Air compressor parts and function

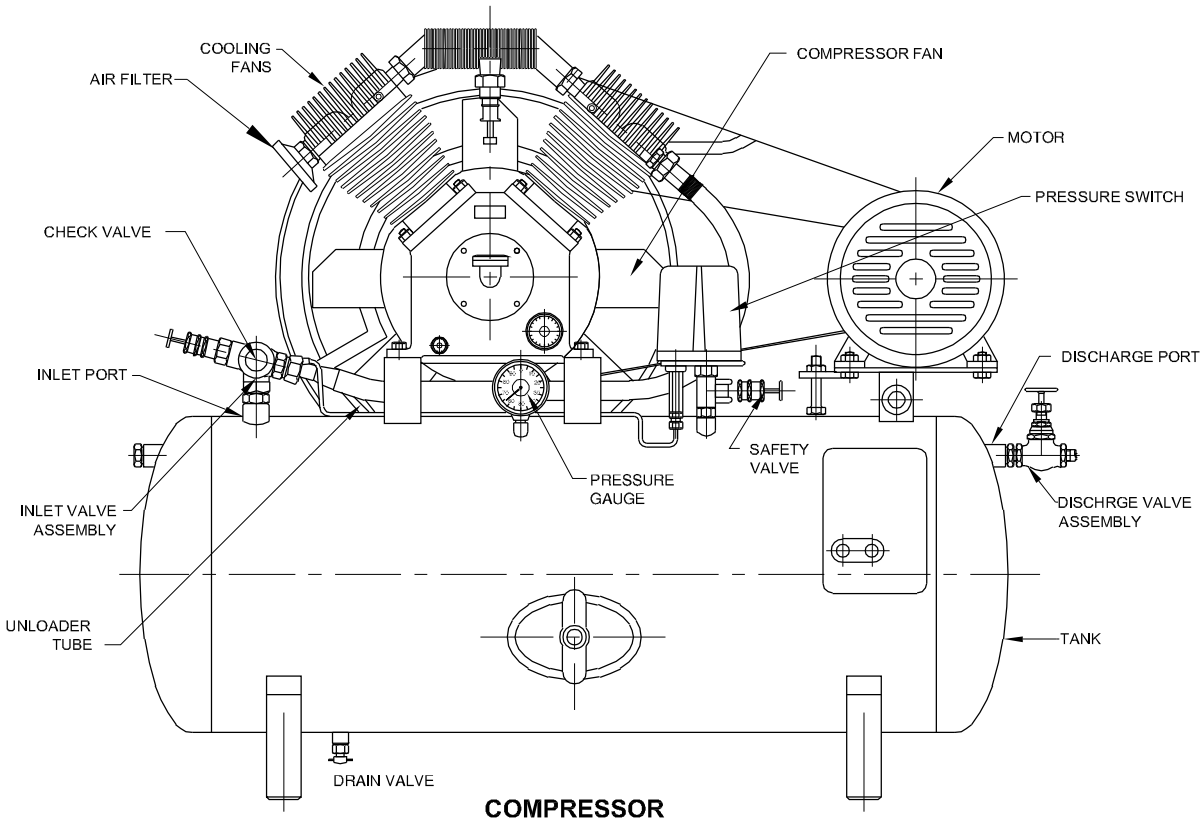
Objectives : At the end of this lesson you shall be able to
- **state construction of compressor**
- **explain parts of compressor**
- **describe working principle of compressor.**

Air compressor parts and functions

Air compressors are a type of machine tool and they work great with other power tools too. It basically provides other tools the ability to function and the power to do household as well as industrial improvement projects and installations. In order for tools to function at their best, air compressor must be working in its optium power and efficiency and that means that the parts of an air compressor must be working 100% of the time to make sure the work is done.

Parts of an air compressor (Fig 1)

Fig 1



COMPRESSOR

The following are the main parts of an air compressor.

Motor

An air compressor needs an electric motor to power up the machine. The motor basically drives two belts a pulley which allows the transfer of power from the motor to the pump pistons and this is done through a flywheel and a crankshaft. One important thing need to install will be a magnetic starter to prevent the motor form overload.

Tank

This is the compressor part that stores the air being compressed. It is biggest part of the air compressor and it can range from 1-10 gallons or even more for bigger construction needs. The tank generally made of steel.

Pressure switch

The pressure switch automatically shuts down the motor when the receiver reaches the factory-set limit. Once the pressure level drops to a pre-set level then the pressure switch restarts the motor therefore resuming the pumping of air by the compressor. We can also call this as an emergency switch that regulates how much pressure in the tank can take.

Drain valve

The main purpose of the drain valve is exactly what its name impiles. It drains the oil,dirt, moisture, and other debris that might be trapped inside the tank. Simple maintenance of air compressors entails draining a tank from impurities and debris from use. Moisture and oil are the most common reasons for rust to develop inside the tank when not drained.

Pressure gauge

This gauge measures compressed air pressure in the tank of the air compressor. It lets the user know that there is a problem if the measurement is higher than the regulated normal limit and serves as a warning to inspect the air compressor or stop the compression before the gauge reaches even higher pressure. On the contrary if the reading is very low from the normal allowed measurement, it also indicates a problem with the compressor such as a leak in the tank. This should also be checked right away to avoid any more complications and accidents.

Inlet port

This port is used to guide the inlet air towards the compressor inlet valve.

Inlet valve assembly

Inlet valve assembly compromises valve plate, and valve spring. Inlet valve controls the flow of air towards the cylinder of compressor. It is opening downwards to allow the air inside when the piston moves downwards. Valve plate is used to hold the inlet valve in proper position.

Cooling fins

Cooling fins are the extended part provided from the cylinder body to assure heat transfer from cylinder to surrounding.Generally these are made of aluminum.

Discharge Port

It is the opening provided at the top of compressor cylinder to guide discharge air towards the discharge line.

Discharge vavle assembly

It comprises discharge valve plate, valve plate and valve spring. Valve plate helps to hold the discharge valve in proper position. Valve is aimed for discharge the high pressure air when the piston reaches its top.

Air filter

Air filter is very important part in an air compressor. It helps to prevent the dirt and dust to enter inside the compressor cylinder. Filter is provided in the suction end of the compressor.

Safety valve

A safety valve is provided on the air storage tank or air outlet line ro prevent the danger occurred when the air pressure reaches beyond the capability of storage tank capacity.

Regulator

Generally an air regulator is provided in the discharge tube to regulate the high pressure air flow.

Check valve/Non return valve (NRV) and unloader tube

An one way check valve is provided in the bypass line in between air receiver tank and compressor head. It will open and admit the high pressure air towards the receiver tank while unloading is going on during the starting time. An unloader tube is connected at the inlet port of the check valve and the valve only opens in one direction (ie from compressor top to receiver air flow). During this time the high pressure air is unloaded towards tank through unloader tube.

