel engine model
diesel fuel enters
exhaust gases leave here
air enters here
air in cylinder
cylinder
piston
COM.AU
connecting rod
crankshaft

DIESEL ENGINE power plant

FIELD OF USE

The diesel electric power-plants are chiefly used in the fields mentioned below.

1. **Peak load plant: The** diesel plants are used in combination with thermal or hydro-plants as peak load plants. This plant is particularly preferable as peak load plant as it can be **started quickly** and it has no standby losses as in the case of thermal plants where boilers always must be kept hot.
2. **Mobile plants**: Mobile diesel plants mounted on skids or trailers can be used for temporary or emergency purposes such as for supplying power to large civil engineering works for supplementing electricity supply systems that are temporarily short of power.
3. **Stand-by Units**: This can be used as a standby unit to **supply part load** when required. For example, this can be used with hydro-plant as stand-by unit. If the water available is not sufficient due to reduced rainfall, a diesel station supply power in parallel with hydro-station. The use is made temporarily till the water is available to take the full load.

4. **Emergency plant:** The plants used for emergency purposes are at to standby units, normally idle but are used where power interruption would mean financial loss or danger in key industrial processes, tunnel lighting and operating rooms of hospitals. They are also used for telecommunication and water supply under emergency conditions.
5. **Nursery station:** When the diesel plant is used to supply the power to a small town in the absence of main grid and which can be moved to another area which needs power on a small scale when the main grid is available is known as "Nursery Station". The main grid cannot extend to every corner of the country till there is enough load. Many times the extension of grid is not possible due to the constructional difficulties as in Assam. Diesel unit of small capacity can be installed to supply the load to a small town during the process of development and it can be removed to another required place till the main grid for tapping the power is available.
6. **Starting stations:** The diesel units are used to run the auxiliaries for starting the large steam plants.
7. **Central stations:** This can be used as central station where the capacity required is small **(5 to 10 MW**). The limit is generally decided by the cost of the plant and local conditions regarding the availability of fuel and water, space requirements and non-availability of the grid. Small supply units for commercial purposes and public utilities *e.g.,, cinema hall, hospital and* municipalities are commonly used in practice.

Diesel power plants in INDIA

- As on July 31, 2013, and as per the Central Electricity Authority the total installed capacity of Diesel based power plants in India is 1,199.75 MW. Normally the diesel based power plants are either operated from remote locations or operated to cater peak load demands. Here is some list of presently operating plants.

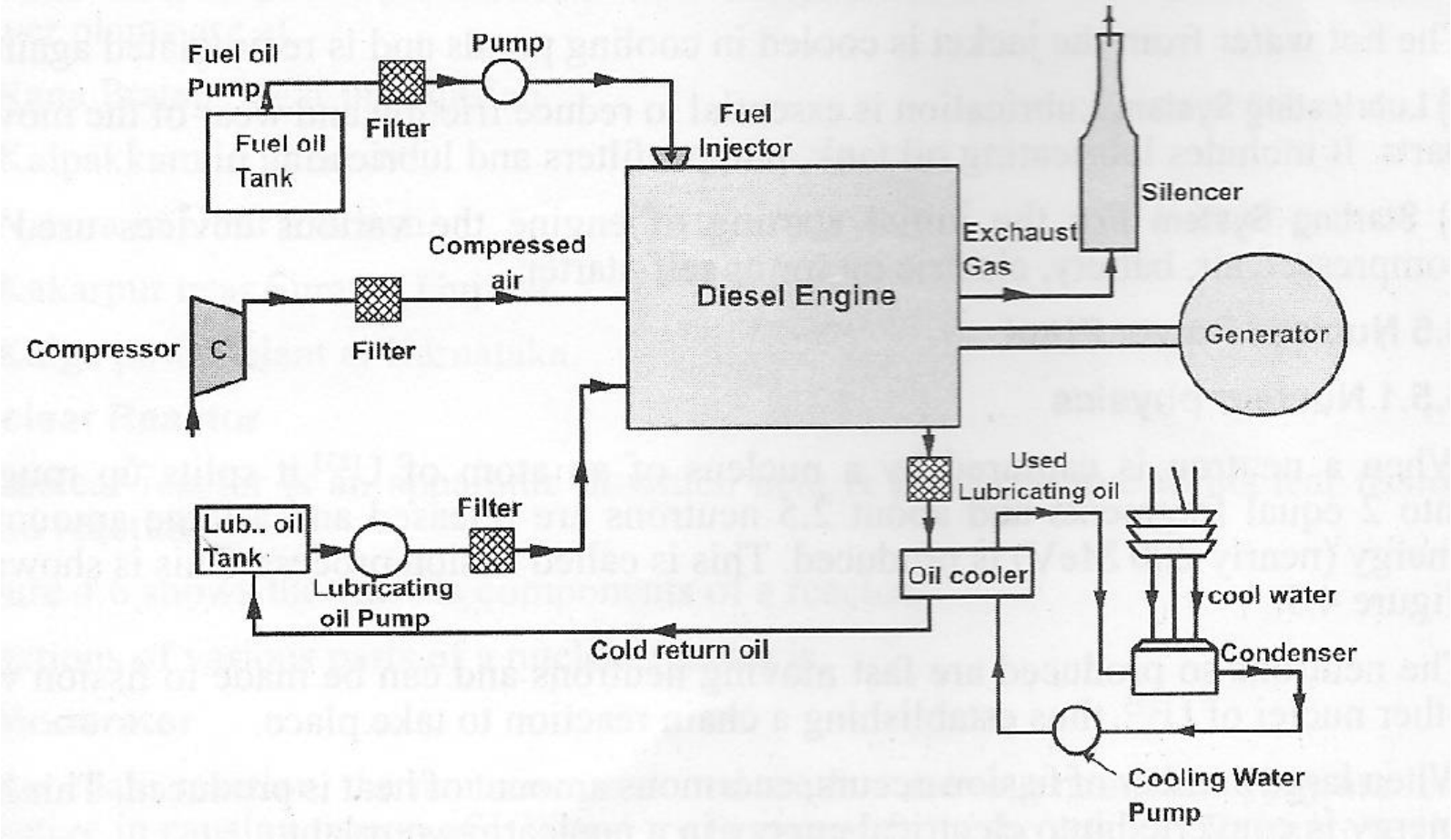
- SOURCE: Wikipedia.

List of diesel power plants in INDIA

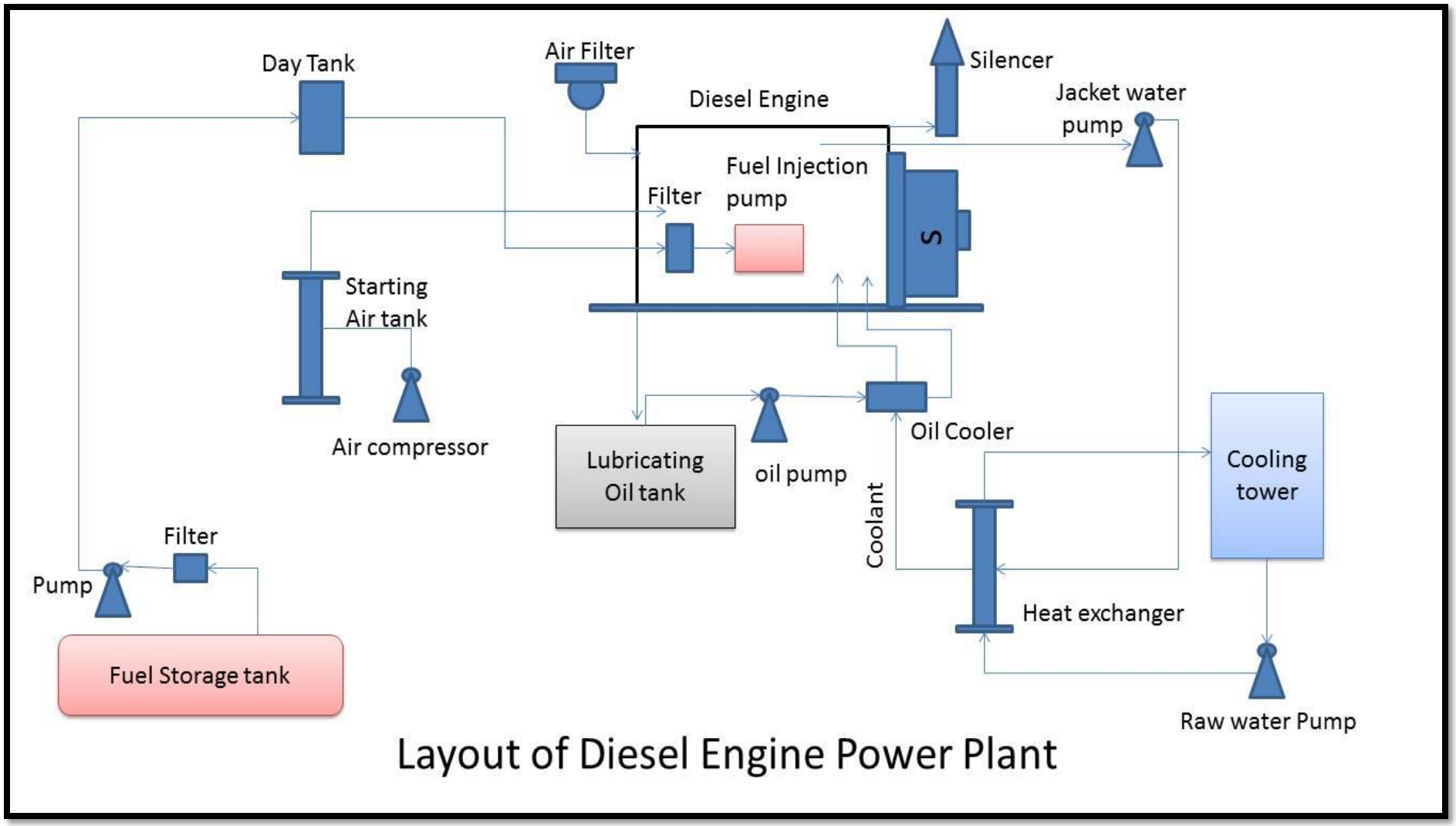
Power station	Operator	Location	District	State	Sector	Region	Units	Capacity (MW)	Plant Coordinates
GMR Vasavi Diesel Power Plant	TNEB	Basin Bridge	Chennai	Tamil Nadu	State	Southern	4 x 50	200	
Kozhikode Diesel Power Station	KSEB	Kozhikode	Kozhikode	Kerala	State	Southern	8 x 16.00	128	
Yelahanka Diesel Power Station	KPCL	Yelahanka	Bangalore	Karnataka	State	Southern	6 x 21.32	127.92	
Brahmapuram Diesel Power Station	KSEB	Brahmapuram		Kerala	State	Southern	5 x 21.32	106.6	
Southern						***4***	***23***	***562.52***	
Suryachakra Diesel Power Station	SPCL	A & N		Andaman & Nicobar	Private	Islands		20	
Islands						***1***		***20***	
Bemina Diesel Power Station	J&K Govt	Bemina	Srinagar	Jammu & Kashmir	State	Northern	1 x 5	5	
Leh Diesel Power Station	J&K Govt	Leh	Leh	Jammu & Kashmir	State	Northern	1 x 2.18	2.18	
Ambala Diesel Power Station	Haryana Govt	Ambala	Ambala	Haryana	State	Northern	1 x 2.18	2.18	
Upper Sindh Diesel Power Station	J&K Govt			Jammu & Kashmir	State	Northern	1 x 1.7	1.70	
Keylong Diesel Power Station	HP Govt	Keylong	Lahaul and Spiti	Himachal Pradesh	State	Northern	1 x 0.13	0.13	
Kamah Diesel Power Station	J&K Govt			Jammu & Kashmir	State	Northern	1 x 0.06	0.06	
Northern						***6***	***6***	***11.25***	
Gangtok Diesel Power Station	Sikkim Govt	Gangtok	East Sikkim	Sikkim	State	Eastern		4	
Ranipool Diesel Power Station	Sikkim Govt	Ranipool	East Sikkim	Sikkim	State	Eastern		1	
Eastern						***2***		***5***	
Total						***13***		***598.77***	

