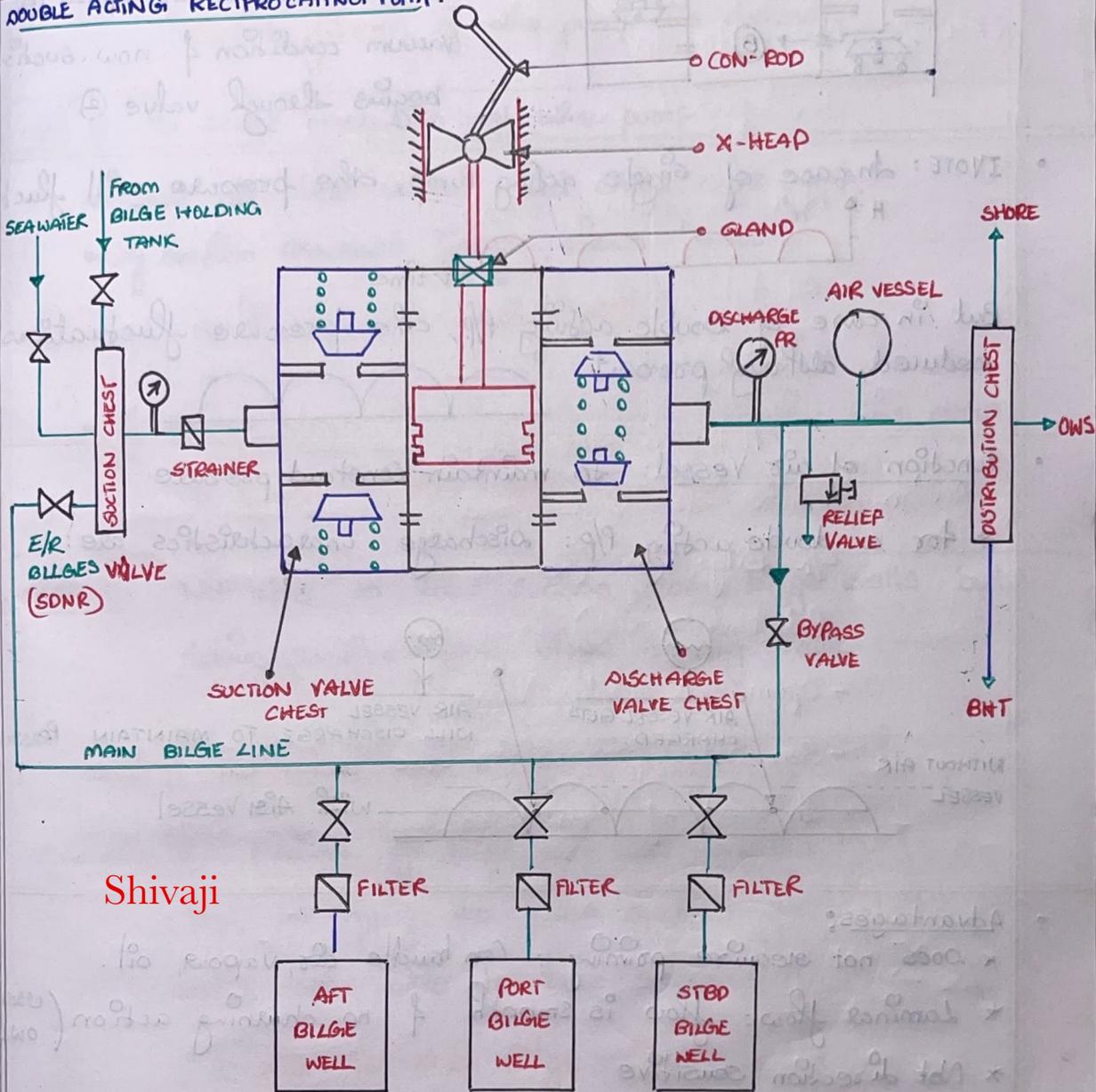


# RECIPROCATING PUMP:

- A type of Positive Displacement PP (liquid follows the direction of plunger move and fixed control volume is displaced)

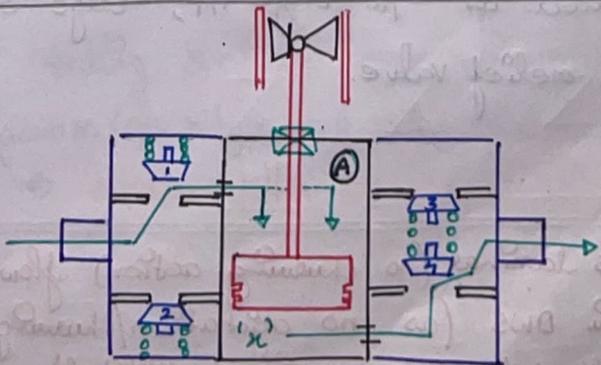
## DOUBLE ACTING RECIPROCATING PUMP:



Shivaji

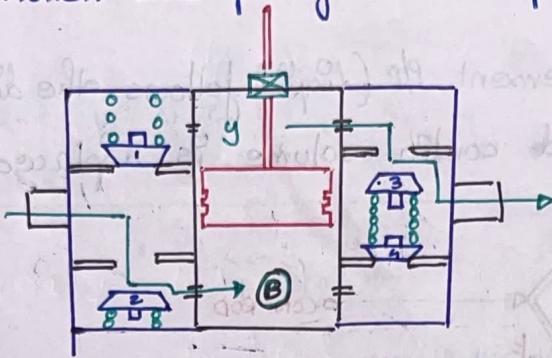
### System Description:

When the plunger moves down, liquid from previous stroke 'x' will be compressed and discharged as shown (Valve 4)



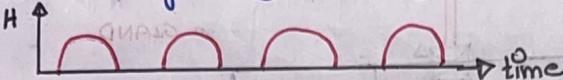
At the same time, space (A) will create vacuum and draw in fluid through Valve 1 i.e. Taking suction from top and discharge at bottom

→ When the plunger moves up, liquid 'y' gets compressed and gets discharged through discharge valve (3) as shown

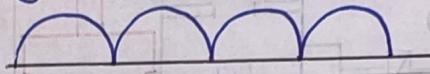


\* At the same time, space (B) gets vacuum condition & now suction begins through valve (2)

- NOTE: In case of single acting pump, the pressure will fluctuate

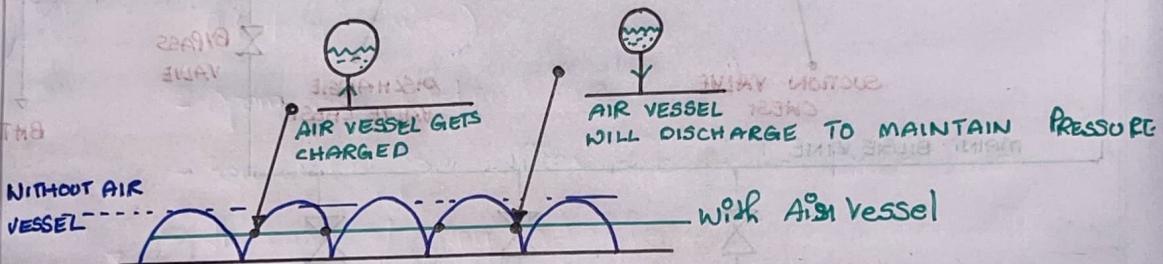


But in case of double acting P/p, the pressure fluctuations are reduced, although present



- Function of air Vessel: to maintain constant pressure

\* for a double acting P/p: discharge characteristics are:



- Advantages:

- \* Does not require priming: Can handle air, vapour, oil.
- \* Laminar flow: flow is smooth & no churning action (used in DWS)
- \* Not direction sensitive

- Disadvantages:

- \* Capacity of pumping is very low (low flow rate)  
i.e., why, used as E/R Bilge P/p, cargo stripping pump
- \* It requires a relief valve.

- NOTE: Due to its laminar (no churning action) flow characteristics, it is used in DWS (as no agitation/churning of oil-water mixture shall take place as it is difficult to separate)

## TROUBLESHOOTING OF BILGE SYSTEM:

CASE I: Vacuum on suction gauge, But pump is not taking suction

⇒ "Suction filter" of the pump is choked.

CASE II: To check operation of the pump

→ shut all inlet valves and start the pump

\* If suction pressure gauge shows "vacuum"

⇒ "Pump works satisfactorily"

\* If vacuum drops immediately upon stopping the pump:

⇒ "Valves in the valve chest are leaking"

CASE III: Not able to take suction from bilge wells but taking suction from Bilge Holding Tank

→ filter/Mud box of Bilge wells are choked.

Scenario I: Earlier Aft bilge well was emptied.

- Now, on trying to take suction from other bilge wells, not able to take suction

⇒ "Air in Main Bilge Line"

→ Aft bilge well line valve open or leaking.

Scenario II: Suppose Aft Bilge Well successfully pumped out and when trying to open post bilge well not taking suction even though gauge shows full vacuum (Aft bilge well valve shut & Pump Suction Gauge → Vacuum)

⇒ "Suction filter of Post Bilge Well choked"

- CASE IV: - All bilge wells have bilge water
- R/p Vacuum Gauge shows Vacuum
  - filters are choked.

CASE V: Not able to pump out any bilges and no vacuum developed (even though valves are shut)

"Air is getting drawn in"

- All bilge wells have water and also, if the valves are shut, No vacuum develops

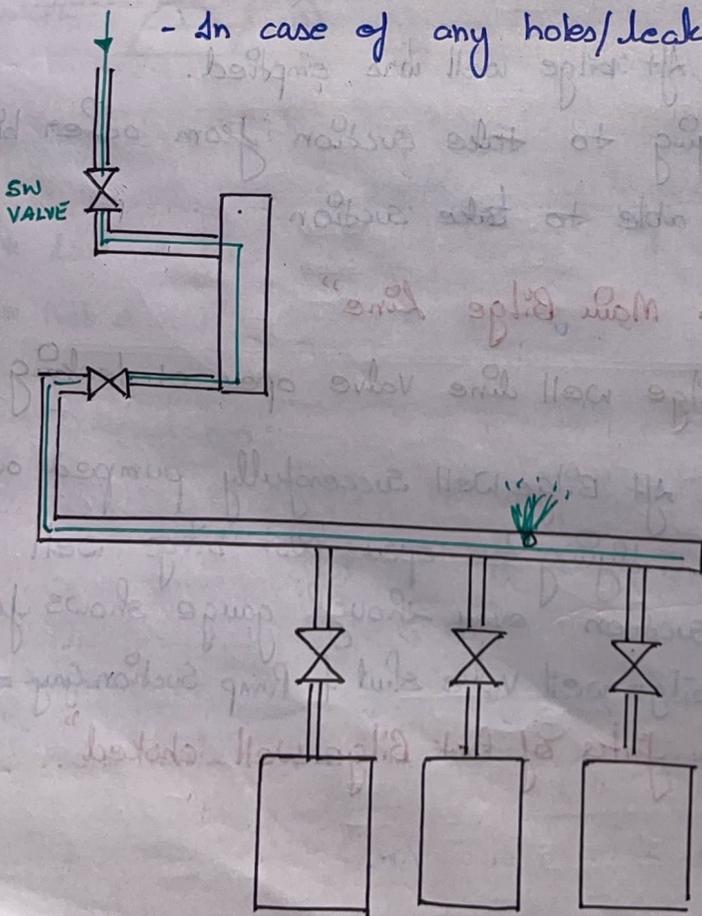
"Hole in the bilge pipeline"

Action: remove the valve and put back the cover of S/R Bilge valve (Remove cover, take out valve lid, Put back cover)

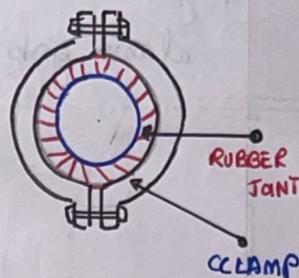
- Open Sea Water Valve

- Sea water permeates the main bilge line

- In case of any holes/leaks, sea water will



- In case of small leak: Rubber Joint + Jubilee clip or C-clamp
- If time available: Clean Area and Apply Cosdabond/Devcon (will dry 5-6 hours)
- Long term repair: Replace the pipe.



### MAINTENANCE:

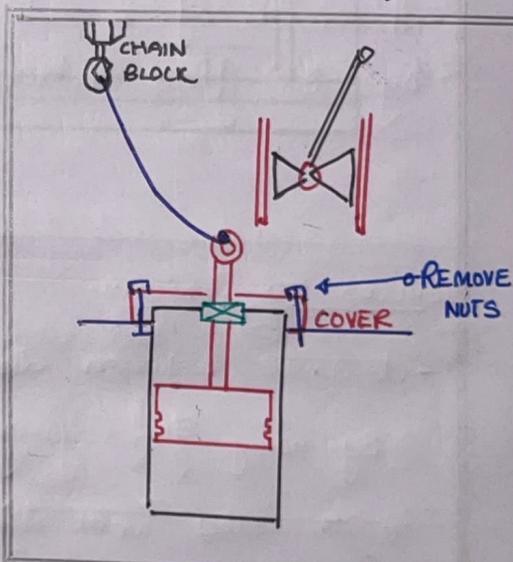
i) Regular cleaning of filters

ii) Valve chest to be cleaned

- Valves may get fouled due to contaminants
- Lap the valve & valve seat
- check spring condition

iii) After 1000 sunny hours or as specified in the manual, Take out the plunger

- Remove a pin on the X-Head
- Attach wire sling to piston rod and with the help of chain block, lift up the piston (Ensure End cover is loosened)
- Cover will come out with piston



- \* Check condition of Piston rings: Replace if worn down
- \* Check liner condition: Gauge if necessary.
- \* Check operation of relief Valve.

• USE OF BY-PASS VALVE: Bypasses back to Bilge line

- To control the quantity (Do not control by discharge valve)
- It can decrease the flow rate upon opening - as the displacement p/p.

### HOW TO CHECK BILGE WELL ALARM?

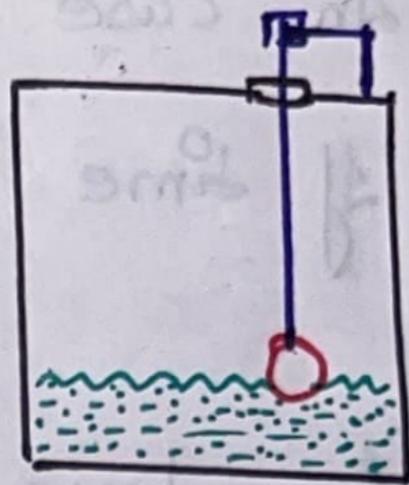
Wrong Method: Lifting up the float. Alarm

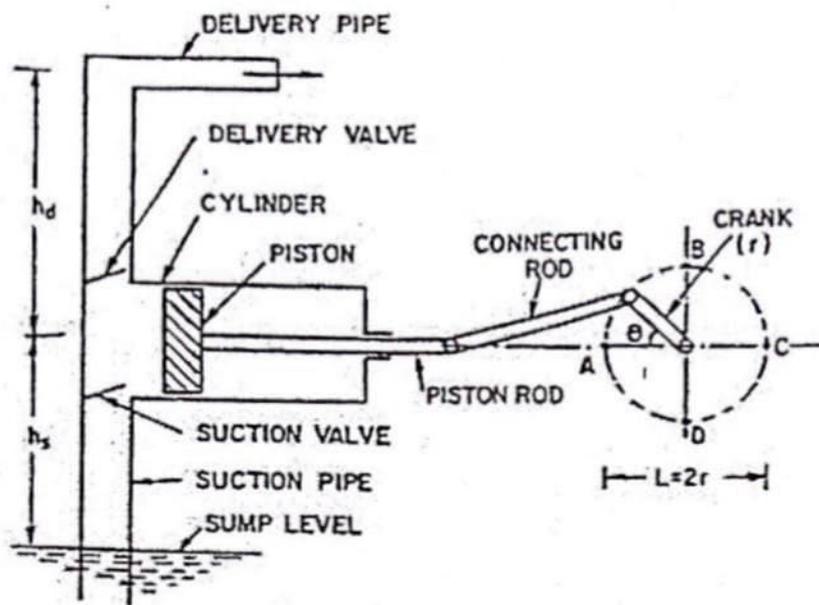
- But if float has a hole, Bilge gets flooded and no alarm gets activated

If the float has a hole, it will not lift.