Compressor fan

A compressor fan is connected at one end of the crank shaft to provide sufficient cooling air to compressor. It will prevent overheating of compressor.

Air compressor working principle

Working principle (Fig 1)

Air compressors collect and store air in a pressurized tank, and use pistons and valves to achieve the appropriate pressure levels within and air storages tank that is attached to the motorized unit. There are a few different types of piston compressors that can deliver even air pressures to the user.

Automotive compressors are combustion engine compressors that use the up-and-down storke of the piston to allow air in and pressurize the air with in the storage tank. Other piston compressors utilize a diaphragm, oil-free piston. These pull air in, and pressurize it by not allowing air to escape during the collection period.

Now the air compressor is capable of building extreme pressure in storage tanks capable of storing enormous amounts of pressurized gases for industrial use.

Air dryer

A compressed air dryer is used for removing water vapor from compressed air.

Compressed air dryers commonly found in a wide range of industrial commercial facilities.

Usage

Drying air for use in commercial or industrial processes that demand dry air:

Telecom industry (pressurizes its underground cables to repel moisture and avoid shorts).

Painting.

Pneumatic tools.

Textile manufacturing.

Pneumatic control systems.

Feed air for zeolite type oxygen and nitrogen generators.

Dental office air.

Truck and train air brake systems.

The process of air compression concentrates atmospheric contaminats, including water vapor. This raises the dew point of the compressed air relative to free atmospheric air and leads to condensation within pipes as the compressed air cools downstream of the compressor.

Excessive water in compressed air, in either the liquid or vapour phase, can cause a variety of operational problems for users of compressed air. These include freezing of outdoor air lines, corrosion in piping and equipment , malfunctioning of pneumatic process control instrument, fouling of processes and products and more

There are various types of compressed air dryers. Their performance characteristics are typically defined by the dew point.

- Refrigeraed dryers
- Deliquescent dryers
- Desiccant dryer
- Memberane dryers

Refrigerated dryer

Refrigeration dryers employ two heat exchangers, one for air-to-air one for air-to-refrigeration. These dryers are used in refrigeration compressors.

Deliquescent dryer

A deliquescent dryer typically consists of a pressure vessel filled with a hygroscopic medium that absorbs water vapor. The medium gradually dissolves-or deliquesces-to form a solution at the base of the pressure vessel. The liquid must be regulary drained from the vessel and new medium must be added.

Deliquescent dryers are used for removing water vapour from compressed air, natural gas, and waste gases.

Desiccant dryer

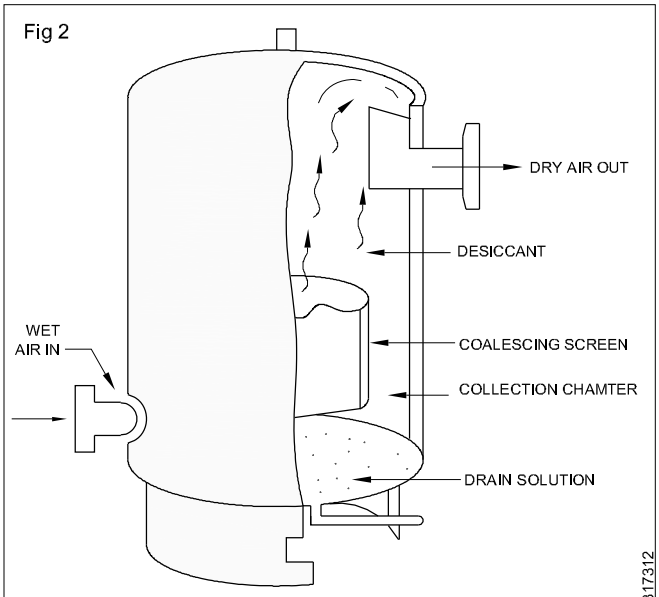
The term “desiccant dryer” refers to a abroad class of dryers. Other terms commonly used are regenerative dryer and twin tower dryer,and to a lesser extent absorption dryer.

The compressed air is passed through a pressure vessel with two “towers” filed with a media such as activated alumina, silica gel, molecular sieve or other desiccant material. This desiccant material attracts the water from the compressed air via adsorption.

Membrane dryer (Fig 2)

Membrane dryer refers to a dehumidification membrane that removes water vapor from compressed air. Typically, the compressed air is first filtered with a high-quality coalescing filter. This filter removes liquid water, oil and particulate from the the compressed air. The water vapor-laden air then passes through the center bore of hollow fibers in the membrance bundle. At the same time, a small portion of the dry air product is redirected along the outside surface of the fibers to seep out the water vapor which has permeated the membrane. The moisture-laden sweep gas is then vented to the atmosphere, and clean, dry air is supplied to the application. The membrane air dryers are designed to operate continuously, 24 hours per day, 7 day per week. Membrane air dryers are quiet, reliable and require no electricity to operate.

Fig 2

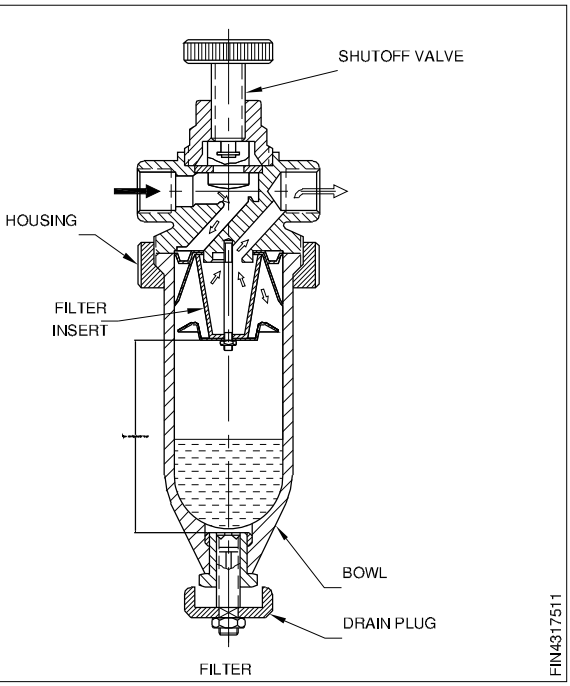


MEMBRANE DRYER

FRL unit (Filter, regulator, lubricator)

Objectives : At the end of this lesson you shall be able to
- **defind FRL unit**
- **state the types of FRL**
- **state the specifications of FRL**

Fig 1



Fitter,regulator,lubricator (FRL) assemblies are pre-packaged or modular assemblies of air filters,pressure regulators,and gauges. Air leaving a compressor is hot,dirty,and wet and can cause damage to equipment and tools if it is not filtered.

