Pumping Stations

Unit-II

Introduction

The necessity of lifting wastewater or sewage arises under the following circumstances

- When the **area of a town is so low lying that it cannot be drained by gravity** to discharge into a sub-main or main unless the entire sewerage system in the other parts is installed correspondingly at low level. In such circumstances, it is more economical to pump the sewage from the low lying area into the upper branch mains
- **Pumping is restorted** to, at intervals for a **sewage system in a flat Country, since laying of sewers at the designed grade continuously** all along will mean expensive excavation.

Necessity of lifting wastewater

- **Pumping is resorted** to when outfall sewer is at lower level than the body of water into which it is to be discharged, or when the outfall is lower than the entrance to the treatment plant.
- **When a sewer has to go across a high ridge**, it **will more economical to pump it into sewer laid across the slope of the ridge at reasonable depth**, rather than driving a tunnel.
- **Pumping is required to take out sewage from the cellars or sub-basements of buildings**, when the level of caller is much lower than the invert level of sewer to which drainage connection is to be made.

Introduction

Problems in Sewage Pumping

- The pumping of sewage is not as simple as pumping of water, since the following special problems are to be faced in sewage pumping.
- **(i) Sewage has foul characteristics**
- **(ii) Sewage Contains a lot of suspended and floating materials these may make the running of pumps difficult and may cause frequent clogging of the pumps.**
- **Sewage contains organic and inorganic wastes which may cause corrosion and erosion of parts of the pumps** and reduce the lifts of the pumps.

Problems in Sewage Pumping

- **The rate of flow of sewage varies continuously** and hence pumping operation are to be adjusted accordingly.
- **The size of sump is limited since large sized sumps** will result in the settlement of silts and organic matter at its bottom
- **The pumps should be of high order reliability since failure of pumps will lead to flooding** which may cause unbearable nuisance.

Problems in Sewage Pumping

Problems in Sewage Pumping

Pumping Stations

Location of pumping stations

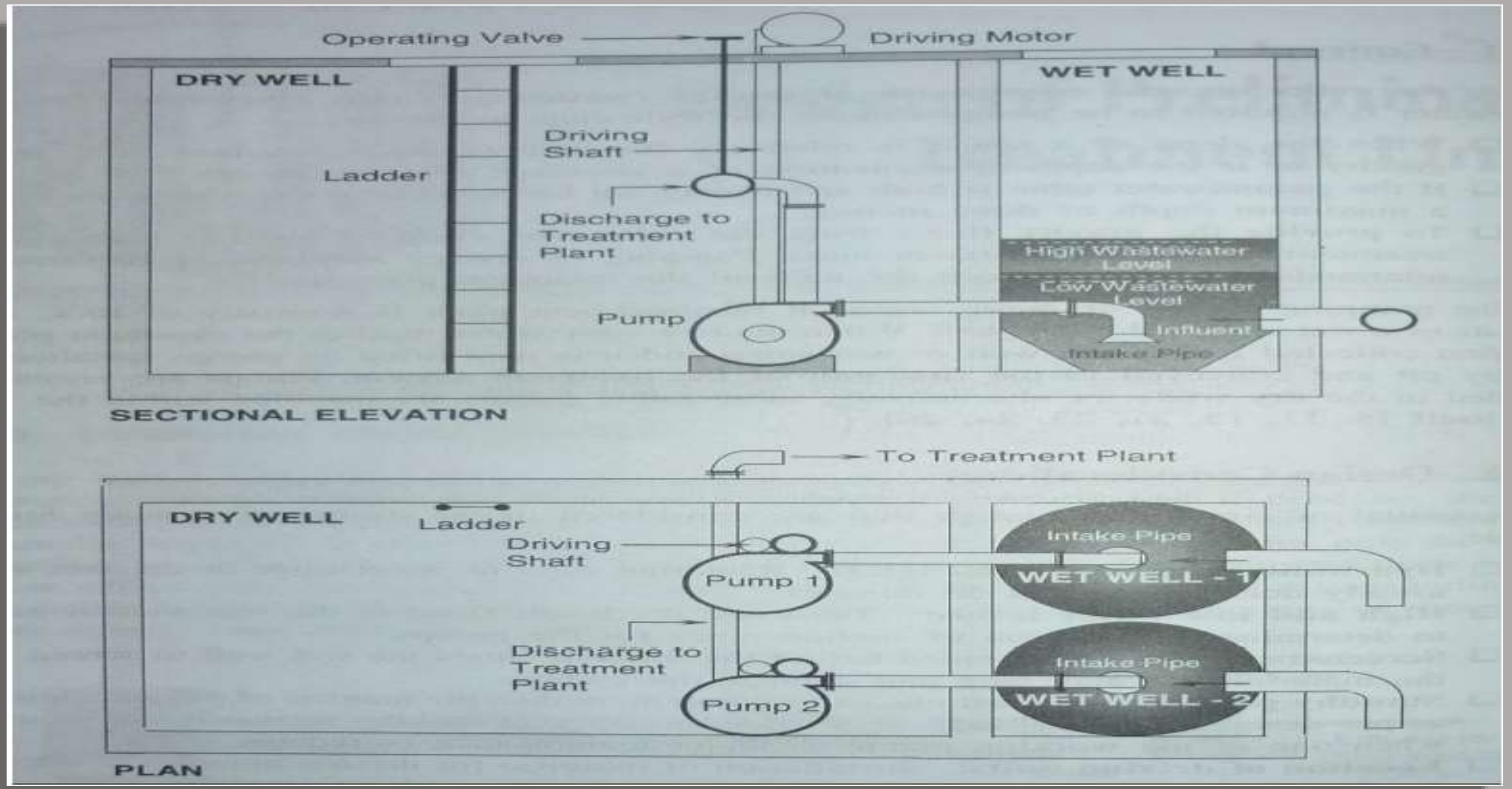
- **Proper location of pumping station requires a comprehensive study of the area to be served to ensure that the entire area can be adequately drained**.
- **If a very large quantity of sewage is to be pumped, the site should be nearer a stream, or a nallah or a storm water drain, into which the sewage could be discharged during emergencies such a break-down of the pumping plant**, failure of power etc.
- **If this precautions is not taken the station should be located and constructed in such a manner that it will not be flooded at any time**. The storm water pumping station capacity. The station be so located that if it is easily accessible under all weather conditions.

Pumping Stations

Elements of Pumping Stations

- Apart from the structure of the pump house, a sewage pumping station consists of the following elements:
- **(i) Grit Channel or detritus pit**
- **(ii) Coarse and fine Screens**
- **(iii) Sump or Wet Well**
- **(iv) Pump room or dry well**
- **(v) Pumps**
- **(vi) Miscellaneous accessories such as pipes, valves, float-switch arrangements, float-switching arrangements**, flow recorders, emergency overflows, ventilation arrangements such as extraction fans etc.

Elements of Pumping Stations



Pumping station

- **Dry well** :- For housing the pumps
- **Wet well: -** For incoming sewage.
- **Rising main**:- To led the pumped sewage to high leveled gravity sewer.
- **Pumps used**:- Centrifugal, Reciprocating, Propeller of axial flow, Air pressure pumps or ejectors

Elements of Pumping Stations

Pump House Structure

- **The pump house structure should be designed to withstand floatation forces to which it may be subjected**. The substructure of the pumping station may be of mass concrete or R.C.C while the superstructure may be constructed of any material. The internal walls & floors should be structurally designed to take the weight of machine along with the live load of **5 kN/ m^2**. **The building should be planned and designed keeping in view the requirements ad there should be enough scope for future expansion.**

