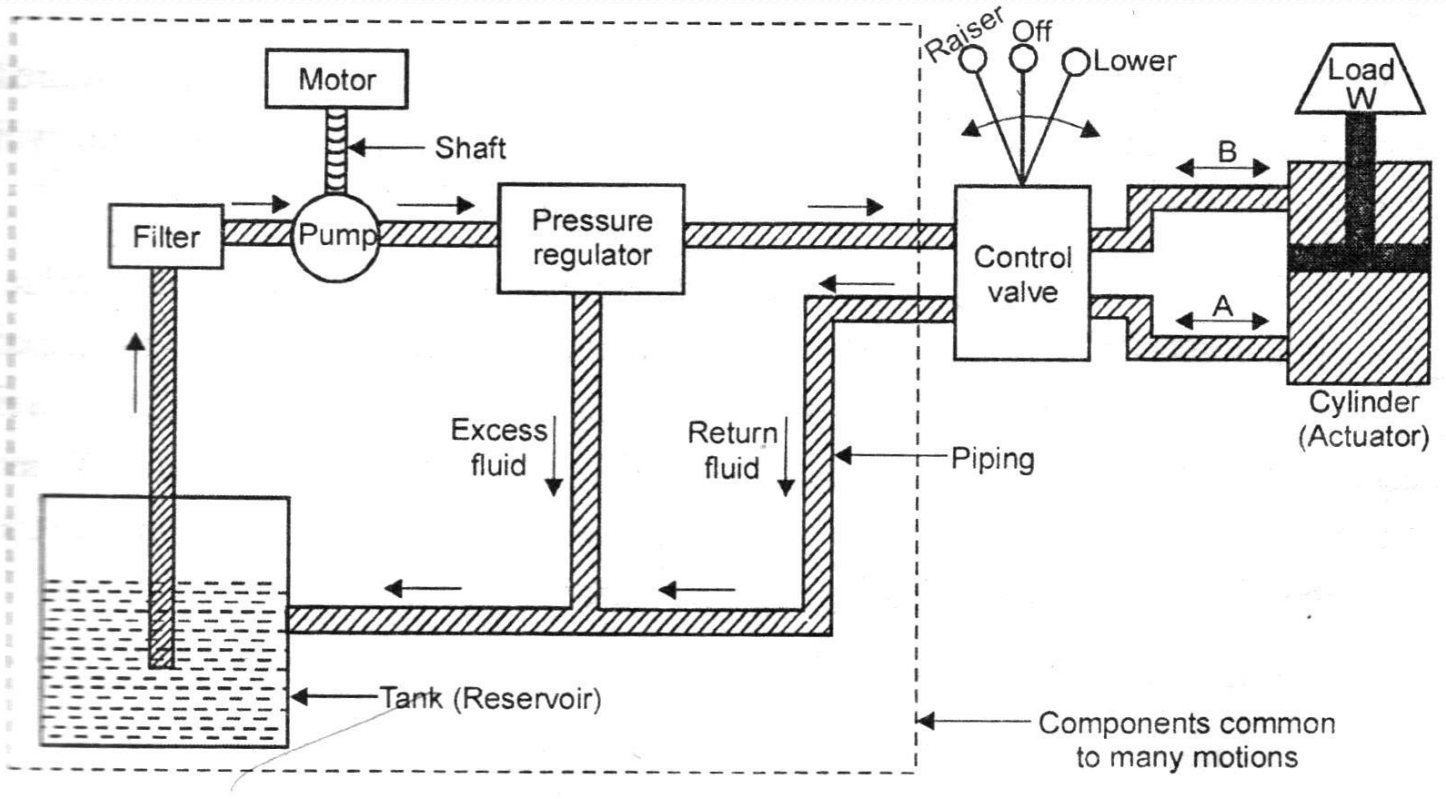
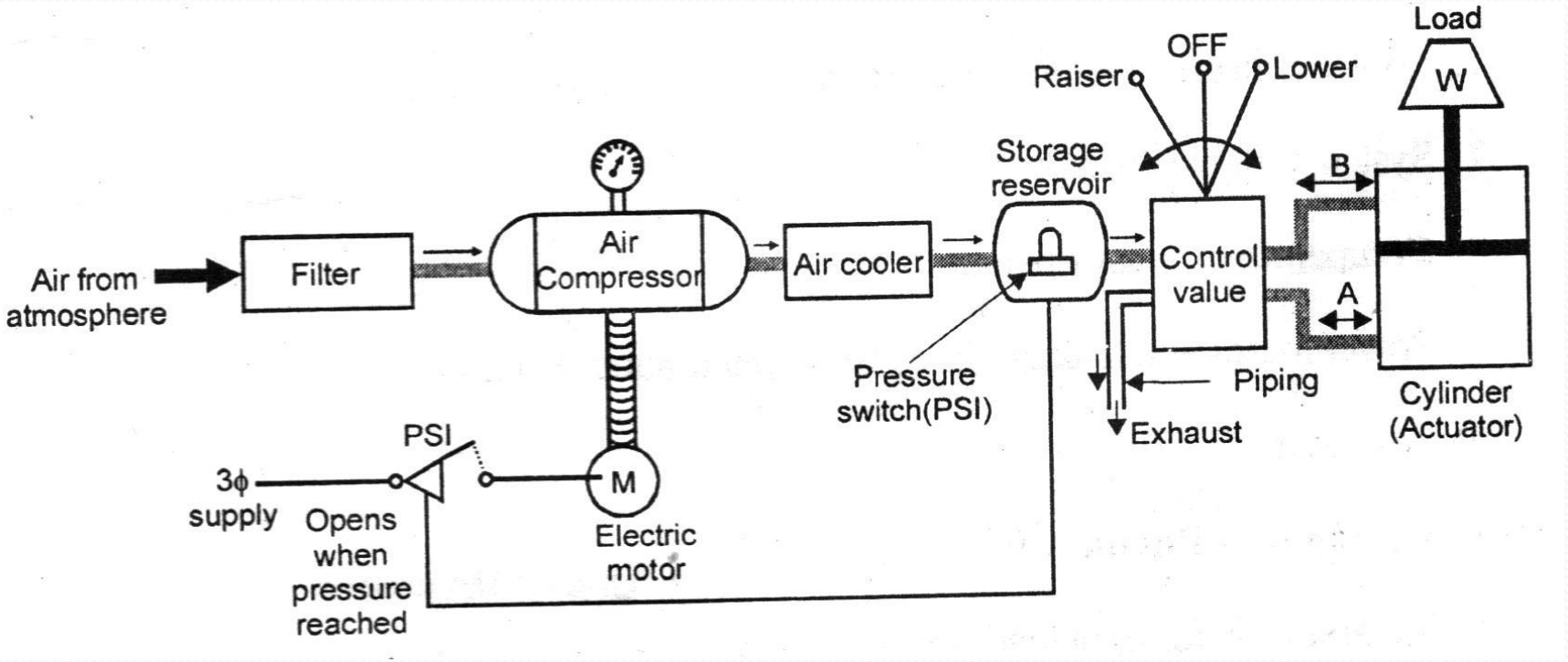
HYDRAULIC SYSTEM



PNEUMATIC SYSTEM



COMPARISION OF HYDRAULIC PNEUMATIC & ELECTRO MECHANICAL POWER SYSTEM

HYDRAULIC	PNEUMATIC	ELECTRICAL / ELECTRO MECHANICAL
Electrical energy is used to drive the hydraulic pumps	Electrical energy is used to drive the compressor motor	Electrical energy is used to drive the electric motor
Pressurized liquid	Air /Gas	No medium only through the mechanical components
Energy stored in the Accumulator	Energy stored in the Reservoir	Energy stored in the Battery
Energy transmitted through Hydraulic cylinders	Energy transmitted through Pneumatic cylinders	Energy transmitted through Gears , Cams, Screw jack etc,.

Operating speed low (0.5 m/sec)	Operating speed High (1.5 m/sec)	ELECTRICAL / ELECTRO MECHANICAL
High accuracy	Low accuracy	High accuracy
Large forces can be generated (F <3999 KN)	limited forces can be generated (F <30 KN)	Low forces can be generated
Hazardous	Noise y	Danger
Closed loop circuit	Open loop circuit	---
High cost	Cheep cost	Low cost
High weight	Medium weight	Less weight
Lubricant is not required	Separate lubricant is required	Separate lubricant is required

Properties of hydraulic fluids

- Mass density (mass / volume)
- Weight density or Specific Weight (weight / volume , $w = \rho g$)
- Specific gravity (density of fluid/ density of standard fluid)
- Specific volume (volume / mass)
- Viscosity ($\tau = \mu \, du/dy$)
- Kinematic Viscosity (ν = Dynamic viscosity / density , = μ/ρ)
- Viscosity index
- Cohesion & Adhesion
- Surface tension
- Capilarity

- Cavitations
- Compressibility
- Bulk modules
- Cloud , Pour, Flash & fire points
- Demulsibility
- Oxidation stability
- Volatility
- Neutralization number
- Corrosiveness

Properties of fluids

- PROPERTIES OF FLUIDS: Viscosity: It is a measure of the fluid's internal resistance offered to flow. Viscosity is the most important factor from the stand point of flow. If the viscosity of the hydraulic oil is higher than recommended, the system will be affected in the following manner.
- 1. The viscous oil may not be able to pass through the pipes. 2. The working temperature will increases because there will be internal friction.

Properties of fluids

- 3. The consumption of power will increase If the viscosity of the oil is lesser than recommended then, 1. The internal and external leakage will increase 2. It cannot lubricate properly and will lead to rapid wear of the moving parts.
- 2. Viscosity Index: This value shows how temperature affects the viscosity of oil. The viscosity of the oil decreases with increase in temperature and vice versa. The rate of change of viscosity with temperature is indicated on an arbitrary scale called viscosity index (VI). The lower the viscosity index, the greater the variation in viscosity with changes in temperature and vice versa.

Properties of fluids

- 3. Oxidation Stability: The most important property of an hydraulic oil is its oxidation stability. Oxidation is caused by a chemical reaction between the oxygen of the dissolved air and the oil. The oxidation of the oil creates impurities like sludge, insoluble gum and soluble acidic products. The soluble acidic products cause corrosion and insoluble products make the operation sluggish.
- 4. Demulsibility: The ability of a hydraulic fluid to separate rapidly from moisture and successfully resist emulsification is known as Demulsibility. If oil emulsifies with water the emulsion will promote the destruction of lubricating value and sealant properties. Highly refined oils are basically water resistance by nature

Properties of fluids

- 5. Lubricity: Wear results in increase clearance which leads to all sorts of operational difficulties including fall of efficiency. At the time of selecting a hydraulic oil care must be taken to select one which will be able to lubricate the moving parts efficiently.
- 6. Rust Prevention: The moisture entering into the hydraulic system with air causes the parts made ferrous materials to rust. This rust if passed through the precision made pumps and valves may scratch the nicely polished surfaces. So additives named inhibitors are added to the oil to keep the moisture away from the surface

Properties of fluids

- 7. Pour Point: The temperature at which oil will clot is referred to as the pour point i.e. the lowest temperature at which the oil is able to flow easily. It is of great importance in cold countries where the system is exposed to very low temperature.
- 8. Flash Point and Fire Point: Flash point is the temperature at which a liquid gives off vapour in sufficient quantity to ignite momentarily or flash when a flame is applied. The minimum temperature at which the hydraulic fluid will catch fire and continue burning is called fire point.

Properties of fluids

- **9. Neutralization Number:** The neutralization number is a measure of the acidity or alkalinity of a hydraulic fluid. This is referred to as the PH value of the fluid. High acidity causes the oxidation rate in an oil to increase rapidly.

- **REQUIRED QUALITIES OF GOOD HYDRAULIC OIL:**
- 1. Stable viscosity characteristics
- 2. Good lubricity
- 3. Compatibility with system materials
- 4. Stable physical and chemical properties
- 5. Good heat dissipation capability
- 6. High bulk modulus and degree of incompressibility
- 7. Good flammability

Properties of fluids

- 8. Low volatility
- 9. Good demulsibility
- 10. Better fire resistance
- 11. Non toxicity and good oxidation stability
- 12. Better rust and corrosion prevent qualities
- 13. Ready availability and inexpensive

Types of Hydraulic fluids

- Gases
- Liquids

LIQUIDS

- Water
- Petroleum based fluids
- Fire resistance fluids

i. Water in oil emulsion
ii. Water glycol mixture
iii. Synthetic fluids
iv. High water content fluids

Hydraulic fluid types

1. Water:

- Clear water
- Water with additives

- o Oldest fluid but nowadays there is a renaissance
- o Used where there is an explosion or fire danger or hygienic problem: Food and pharmaceutical industry, textile industry, mining

Advantages:

- No environmental pollution
- No disposal effort
- Cheap
- No fire or explosion danger
- Available everywhere
- 4 times larger heat conduction coefficient than mineral oils
- 2 times higher compression module than mineral oils
- Viscosity does not depend strongly on temperature

Hydraulic fluid types (contd.)

1. Water:

Disadvantages:

- Bad lubrication characteristics
- Low viscosity (problem of sealing, but has good sides: low energy losses)
- Corrosion danger
- Cavitation danger (relatively high vapour pressure)
- Limited temperature interval of applicability (freezing, evaporating)

Consequences: needs low tolerances and very good materials (plastics, ceramics, stainless steel) $\Rightarrow$ components are expensive

Hydraulic fluid types (contd.)

2. Mineral oil:

- Without additives
- With additives

- „Conventional" use, stationary hydraulics
- Always mixtures of different oils, often with additives

  Additives:
  - decrease corrosion
  - increase life duration
  - improve temperature dependence of viscosity
  - improve particle transport

Advantages:

- Good lubrication
- High viscosity (good for sealing, bad for losses)
- Cheap

Disadvantages:

- Inflammable
- Environmental pollution

Hydraulic fluid types (contd.)

4. Biologically degradable fluids:

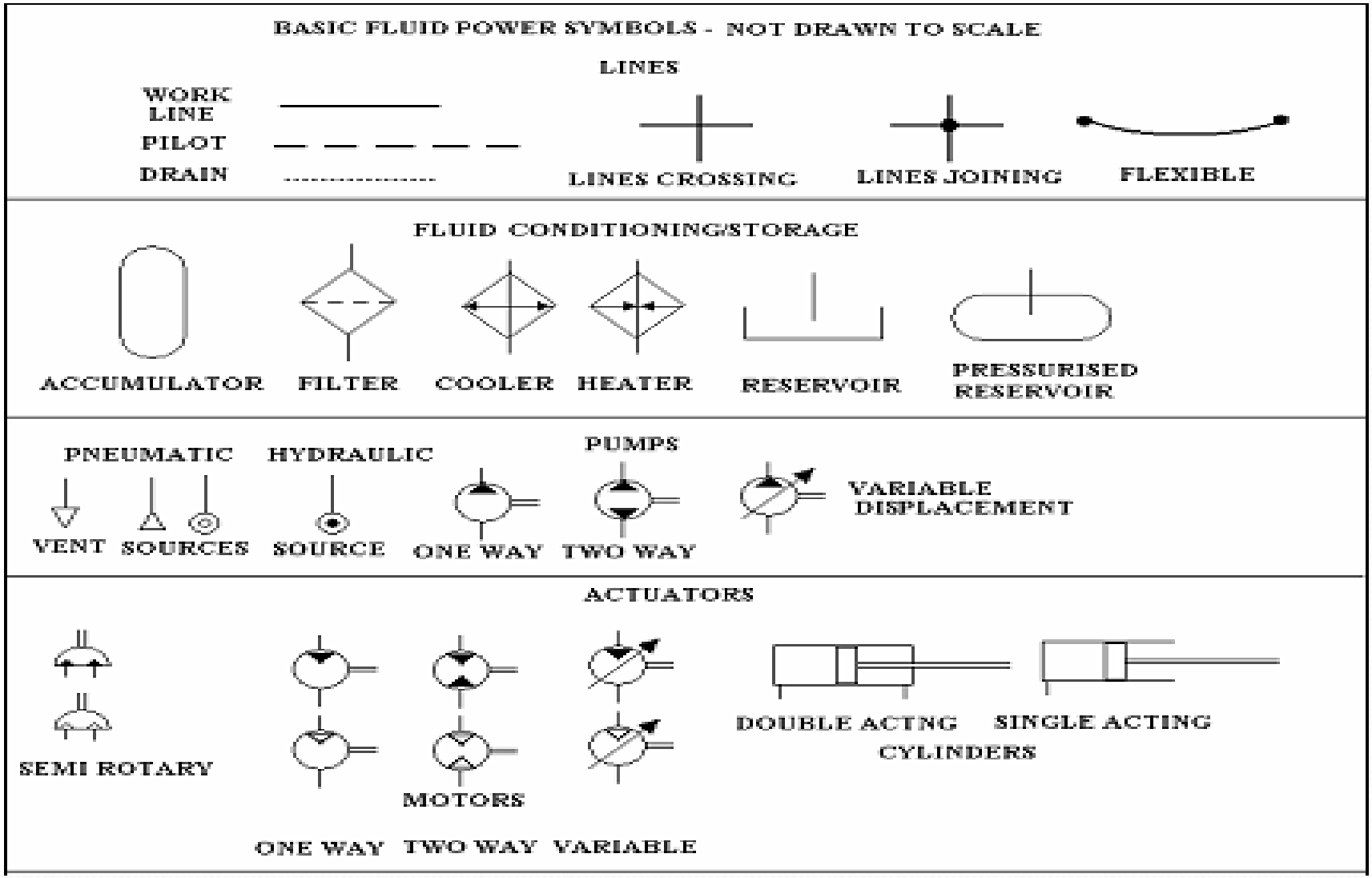
- Natural
- Synthetic

- Environmental protection, water protection
- Agricultural machines
- Mobile hydraulics

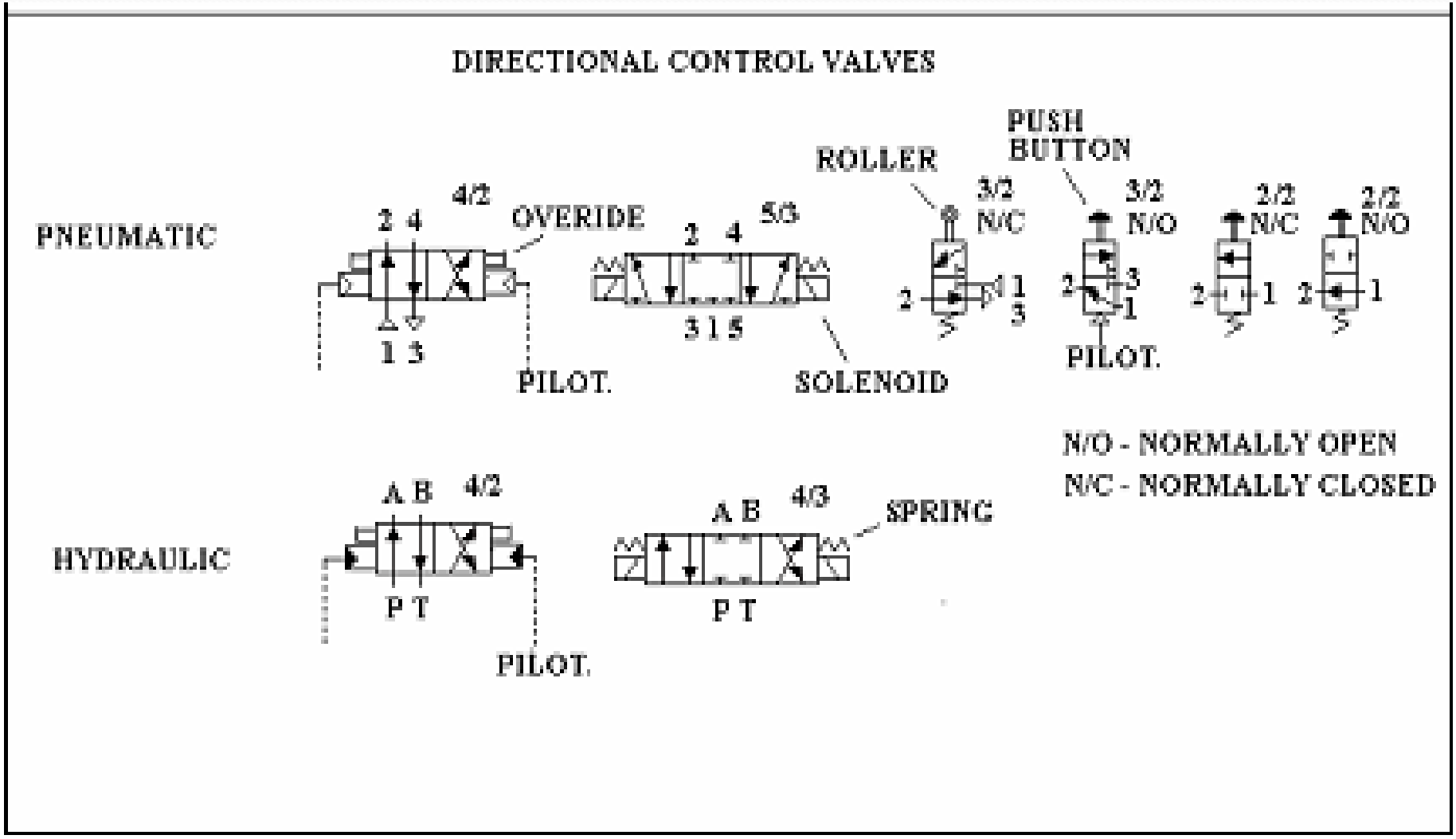
Characteristics similar to mineral oils but much more expensive.

If the trend continues its usage expands, price will drop.

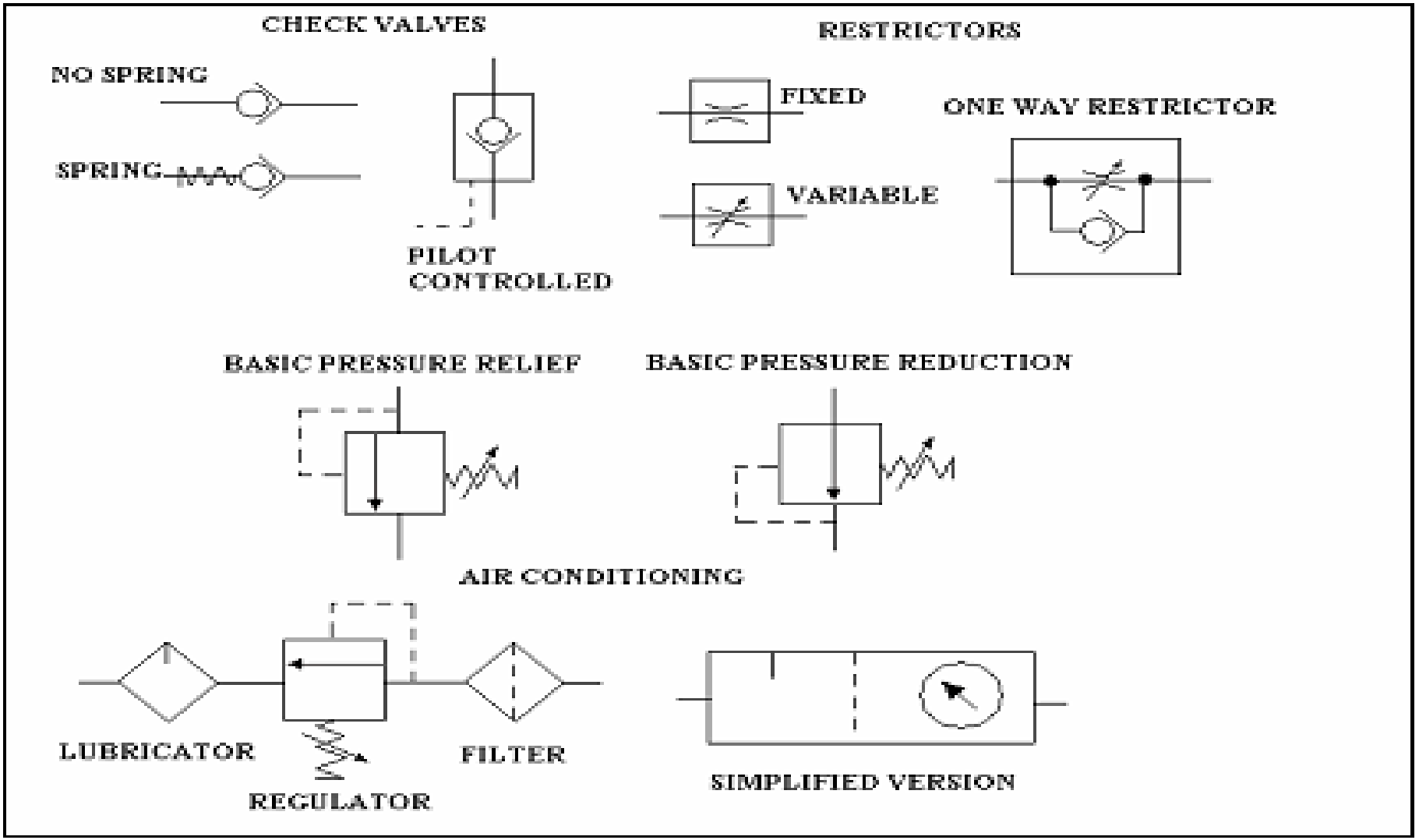
Fluid power symbols



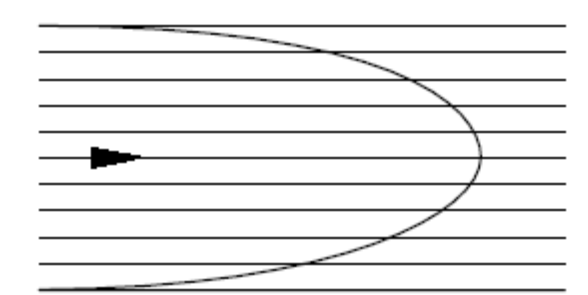
Fluid power symbols



Fluid power symbols

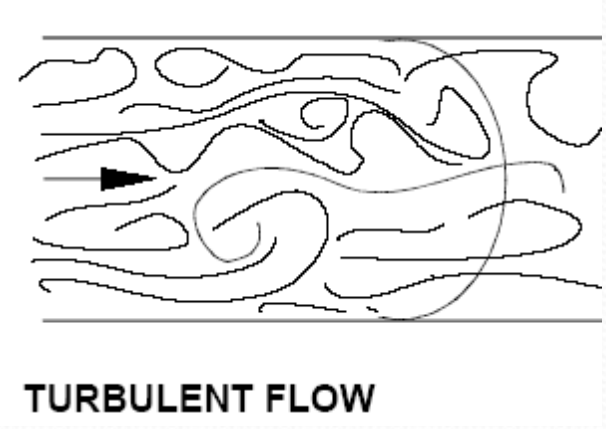


Laminar and Turbulent flow



LAMINAR FLOW

- It is a stream line flow as all the fluid particles moves in a parallel path



TURBULENT FLOW

- It is a irregular flow
- Some fluid particles move parallel and some move perpendicular to the mean flow direction

HYDRAULIC PUMP

Sources of Hydraulic powers:

Pumping theory or working principle of pump:

when the input energy is applied the internal operation of pump creates negative pressure. This pressure difference creates a partial vacuum at inlet which draws the fluid in to the pump. Then the pump mechanically pushes the fluid in to rest of the hydraulic circuit.

HYDRAULIC PUMP

Function of hydraulic pump

The function of a pump is to convert mechanical energy into hydraulic energy. It is the heart of any hydraulic system because it generates the force necessary to move the load. Mechanical energy is delivered to the pump using a prime mover such as an electric motor. Partial vacuum is created at the inlet due to the mechanical rotation of pump shaft. Vacuum permits atmospheric pressure to force the fluid through the inlet line and into the pump. The pump then pushes the fluid mechanically into the fluid power actuated devices such as a motor or a cylinder.

HYDRAULIC PUMP

Pumps are classified into three different ways as follow …

I. Classification based on displacement:

1. Non-positive displacement pumps
2. Positive displacement pumps

II. Classification based on delivery:

1. Constant delivery pumps.
2. Variable delivery pumps.

III. Classification based on motion:

1. Rotary pump.
2. Reciprocating pump.

HYDRAULIC PUMP

I. Classification Based on Displacement

1. Non-Positive Displacement Pumps

Non-positive displacement pumps are primarily velocity-type units that have a great deal of clearance between rotating and stationary parts. Non-displacement pumps are characterized by a high slip that increases as the back pressure increases, so that the outlet may be completely closed without damage to the pump or system. Non-positive pumps do not develop a high pressure but move a large volume of fluid at low pressures. They have essentially no suction lift. Because of large clearance space, these pumps are not self-priming.

HYDRAULIC PUMP

I. Classification Based on Displacement conti…

2. Positive Displacement Pumps

Positive displacement pumps, in contrast, have very little slips, are self-priming and pump against very high pressures, but their volumetric capacity is low. Positive displacement pumps have a very close clearance between rotating and stationary parts and hence are self-priming. Positive displacement pumps eject a fixed amount of fluid into the hydraulic system per revolution of the pump shaft. Such pumps are capable of overcoming the pressure resulting from mechanical loads on the system as well as the resistance of flow due to friction. This equipment must always be protected by relief valves to prevent damage to the pump or system. By far, a majority of fluid power pumps fall in this category, including gear, vane and piston pumps.