Layout of Diesel Power Plant

GENERAL LAYOUT



Simple layout



Essential elements of Diesel Power Plant

- Engine System
- Starting System
- Lubrication System
- Fuel System
- Air filter and Supercharge
- Cooling System
- Exhaust System
- Governing System

Engine system

- **ENGINE:** This is the **main component** of the plant which develops required power. The engine is generally directly coupled to the **generator**
- Generally classified as two stroke engine and four stroke engines

Industrial GenSet

Engine and Air intake system

- Engine-
- This is the main component of the plant which develops the required power. The electrical generator is usually direct coupled to the engine.
- Air intake system-
- The air intake system conveys fresh air through pipes or ducts to (i) air intake manifold of 4 stroke engine (ii) The scavenging pump inlet of a two stroke engine (iii) The supercharger inlet of a supercharged engine.

Air filter and supercharger

- Air filter is used to remove the dust from the air which is taken by the engine.
- The supercharger is used to increase the pressure of the air supplied.

Air intake system

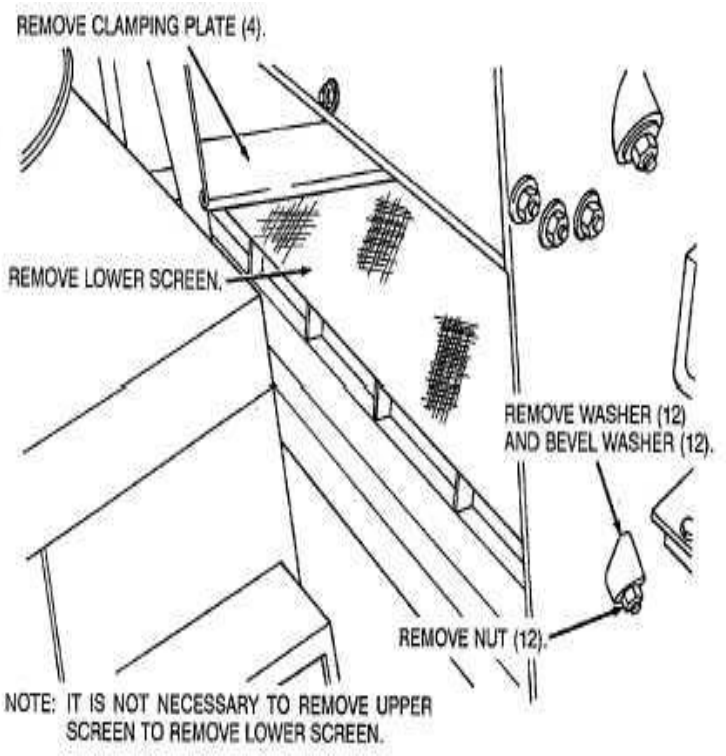
- Air is first drawn through a filter to catch dirt or particles that may cause excessive wear in cylinders. Filters may be of following types:
- Dry type (paper, cloth, felt, glass wool etc)
- Wet type (oil impingement type, oil bath type where oil helps to catch particles)
- Following precautions should be taken while designing air intake systems

Following precautions should be taken while designing air intake systems

- Air intake should be located outside the engine room.
- Air intake should not be located in confined places to avoid undesirable acoustic vibrations.
- Pressure drop in the air intake line should minimum to avoid engine starvationbe
- Air filters should be accessible for periodic cleaning.
- In some cases a muffler may be introduced to prevent engine noise from reaching outside air.

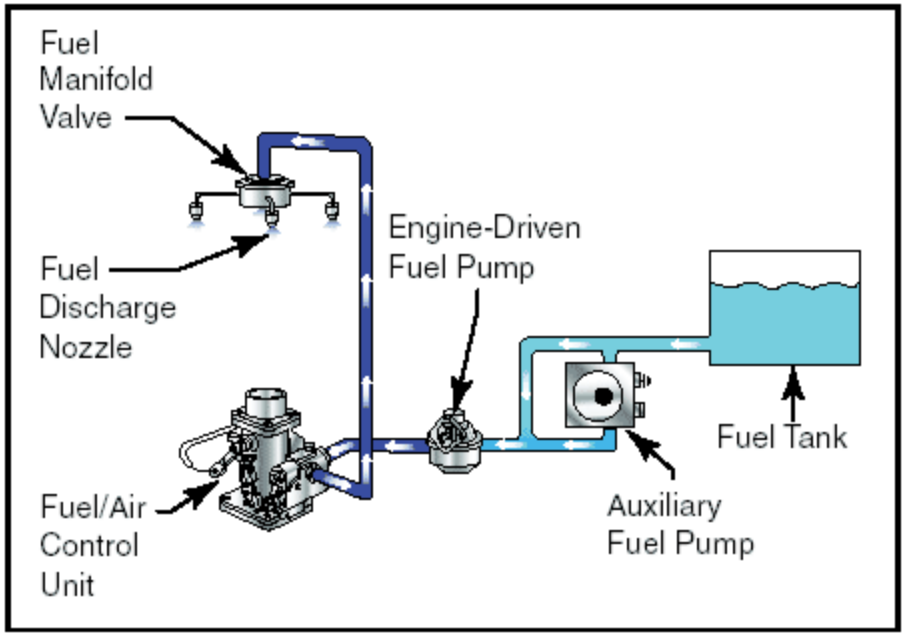
Air intake system

- The air required for the combustion of fuel inside the diesel engine cylinder is drawn through the air filter. The purpose of the filter is to remove dust from the incoming air.
- dry filter- may be made of felt , wood or cloth.
- wet filter- oil bath is used.



Fuel supply system

- Fuel from the storage tank is pumped through a filter into a smaller tank called all day tank . this tank supplies the daily requirements of the diesel engine.



Starting system

- The function of this system is to start the engine from cold by supplying compressed air at about 17 bar supplied from an air tank is admitted to a few cylinders making them work like reciprocating air motors to run the engine shaft. Fuel is admitted to the remaining cylinders and ignited in the normal way causing the engine to start.

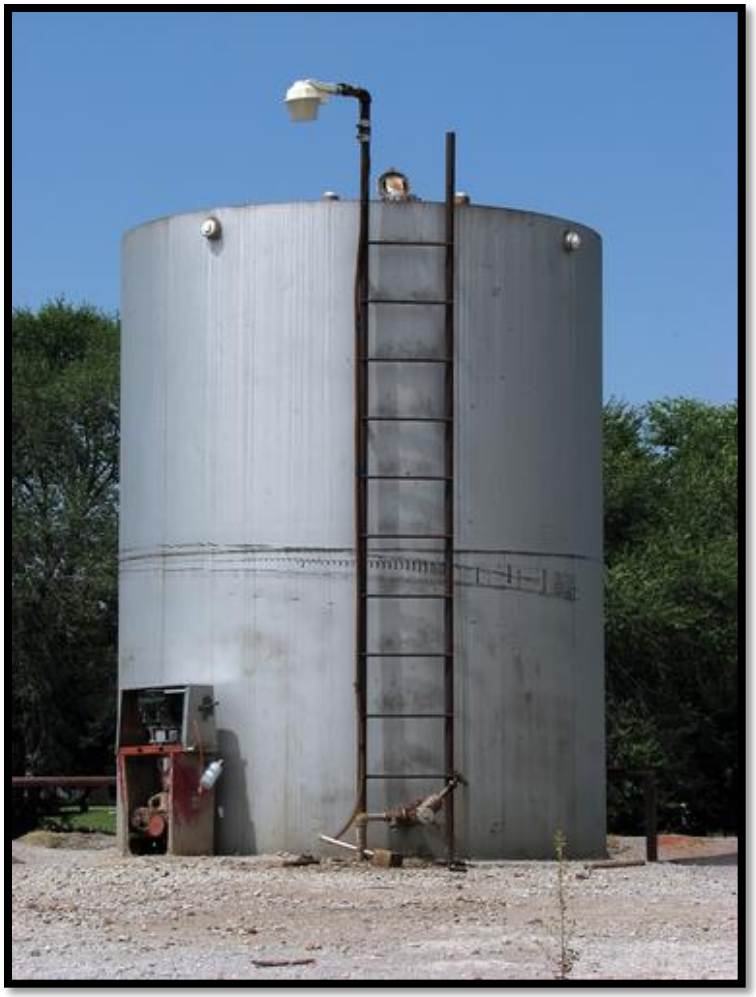
Lubrication system

- It includes the oil pumps, oil tanks, filters, coolers and connecting pipes.
- The purpose of the lubrication system is to reduce the wear of the engine moving parts
- Part of the cylinder such as piston , shafts , valves must be lubricated. The lubricant is cooled before recirculation.
- Lubrication also helps to cool the engine

The following are the important functions of a lubrication system

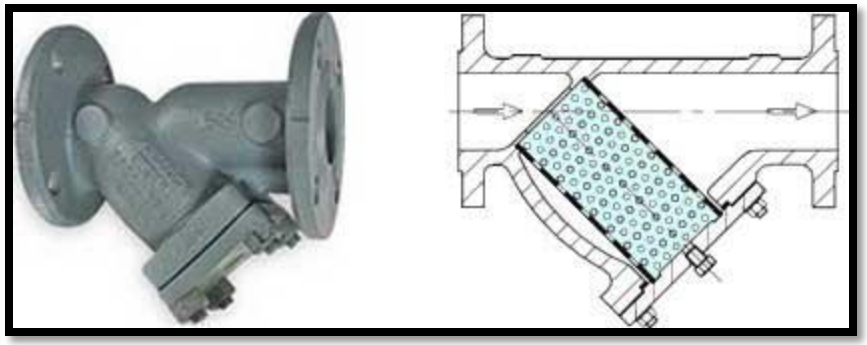
- LUBRICATION: To keep parts sliding freely past each other, reducing friction and wear.
- COOLING: To keep surfaces cool by taking away part of the heat caused by friction.
- CLEANING: To keep the bearings and piston rings clean.
- SEALING: To form a good seal B/W the piston rings and cylinder walls.
- REDUCING NOISE: to reduce the noise of the engine by absorbing vibration.

oil tank



Fuel system

- It includes the storage tank, fuel pump, fuel transfer pump, strainers and heater.
- Pump draws diesel from storage tank to day tank through the filter
- The day tank is usually placed high so that diesel flows to engine under gravity.
- Diesel is filtered before being injected into the engine by the fuel injection pump.



