UNIT 4

Introduction to and Components of Pneumatic Systems

CO related to chapter

C602.1

List and draw components of hydraulic & pneumatic systems with symbols and draw its general layout.

C602.1

Describe working principle of various components used in hydraulic & pneumatic systems.

C602.3

Choose valves, actuators and accessories required for simple hydraulic and pneumatic circuits.

INTRODUCTION

- Pneumatic technology deals with the study of behavior and applications of compressed air in our daily life in general and manufacturing automation in particular.
- Pneumatic systems use air as the medium which is abundantly available and can be exhausted into the atmosphere after completion of the assigned task.

General layout

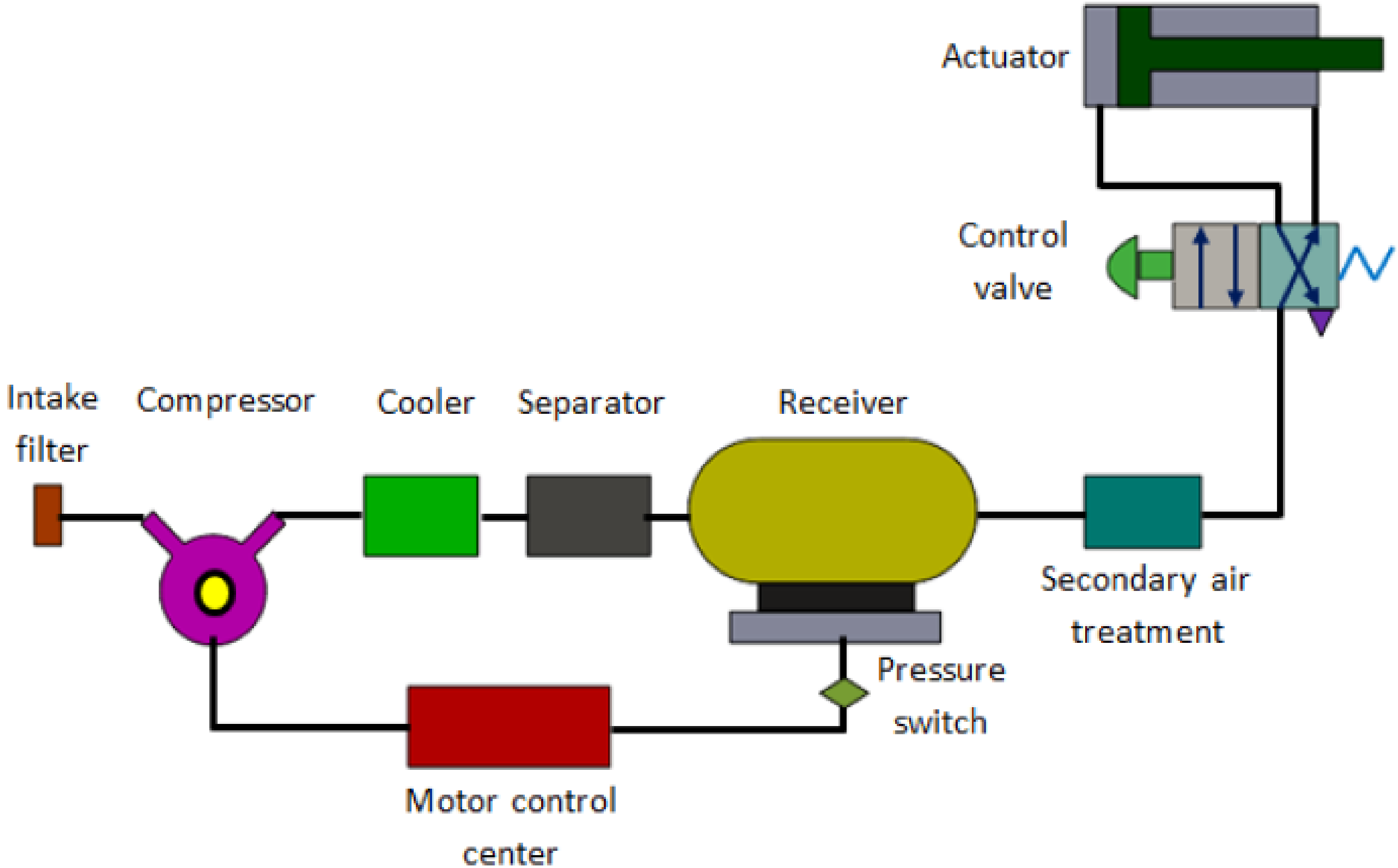


Fig. 6.1.1 Components of a pneumatic system

General layout

- Air filters: These are used to filter out the contaminants from the air.
- Compressor: Compressed air is generated by using air compressors. Air compressors are either diesel or electrically operated. Based on the requirement of compressed air, suitable capacity compressors may be used.
- Air cooler: During compression operation, air temperature increases. Therefore coolers are used to reduce the temperature of the compressed air.
- Dryer: The water vapor or moisture in the air is separated from the air by using a dryer.
- Control Valves: Control valves are used to regulate, control and monitor for control of direction flow, pressure etc.
- Air Actuator: Air cylinders and motors are used to obtain the required movements of mechanical elements of pneumatic system.