Pump House Structure

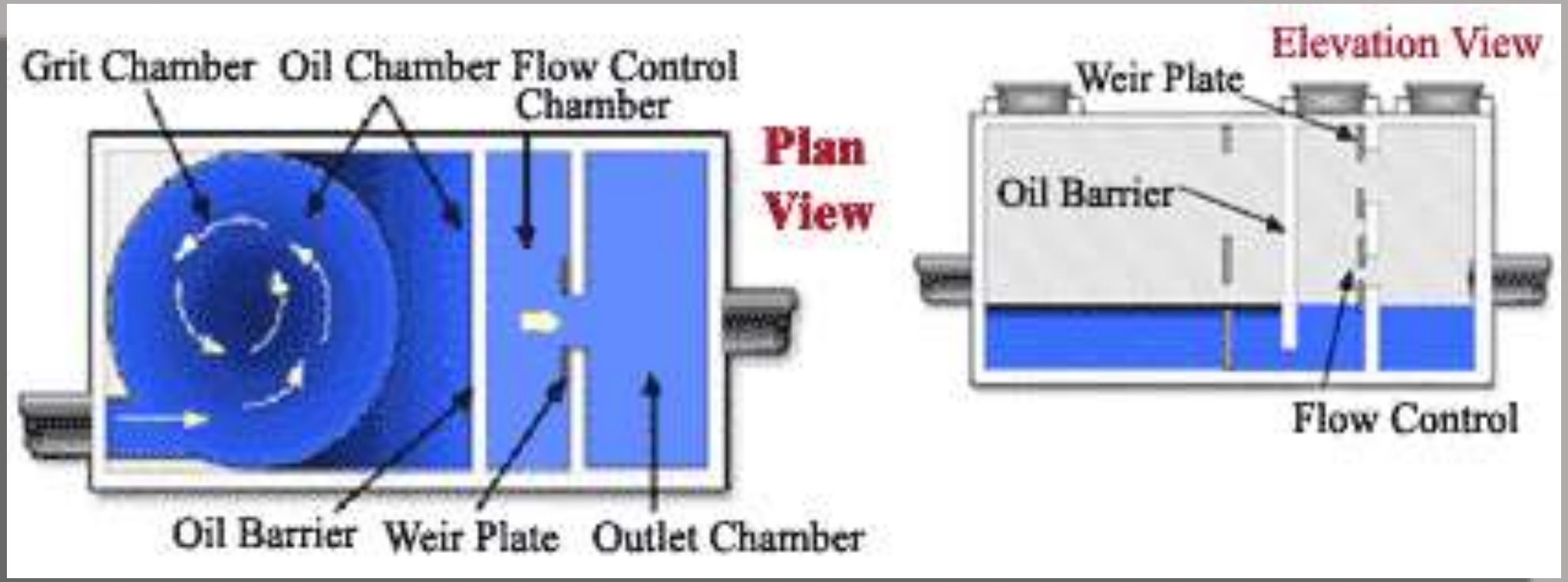
Pump House Structure

- **The building should contain wide passages, without any abrupt changes in levels**. The building should possess enough ventilation so that foul gases, moisture etc. are easily carried out of the building.
- **The ventilation equipment should have a minimum capacity of six air changes per hour.**
- The **component of the building should be safe against vibrations** caused due to pumping machinery. In designing the substructure due to allowances should be made for earth pressure, water pressure, and uplift pressure.
- **Natural or artificial illumination of the interior of the building should be adequate**. Dust proof, vapor Proof, fire proof and expansion proof, fixtures and **luminaries should be provided. It is advisable to provide stairs instead of ladders between different floors of the buildings** The use of spiral stairs should be avoided as far as possible

Pump House Structure

- **Grit Chamber or Detritus Pit**
- **The sewage entering into a pumping station contains a lot of Indestructible solid matter such as grit, rags, sticks, faeces.** Etc. all of which is in suspension as long as the sewage is flowing It is therefore essential to remove as much of this matter as possible before pumping so as to minimize the wear and tear of the pump impeller and the rising main.
- **The grit is separated from the sewage by the provision of grit or detritus pit before or after the screens.** A grit channel is a long basin with enlarged cross- section. **This results in the reduction of velocity of flow to 0.15 to 0.3 m/sec.**
- **The bottom of the pit is kept below the invert line of the sewer to allow the deposition of the grit that will not interfere with a sewage flow through the pit. The channel or pit should have a minimum capacity of 1 %** of daily dry weather flow. The channel or pit is designed to have a detention period of about 30 sec and the grit storage capacity of **0.013 to 0.028 ,m^3 per million ltres.** There should be two such unit each of which can be used, allowing the other to be cleaned. **The grit collected is removed manually once in a week in small installations, while in large installation, the removal is continuous daily process by means of a series of perforated buckets mounted or endless chain which is power driven**

Grit Chamber or Detritus Pit



Screens

Screens

- **After the removal of grit from the sewage, it is made to pass through the screens to trap the floating matter such as rags, sticks, paper**, etc.
- **It is necessary to remove these, otherwise they choke and damage the pumps.** Screens are of two types: Coarse and fine. In large Installations, it is usual to provide both the coarse screen being the first to intercept the flow. **Coarse screen is made up of wrought iron bars kept parallel to each other and having a clear spacing of 50 to 100 mm in between them.**
- **The material trapped by coarse screen can be removed by hand raking**. Fine screens should not trap any organic matter as far as possible.
- **The screenings trapped by fine screens are removed by mechanical rakes.**

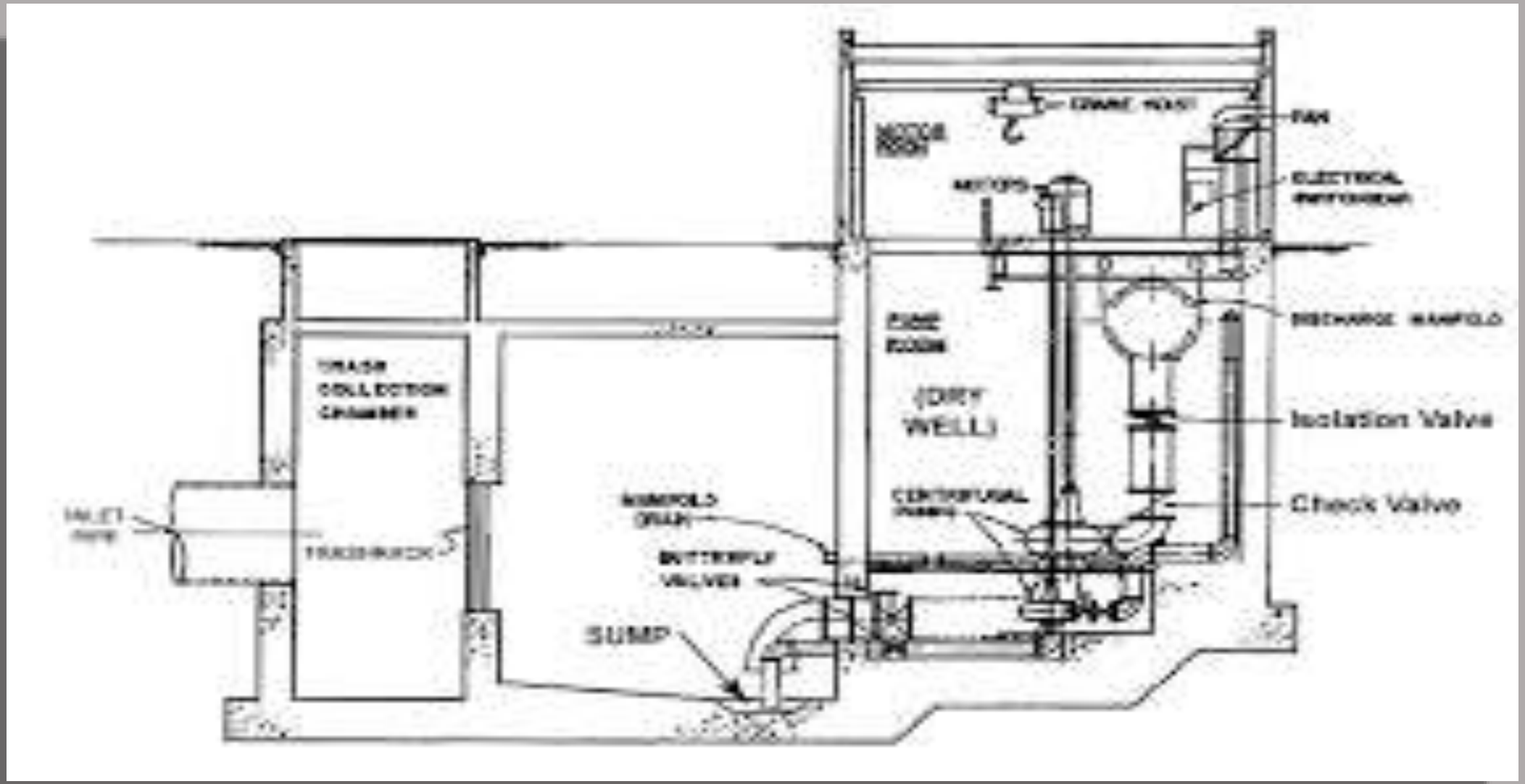
Screens

Sump Well

Sump Well

- **Pumping Station are provided with two separate wells**: Wet Well for receiving the incoming sewage and dry well for housing the pumps.
- **The function performed by a sump or wet well are to act as a suction pit from which pumps draw sewage and as equalizing basin** to minimize the load fluctuations on the pumps. The sump (or wet well) **is provided either below the floor of a pump house or by side of dry wells,**

Sump Well



Sump Well

- **The sump is so designed that the sewage can collect in it for a time the rise in the level operates a float switch which s suction linetarts the pumping unit and the sewage is operated at very frequent intervals due to smaller capacity of sump**. Usually a detention period of 30 min of sewage flow is adopted in design. **The shape of wet well and the detention time provided for sewage stations shall be such that depositions of solids is avoided and sewage does not turn septic.**
- **The capacity of wet well is reckoned between the levels at which air affects the suction line of the pump of minimum duty installed in the pump house** and the designed sewer level in the incoming sewer, i.e. the portion of the well below the upper most starting point and the lower most starting point. **It is governed by the pump set installed to deal with varying flow.**

Sump Well

In the dry well pumps are installed. **The pump is locate end of the suction pipe of pump** is located near the bottom of wet well.

