Pneumatic valves

Objectives: At the end of this lesson you shall be able to
- **state the directional control valve**
- **list the classification or directional control valve**
- **state the sealing action in valves**
- **explain the different types of directional control valve**

Valves are the devices used to control, regulate commence, terminate or change direction of flow and pressure of fluid used in the system.

Valves in pneumatics are grouped according to their function. They are

- Directional control valves
- Non-return valves
- Pressure control valves
- Flow control valves.

These valves will be discussed in the following lessons.

Directional control valve

Directional control valves are used to control the (1) direction of flow of the fluid, (2) commencement and termination of the flow of fluid. Direction control valve finds its place in the circuit immediately before the cylinder/air motor.

Classification of directional control valve

Directional control valves can be classified according to the following features by virtue of construction and function

- According to the internal design
- According to the number of ports and position
- According to the valve actuating mechanism.

According to the internal design

The design of the valve even though not affecting the function, plays an important role in terms of

- Life of valve
- Actuating force
- Means of actuation
- Means of connection.

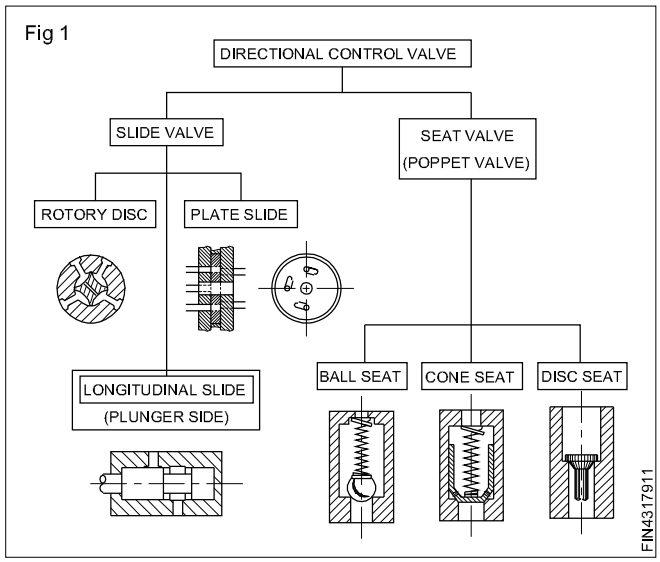
Directional control valves are classified in two major group as shown in Fig 1

Slide valves

Slide valves are called so, because the opening and closing takes place by sliding of one of its member. Further in slide valve we have

- Rotary disc valve
- Longitudinal slide or spool valve
- Plate slide valve

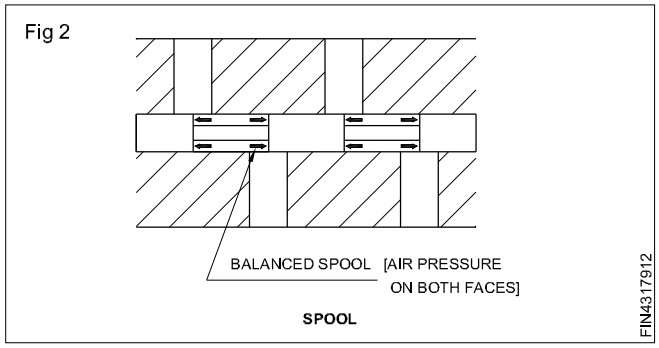
Fig 1



Slide valves are used extensively in pneumatics because of its advantages like.

- Balanced spool (Fig 2)
- Less force required to actuate

Fig 2



However they have their disadvantages also

- A fine finish and accuracy are required for sliding parts
- Sensitive towards dirt in the air
- Length of actuation is more

- Wear and tear is more
- Life is less.

Seat valves

Seat valves are also called as poppet valves. The valve is opened or closed by the lift of seating element.

These valves are further grouped as

- Ball seat valve
- Cone or taper seat valve
- Disc seat valve.

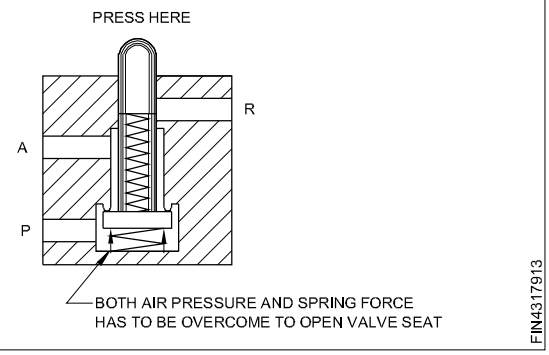
Seat valve are superior in terms of the following

- Wear and tear is minimum
- Actuating length or lift is very less
- Provides leakproof arrangement
- Long life
- Insensitive to dust/dirt

However these valve also have a few disadvantages

- Force, required to operate is more
- Balancing of force not adequate. (Fig 3)

Fig 3



Valve classification according to the number of ports and position

A directional control valve has a number of ports through which air enters and exits.

It also takes various position according to flow path of air.

The valve shown has inlet(P) and outlet(A) position (Fig. 4)

It also has two positions.

Initial position - No flow. Final position - Full flow. This is graphically represented as one square for each operating position.

Inside this square the path of flow of air is indicated by arrow marks. The valve shown in the Figs 4 & 5 is designated a 2/2 valve.

The ports are named as follows:

P - Pressure port

This is to indicate the entry of the compressed air from

Fig 4

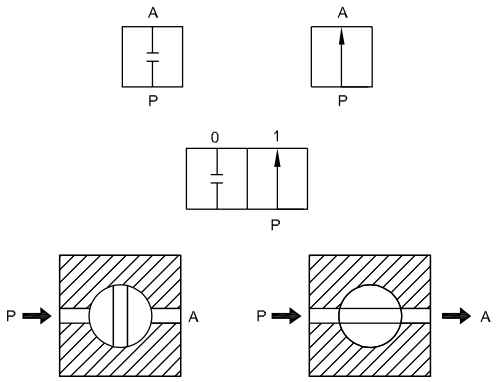
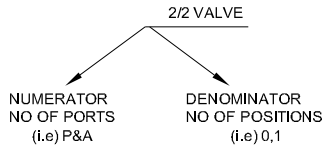


Fig 5



the compressor into the valve. (which is represented by a square)

A,B,C - working parts

These ports supply air to the cylinder and receive air from cylinder.

R,S,T = Exhaust parts

These are the ports from where used air is exhausted.

X, Y, Z - Control or signal ports.

These ports are used as signal input and signal outputs.

The positions of valves are named as 0, 1 and 2 or 1, 2 according to the type of actuation.

Valve classification according to the type of actuation

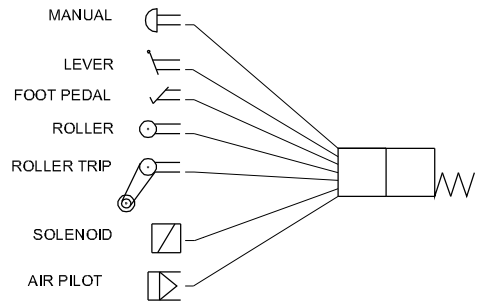
The valves have more than one marking position. For the position to change, an external force is required. The method of actuating the valve plays a very significant role to suit the purpose for which the valve is employed. This also determines the level of automation of the circuit. The actuation is grouped into 2 major groups as

- Spring return valve
- Detent valve

Spring return

In this mechanism the valve always assumes a particular position because of the spring. When operated it changes ts position. Actuation of other end may be of the following types. (Fig. 6)

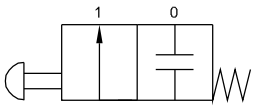
Fig 6



- Manual type
- Lever type
- Pedal type
- Roller type
- Roller trip type
- Solenoid
- Pilot operated

Initial position of a spring return valve is always named as '0' and other position as 1. (Fig 7)

Fig 7

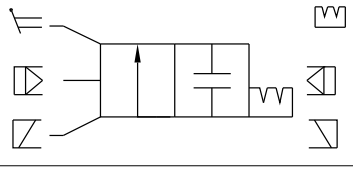


Detent valve

In this mechanism the change of position of the valve is retained (by latch), unless it is actuated, again. This type of valve is called a detent valve.

Under this category we have (Fig 8)

Fig 8

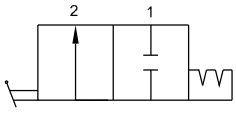


- Lever operated
- Impulse operated
- Solenoid operated

The return is also effected by any of the above mechanism.

The positions of these detent valves are indicated as 1 and 2 since it does not have a normal position, that is generally denoted by '0'. (Fig 9)

Fig 9

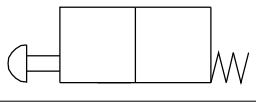


According to the proximity of actuation mechanism from control again actuations can be

- Direct or
- Remote

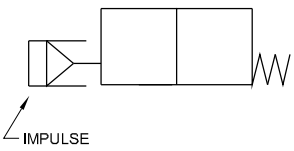
Direct actuations are hand lever,pedal,rolleretc. (Fig 10)

Fig 10



Remote control is by air, air impulse solenoid et (Fig 11)

Fig 11



Various types of directional control valve

Here we discuss various types of valves according to their function. The type of actuation and constructions are not considered.