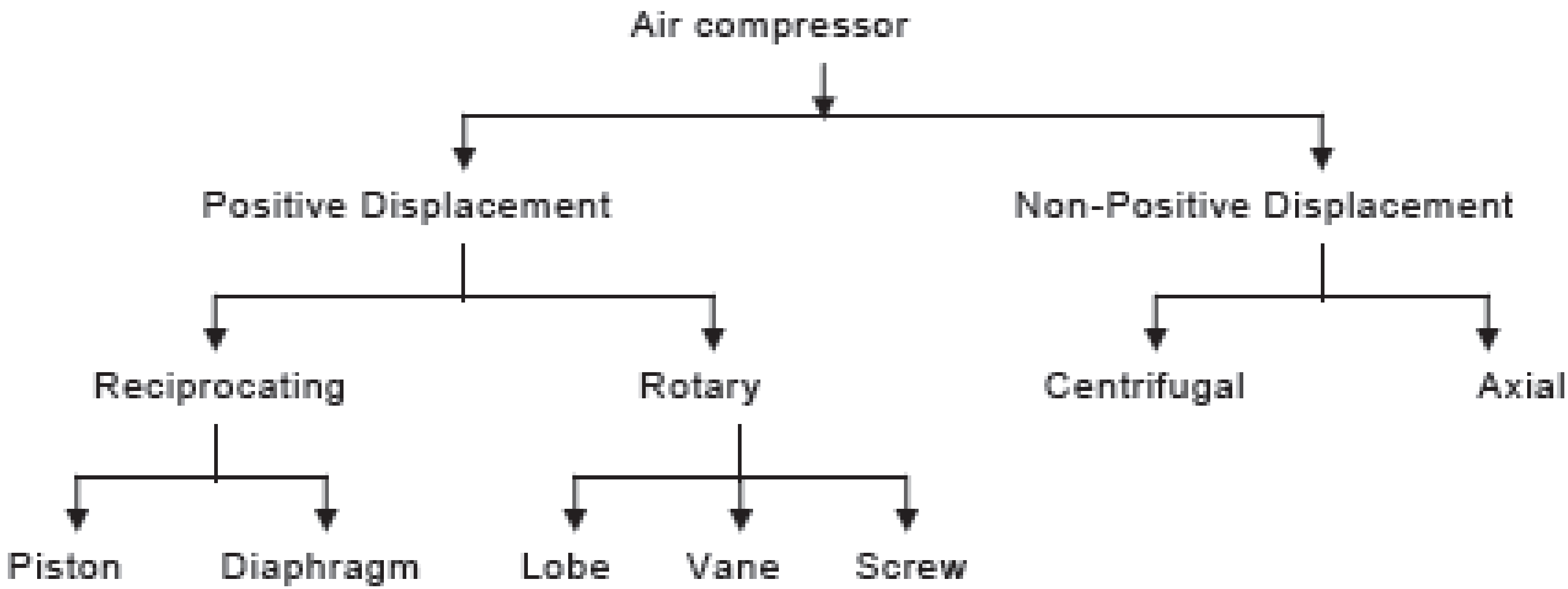
DIFFERNCE BETWEEN

S. No.	Hydraulic System	Pneumatic System
1.	It employs a pressurized liquid as a fluid	It employs a compressed gas, usually air, as a fluid
2.	An oil hydraulic system operates at pressures up to 700 bar	A pneumatic system usually operates at 5–10 bar
3.	Generally designed as closed system	Usually designed as open system
4.	The system slows down when leakage occurs	Leakage does not affect the system much
5.	Valve operations are difficult	Valve operations are easy
6.	Heavier in weight	Lighter in weight
7.	Pumps are used to provide pressurized liquids	Compressors are used to provide compressed gases
8.	The system is unsafe to fire hazards	The system is free from fire hazards
9.	Automatic lubrication is provided	Special arrangements for lubrication are needed

Selection of air compressors for pneumatic circuits

- Air pressure required
- Free air delivery required
- Space available
- Working environment
- Availability of space

CLASSIFICATION OF AIR COMPRESSORS:



Piston compressor

Piston compressors are commonly used in pneumatic systems.
The simplest form is single cylinder compressor (Fig. 6.1.3).
It produces one pulse of air per piston stroke.
As the piston moves down during the inlet stroke the inlet valve opens and air is drawn into the cylinder.
As the piston moves up the inlet valve closes and the exhaust valve opens which allows the air to be expelled.
The valves are spring loaded.
The single cylinder compressor gives significant amount of pressure pulses at the outlet port.
The pressure developed is about 3-40 bar.