The motor room is situated above the pump rooms dry well. Apart from electric motors, it also accommodates other appurtenances such as automatic starter flow recorder etc.

The flow recorders installed to know the quantity of sewage which is pumped per unit time, may be in the form of rectangular weir, standing wave flume, triangular weir or venture meter. The flow can also be recorded by suitable electrical device.

Rising Main Valves & fittings

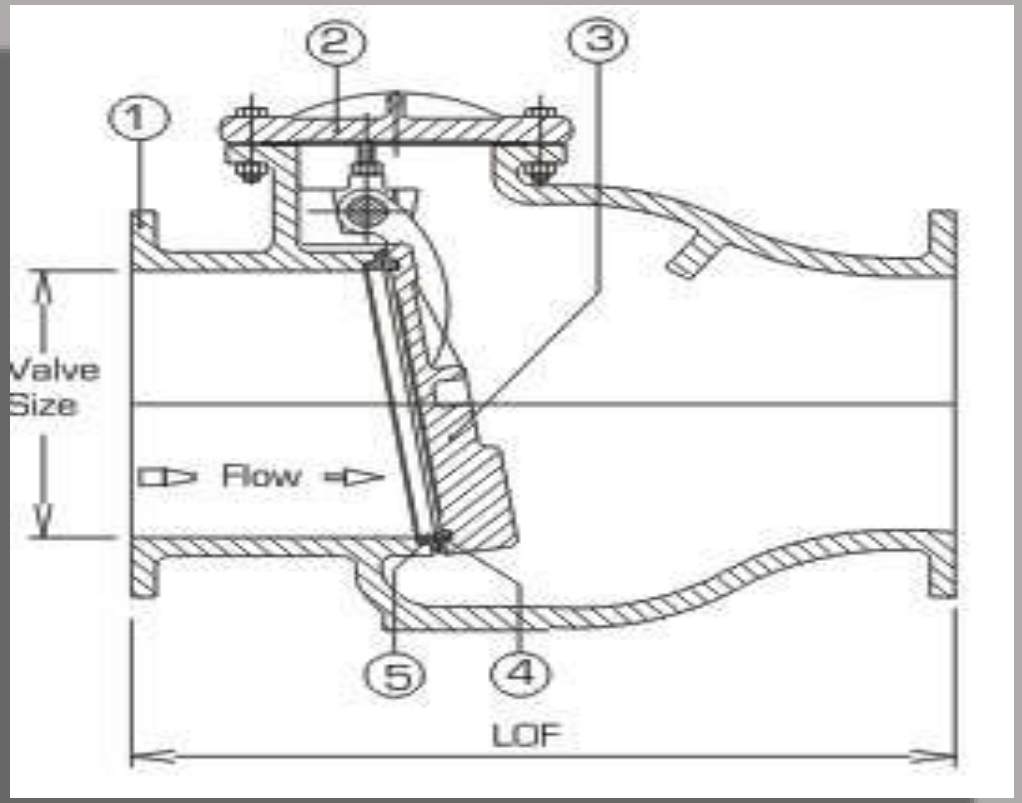
- **Rising Main valves & fittings**
- **The pumped sewage is led to high levelled gravity sewer through rising mains**.
- **The rising mains are made up of steel, cast iron spun iron or asbestos cement pressure pipes**, Generally, cast iron pipes with flanged joints are provided. The flanged joint provide easiness in dismantling the repair of pumping station equipment. **The length of the discharge pipe should be kept as small as possible beause long detention of sewage in closed pipes under pressure causes their anaerobic deterioration**. As far as possible rising main should rise steadily from the pumping stations to the point of discharge. The velocity of flow in the rising main should not be less than 0.75 m/sec. As the same time velocities higher than 2 m/sec should be avoided.
- **For economic design, the velocity of 0.85 m/sec for normal rate of pumping is desirable.**

Rising Main Valves & fittings

Rising Main Valves & fittings

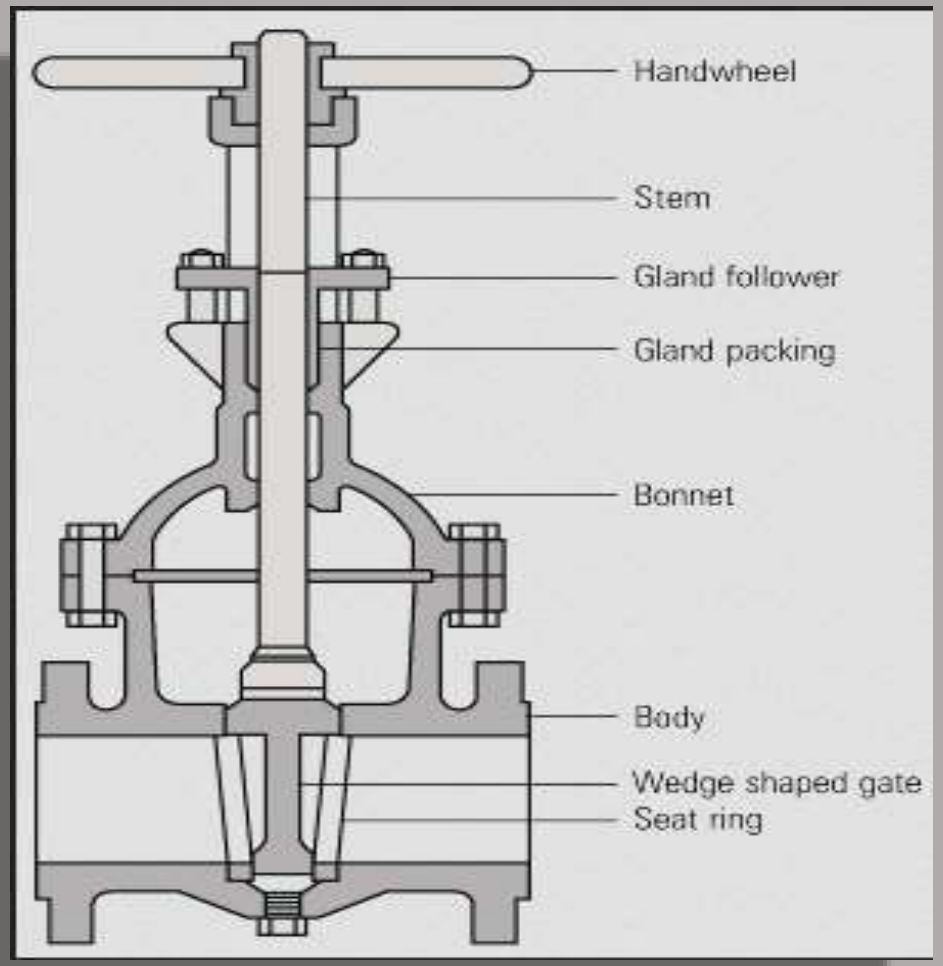
- **A reflux or non- return valve is fitted on the rising main, just next to the pump**, to prevent a backflow through the pump when the pump is stopped.
- **Check valve should be provided in the sewer line discharging** the sewage, to prevent the back flow of sewage during floods in the river or discharge area.
- **Gate valves should be provided on the sewer line just before the wet well and on the suction and discharging pipe to close** the flow of sewage during maintenance, inspection and repair of the pumps.