The filter cleans compressed air by trapping solid particles and separating liquids,such as oil and water,that are trapped in the compressed air. Filters are installed in the air line upstream of regulators,lubricators,and all pneumatically-powered tools and equipment. They remove contaminants from pneumatic systems,preventing damage to equipment and reducing production losses due to contaminant-related downtime.

Pressure regulators control fluid pressure in compressed air systems. Regulators are also known as pressure reducing valves(PRVS). Pressure regulators maintain a constant output pressure regardless of input perssure variations and demands made on the system by downstream components.

Lubricators add controlled quantities of oil into the compressed air system to reduce the friction between moving components within air tools and other equipment that are powered by the system. Adding lubrication oil to the system also clears compressor oils that travel through the system in vapor form. To prevent build-up of oil within system components,mineral oils are added to the system to flush away the deposits.

Downstream equipment flow and pressure requirements determine the correct regulator and lubricator for the application. Manufactures offer flow characteristics charts on their products to help chose the correct combination of regulators and lubricators.

Types

There are several choices for regulator type.

- **General-purpose regulators** are designed for typical industrial use;they generally operate only above atmospheric pressure.
- **High- pressure regulators** are rated for inlet pressures higher than general purpose,typically over 1,000 psi.
- **Low- pressure regulators** have special design characteristics for precise control of pressures typically below 15-20 psi.
- **Differential** or **bias regulators** maintain a pressure differential between two locations in the system.
- **Pressure- reducing valves** provide a sub-circuit with a supply of fluid at a pressure that is less than the pressure in the main circuit.

specifications

Performance specifications:

- **Regulating (adjustment) range** - Dictates the limits of adjustment control
- **Maximum flow (gas or air)** - Unnecessary to specify if primary application is liquid
- **Maximum pressure rating**- Refers to the pressure rating for the valve or inlet pressure for the regulator
- **Filter minimum particle size rating** - Applies to filter,regulator,and lubricator (FRL) assemblies. It is the smallest size particle that will be entrapped by the filter. This rating is an indication of the largest opening in the filter element.

other important specifications include:

- Regulator type
- Medium
- Adjustement control
- Connectors or pipe size
- Body material
- Environmental parameters

Applications of pneumatics

Objectives : At the end of this lesson you shall be able to
- **state the application of pneumatic cylinders**
- **state various areas of automation**
- **describe the hazards and safety precautions in pneumatic system**

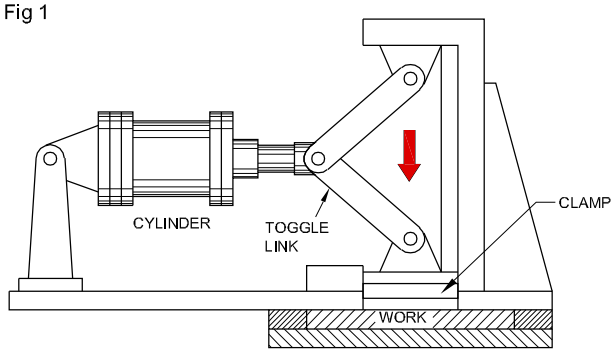
Application

In any control system or automation,penumatics can be economically applied. Besides,in other inaccessible areas like furnaces Pharmaceutical industry Food Processing and nuclear/reactors,compressed air is the only choice to operate the control sytem.

Air cylinders are widely used in pneumatic systems,since the liner motion is the most common requirement of the sytem.But rotaing actuators (motors)find their application in hand tools like portable drilling machine. As a general practice pneumatics is efficiently used in speed control rather than power requirements.

In the Fig 1 the piston moves the toggle link. The free ends of the toggle link moves down to clamp the work.

Fig 1



TOGGLE LEVER SYSTEM FOR WORK CLAMPING

The Fig 2 Shows feed unit. For a slot milling machine. The pedal operates valve 1. 1 clamps the jobs on the table. The piston rod at the end of its travel operated the valve 2. 1 and make the cylinder to move forward, in turn operating the valve 3.1. The valve operates the cylinder 3 to enact the feed to the work.

In Fig 3, the movement of the piston rod to the right tils the pivoted link to the left. By this movement the load is swing to the left hand side.

Fig 3

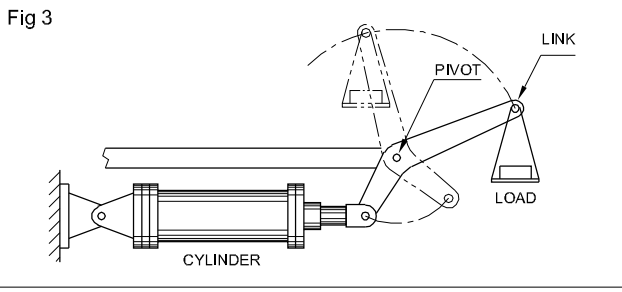
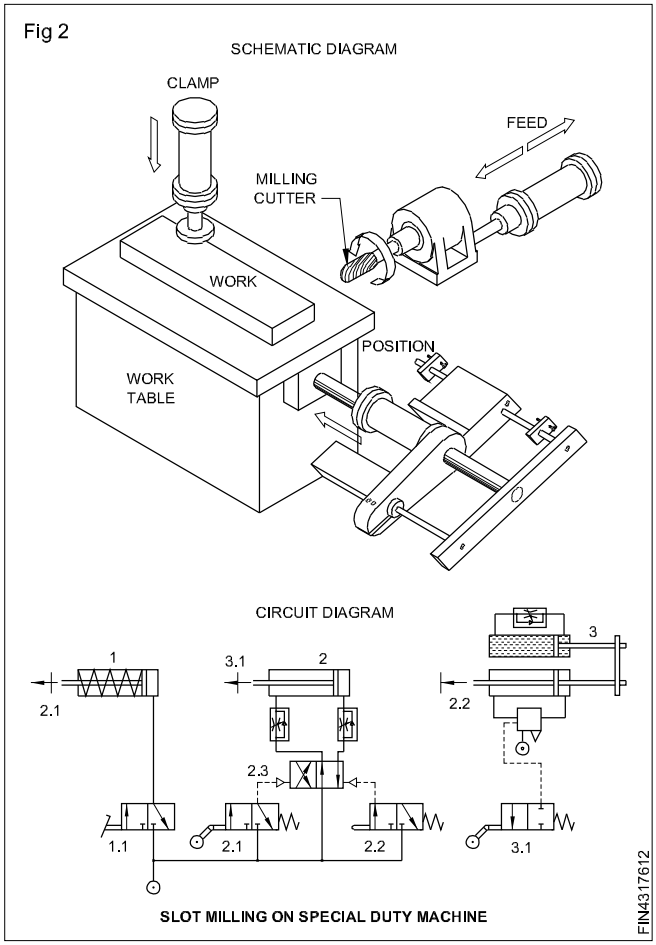