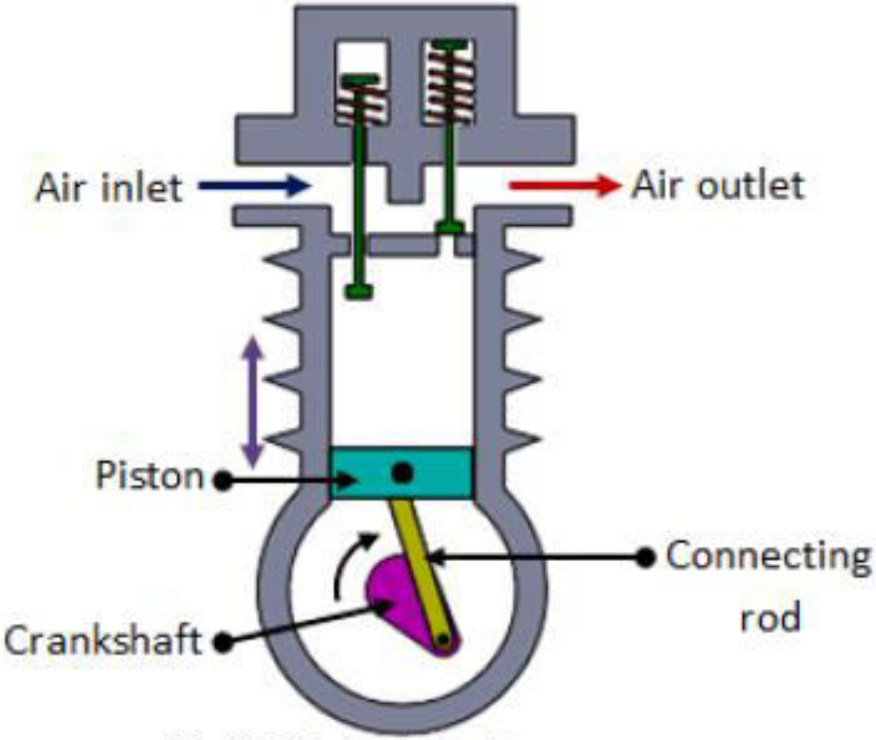


Fig. 6.1.3 Single acting piston compressor

Diaphragm compressor

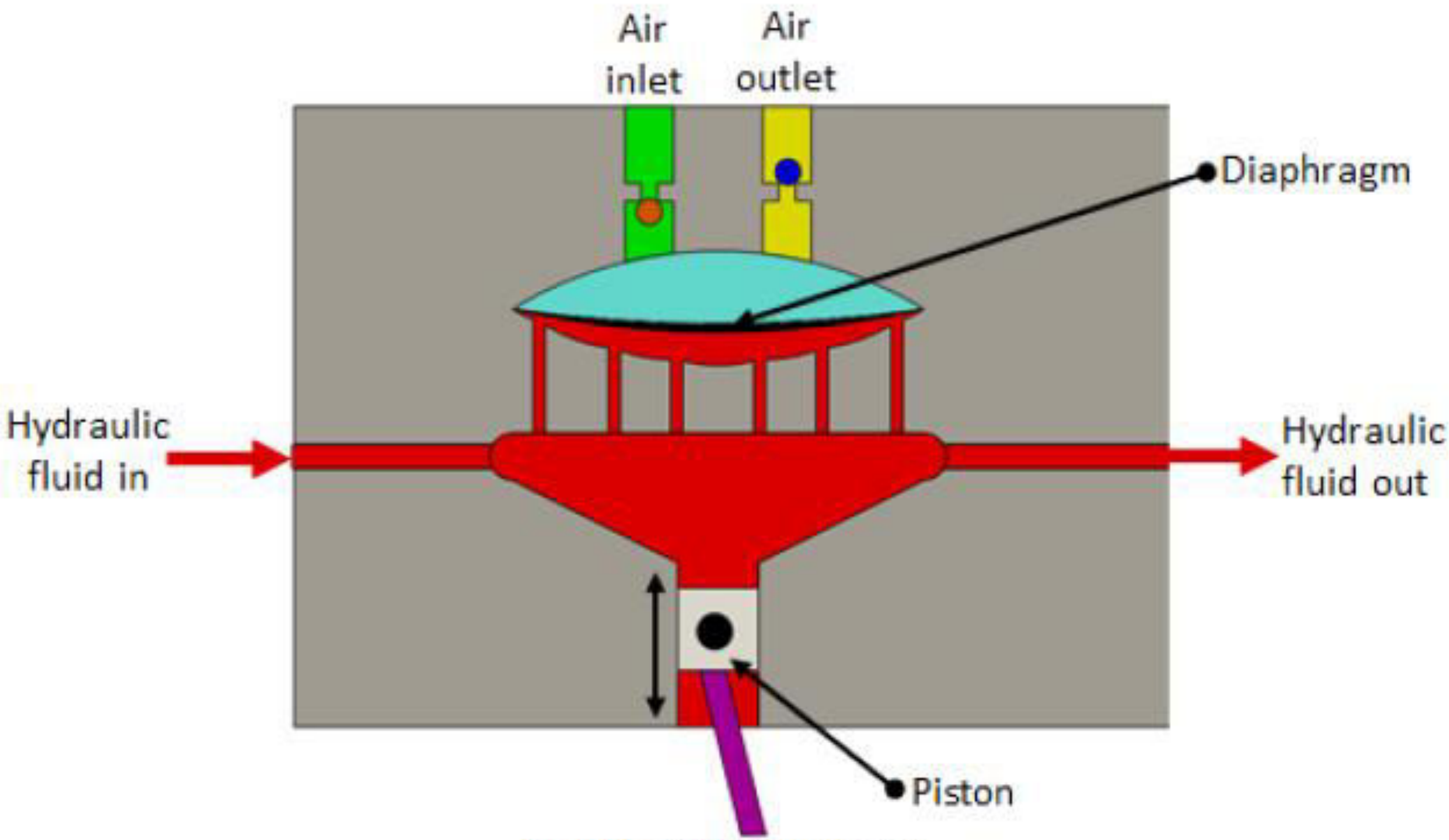


Fig. 6.2.1 Diaphragm compressor

Diaphragm compressor

- These are small capacity compressors. In piston compressors the lubricating oil from the pistons walls may contaminate the compressed air.
- The contamination is undesirable in food, pharmaceutical and chemical industries. For such applications diaphragm type compressor can be used.
- Figure 6.2.1 shows the construction of Diaphragm compressor.
- The piston reciprocates by a motor driven crankshaft.
- As the piston moves down it pulls the hydraulic fluid down causing the diaphragm to move along and the air is sucked in.
- When the piston moves up the fluid pushes the diaphragm up causing the ejection of air from the outlet port.
- Since the flexible diaphragm is placed in between the piston and the air no contamination takes place.

Lobe compressor

The lobe compressor is used when high delivery volume but low pressure is needed.

It consists of two lobes with one being driven and the other driving. Figure 6.2.5 shows the construction and working of Lobe compressor.

It is similar to the Lobe pump used in hydraulic systems.

The operating pressure is limited by leakage between rotors and housing.

As the wear increases during the operation, the efficiency falls rapidly.

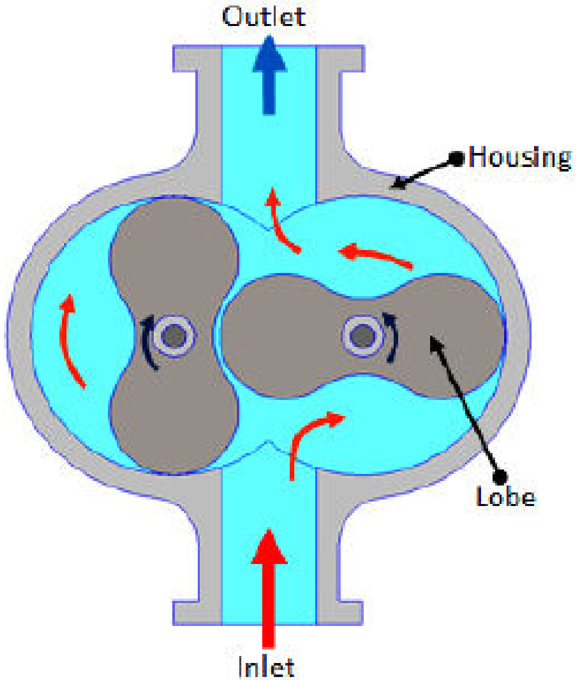


Fig. 6.2.5 Lobe compressor

Rotary vane type compressor

The principle of operation of vane compressor is similar to the hydraulic vane pump. Figure 6.2.3 shows the working principle of Rotary vane compressor. The unbalanced vane compressor consists of spring loaded vanes seating in the slots of the rotor. The pumping action occurs due to movement of the vanes along a cam ring. The rotor is eccentric to the cam ring. As the rotor rotates, the vanes follow the inner surface of the cam ring. The space between the vanes decreases near the outlet due to the eccentricity. This causes compression of the air. These compressors are free from pulsation. If the eccentricity is zero no flow takes place.

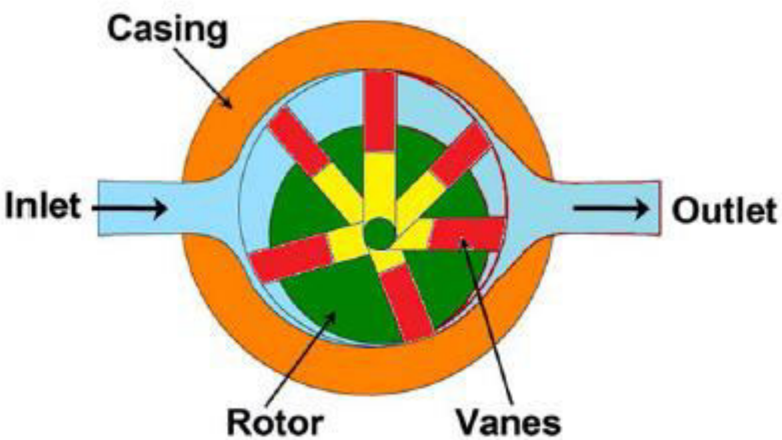


Fig. 6.2.3 Rotary vane compressor

Screw compressor

Piston compressors are used when high pressures and relatively low volume of air is needed.
The system is complex as it has many moving parts. For medium flow and pressure applications, screw compressor can be used. It is simple in construction with less number of moving parts. The air delivered is steady with no pressure pulsation. It has two meshing screws. The air from the inlet is trapped between the meshing screws and is compressed. The contact between the two meshing surface is minimum, hence no cooling is required. These systems are quite in operation compared to piston type. The screws are synchronized by using external timing gears.

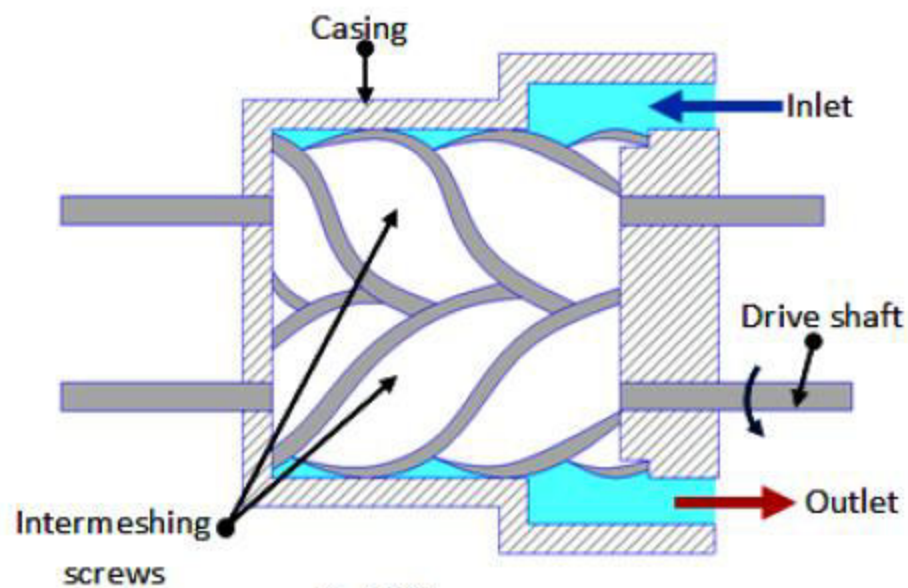
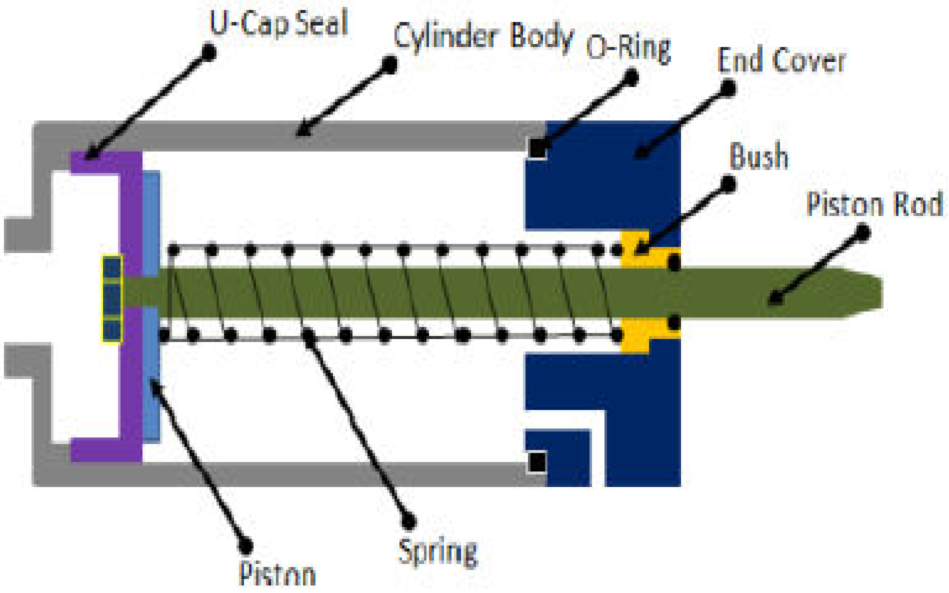