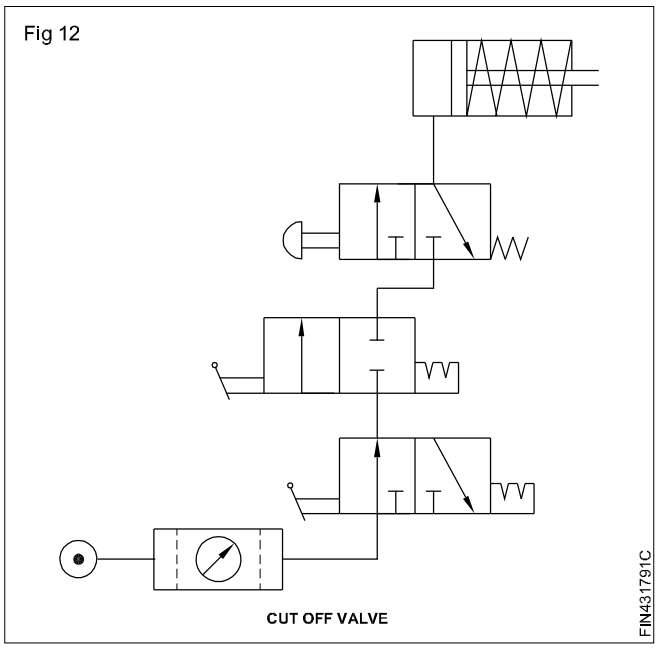
2/2 directional control valve

This has 2 ports and 2 positions

This valve normally is used for termination and commencement of air flow. This valve ideally serves as a cut-off valve in circuit. For emergency situations a cut-off valve shown in the circuit diagram, (Fig.12) can stop the cylinder movement, suddenly by cut-off the air supply. The various 2/2 valves according to the internal design are shown in Fig 13 in both normal and operated conditions. These valves can be normally closed type or opened type. (Fig 14)

3/2 directional control valve

Fig 12



The main advantage of the 3/2 valve is that it gives vent for the used air through the exhaust port. It has 3 ports P, A and R. This facilitates to generate a signal and also to cancel the signal in the valve as shown in the Fig 15 initial position P is blocked, A is connected to R. In the actuated position P gets connected to A, R gets blocked.

Fig 13

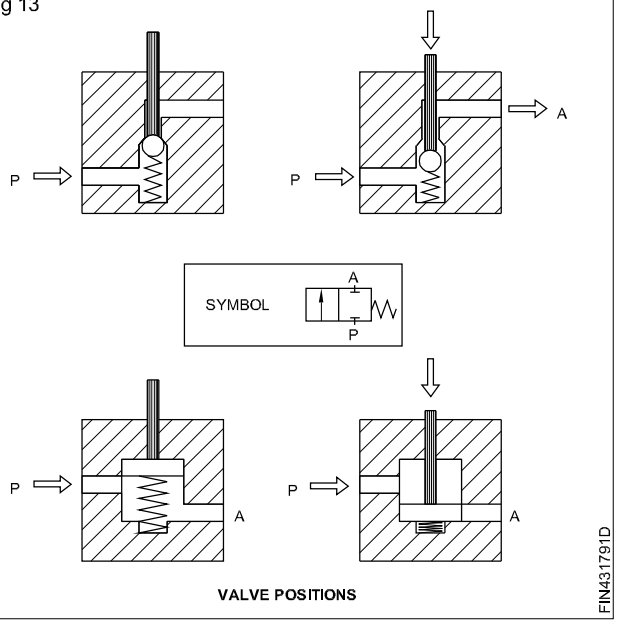
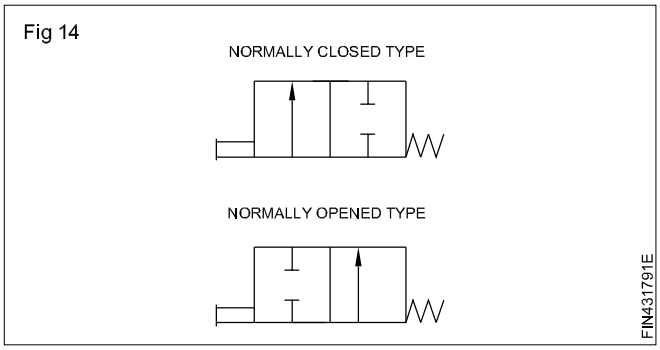
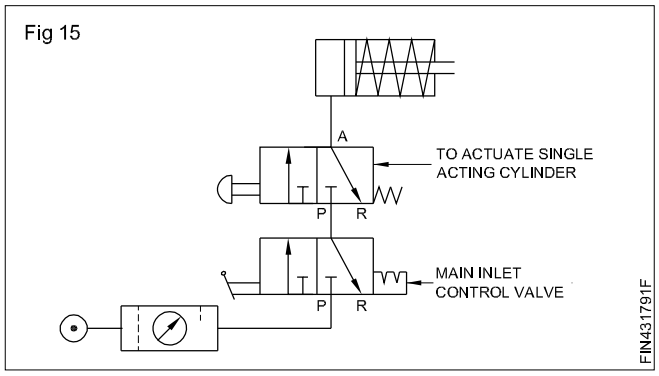


Fig 14



A 3/2 valve is ideally suited for an application of inlet valve, and also for actuating a single acting cylinder (Fig 15).

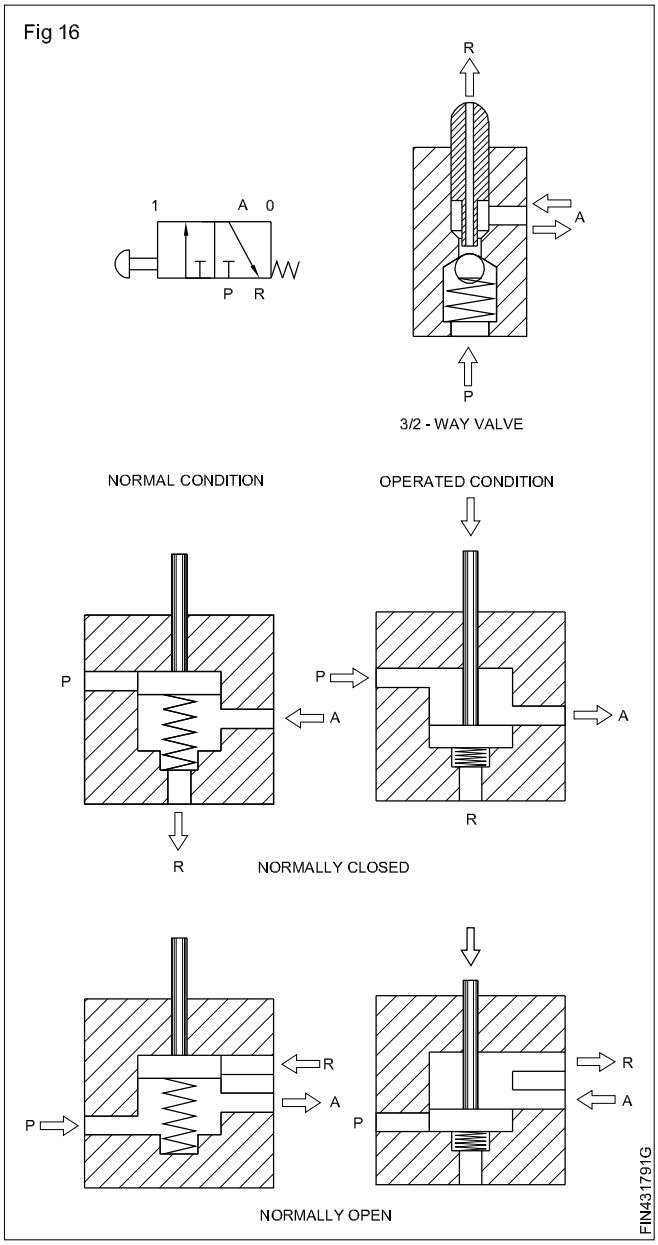
Fig 15



This valve is also very ideal for remote control of main direction control valves as impulse and pilot type. The construction of various 3/2 valves in normal and actuated conditions are shown in Fig 15.

3/2 valves are available as both normally opened type or closed type, which can be selected according to the requirement of the circuit. (Fig 16)

Fig 16



4/2 directional valve

The main application of a 4/2 valve is in actuation of a double acting cylinder. This valve has 4 ports namely

P - Pressure port

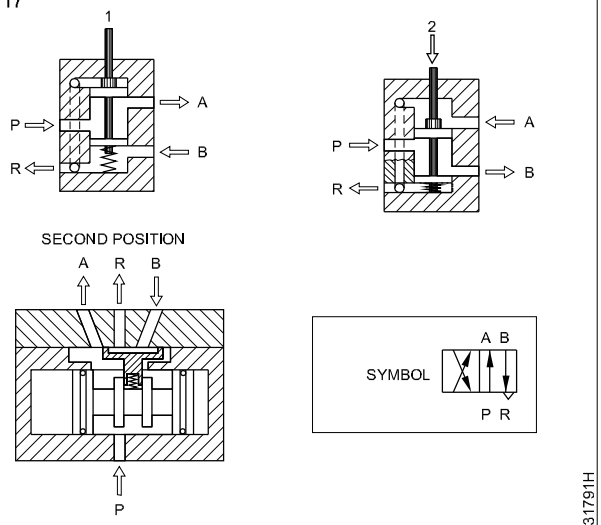
A & B - Working port

R - Exhaust port

In normal position (Fig 17) P is connected to A and B is connected to R and vice-versa in the other position.

The application of a 4/2 valve to actuate of double acting cylinder is shown in Fig 18.