HYDRAULIC PUMP

Differences between positive displacement pumps and non-positive displacement pumps

Positive Displacement Pumps

1. The flow rate does not change with head.
2. The flow rate is not much affected by the viscosity of fluid.
3. Efficiency is almost constant with head.

Non-positive Displacement Pumps

1. The flow rate decreases with head.
2. The flow rate decreases with the viscosity.
3. Efficiency increases with head at first and then decreases.

Classification of pumps

- Hydro dynamic (non positive displacement)
- Hydro static (positive displacement)

Hydro dynamic pump:

it is used to carry the fluid from one location to another location (low pressure 17 – 21 Bars)

Example: centrifugal pump

Hydro static pump:

it is used to transmit fluid pressure to fluid power. It is whether fixed or variable displacement pump

HYDRAULIC PUMP

Fixed displacement pump:

- The amount of fluid delivered per revolution cannot be varied.

Variable displacement pump:

- The displacement can be varied by changing the physical conditions of various pump elements.
- The amount of fluid delivered per revolution can be varied.

Classification of Positive displacement pump (Hydro static)

1. Gear pumps (fixed displacements only)
   a. External
   b. Internal
   c. Lobe
   d. Screw
   e. Gerotor
2. Vane pump (Fixed or Variable)
   a. Balanced
   b. Unbalanced

HYDRAULIC PUMP

3. Piston pump (Fixed or Variable)
   a. Axial design
   b. Radial design

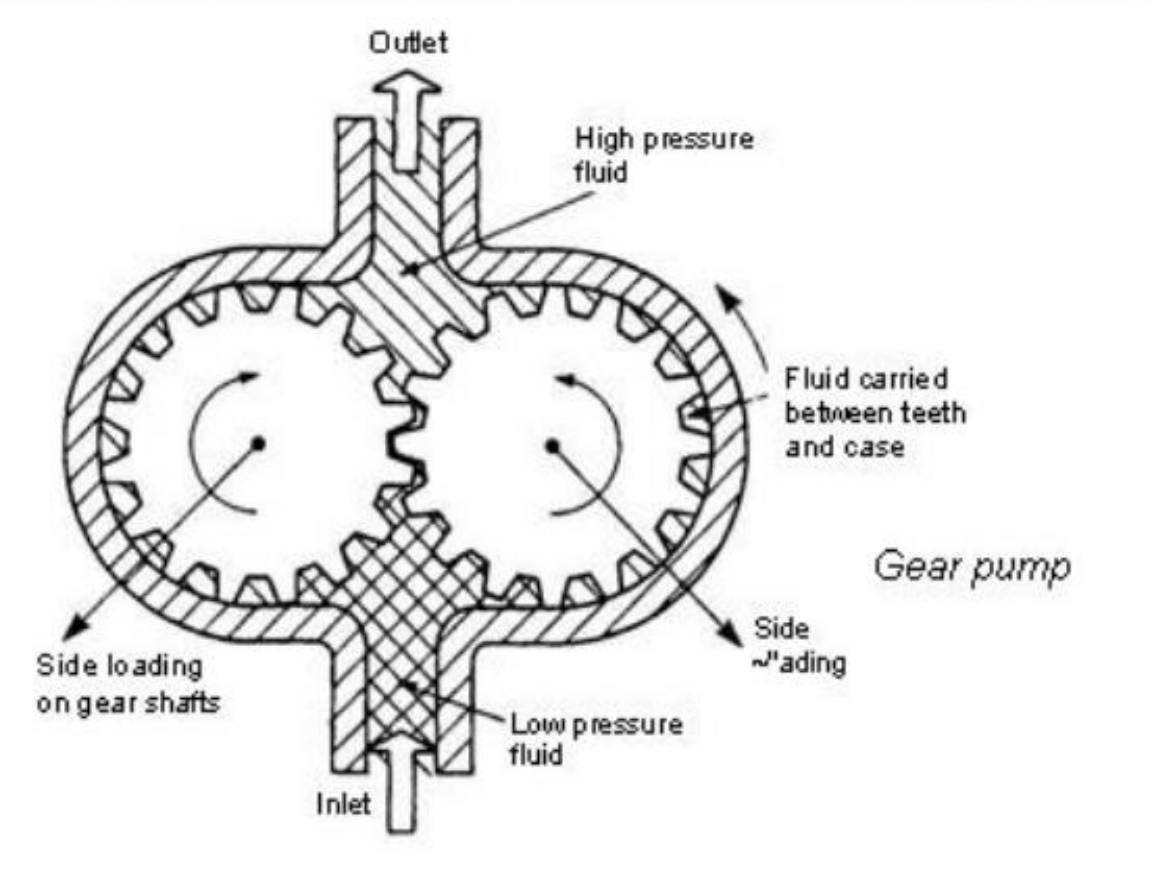
Gear pumps

- Simplest and robust type
- Operating speed is 4000 rpm
- Operating pressure is 15 Mpa
- Delivery 6751 Lpm
- Volumetric efficiency 90%
- ADVANTAGES:
- Long life
- High efficiency
- Simple in design & low cost

External gear pump

- DISADVANTAGES
- Four bushings in liquid area
- No solids allowed
- Fixed End Clearances
- ADVANTAGES:
- High speed
- High pressure
- No overhung bearing loads
- Relatively quiet operation
- Design accommodates wide variety of materials

External gear pump

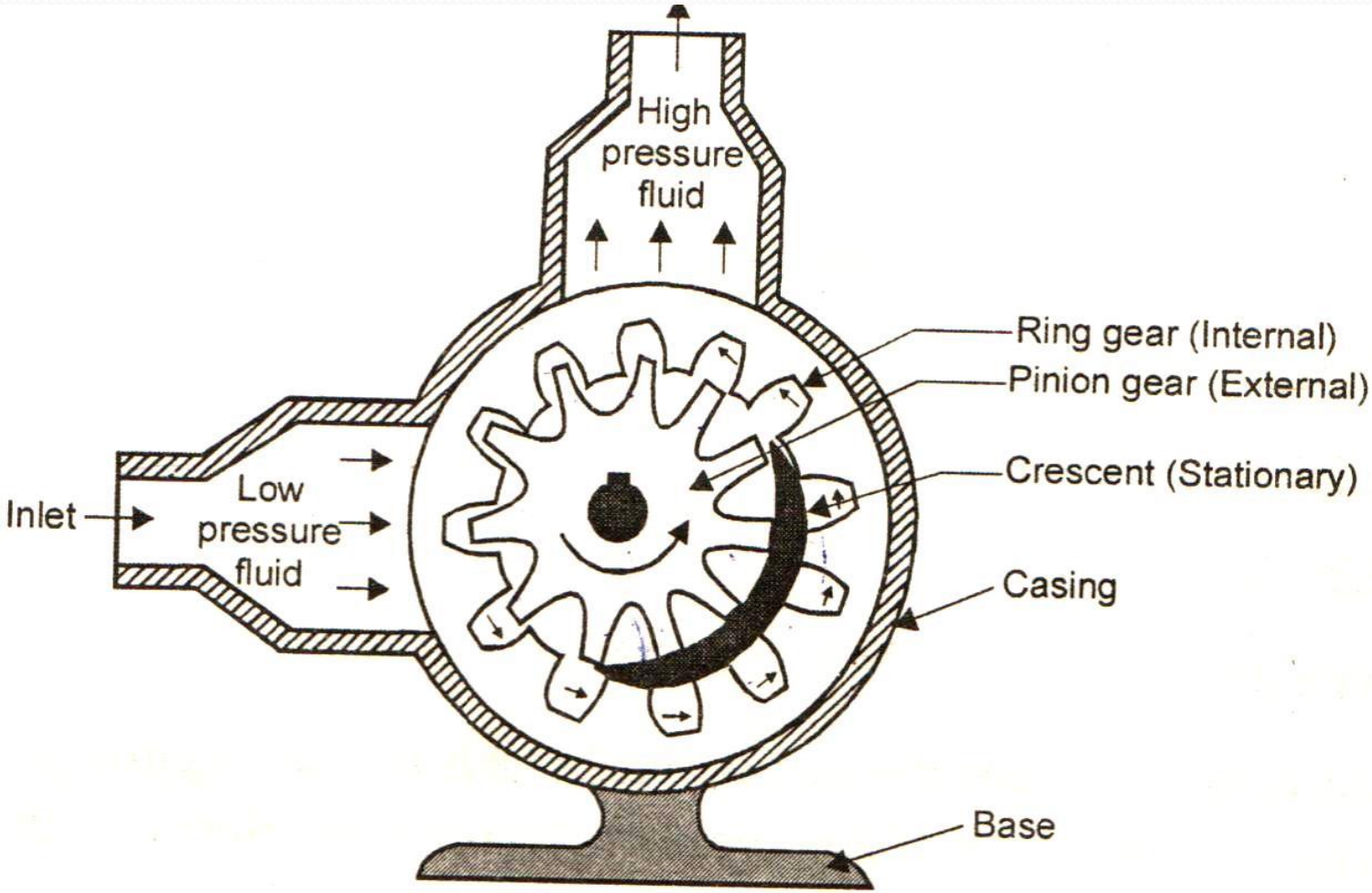


External gear pump

- Two spur gears rotating in opposite direction
- Rotation of these gear wheels open and closes the inlet and outlet
- Suction side where the gear teeth comes out of mesh expands the volume bringing out reduction in pressure
- Fluid from reservoir is drawn in to the pump
- In the discharge side reduction in volume increase the pressure

- Due to this the fluid is forced out of the system

INTERNAL GEAR PUMP



- Two gears rotate in same direction internal(ring gear)and external(pinion gear)
- Crescent is act as a seal between suction and discharge side

LOBE PUMP

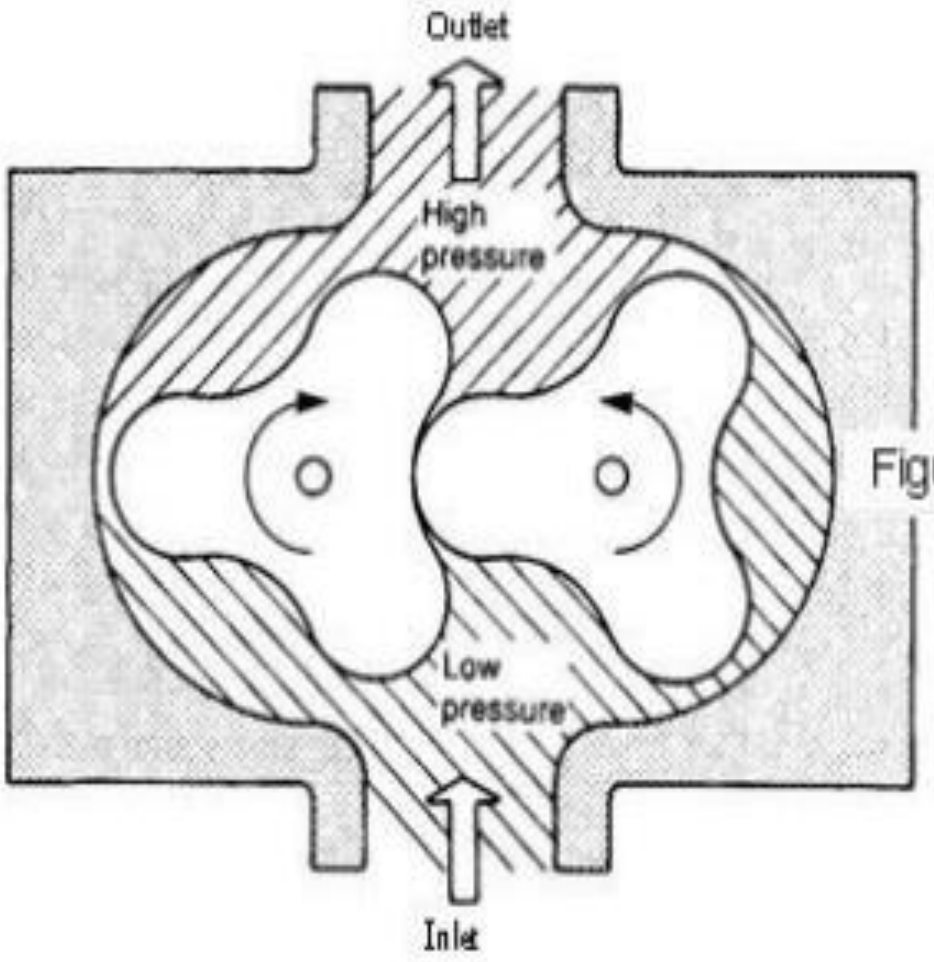
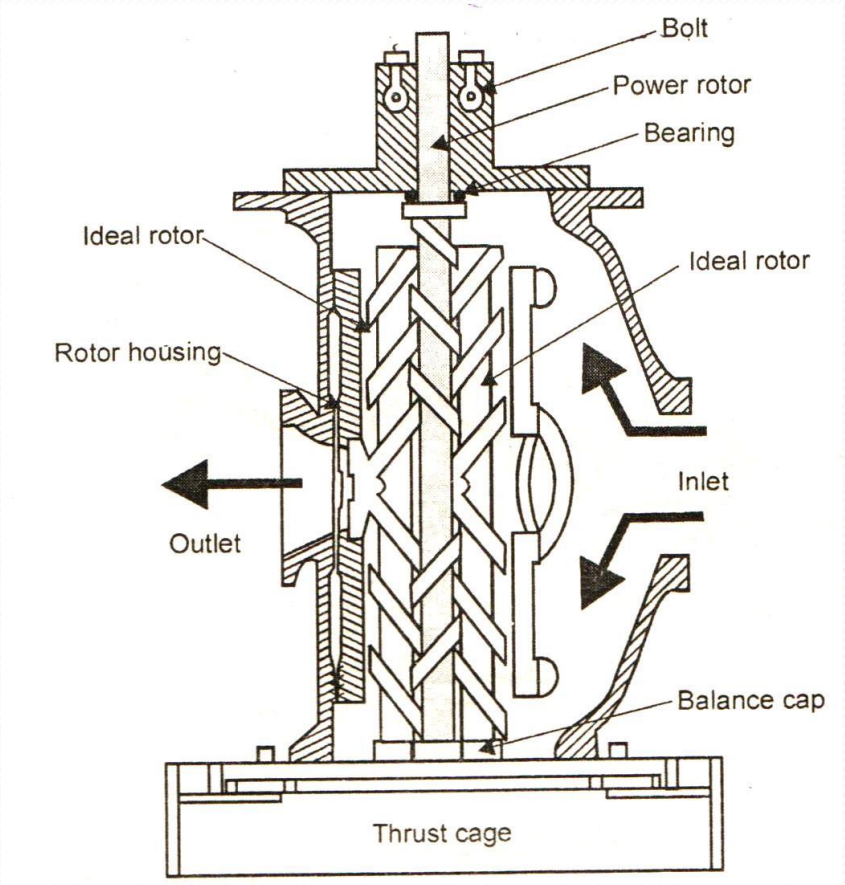


Figure 2.8 *The lobe pump*

- Similar to external gear pump
- Gears are replaced by lobes
- Both lobes are driven externally they are not in actual contact with each other
- Quiter in operation

Screw pump

- Axial flow type uses meshing screws to develop desired pressure.
- The driving and driven screw(ideal rotor) are connected by timing gears.
- Timing gears provides the timing force between the meshing screws.
- In this pump fluid not rotate but moves as nut on thread, hence smoothest flow at high speed.

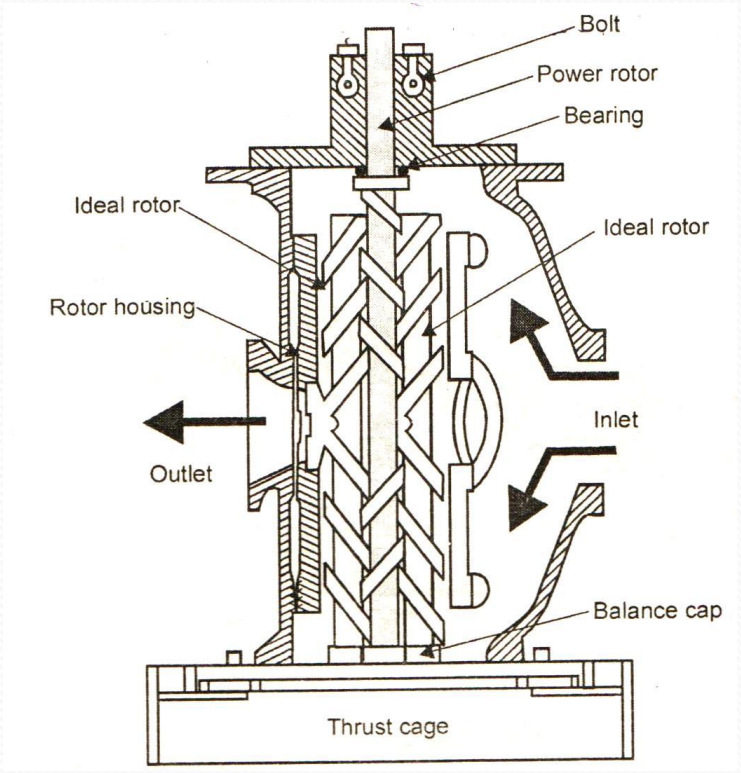


Screw pump

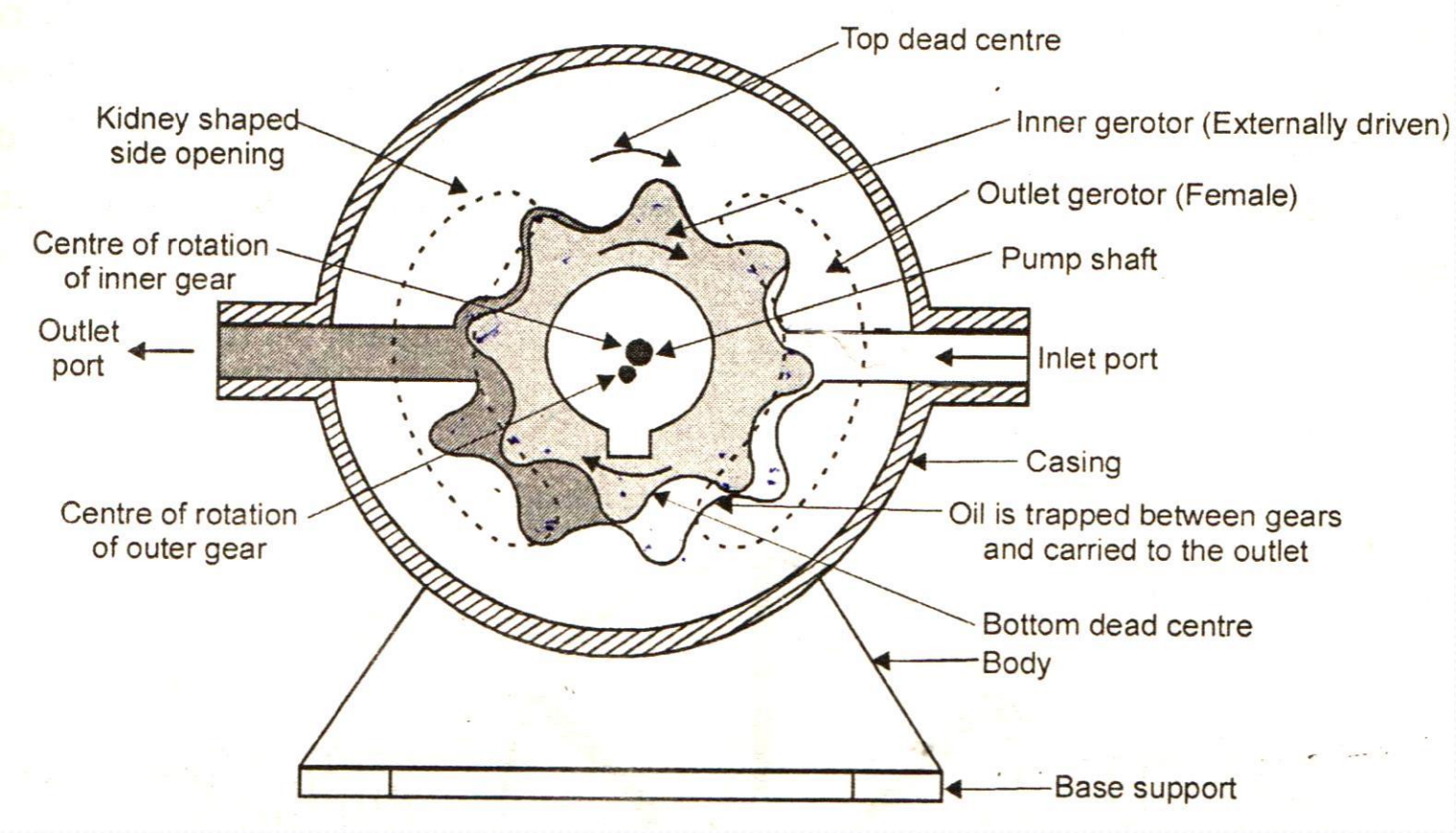
Working

When screw turns,

- Space between the threads are divided into compartment.
- During this vacuum created fluid forced through the inlet
- As the screw rotate fluid travels between meshing element
- When screw turns normal, fluid discharged along outlet port

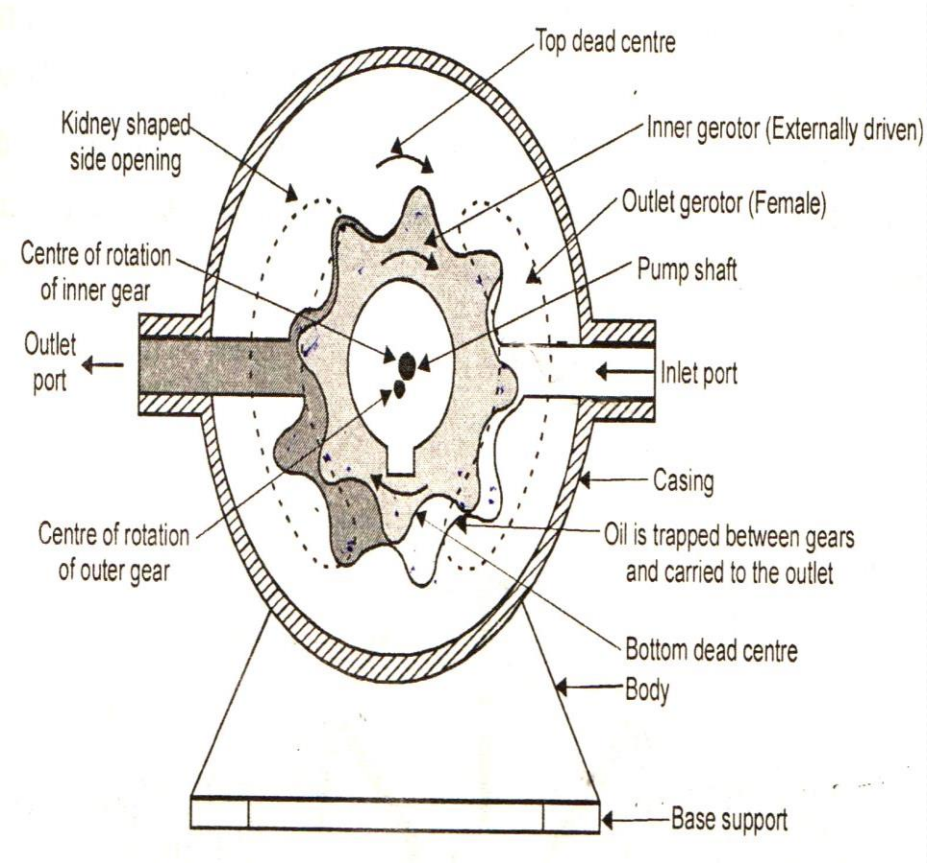


GEROTOR PUMP



GEROTOR PUMP

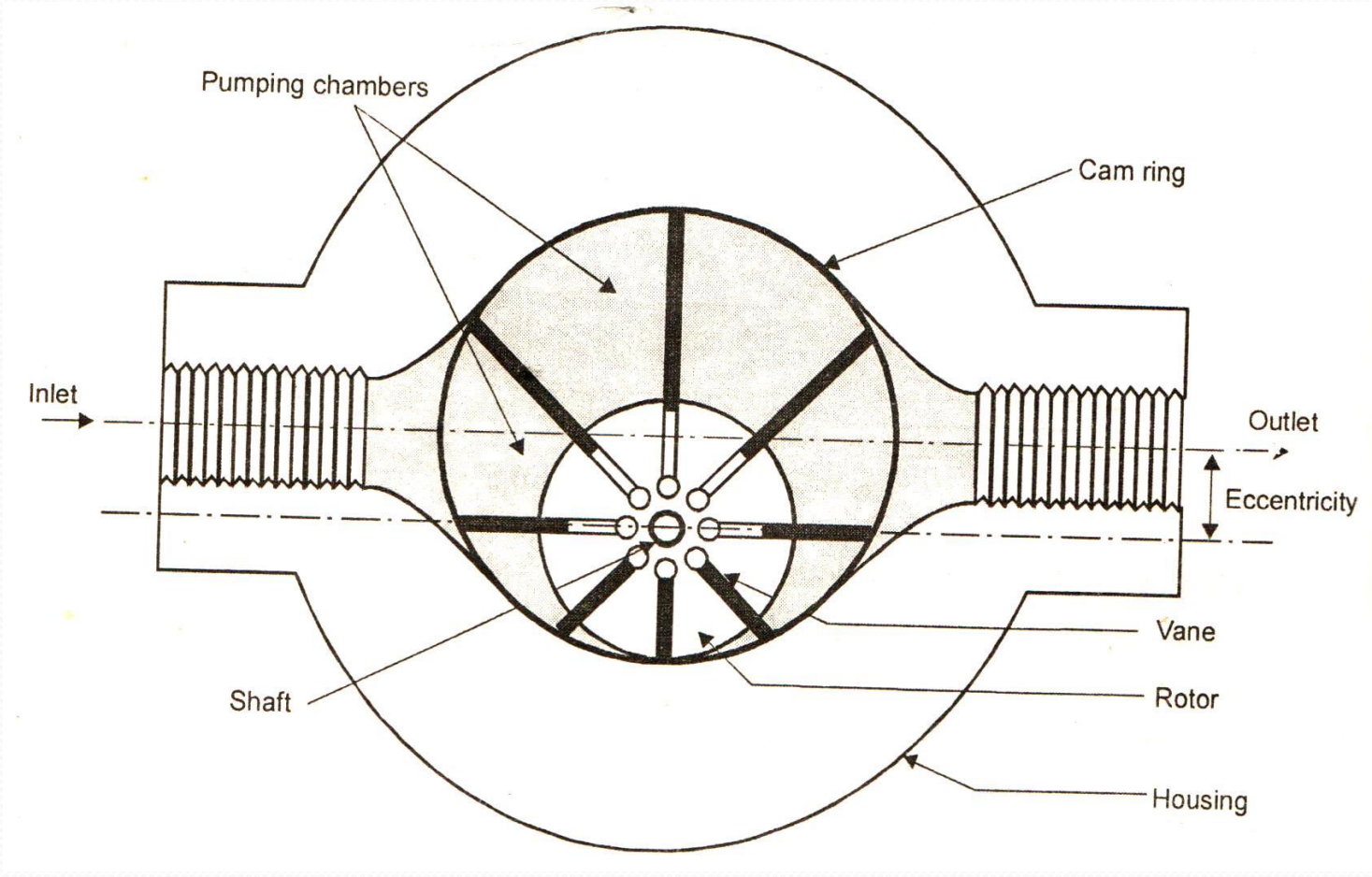
- Inner gear has one teeth lesser than external
- The inner gear rotor drives the outer gear rotor around, as they mesh.
- Vacuum created at inlet port when the right side is meshed, fluid drawn in.
- In the left side chamber, area decreases causing increase in pressure, forces fluid through outlet