### Authentic Method:

- fill the bilge well with water and test if alarm gets activated.





Single acting reciprocating pump:- A single acting reciprocating pump, which consists of a piston which moves forwards and backwards in a close fitting cylinder. The movement of the piston is obtained by connecting the piston rod to crank by means of a connecting rod. The crank is rotated by means of an electric motor. Suction and delivery pipes with suction valve and delivery valve are connected to the cylinder. The suction and delivery valves are one way valves or non-return valves, which allow the water to flow in one direction only. Suction valve allows water from suction pipe to the cylinder which delivery valve allows water from cylinder to delivery pipe.

The rotation of the crank brings about an outward and inward movement of the piston 'P' in the cylinder 'C'. During the suction stroke the piston is moving towards right in the cylinder, this movement of piston causes vacuum in the cylinder. The pressure of the atmosphere acting on the sump water surface forces the water up in the suction pipe 'S'. The forced water opens the suction valve V1 and the water enters the cylinder. The piston from its extreme right position starts moving towards left in the cylinder. The movement of the piston towards left increases the pressure of the liquid inside the cylinder more than atmospheric pressure. Hence suction valve closes and delivery valve V2 opens. The liquid is forced into the delivery pipe and is raised to a required height.

For one revolution of the crank, the quantity of water raised up in the delivery pipe is equal to the stroke volume in the cylinder in the single acting pump and twice this volume in the double acting pump.

Discharge through a single acting reciprocating pump.

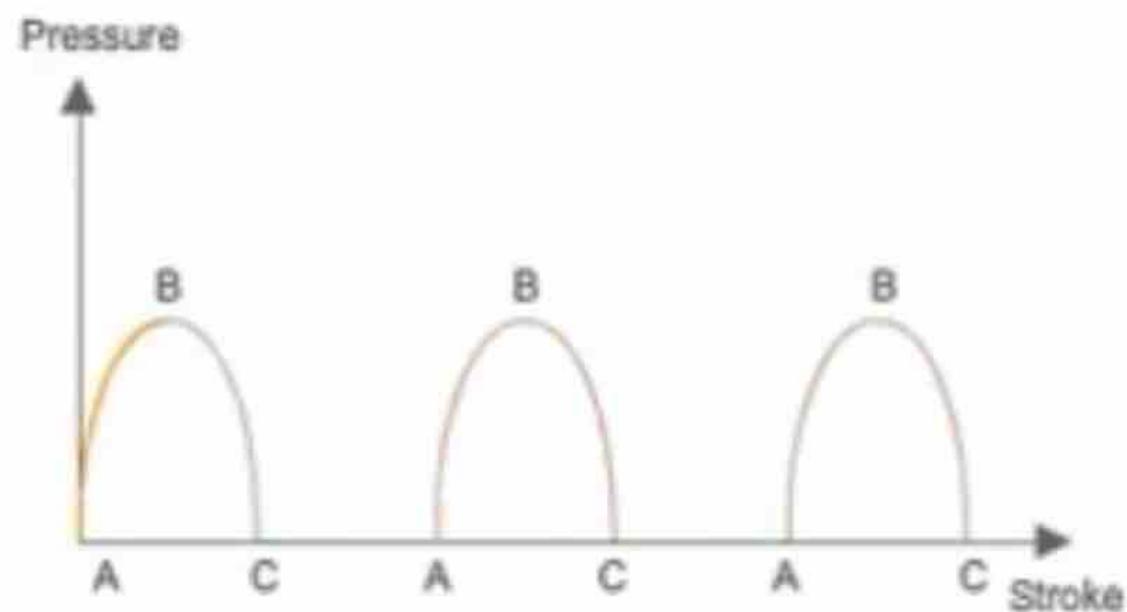
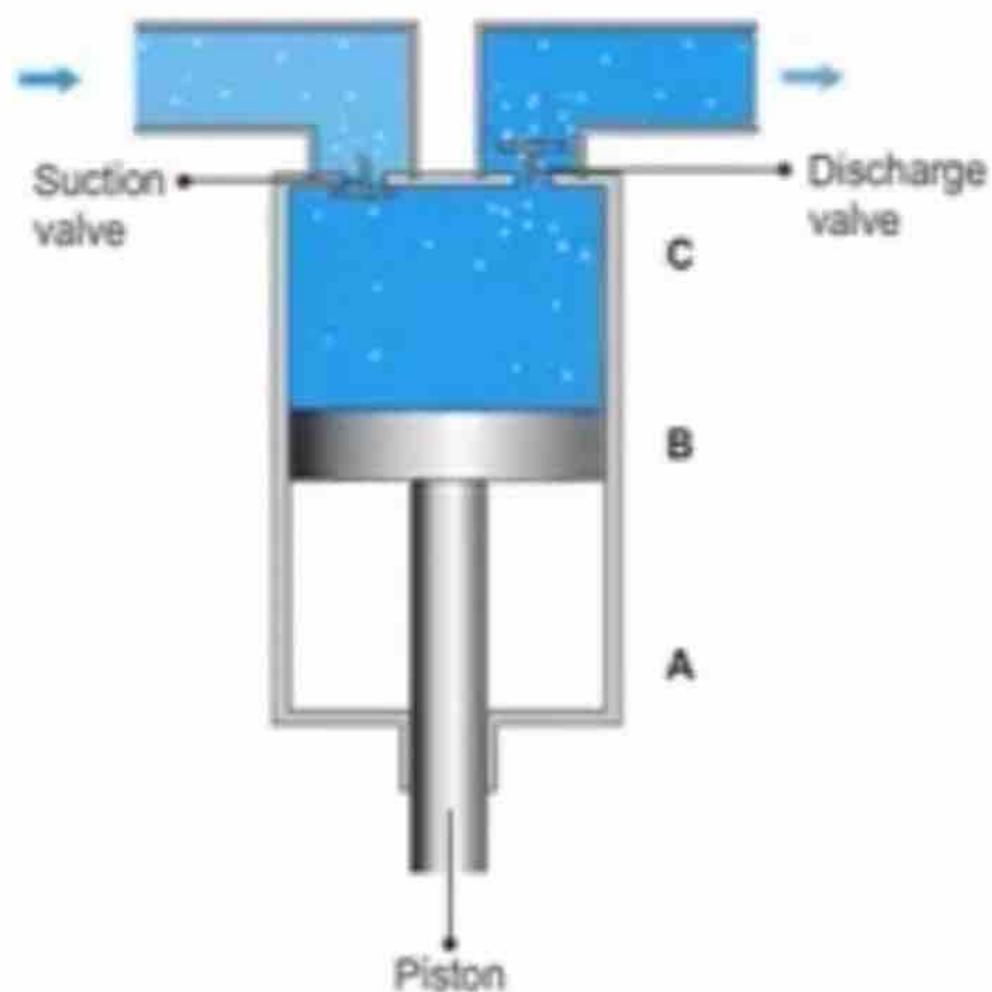
$D$  = diameter of the cylinder

$A$  = cross section area of the piston or cylinder

$r$  = radius of crank

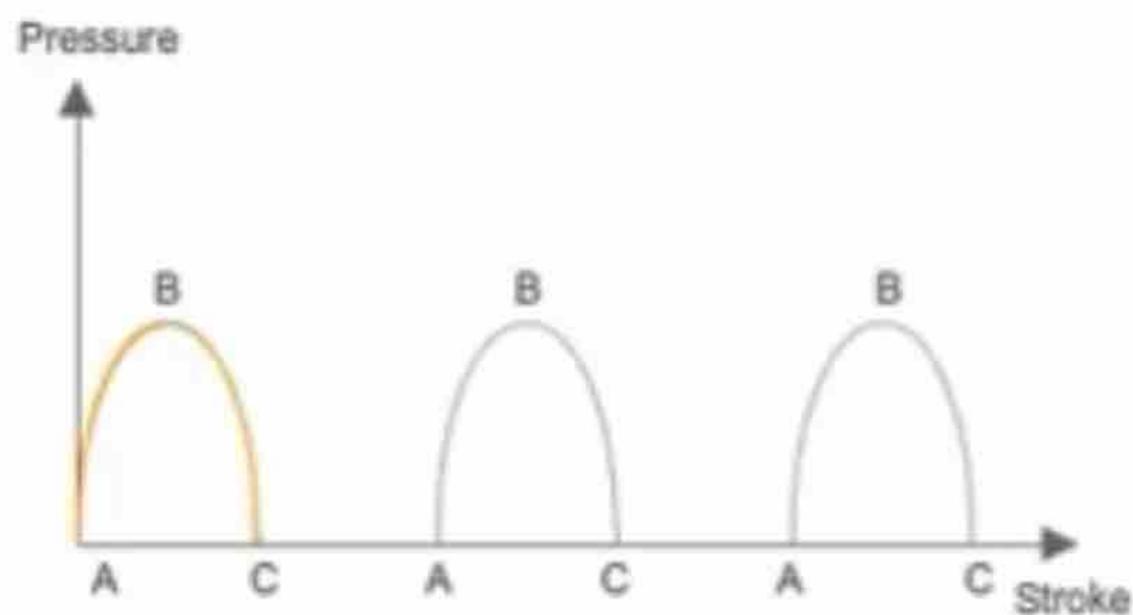
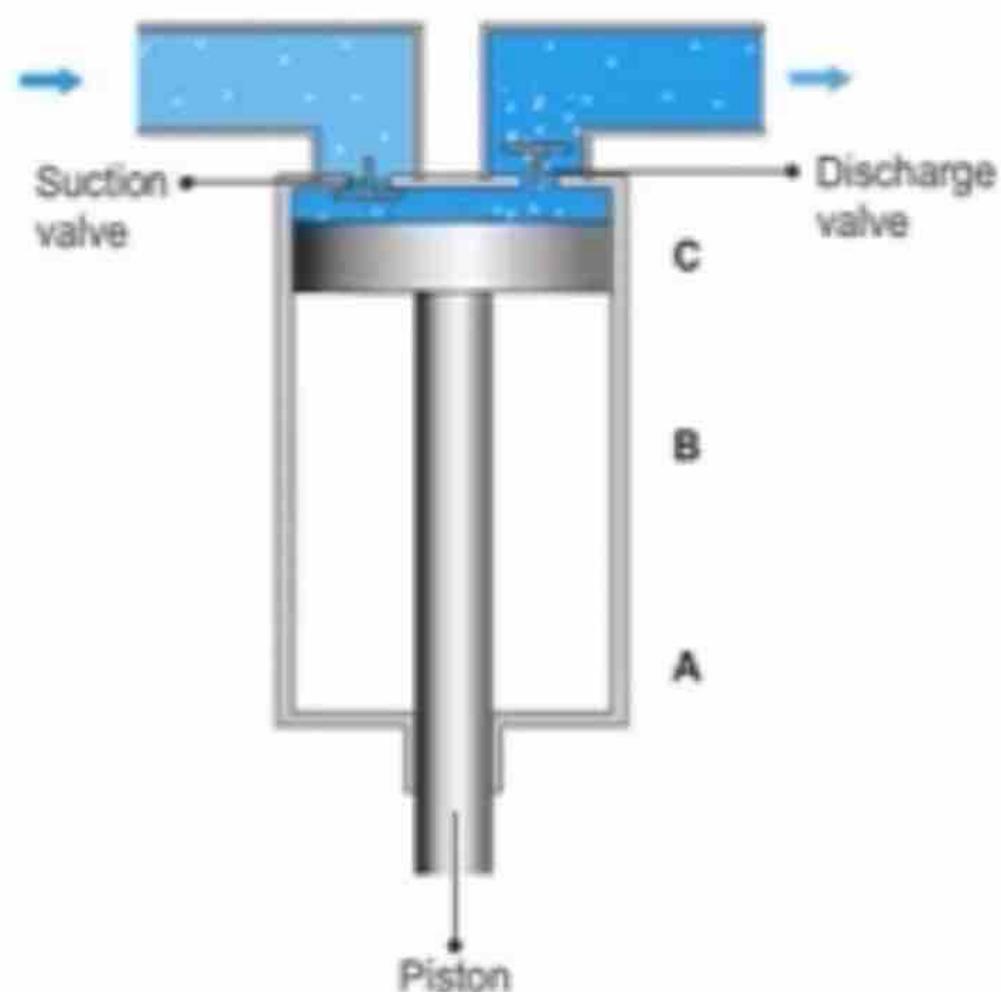
$N$  = r.p.m of the crank