Fig. 6.2.2 Screw compressor

LINEAR ACTUATORS

- These cylinders produce work in one direction of motion hence they are named as **single acting cylinders**.
- Figure 6.4.1 shows the construction of a single acting cylinder.
- The compressed air pushes the piston located in the cylindrical barrel causing the desired motion.
- The return stroke takes place by the action of a spring.
- Generally the spring is provided on the rod side of the cylinder.



Double acting cylinder

The main parts of a hydraulic double acting cylinder are: piston, piston rod, cylinder tube, and end caps.

These are shown in Figure 6.4.2. The piston rod is connected to piston head and the other end extends out of the cylinder.

The piston divides the cylinder into two chambers namely the rod end side and piston end side.

The seals prevent the leakage of oil between these two chambers. The cylindrical tube is fitted with end caps.

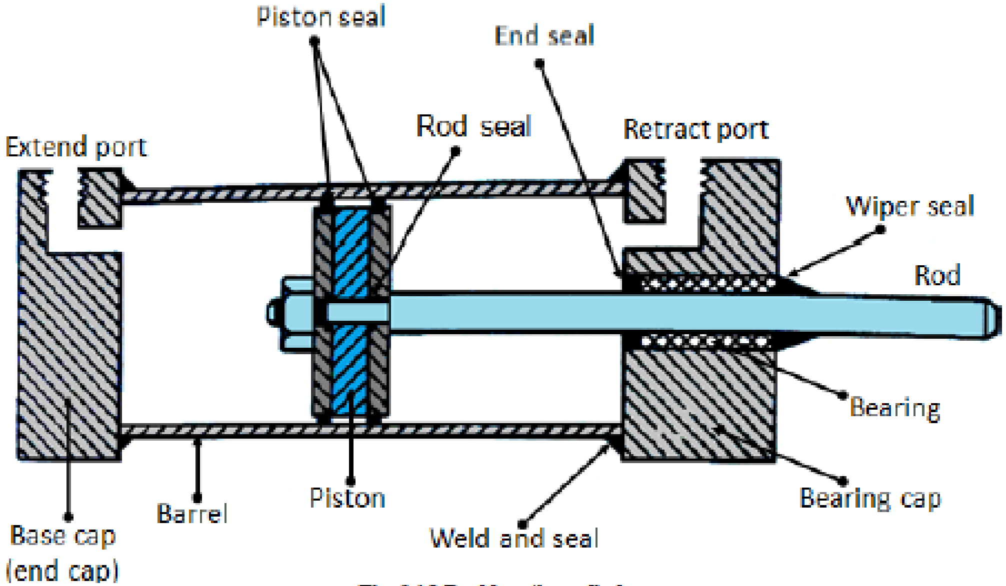


Fig. 6.4.2 Double acting cylinder

Double acting cylinder

The pressurized oil, air enters the cylinder chamber through the ports provided.

In the rod end cover plate, a wiper seal is provided to prevent the leakage of oil and entry of the contaminants into the cylinder.

The combination of wiper seal, bearing and sealing ring is called as cartridge assembly.

The end caps may be attached to the tube by threaded connection, welded connection or tie rod connection.

The piston seal prevents metal to metal contact and wear of piston head and the tube.

These seals are replaceable. End cushioning is also provided to prevent the impact with end caps.

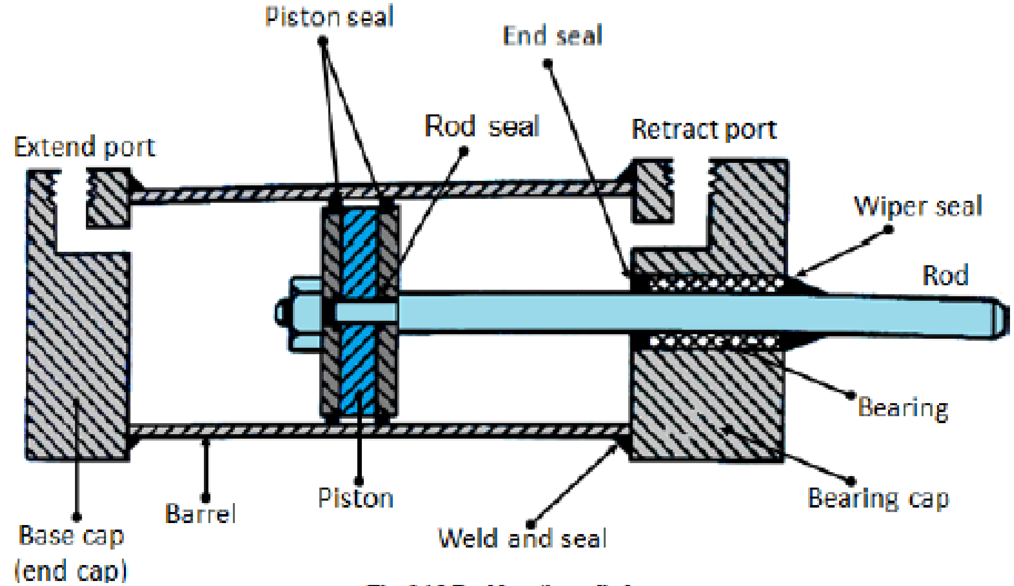


Fig. 6.4.2 Double acting cylinder

Cylinder with cushioning

- Double acting cylinders generally contain cylinder cushions at the end of the cylinder to slow down the movement of the piston near the end of the stroke. Figure 6.4.3 shows the construction of actuating cylinder with end cushions. Cushioning arrangement avoids the damage due to the impact occurred when a fast moving piston is stopped by the end caps. Deceleration of the piston starts when the tapered plunger enters the opening in the cap and closes the main fluid exit.