VANE PUMP

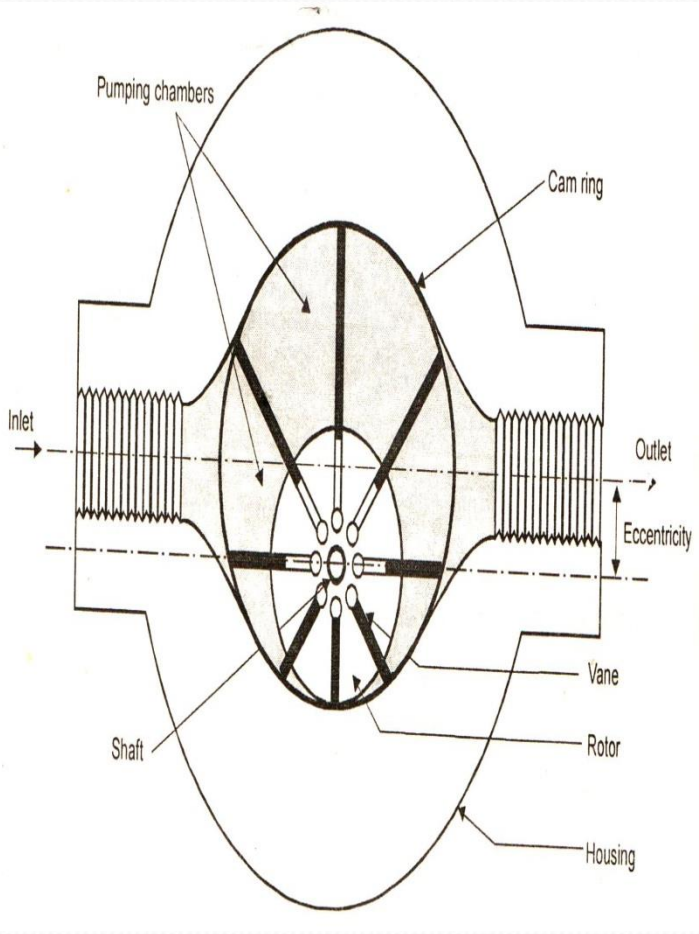
- Vane pump operating speed is4500 rpm
- Delivery flow rate 270 lpm
- Operating pressure is 25 Mpa
- Volumetric efficiency is 92%
- **ADVANTAGES:**
- High reliable
- Reversible pump
- It reduces the leakage losses

UN BALANCED VANE PUMP

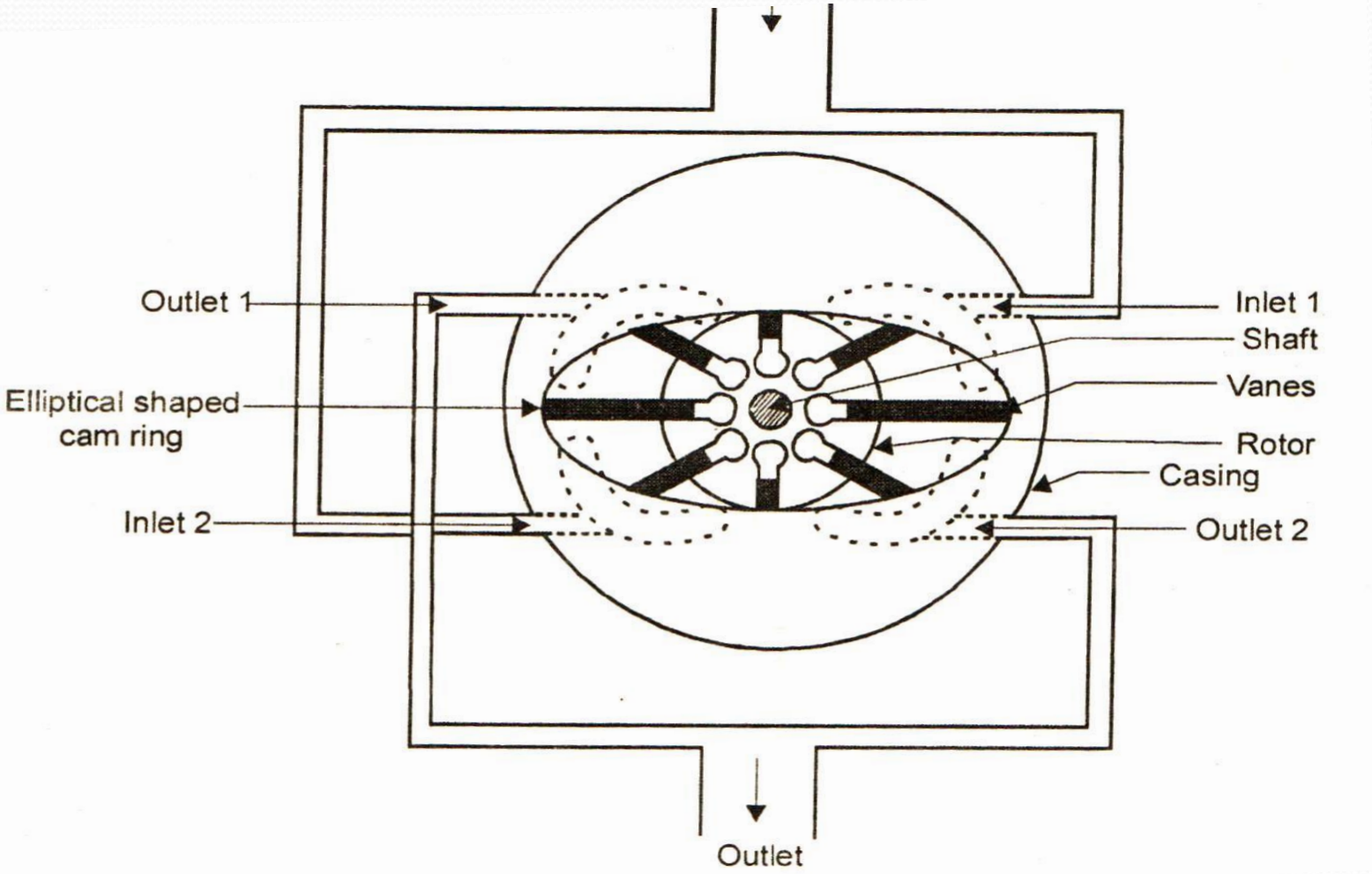


UN BALANCED VANE PUMP

- As rotor rotates vanes pushed out against cam ring surface by centrifugal force, which in turn vane kept in contact with the cam surface.
- Vanes divide the space between rotor and cam ring into serial of small chambers.
- During one half of rotor rotation vacuum created and fluid drawn inside
- During second half vanes pushed back pressure increased, forces fluid outside

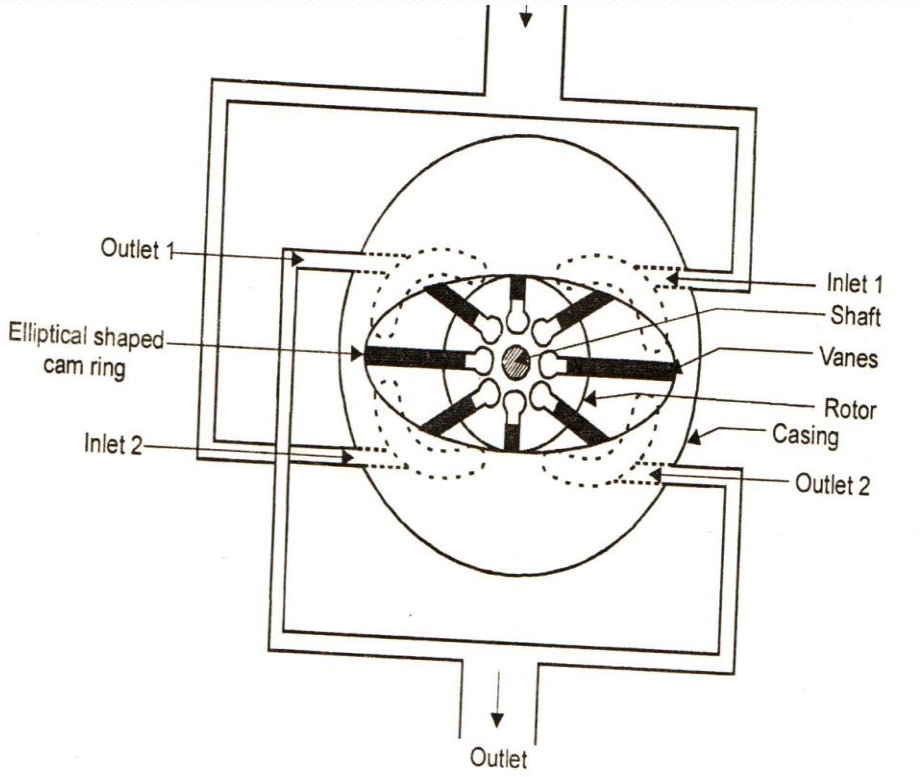


BALANCED VANE PUMP



BALANCED VANE PUMP

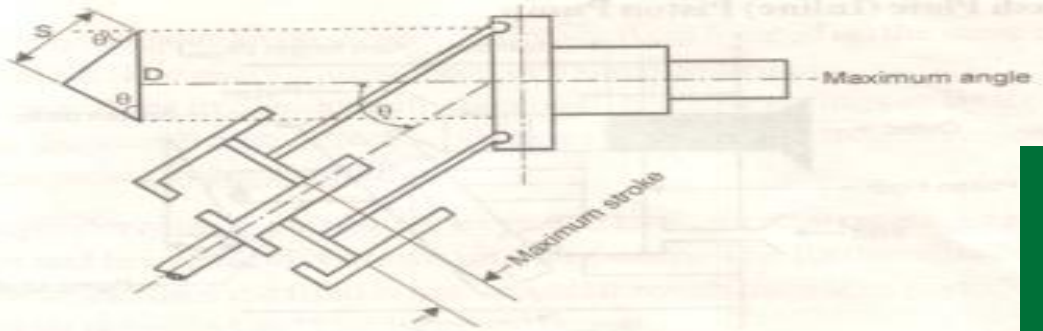
- When rotor rotates inside elliptical cam ring, the vanes strokes twice/rev of pump shaft.
- Resulting in increase or decrease in volume of pumping chambers twice per cycle.
- For increase in volume fluid drawn through inlet port and for decrease fluid forced out through outlet port.



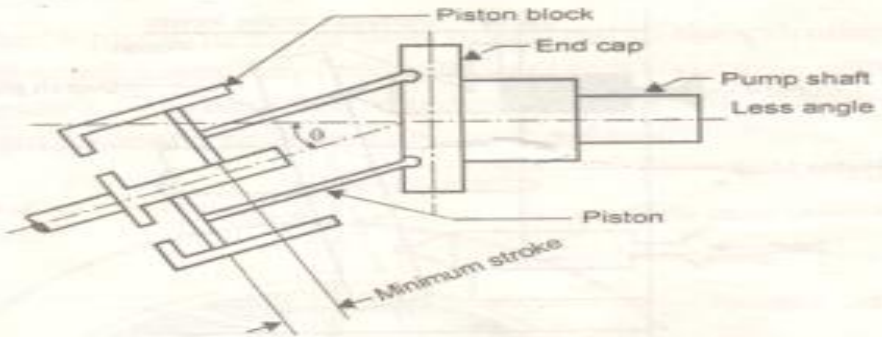
PISTON PUMPS

- Operating speed is 6000 rpm
- Delivery flow rate 600 lpm
- Operating pressure 70Mpa
- Volumetric efficiency 98%
- **ADVANTAGES:**
- Simple and compact design
- High Volumetric efficiency
- High pressure with high flow rate
- Least tolerant of contamination

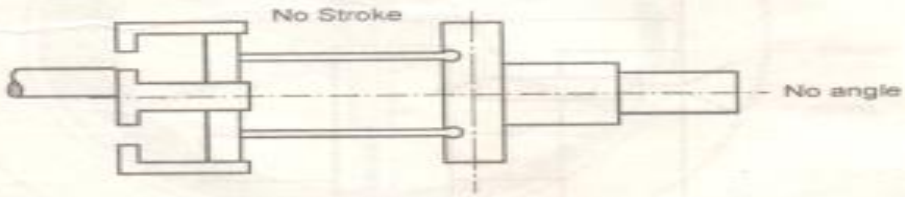
BENT AXIS TYPE PISTON PUMP TYPE



(a) Maximum Offset angle

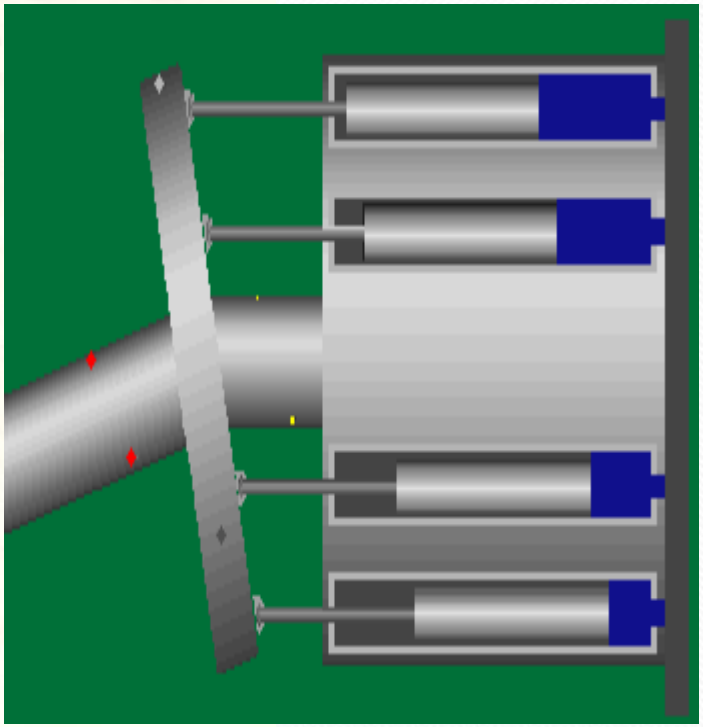


(b) Reduced Offset angle



(c) Zero Offset angle

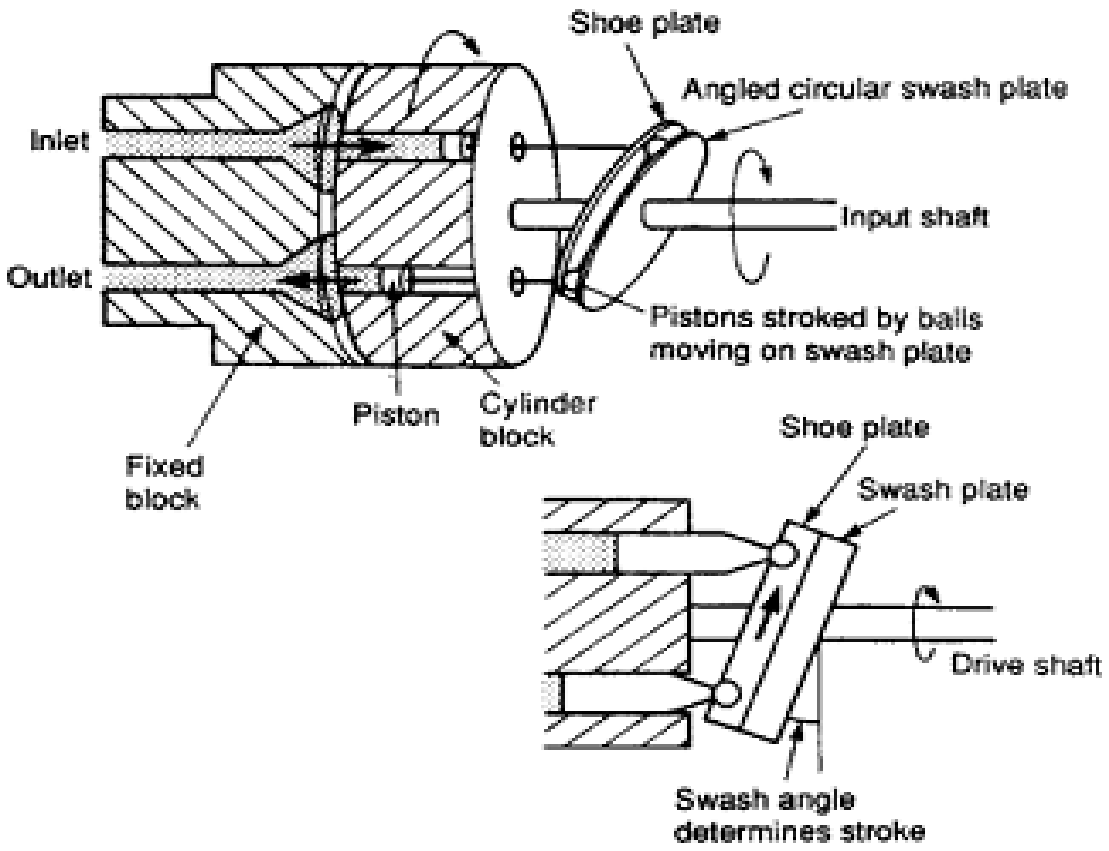
Figure 2.8: Bent axis type piston pump

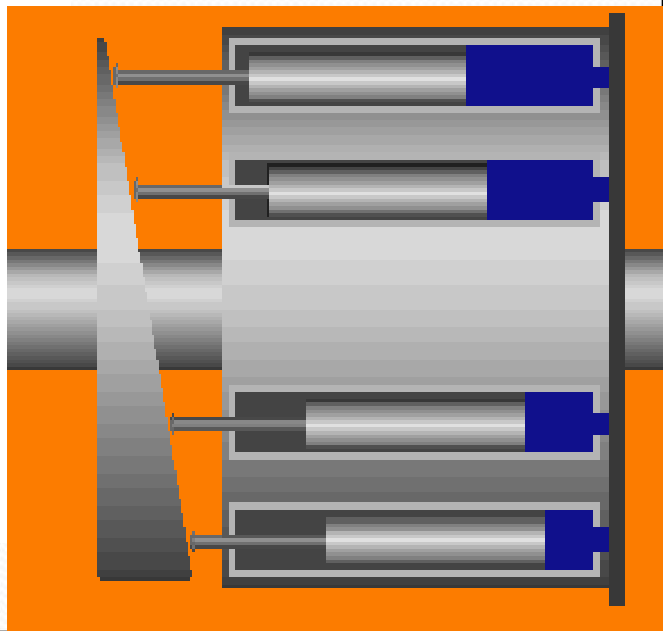


BENT AXIS TYPE PISTON PUMP TYPE

- When the pump shaft rotates the piston and piston block also rotates.
- This causes piston to reciprocate in their bores.
- When piston pulls back fluid drawn in, during 180° of rotation, fluid drawn out during other 180° of rotation

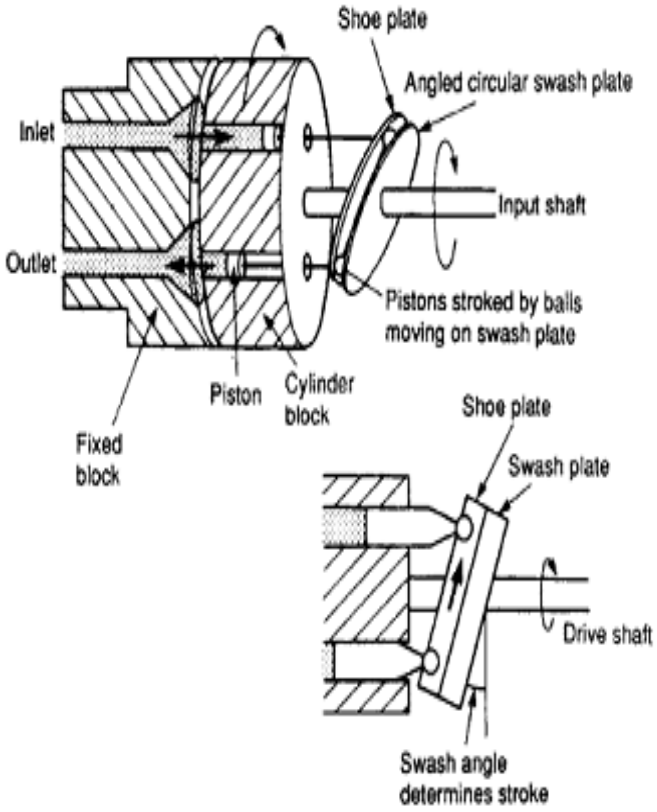
SWASH PLATE PISTON PUMP





Swash plate piston pump

- The cylinder block and driven shaft are located on the same centreline.
- The pistons are stroked by a fixed angled plate called the swash plate.
- Each piston can be kept in contact with the swash plate by springs or by a rotating shoe plate
- As cylinder rotated piston pulled back, vacuum created in inlet port and hence fluid drawn in. further rotation of cylinder pushes piston and fluid discharged through outlet port.
- Max swash plate angle limited to 17.5° by construction.



RADIAL PISTON PUMP

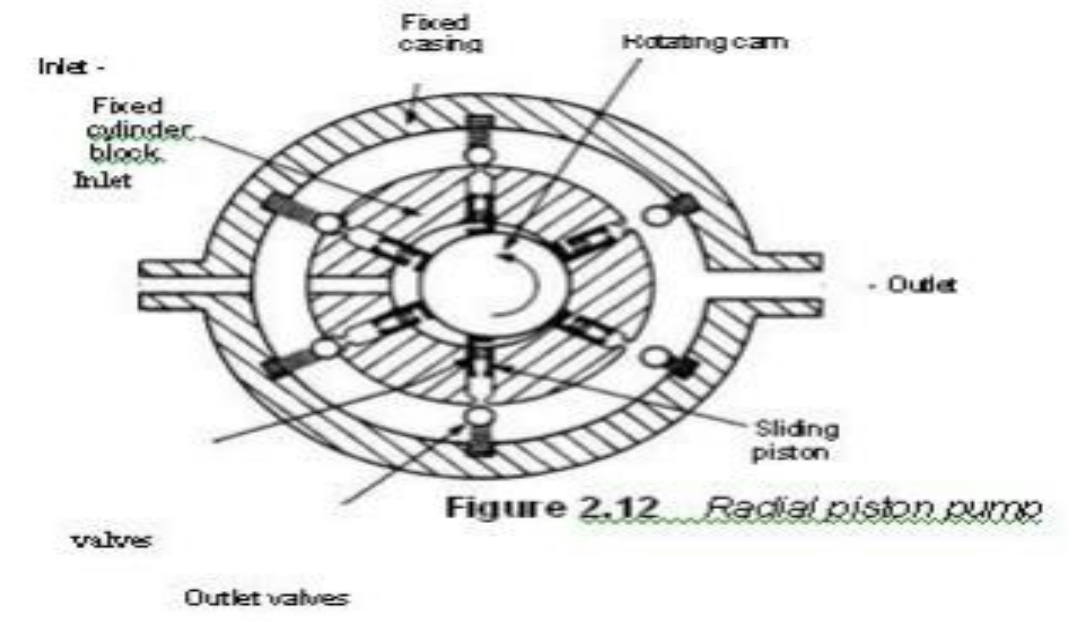
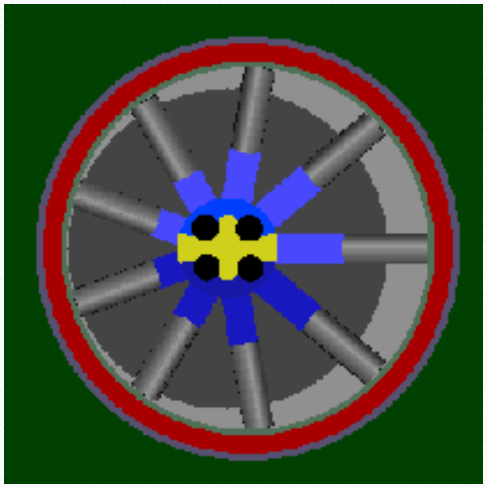


Figure 2.12 *Radial piston pump*



RADIAL PISTON PUMP

- Has pistle to direct fluid in and out of the cylinder.
- Consists of cylindrical barrels in which no. of plates reciprocates and rotor containing a reaction ring.
- The piston remains always in contact with the reaction ring due to centrifugal force and back pressure on the pistons

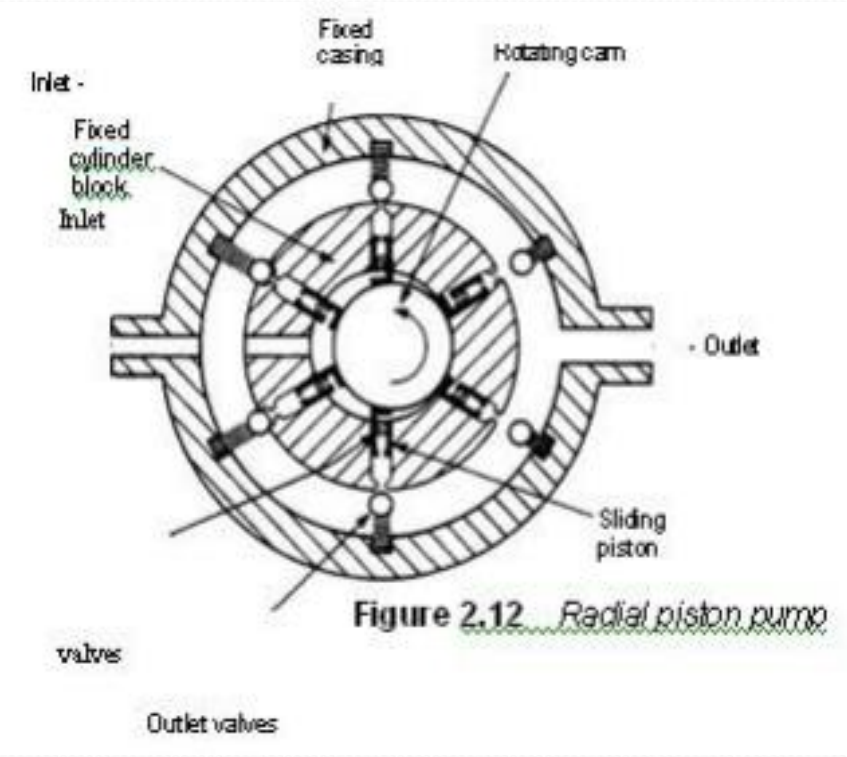


Figure 2.12 Radial piston pump

RADIAL PISTON PUMP

working

- As cylinder barrel rotates the reaction ring moved eccentrically to the pistle axis and this eccentric change causes the piston to stroke
- When piston outside – fluid drawn in.
- When the piston at max eccentricity, it is forced inward and forces the fliud out of the casing.

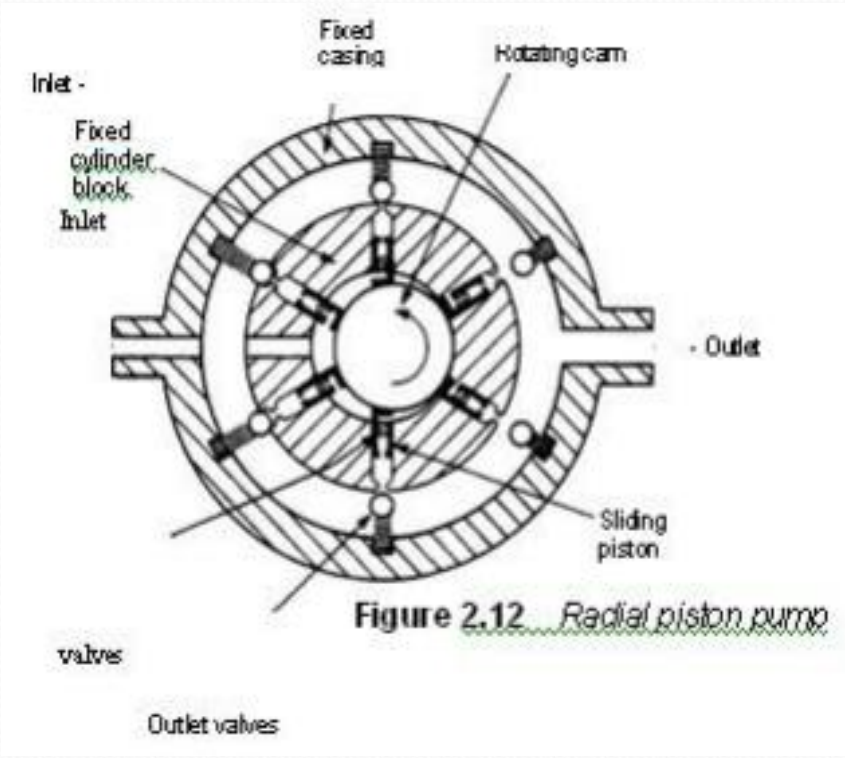
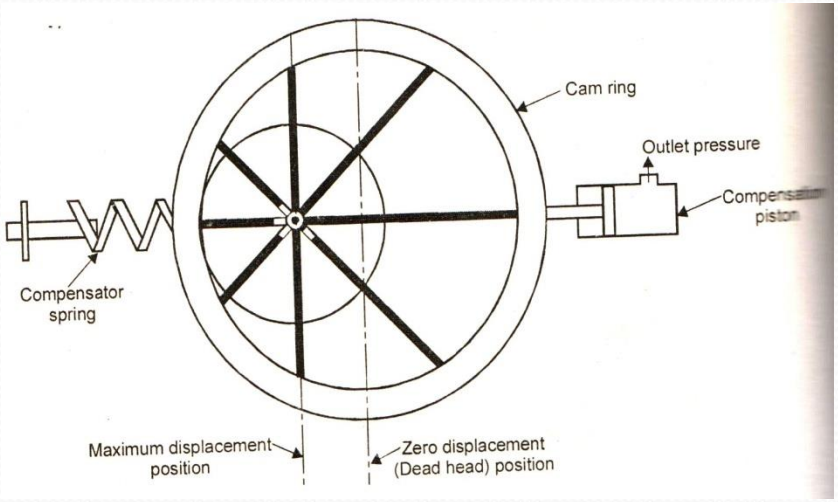
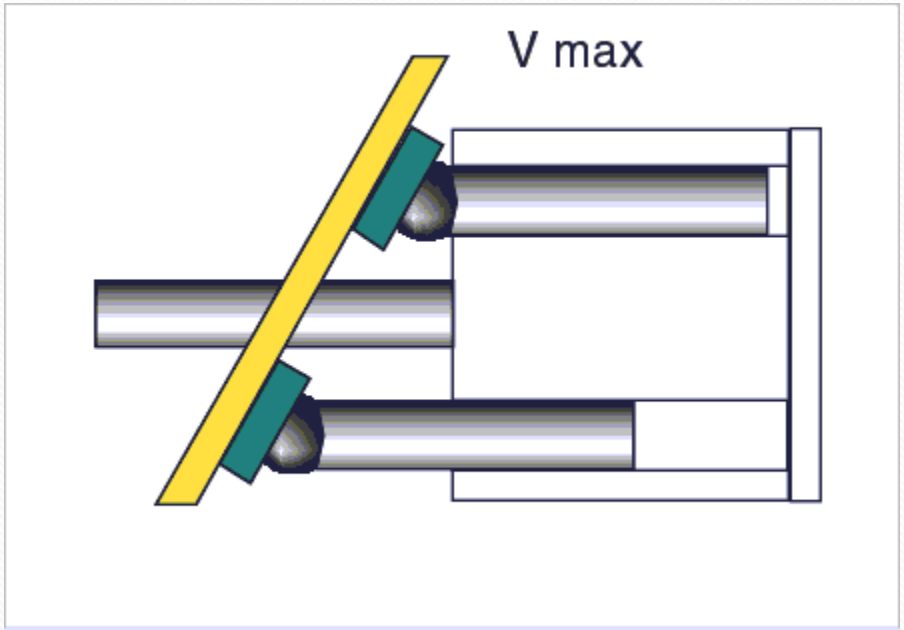


Figure 2.12 Radial piston pump

VARIABLE DISPLACEMENT PUMP





CAVITATION

- When partial vacuum become excessive at inlet, air in the fluid comes out and forms bubbles.
- When these bubbles travels with high velocity and high impact force, erode metallic life and reduces the pump life.