Fig 17



4/2 D.C. VALVE POSITIONS

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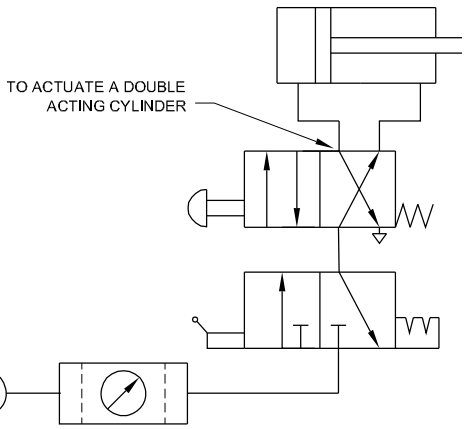
Fig 18



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5/2 directional control valve

A 5/2 directional control valve functions similar to that of a 4/2 valve, to actuate a double acting cylinder. 5/2 valve has the advantage of having separate exhaust paths for forward and retraction motion, thereby the motion can be controlled independently. 5/2 valve also has advantage in its simple manufacturing process. 5/2 valve has 5 ports

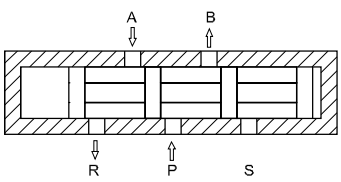
P - Pressure port

A & B - Working ports

R & S - Exhaust ports.

The construction of a 5/2 valve is shown in Fig 19

Fig 19



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Sealing action in valves

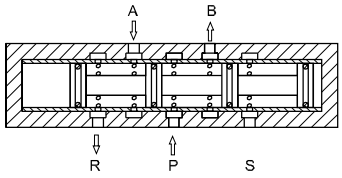
The body of the valve and the seat or the spool should have minimum leakage between them. This is a very important criteria in the design of valves.

The sealing is done by the following methods.

In spool valves

- The bore of the body and spool are matched by super finishing to have a minimum working clearance (Fig 19) and a metal to metal sealing.
- A separate sleeve (Fig. 20) is inserted into the body of the valve. The sleeve ID and the spool have a close tolerance, with (Fig. 21) 'O' rings on the spool creating a leak proof working.

Fig 20



D.C. VALVE SLEEVE BORE

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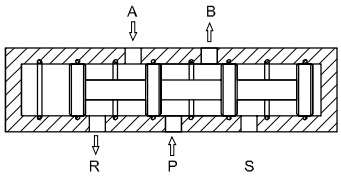
Fig 21



D.C. VALVE 'O' RING SPOOL

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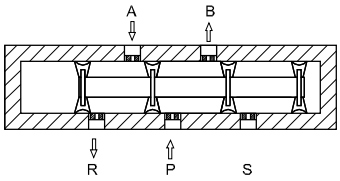
- 'O' ring mounted on the bore of the body (Fig 21) also helps in sealing.
- Cup seats mounted on the spool also helps in having a leak proof (Fig 22) spool movement.

Fig 22



D.C. VALVE CUP SEALING ARRANGEMENT

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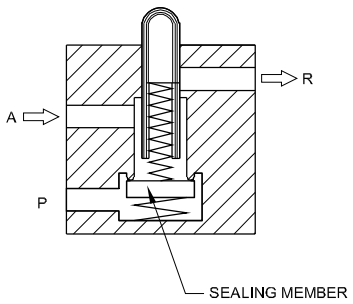
Sealing in seat valve

In seat valves the seat or the disc is usually made of non-metallic substance line rubber nylon etc, so as to have perfect sealing of the ports. These valves have better sealing compared to slide valves. Hence seat valves are more reliable. (Fig. 23)

Fig 23



Pneumatic symbols

Objectives: At the end of this lesson you shall be able to
- **identify components using ISO 1219 symbol**
- **interprete symbol of direction control valve symbol.**

Symbol: It is a representation of pneumatic component. Commonly pneumatic symbols are drawn as pe IS 1219 standards.

> Symbol does not indicate size of the Component.
>
> It does not indicate orientation or arrangement of inner components.

Symbols uses common geometrical shape which is to catagorise the type of component. The shape used in general are:

Square: It represents a valve.

Circle: It represents compressor,pneumatic motor and gauge.

Line: it represents piping.

Dimond: It represents filter, dryer, lubricator.

Cylinder: It represents receiver.

Rectangle: It represents cylinders.

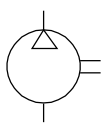
Dotted box: It represents an assembly of various components.

Triangle: It represents pneumatic energy i.e service air.

Symbol with circle:

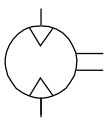
Unidirectronial (Fig 1)

Fig 1



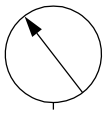
pneumatic Motor (Fig 2) Bidirectional

Fig 2



Pressure Gauge (Fig 3)

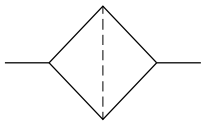
Fig 3



Symbol with diamond shape

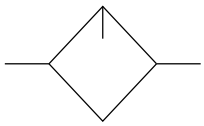
Filter (Fig 4)

Fig 4



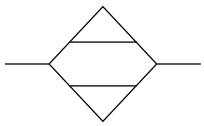
Lubricator (Fig 5)

Fig 5



Dryer (Fig 6)

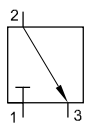
Fig 6



Symbol with square

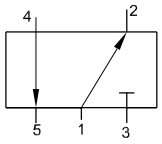
As explained earlier square means valve. Look at the figure 7 given below.

Fig 7



In this figure three extended lines 1,2,& 3 are shown which shows that the port, means where you connect pipes. Arrow inside the square shows the path of air flow inside the valve. The figure shows port 1 is closed but port 2 & 3 are connected internally.

Fig 8



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In figure 8 there are 5 ports namely 1,2,3,4 & 5 where you can connect pipes. The figure shows that ports 1 & 2 are connected such a way that flow direction is from 1 to 2, similarly ports 4 & 5 are connected in such a way that flow direction is 4 to 5. But port 3 is closed.

The port numbering has certain meaning as follows:

Input port: Port where incoming compressed air is connected. It is always “1” and also represented by port “p”.

Output port: From where air comes out of the valve is always even number “2” and “4”. Output ports are also represented by port “A” & “B”.

Exhaust port: From where air is vented to the atmosphere is always odd number “3” and “5”. Output ports are also representd by port “R” & “S”.

Types of Valves

There are three types of valves used in pneumatic system.

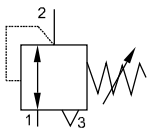
Pressure Valve: Used to control pressure there by force in the pneumatics. It is always represented by single square.

Direction control valve: Used to control the direction of movement of load connected to piston rod; like forward or reverse, clockwise or counter clockwise. It is always represented by combination of minimum two squares.

Flow control valve: Used to control speed of load, in this case square is not used.

Pressure Regulator: Symbol of pressure regulator is shown in fig 9

Fig 9



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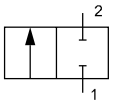
Direction control valves: Look at the symbol shown in fig 10

Fig 10



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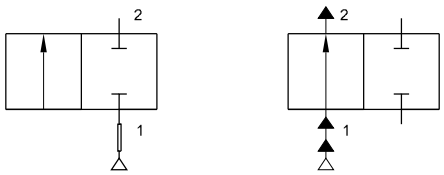
In this symbol there are two squares drawn side by side. A square indicates position, thus right square indicate one position and left square other position.

Position refers to status. In the right position port 1&2 are closed, but in the left position both ports are connected.

Let us compare the two positions as shown in fig 11.

Fig 11

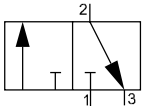


FIN431792B

In this valve there are 2 ports and 2 positions, hence called two port two position valve or simply 2/2 way valve.

3/2 Way valve: By name it is clear this valve is having 3 ports and 2 position. Symbol is shown Fig 12

Fig 12



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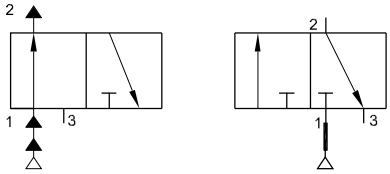
Compare the two positions as shown in fig 13

Fig 13



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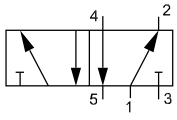
5/2 Way valve: By name it is clear this valve is having 5 ports and 2 position. Symbol is shown in Fig 14

Fig 14



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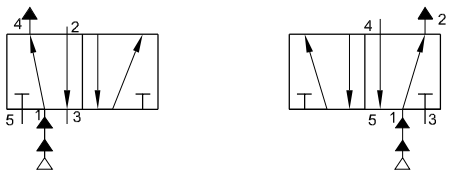
Compare the two positions as shown in Fig 15

Fig 15



FIN431792F

Actuation Type

It is a device which indicates how to operate the valve There are several types available but our scope is limited to following types.

- Manual Type
- Mechanical Type
- Pilot Type
- Solenoid Type

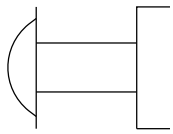
Manual Type

This mechanism is operated by a person, like

- Push Button
- Lever
- Foot pedal

Push Button: It is a button type device when pressed by operator valve actuates (Fig 16)

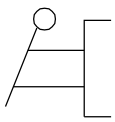
Fig 16



FIN431792G

Lever: It is a handle type device when pressed by operator valve actuates (Fig 17)

Fig 17

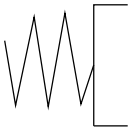


FIN431792H

Mechanical Type: Valve is operated by some mechanical force.