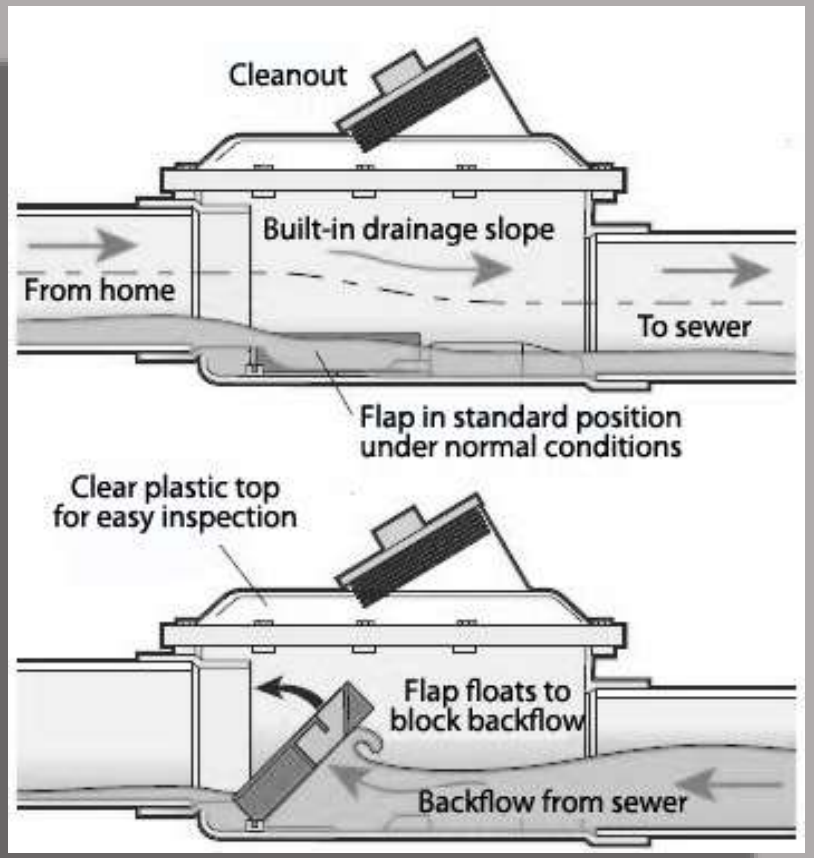
Rising Main Valves & fittings



Check Valve & Gate Valve

Check Valve & Gate Valve





Types of Pumps

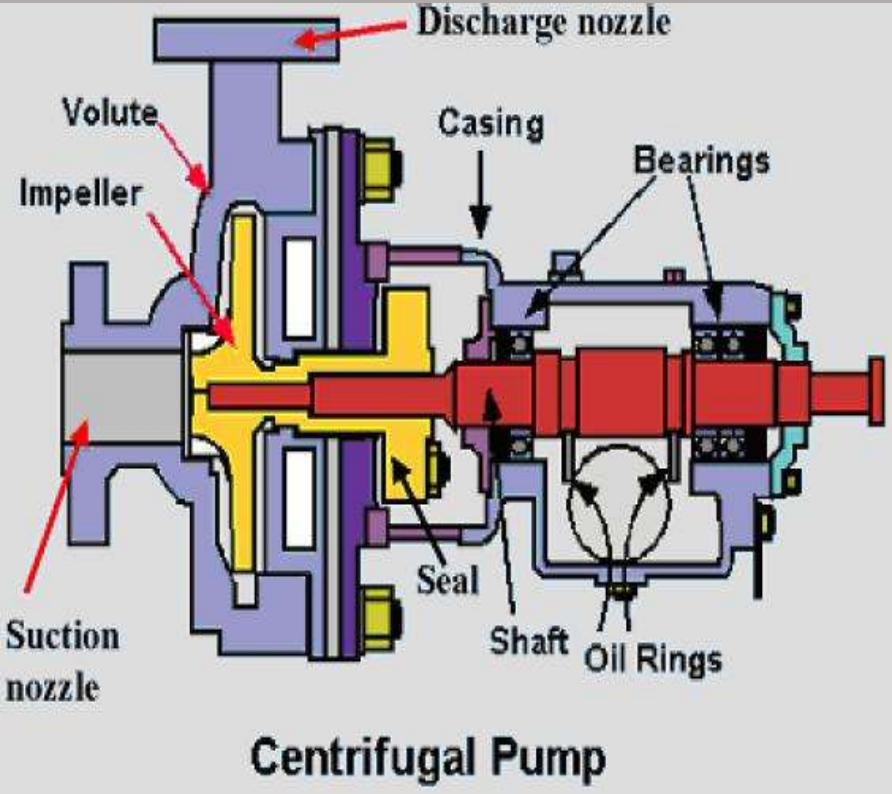
- **Following are the types of pumps commonly used for sewage and storm water pumping**
- (i) Centrifugal pumps
- (ii) Reciprocating pumps
- (iii) Propeller or axial flow pumps
- (iv) Air Pressure pumps or ejectors

Types of Pumps

Centrifugal Pump

- **Centrifugal pumps are most widely used for pumping sewage and storm water, as these can be easily installed in pits and sumps, and can easily transported the suspended matter in the sewage without getting clogged too often .** These pumps work on the principle of centrifugal force, **These essential consists of two main parts**
- **(i) The casing and**
- **(ii) The impeller**
- **The impeller rotates with high speed inside the casing**

Centrifugal Pump

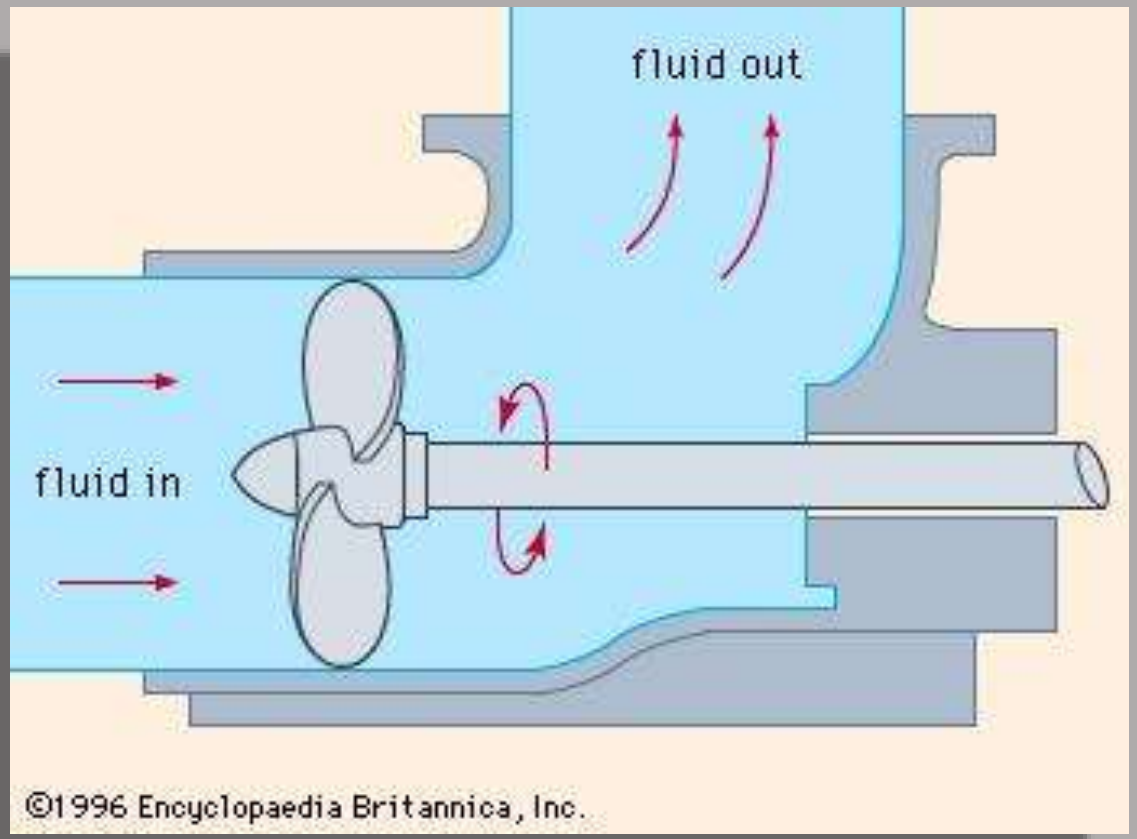


Centrifugal Pump

The centrifugal pump can be classified under

(a) **Axial flow pumps: Axial flow pumps develop most of their head by propelling action of the impeller vanes on the liquid**. They are characterized by a single inlet impeller with the flow entering axially and generally used for large installations with capacities greater than 2000 m^3/hr. and head less than 9 m. **The pumps are generally of vertical type. The axial flow pumps have relatively high specific speed ranging from 8000 to 16000**