$L$  = Length of the stroke =  $2 \times r$



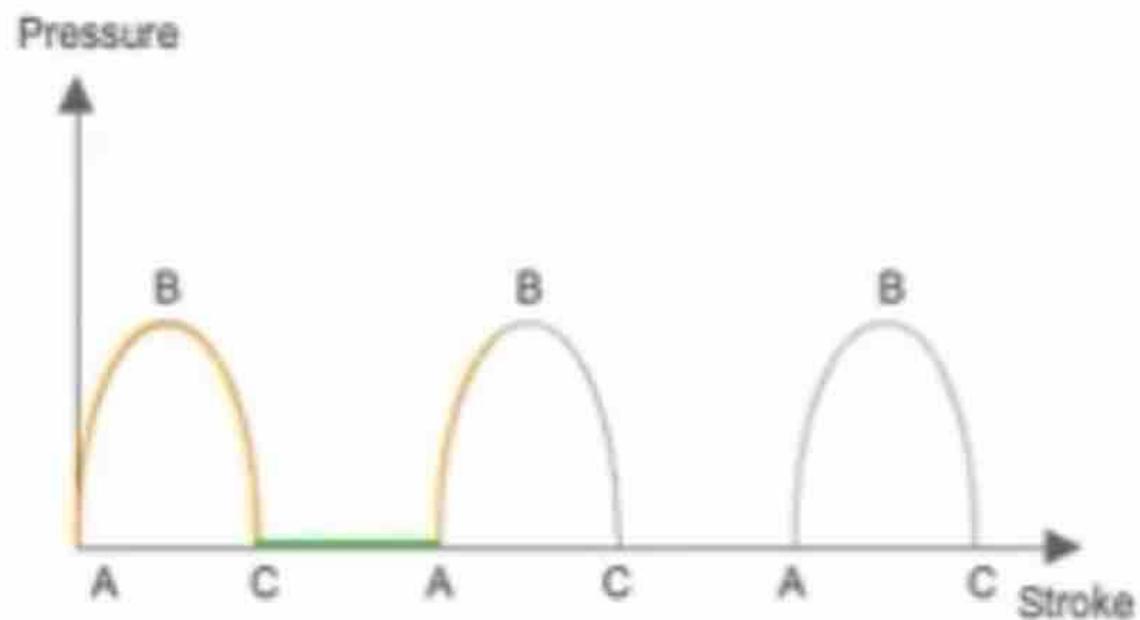
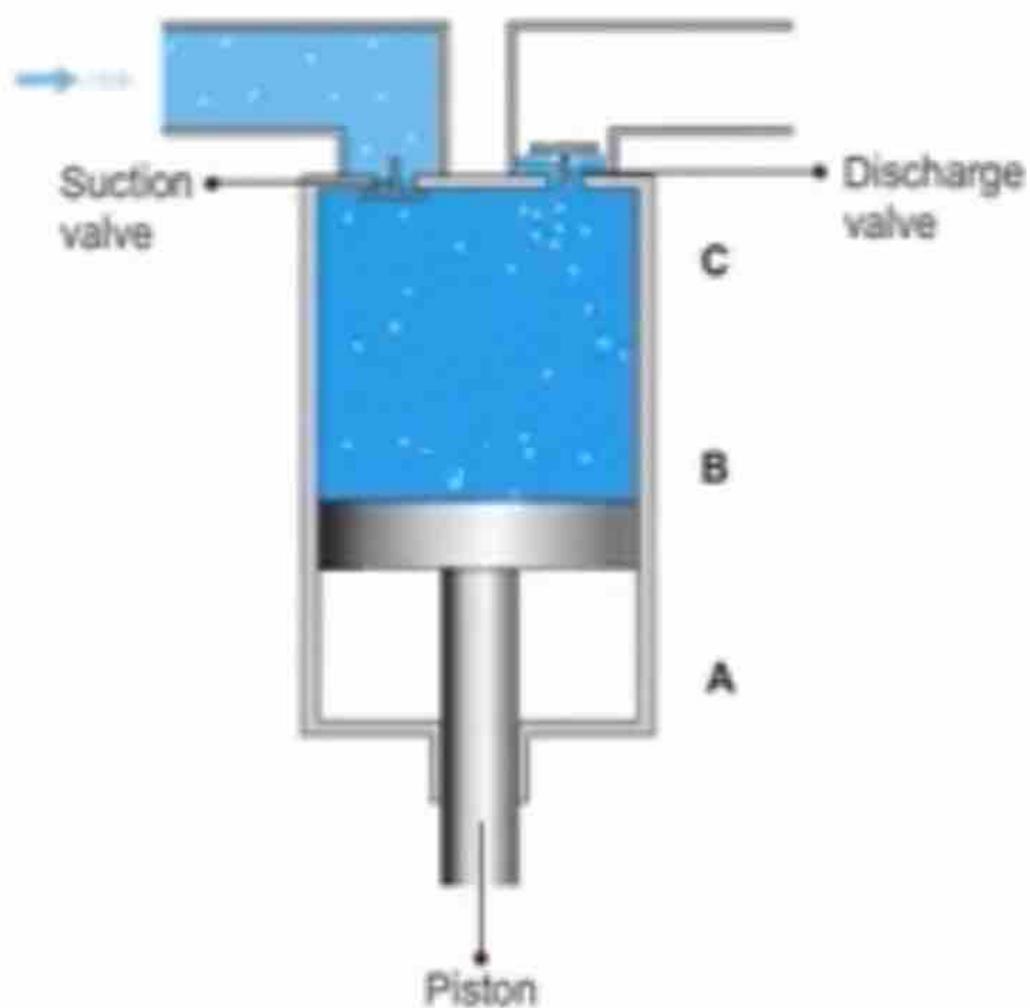
- A – Piston at bottom
- B – Piston in middle
- C – Piston at top

As the piston moves from A to C, it reaches maximum speed at B, before slowing down to a stop at C.



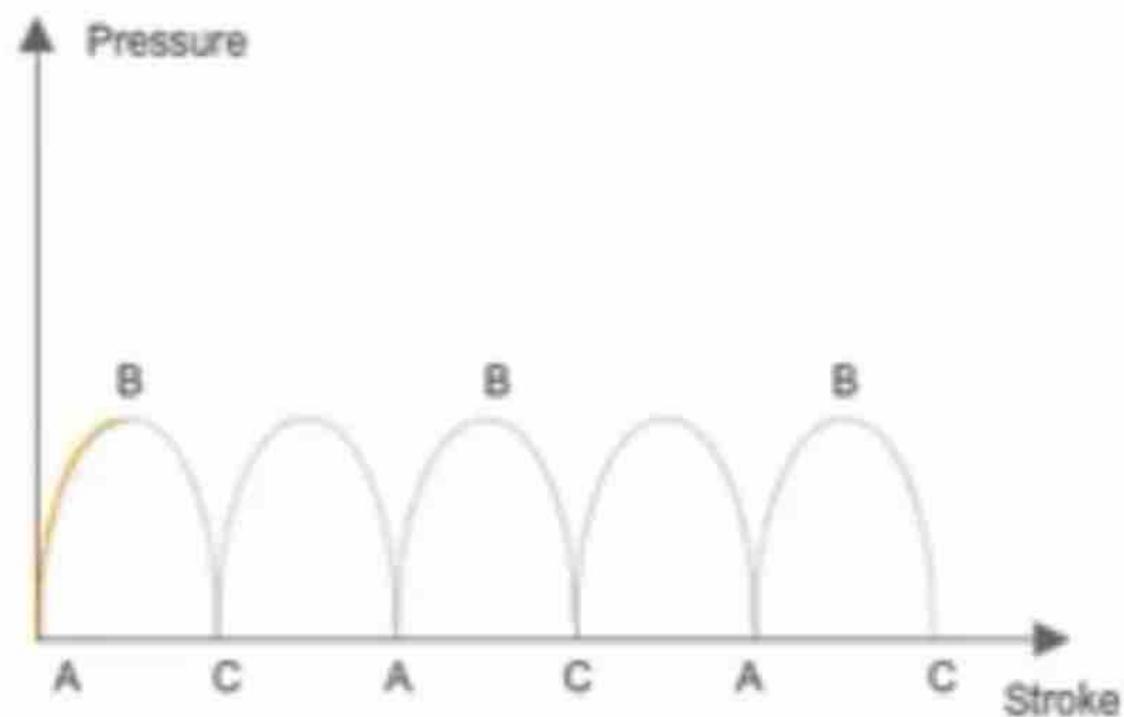
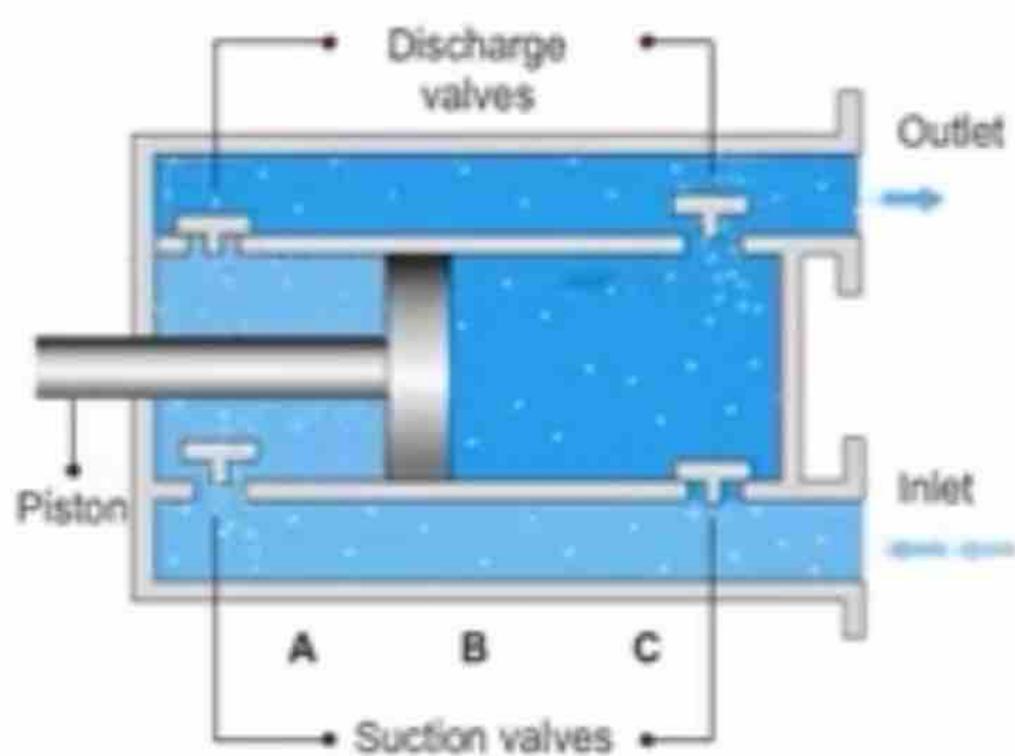
- A – Piston at bottom
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As the piston moves from A to C, it reaches maximum speed at B, before slowing down to a stop at C.



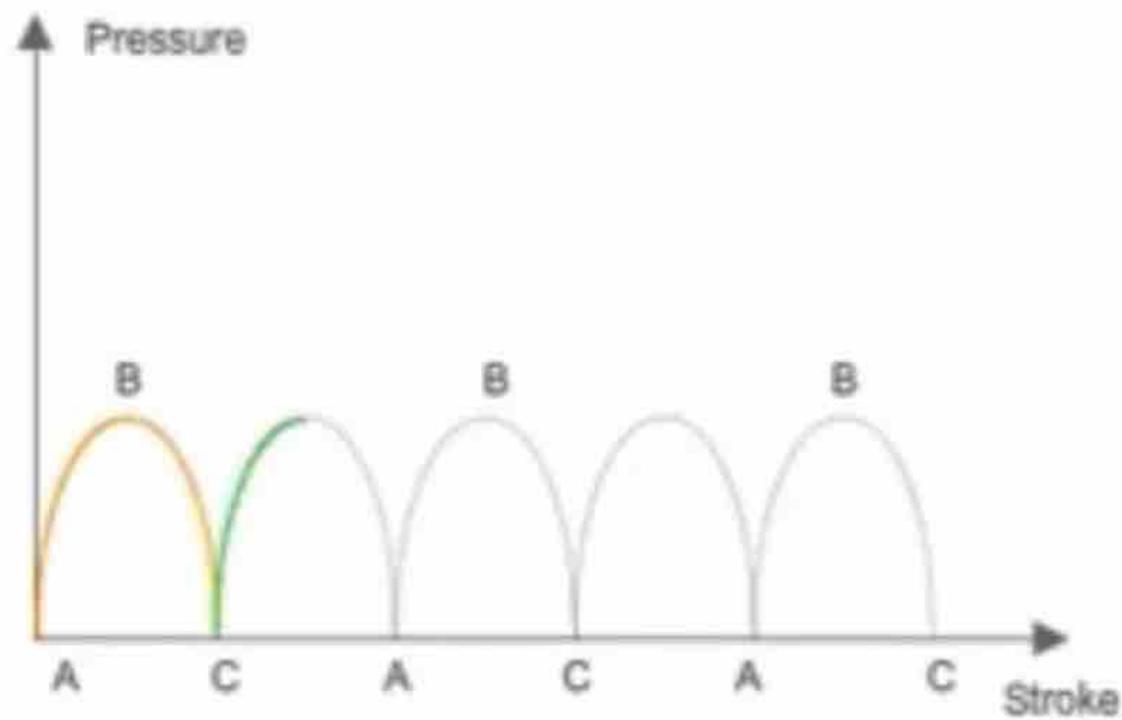
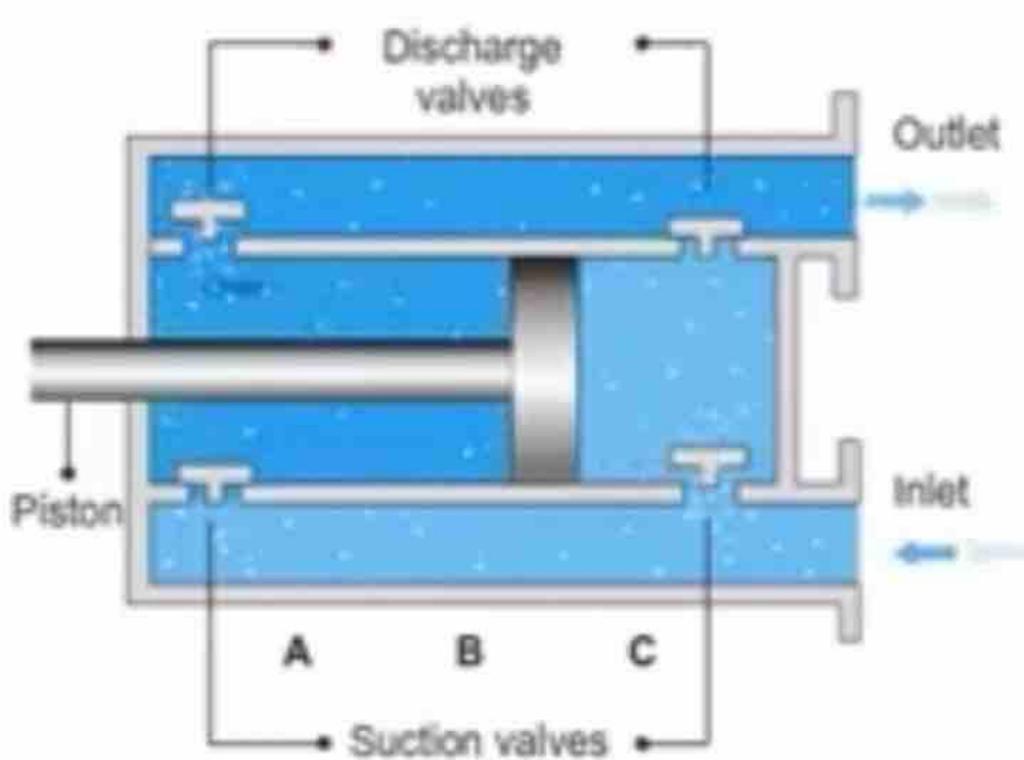
A – Piston at bottom  
B – Piston in middle  
C – Piston at top

The piston stops and reverses its direction from C to A. Hence the pressure is highest at B and lowest at A and C. The cycle is then repeated.