The fuel injection system performs the following functions

- Filter the fuel
- Meter the correct quantity of the fuel to be injected
- Time the injection process
- Regulate the fuel supply
- Secure fine atomization of fuel oil
- Distribute the atomized fuel properly in the combustion chamber

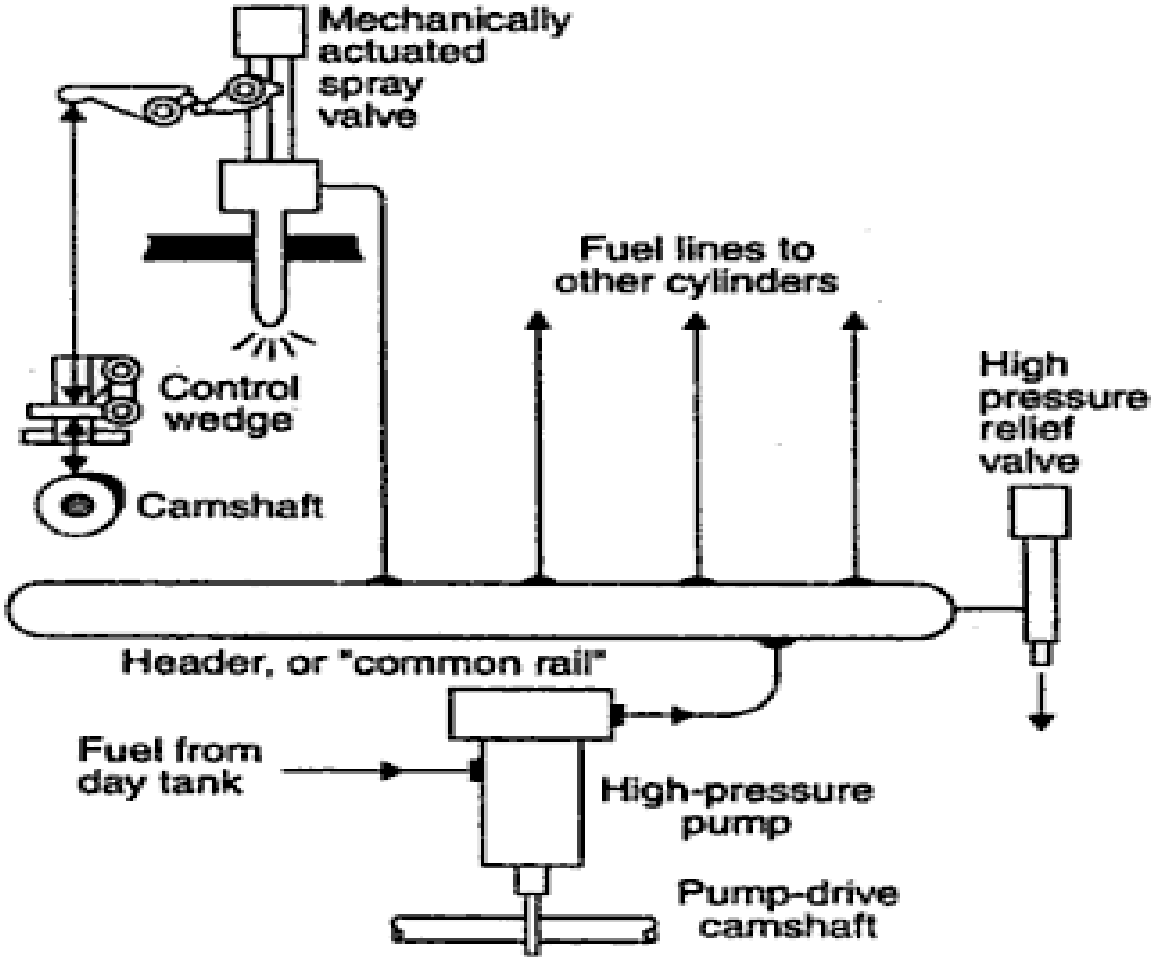
➢ Oil is atomized either by **blast** or **pressure jet**.

In **pressure jet atomization** oil is forced to flow through spray nozzles at pressure above **100 bar**. It is known as **solid injection**

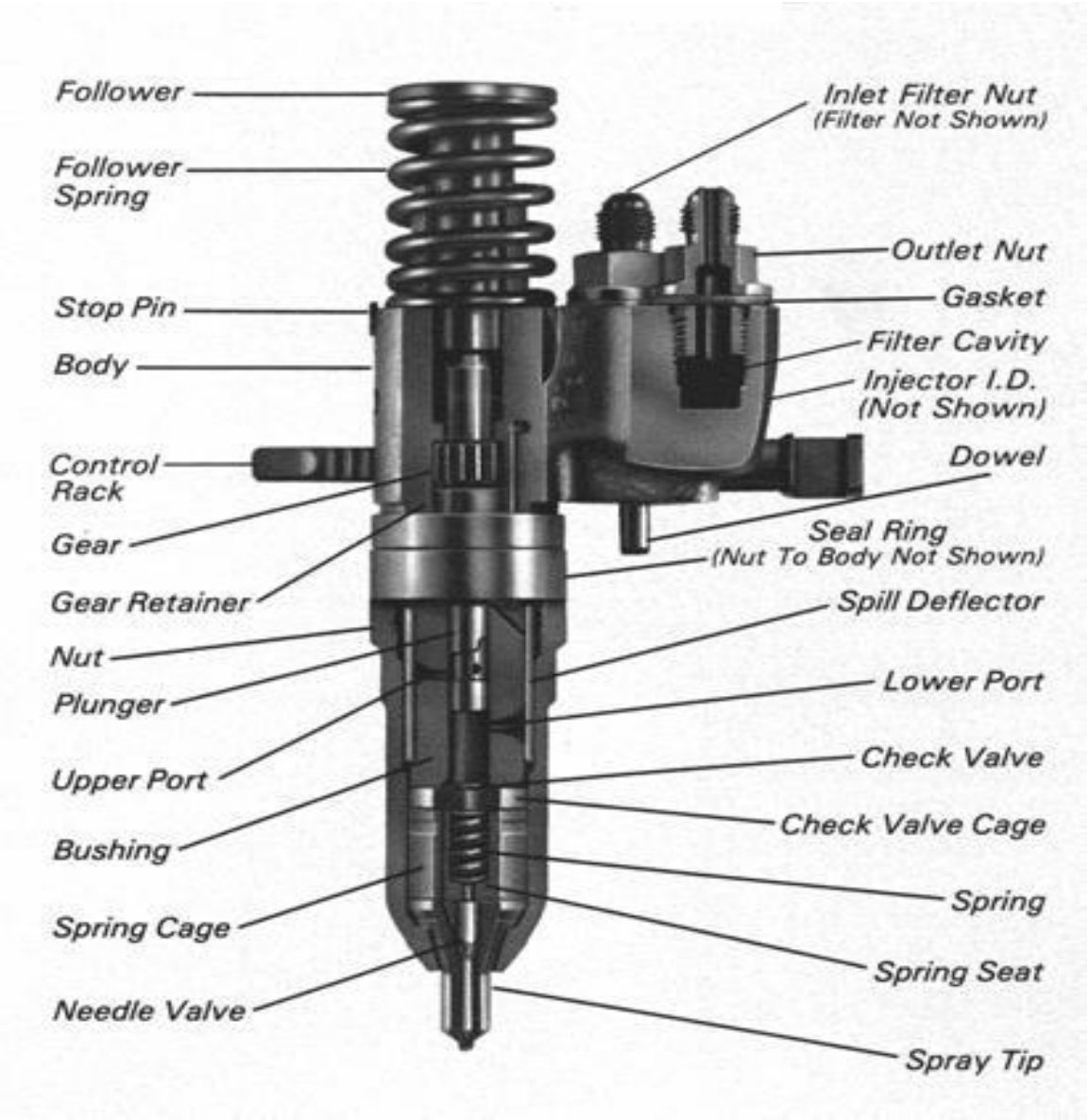
Classification of solid injection systems

- **Common rail injection system:** The system is named after the shared high-pressure (100 to 200 bars)reservoir (common rail) that supplies all the cylinders with fuel. With conventional diesel injection systems, the fuel pressure has to be generated individually for each injection. With the common rail system, however, pressure generation and injection are separate, meaning that the fuel is constantly available at the required pressure for injection.
- **Individual pump injection system:**
- **Distributor system:**