Axial flow pumps

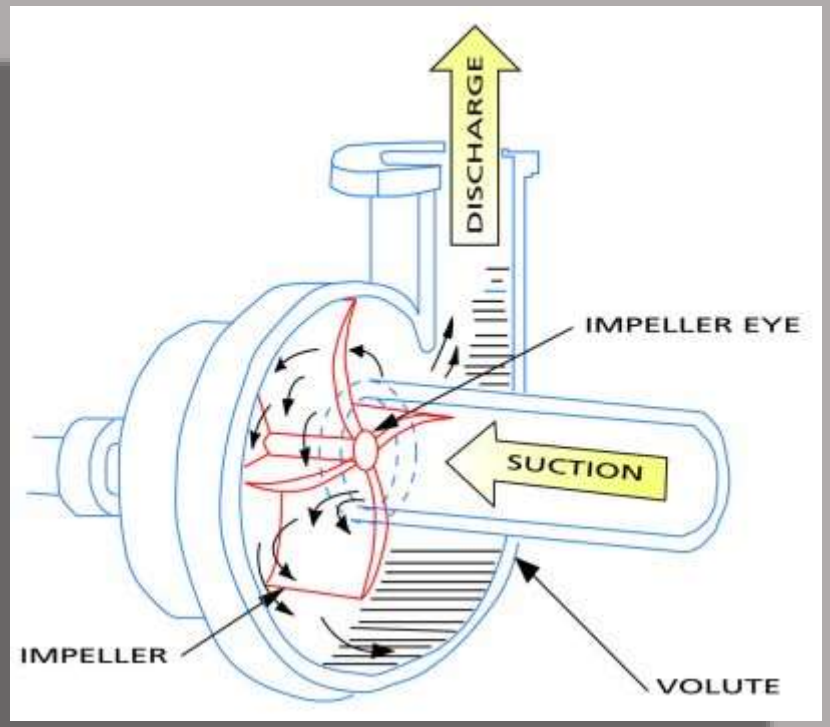


Mixed flow pump

Mixed flow pump

- **The head developed by mixing flow pumps is partly by centrifugal action and partly by the lift of the impeller vanes on the liquid.** The pump has a single inlet impeller with the flow entering axially and discharging in an axial and radial direction, usually into a volume type casing. **They are used for medium heads of 8 to 15 m and for medium to large capacities**

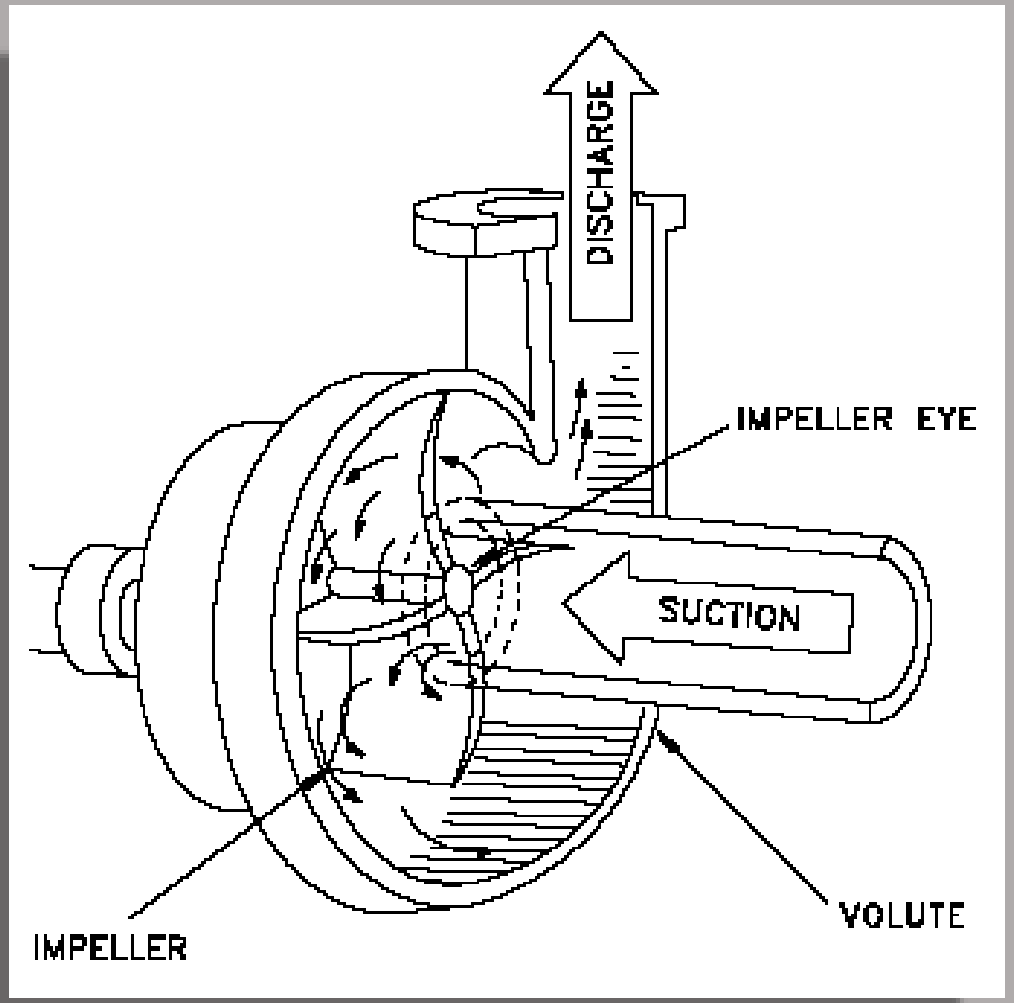
Mixed flow pump



Radial flow pumps

- **The head developed in these types of pumps is principally by the action of force. Pump of this type can be obtained with either single suction or double suction inlet impellers**, the flow leaving the impeller radially and normal to the shaft axis.
- **These pumps are characterized by relatively low speeds, with single inlet impeller having specific speed less than 4200 and double suction units having specific speed less than 6000** single suction pumps are generally used for sewage and storm water pumping as they are less susceptible to clogging