Effects of cavitation

- Vibration
- Damage to bearing due to poor lubrication
- overheating

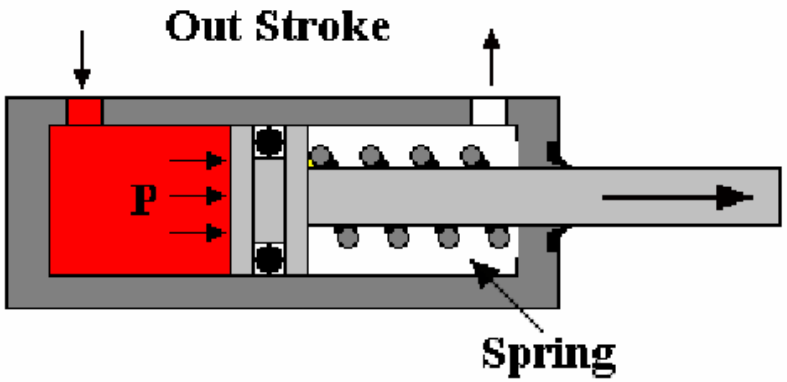
UNIT II
HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

- Hydraulic Actuators: Cylinders — Types and construction, Application, Hydraulic cushioning — Hydraulic motors — Control Components : Direction Control, Flow control and pressure control valves — Types, Construction and Operation — Servo and Proportional valves — Applications — Accessories : Reservoirs, Pressure Switches — Applications — Fluid Power ANSI Symbols — Problems.

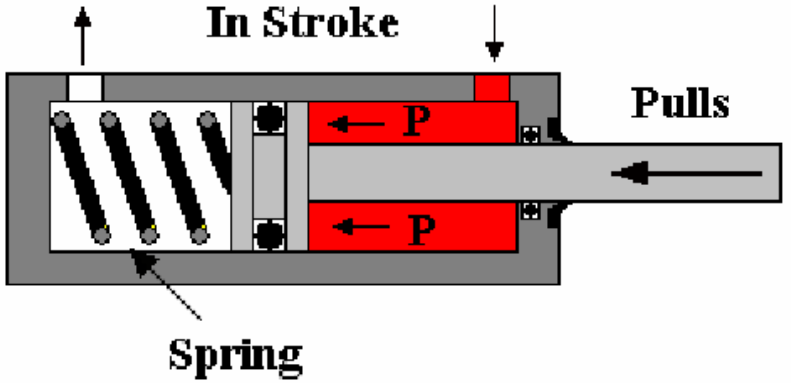
FLUID POWER ACTUATORS

- Extracting energy from the fluid and convert it to mechanical energy.
- Types of actuators; linear actuators ,rotary actuators
- linear actuators:[Cylinder]Which converts the fluid power in to linear mechanical force and provide straight line motion
- Types of hydraulic cylinders:
- 1.Single acting
- 2.Double acting

Single acting cylinder



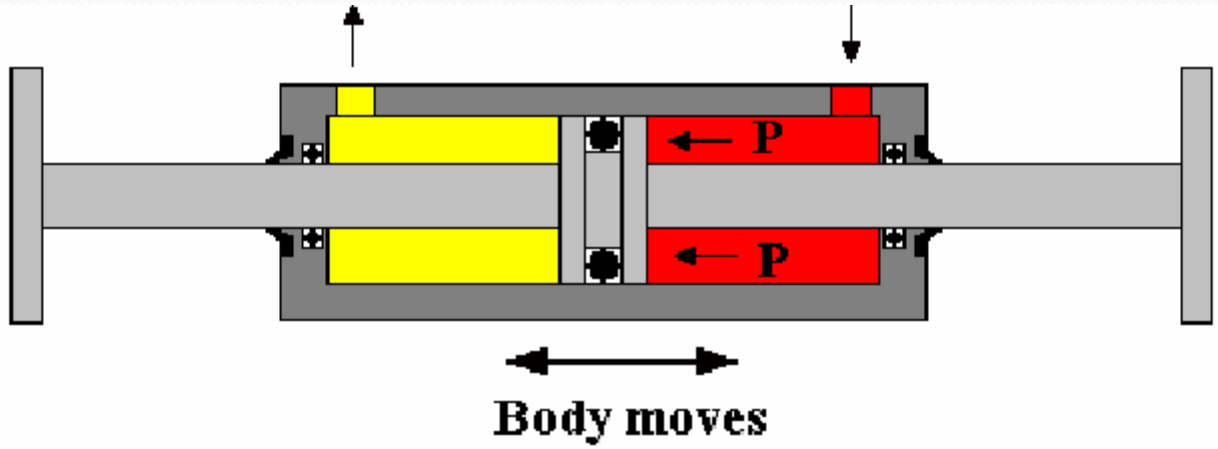
Single Acting Cylinder for Pushing



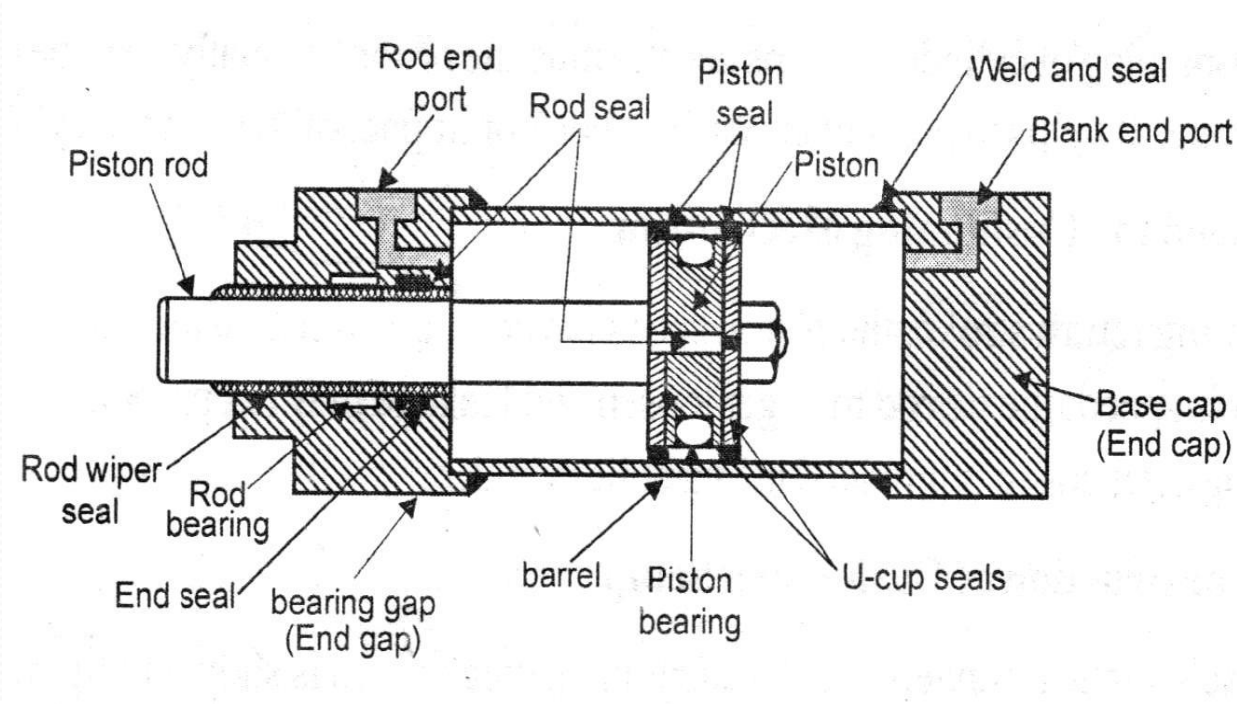
Single Acting Cylinder for Pulling

Figure 2

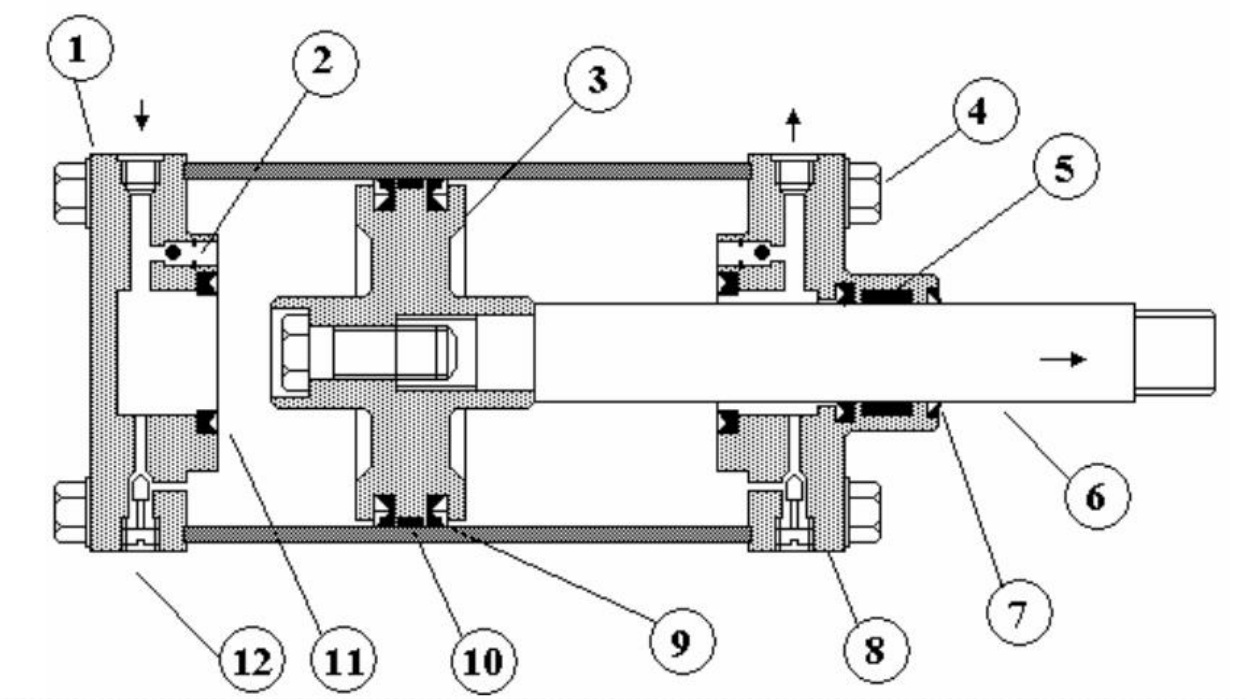
DOUBLE ACTING CYLINDER



Construction of Double acting cylinder



Construction of double acting cylinder



Double acting cylinder

1. Rear end cap
2. Quick start valve
3. Piston
4. Draw bolts
5. Rod bearing
6. Rod
7. Wiper ring
8. Front end cap
9. Piston seal
10. Low friction bearing ring
11. Cushioning boss seal
12. Cushioning valve

cylinder

4. SYMBOLS

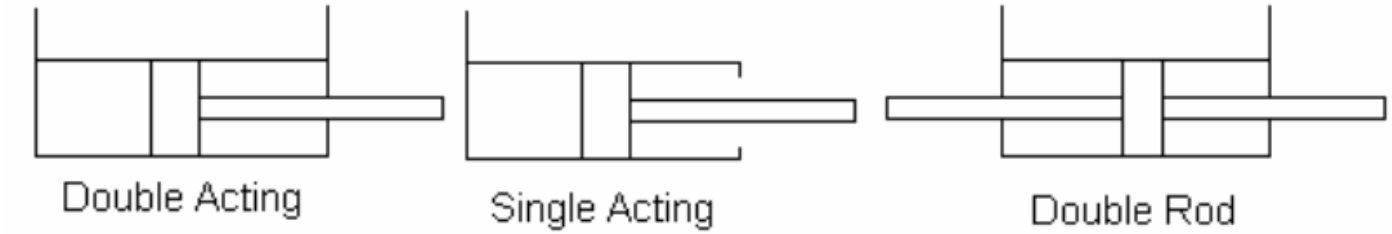
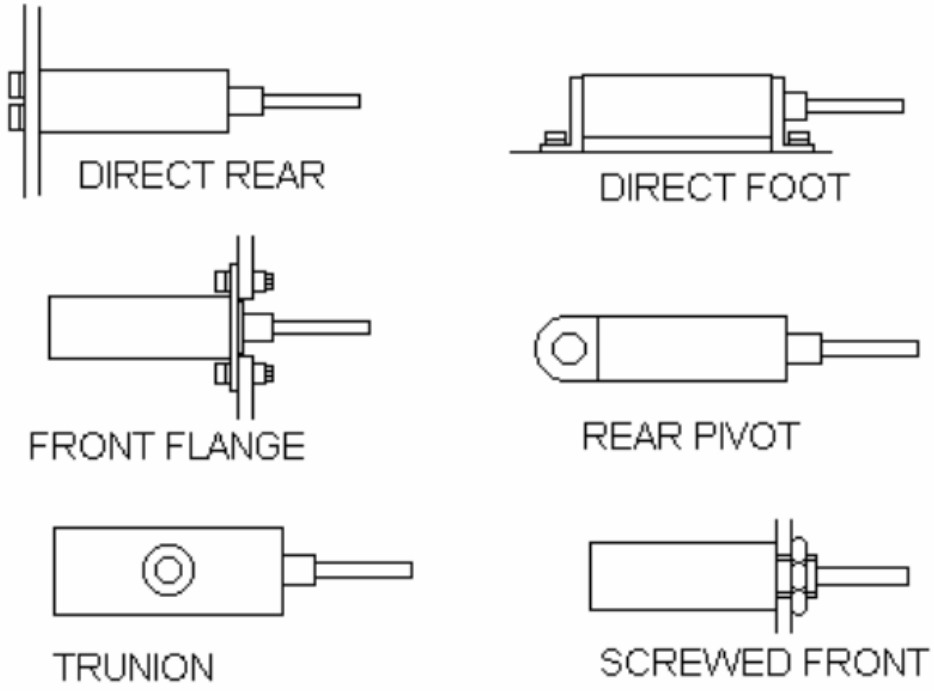


Figure 6

Cylinder mounting

8. END FIXINGS

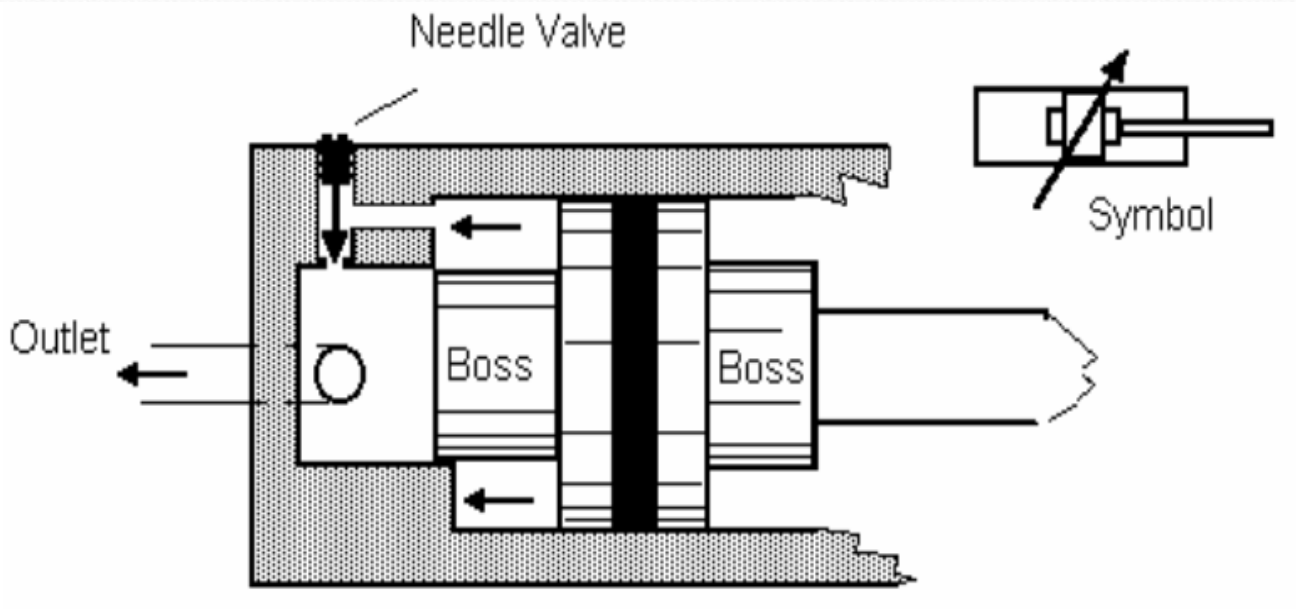
The diagram shows typical ways of mounting cylinders and attaching them to machines.



Cushioning Mechanism

- Cushioning of cylinder means decelerating the piston gradually near the end of the return stroke.
- It helps to prevent excessive shock or impact of load on the cylinder
- During return stroke the piston speed is very high. If the piston hits the cylinder head at this speed. The tie rod may get loosen and leakage may occur.
- To avoid this cushioning mechanism is provided in hydraulic cylinder.

Working - Cushion assembly



Special Cylinders

A. Tandem Cylinder
B. Telescopic Cylinder
C. Rod less Cylinder

<u>Tandem Cylinder</u>

- Two or more cylinders with inter connecting piston assemblies with a common piston rod to increase the output

Tandem Cylinder

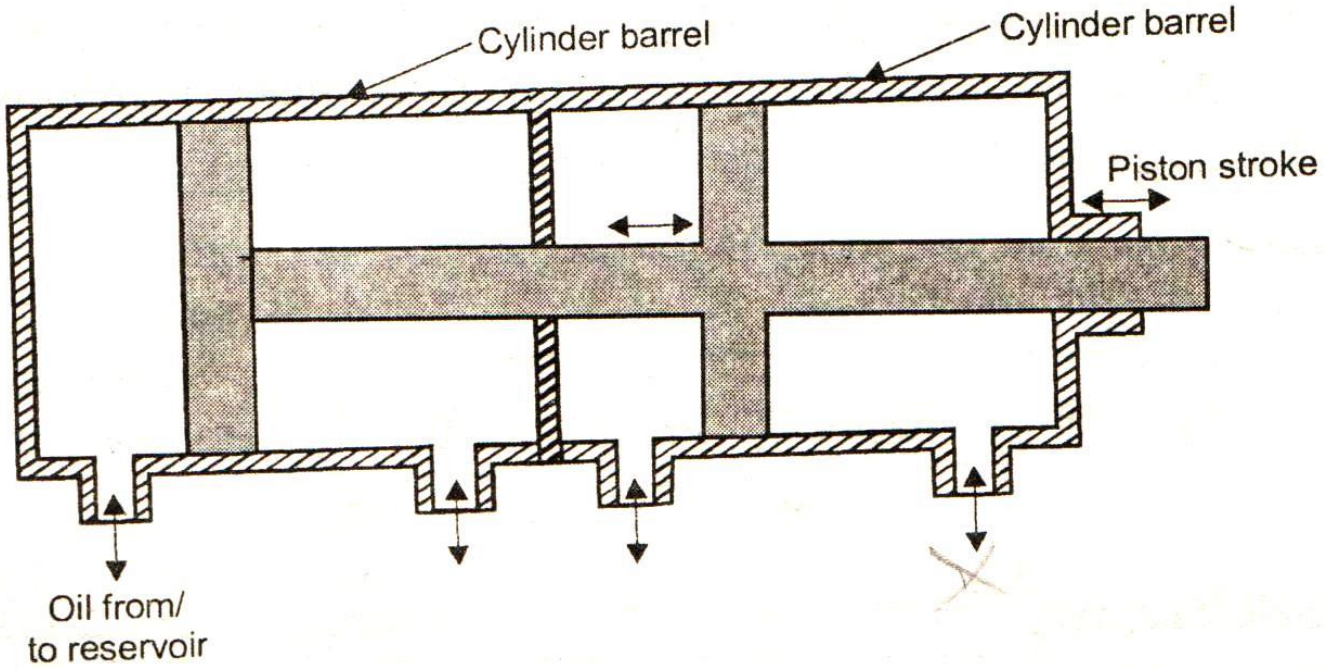
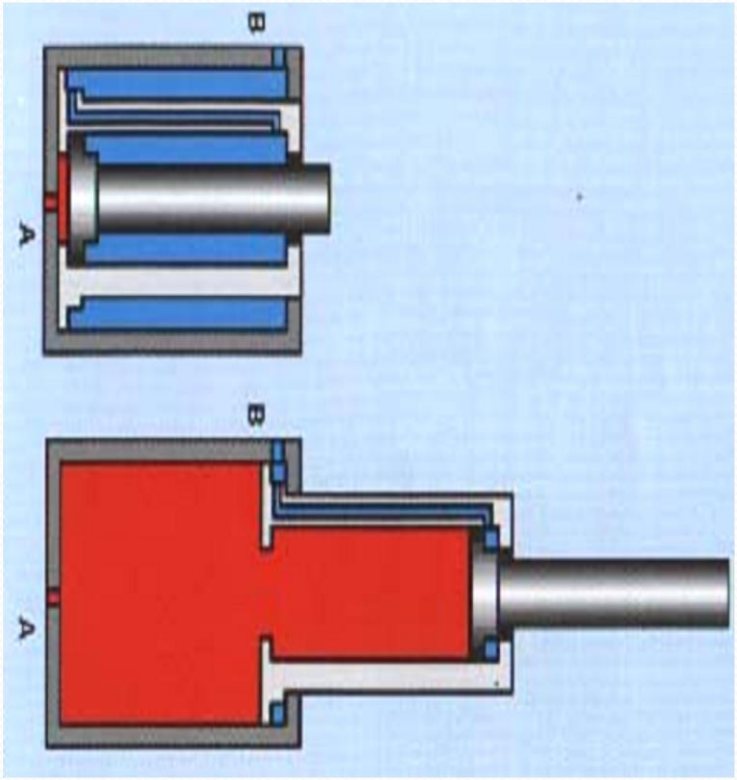


Figure 2.17: Tandem Cylinder

Telescopic cylinder

- Telescopic cylinder used where long work strokes are needed in a short envelop.



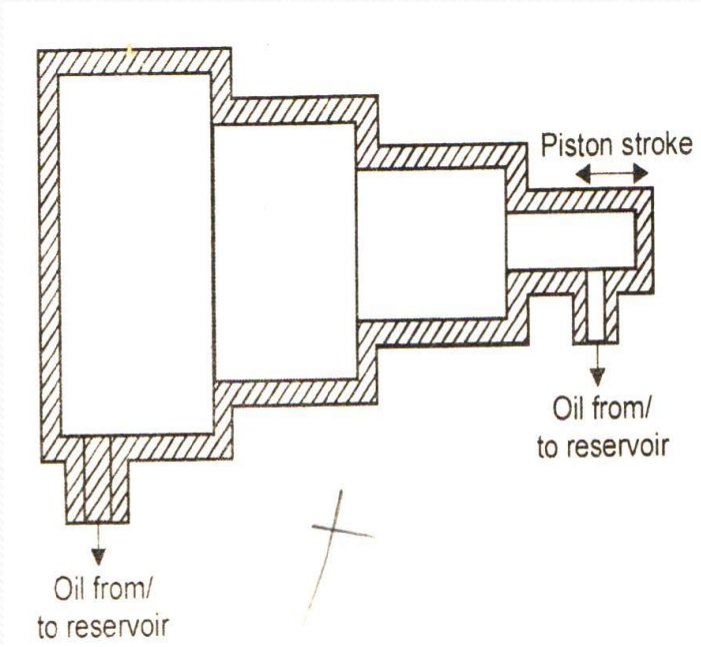


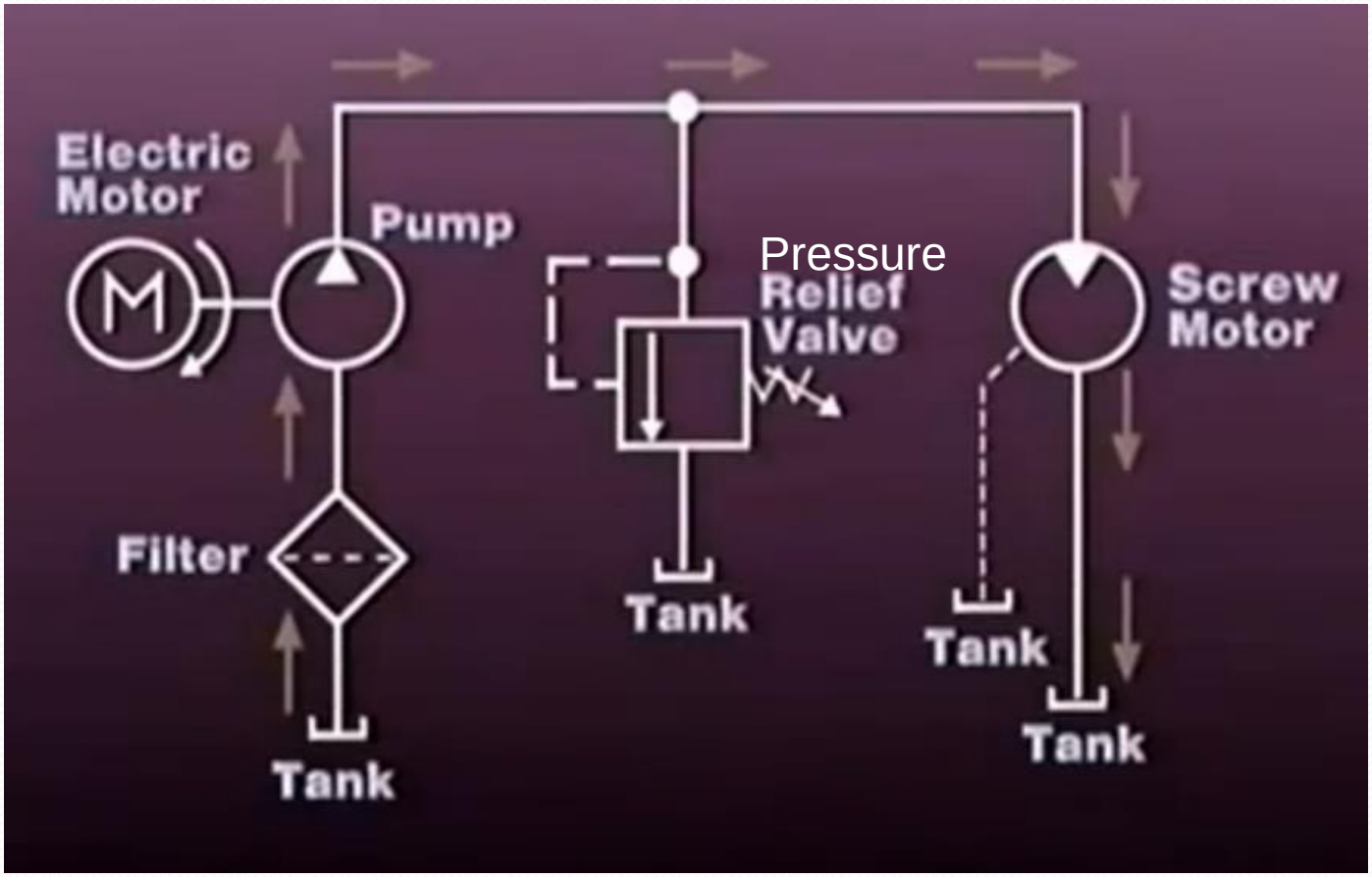
Figure 2.18: Telescopic cylinders

Fluid motors

- A fluid motor is a device which converts fluid power into mechanical force and motion and provides rotary mechanical motion.
- Types of fluid motors
- Gear motors
- Gerotor motors
- Vane type fluid motors
- Piston motors

INTRODUCTION

- Hydraulic circuit example



VALVES – CONTROL COMPONENTS

Hydraulic valves are device used to control pressure, flow direction or flow rate in hydraulic circuits .