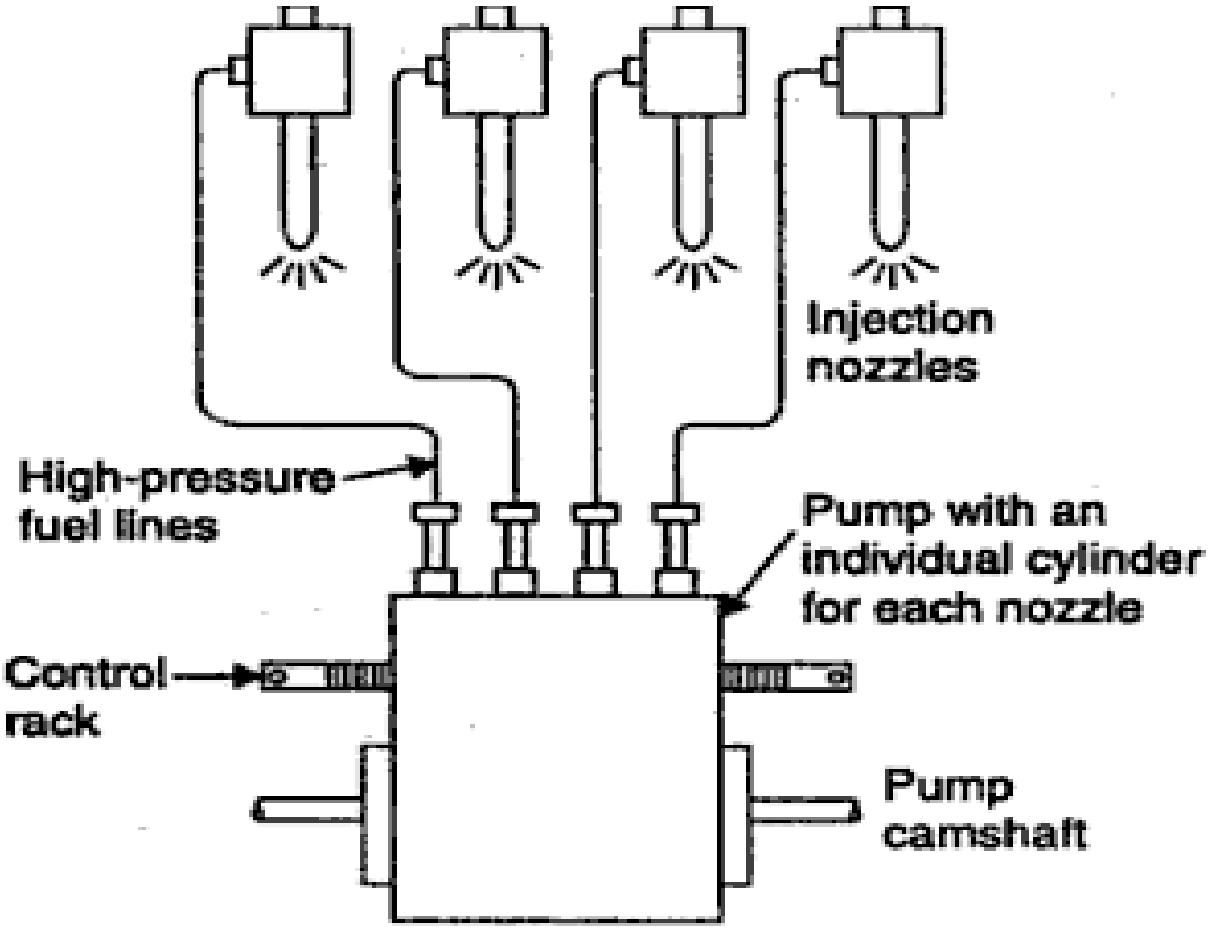
CRDI


Mechanically actuated spray valve
Fuel lines to other cylinders
High pressure relief valve
Control wedge
Camshaft
Header, or "common rail"
Fuel from day tank
High-pressure pump
Pump-drive camshaft

Fuel Injector

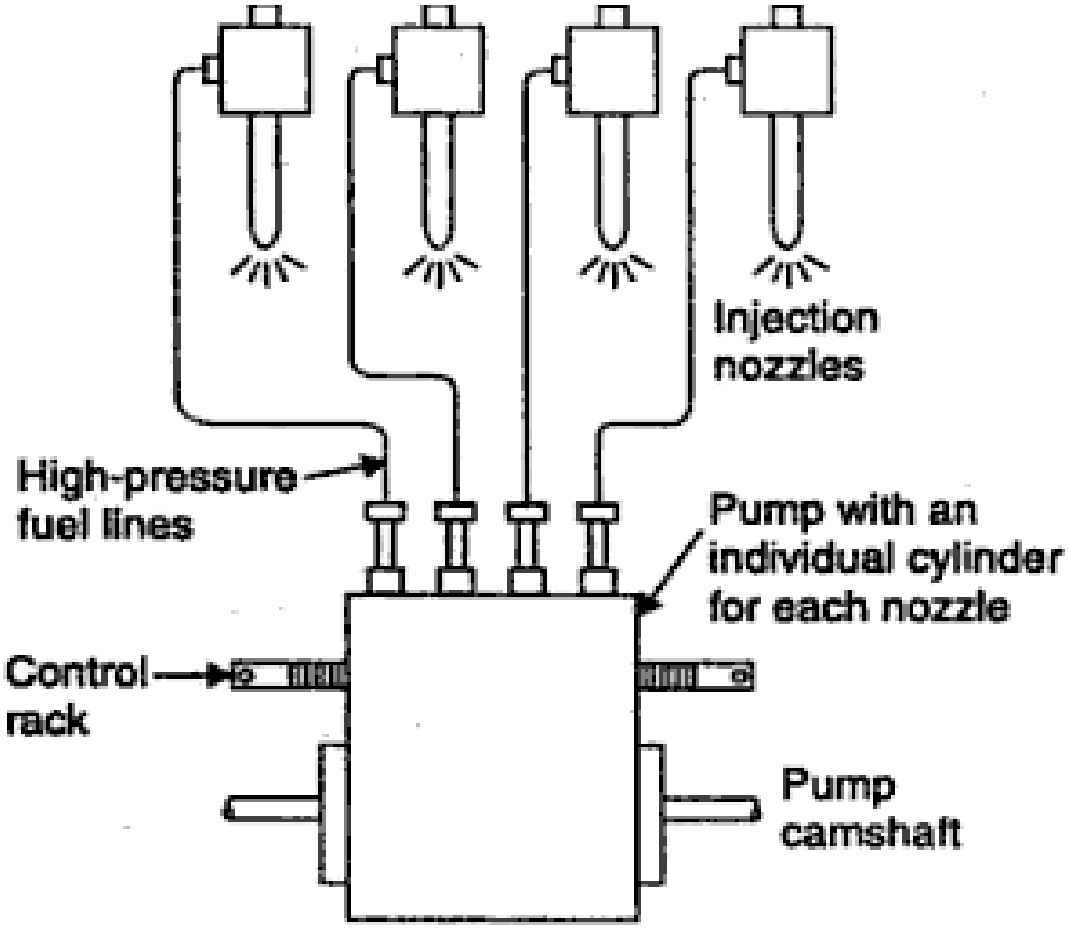


Individual pump Injection System

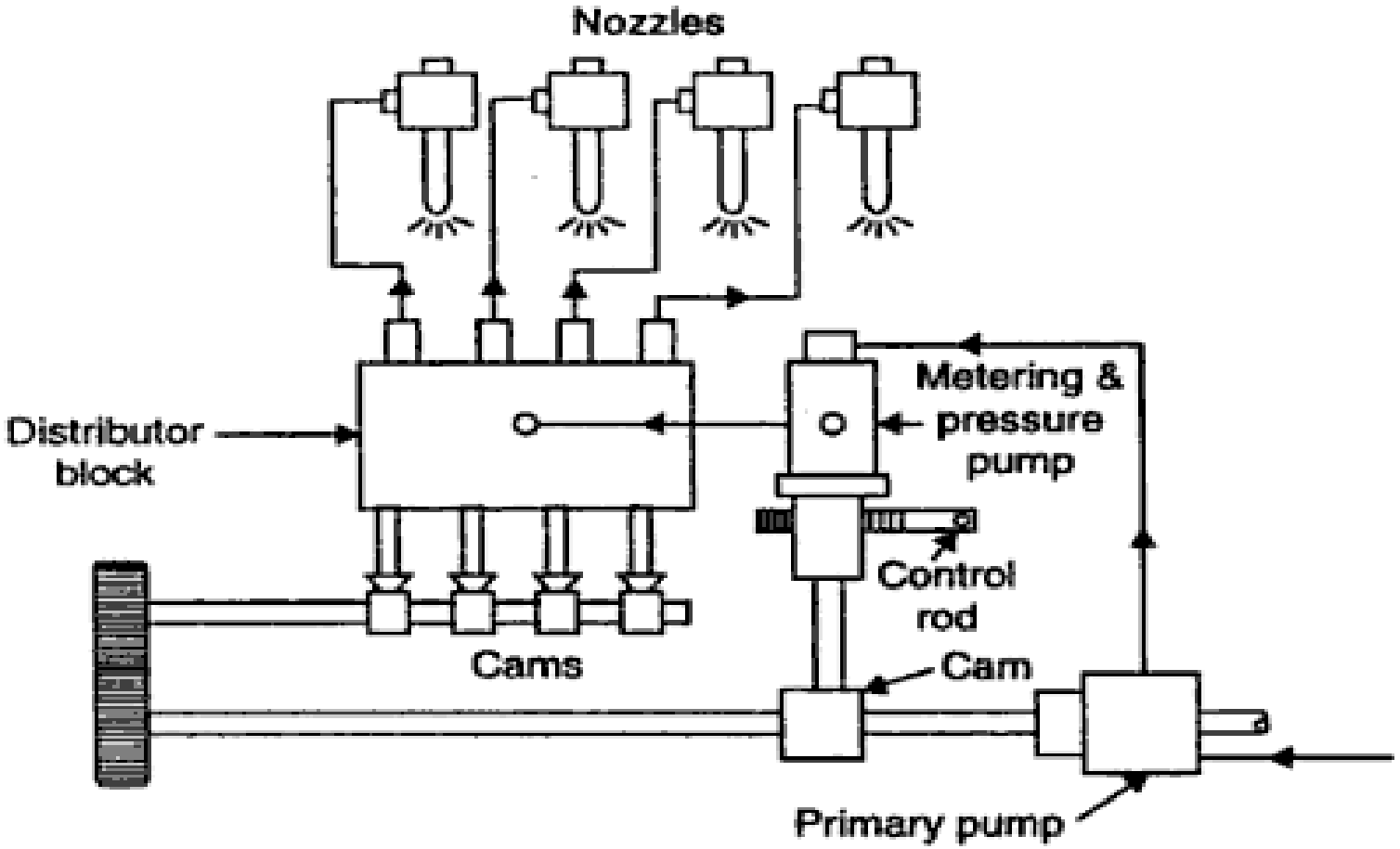


Individual pump Injection System

- The schematic is shown in fig.
- An individual pump or pump cylinder connects directly to each fuel nozzle.
- Metering and injection timing controlled by individual pumps.
- Nozzle contains a delivery valve actuated by the fuel pressure.