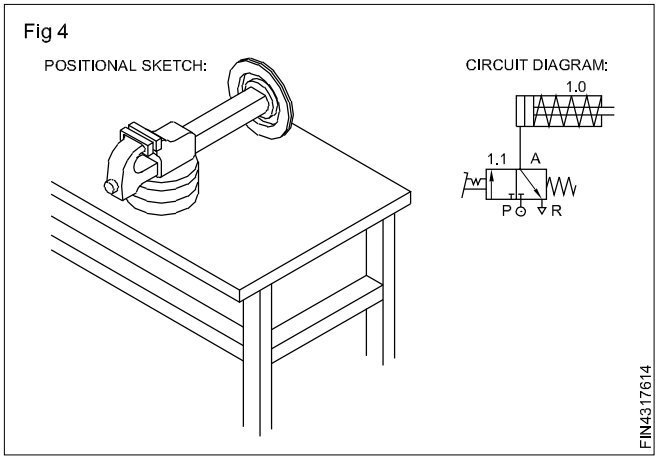
Fig 2



SLOT MILLING ON SPECIAL DUTY MACHINE

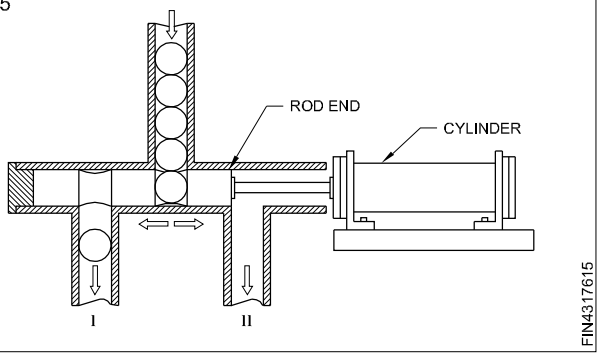
The operation of vice is shown in Fig 4. The 3/2 way valve extends and retreats the single acting cylinder attached to the movable vice.

Fig 4



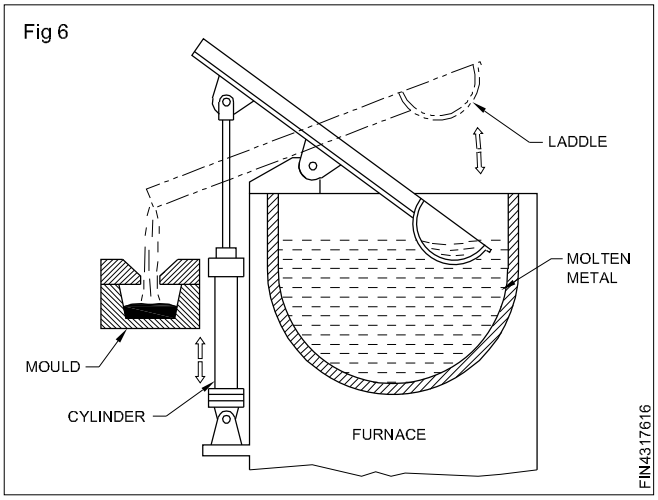
In Fig 5 the ball falling by gravity is distributed in two passages I & II, by means of the cylinder action.

Fig 5



In Fig. 6 the vertical movement of the piston rod lifts or lowers the laddle of molten metal to pour it into the mould.

Fig 6



Hazards & Safety precautions in pneumatic system

Whenever you are working with Pneumatic system you must take following safety precautions:

- Take precaution against corrosion in pneumatics components.
- Do not use compressed air to clean body parts.
- Never use kerosene to clean pneumatic system.
- Compressed air does not lignite but can explode due to pressure.
- Pneumatic system operates at high speed, most of the accidents happen due to crushing, hence takecare when handling.
- Do not put hands in the path of operating components.
- Avoid contact of plastic pipes with sharp edges.
- Close main valve to unpressurise pneumatic system prior to maintenance work.
- Loose connection may cause withdrawal of pneumatic hose, that whips due air flow. This whipping action may cause injury.

Pneumatics actuators

Objectives : At the end of this lesson you shall be able to
- **define pneumatic actuators**
- **state the types of pneuatic actuators**
- **to calculate cylinder forces**
- **define stroke length**

Pneumatics actuators

pneumatic actuators are the devices used for converting pressure energy of compressed air into the mechanical energy to perform useful work. In other words, Actuators are used to perform the task of exerting the required force at the end of the stroke or used to create displacement by the movement of the piston. The pressurised air from the compressor is supplied to reservoir. The pressurised air from storage is supplied to pneumatic actuator to do work.

The air cylinder is a simple and efficient device for providing linear thrust or straight line motions with a rapid speed of response. Friction losses are low, seldom exceeds 5% with a cylinder in good condition, and cylinders are particularly suitable for single purpose applications and / or where rapid movement is required. They are also suitable for use under conditions which preclude the employment of hydraulic cylinders that is at high ambient temperature of up to 200 °C to 250 °C

Their chief limitation is that the elastic nature of the compressed air makes them unsuitable for powering movement where absolutely steady forces or motions are required applied against a fluctuating load, or where extreme accuracy of feed is necessary. The air cylinder is also inherently

Limited thrust output by the relatively low supply pressure so that production of high output forces can only by achieved by a large size of the cylinders.

1.2. TYPES OF PNEUMATICS ACTUATORS

Pneumatic sylinders can be used to make linear, rotary and oscillatory motion. There are three types of pneumatic actuator: they are

1 Linear Actuator or Pneumatic cylinders

2 Rotary Actuator or Air motors

3 Limited angle Actuators

Calculation of cylinder forces - metric based products

General Formula

The cylinder output forces are derived from the following formula:

$$F = \frac{PxA}{10}$$

Where F = Force in N

P = Pressure at the cylinder in Bar

A = Effective area of cylinder piston in square mm.

Prior to selecting the cylinder bore size, properly size the piston rod for tension (pull) or compression (push) loading. (see the piston Rod Selection Chart)

If the piston rod is in compression, use the 'Push Force' table below, as follows:

1 Identify the operating pressure closest to that required.

2 In the same column, identify the force required to move the load (always round up).

3 In the same row, look over to the cylinder bore required.

If the cylinder envelope dimensions are too large for the application, increase the operating pressure, if possible, & repeat the exercise.

If the pistion rod is in tension,use the 'Deduction for Pull Force' table. The procedure is the same but due to the reduced area caused by the piston rod, the force availabel on the 'pull' stroke will be smaller. To determine the pull force:

1 Follow the procedure for 'push' force as described previously.

2 using the 'Deduction for Pull Force' table, identify the force indicated according to the rod & pressure selected.

3 Deduct this from the original 'push' force. The resultant is the net force availabel to move the load.

If this force is not large enough, repeat the process & increase the system operating pressure or cylinder diameter if possible.