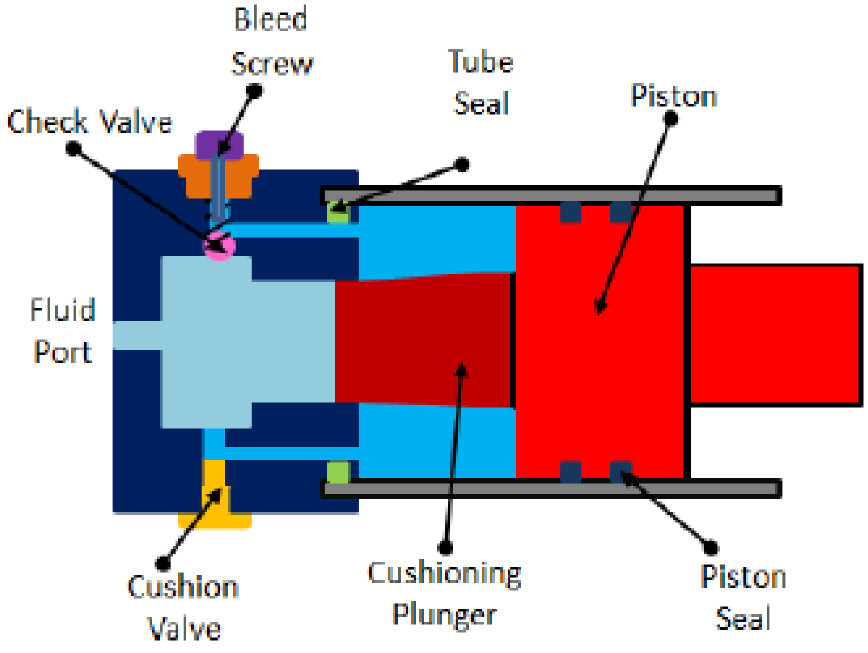


Fig. 6.4.3 Cylinder end cushioning

Cylinder with cushioning

- This restricts the exhaust flow from the barrel to the port. This throttling causes the initial speed reduction. During the last portion of the stroke the oil has to exhaust through an adjustable opening since main fluid exit closes. Thus the remaining fluid exists through the cushioning valve. Amount of cushioning can be adjusted by means of cushion screw. A check valve is provided to achieve fast break away from the end position during retraction motion. A bleed screw is built into the check valve to remove the air bubbles present in a hydraulic type system.

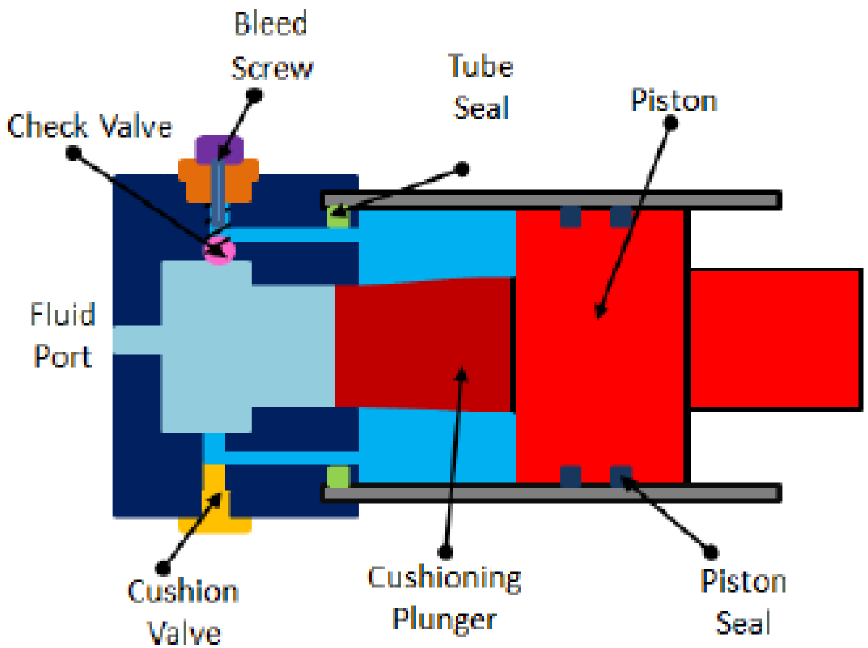


Fig. 6.4.3 Cylinder end cushioning

Rotary actuator-Gear motor

It consists of two inter meshing gears inside a housing with one gear attached to the drive shaft. Figure 6.4.4 shows a schematic diagram of Gear motor. The air enters from the inlet, causes the rotation of the meshing gear due to difference in the pressure and produces the torque. The air exists from the exhaust port. Gear motors tend to leak at low speed, hence are generally used for medium speed applications.

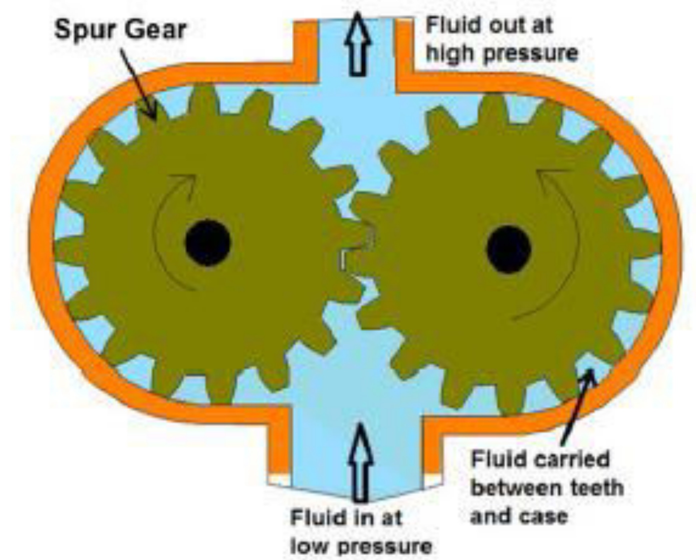


Fig. 6.4.4 Gear motor

Rotary actuator-vane type

A rotary vane motor consists of a rotor with sliding vanes in the slots provided on the rotor (Fig. 6.4.5). The rotor is placed eccentrically with the housing. Air enters from the inlet port, rotates the rotor and thus torque is produced. Air is then released from the exhaust port (outlet).

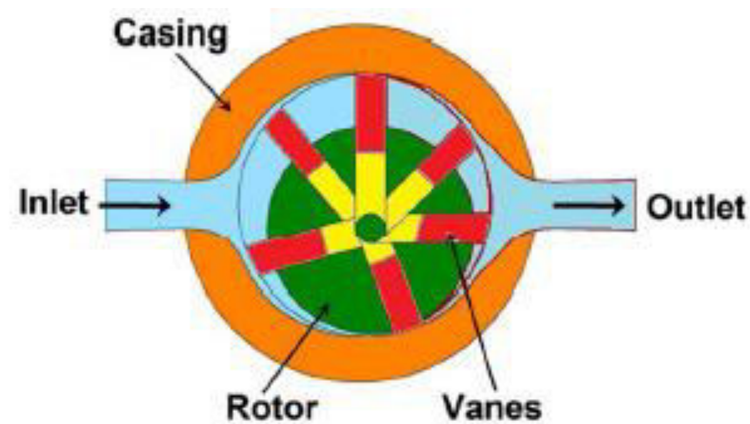


Fig. 6.4.5 Vane motor

Rotary actuators-vane type limited rotation

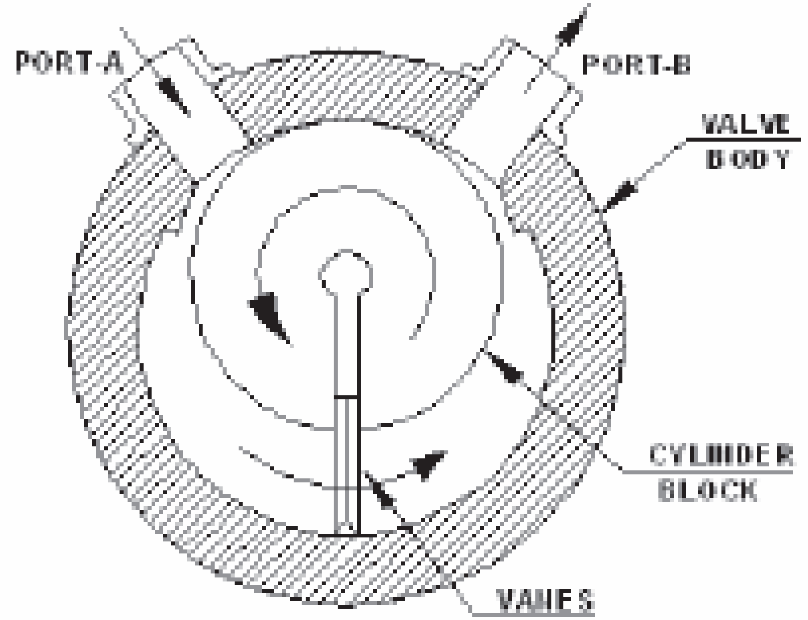
These motors are bi-directional motors. They can run in both directions, but for a limited number of rotations.