Radial flow pumps

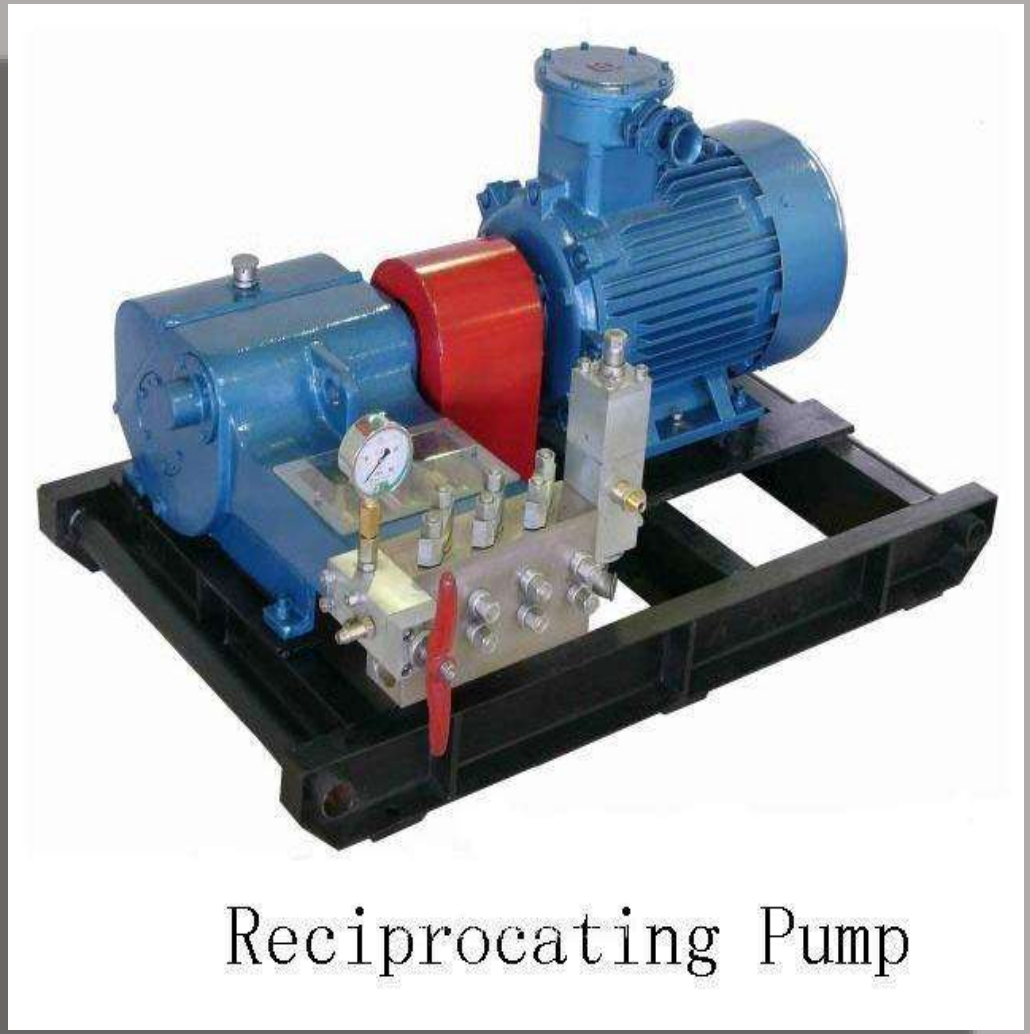


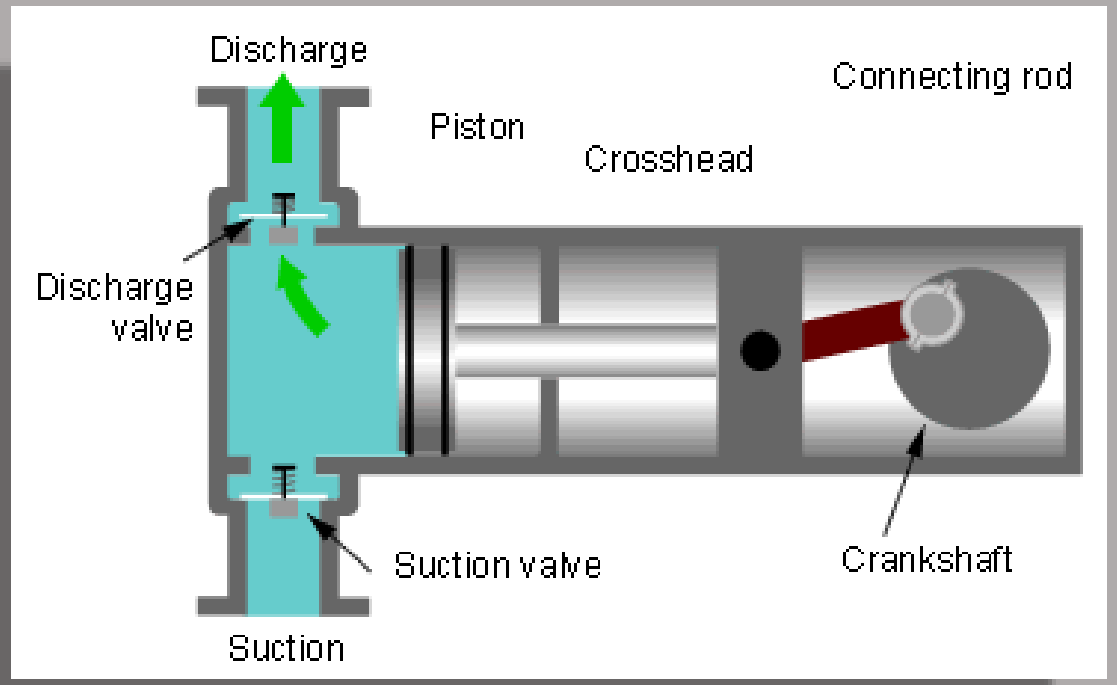
Reciprocating Pumps

Reciprocating Pumps

- **Reciprocating pumps are more or less obsolete in modern sewage pumping station since they are liable to be clogged by solids or fibrous material, even through sewage may have to pass through coarse screens.** Also their initial cost is higher and efficiency is lower than those of a centrifugal pump. **However, in cases where it is required to deal with difficult sludge's and where large quantity is to be pumped against low heads, reciprocating pumps may be used after passing the sewage through screen with 20 mm spacing.**