Deduction for pull force

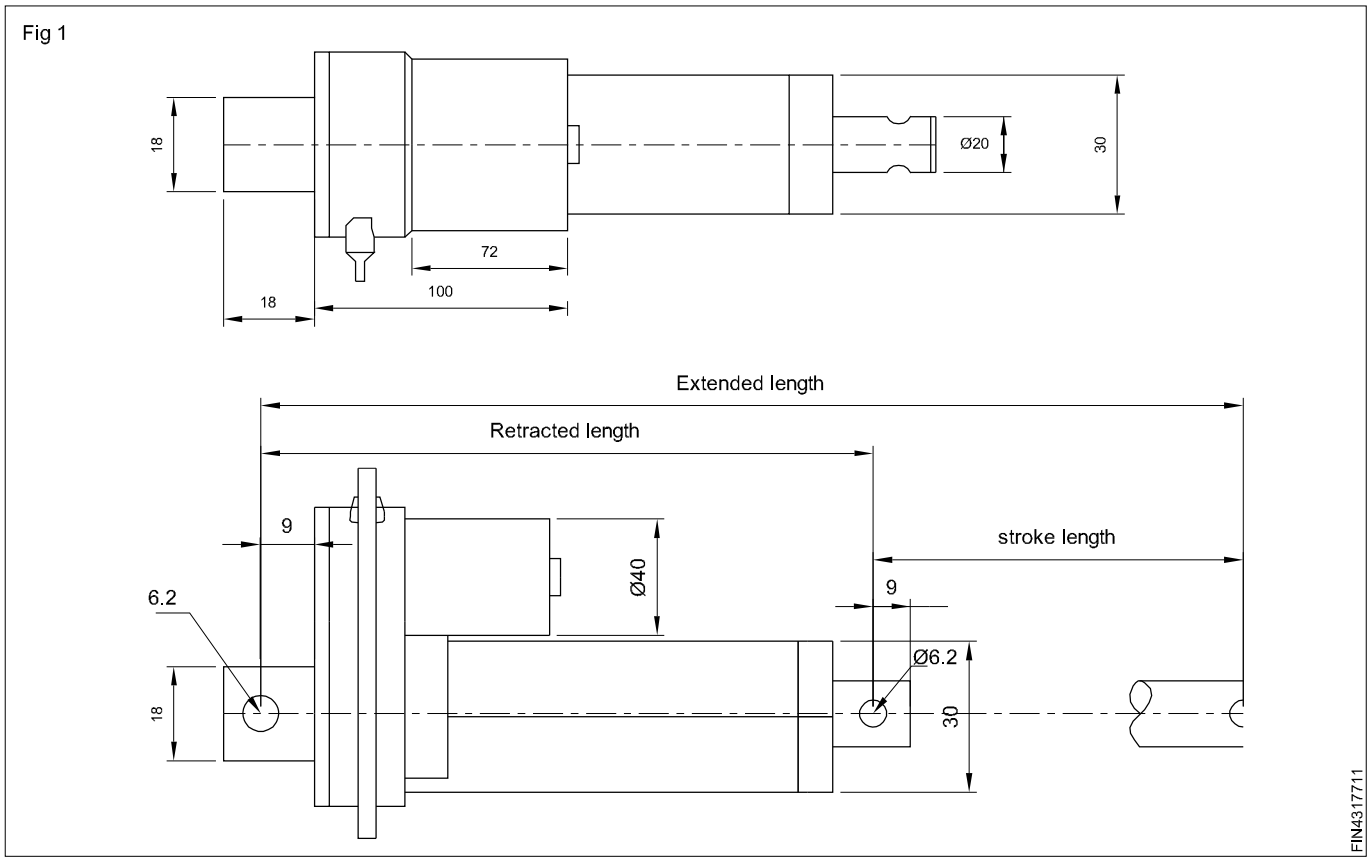
Piston rod size (mm)	Piston rod Area (mm^2)	Reduction in Force (N) at various Pressures in Bar			
		1	5	7	10
4	13	1	6	9	13
6	28	3	14	20	28
8	50	5	25	35	50
10	79	8	39	55	79
12	113	11	57	79	113
16	201	20	101	141	201
20	314	31	157	220	314
25	491	49	245	344	491
32	804	80	402	563	804
40	1257	126	628	880	1257

Stroke is the distance travelled by an **actuator** in motion. This is a measurement of the capability of a linear **actuator**. ... **Stroke** helps determine key factors such as the weight capacity of the actuator, how much time will it take, the speed of the motion, and the force that can be generated.

Push Force

Cylinder Bore size (mm)	Piston Area Area (mm^2)	Reduction in Force (N) at various Pressures in Bar			
		1	5	7	10
6	28	3	14	20	28
8	50	5	25	35	50
10	79	8	39	55	79
12	113	11	57	79	113
14	154	15	77	108	154
16	201	20	101	141	201
20	314	31	157	220	314
25	491	49	245	344	491
32	804	80	402	563	804
40	1257	126	628	880	1257
50	1963	196	982	1374	1963
63	3117	312	1559	2182	3117
80	5027	503	2513	3519	5027
100	7854	785	3927	5498	7854
125	12272	1227	6136	8590	12272
160	20106	2011	10053	14074	20106
200	31416	3142	15708	21991	31416

Fig 1



Single acting cylinder and its application

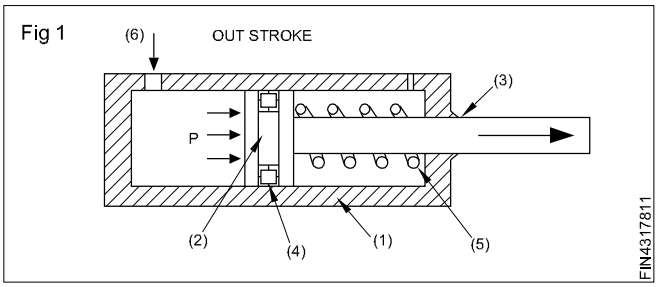
Objectives : At the end of this lesson you shall be able to
- **identify internal parts of single acting cylinder**
- **explain working principle of single acting cylinder**
- **explain working of 3/2 way valve**
- **interprete circuit to control single acting cylinder.**

Single acting cylinder

It is an actuator which moves load along the straight line. It can apply pneumatic force only in one direction therefore called single acting. Movement in opposite direction is caused by external force like spring or own weight of the load.

Construction: Construction of single acting cylinder is shown in the fig 1.

Fig 1



Main parts of single acting cylinder are listed as follows:

1 Cylinder

2 Piston

3 Piston rod

4 Seal

5 Spring

6 Inlet Port

Working principle of single acting cylinder

Initially piston remains at the innermost position in the cylinder due to spring force (Fig 1)

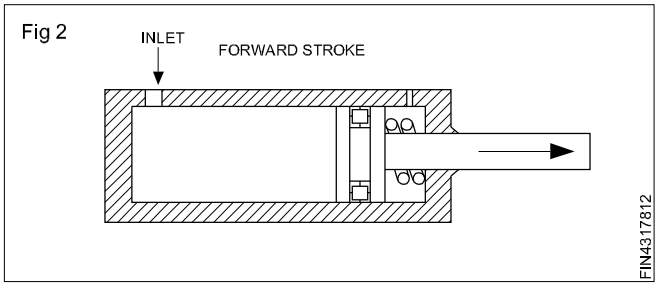
When compressed air is supplied through inlet port, pressure acts on cross section of the piston.