Vane type:

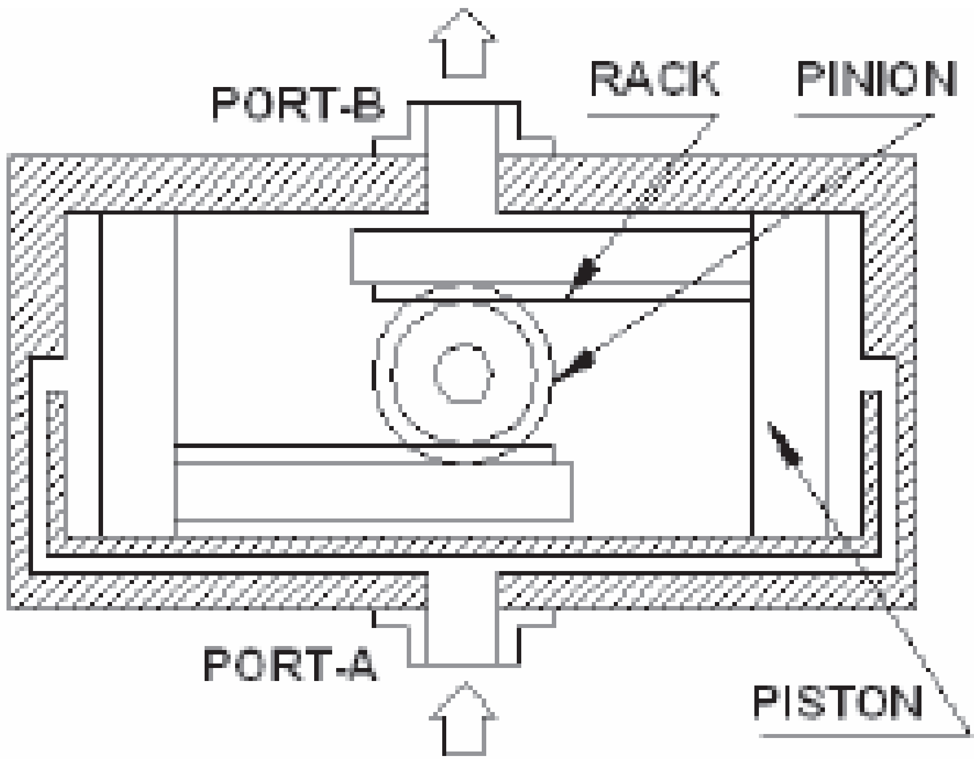
Figure shows vane type limited rotation motor. It has a cylindrical block with a pairs of finely ground flat vanes in its radial slot.

When fluid under pressure is supplied through port-A, it exerts pressure on the vanes and hence, the motor shaft rotate in counter clock-wise direction.

When fluid under pressure is supplied through port-B, the motor shaft rotates in clock-wise direction.



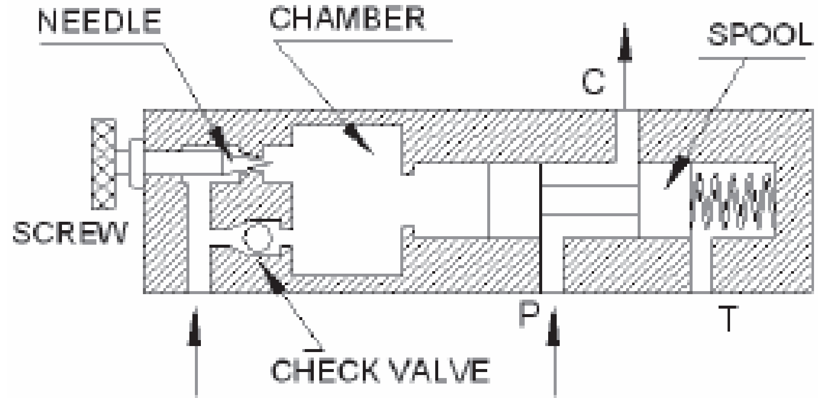
Rack and pinion type motor



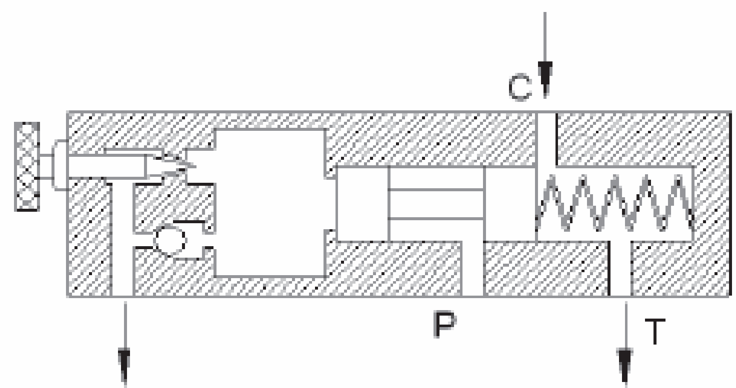
Time delay valve:

This valve is used to have required amount of time delay between two operations. For example a cylinder extends first and it retracts automatically after preset amount of time.

Figure shows a time delay valve. It has an in-built reservoir, flow control, a check valve, and pilot operated 3/2 direction control valve.