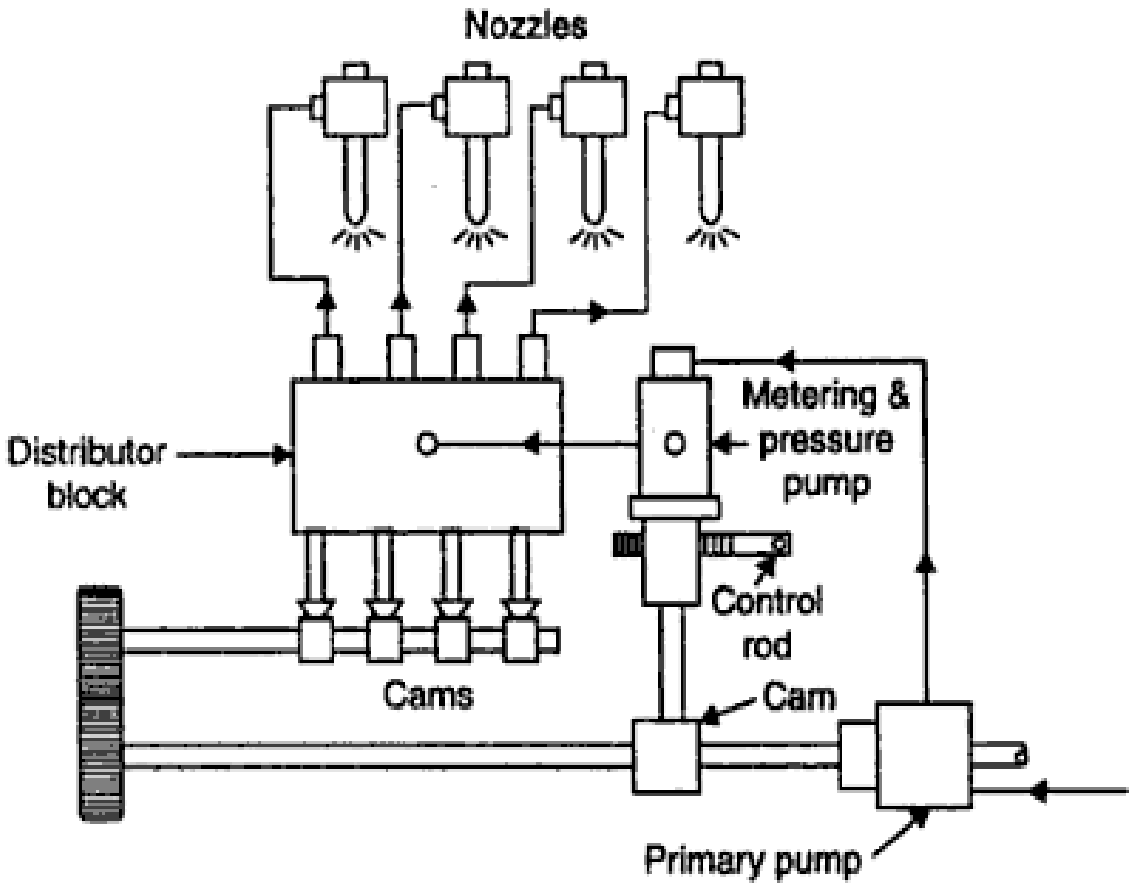


Distributor System



Distributor System

- The schematic is shown here.
- The fuel is metered at a central point.
- A pump meters, pressurizes and times the fuel injection.
- Fuel is distributed to cylinders in correct firing order by cam operated poppet valves which admit fuel to nozzles.



Cooling system

- The cooling system consists of a water source, pump and cooling towers. The pump circulates water through cylinder and head jacket. The water takes away heat form the engine and it becomes hot. The hot water is cooled by cooling towers and re circulated for cooling.

Cooling system

- The temperature of the hot gases inside the cylinder may be as high as 2750 c . If there is no external cooling, the cylinder walls and piston will tend to assume the average temp. of the gases.
- Cooling is necessary because:
- To avoid deterioration or burning of lubricating oil.
- The strength of the materials used for various engine parts decreases with increase in temperature. Local thermal stress can develop due to uneven expansion of various parts.
- Increase in pre-ignition and knocking
- Due to high cylinder head temp. the volumetric efficiency and hence power O/P of the engine are reduced.

cooling system

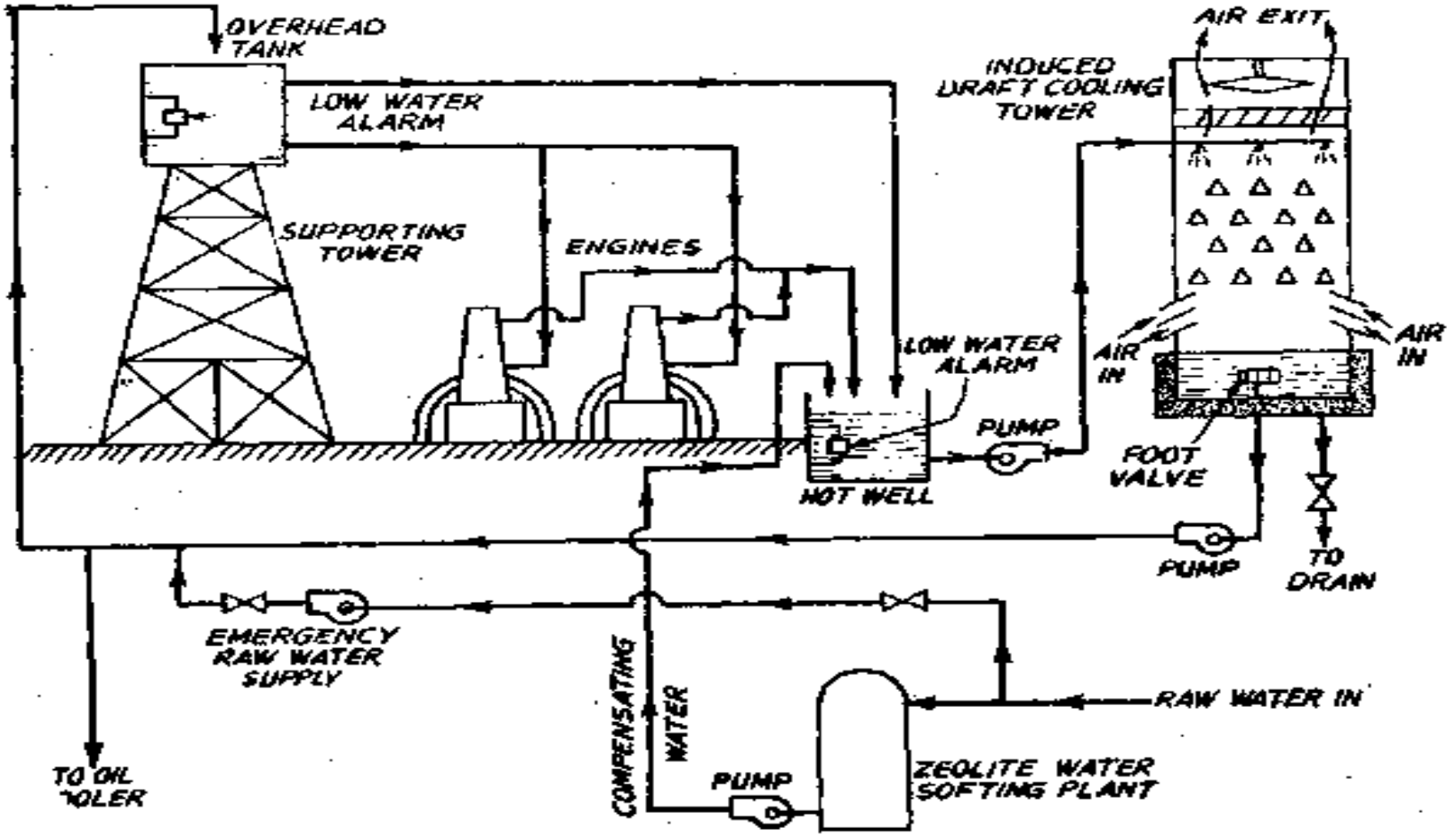


Fig. 23.3. Cooling water system using water softing plant and cooling-tower.