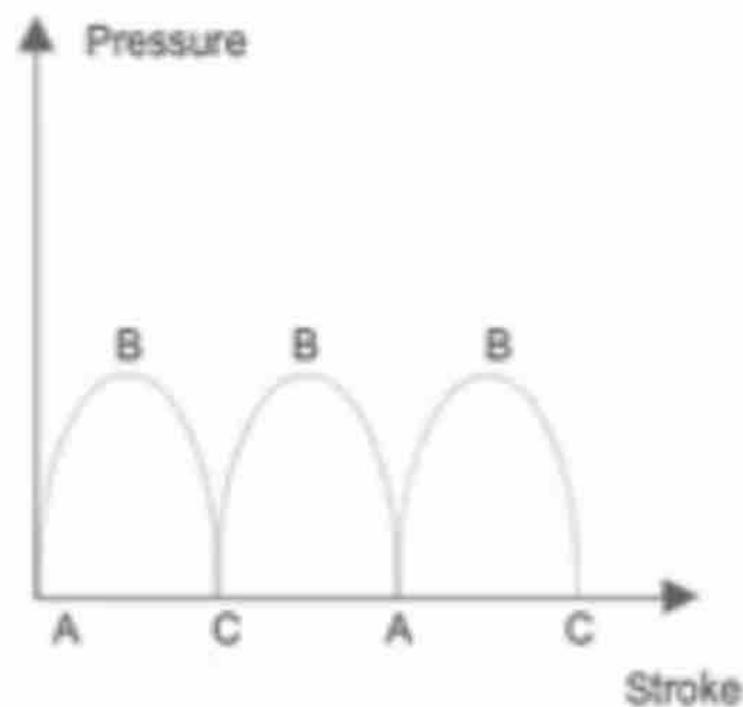
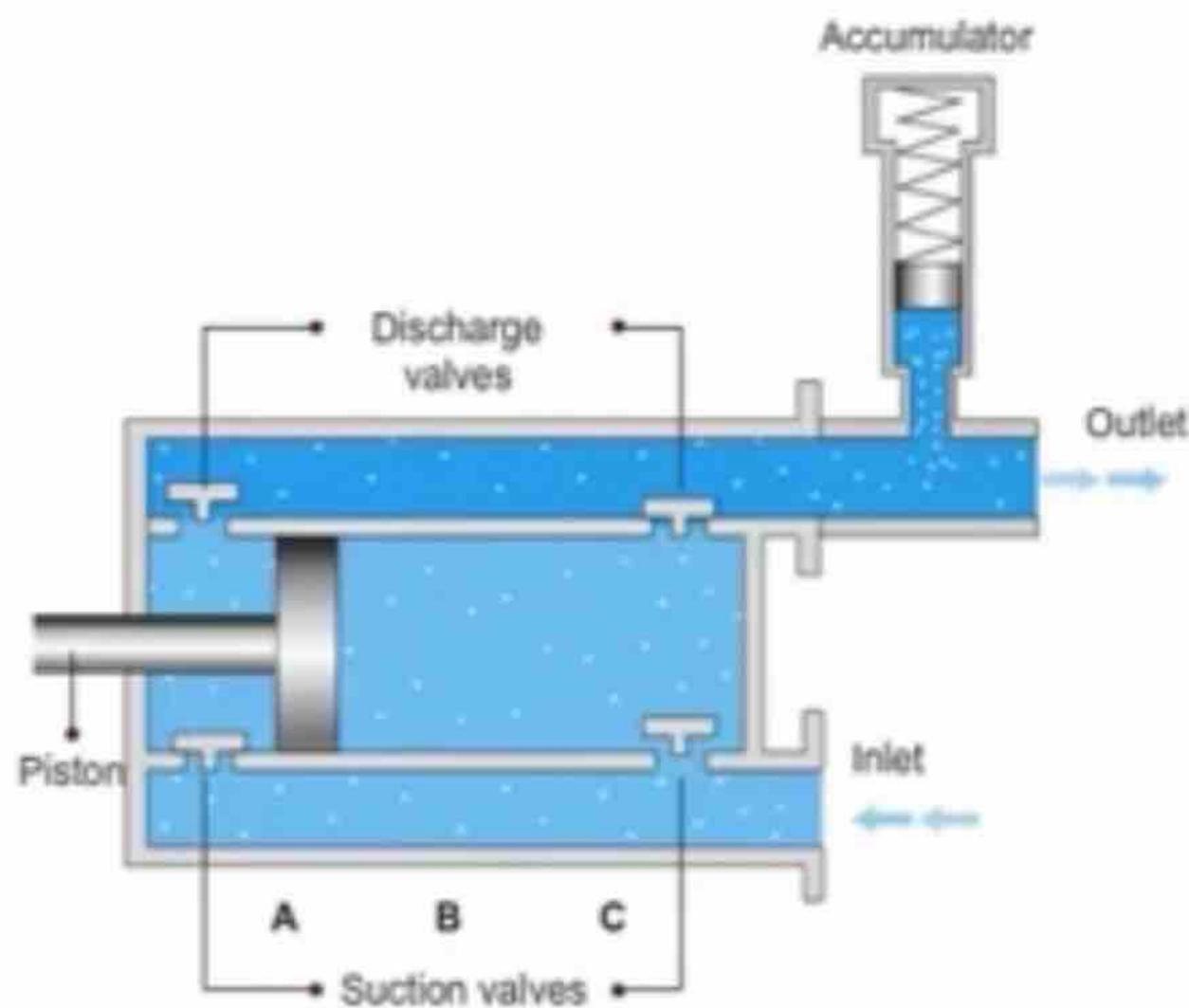
A – Piston at left  
 B – Piston in middle  
 C – Piston at right

When the piston moves to right, the suction valve on the lower left opens due to low pressure, to allow liquid to fill the cylinder.



A – Piston at left  
 B – Piston in middle  
 C – Piston at right

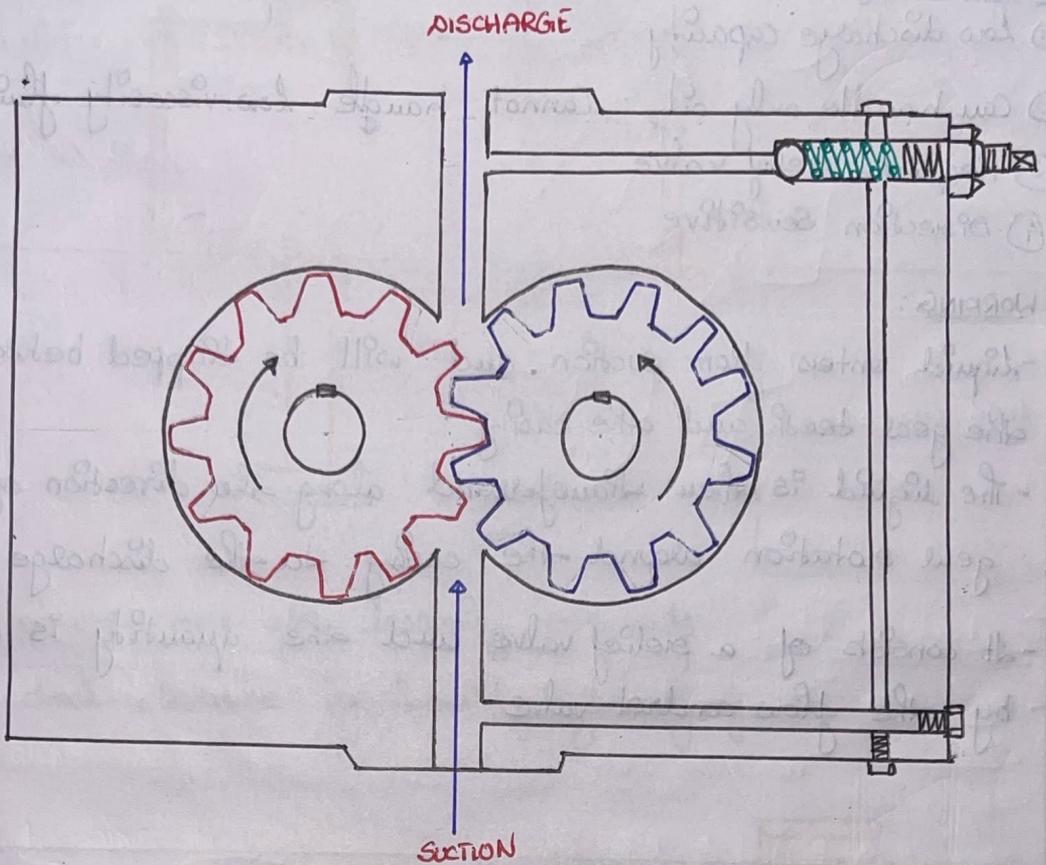
The reverse happens when the piston returns to the left. Unlike single-acting pumps, where there are no discharges during one stroke of the piston, in double acting pumps, the pulsations are still there.



A – Piston at left  
 B – Piston in middle  
 C – Piston at right

Pressure pulsations cause the pipes to vibrate severely, producing stress that shortens the lifespan of the materials.

## GEAR PUMP:



### System Description:

A gear pump consists of

→ 2 gears : ① Driving gear } that engage together.  
                  ② Driven gear } (Case hardened Nikide steel)

b) Casing (cast steel)

c) Bush Bearings to support gears

- There is very fine clearance between the tip of the gear teeth and casing ( $\approx 0.1\text{mm}$ )

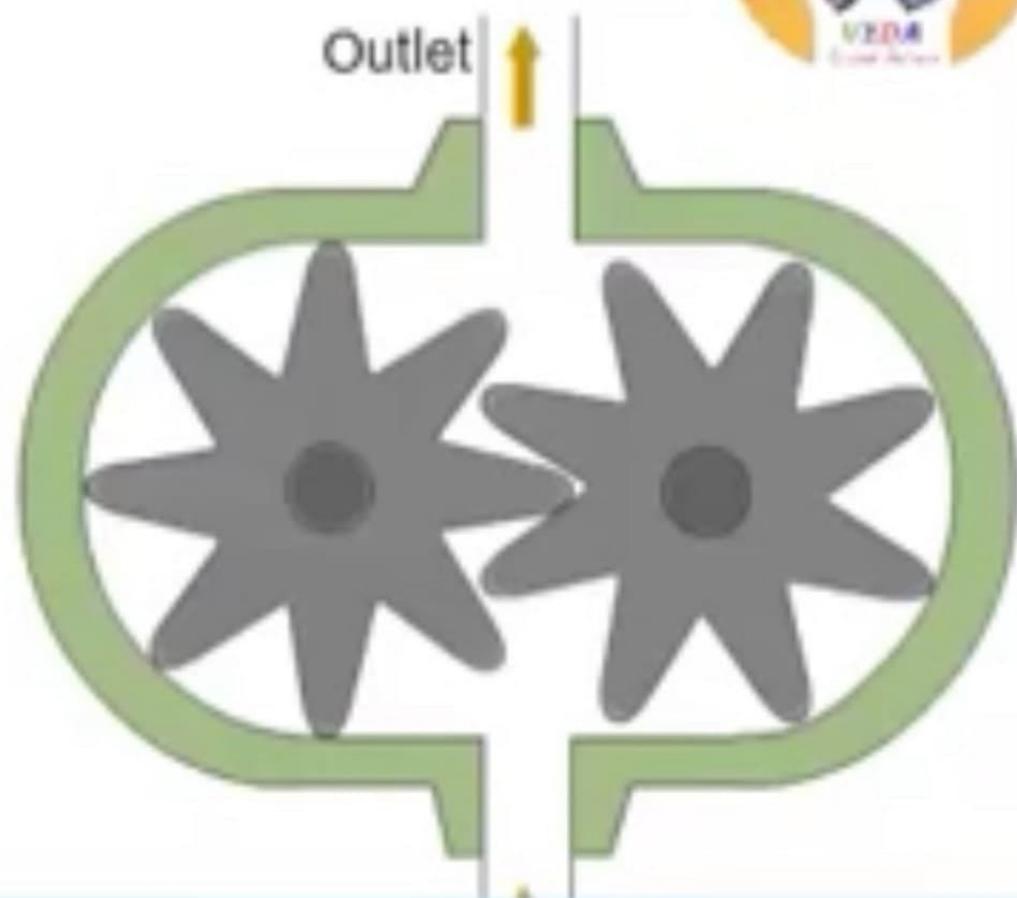
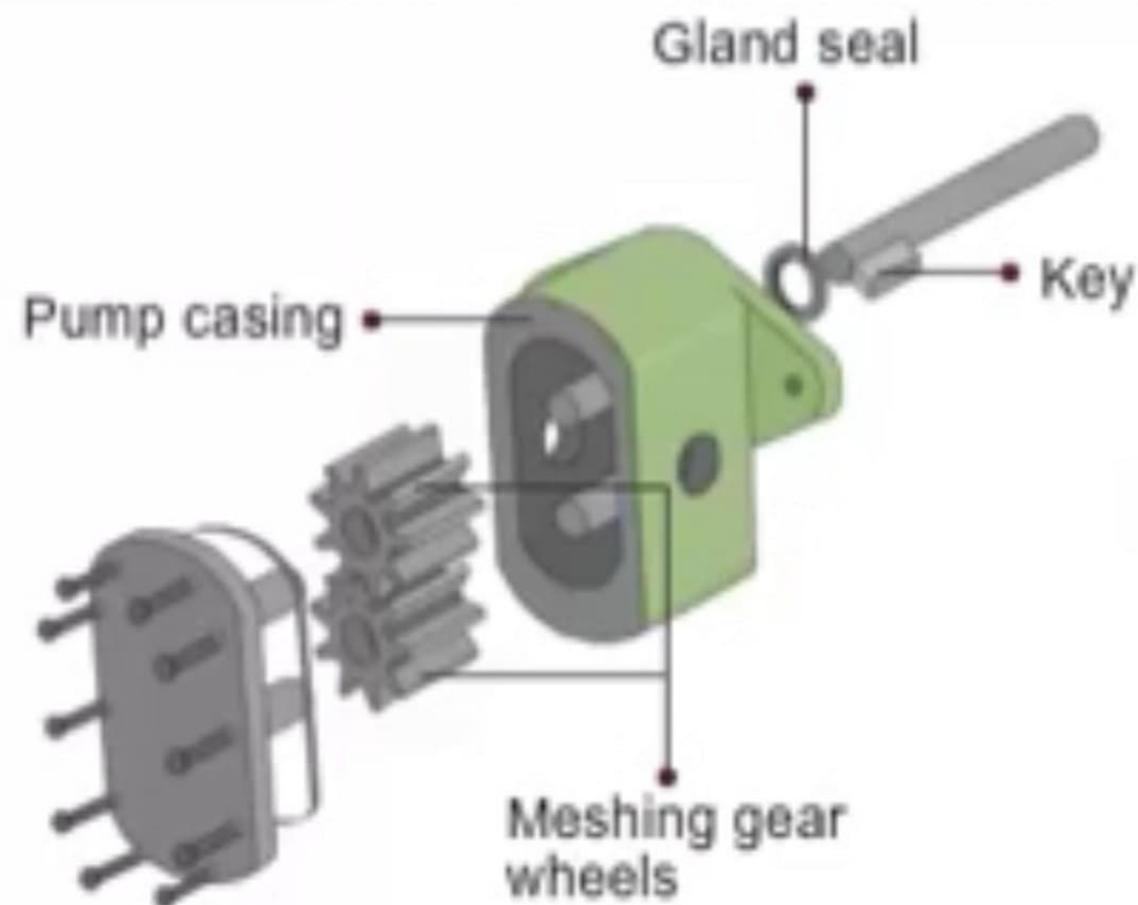
Lesser the clearance, better is the efficiency