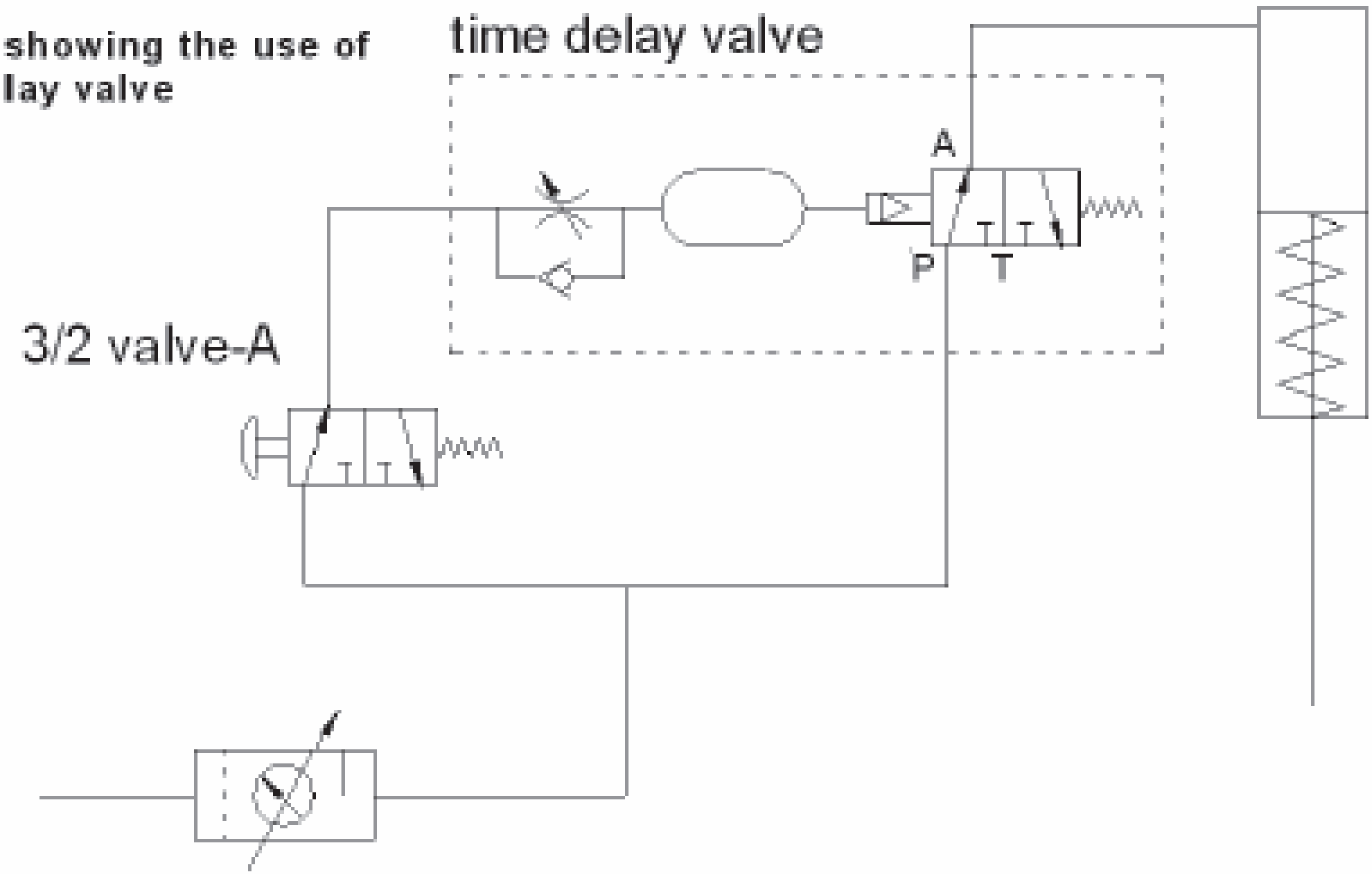


When the fluid under pressure id admitted through inlet port of this valve, it fills in the chamber, and exerts force on the spool. Due to this, the spool is pressed against the spring force, making the connection from port-P to port-C.



When the inlet port of this valve is open to oil reservoir (incase of hydraulic systems) or to atmosphere (incase of pneumatic systems), the fluid flows slowly through FCV. Hence pressure in chamber reduces slowly. Once the pressure becomes less than the spring pressure, the spool shifts back to make the connection between port-C to port-T, port-P gets closed.

Circuit showing the use of time delay valve



FRL UNIT-AIR FILTER

Air filter and water trap is used to

- prevent any solid contaminants from entering in the system.
- condense and remove water vapor that is present in the compressed air.

The filter cartridge is made of sintered brass. The schematic of the filter is shown in Fig. 6.3.2.

The thickness of sintered cartridge provides random zigzag passage for the air to flow-in which helps in arresting the solid particles.

The air entering the filter swirls around due to the deflector cone.

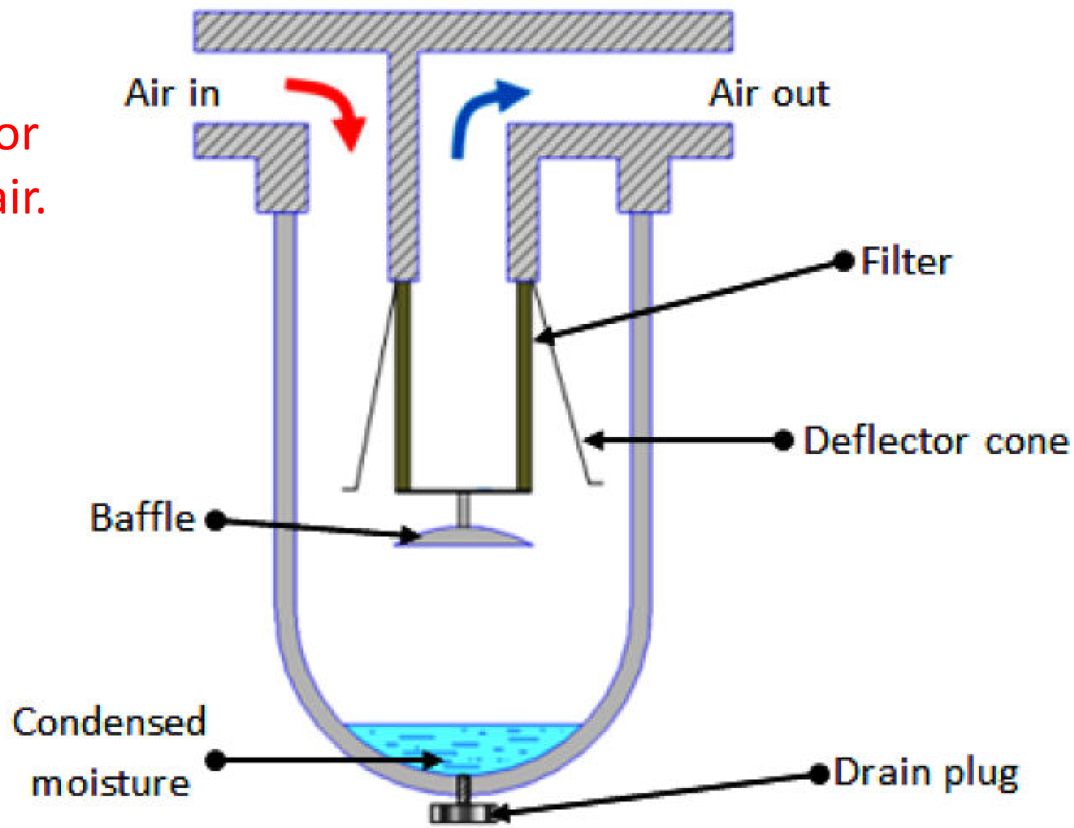


Fig. 6.3.2 Air filter and water trap

FRL UNIT-AIR FILTER

The centrifugal action causes the large contaminants and water vapor to be flung out, which hit the glass bowl and get collected at the bottom.

A baffle plate is provided to prevent the turbulent air from splashing the water into the filter cartridge.

At the bottom of the filter bowl there is a drain plug which can be opened manually to drain off the settled water and solid particles.