Spring: Common compression spring which actuates valve on de-compression (Fig 18)

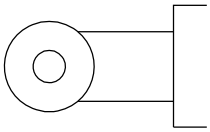
Fig 18



FIN431792I

Roller: It is like a lever with small wheel type device when pressed by some object valve actuates (Fig 19)

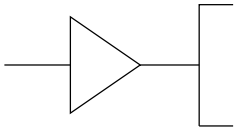
Fig 19



FIN431792J

Pilot: It is air operated type (Fig 20)

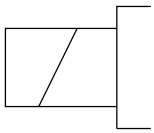
Fig 20



FIN431792K

Solenoid: IT is electrical operated type (Fig 21)

Fig 21



FIN431792L

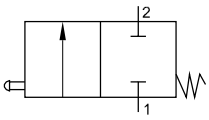
Identifying the direction control valve

To identify direction control valve follow the procedure given below.

- Identify number of ports.
- Identify number of positions.
- Identify actuation mechanism.
- Observe air flow path in the symbol, in each position.

Observe the symbol given in Fig 22

Fig 22



FIN431792M

In the fig 22

- No of ports: Two (1 & 2)
- No of positions: Two; (2 Squares)
- Actuation methods: Push Button (at left side), spring (at right side)

Write this information in the format given:

--------Port-------- Postion--------operated-------return

So you get:

2 port 2 position push button operated spring return Direction control valve. Whenever you observe spring in the symbol it means “Normal” position exists. Normal position refers to predominant unactuated condition.

In the symbol shown in Fig 22, right side positon is achieved due to spring when there is no force applied on push button, means right side position is the normal position.

It is important to note that whether input port (1 or p) is open or closed in normal position.

If input port is closed, we say normally closed valve.

If input is connected to output port (2,4 or A, B then we say normally open valve:

In the symbol shown above, in normal position input port is closed therefore valve is normally closed valve.

We can rewrite complete designation of the valve as follows:

2 port 2 position push button operated spring return normally closed Direction Control Valve.

Lets try to identify valves given in the next pages. (Fig 23 to Fig 59)

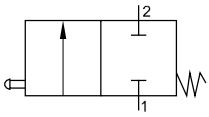
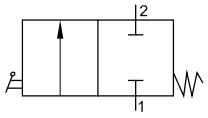
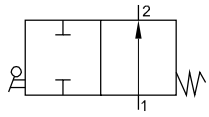
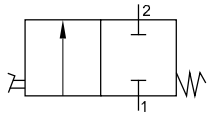
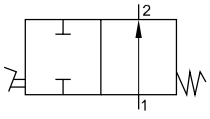
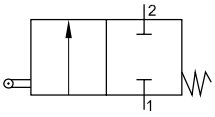
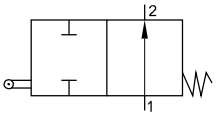
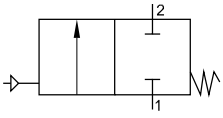
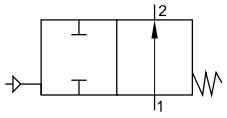
Symbol	Designation
Fig 23  FIN431792N	2 port 2 position push button operated spring return normally closed Direction Control Valve.
Fig 24  FIN431792O	2 port 2 position lever operated spring return normally closed Direction Control Valve.
Fig 25  FIN431792P	2 port 2 position lever operated spring return normally open Direction Control Valve.
Fig 26  FIN431792Q	2 port 2 position foot pedal operated spring return normally closed Direction Control Valve.
Fig 27  FIN431792R	2 port 2 position foot pedal operated spring return normally open Direction Control Valve.
Fig 28  FIN431792S	2 port 2 position roller operated spring return normally closed Direction Control Valve.
Fig 29  FIN431792T	2 port 2 position roller operated spring return normally open Direction Control Valve.
Fig 30  FIN431792U	2 port 2 position pilot operated spring return normally close Direction Control Valve.

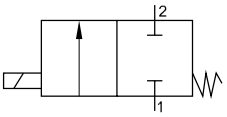
Fig 31



FIN431792V

2 port 2 position pilot operated spring return normally closed Direction control Valve.

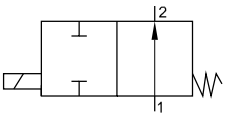
Fig 32



FIN431792W

2 port 2 position Solenoid operated spring return normally closed Direction Control Valve.

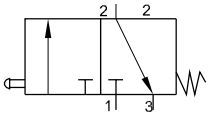
Fig 33



FIN431792X

2 port 2 position Solenoid operated spring return normally open Direction Control Valve.

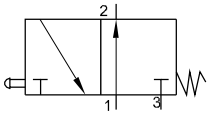
Fig 34



FIN431792Y

3 port 2 position push button operated spring return normally closed Direction Control Valve.

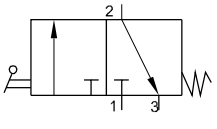
Fig 35



FIN431792Z

3 port 2 position push button operated spring return normally open Direction Control Valve.

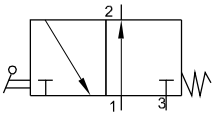
Fig 36



FIN43179A1

3 port 2 position lever operated spring return normally closed Direction Control Valve.

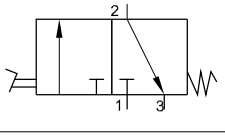
Fig 37



FIN43179A2

3 port 2 position lever operated spring return normally open Direction Control Valve.

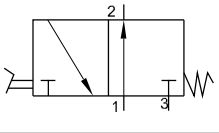
Fig 38



FIN43179A3

3 port 2 position foot pedal operated spring return normally close Direction Control Valve.

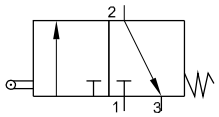
Fig 39



FIN43179A4

3 port 2 position foot pedal operated spring return normally open Direction Control Valve.

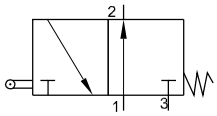
Fig 40



FIN43179A5

3 port 2 position roller operated spring return normally close Direction Control Valve.

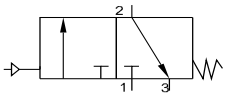
Fig 41



FIN43179A6

3 port 2 position roller operated spring return normally open Direction control Valve.

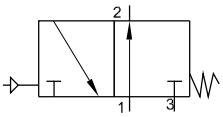
Fig 42



FIN43179A7

3 port 2 position pilot operated spring return normally close Direction Control Valve.

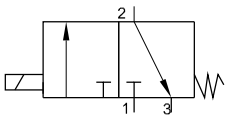
Fig 43



FIN43179A8

3 port 2 position pilot operated spring return normally open Direction Control Valve.

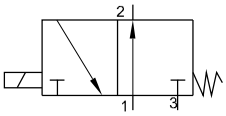
Fig 44



FIN43179A9

3 port 2 position solenoid operated spring return normally close Direction Control Valve.

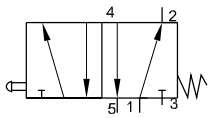
Fig 45



FIN43179AA

3 port 2 position solenoid operated spring return normally open Direction Control Valve.

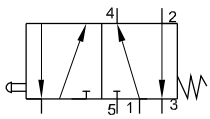
Fig 46



FIN43179AB

5 port 2 position push button operated spring return Direction Control Valve,normally 1 is connected to 2.

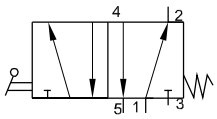
Fig 47



FIN43179AC

5 port 2 position push button operated spring return Direction Control Valve, normally 1 is connected to 4.

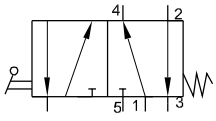
Fig 48



FIN43179AD

5 port 2 position lever operated spring return Direction control valve,normally 1 is connected to 2.

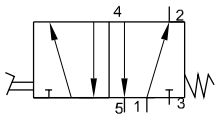
Fig 49



FIN43179AE

5 port 2 position lever operated spring return Direction Control Valve normally 1 is connected to 4.

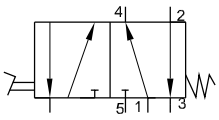
Fig 50



FIN43179AF

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 2.

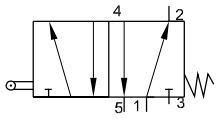
Fig 51



FIN43179AG

5 port 2 position foot pedal operated spring return Direction Control Valve normally 1 is connected to 4.

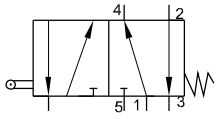
Fig 52



FIN43179AH

5 port 2 positionr roller operated spring return Direction Control Valve normally 1 is connected to 2.

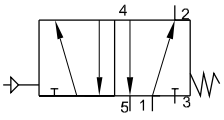
Fig 53



FIN43179AI

5 port 2 position roller operated spring return Direction Control Valve normally 1 is connected to 4.

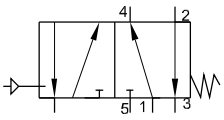
Fig 54



FIN43179AJ

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 2.

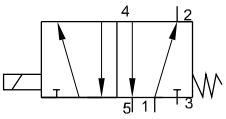
Fig 55



FIN43179AK

5 port 2 position pilot operated spring return Direction Control Valve normally 1 is connected to 4.

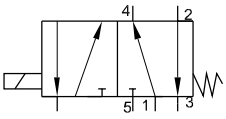
Fig 56



FIN43179AL

5 port 2 position solenoid operated spring return Direction Control Valve,normally 1 is connected to 2.

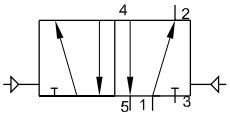
Fig 57



FIN43179AM

5 port 2 position Solenoid operated spring return Direction Control Valve, normally 1 is connected to 4

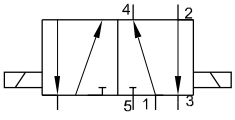
Fig 58



FIN43179AN

5 port 2 position double pilot operated Direction Control Valve.