Classification of control valves

- Direction Control Valves
- Pressure control valves
- Flow control valves

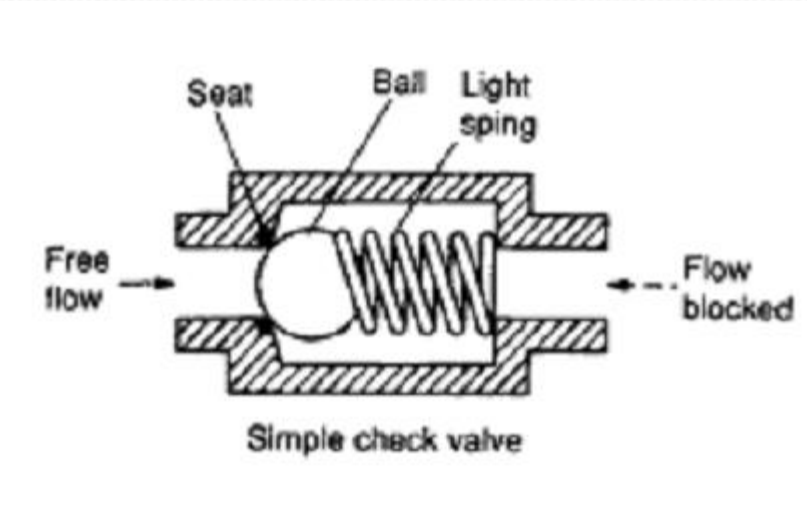
Classification of DCV

2 way DCV, 3 way DCV and 4 way DCV.

Apart from these three type there are check and shuttle valve comes under DCV.

Check valve

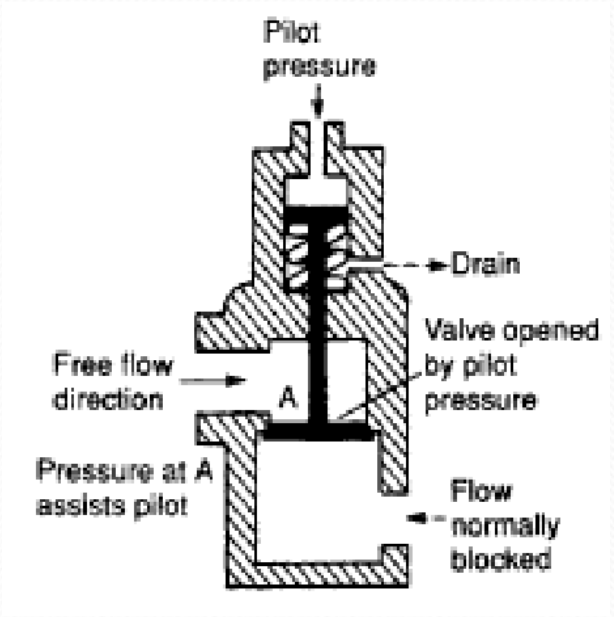
- One way valve
- Allows flow in one direction only



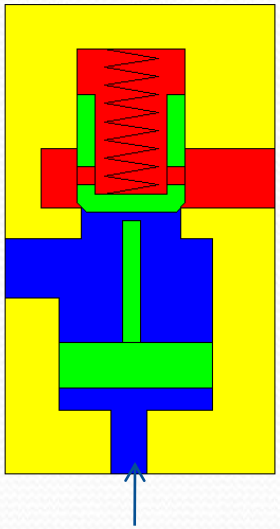
Check valve

Pilot check valve (2/2 DCV)

Check valve is modified and designed as pilot check valve- two way type



Pilot check valve

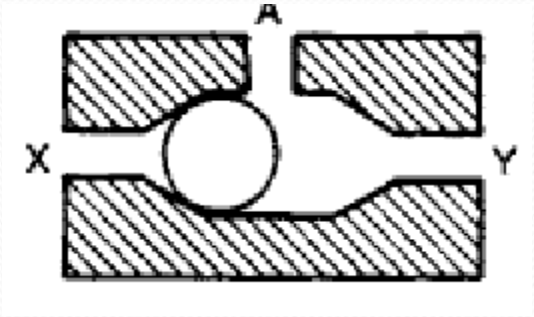


Pilot check valve animation
(Reverse to left one)

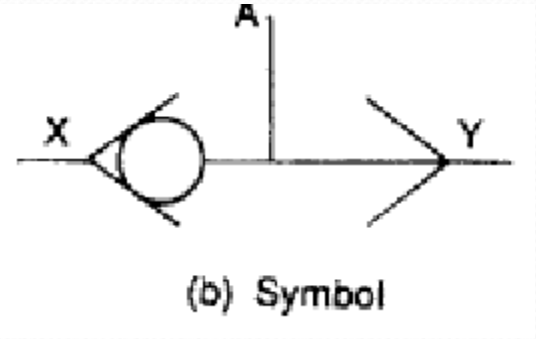
Simplest DCVs

Shuttle valve

- Allows two circuit(X,Y) to be connected to one branch circuit(A). If flow pressure X>Y, then the direction of flow will be from X→A and vice Versa for Y→A .



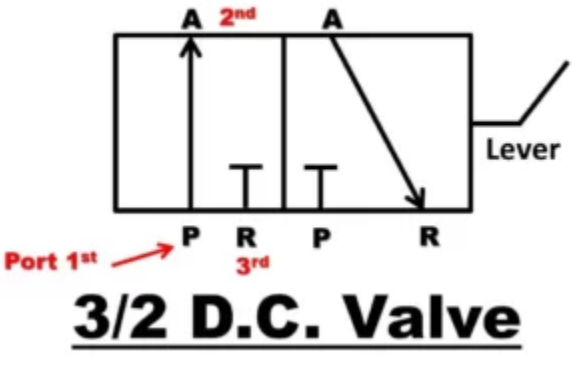
Shuttle valve

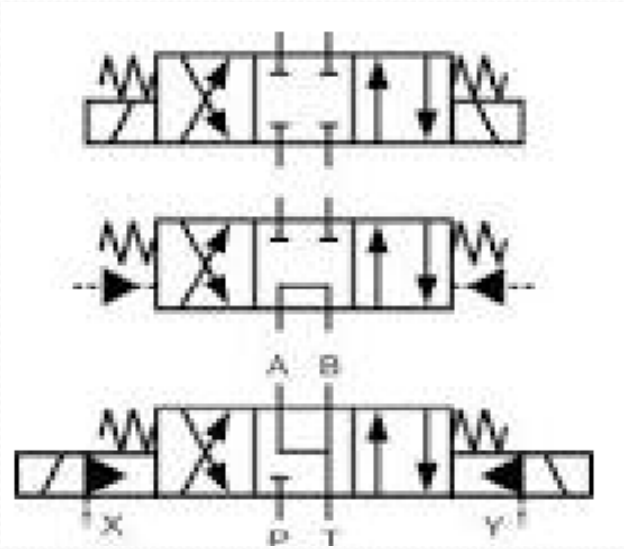


(b) Symbol

Direction control Valve

3/2 and 4/3 way valve



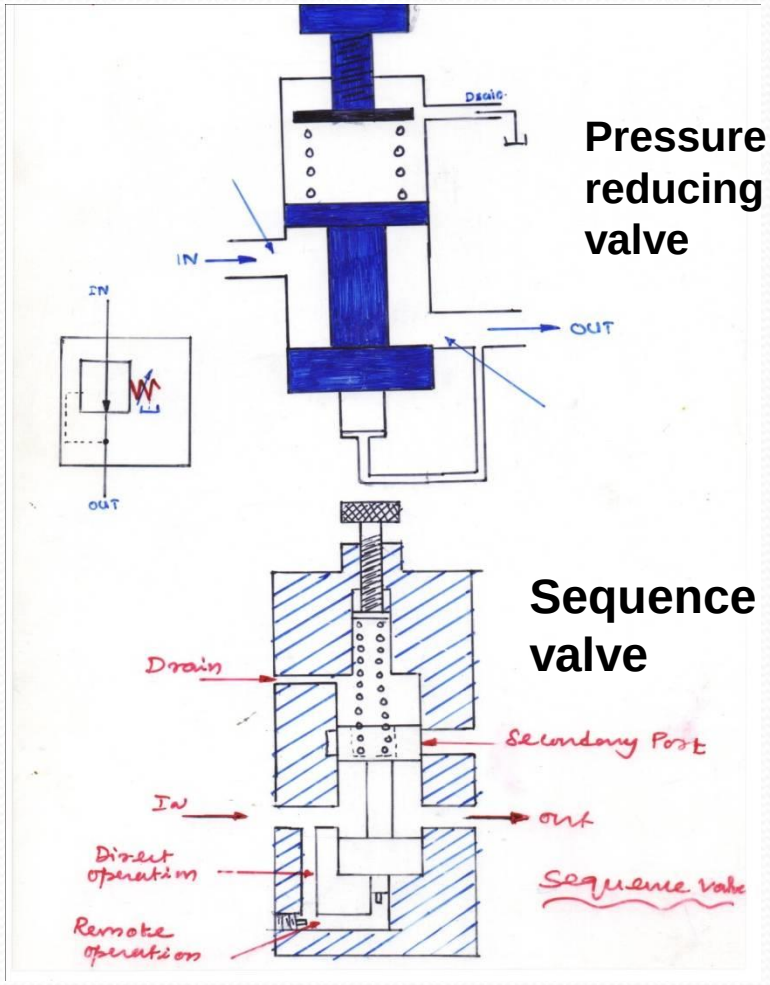


4/3 way valve

Pressure reducing valve

Pressure reducing valve

- Normally open
- Used to maintain reduced pressure.
- If IN is of normal, flow will also be normal to outlet.
- If IN flow pressure is more spool blocks outlet, enough to maintain normal flow.



Sequence valve

- Normally closed.

In normal position,

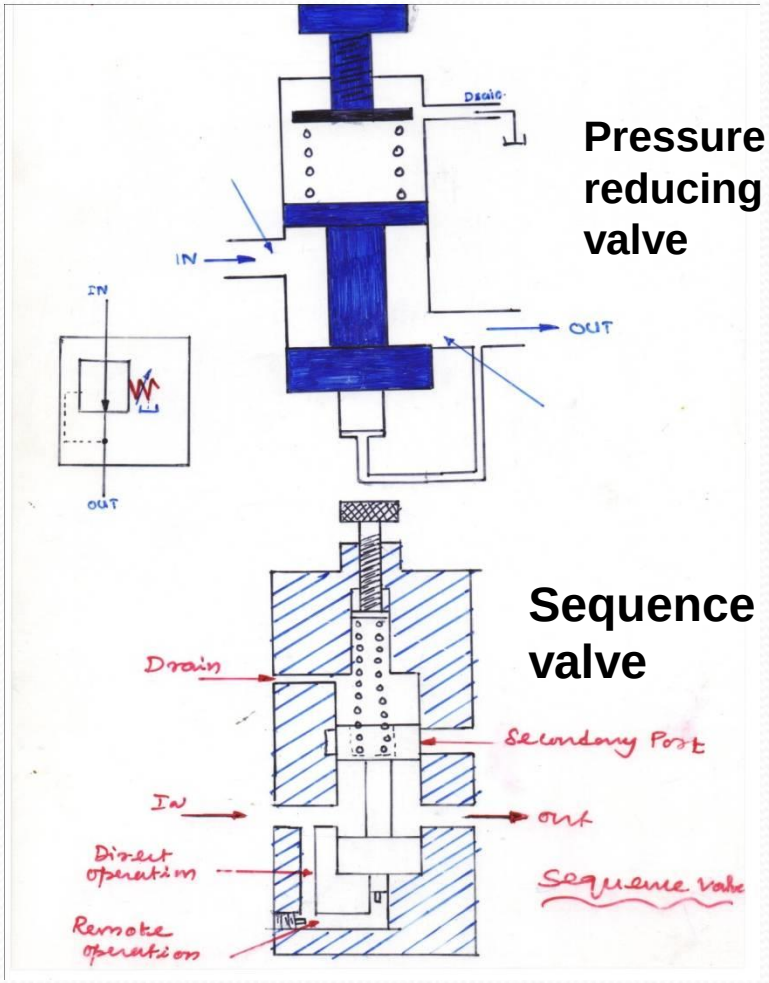
- Fliud flow from IN to out (cylinder 1)

When cylinder 1 work is done,

- Further flow is not possibe, thus increases pressure in system.

When this pressure overcomes the valve setting, spool moves up and flow is to secondary port (cylinder 2).

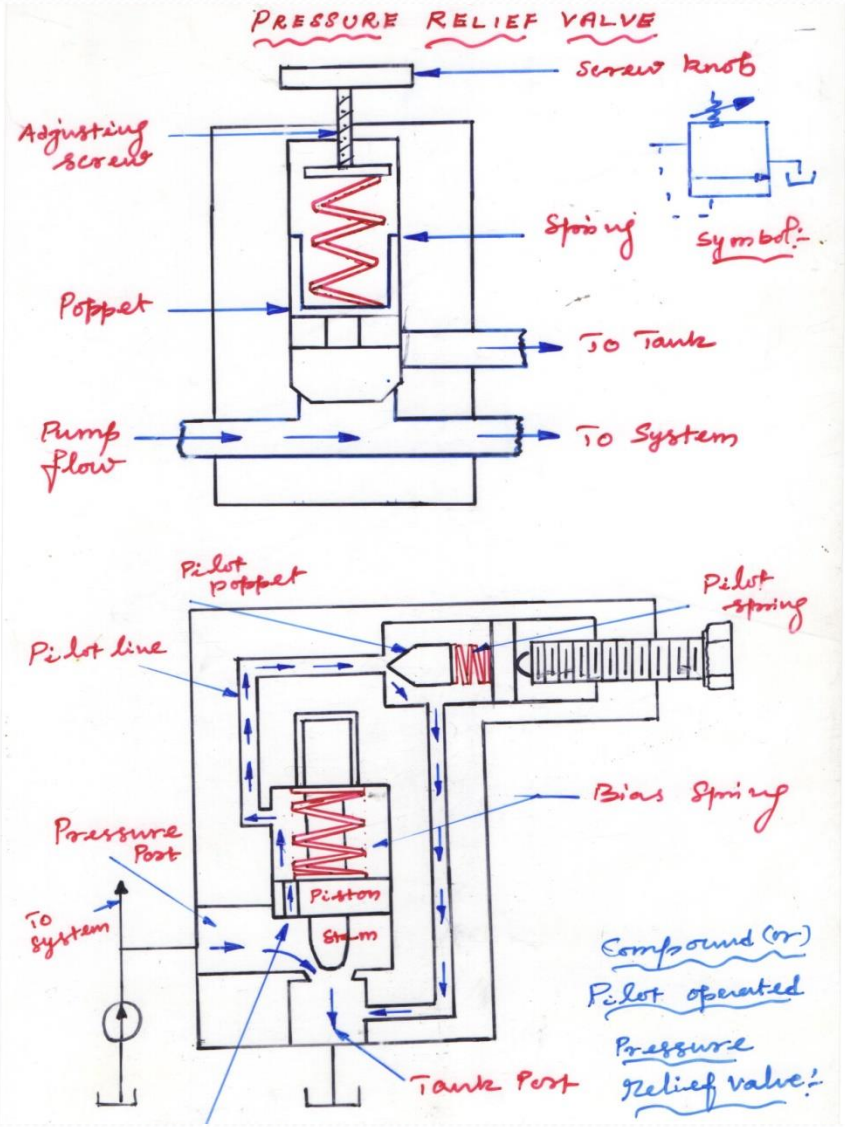
Sequence may be direct or pilot operated



Pressure relief valve

- Pressure relief valve animation

http://www.opwftg.com/www/en/opwftg/products/cargotank/overview/pressurerelief.jsp



Flow control valve

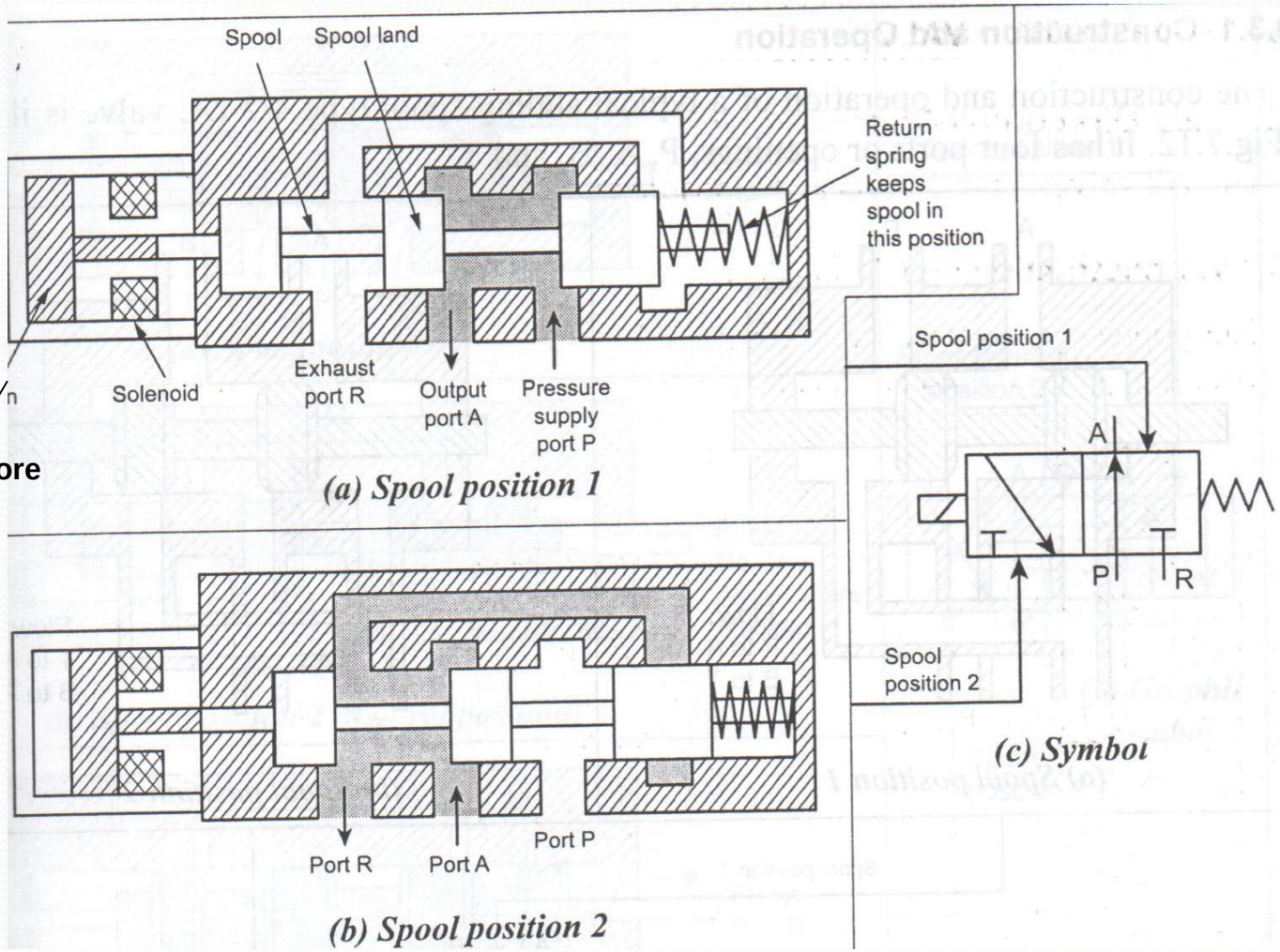
- Controls the rate of fluid flow, thereby allows us to control the velocity of cylinder or actuators.
- Applications
  - Tool speeds
  - Spindle speed
  - Surface grinder speeds etc.
- Classification
  - Fixed devices(with orifice plate)
  - Adjustable device (Needle, Global and gate valve)
    - Needle valve

      Needle Valve Animation click below

      http://www.oilennium.com/2010/08/19/e-learning-course-needle-valve-animation/
    - Globe valve (http://www.youtube.com/watch?v=yTr4kpkHovg) and
    - Gate valve (http://www.youtube.com/watch?v=-5OuXJXOSHE)

Electrical control solenoid valve

Basic solenoid valve animation
(http://www.youtube.com/watch?v=SwqM8zpmAD8&feature=related)



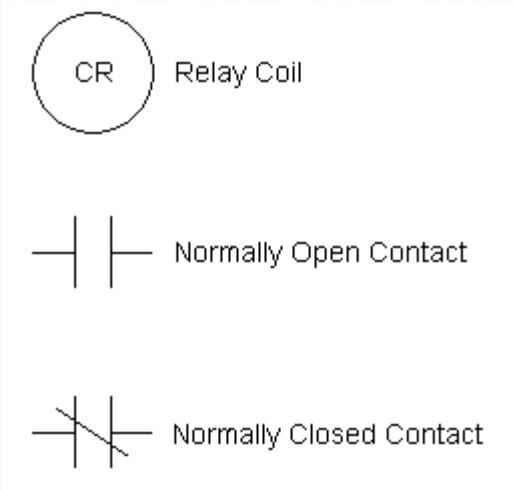
Construction and operation of a solenoid activated 3/2 vane

Relays

- Electrically actuated switch, open or close when corresponding coil energize.
- Commonly used to energize/de energize solenoid.

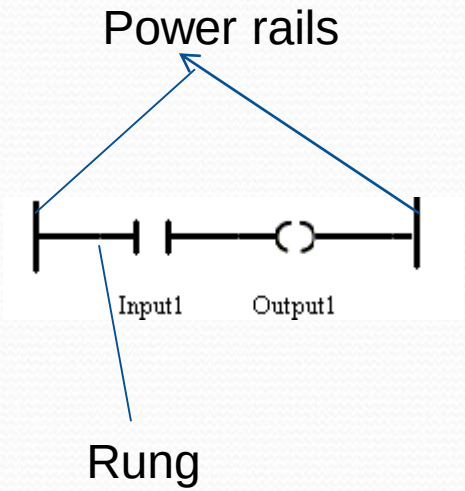
When energized,

Normally open will close and vice versa.



Ladder diagram

- Schematic representation of physical components arrangements and its way of connection.
- Power connected to left side and ground connected to right side.



Accumulators

- Temporary potential energy (Fluid) storage device under high pressure.
- Also acts as a secondary source when demanded by the system.

Types of Accumulators

- Weight or gravity loaded accumulators
- Spring loaded accumulators

} Mechanical accumulator

- Gas loaded accumulators

} Pneumatic accumulator

Weight-loaded Accumulators

- Temporary potential energy (Fluid) storage device under high pressure.
- Also acts as a secondary source when demanded by the system.

Types of Accumulators

- Weight or gravity loaded accumulators
- Spring loaded accumulators
- Gas loaded accumulators

Mechanical accumulator

Pneumatic accumulator

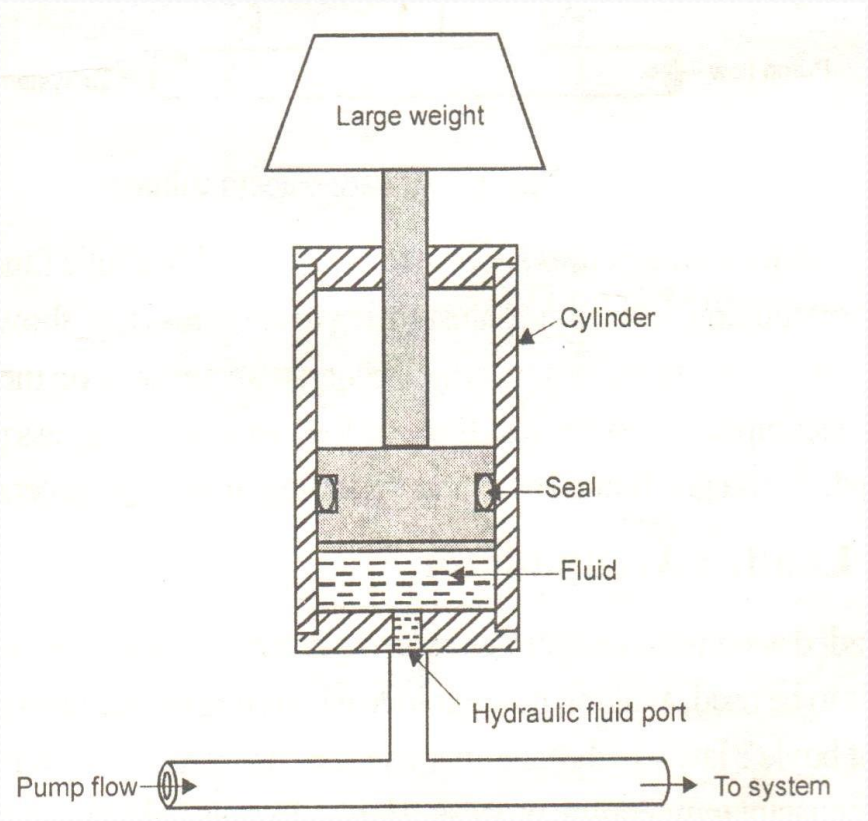
Weight loaded accumulators

- A vertically mounted cylinder with weight attached at its top.
- Consists of piston with packaging to prevent leakage.

When fluid is pumped into the accumulators,

- The weight is raised- exerts a force to the piston generates a pressure on the fluid side of the piston.

Advantage of this type – constant pressure on the fluid throughout the volume

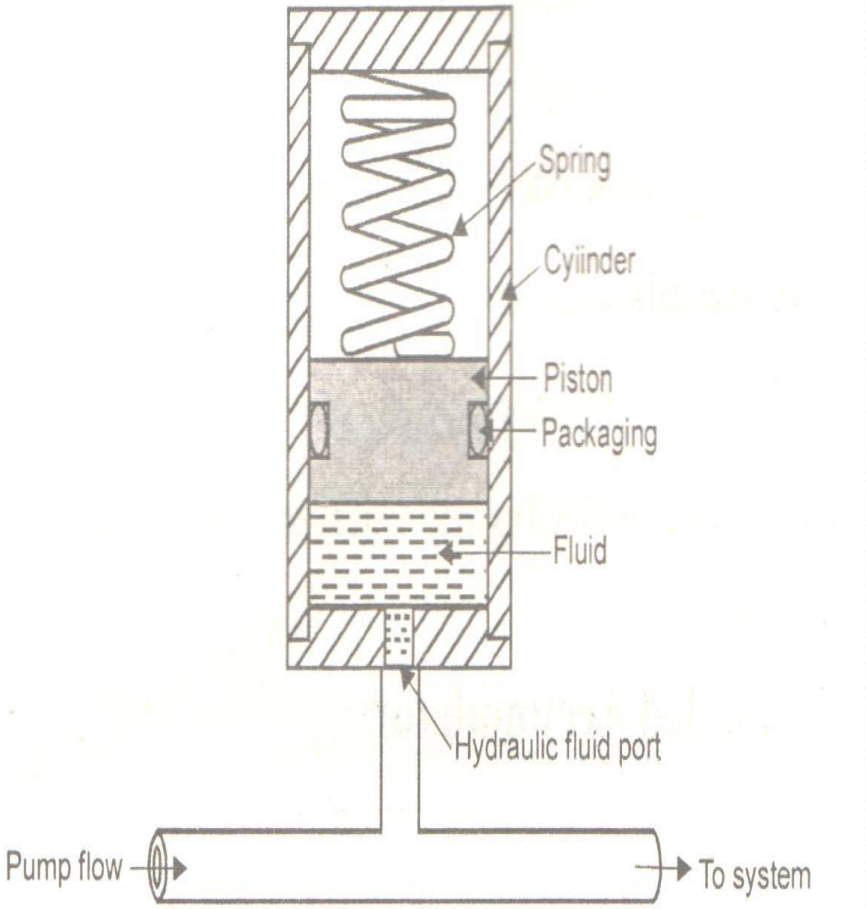


Spring loaded accumulators

- Uses spring to store energy.

When excess pressure,

Hydraulic fluid is pumped into the accumulator, moving the piston against the spring. Thus the spring exerts a force to the piston, generates pressure on the fluid.



Gas loaded accumulators

- Operates by using compressed gas to store energy.
- Only dry nitrogen is used (As air oil may explode when compressed)
- Working principle based on,

Boyles law: At constant volume,

$$\text{Pressure of gas } \alpha \ \frac{1}{\text{Volume}}$$

Classification,

- Non separator type
- Separator type

Gas loaded accumulators

Separator type

Some flexible material is used to separate the gas from the oil.