Elements of cooling system

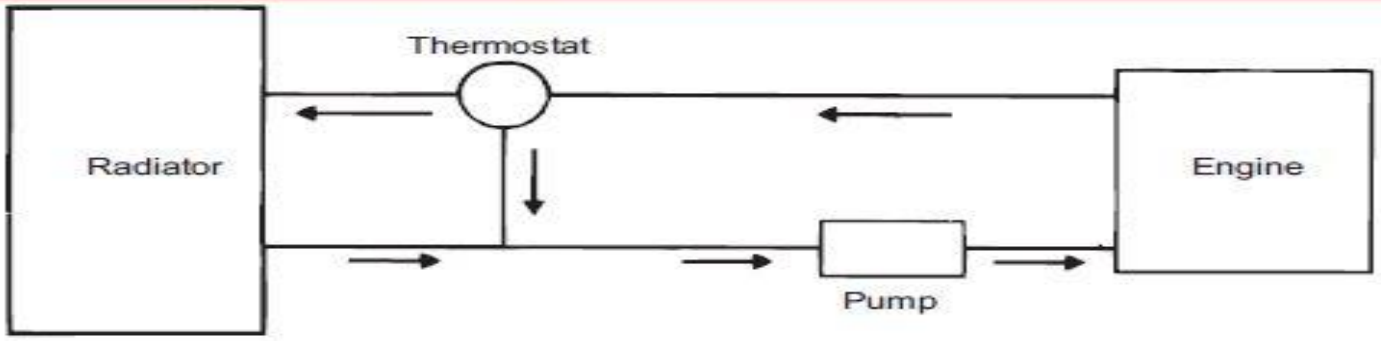


Figure 5.4 : Water Cooling System using Thermostat Valve

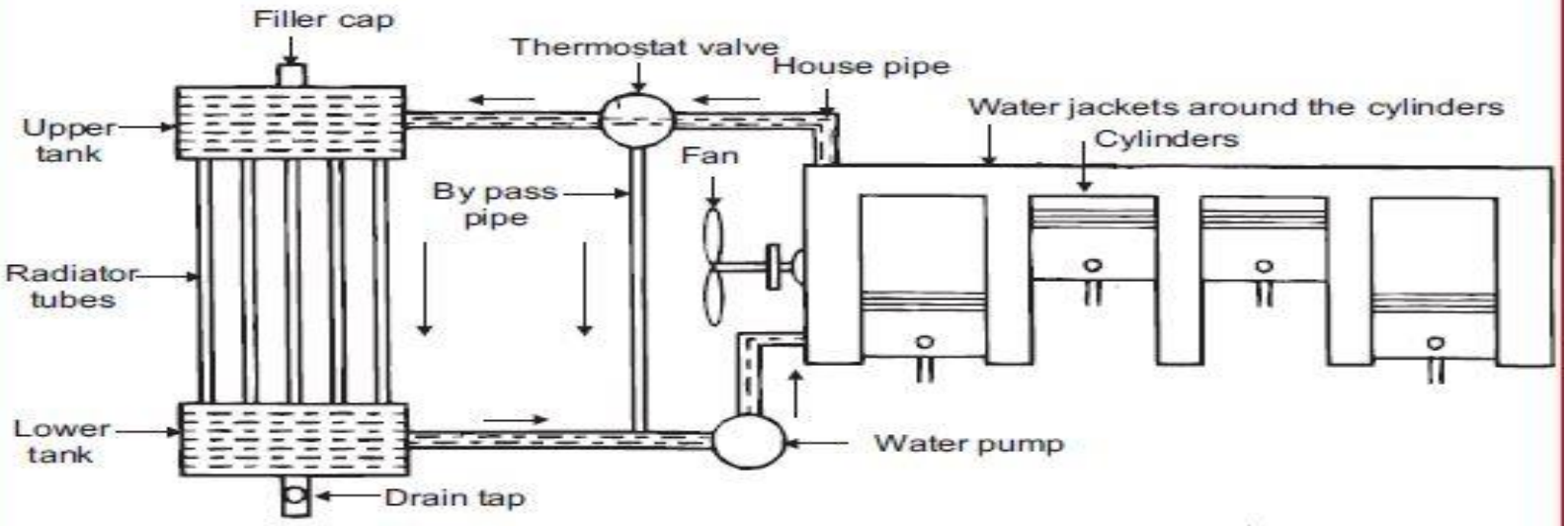
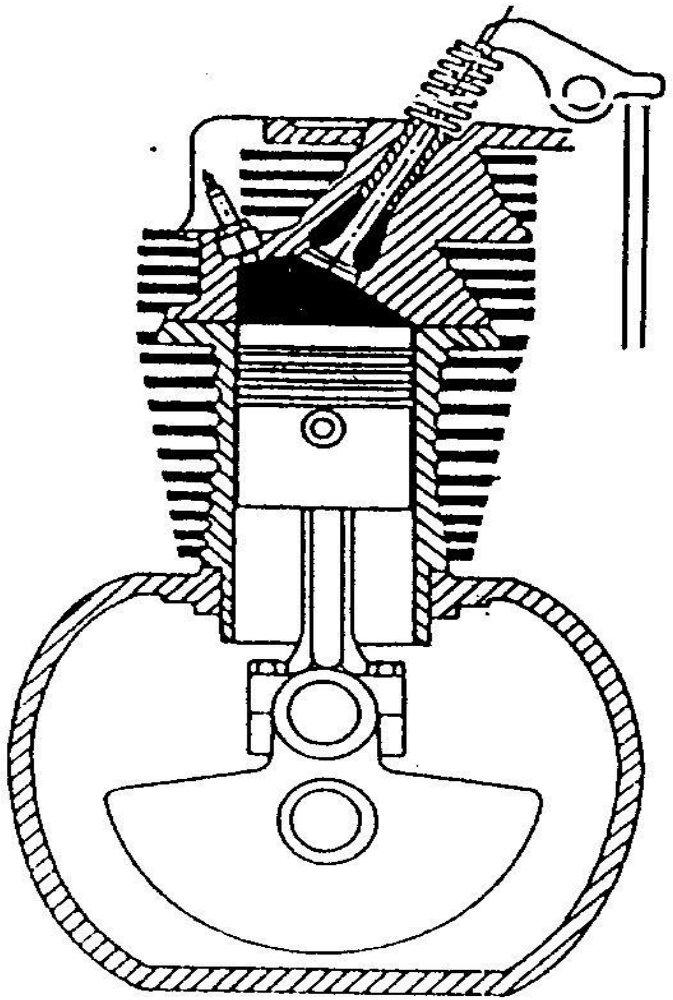


Figure 5.5 : Water Cooling System of a 4-cylinder Engine

There are two methods of cooling I.C. engi

- 1.Air cooling.
- 2. Liquid cooling



Air cooling :

- In this method, heat is carried away by the air flowing over and around the cylinder.
- Fins are added on the cylinder which provide additional mass of material for conduction as well as additional area for convection and radiative modes of heat transfer

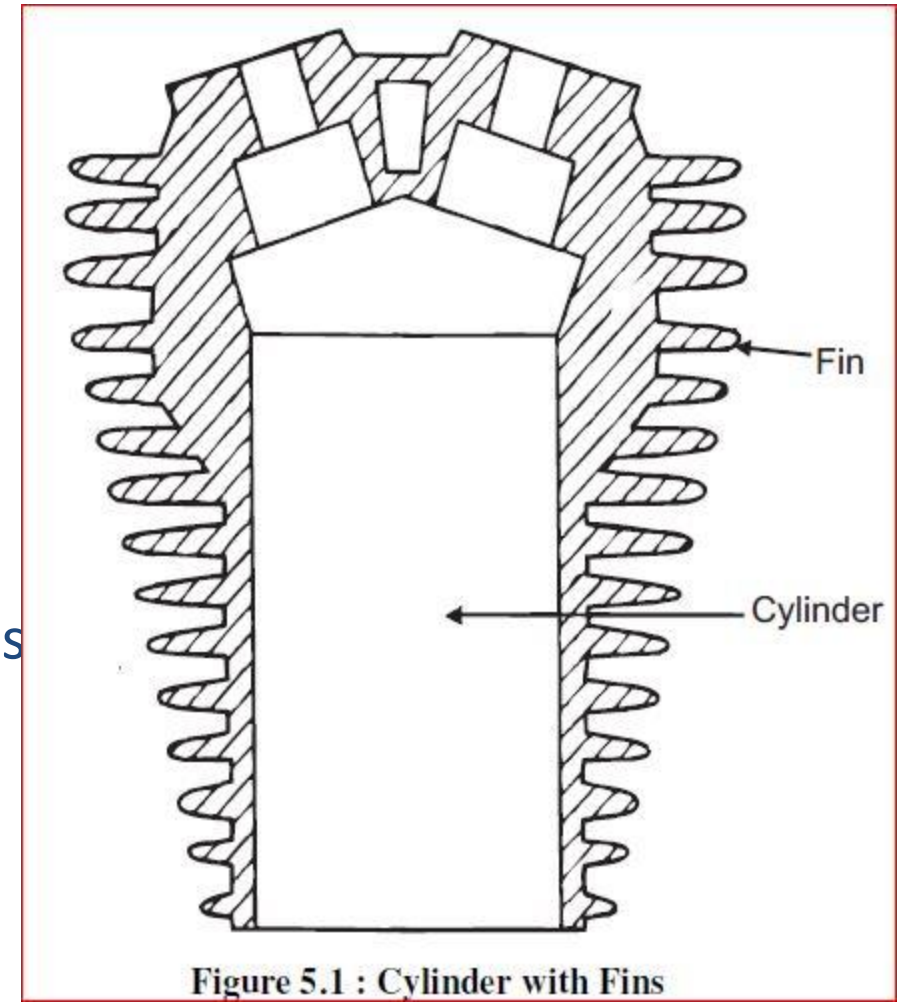
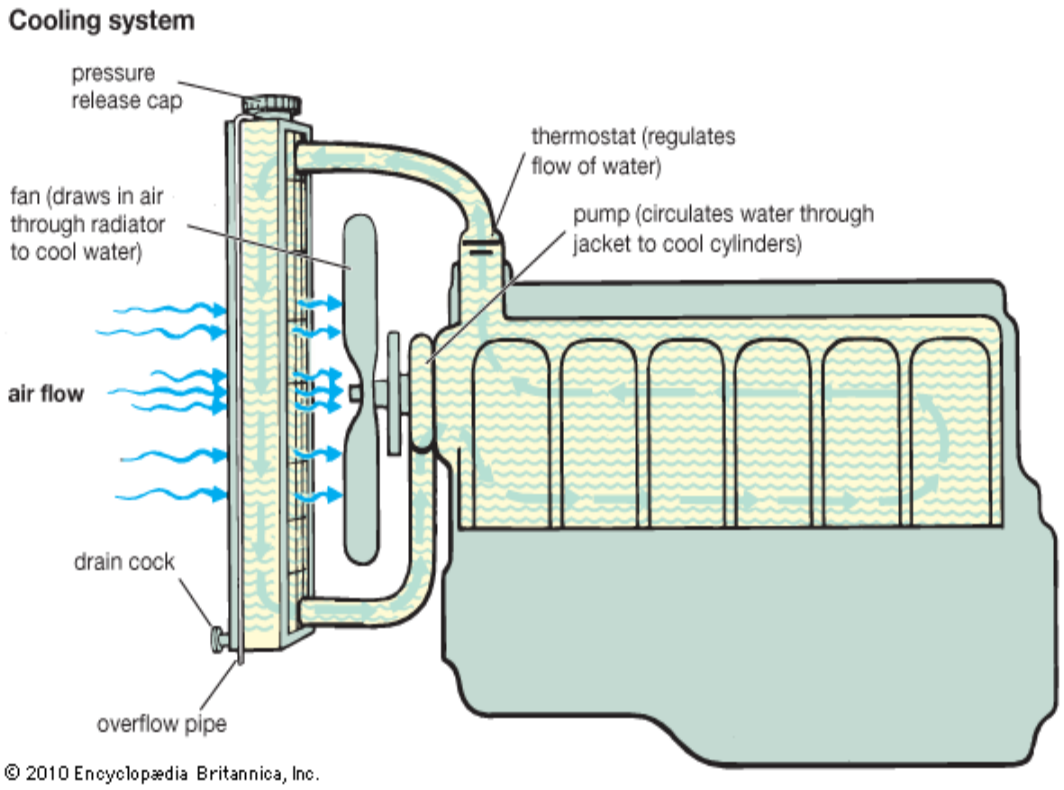