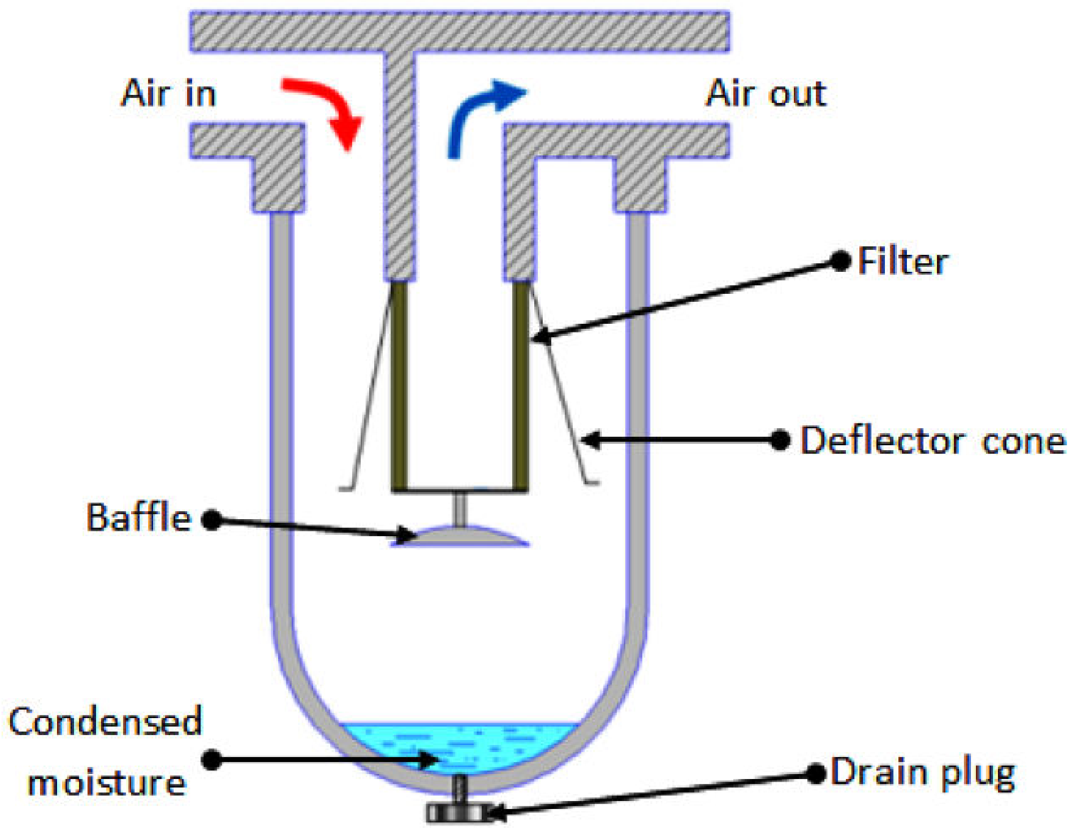
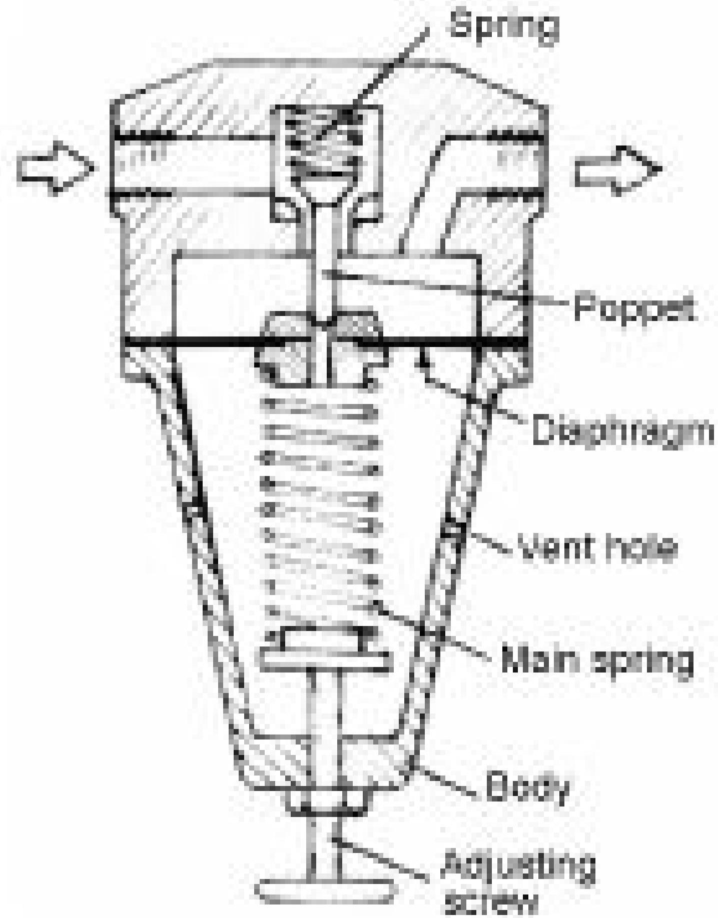


Fig. 6.3.2 Air filter and water trap

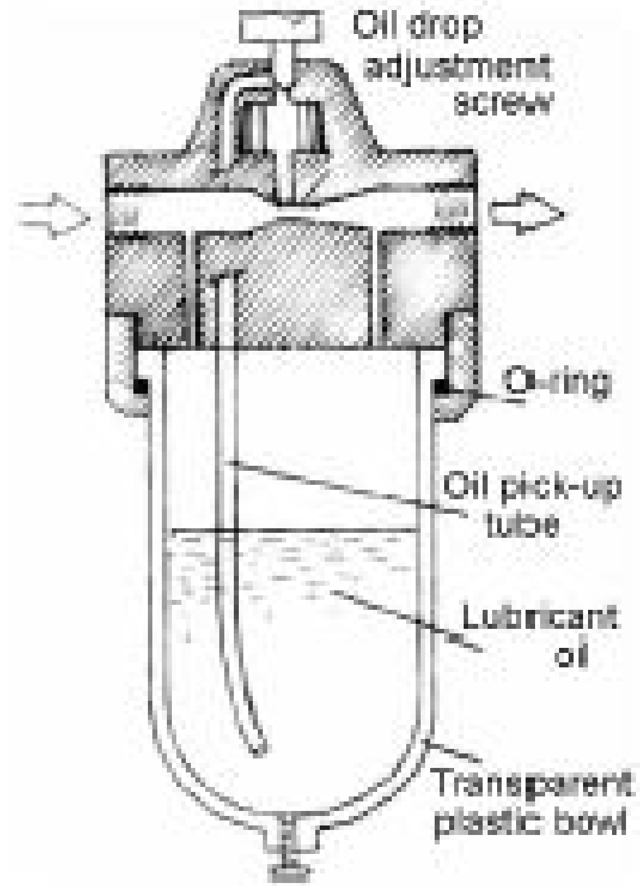
FRL UNIT- REGULATOR

It *maintains constant pressure in the system*. It is shown in figure. When outlet pressure DECREASES , the diaphragm deflects upward causing the poppet to lift up, to create more passage for air to flow. Similarly, when outlet pressure increases, the diaphragm deflects downward causing the poppet to move down, to reduce the passage and hence pressure comes to normal. In case, if the pressure is too high, that, even after complete closure of the passage, pressure do not comes to normal, then the diaphragm deflects downward causing the hole in the diaphragm to open, to release air to atmosphere through the vent holes.



FRL UNIT-LUBRICATOR

It *adds lubricating oil to the flowing compressed air* in the form of mist or fog. Lubricating oil is necessary to reduce friction between moving parts in the system. Air lubricator uses the principle of venturi effect. If the area of flow is reduced, then pressure of air also reduces since there is increase in velocity. The transparent bowl contains oil in it. Due to the difference in pressure between inlet and throat of venturi, oil is forced to flow into the throat. Oil get mixed up with the compressed air at the throat and carried along with it to the different parts of the system. An adjustment screw is there to control the flow of into the system.



Application of pneumatic system

Material Handling	**Manufacturing**	**Other applications**
Clamping	Drilling	Aircraft
Shifting	Turning	Cement plants
positioning	Milling	chemical plants
Orienting	Sawing	Coal mines
Feeding	Finishing	Cotton mills
Ejection	Forming	Dairies
Braking	Quality Control	Forge shops
Bonding	Stamping	Machine tools
Locking	Embossing	Door or chute control
Packaging	Filling	Turning and inverting parts
Feeding		
Sorting		
stacking		

Advantages of pneumatic system

(a) The advantages of pneumatic systems

(i) High effectiveness

(ii) High durability and reliability

(iii) Simple design

(iv) High adaptability to harsh environment

(v) Safety

(vi) Easy selection of speed and pressure

(vii) Environmental friendly

(viii) Economical

Disadvantages of pneumatic system

- Relatively low accuracy
- Low loading
- Processing required before use
- Uneven moving speed
- Noise