Separator may be

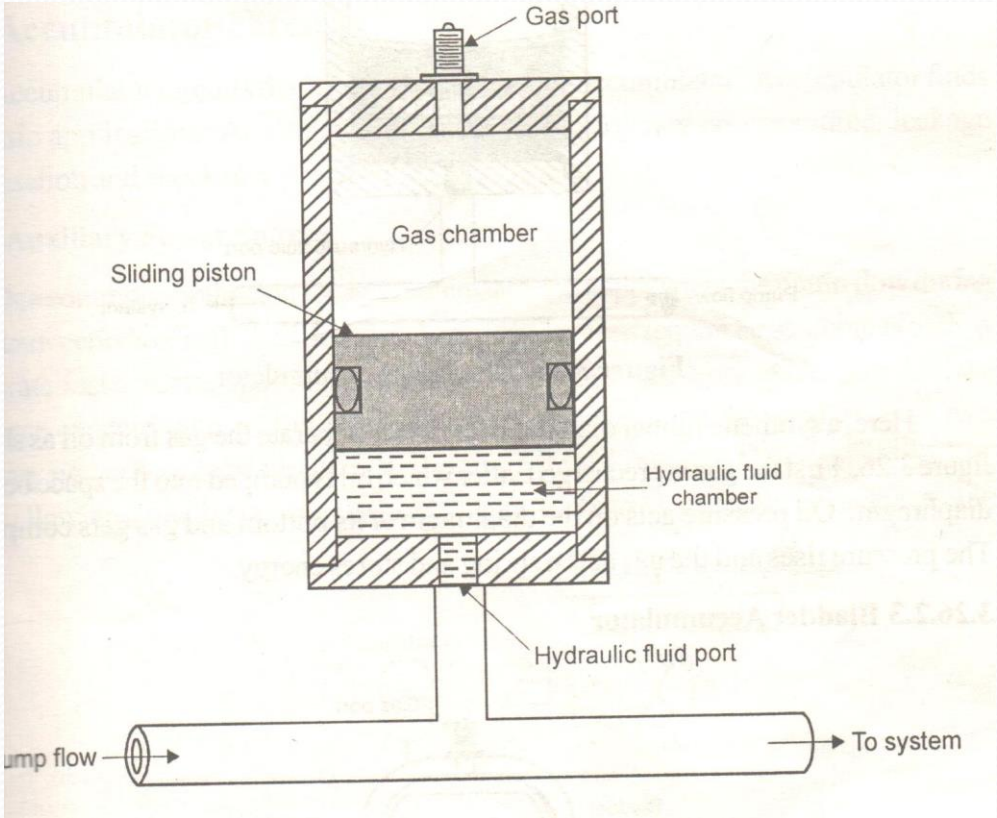
- Piston, Diaphragm or Bladder.

Gas loaded accumulators

Separator type

Piston Accumulator

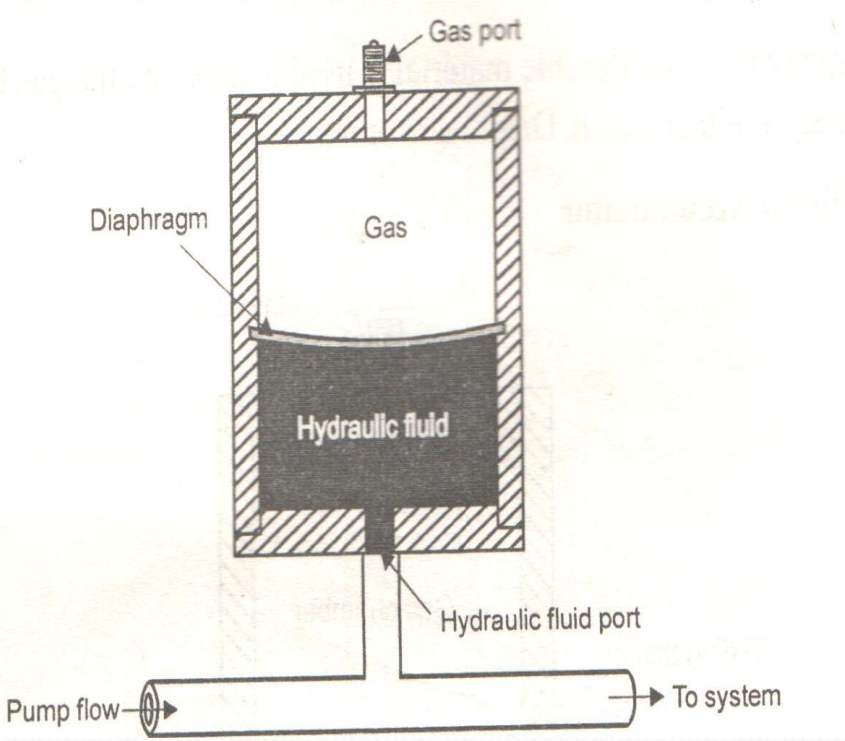
- Free floating piston is used to separate the gas from oil



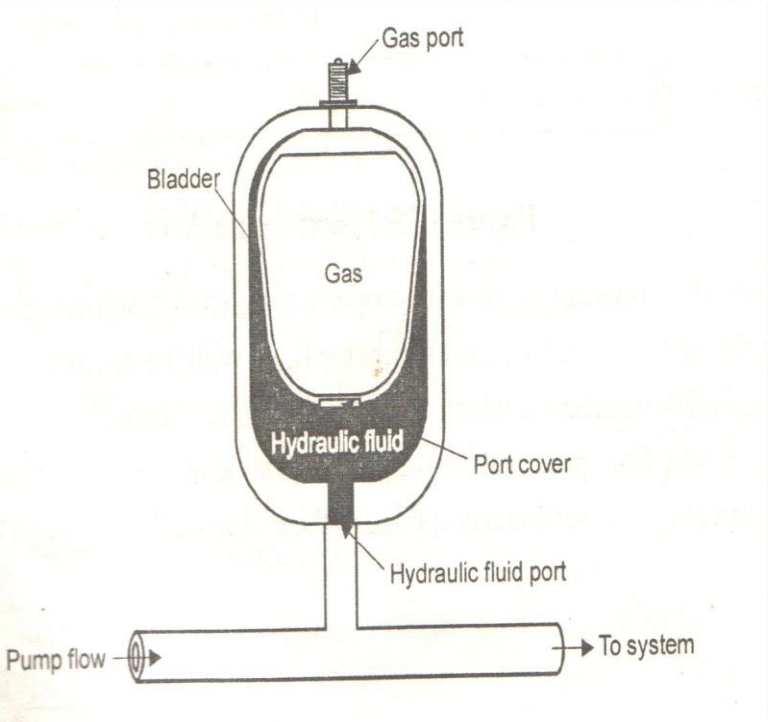
Piston Accumulator

Gas loaded accumulators

Diaphragm Accumulator



Bladder Accumulator



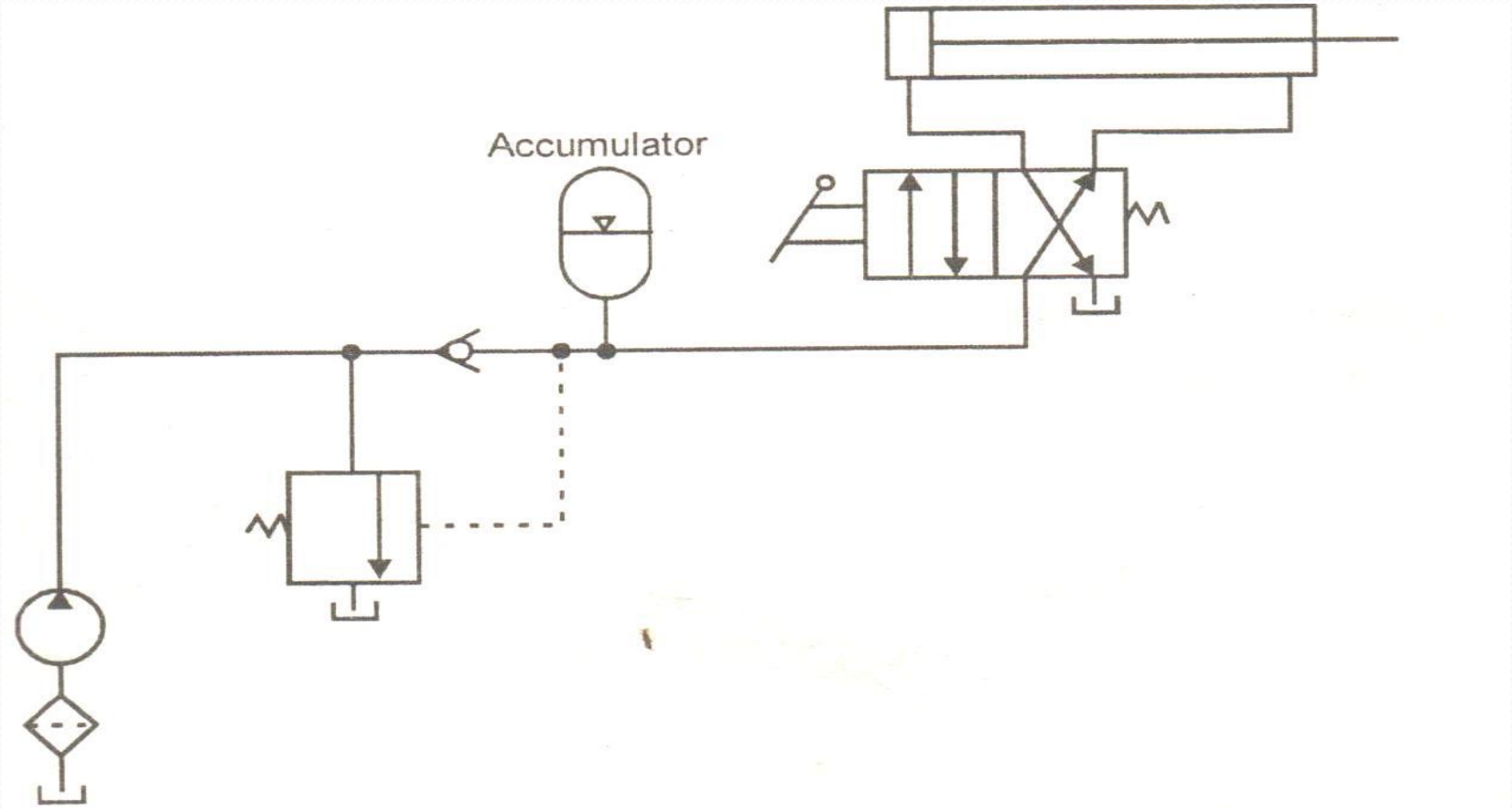
Application of Accumulators

Application of Accumulators

- Auxiliary power source
- Emergency power source
- Leakage compensation and
- Shock absorber.

Accumulator Circuits

Auxiliary power source

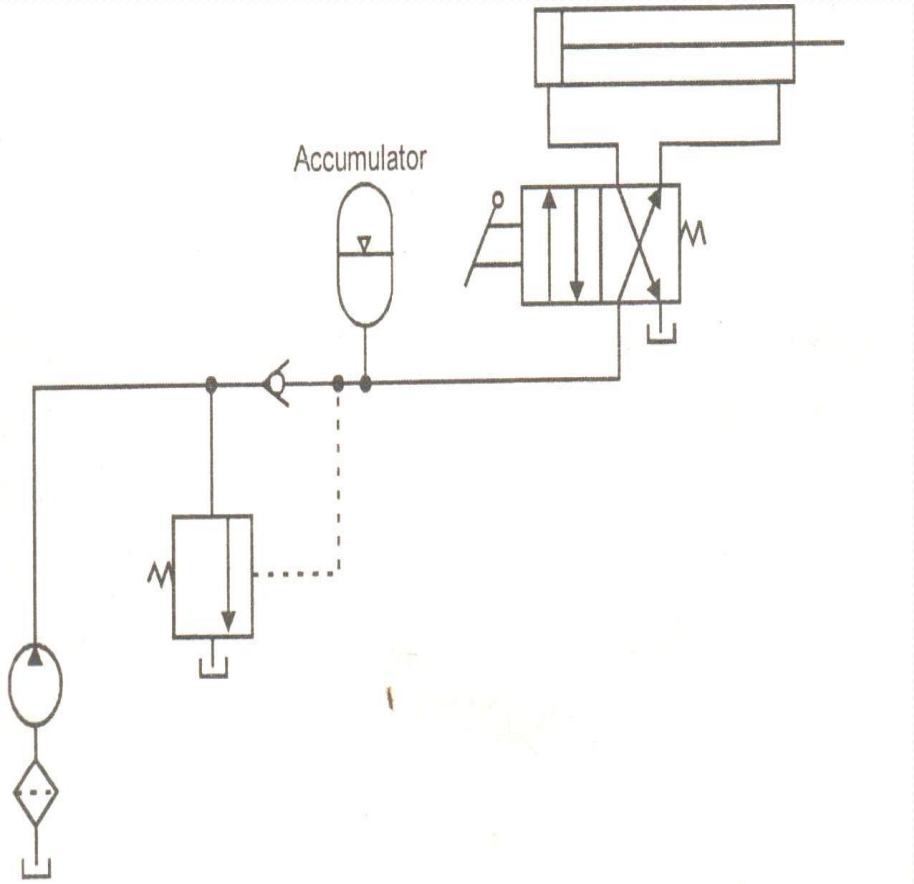


Accumulator Circuits

Auxiliary power source

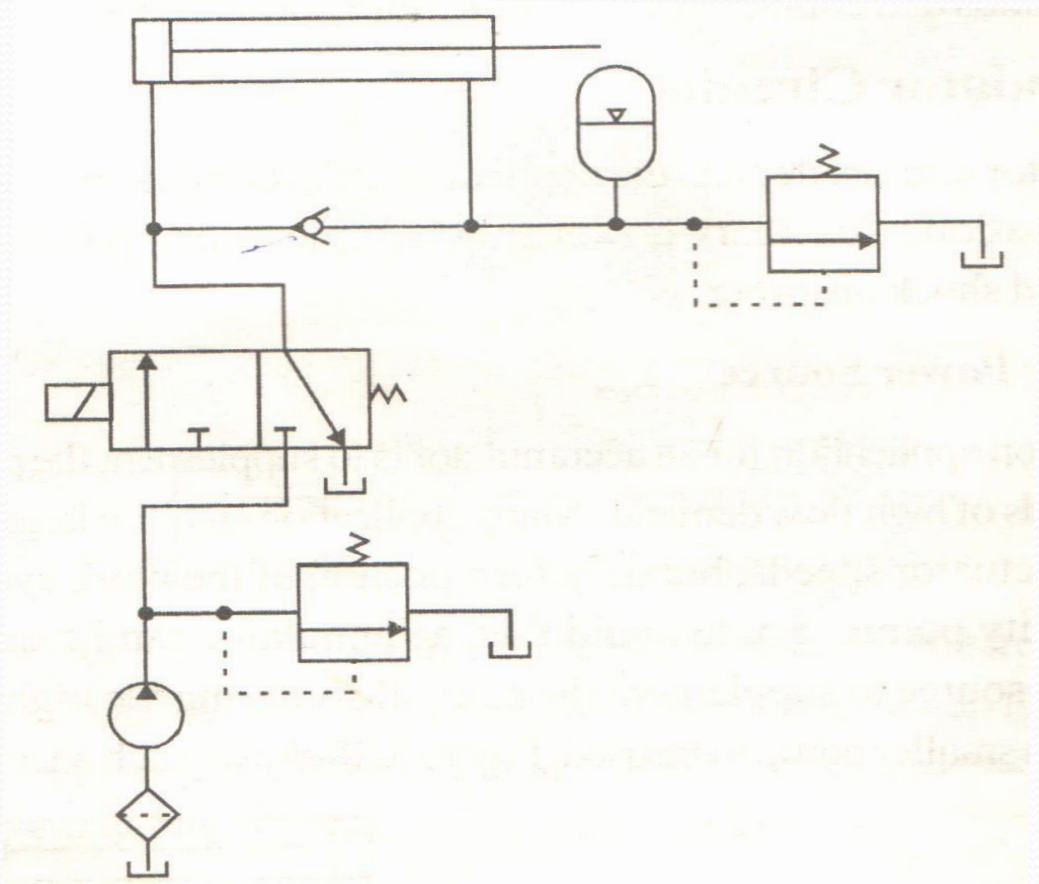
Many applications require large amounts of flow to generate fast actuator speeds for a portion of work alone.

In this instead of large capacity pump, accumulators can be used as secondary power source.



Accumulator Circuits

Emergency power source



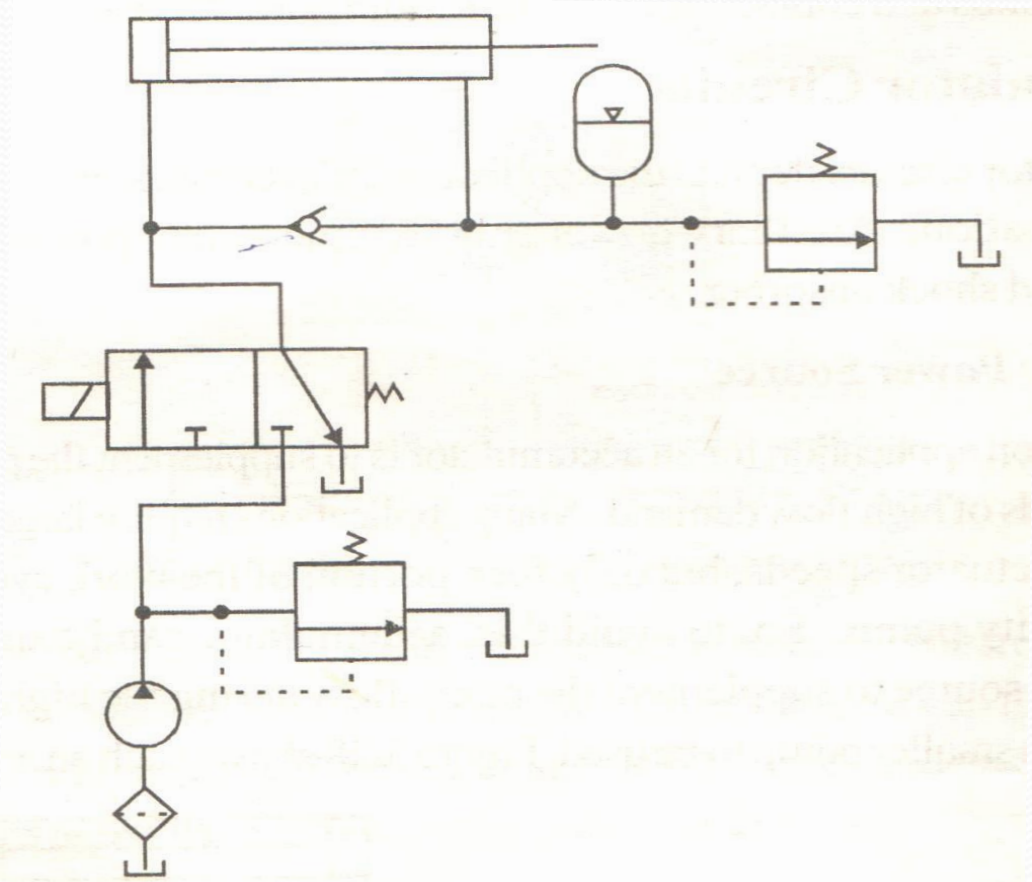
Accumulator Circuits

Emergency power source

Emergency- power failure

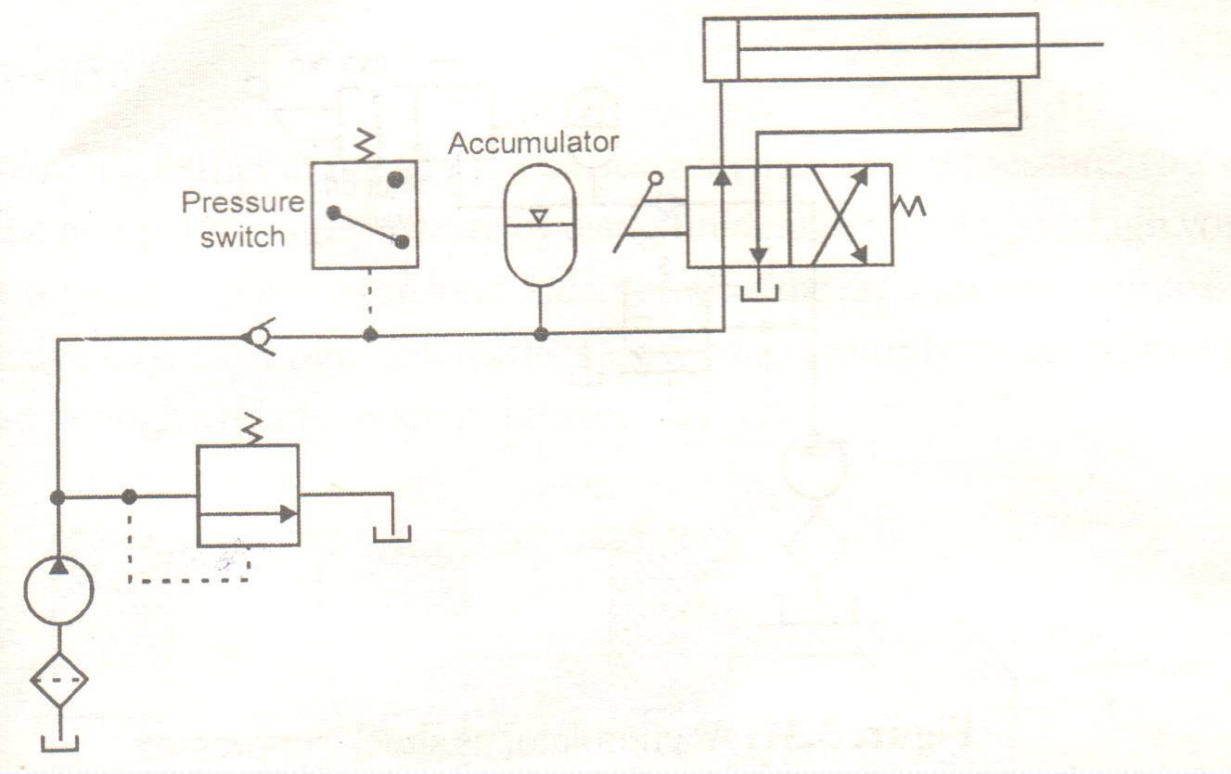
When three way valve is energized, oil flows from pump to the blank end of the cylinder and also to accumulator.

When power failure occurs, solenoid deenergize-shifting the valve to its spring offset mode & oil stored in accumulator makes retraction of piston.



Accumulator Circuits

Leakage compensator



Accumulator Circuits

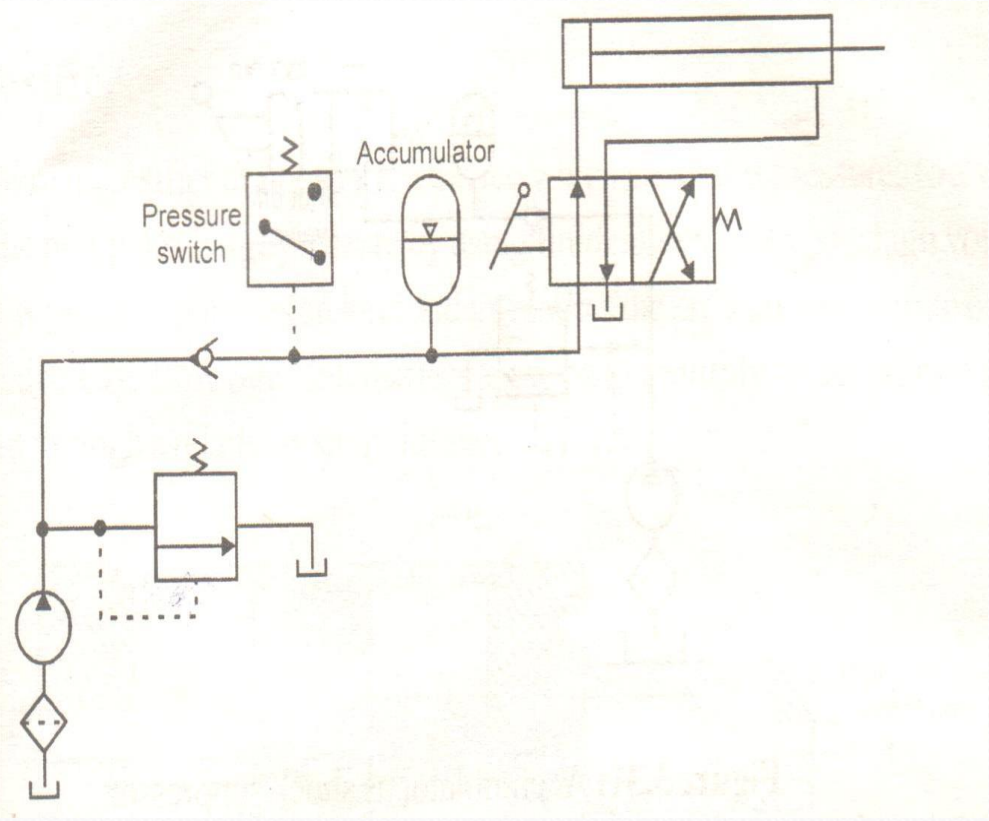
Leakage compensator

Pressure switch is used to OFF the electric motor that drives the accumulator, when it is desired to shut down the pump completely once the accumulator has been fully charged.

When the valve is actuated – oil flow to blank end of the cylinder & fills the accumulator.

When accumulator is fully charged – pressure switch activated and stops the pump.

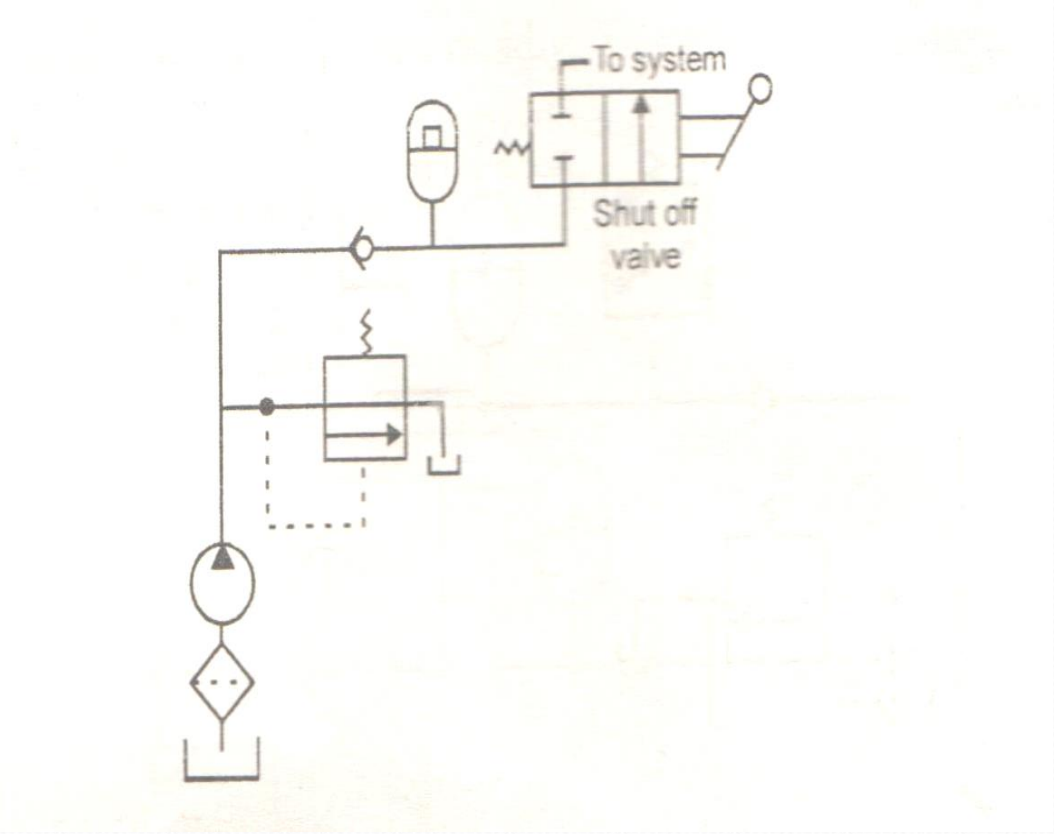
Accumulator supplies enough flow to compensate for leakage.



Accumulator Circuits

Accumulator as shock suppressor

Another application of accumulator is to damp out high pressure spikes or hydraulic shock.



Actuation devices

Figure 3.6: Manual Actuation Devices

Mechanical Actuation Devices

includes cam, roller, plunger, roller tappet etc; In figure 3.7, the spool end containing that is typically actuated by a cam-type mechanism. These valves shift when ed by some mechanical component of the machine.