Figure 5.1 : Cylinder with Fins

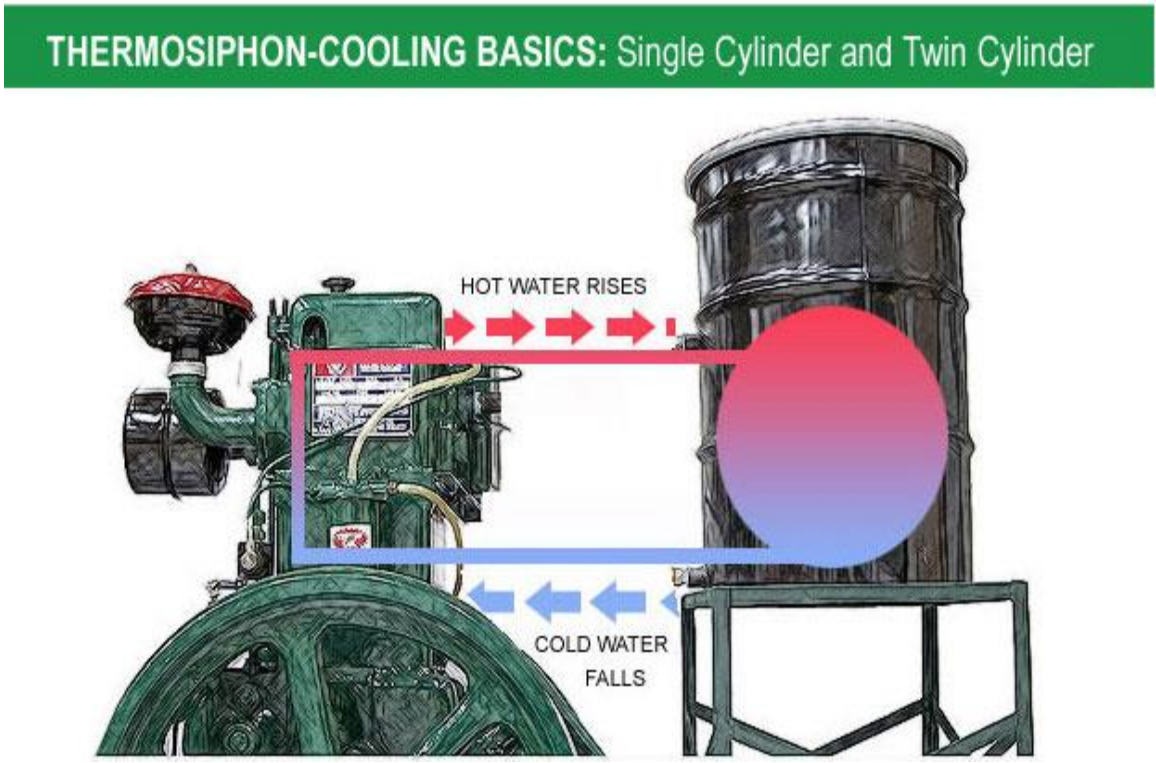
Liquid cooling

- In this method, the cylinder walls and head are provided with jackets through which the cooling liquid can circulate.
- The heat is transferred from the cylinder walls to the liquid by convection and conduction.
- The liquid gets heated during its passage through the cooling jackets and is itself cooled by means of an air cooled radiator system.

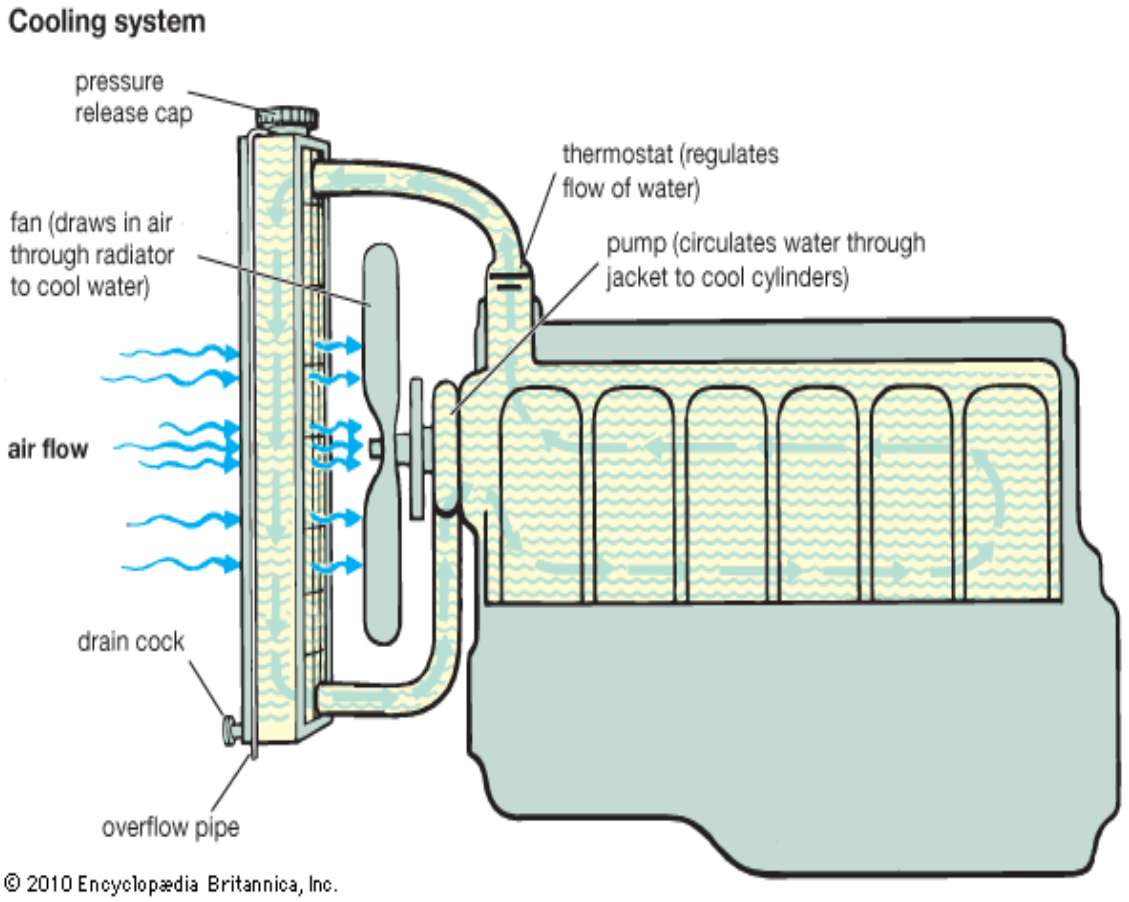


Types of Water Cooling System

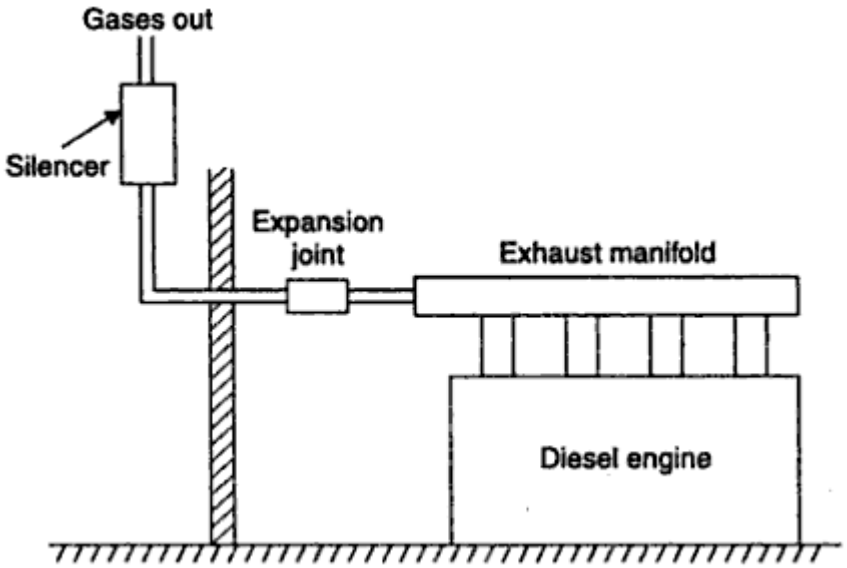
- **Thermo Siphon System**
- In this system the circulation of water is due to difference in temperature
- (i.e. difference in densities) of water. So in this system pump is not required
- but water is circulated because of density difference only.



- ***Pump Circulation System***
- In this system circulation of water is obtained by a pump. This pump is
- driven by means of engine output shaft through V-belts.

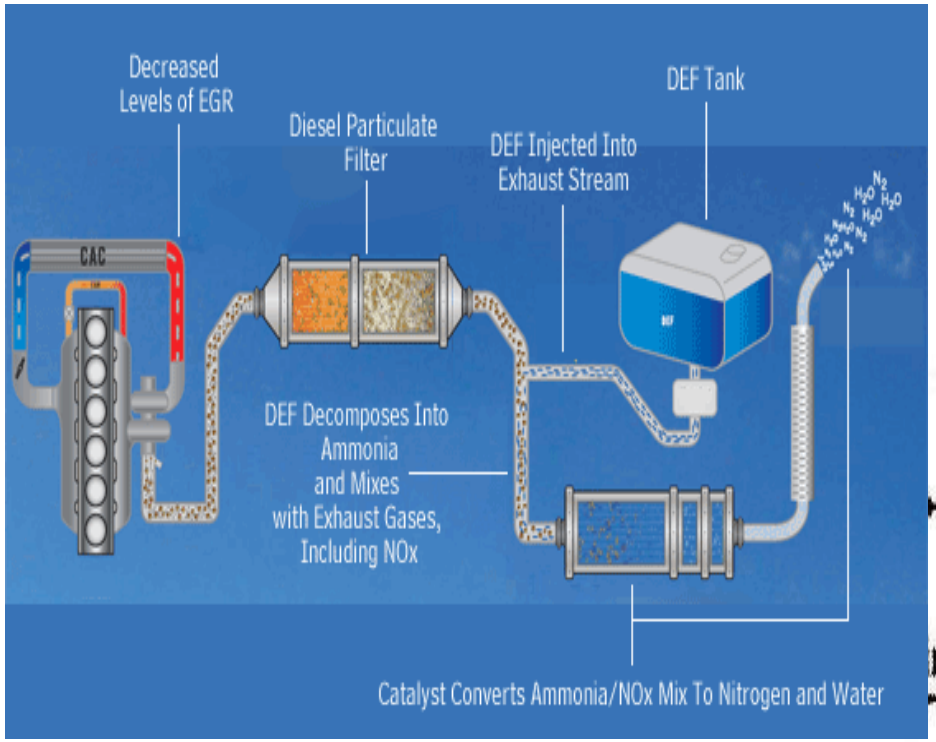


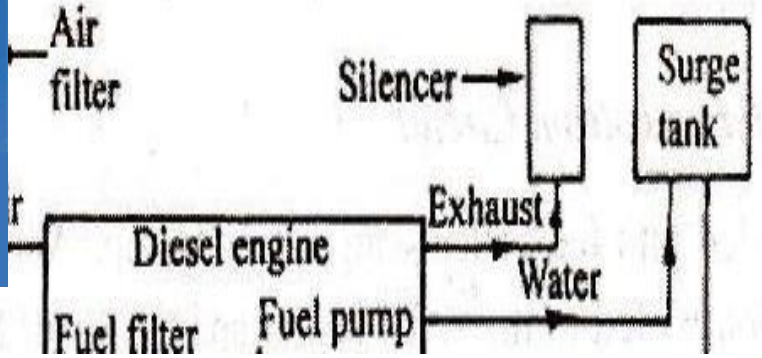
Exhaust system



Exhaust system

- The exhaust gases coming out of the engine is very noisy. In order to reduce the noise a silencer is used.





Exhaust system

- This includes the silencers and connecting ducts.
- The exhaust gases coming out of the engine is very noisy.
- silencer (muffler) is provide to reduce the noise.