Product of pressure and piston cross section area gives rise to a force which acts opposite to the spring force. If pneumatic force is greater than the spring force then spring gets compressed and piston starts moving.

Seal prevents air leak across the piston.

Continuous flow of air causes continuous motion of piston.Load is attached to piston through piston rod; therefore load also moves with piston.

Fig 2



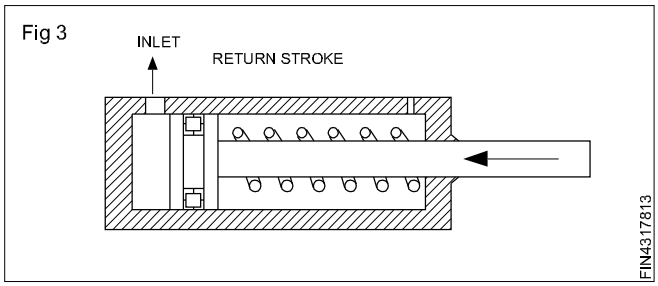
Piston and load move till piston reaches to other end. At the end there is no further space for piston to move, hence piston and load movement stops. (Fig 2)

This piston movement is called forward stroke.

In forward stroke pistion rod comes out of the cylinder. If we denote piston by A, then forward stroke is denoted by A

If pressure acting on piston is released, pneumatic force acting opposite to spring becomes weak, therefore spring pushes piston back. (Fig 3)

Fig 3



This stroke is called return stroke.

In return stroke piston rod goes inside the cylinder. Return stroke is denoted by A^-.

Direction control of single acting cylinder

To control single acting cylinder or in other words to push and pull load by single acting cylinder you always need 3 port 2 position direction control valve as main control element.

Construction of 3 port 2 position valve

Construction is shown in the Fig 4.

It consists of lollowing parts:

1 Valve body

2 Spool

3 Actuation mechanism: Push button & Spring

4 Air flow path

5 Ports (P,A,R)

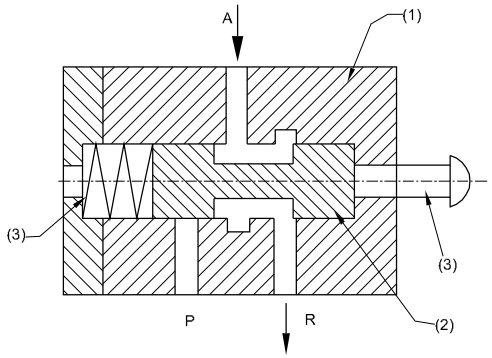
Valve body provides cavity whch accommodates spool, internal passage for air flow and actuation mechanism.

Spool is a piston shaped element which when shifts changes air flow path.

Actuation mechanism provides facility to shift the spool.

Port is a point where you can connect air pipe with the help of connector.

Fig 4

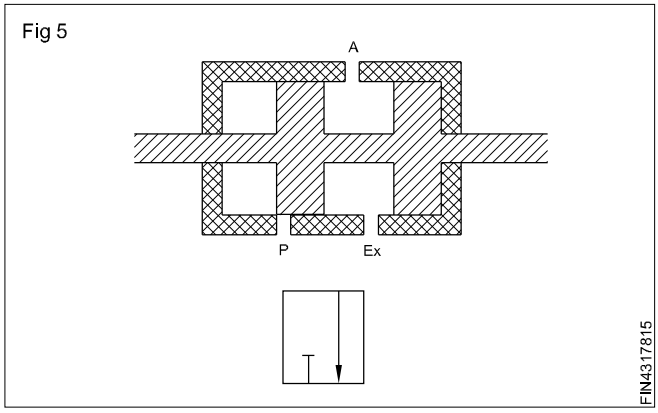


Working principle of 3 port 2 position valve:

3 port 2 position valve gives two status or positions of air flow.

Input port is blocked and output is connected to exhaust. In this status compressed air does not flow through the valve. Also output port is connected to exhaust port so that output line remains at atmospheric pressure. (Fig 5)

Fig 5



Input port is connected to output port and exhaust port is blocked. In this status compressed air flow through the valve and push the piston. (Fig 6)

Fig 6

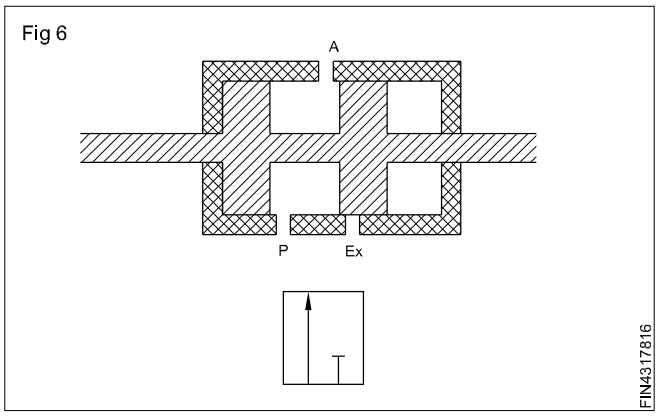
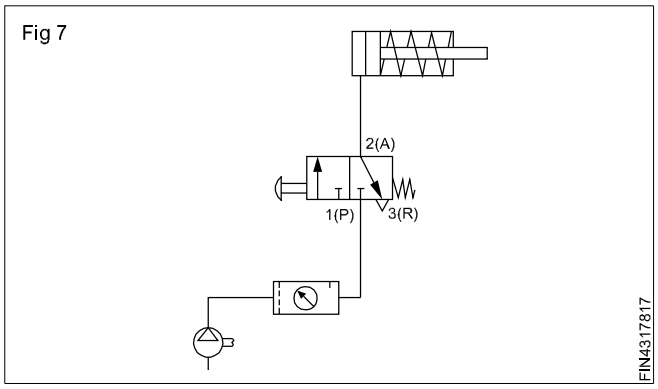


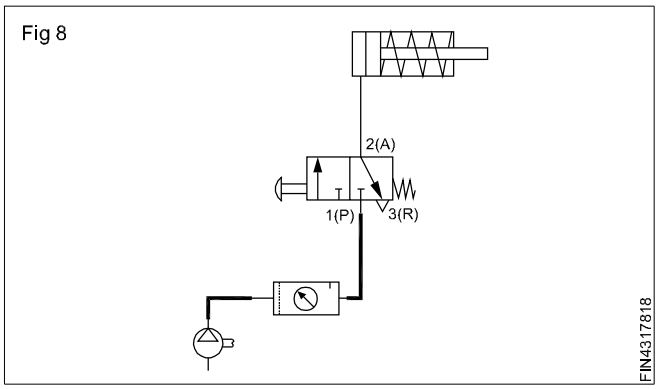
Fig 7 shows the circuit to operat single acting cylinder.