Fig 59



FIN43179AO

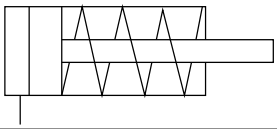
5 port 2 position double solenoid operated Direction Control Valve.

Symbol with Rectangle

In general rectangle is used to represent linear actuator like single acting cylinder and double acting cylinder.

Single acting cylinder (Fig 60)

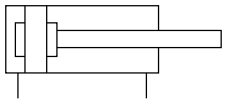
Fig 60



FIN43179AP

Double acting cylinder (Fig 61)

Fig 61



FIN43179AQ

Symbol with cylinder:

In general cylindrical shape is used to represent air receiver or air storing device (Fig 62).

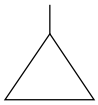
Fig 62

FIN43179AR

Symbol with triangle:

In general triangular shape is used to represent air source (Fig 63).

Fig 63



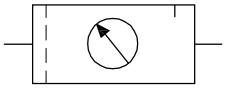
FIN43179AS

Symbol with dotted box:

Symbol shwon in dotted box represents assembly of components like FRL, Time delay valve.

FRL: It is an assembly of Filter, regulator and lubricator. (Fig 64).

Fig 64



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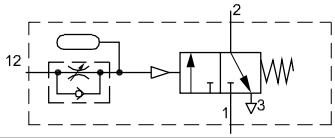
Time delay valve

It is an assembly of flow control valve, 3/2 way valve and an air receiver (Fig 65.)

Fig 65



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Other Symbols

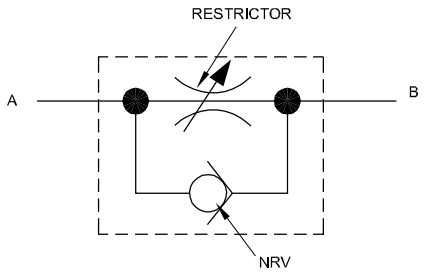
Non return valve (Fig 66)

Fig 66

FIN43179AV

Flow control valve (Fig 67)

Fig 67



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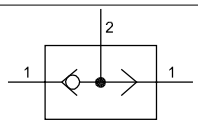
Shuttle valve (Fig 68)

Fig 68



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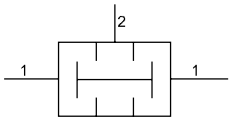
AND valve (Twin pressure valve) (Fig 69).

Fig 69



FIN43179AY

Non-return valve/check valve

Objectives : At the end of this lesson you shall be able to
- **name the parts of a non-return valve**
- **state the working principle of a non-return valve**
- **differentiate between swing and ball type check valves.**

Non-return valve

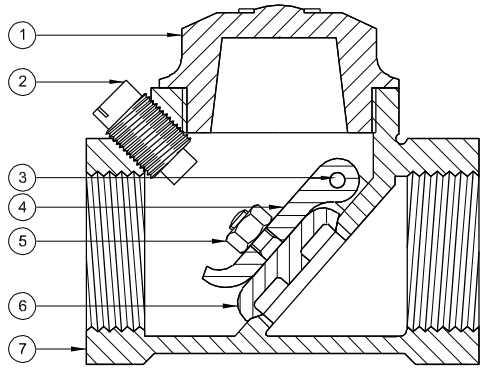
Water supply piping systems use several mechanical devices to control and regulate the fluids and gases flowing through them.

The non-return valve allows one-way flow in water supply or drainage lines. It is also called a check valve. Valves are made of cast iron, brass, bronze or plastic.

Sometimes two or more different kinds of material are used on a single valve. There are many types of check valves available in the market.

The swing check valve consists of the following parts. (Fig 1)

Fig 1



1 Cap

2 Stop plug

3 Hinge pin

4 Hinge

5 Disc hinge nut

6 Disc

7 Body

In the swing check valve, the flow of a fluid or gas in one direction lifts the disc and allows one-way flow only. The return of the disc to its seating position prevents the flow in the reverse direction.(Figs 2 & 3)

Fig 2

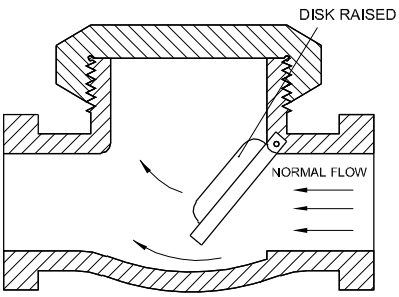
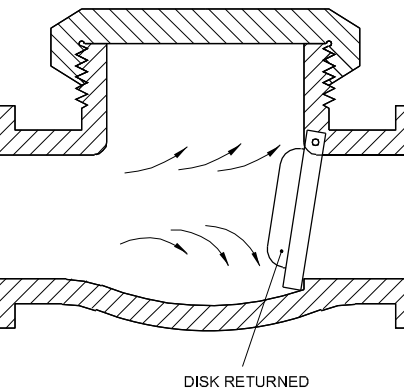
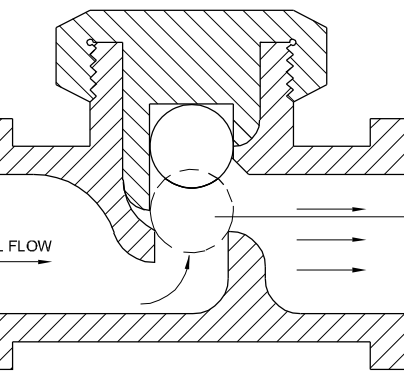


Fig 3



In the ball-type check valve, the flow of a fluid or gas in one direction lifts the ball; when the pressure is released the ball falls against its seating and prevents flow in the reverse direction. (Fig 4)

Fig 4



Flow control valve

Objectives : At the end of this lesson you shall be able to

- **explain the flow control valve**
- **state the difference between variable and one way flow control valve**
- **interpret and draw meter - in speed control hydraulic control**
- **explain meter - out speed control method**
- **explain bleed - off speed control circuit and its function.**

The purpose of flow control in a hydraulic system is to regulate speed of a cylinder or the R.P.M. of a motor. Since both values are dependent on the flow rate,however constant pumps supply a uniform flow rate.

Reduction in the flow rate is achieved according to the following principle

A reduction in the flow cross - section in the flow control valve causes an increase in pressure ahead of this. This pressure causes the pressure relief valve to open and flow rate is divided. This divison of the flow rate causes enough flow volume required for the r.p.m. or speed to flow to the actuator and the excess delivery to be discharged via pressure relief valve.

Flow control valve is a orifice or restrictor in hydraulic system.

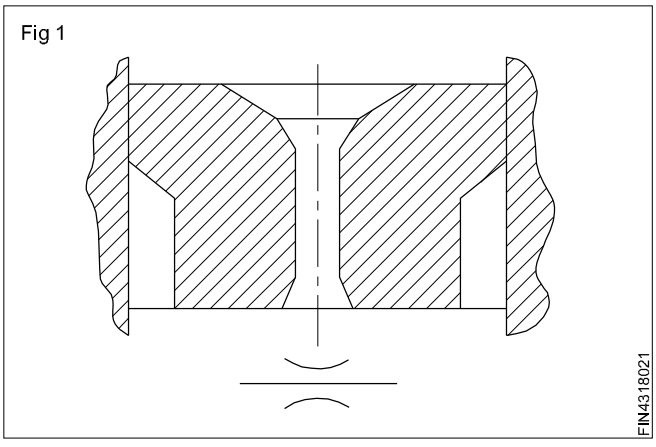
Orifices

- A simple orifice is the most elementary method for controlling flow.
- The orifice is always placed in series with the pump.
- A fixed orifice can be a drilled hole in a fitting, but variable orifice is a calibrated needle valve.

Fixed orifice (Fixed flow control valve)

Fixed orifice is a simple small opening in line which is not variable. (Fig 1)

Fig 1

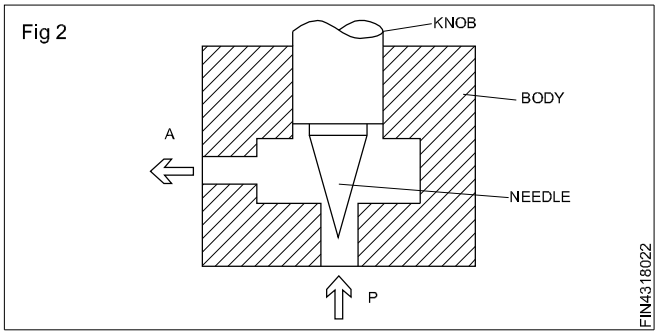


Variable flow control valve

Throttle and orifice valves are used to achieve a certain pressure drop. This is done by creating a specific flow resistance.