- It is only applicable for use with oil and not water

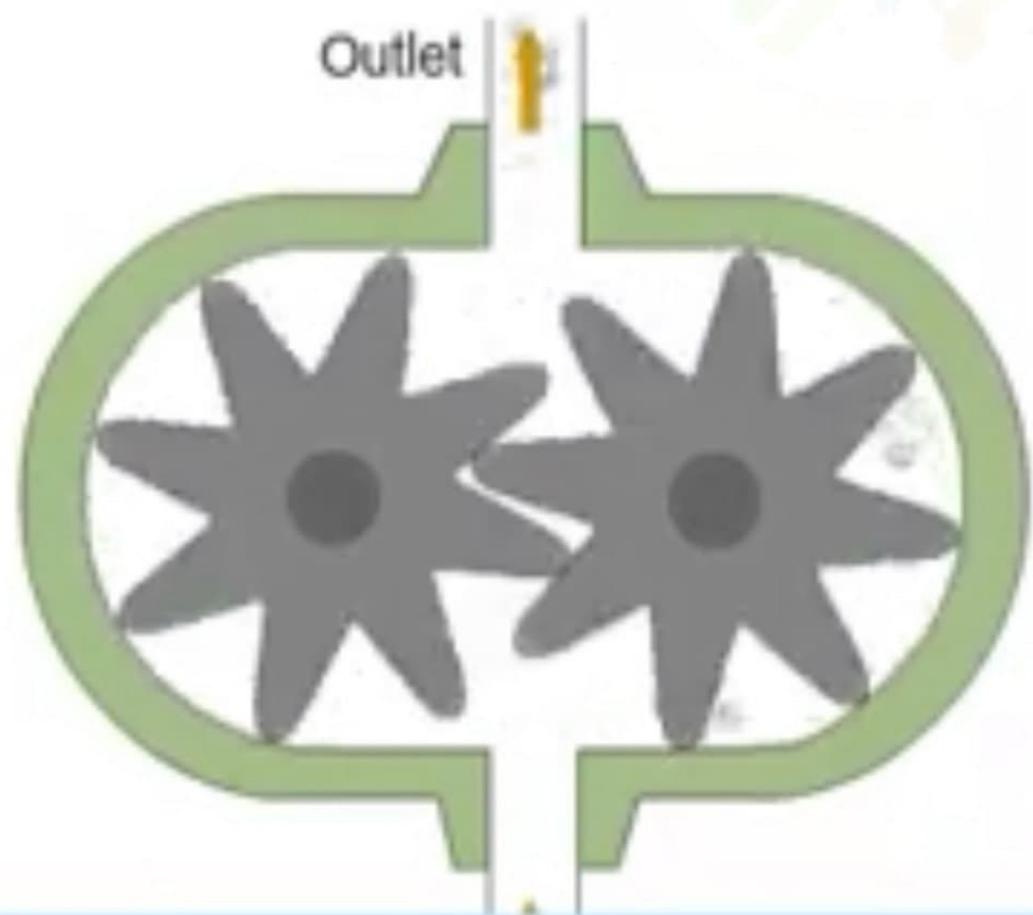
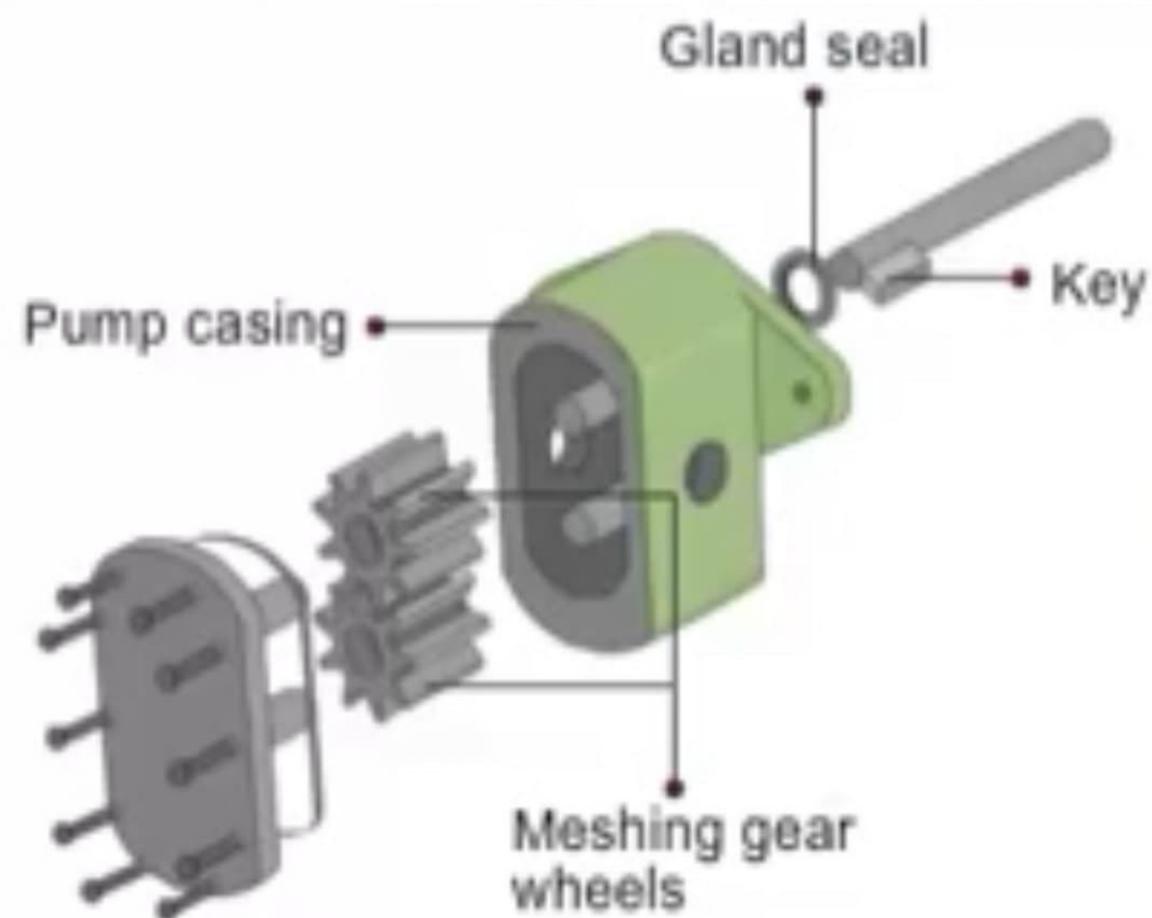
- As it requires lubrication.

- Used for F.O. Transfer, L.O. Transfer, AE attached P/p for L.O.

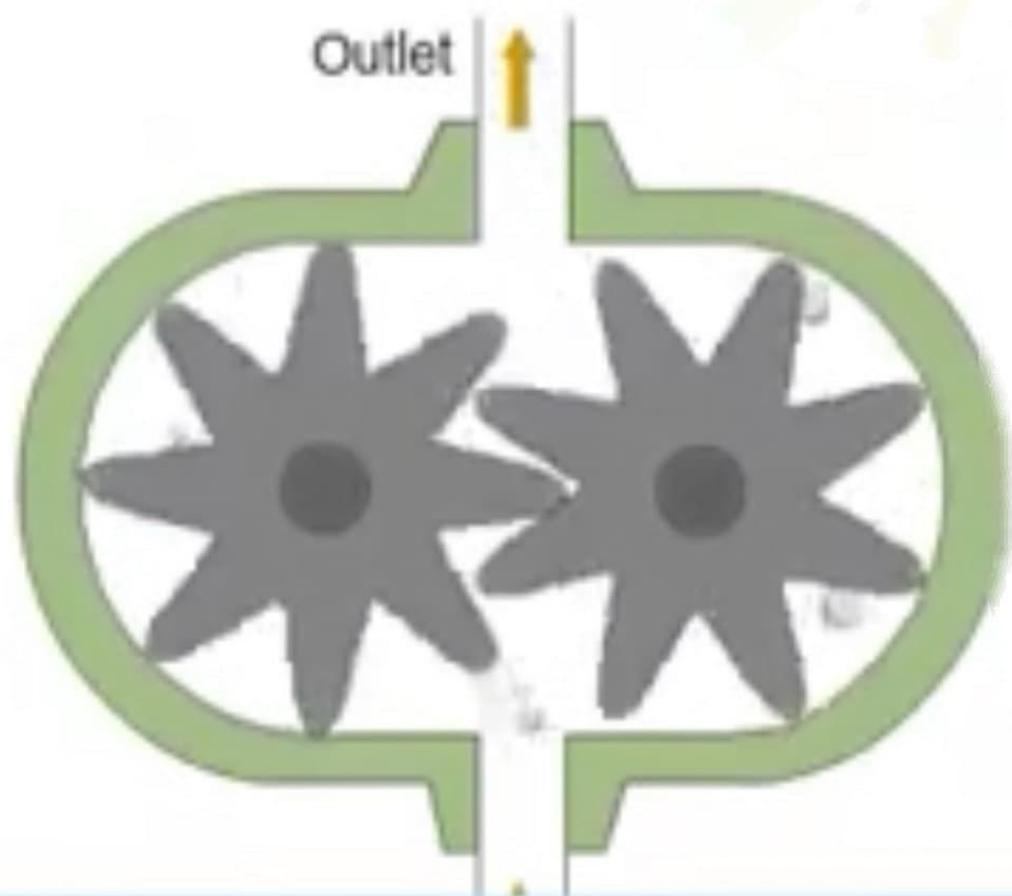
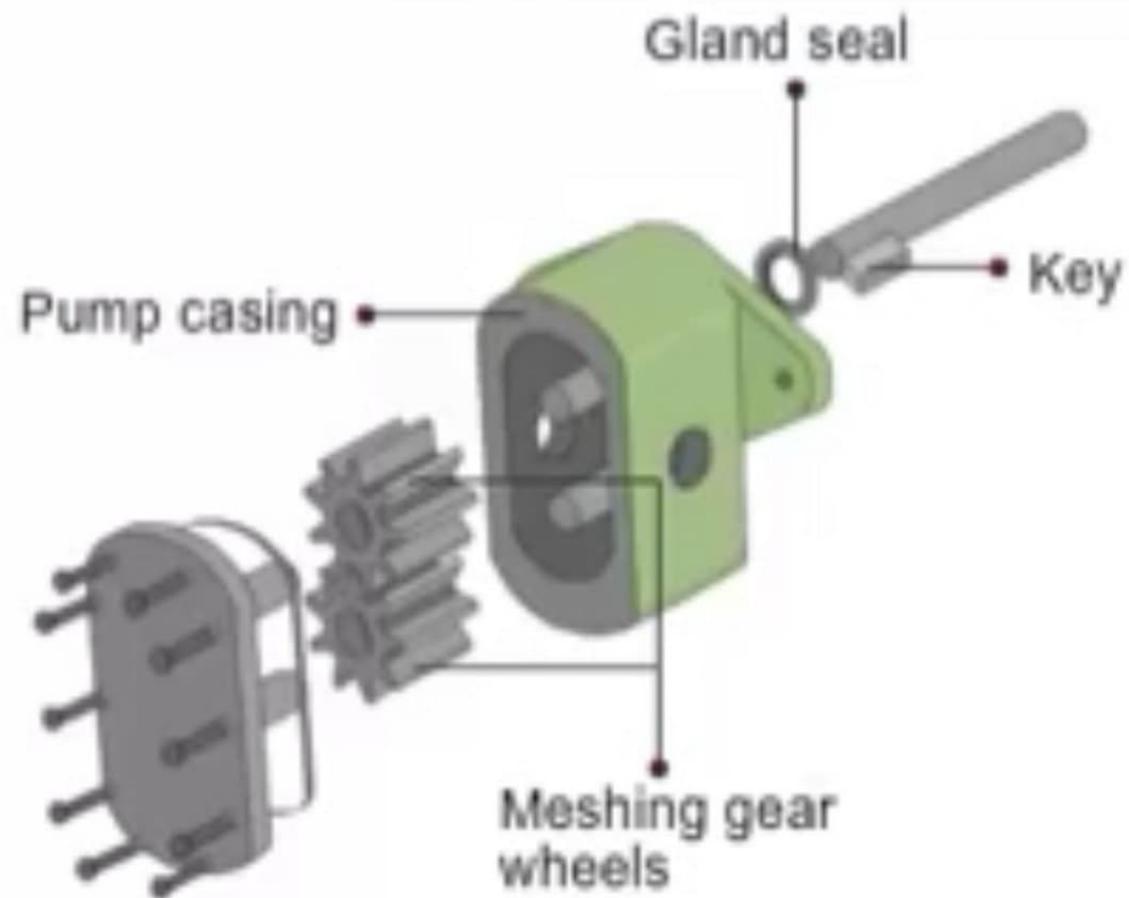
Shivaji



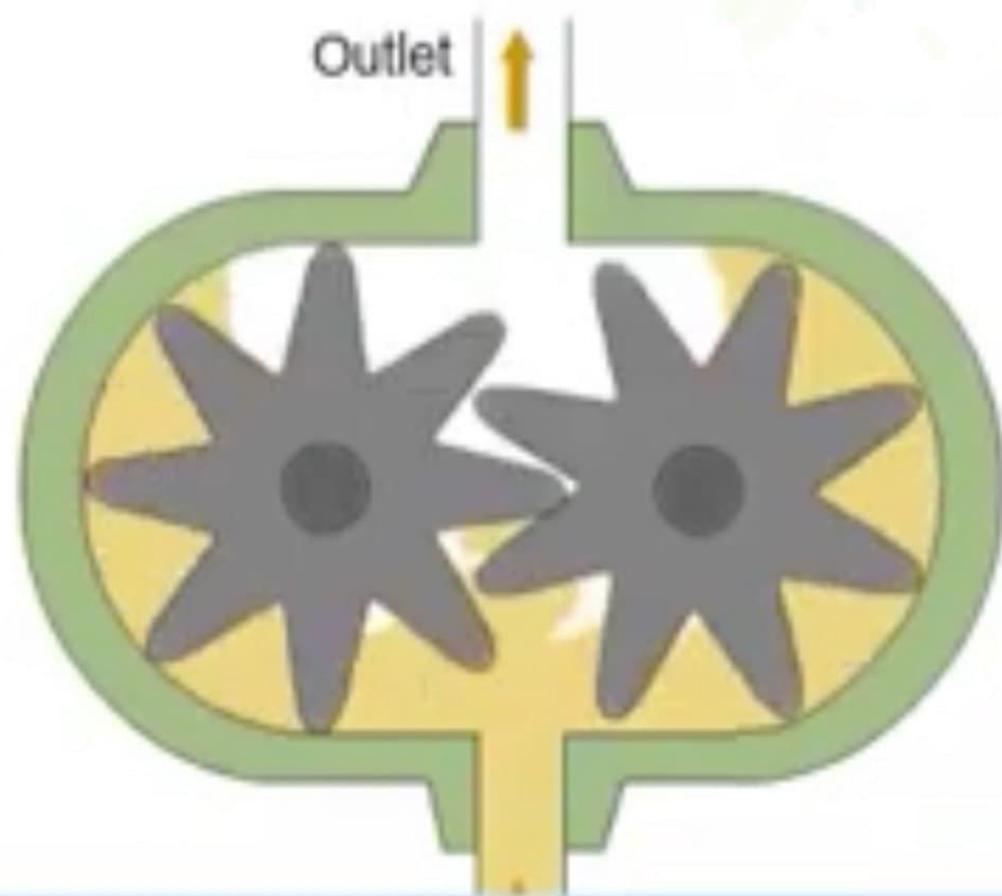
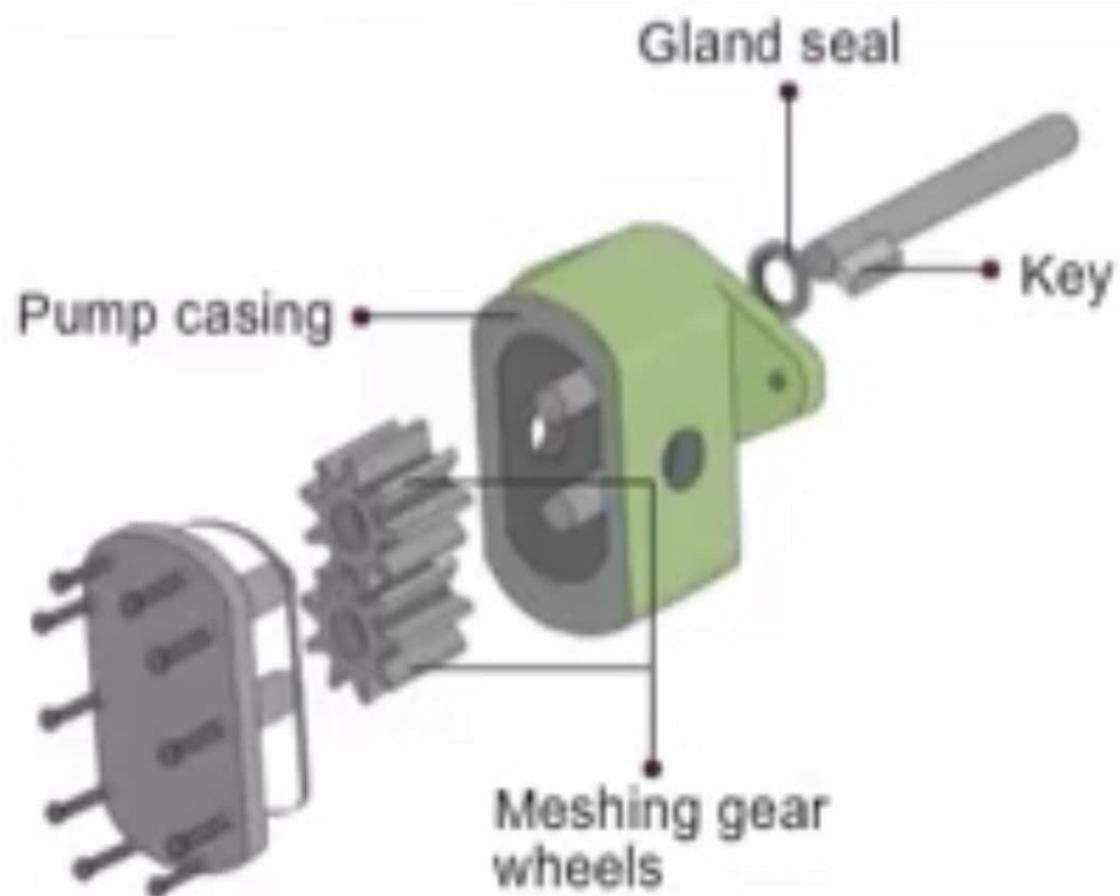
The prime mover is an electric motor and these types of gear wheels are often called 'spur gears'.