Reciprocating Pumps

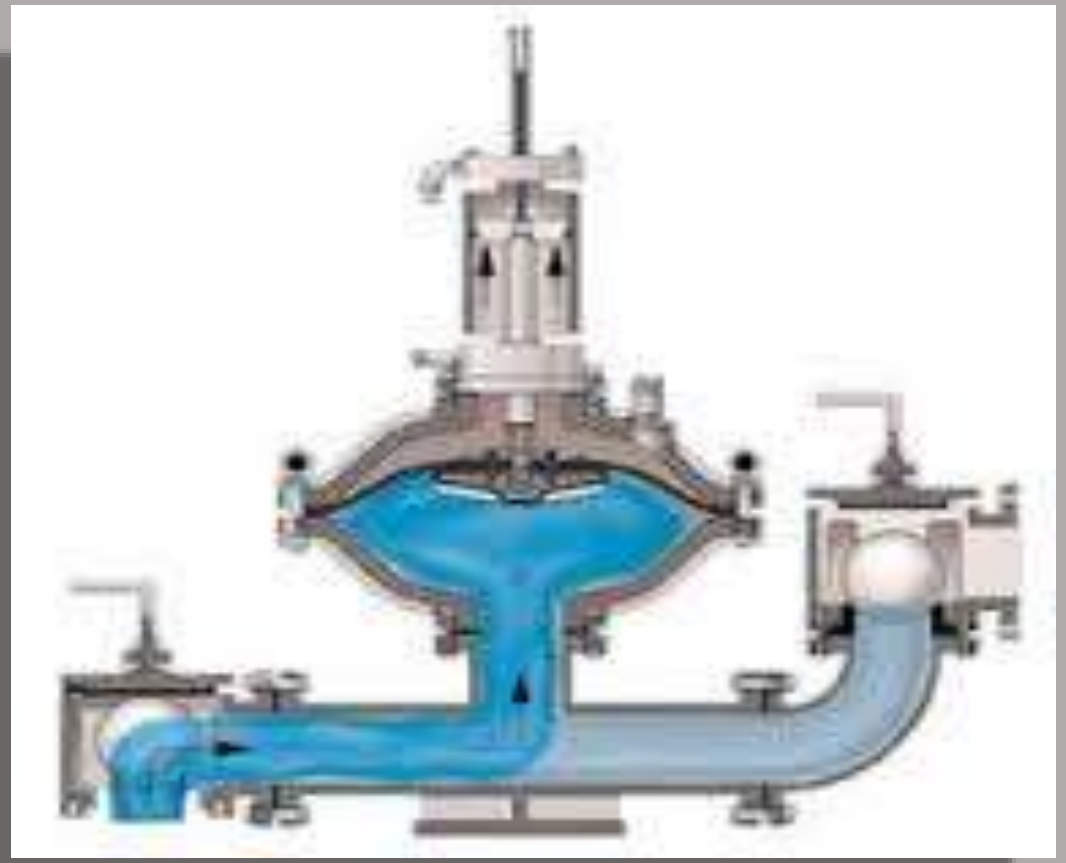


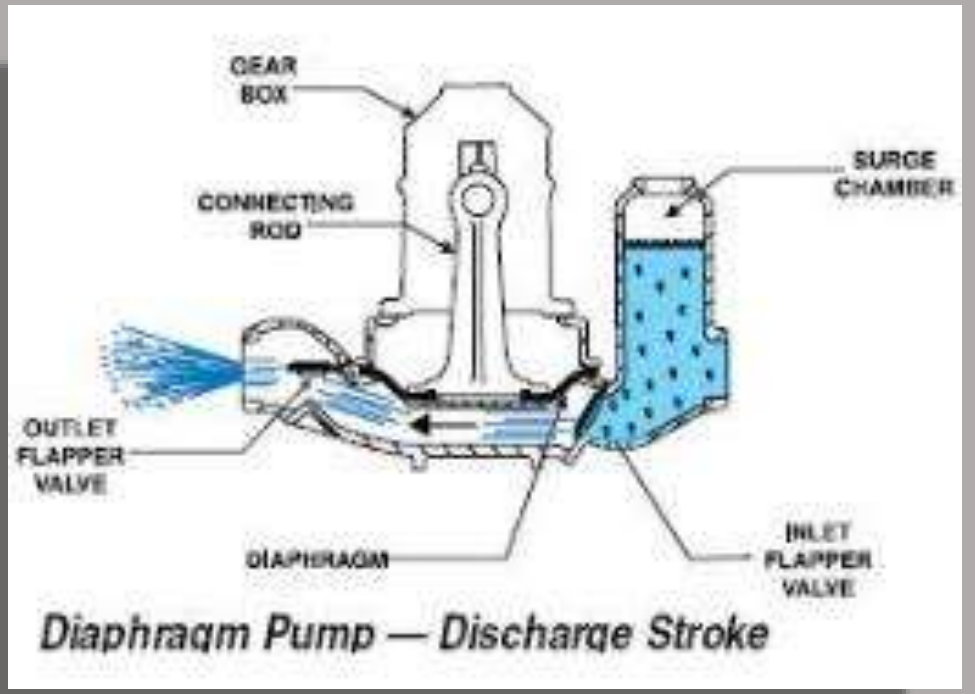


Reciprocating Pumps

- **Reciprocating pumps are of two types**
- **(i) Ram Type**
- **(ii) Propeller Type**
- **In the ram type reciprocating pump, a piston or plunger moves through gland displacing liquid in a vessel**. The piston is not arranged to fit closely in the cylinder .
- The **diaphragm pump is an example of the ram type reciprocating pump**.
- Diaphragm pump is a ram type reciprocating pump. In this pump a piston or plunger is attached to the centre of a circular rubber diaphragm permits the up & down motion of the plunger

Reciprocating Pumps





Propeller or axial flow pumps

- **Propeller or axial flow pumps**
- **The axial flow pump is sometimes called a propeller pump as its impeller resembles the propeller of a ship.**
- **The pump consists of a number of blades fixed like a screw threads on a vertical shaft, and there are vanes both on the inlet and outlet sides. When the propeller rotates**, these wanes guide the flow axially along the shaft. **The efficiency of axial flow pump is very low, to the extent of about 25 % or so. These pumps are suitable to pump large volumes of sewage against low head**

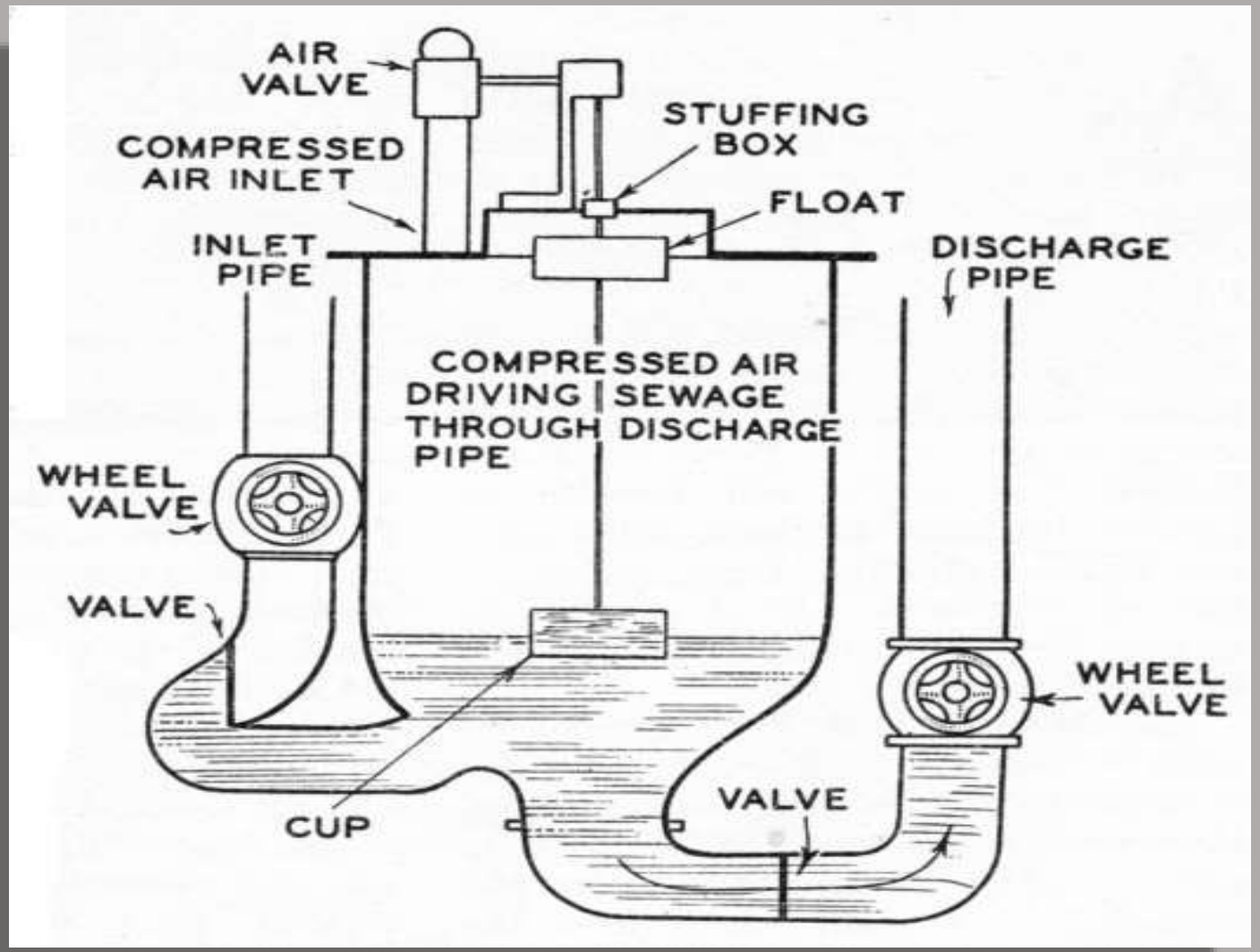
Propeller or axial flow pumps

Air Pressure pump or pneumatic ejectors

Air Pressure pump or pneumatic ejectors

- **Pneumatic ejectors work on the action of compressed air**
- These are used for the following conditions:
- **Where the small quantity of sewage is to be lifted from basement of buildings, to a high level sewer**
- **Where the quantity of waste water from the low lying area does not justify the construction of a pumping station**
- Where centrifugal pumps of smaller capacity are likely to clogged.