Exhaust system

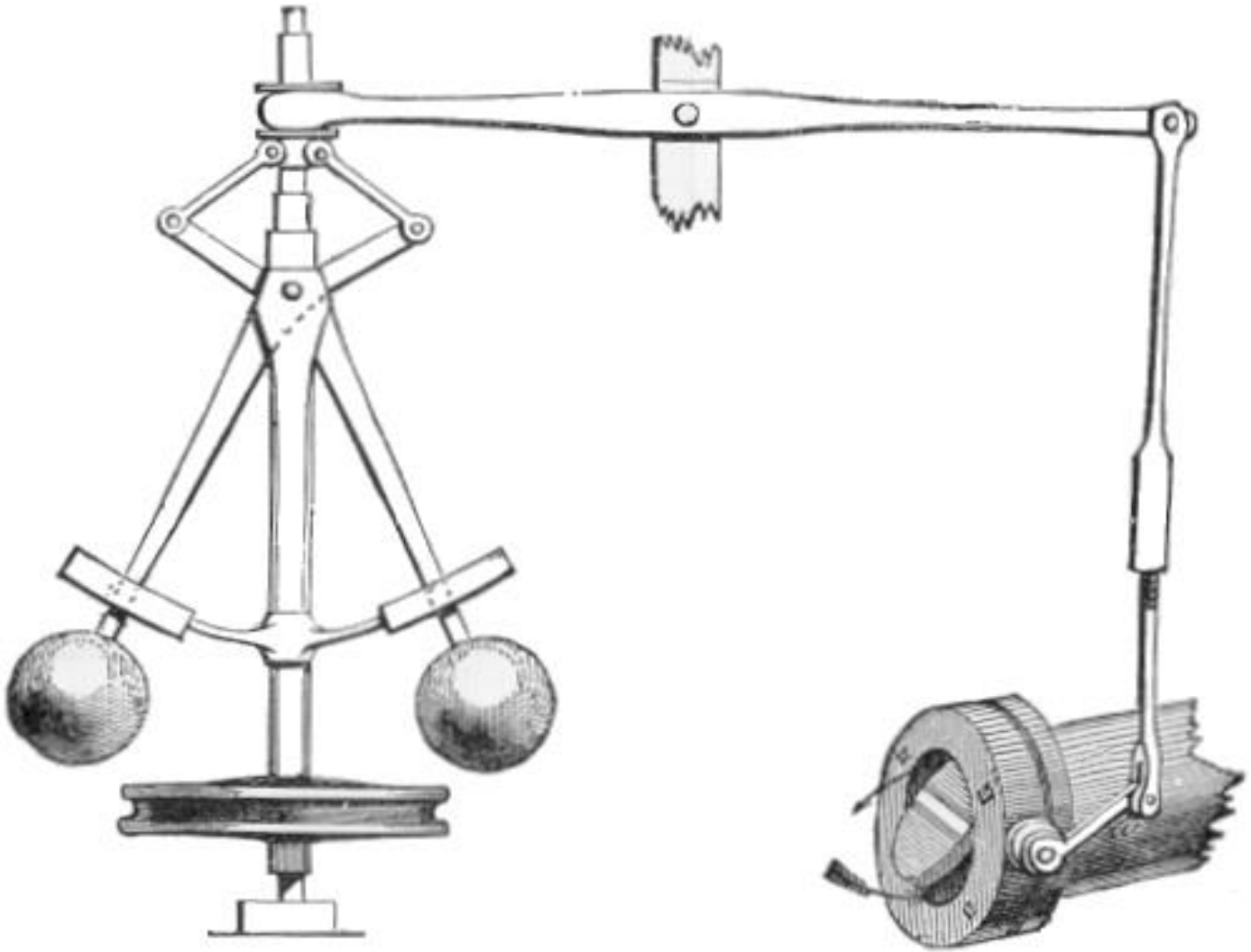
- Exhaust pipe leading out of the building should be short in length with minimum number of bends to provide as low a pressure loss as possible.
- Flexible tubings may be added in exhaust pipe to take care of misalignments and expansion/contraction and also to isolate the system from engine vibrations.

Exhaust system

- Each engine should have its independent exhaust system.
- Where possible, exhaust heat recovery should be made to improve plant thermal efficiency. E.g., air heating, low pressure steam generation in diesel-steam power plant etc

Governing system

- The function of the governing system is to maintain the speed of the engine
- This is done generally by varying fuel supply to the engine according to load.
- It is achieved with use of governors.



ADVANTAGES AND DISADVANTAGES OF DIESEL POWER PLANT

ADVANTAGES->

- Simple design & layout of plant
- Occupies less space & is compact
- Can be started quickly and picks up load in a short time
- Requires less water for cooling
- Thermal efficiency better that of Steam Power Plant of same size
- No ash handling problem
- Less operating and supervising work is required

DISADVANTAGES->

- High running charges due to costly price of Diesel
- Generates small amount of power
- Cost of lubrication very high
- Maintenance charges are generally high
- Noise problem
- Capacity is restricted. Cannot be of very big size

Hydro-Electric Power Plant

Definition of Hydro-Electric Power Plant

- A generating station which utilizes the potential energy of water at a high level for the generation of electrical energy is known as a hydro-electric power station.
- **Principal of Hydro-Electric Power Plant.**

PE↔KE↔ME↔EE

(Potential Energy↔ Kinetic Energy ↔Mechanical Energy ↔Electrical Energy)

- **Selection of Site for Hydro-Electric Power Plant:**

1. **Quantity of Water Required:**

   As we know that, the hydro-electric power plant totally runs on water, so that ample quantity of water is continuously available throughout the year.

2. **Hilly Area Required:**

   For storage of ample quantity of water, both side of dam hilly area or strong mountains required for storage of water.

3. Civil Work:

It should have strong foundation or the cost of foundation should be as low as possible.

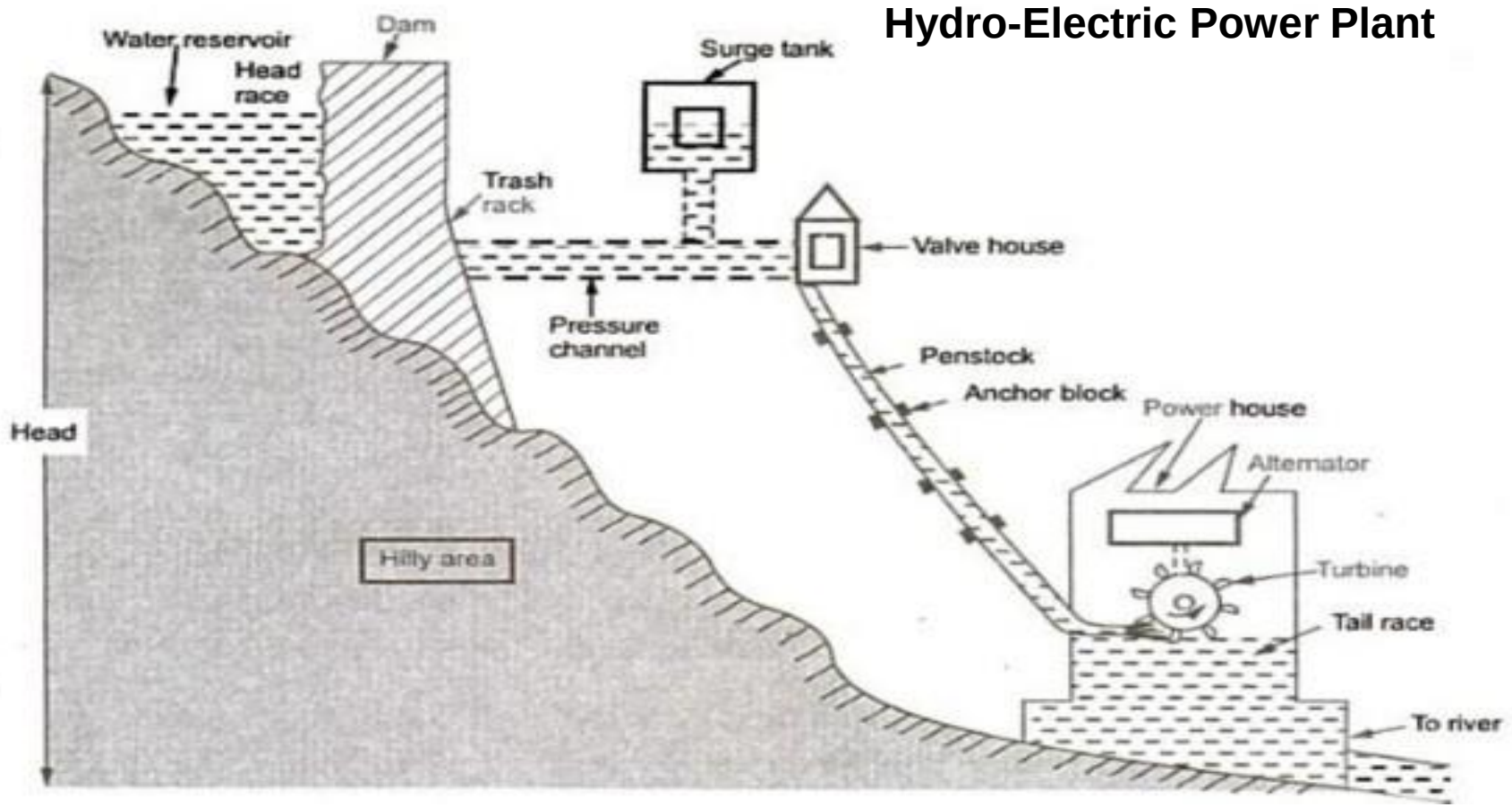
4. Large Catchment Area:

Large catchment area required, so that the water in it should never fall below the minimum level.

5. Transportation Facility:

For Workers & Civil Material required better transportation facility.

Schematic arrangement of Hydro-Electric Power Plant:



Function of Different Components used in Hydro-Electric Power Plant:

1. **Catchment Area:**

   In hydro-electric power plant collect the rain water through surrounding hilly area, the surrounding all water collect & stored area to those place is known as catchment area.

2. **Reservoir:**

   The function of reservoir is to store the water near dam; this water is useful to drive the water turbines. The reservoir is useful to provide a head of stored water.

3. **Track Rash:**

   It is used in hydro-electric power plant to filter the water before it flows towards turbine. The unwanted impurities (e.g. fish, plastics etc.) present in the stored water are avoided to flow towards turbine.

4. Head-Race Level:

The water surface in the reservoir up to the dam is known as head-race level.

5. Dam:

The dam is used in hydro-electric power plant to store the water. Whenever the dam stored the water, it provides suitable head to this stored water. This stored water is useful throughout the year to run the hydro-electric power plant. Dam is made up of cement, concrete & sand materials. If higher rainfall occurs then door of dams are opened to flow of water.