Fig 7



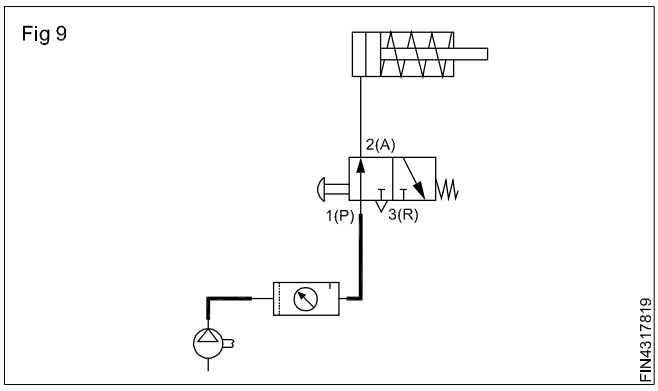
When compressor is switched on compressed air is available up to input port “1” (Fig 8)

Fig 8



When push button is pressed,direction of air changes due to valve shift. Piston moves forward. (Fig 9)

Fig 9



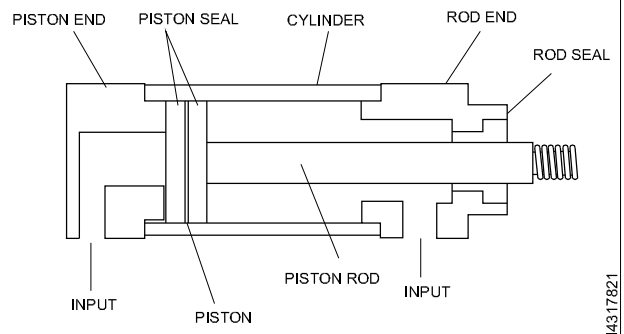
Push button is when released piston returns back. (Fig 8)

Double acting cylinder and its application

Objectives: At the end of this lesson you shall be able to
- **explain working principle of Double Acting Cylinder**
- **explain operation of 5/2 way valve**
- **use 5/2 way valve to operate double acting cylinder.**

Double acting cylinder is an actuator which can push and pull the load using compressed air. It has two ports for air sypply. Fig 1 shows the construction of double acting cylinder.

Fig 1

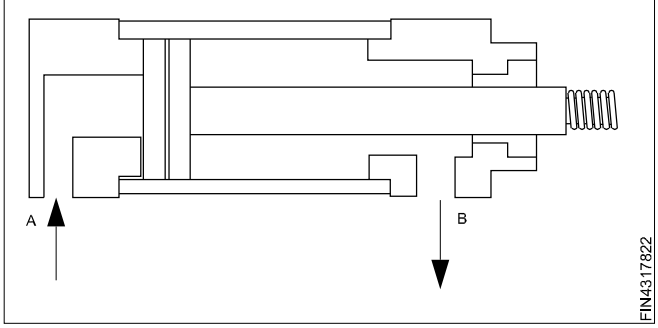


Input Ports: For air supply

- Piston: Element which moves to and fro inside the cylinder.
- Cylinder: It confines air for the piston movement.
- Piston rod: A rod which connects piston and a load.
- Piston Seal: Seal which prevent leakage across the piston.
- Rod Seal: Seal which prevents air leakage from cylinder to the atmosphere.
- Piston End: Part of the cylinder consisting air passage and connected to the piston side.
- Rod End: Part of the cylinder consisting air passage and connected to the piston side.

When air is supplied through port A, force is exerted on the piston so that it moves in forward direction. This movement is called forward stroke. During forward stroke air already present at the rod side exhausts through port B. (Fig 2)

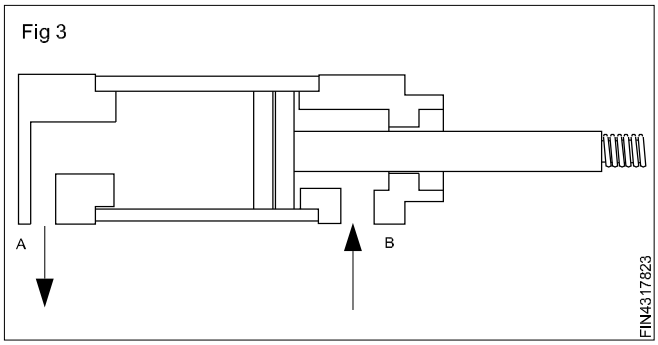
Fig 2



Piston movement will stop if air does not exhaust.

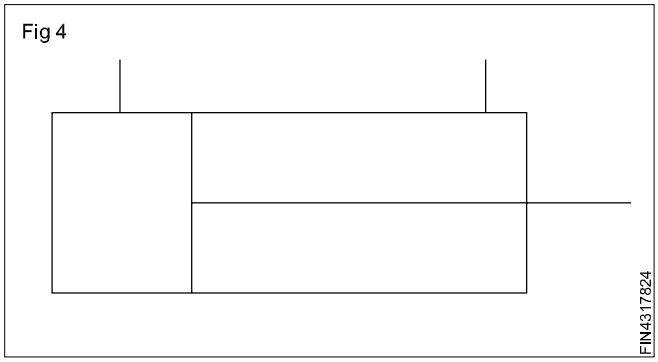
When air is supplied through port B, air already present exhausts through port A and piston retracts. (Fig 3)

Fig 3



Symbol of double acting cylinder is shown in fig 4

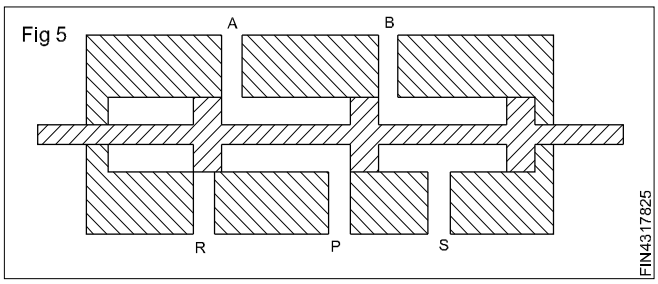
Fig 4



5 port 2 position valve

To operate double acting cylinder it is needed to change the direction of air between ports A & B. Therefore a valve is required whcih has two output ports. 5 port 2 position valve has two output ports. Construction is shown in fig 5.