One gear wheel drives the other. As the pump rotates, the movement of the gear first removes all air in the system, thus creating a vacuum.



After all the air is expelled, liquid is drawn and pumped into the discharge pipe.



The liquid is transported circumferentially between the casing and the gear teeth and not between the two gears.

## Advantage:

- ① No priming required

## Disadvantage:

- ① Low discharge capacity
- ② Can handle only oil : Cannot handle low viscosity fluids
- ③ Requires relief valve
- ④ Direction sensitive

## WORKING:

- Liquid enters from suction and will be trapped between the gear teeth and the casing
- The liquid is then transferred along the direction of the gear rotation around the casing to the discharge side.
- It consists of a relief valve and the quantity is controlled by the flow control valve

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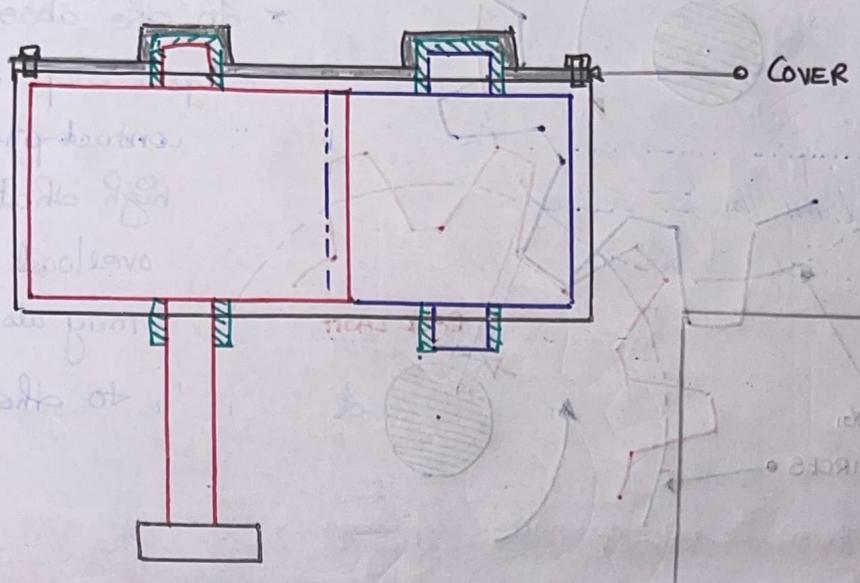
## CHECKS TO PERFORM:

- clearance between the gear teeth and casing
  - a) By using feeler gauge
  - b) Or, take inner diameter of casing ' $x$ '  
take outer diameter of gear ' $y$ '  
 $\Rightarrow x - y = \text{clearance.}$
- \* To take clearance, open the pump while keeping it horizontal.
  - remove the driven gear (gear cover)
  - and use feeler gauge.
- check condition of the gear (wear down) : Mark prior removal
- check the condition of the bush bearings
- check the shaft (shaft has a gland pack  $\rightarrow$  grooving)
- check backlash of the gear
- check the clearance between gear teeth and end cover

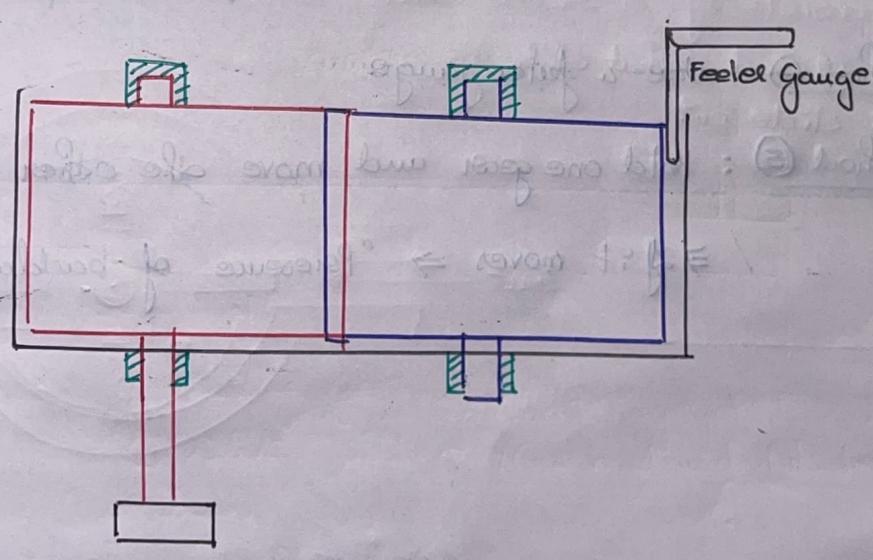
\* Backlash is important as it allows for heat expansion

\* To the absence of backlash the contact point is a right offset it would be over load

to the tooth



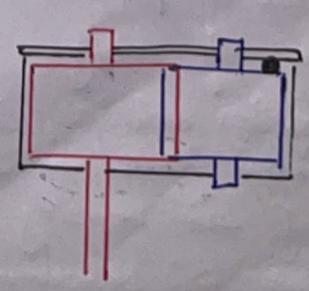
- \* Remove cover after loosening cover nuts
- \* check clearance by inserting feeler gauge



\* To check clearance between the gear teeth and end cover

- Place a lead ball
- Tighten the cover
- Measure the thickness of the ball

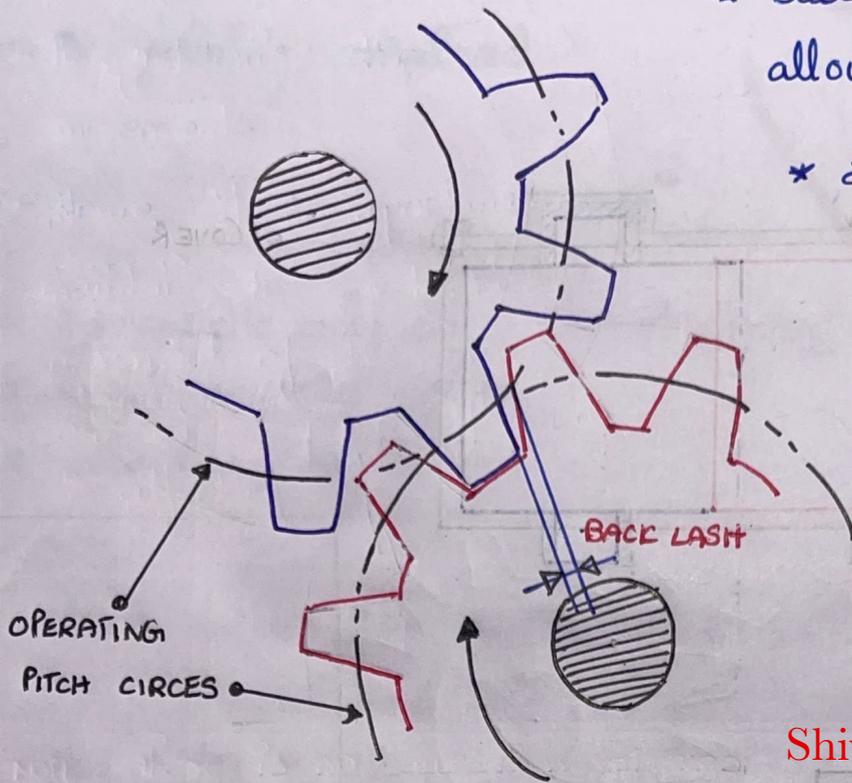
- If clearance is more, pump efficiency drops



## SIGNIFICANCE OF BACKLASH:

\* Backlash is important as it allows for heat expansion

\* In the absence of Backlash, upon stop condition, the contact pressure is so high that it would overload the motor & may also cause damage to the teeth



Shivaji

To check Backlash: \* Remove cover after loosening cover nuts

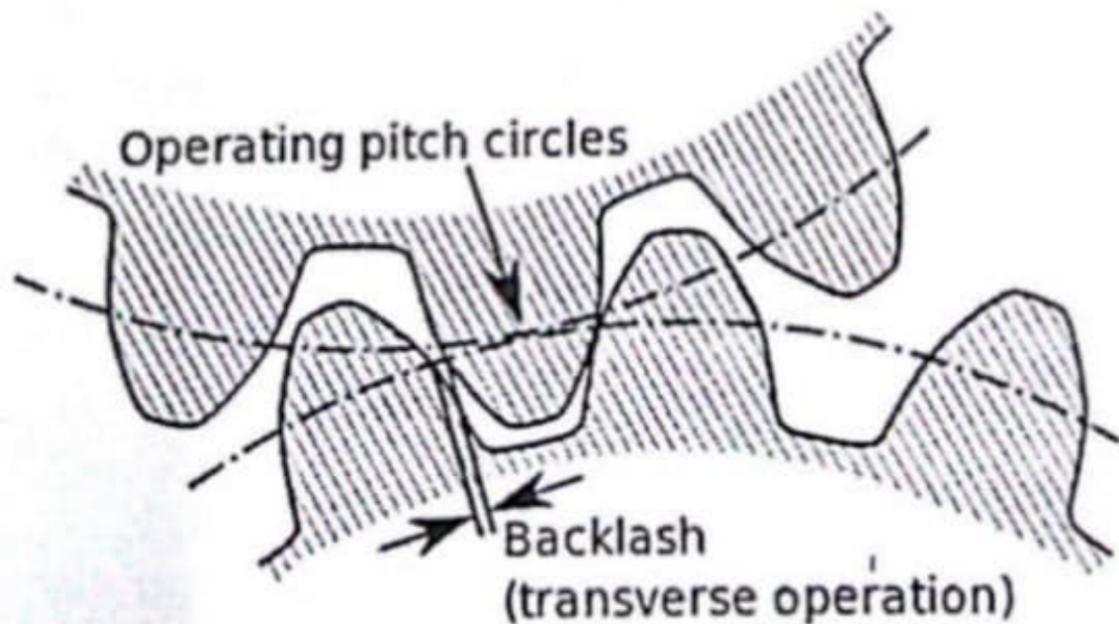
- Method ①: Pass a lead wire between adjacent teeth and measure the thickness of the pressed wire

- Method ②: Use a feeler gauge

- Method ③: Hold one gear and move the other

⇒ If it moves ⇒ "Presence of backlash"

## Importance of backlash in gear pump -



1. Backlash is important because of heat little expansion of teeth will be there
2. If you don't have backlash so the time when your pump rotate in opposite direction by mistake so sudden load come on to the motor and it will trip on overload

Q – At the time of overhauling what things to be checked in gear pump (MA)

Ans – 1. Remove the cover of non-driving end

2. If possible put it in the upside direction

3. After removal of cover put the feeler gauge between the gear and the body (clearance should not be too high else the pump won't work properly)

4. Check the condition of bush bearing

5. Check the relief v/v ( Never ever pressure test the relief v/v on its place, to test the relief v/v one pump is provided which is now the regulation also)

**Note** – In between the teeth boundary lubrication takes place and when teeth transmit the power so little tilting will be there so that was the reason we make inner cone of the teeth little soft and the outer cone we make it hard with the help of case hardening or nitriding

Q – Explain the basic principle of screw pump and importance of timing gear in it (GA)

Ans – The two-screw, low-pitch, screw pump consists of two screws that mesh with close clearances, mounted on two parallel shafts. One screw has a right-handed thread, and the other screw has a left-handed thread. One shaft is the driving shaft and drives the other shaft through a set of herringbone timing gears. The gears serve to maintain clearances between the screws as they turn and to promote quiet operation. The screws rotate in closely fitting duplex cylinders that have overlapping bores. All clearances are small, but there is no actual contact between the two screws or between the screws and the cylinder walls.

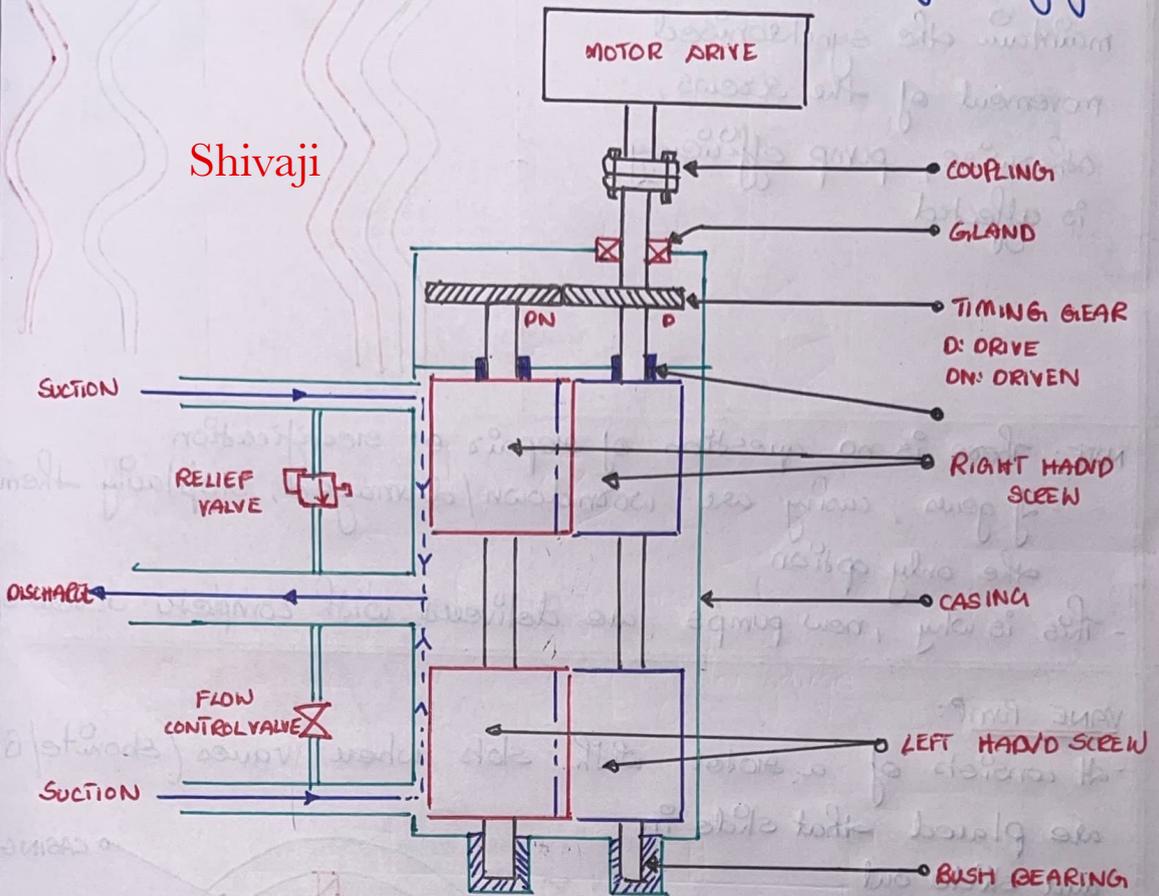
The complete assembly and the usual flow path are shown in Figure 17. Liquid is trapped at the outer end of each pair of screws. As the first space between the screw threads rotates away from the opposite screw, a one-turn, spiral-shaped quantity of liquid is enclosed when the end of the screw again meshes with the opposite screw. As the screw continues to rotate, the entrapped spiral turns of liquid slide along the cylinder toward the center discharge space while the next slug is being entrapped. Each screw functions similarly, and each pair of screws discharges an equal quantity of liquid in opposed streams toward the center, thus eliminating hydraulic thrust. The removal of liquid from the suction end by the screws produces a reduction in pressure, which draws liquid through the suction line.