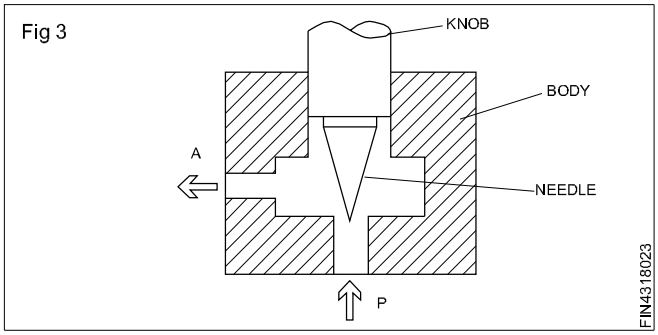
If needle of flow control valve moves closer to the seat then opening is less and flow also reduced. (Fig2)

Fig 2



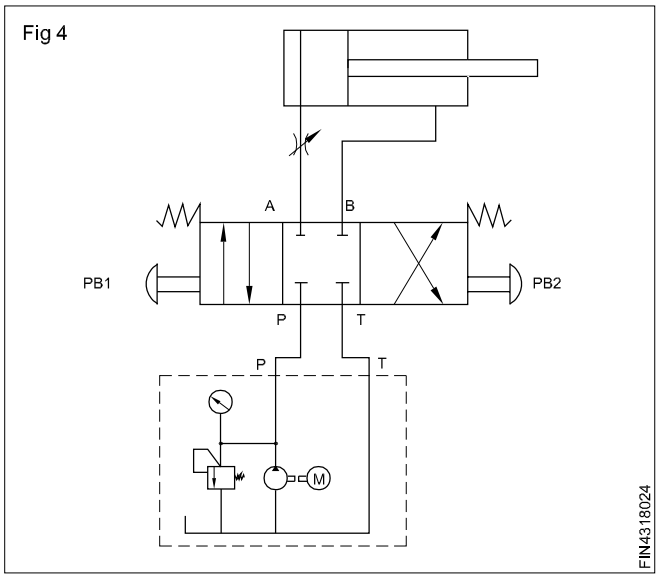
When needle move away from valve seat (Fig 3) opening increases and flow also increases.

Fig 3



One advantage of this design is that it is simple and inexpensive. Hyadraulic circuit diagram with variable flow control valve is given below in fig 4

Fig 4



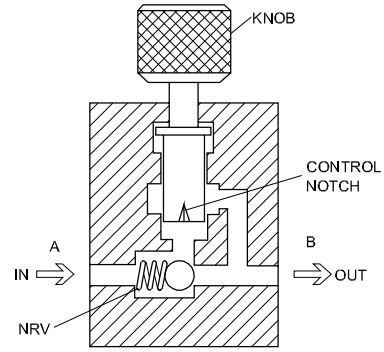
One - way flow control valve

The one - way flow control valve is a combination of an orifice or throttle valve and a non - return valve. The restrictor controls the flow rate in a single direction

dependent on flow. In the opposite direction, the full cross - sectional flow is released and the return flow is at full, pump delivery.

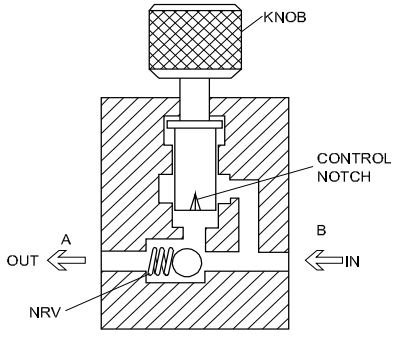
The flow is throttled in the flow direction from A to B. So less flow is going inside the actuator and speed of actuator is reduced. (Fig 5)

Fig 5



Flow is not restricted in the opposite direction from B to A because the non - return valve is lifted from its valve seat and the full cross - section flow is released. (Fig 6)

Fig 6



With adjustable one - way flow control valves, the throttling point can either be enlarged or reduced.

Speed - control Methods

Three methods are generally used to control the speed of actuator

- Meter - in speed control
- Meter - out speed control
- Bleed off speed control

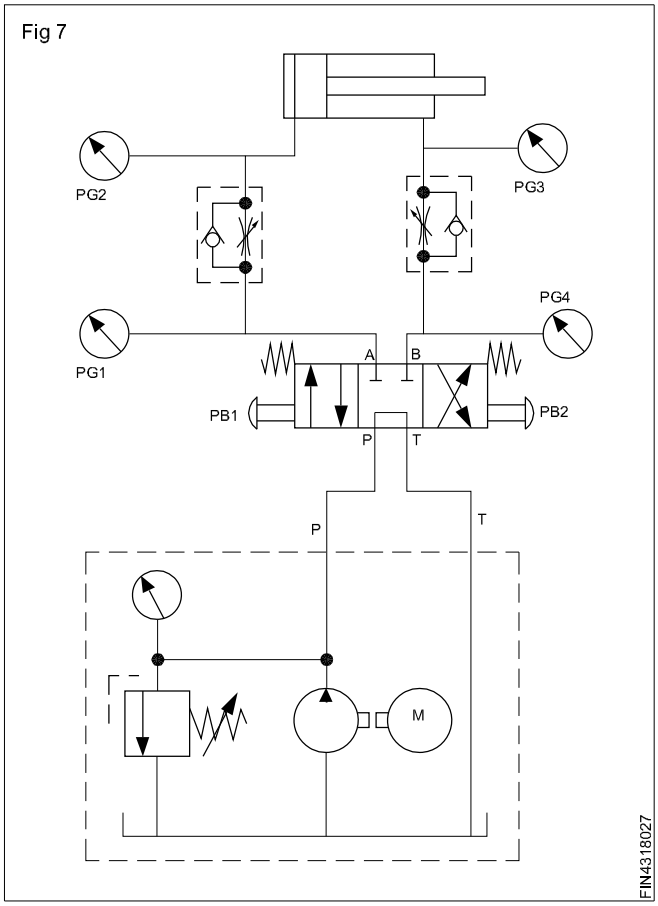
Meter - in speed control

Fig 8 provides a schematic drawing of a meter - In flow control circuit restriction fluid as it enters an actuator port. Meter -in circuits work well with hydraulic fluids, but can give erratic action with air. Meter - in flow controls only work on resistive loads because a running - away load can move the actuator faster than the circuit can fill it with fluid.

The method in which the flow of oil is reduced which is going inside the actuator is known as meter - in speed control method.

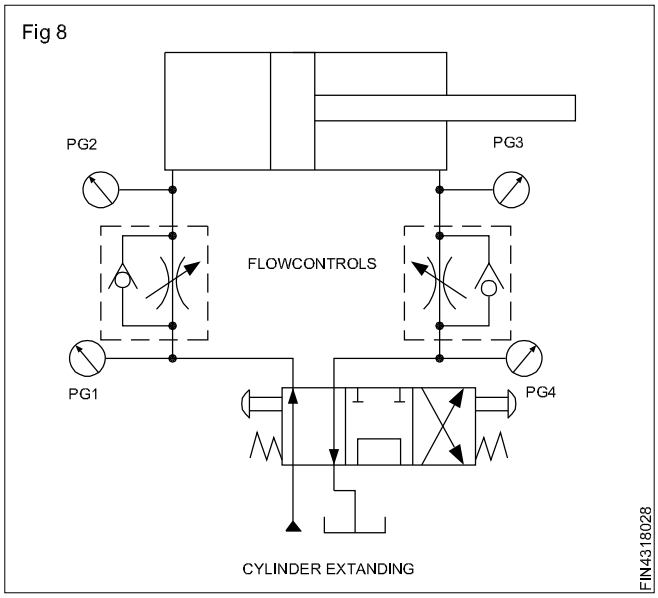
In Fig 7 pump running in unload condition due to open centre valve. Notice that the check valves in the flow controls force fluid through the orifices as it enters the cylinder and lets fluid by pass them as it leaves.

Fig 7



It is obvious that if the cylinder had an external foce pulling on it, it would extend rapidly. Because fluid enters the cap end at a reduced flow rate, a vacuum void would form there until the pump had time to fill it.

Fig 8



- For any normal application meter - in speed control method is preferable.
- It gives finer & smooth speed control

Meter - out speed control

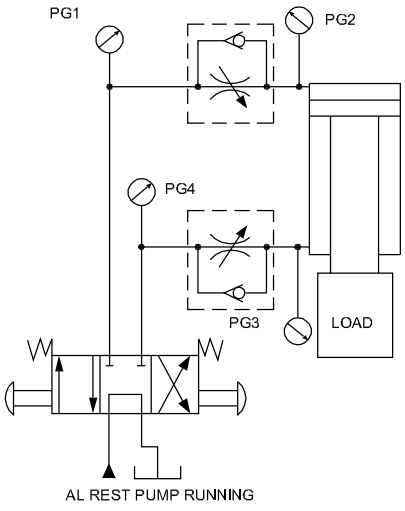
Fig 10 shows a schematic drawing of a meter - out flow control circuit that restricts fluid as it leaves an actuator port. Meter - out circuits work well with both hydraulic and pneumatic actuators. Cylinder - mounting attitude is not important because outlet flow is restricted and an actuator cannot run away. Meter - out flow controls work on resistive loads or running away loads.

Speed control by regulating flow coming out of actuator is called Meter out method.

Below circuit in Figure 9 is shown at rest with the pump running. Notice how check valves in the flow controls allow fluid to by pass the orifices and freely enter the cylinder. As fluid leaves the cylinder, it is forced through the orifices at a set rate. Only PG3 pressure gauge will show the pressure because the load on the cylinder rod is inducing pressure at the valve's blocked port**.**

- If nature of load on actuator is pulling type or pushing type then meter - out speed control is preferable method to use.
- This circuit maintains a constant back pressure during rod extension if the load drops quickly or reverses.

Fig 9



The below circuit shows conditions when the cylinder is extending. The directional control valve shifts to straight arrows and pump flow by passes the upper flow contorl to go to the cylinder cap end. Fluid leaving the cylinder rod end is held back before it goes to tank even with an external load trying to move it. The cylinder extends at a reduced speed in hydraulic circuits until it meets a resistance.

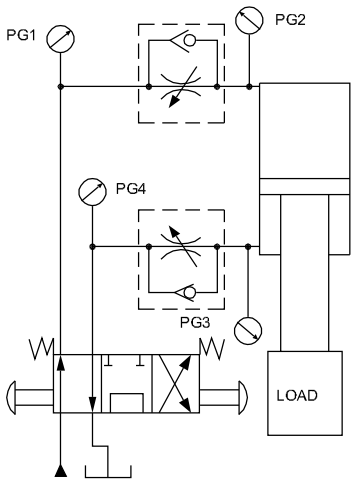
Bleed - off speed control

Bleed - off flow control circuits are found only in hydraulic systems and normally only in those with fixed - volume pumps.