Figure 3.7: Mechanical (roller) Actuation Devices

Pilot Operated Actuation Devices

Figure 3.8: Pilot operated actuation devices

hese valves are shifted with system pressure. When a pilot signal (oil or air) is against a piston at either end of the valve spool, it pushes the piston to shift the

Solenoid Operated Actuation Devices

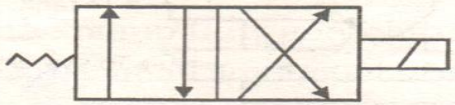


Figure 3.9: Solenoid actuation

What is Compressor

……..a device used for pumping compressible fluids i.e,

air, gas & steam

What is the basic difference between Compressor & Blower

… acc. to API pressure rise above 0.35 bar is compressor and below is blower

Compressor Classification

a) By principle of operation

b) By construction type

c) By staging

d) By service duty

e) Lubricated/ non lubricated

Classification

Operation Principle

- Positive Displacement/ Dynamic or Turbo

Staging

- Single / Multi stage

Service

- Critical service or non critical duty

Lubricated / Non Lube

Positive Displacement

(Increase press. by reducing volume)

Types are -

- Reciprocating
- Rotary - Screw, Vane , Liquid Ring & Lobe
- Diaphragm

Dynamic or Turbo Compressors

(By imparting K.E. to air/gas and then converting it into pressure)

Types are -

- Centrifugal or Radial Compressors
- Axial Flow Compressors

Classification by staging of compressors

Single Stage (compression of gas in one stage)

Multi-stage (compression of gas in more then one stage)

Lubricated or Non Lube Compressors

Lubricated Compressors : Where the gas is mixed with lubricant

Non Lubricated Compressors: Where process gas or air remains uncontaminated by the the lubricant during the compression process

Parameters for selection of compressor-

Application:

Gas handled:

Gas analysis:

Flow rate:

Suction Pressure :

Suction Temperature:

Mol wt. of Gas:

Z (Compressibility) & Cp/Cv:

Discharge Pressure:

Drive System:

Reciprocating Compressors-

Advantages:

- simple & open in construction
- site repairs possible
-do not require specialist at site
-not effected by changes in ambient conditions
-no adverse effect due to changes in the gas mol. Wt.
-single and multistage with inter-cooling
-achieve very high pressure ratios
-low & medium speed machines (250 - 1200 rpm), low noise level
-cooling of cylinder jackets & inter-cooling keeps temp. down and saves power
-non lubricated cylinders by using special piston/ rider rings

Reciprocating Compressors-

Disdvantages:

-Maintenance prone mainly valves, piston/rider rings

-Large bulky foundation

-Long installation time

-In fact large compressors are assembled at site

-Hooking up of auxiliaries such lube oil console, tempered c/w console for cyl. Jacket cooling, mounting of pulsation separators etc.

-Pulsating flow requires costly piping and flow analysis

-Step-less capacity regulation not possible

-Loss in capacity with operation

-Standby machines required

Rotary Screw Compressors-

Advantages:

- fewer components
- compact design, very good for portable applications
- package skid mounted concept
- quick site installation & no heavy foundation
- not effected by changes in ambient conditions
- no adverse effect due to changes in the gas mol. Wt. , infact good examples with dirty gases like in soda ash , coke oven plants
- non lube design possible
- streamlined flow

Rotary Screw Compressors-

Disdvantages:

-Not very reliable. Mainly anti-friction bearings used and these have limited life

-Close tolerances between screw elements

-Site repairs not possible

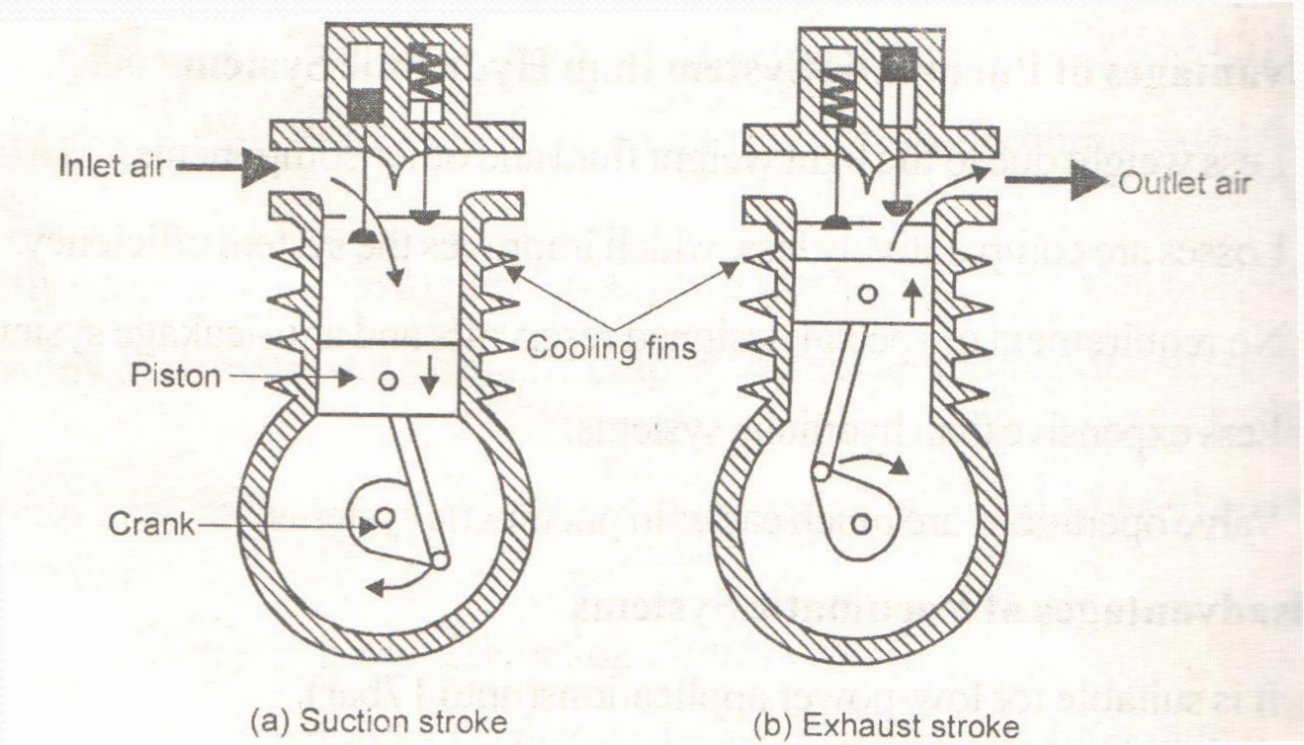
-Higher power consumption in lube design and also due to leakage between rotors.

-Process gas / air mixed with lube oil hence very effeicient oil separator is required which requires frequent maintenance

-Multi-staging not very easy

-High speed and high noise level

Single stage reciprocating compressor

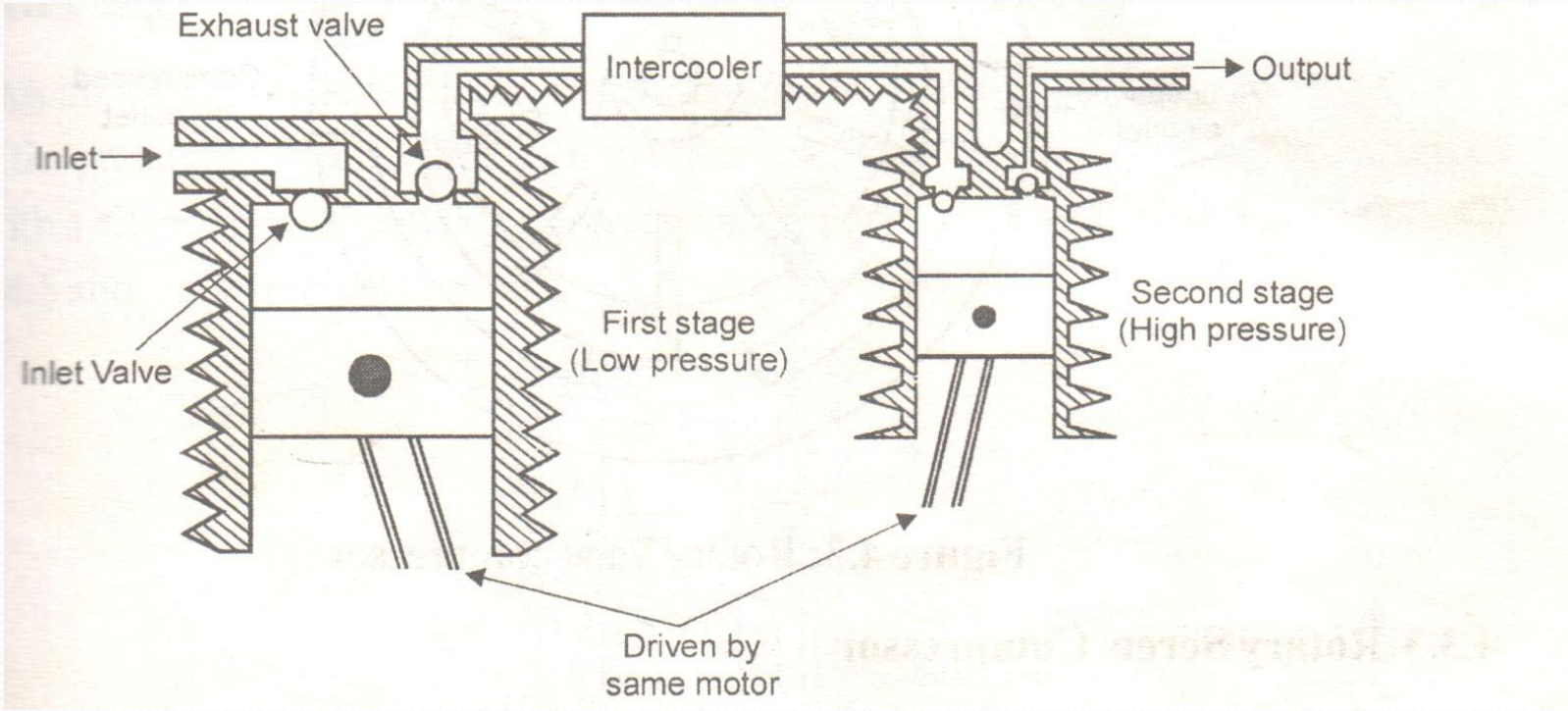


Single stage reciprocating compressor

Single stage reciprocating compressor

1. During the downward movement of the piston Air from the atmosphere at low pressure is drawn into the cylinder through the inlet then the inlet valve closes.
2. During the upward movement of the piston the pressure raises continuously up to a desired level then the delivery valve opens.

Two stage reciprocating compressor

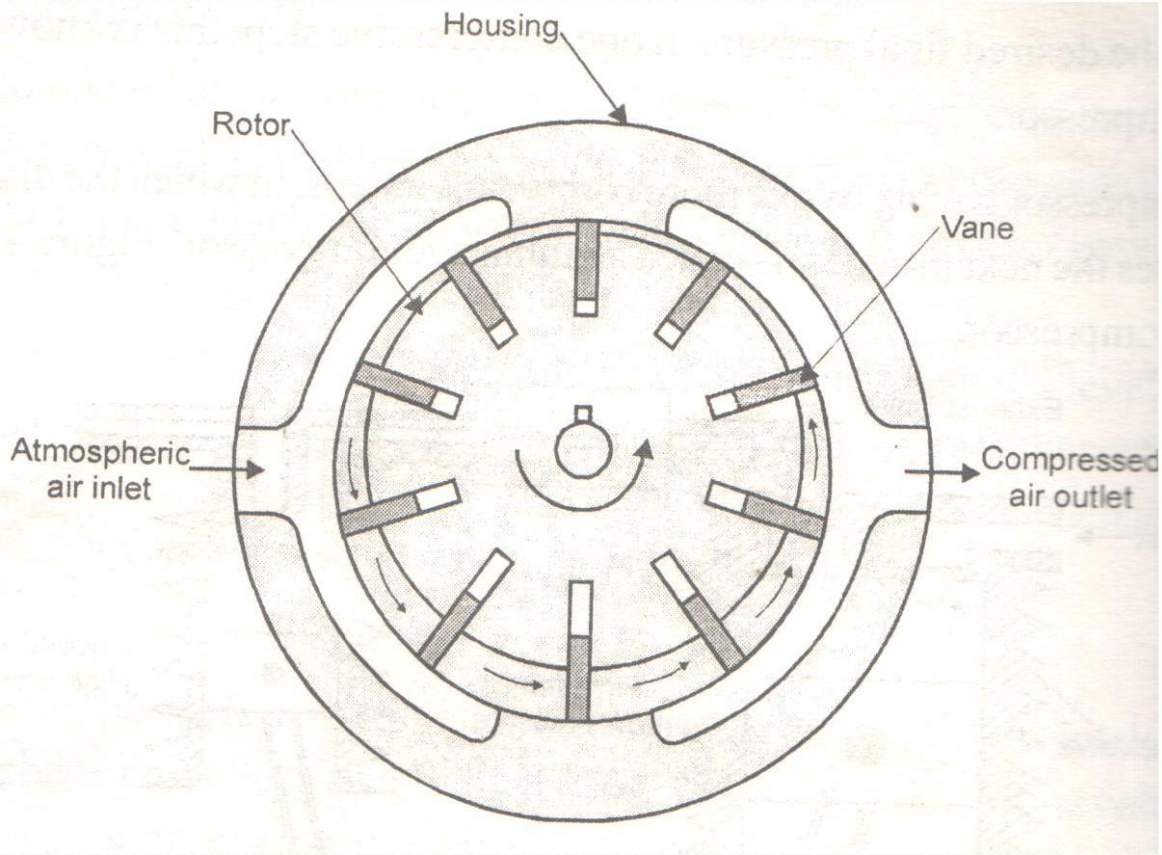


Two stage reciprocating compressor

Two stage reciprocating compressor

1. During the downward movement of the piston air from the atmosphere at low pressure is drawn into the cylinder through the inlet then the inlet valve closes.
2. During the upward movement of the piston the pressure raises continuously up to a desired level then the delivery valve opens.
3. If single cylinder is used for high pressure air the cylinder size will be two large and temperature raise will be high which damages the cylinder.
4. So it is necessary to two stage or multi compressor.
5. In this two stage compressor first cylinder outlet is passes through the intercooler and intercooler outlet air is passes through the second cylinder inlet and then compressed into high pressure.
6. To reduce the temperature of the air and power consumption we are using intercooler.

Rotary vane compressor

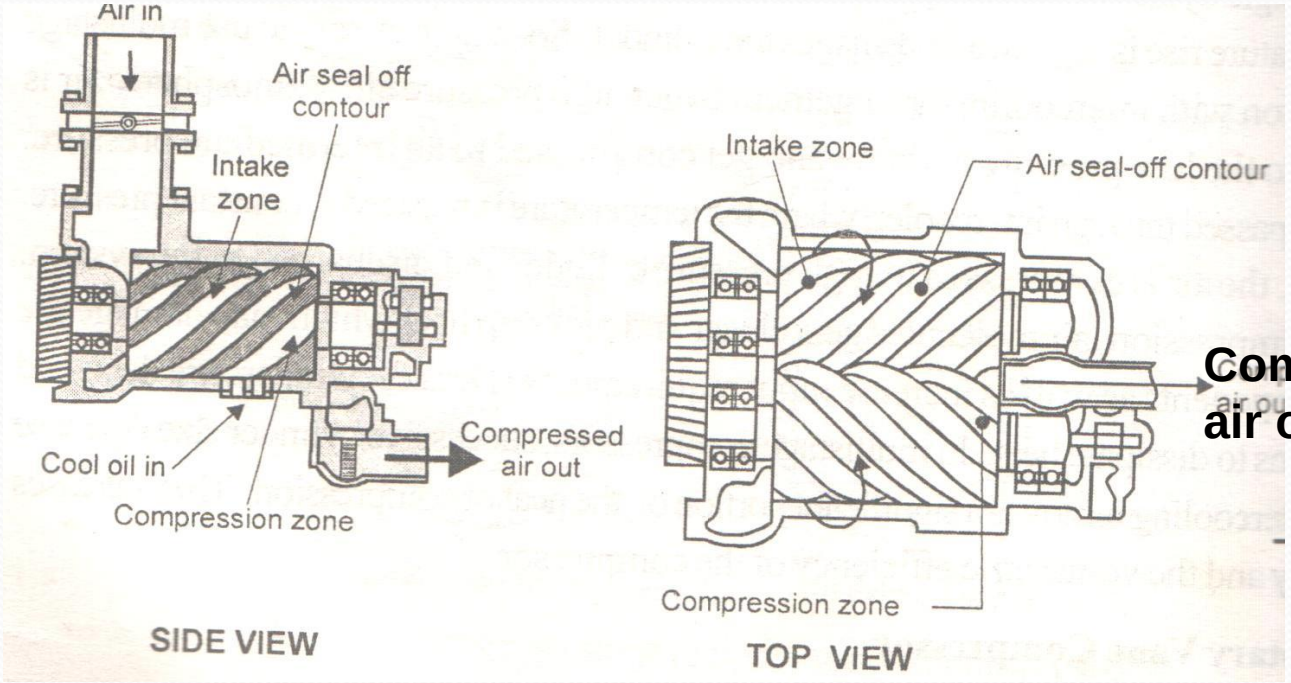


Rotary vane compressor

Rotary vane compressor

1. This rotary vane compressor is working due to the centrifugal force created. Due to the centrifugal force the vanes slides out.
2. As the rotor turns air is dropped between the vanes during one half of each revolution And compressed the vanes
3. Air is pushes out during the other half of each revolution.

Rotary screw compressor



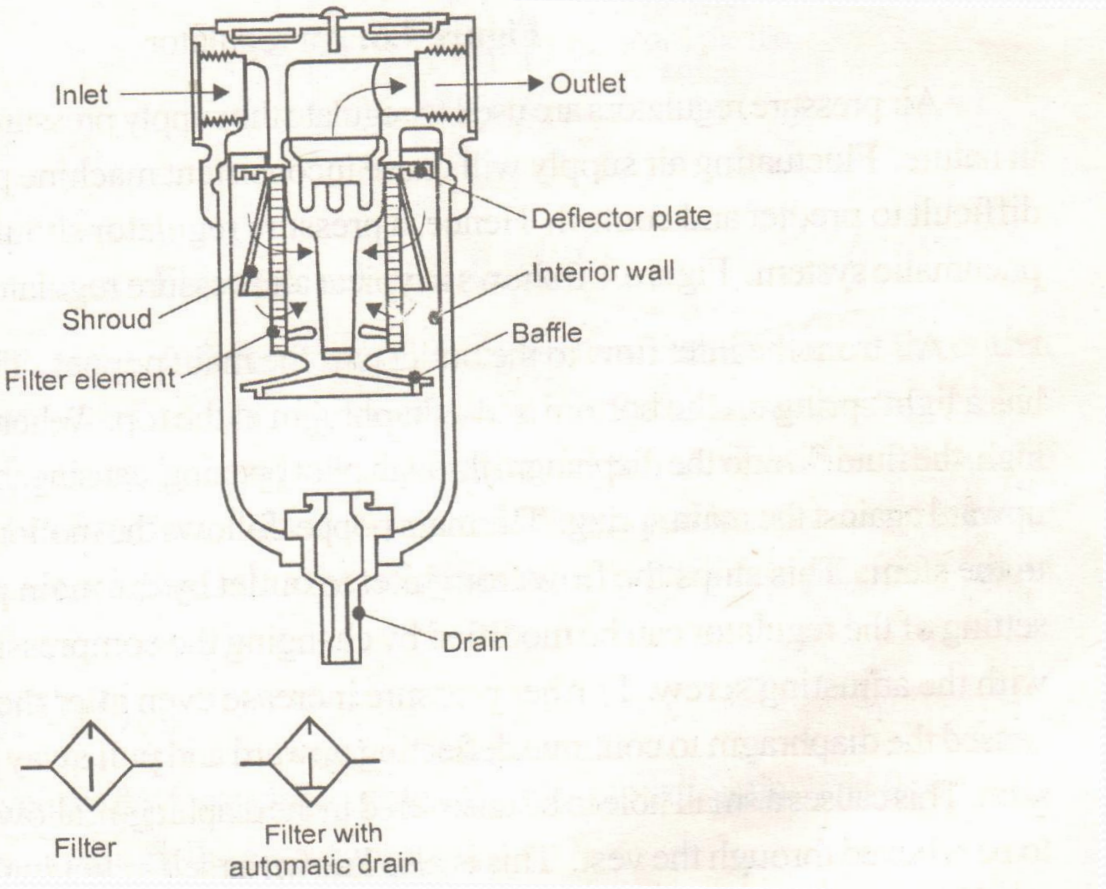
Compressor air out

Rotary screw compressor

Rotary screw compressor

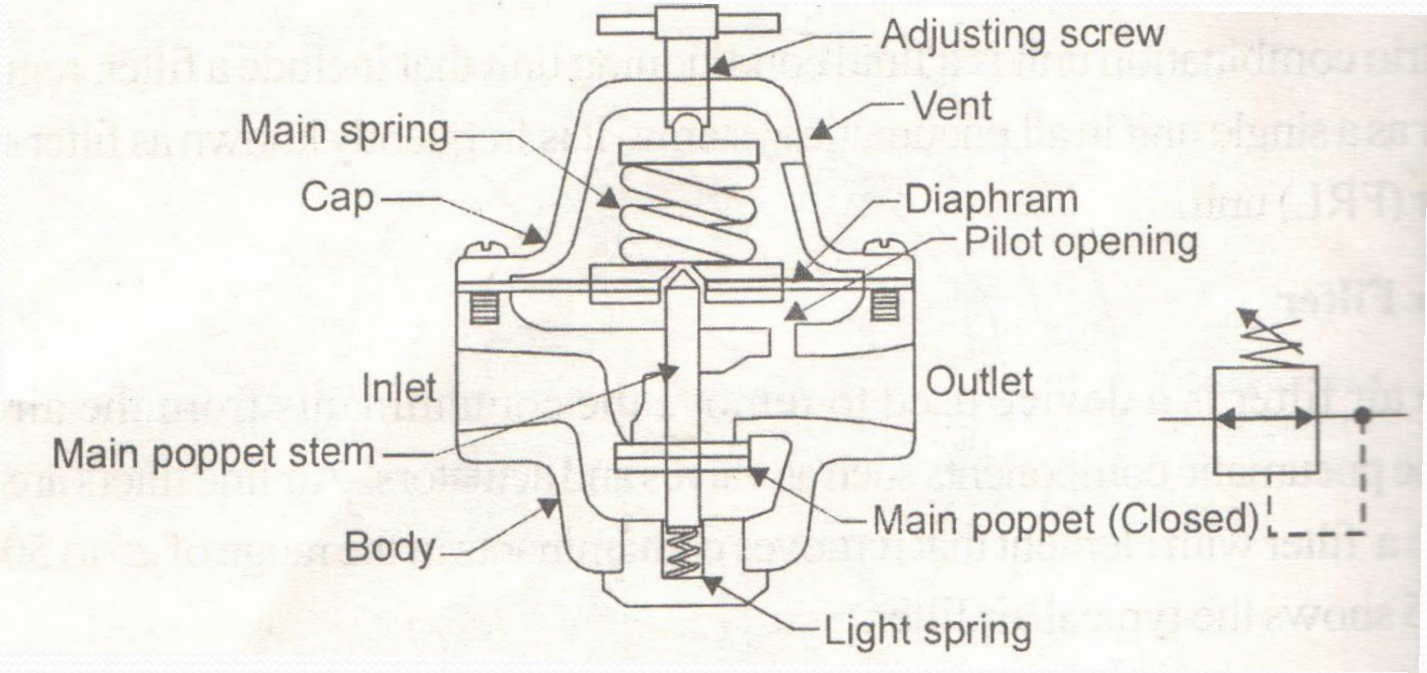
1. A rotary screw compressor compresses air between two inter meshing screws
2. Oil is used as a coolant to remove some of the heat dissicipating due to compression.