Fig 5



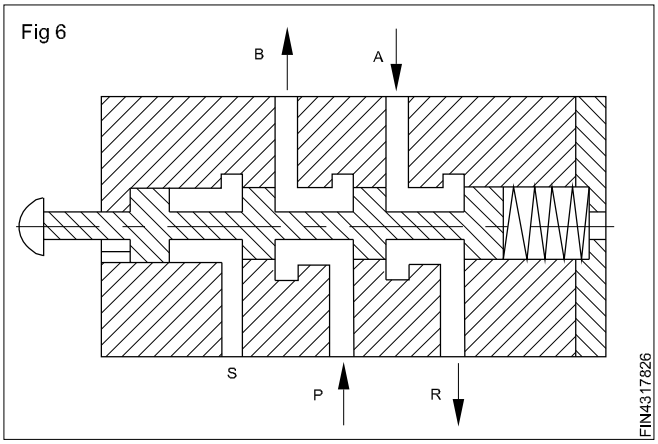
- Valve body: It provide cavity to move spool and ports.
- Spool: It is an element which change flow path when moves inside the valve body.
- Input port: Connection point where air enters into valve. It is denoted by ‘P’ or number ‘1’.

- Output port: Connection points from where air comes out of valve. Output ports are denoted by ‘A” & ‘B’ or number ‘2’ & ‘4’ respectively.
- Exhaust port: Connection points from where air exhausts.Exhaust ports are denoted by ‘R’ & ‘S’ or number ‘3’ & ‘5’ respectively.

Position refers to status of direction of air flow path in the valve.

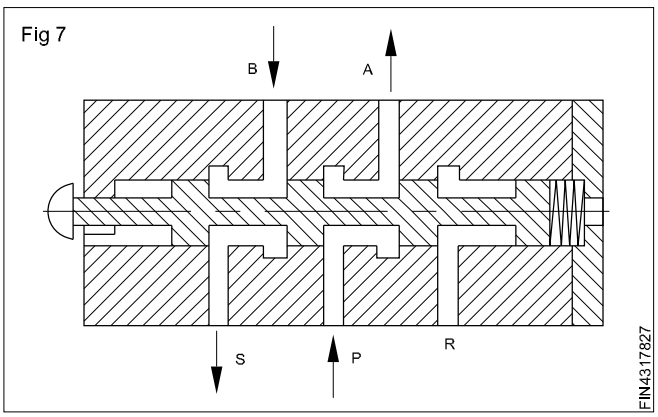
In one position port ‘P’ is connected to ‘B’ and port ‘A’ exhausts through ‘R, but exhaust port ‘S’ closed. (Fig 6)

Fig 6



In other position port ‘P’ is connected to ‘A’ and port ‘B’ exhausts through ‘S’ but exhaust port “R’ is closed. (Fig 7)

Fig 7



Symbol of 5 port 2 position valve is shown in fig 8

Fig 8

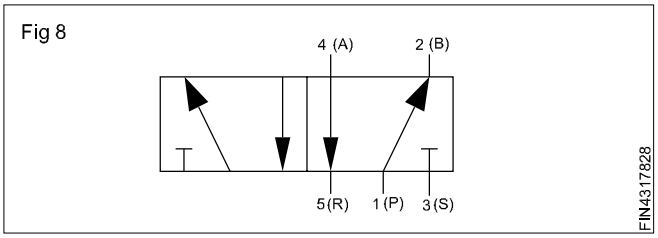
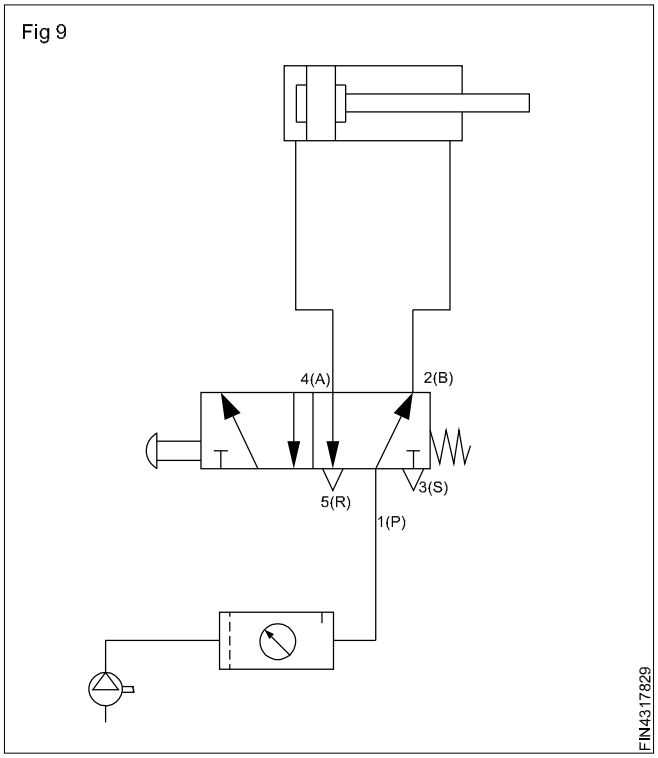


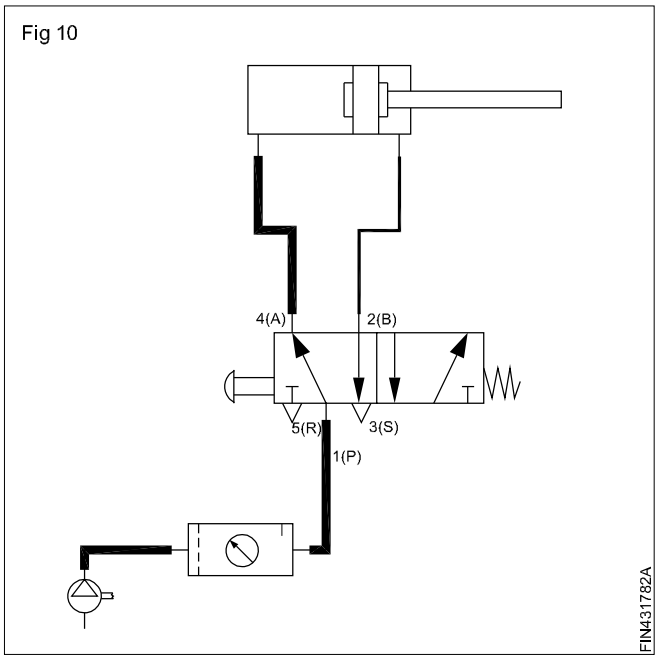
Fig 9 Shows circuit to operate double acting cylinder. initially in normal position (Spring operated position), supply direction is from 1 (p) to 2 (B) and 4 (A) to (R) so that piston is always in retracted position unless actuated. (Fig 9)

Fig 9



When push button is operated air flow path changes inside the valve so that supply direction is 1 (P) to 4 (A) and 2 (B) to 3 (S), thus gauses piston moves forward. (Fig 10)

Fig 10



When push button is deactuated piston retracts. Fig 9