Speed control by metering part of the pump flow to tank is known as bleed off flow contol (Fig 11)

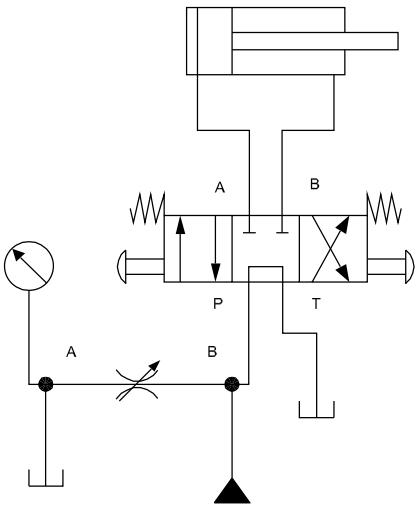
Fig 11 shows a bleed - off circuit at rest with the pump

Fig 10



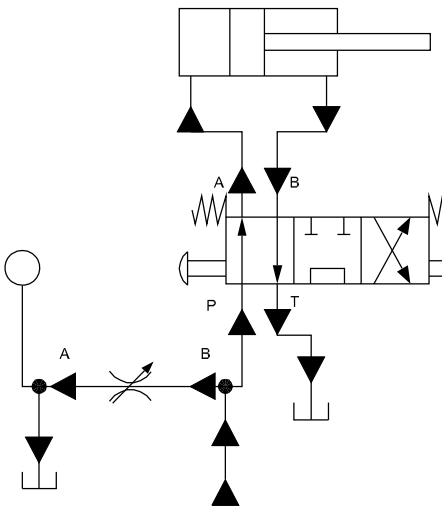
running. One port of flow control valve (Needle valve) is connected to P port or any output (A or B port) and another port of flow control valve is connected to T port.

Fig 11



When the directional valve in Fig 12 shifts or actuated in parallel port position then all pump flow passes from P port to A port through direction control valve.

Fig 12



On the way to the actuator, part of the flow is bled off to tank, so the actuator forward speed is decreased as per setting of bleed off flow control valve.

This circuit is more efficient than meter - in or meter - out, as pump output is only high enough to overcome resistance, but part of pump output is wasted.

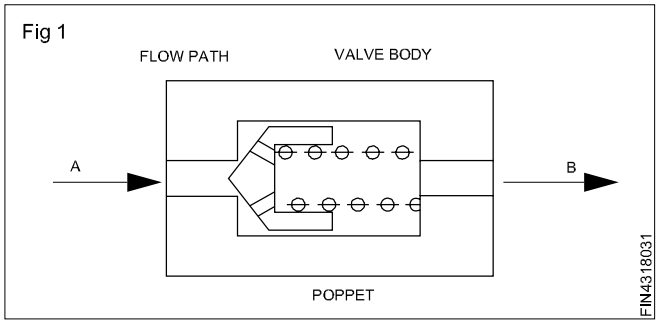
Shuttle valve and application to control single acting cylinder

Objectives : At the end of this lesson you shall be able to
- **explain working principle of non return valve (NRV) and shuttle valve**
- **state use of shuttle valve in pneumatic applications**
- **draw circuit to operate Single Acting Cylinder using two 3/2 way valves and shuttle valve.**

Working principle of Non Return Valve:

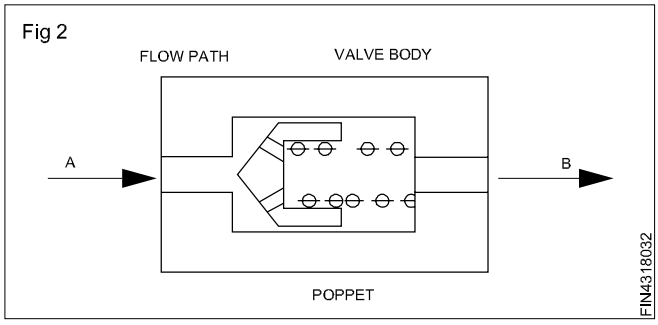
This valve allow air flow in one direction but does not allow air to flow in opposite direction. Non return valve is also known as check valve.

Fig 1 shows the construction of non return valve.

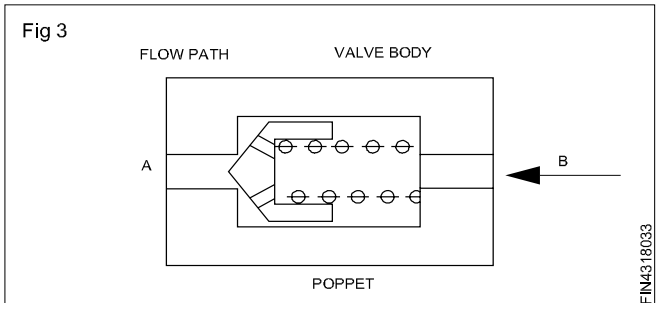


It consists of a valve body having flow path and accommodates poppet and spring. Spring exerts very small force on poppet so that it is closing the path and poppet does not dislocate even if NRV is connected vertically or at an angular position.

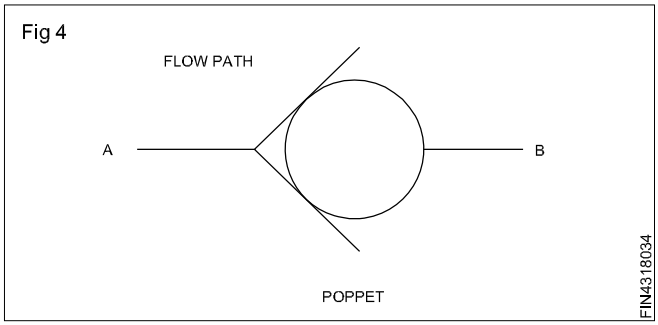
When air flows from port A to B, pneumatic force acts on poppet and spring gets compressed. It causes poppet to shift right side and air flow freely in A to B direction (Fig 2)



When flow direction is reversed (fig 3) means directed from port B, air pressure acts on poppet which further blocks flow path tightly thus no flow from port A.



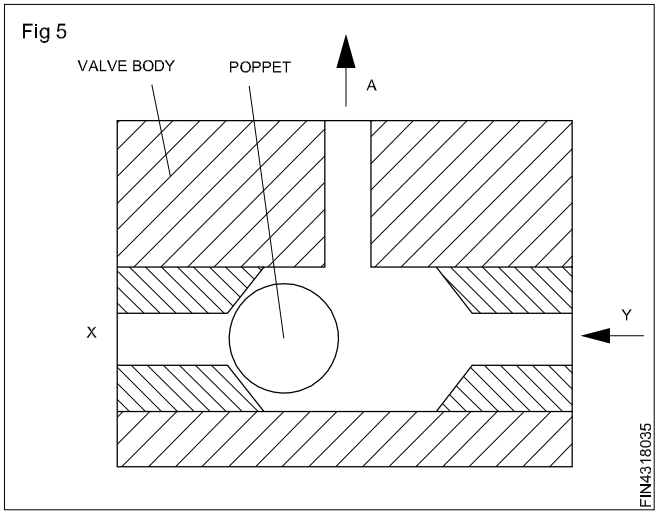
Symbol of NRV is shown if fig 4



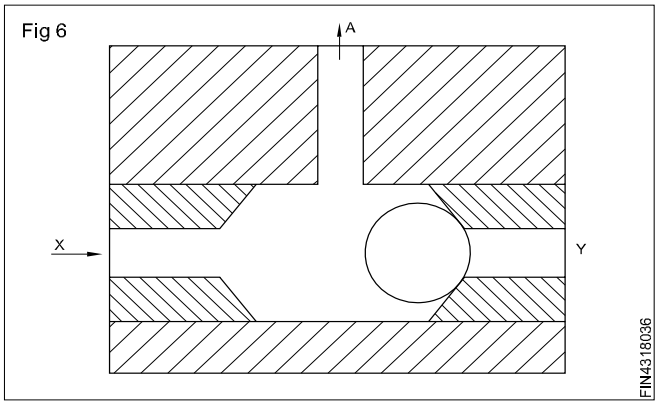
Working principle of Shuttle Valve

Shuttle valve is a combination of two NRV placed face to face, but having common poppet as shown in the Fig 5

If air is supplied through port Y as shown in fig 5, poppet shifts and block port x, thus air flow from Y to A.

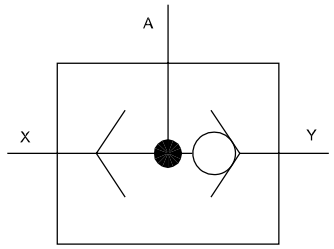


If air is supplied through port X as shown in fig 6 poppet shifts and block port Y, thus air flow from X to A



You can conclude that if air is supplied either from X or Y, poppet shuttles between the ports and you get the output from A. Symbol of shuttle valve is shown in fig 7.