Air filter



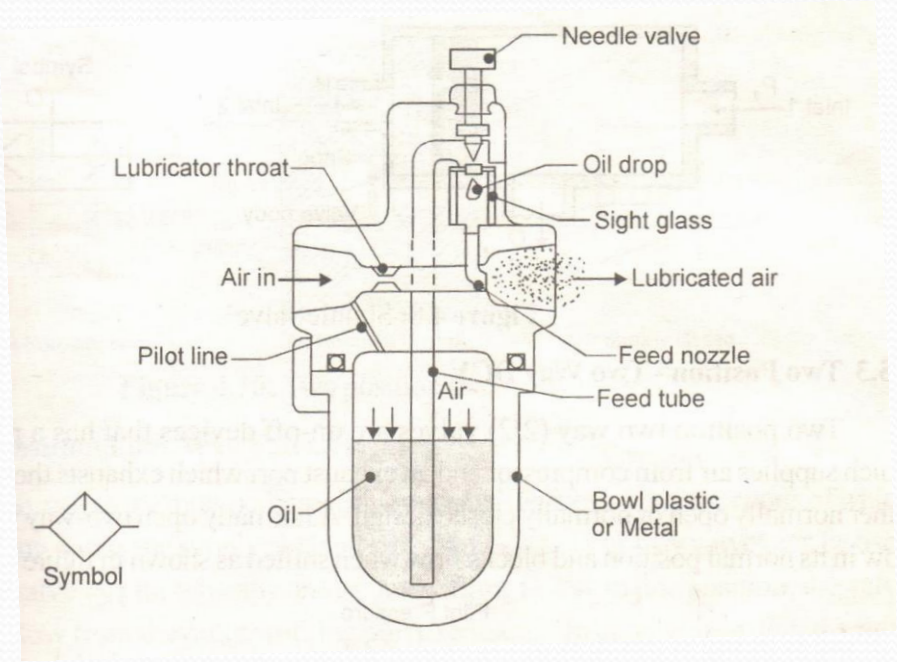
Air filter

Air regulator



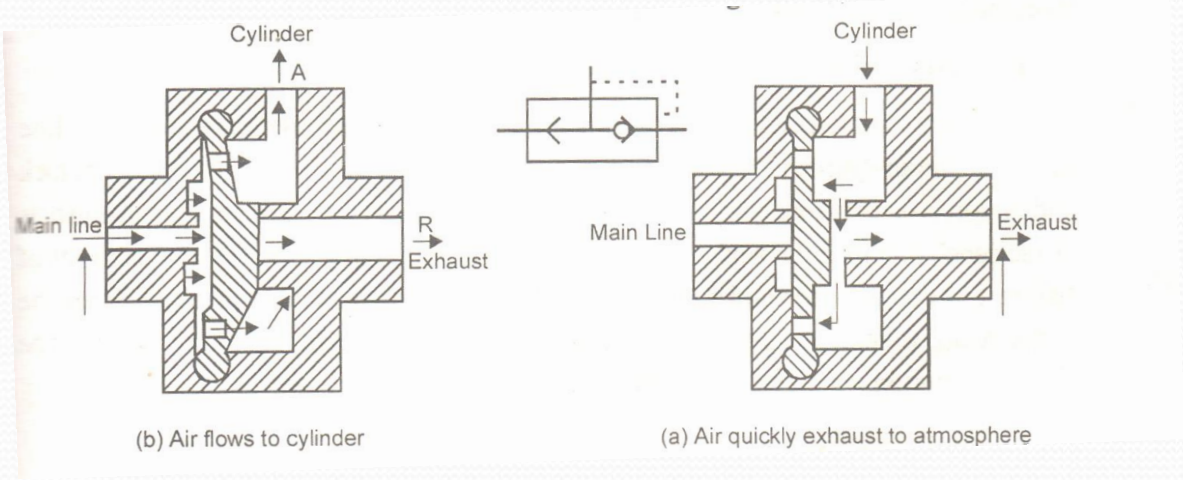
Air regulator

Air lubricator

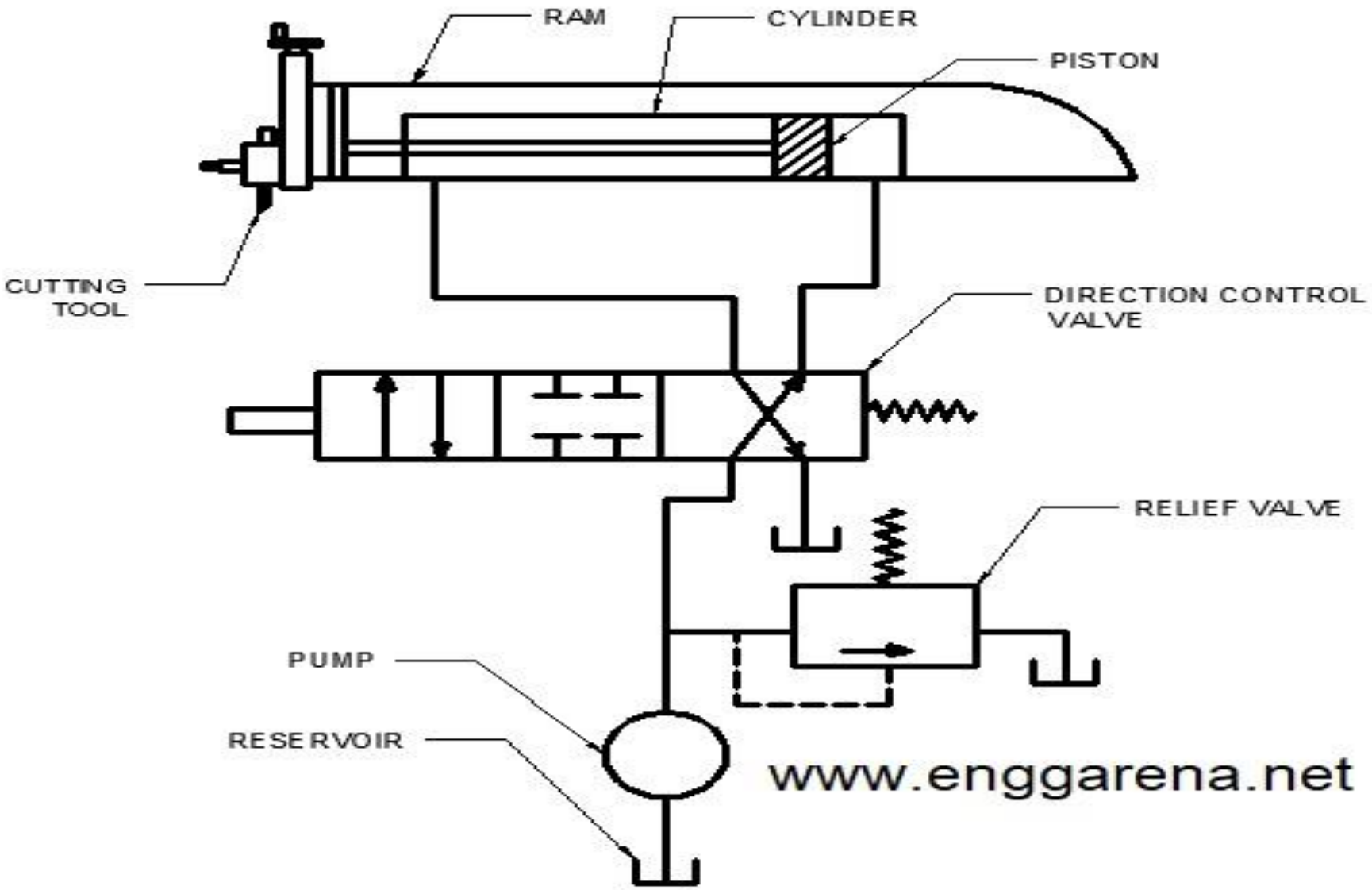


Air lubricator

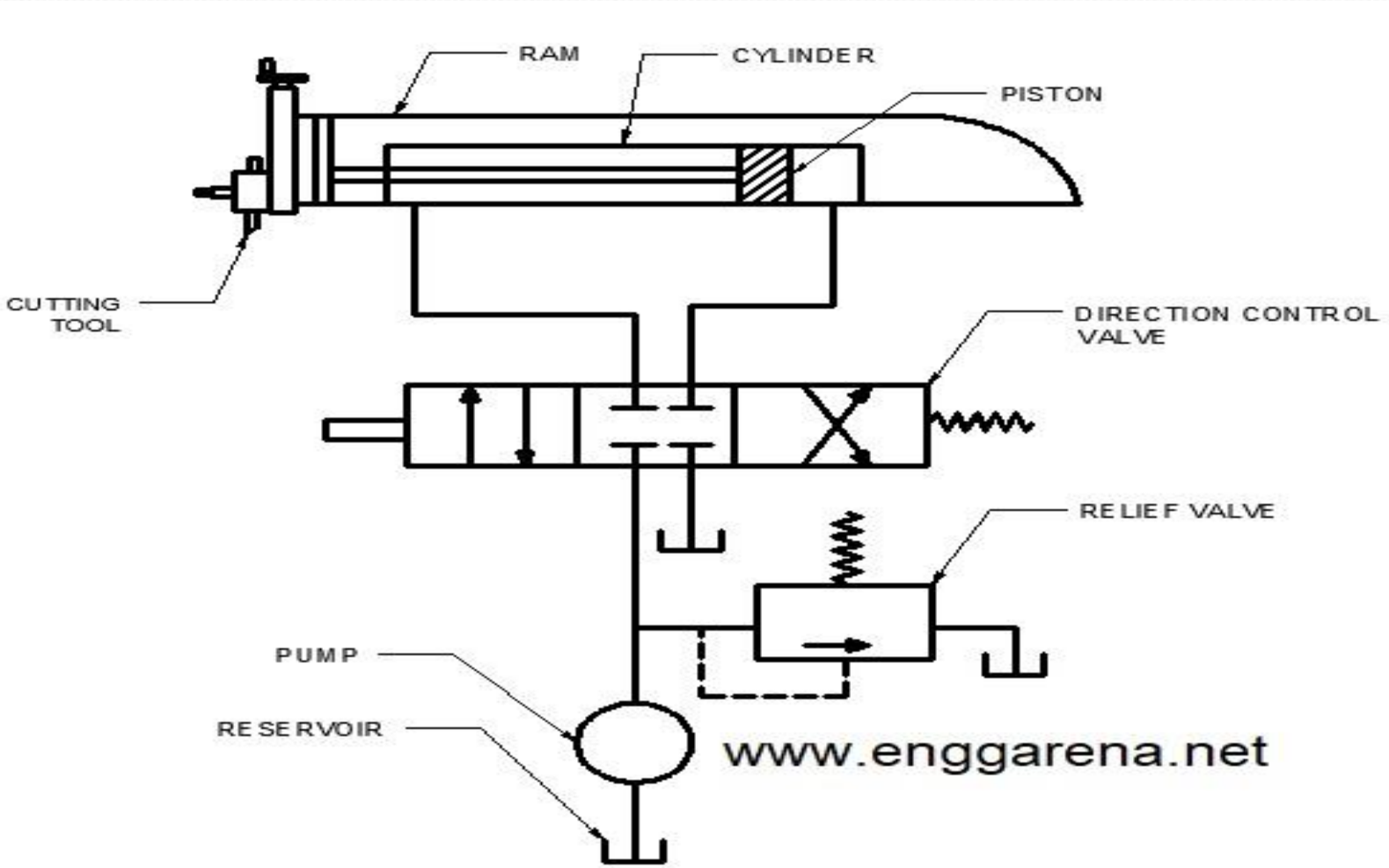
Quick exhaust valve

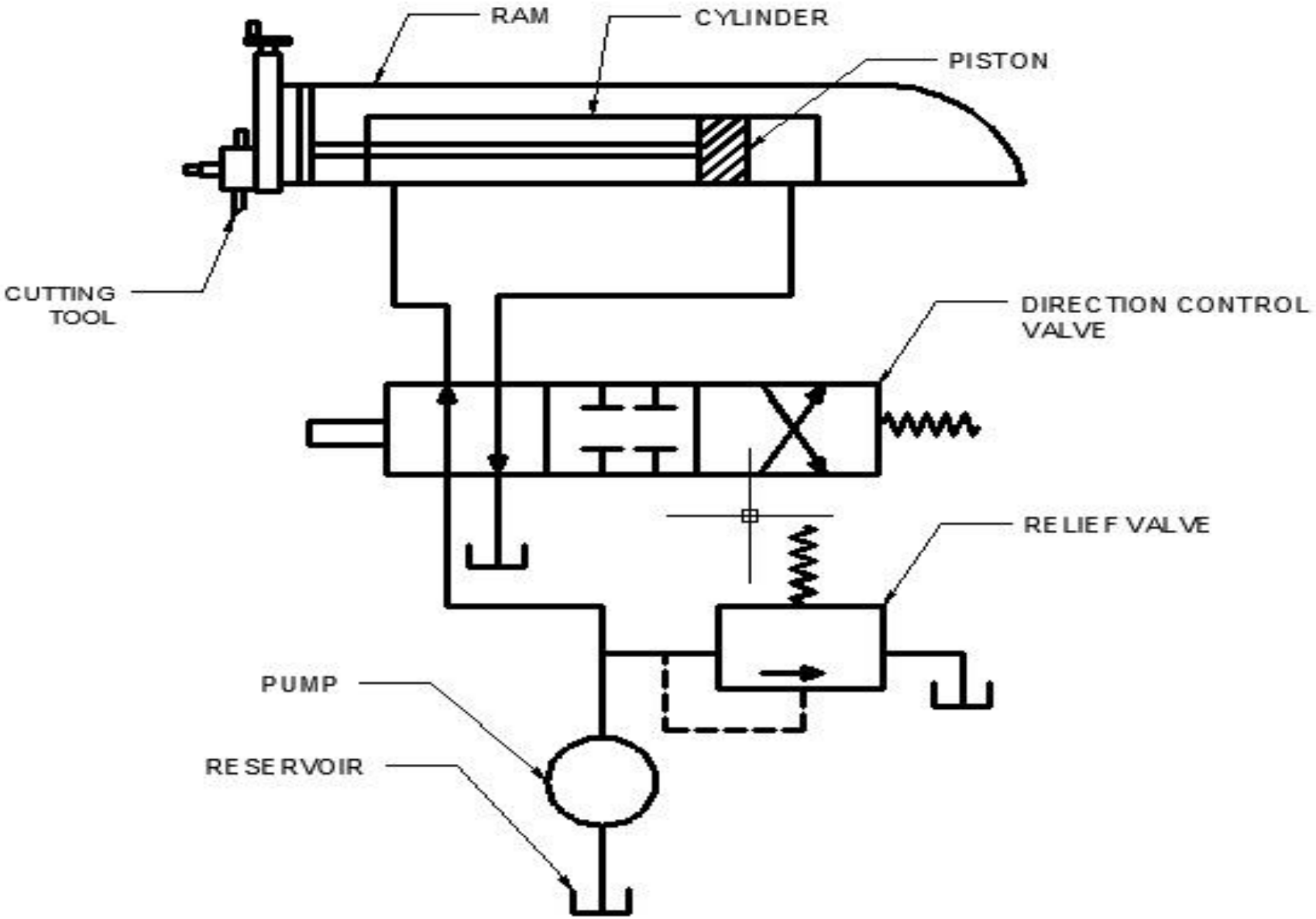


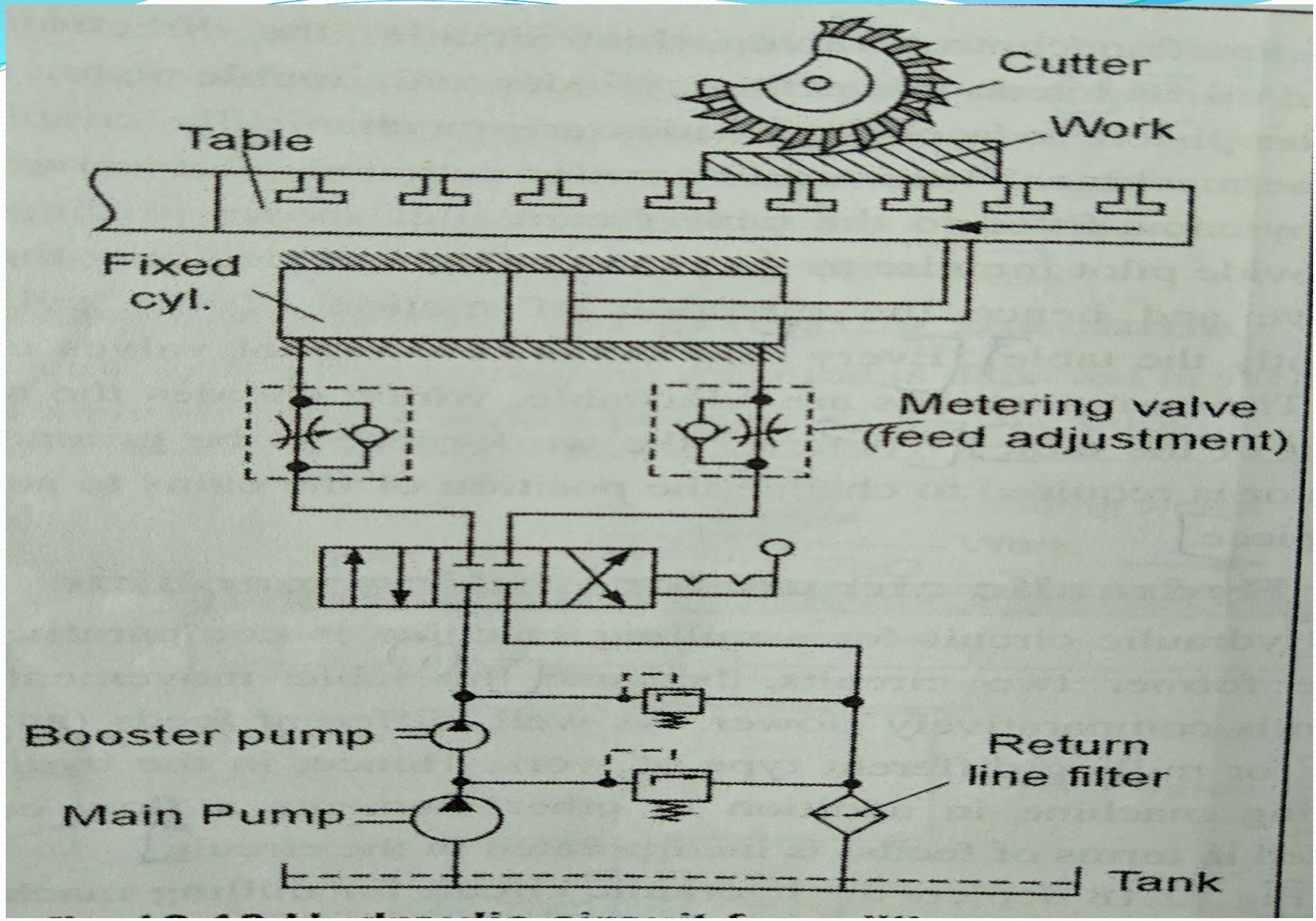
Quick exhaust valve

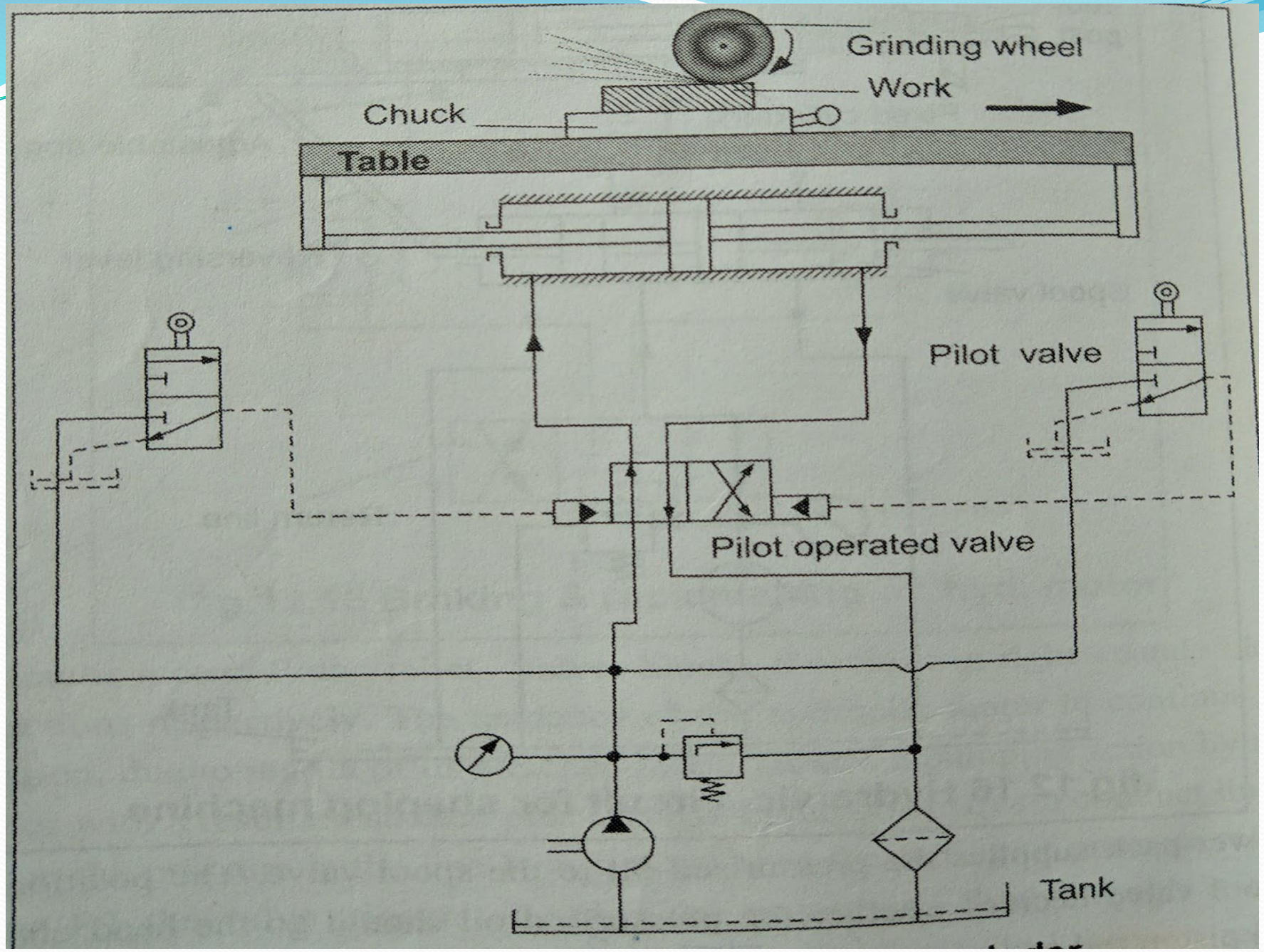

RAM
CYLINDER
PISTON
CUTTING TOOL
DIRECTION CONTROL VALVE
RELIEF VALVE
PUMP
RESERVOIR
www.enggarena.net

Due to the difference in annular areas of head-end and piston rod end, the return stroke is faster than the forward stroke.




RAM
CYLINDER
PISTON
CUTTING TOOL
DIRECTION CONTROL VALVE
RELIEF VALVE
PUMP
RESERVOIR


Cutter
Work
Table
Fixed cyl.
Metering valve (feed adjustment)
Booster pump
Main Pump
Return line filter
Tank


Grinding wheel
Work
Chuck
Table
Pilot valve
Pilot operated valve
Tank

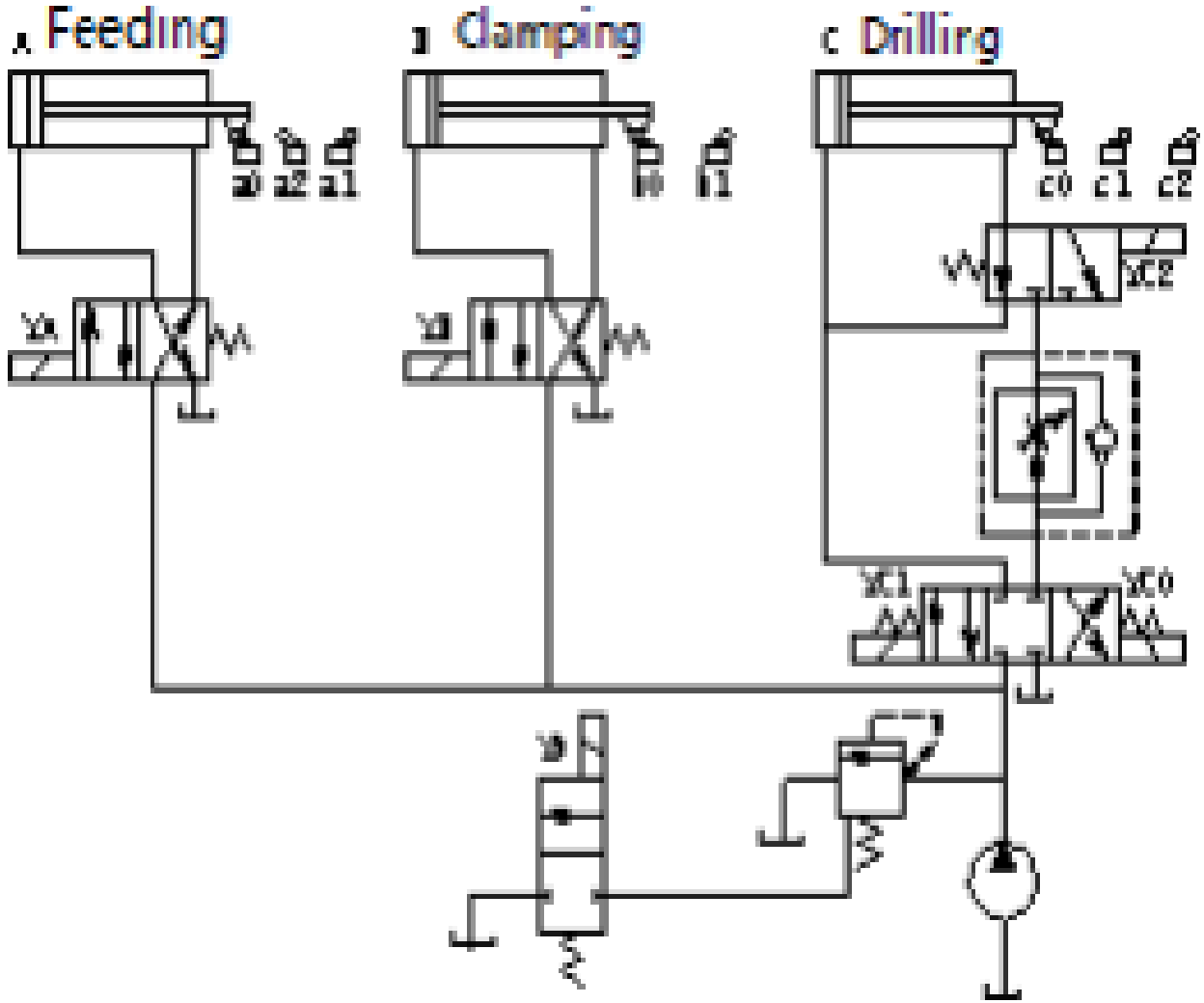
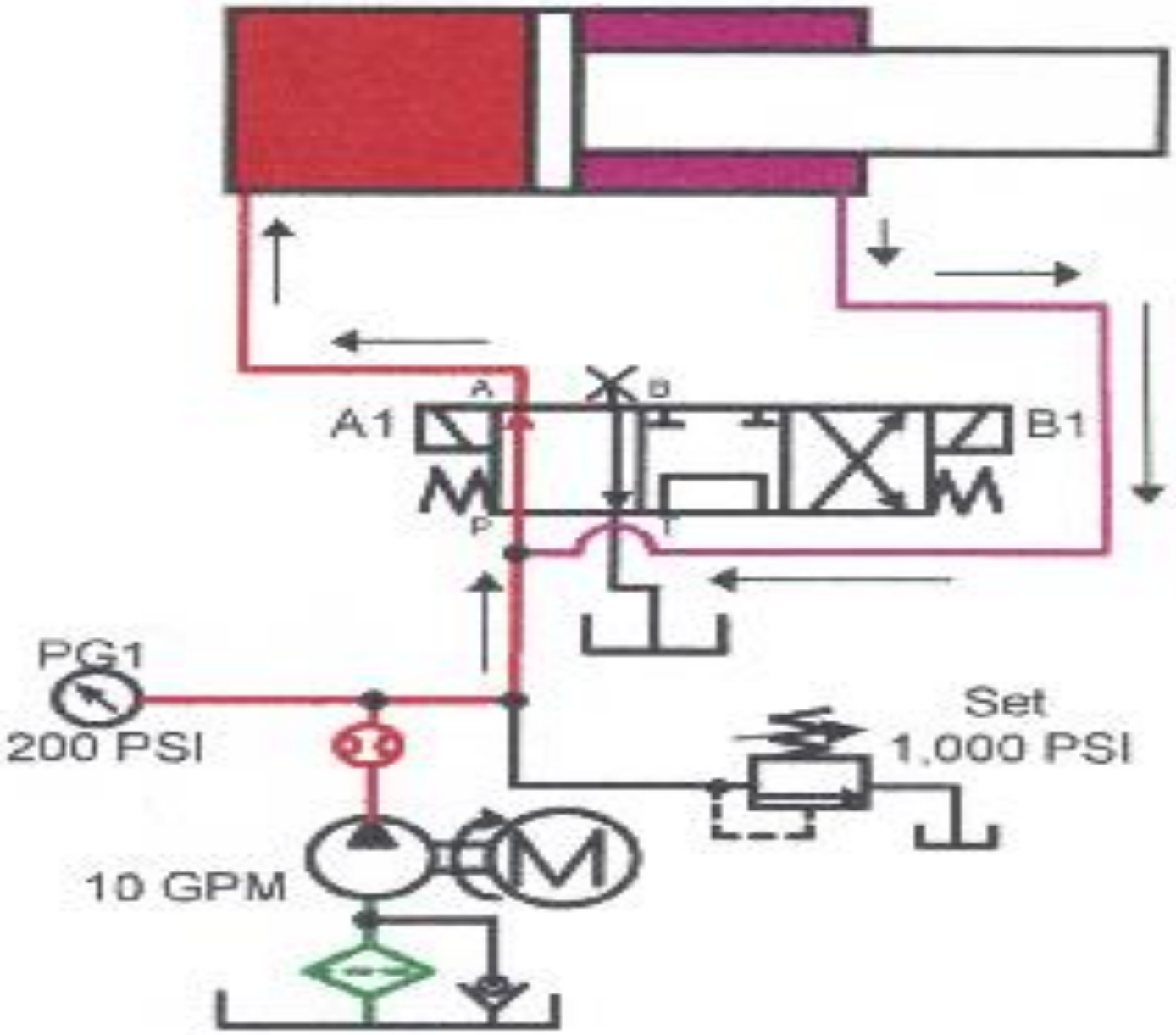
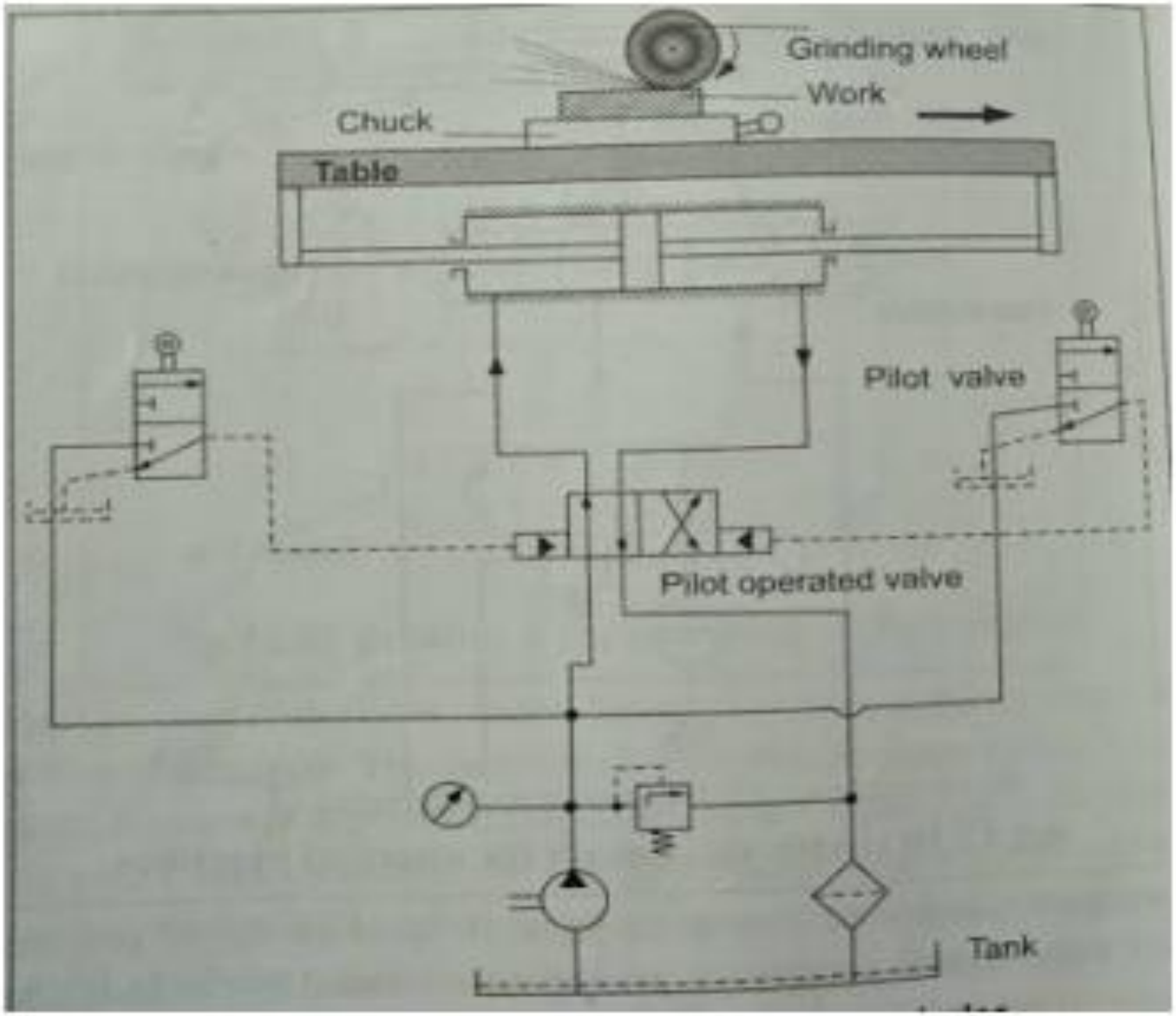


Fig. 2 Full-automatic special drill hydraulic system loop


A1
A
B
B1
P
T
PG1
200 PSI
Set
1,000 PSI
10 GPM
M


Grinding wheel
Work
Chuck
Table
Pilot valve
Pilot operated valve
Tank