**Sailent features of screw pump –**

1. Again it is only used for oil but its capacity is more than gear pump
2. If clearance is increased too much then you cannot do anything other than to change the screws (clearance mostly increase due to the erosion or pitting because of the flow of oil)
3. Screw cannot give drive to each other that was the reason we use timing gears

## SCREW PUMPS:

- It consists of 2 screws that do not engage with each other
- they maintain fine clearances between each other as they turn so as to promote quiet operation. (maintained by timing gear)



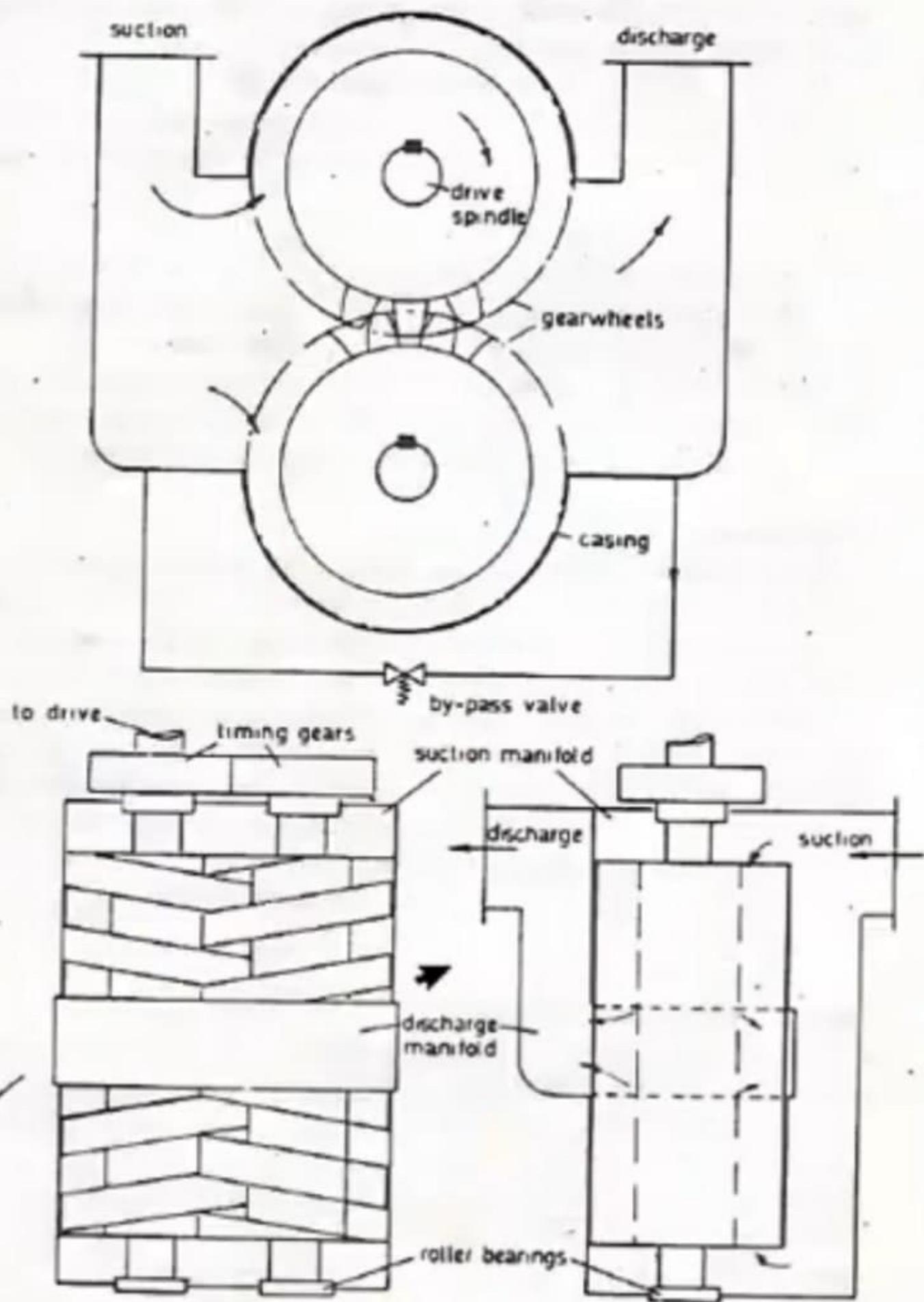
It works on the principle of bolt and nut

- When bolt rotates, nut moves axially, or vice versa
- similarly, as the screw rotates, liquid acts like a nut and it will move.

- While removal, make markings on timing gear prior removal
- check condition of the screws for erosion. (Replace if worn out)
- check clearance between screw & casing/cylinder
- check timing gear condition
- check condition of the bushes, casing

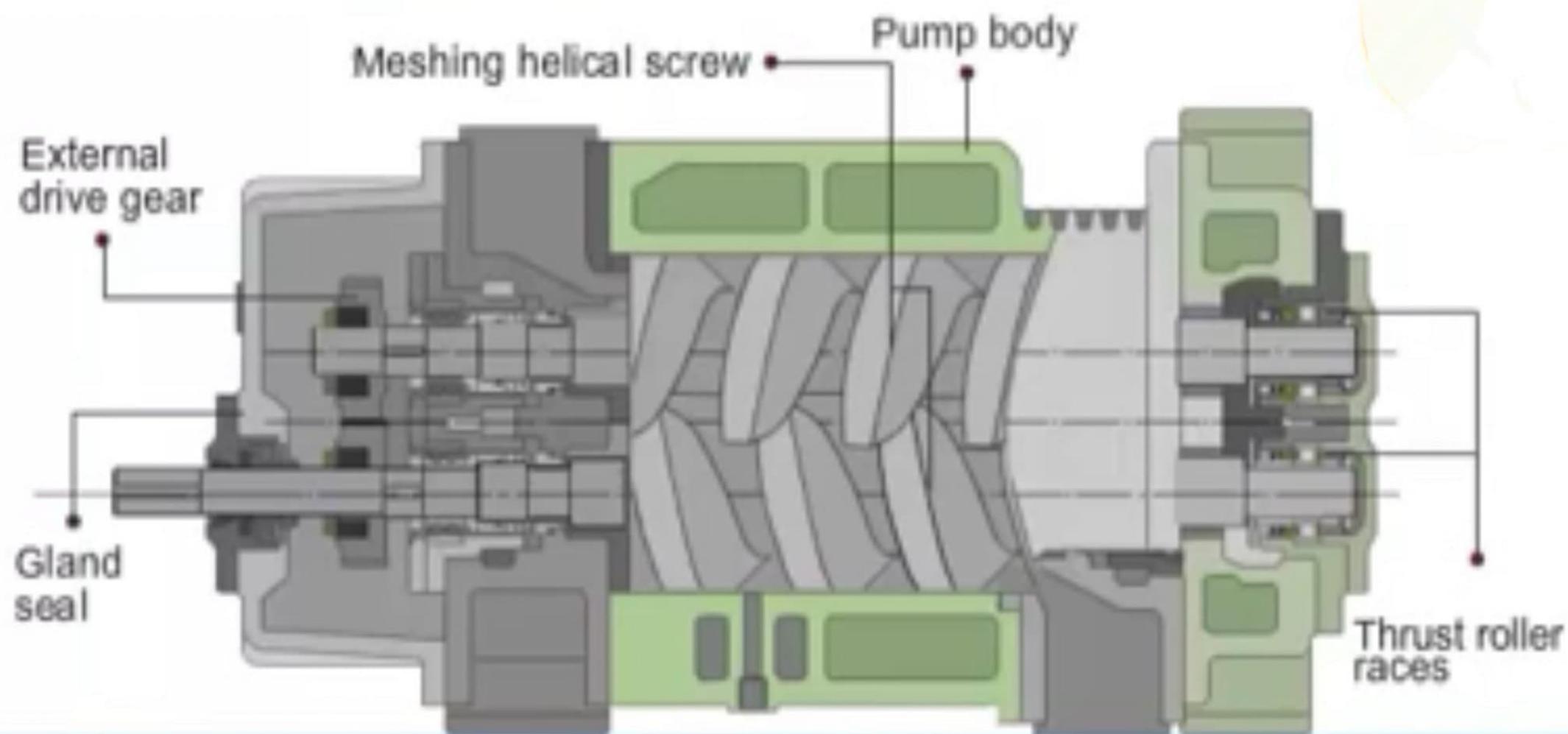
## IMPORTANCE OF TIMING GEAR:

- ⇒ To synchronise the movement of screws
- ⇒ Lay out driving of the screws

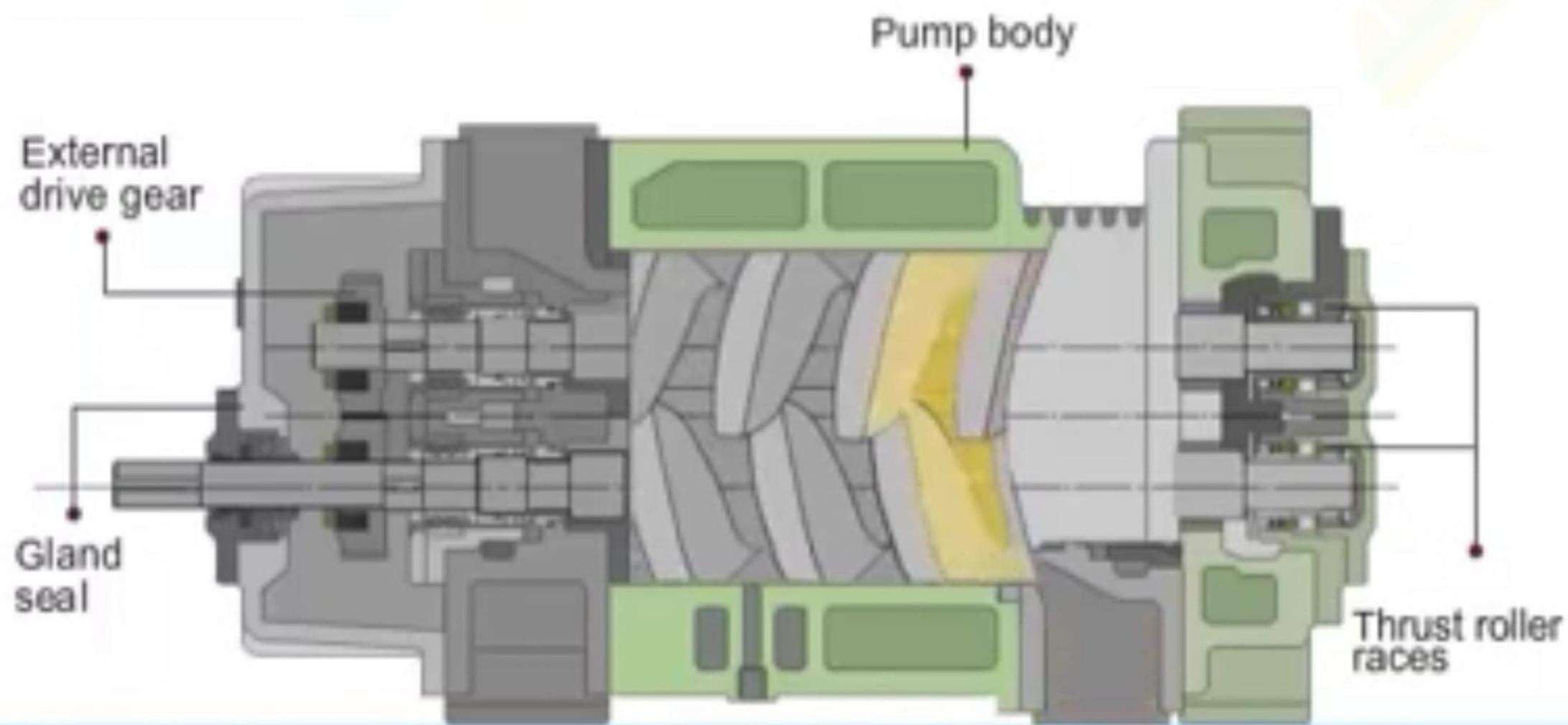


**SCREW DISPLACEMENT PUMP**

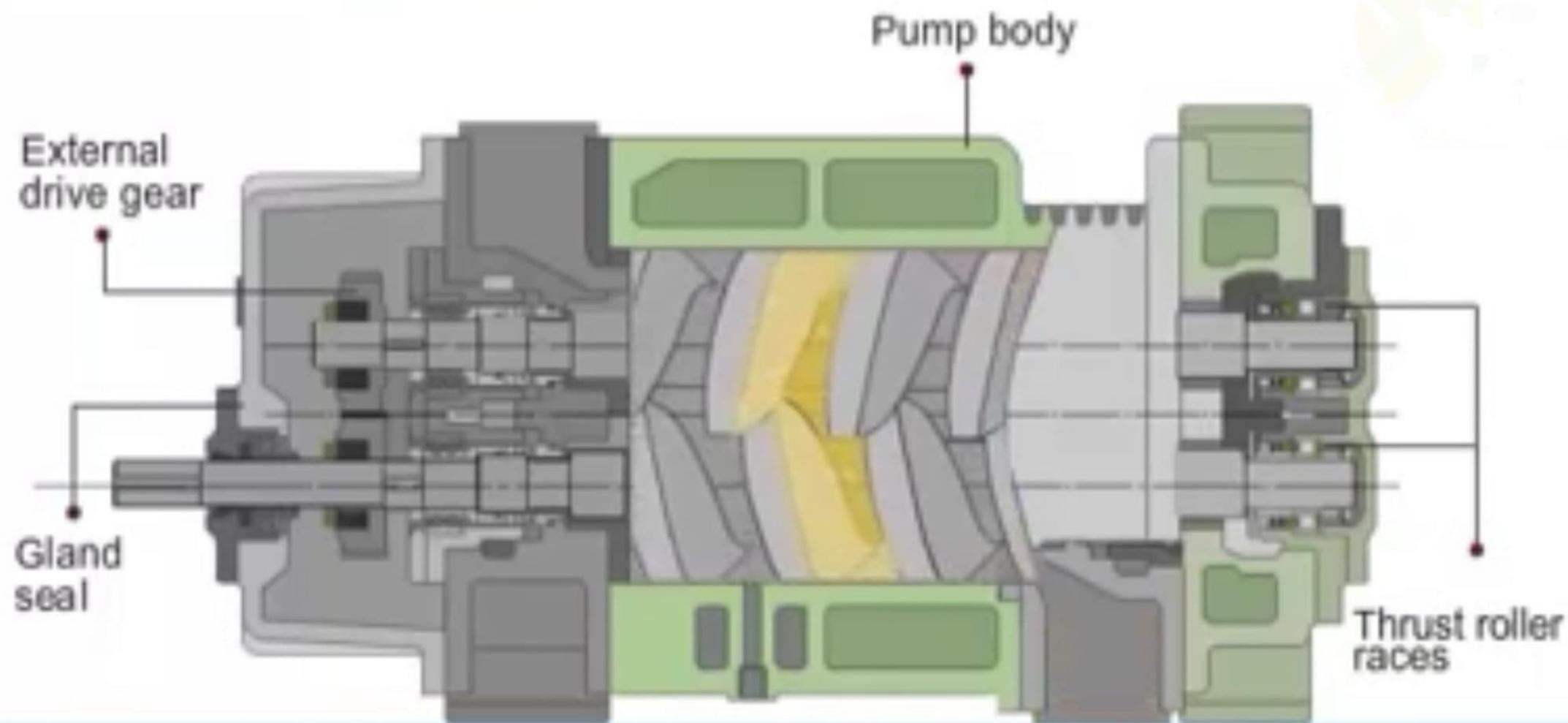
**Fig. 9.11**



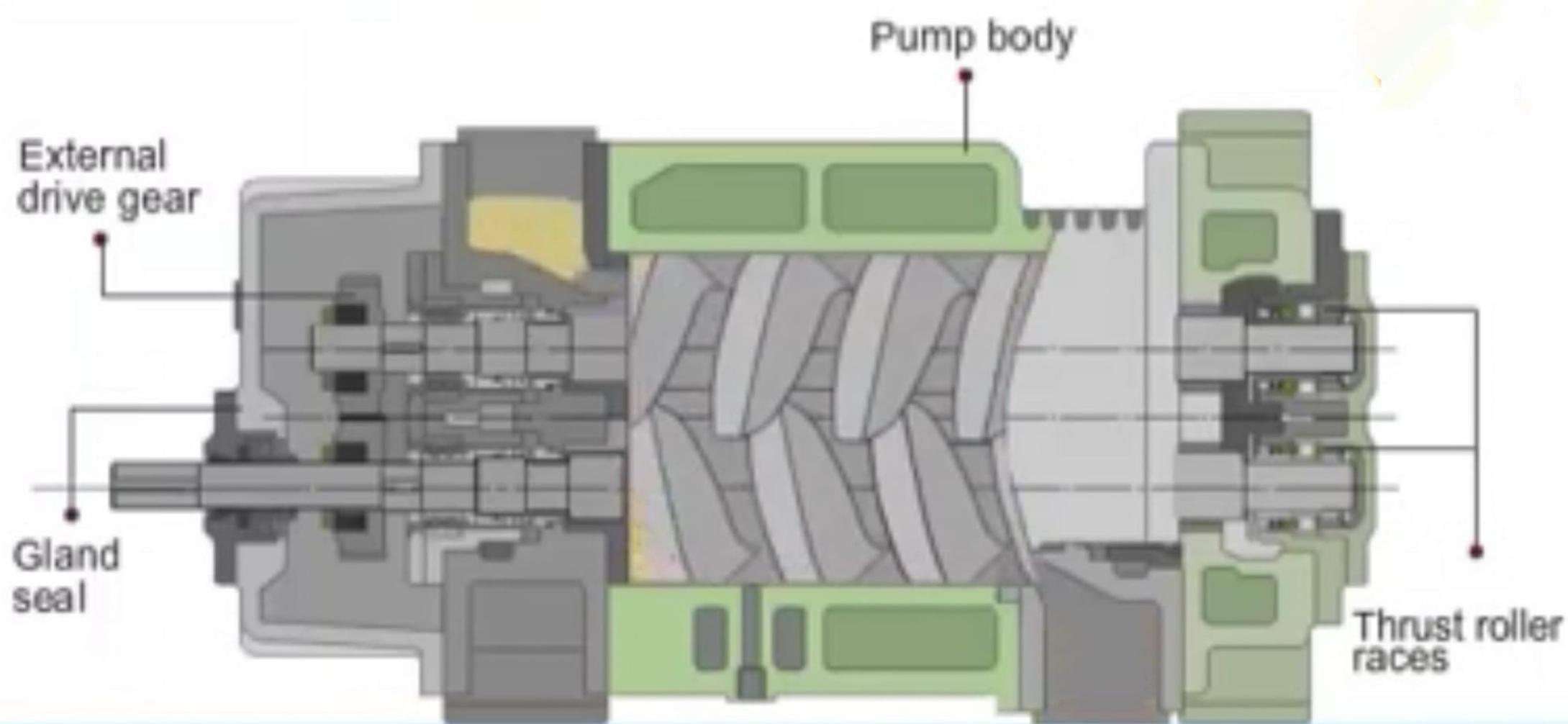
Like gear pump screw pump has screws instead of gears meshed together. Both the screw shafts are provided with gears.



As the screws turn, the trapped air in between the screw is pumped out to the discharge side.



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3. Screw cannot give drive to each other that was the reason we use timing gears

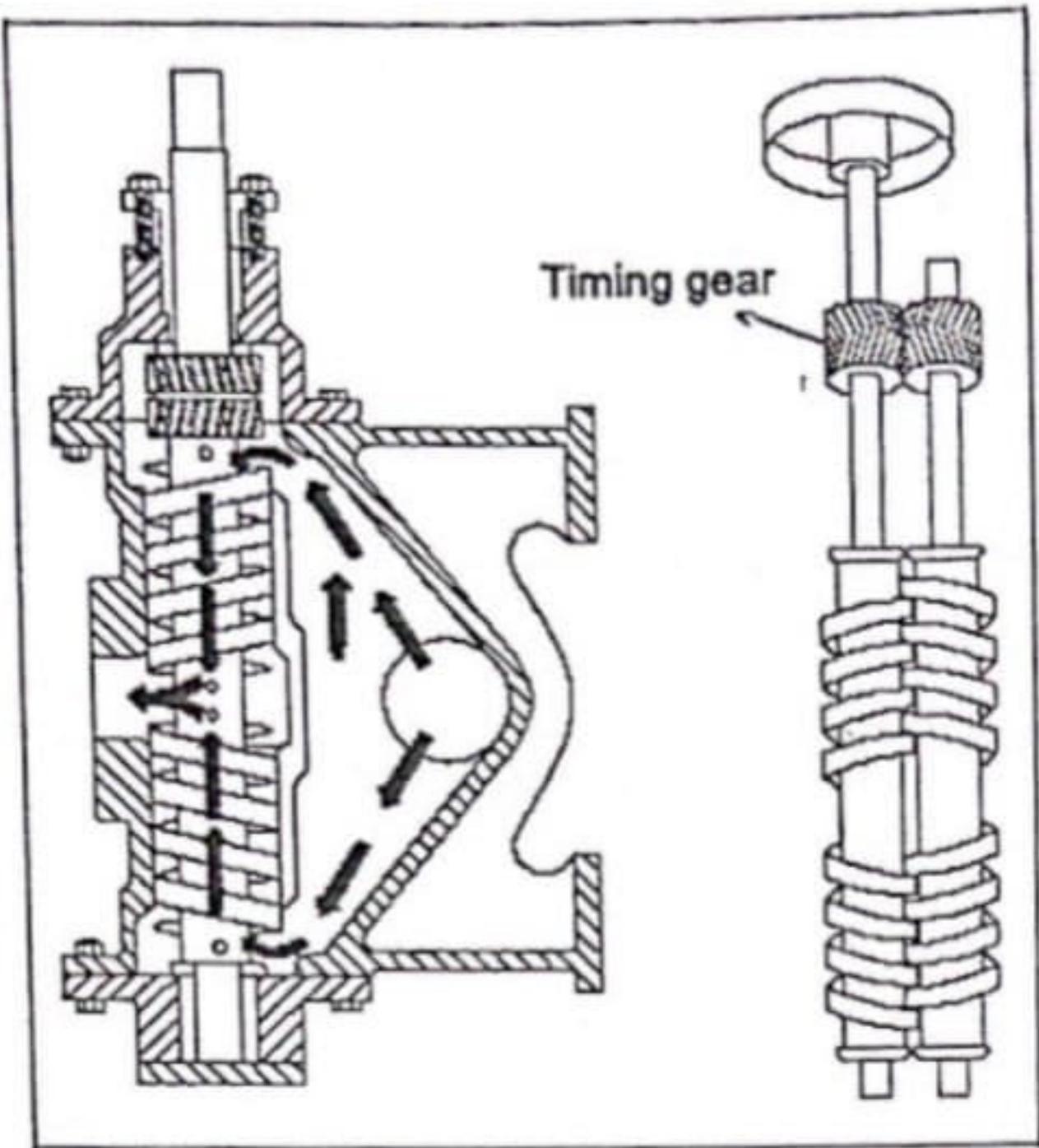
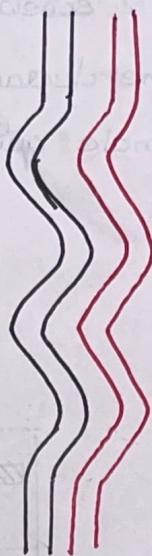


Figure 17 Two-Screw, Low-Pitch, Screw Pump

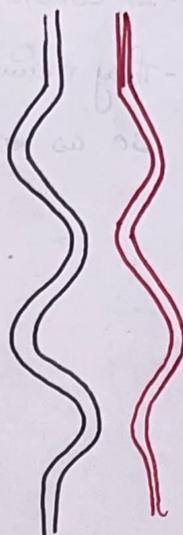
## IMPORTANCE OF TIMING GEAR:

- To synchronise the screw movements
- Hence, it is important to maintain the synchronised movement of the screws, otherwise, pump efficiency is affected

synchronised



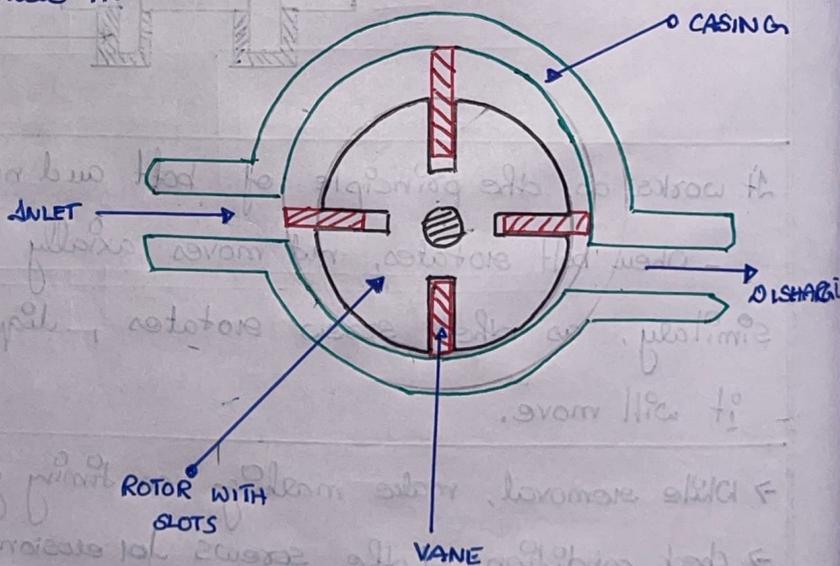
Asynchronised



- NOTE: There is no question of repair or rectification of gears, casing are worn down/damaged, replacing them is the only option
- This is why, new pumps are delivered with complete screw space.

## VANE PUMP:

- It consists of a rotor with slots where vanes (ebonite/Brass) are placed that slide in and slide out

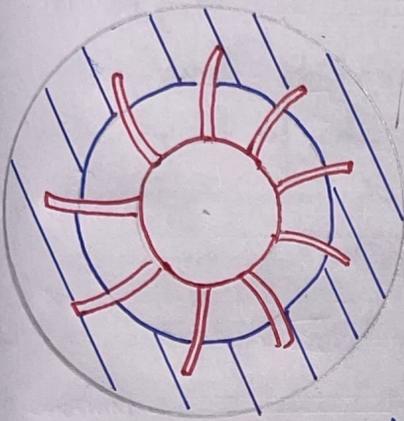


- \* The rotor is positioned eccentrically to the centre of rotation of casing
- \* As impeller rotates, fluid enters the pump and the centrifugal force of the liquid, pushes the vanes to the walls of the housing
- \* The tight seal between the vanes, rotor & casing provides effective pump efficiency

WATER RING Pump: used for Priming:

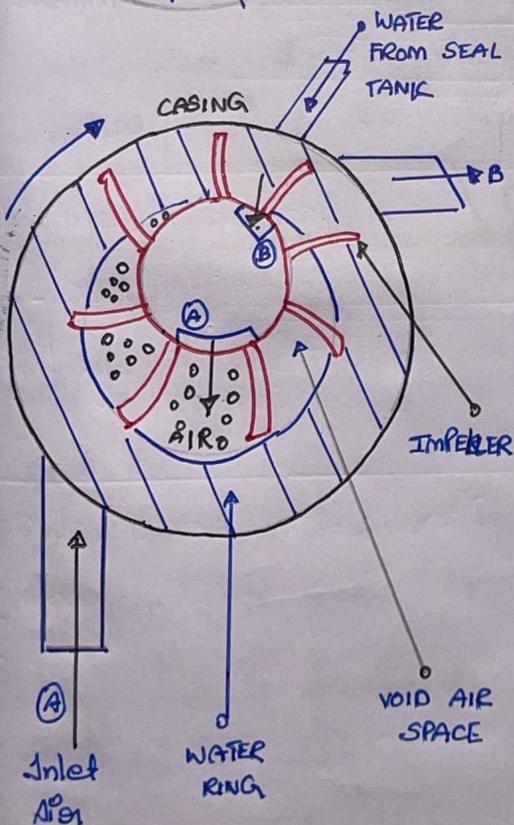
= Also called 'Vacuum Ring Pump': Used to expell air & create vacuum.

- It consist of an impeller and a casing
- If the centre of the rotation of impeller and centre of the casing are concentric, no suction & discharge will take place  $\rightarrow$  when partially filled with water, it forms a water ring concentric to the casing



\* An impeller rotating concentrically in the casing partially filled with fluid, forms a liquid ring which is concentric with the casing itself

### Shivaji



\* When the impeller is eccentric, it throws out the water forming a liquid seal ring due to centrifugal force

\* The void formed is due to the water ring that draws in air at (A) through the inlet port

$\Rightarrow$  Area is more: "Suction"

\* As impeller rotates, air gets compressed as the volume decreases due to the eccentric water ring