Air Pressure pump or pneumatic ejectors



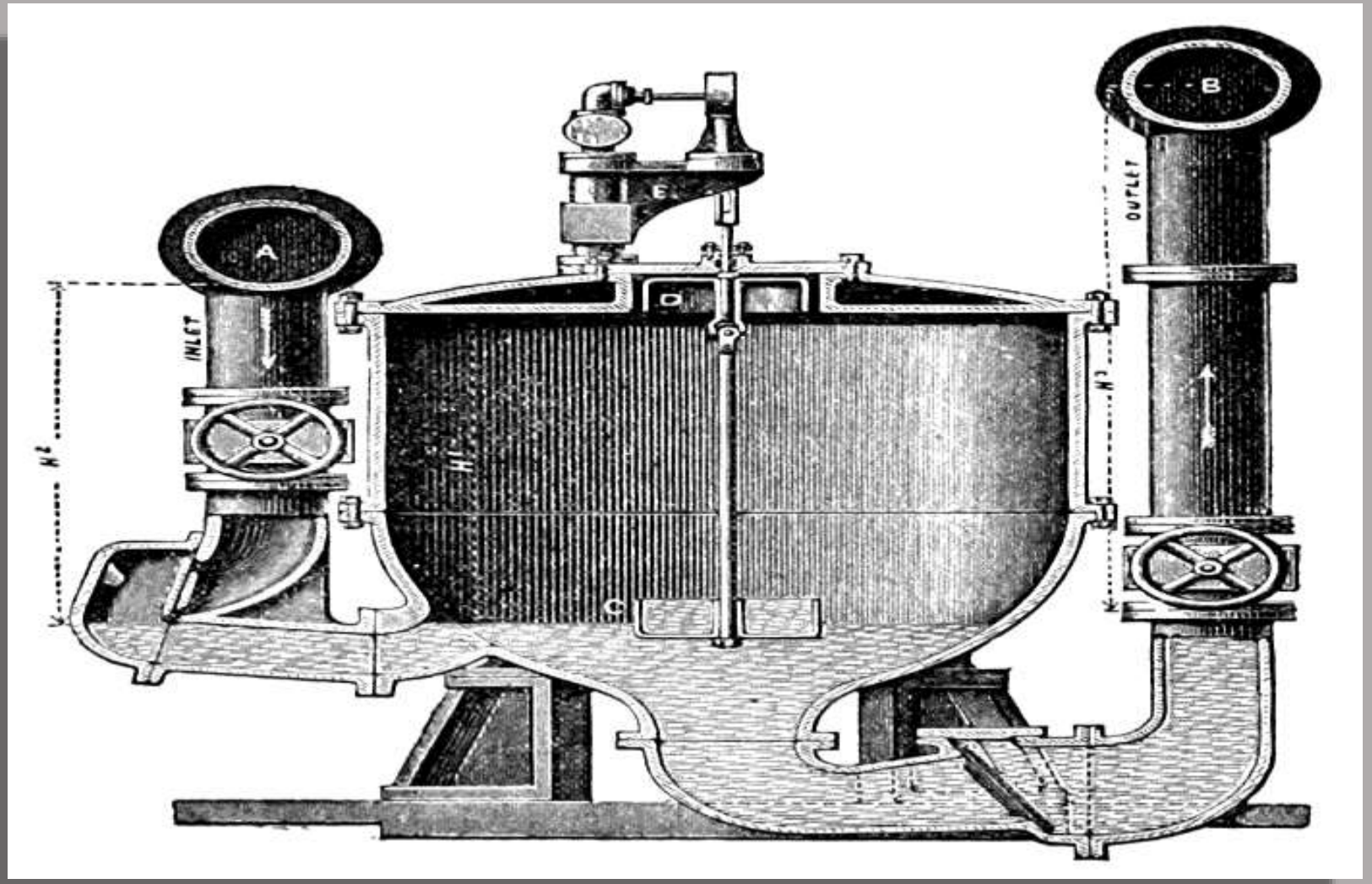
Advantages

- **The ejector possess the following advantages**
- (a) **No sewer gases escape except through the vent shaft as sewage is completely enclosed**
- (b) **Operation is fully automatic and the ejector comes into operation only when needed**
- (c) **Only a few part in contact with sewage thus necessitating** little attention or lubrication.
- (d) Ejector less **susceptible to clogging**

Air Pressure pump or pneumatic ejectors

- **The ejector consist of a cast iron chamber with a spindle having a bell at its upper end and a cup at its lower end. Two check valves V1 & V2 are provided at entrance and exit ends respectively The Compressed air** is supplied through this valve at a pressure of about 1.5 kg/ cm^2
- **The sewage enters through valve V1 and rises slowly in the chamber, the exit valve V2 and air inlet valve V3 being closed at this stage. As the level rises, the air from the chamber escapes through the exhaust. When the sewage reaches the bottom of upper cup is entrapped.** Further rise in level of sewage makes the entrapped air to exert vertical pressure on the spindle. Due to this , spindle is lifted up the lever is operated, the exhaust is closed and air entrance valve V3 opened. The air entering under pressure forces the sewage inside the chamber to rise in the outlet pipe through the exit valve V2 which also opens at this stage while entrance valve V1 closes. The sewage in the chamber is discharged.

Air Pressure pump or pneumatic ejectors



Air Pressure pump or pneumatic ejectors

- **When the sewage in the chamber is discharged. When the sewer level in the chamber fall below the cup, the weight of the sewage in the cup causes the spindle to be dragged down**, This cuts off the compressed air and open the ejector to the atmosphere by opening the exhaust.
- **The volume of air storage tank and the characteristics of the compressor should be adequate to provide at least 40 % higher than that required to raise all the sewage to the maximum computed lift.**

Power for Pumps

Power for pumps

- Power for the operation of pump can be supplied by use of the following
- **(i) Stream engine**
- **(ii) Internal Combustion engine**
- **(iii) Electric Motors**

Power for Pumps

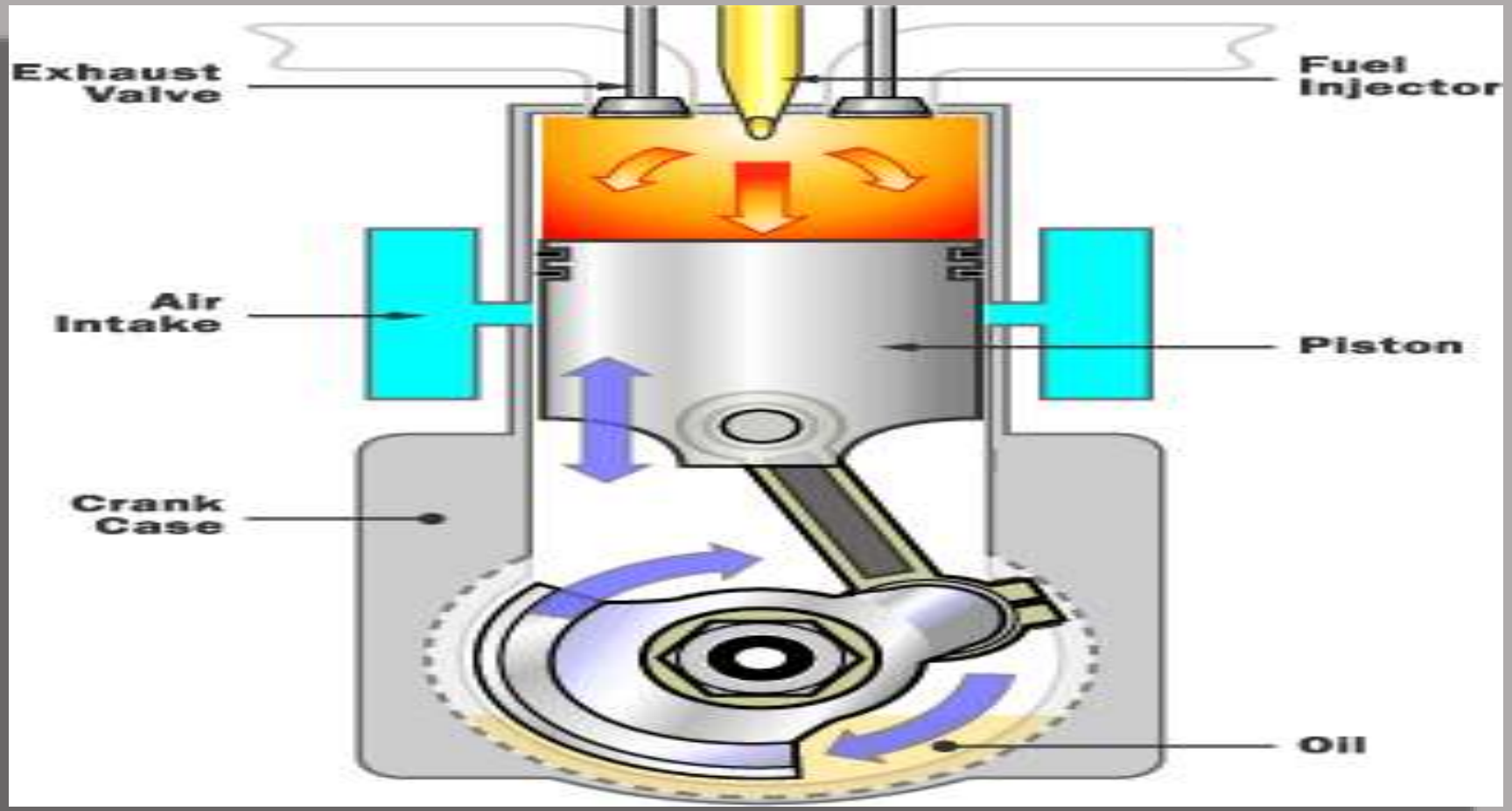
Steam engine

- **Earlier, steam engine were used for the operation of pumps, but they are not much in favor due to the following reasons**
- They have large initial cost and are not economical unless their use is on the large scale such as in mine or forest area
- Because large number of moving parts, they have high maintenance cost.
- However steam power is more reliable.

Internal Combustion engine

- **Internal Combustion engine**
- **I.C engine may run either on diesel or gasoline**. The initial cost of diesel engine is **very high and they are difficult to start, and also their speed is low**
- Similarly the **operational cost of gasoline engine is very high .**
- Hence **I.C engines are used only in emergency, or when electric power is not available.**

Internal Combustion engine



Electric Motor

- **Electric motor**
- **Pumps are operated through electric motors, in the majority of the cases.** They are very convenient and free from most of the objections mentioned above They are compact, silent, automatic in action and free from nuisance of smoke. **They occupy less building space and can be installed immediately above the pumps,**

Electric motor

References

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- Environmental Engineering : By *Prof B.R.Shah*
  Prof A M Malek

- Internet Websites

Thanks !

GHT