Fig 7



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Application

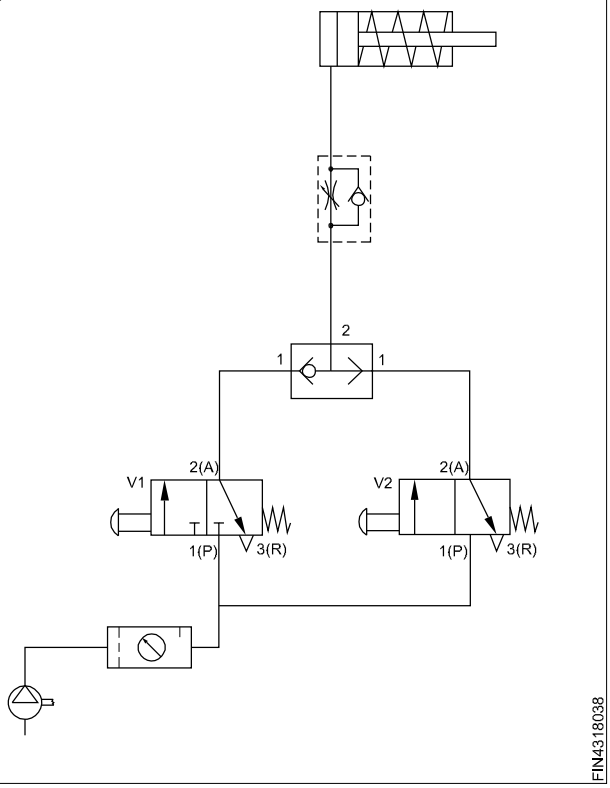
If we use two 3/2 way valves and connect their outputs fo ports x & y then on actuation of any of the valves we get output from A.

Fig 8 shows the application of shuttle valve in pneumatic circuit to operte single acting cylinder from two different locations.

When you operate valve V1 air flows through shuttle valve to cylinder and piston moves forward. (Fig 9)

As soon as valve is released cylinder side air exhausts through valve V1 and piston retracts.

Fig 8



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When Valve V2 is operated air flows through shuttle valve to cylinder and piston moves forward. (Fig 10)

As soon as valve is released cylinder side air through valve V2 and piston retracts.

If you operate both valves V1 & V2 simultaneously, poppet shifts due to flow from either of the valves and air flow to cylinder, thus piston moves forward. (Fig 11)

As soon as both valves are released cylinder side all exhausts through either of the valves and piston retracts. (Fig 12)

Fig 9

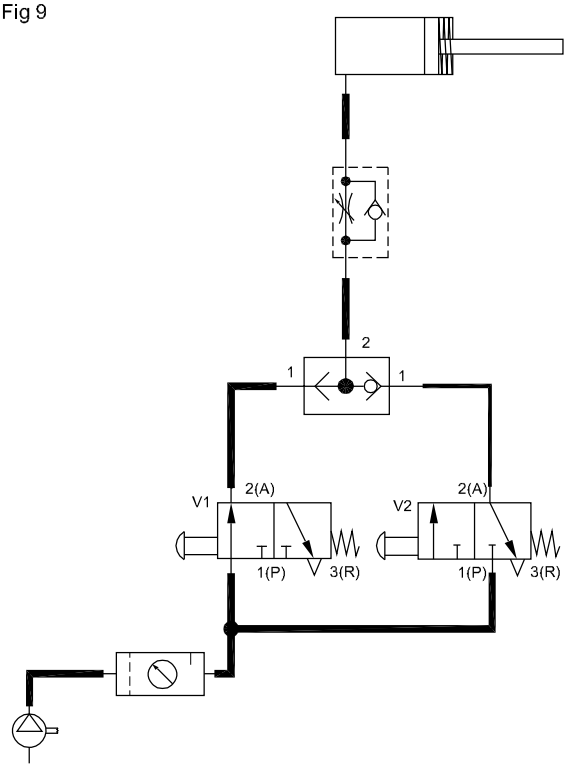

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Fig 10

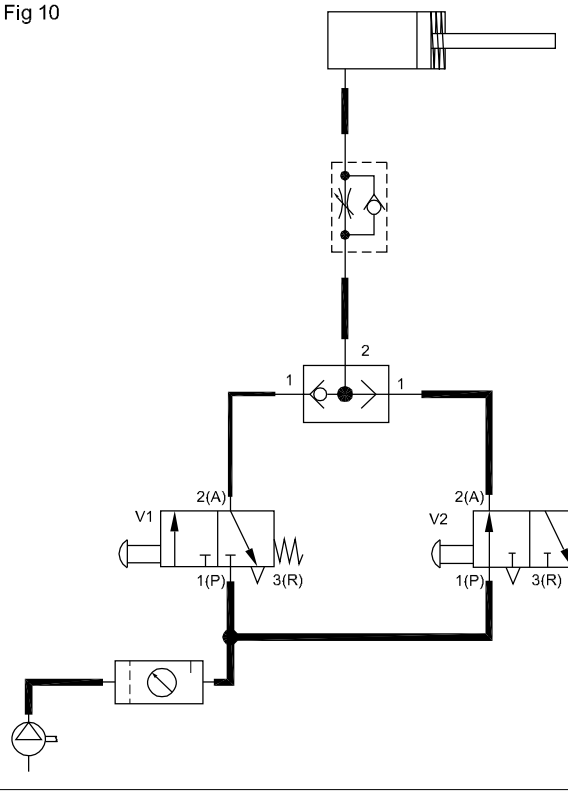

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Fig 11

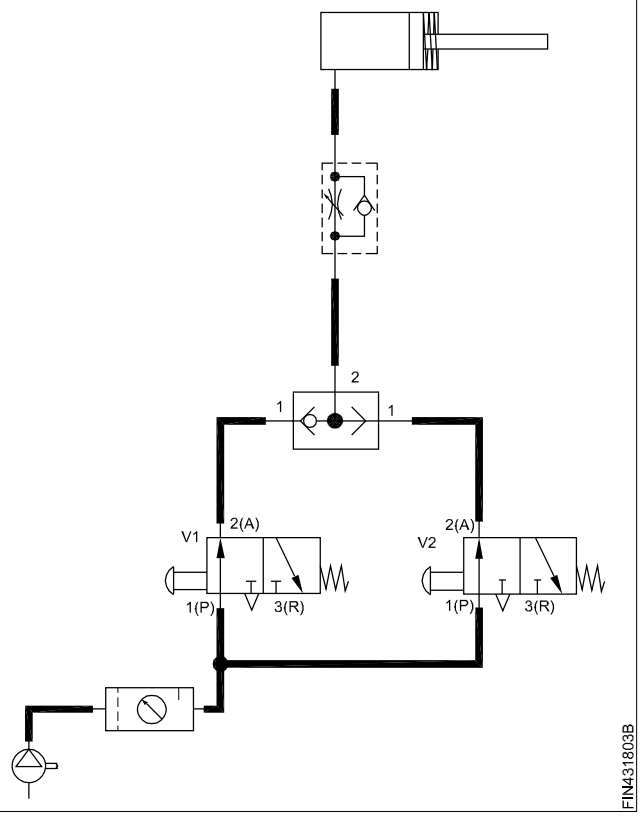
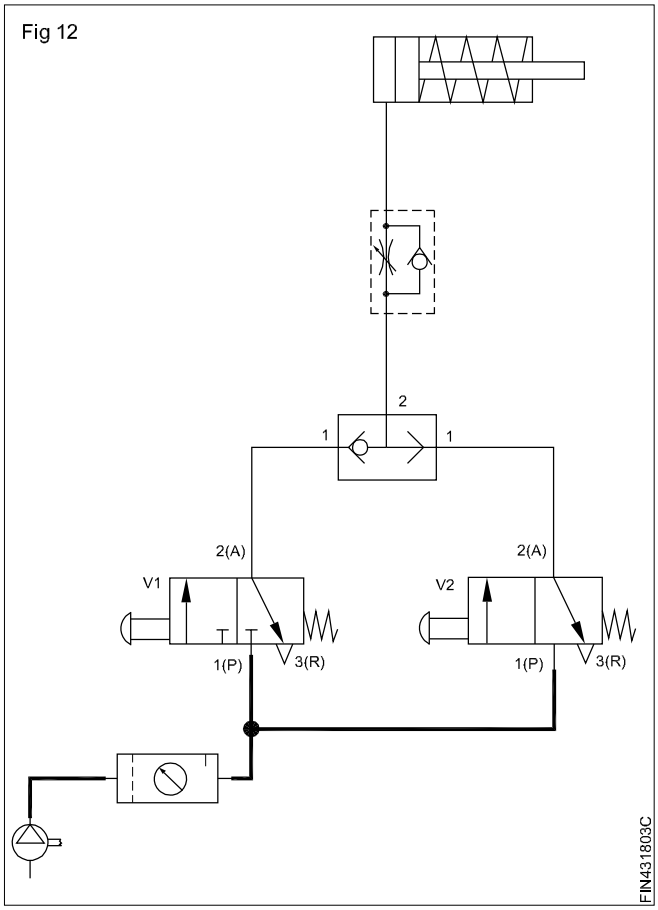


Fig 12



Roller valve

Pneumatic roller lever valves, used for mechanical position sensing in machine automation systems. The linear horizontal movement of a machine part of passing material, for example on a conveyor line, moving over the roller operates the valve. The wheel rotates in the direction of the moving part which reduces friction, this minimises wear and tear of both the pneumatic roller lever valve and the travelling part, for this reason, a preferred method of mechanical sensing.

Pneumatic roller lever valves, constructed from a die - cast zinc aluminium alloy that is machined and lacquered offering strength and reliablility, an overall excellent quality product. We offer 2 or 3- way normally closed, or a 5 way roller lever valve in either poppet or spool designs. Choose from a standard pneumatic roller lever valve or a compact design should space be limited. An air pilot assisted version can be ordered, used when less force is available to actuate the lever for lighter operation.

Order one- way or two - way roller levers with spring return, air pilot return or double rollers. A double roller lever is used on machine carriages to reverse the direction of travel. Port sizes are G 1/8 as standard.

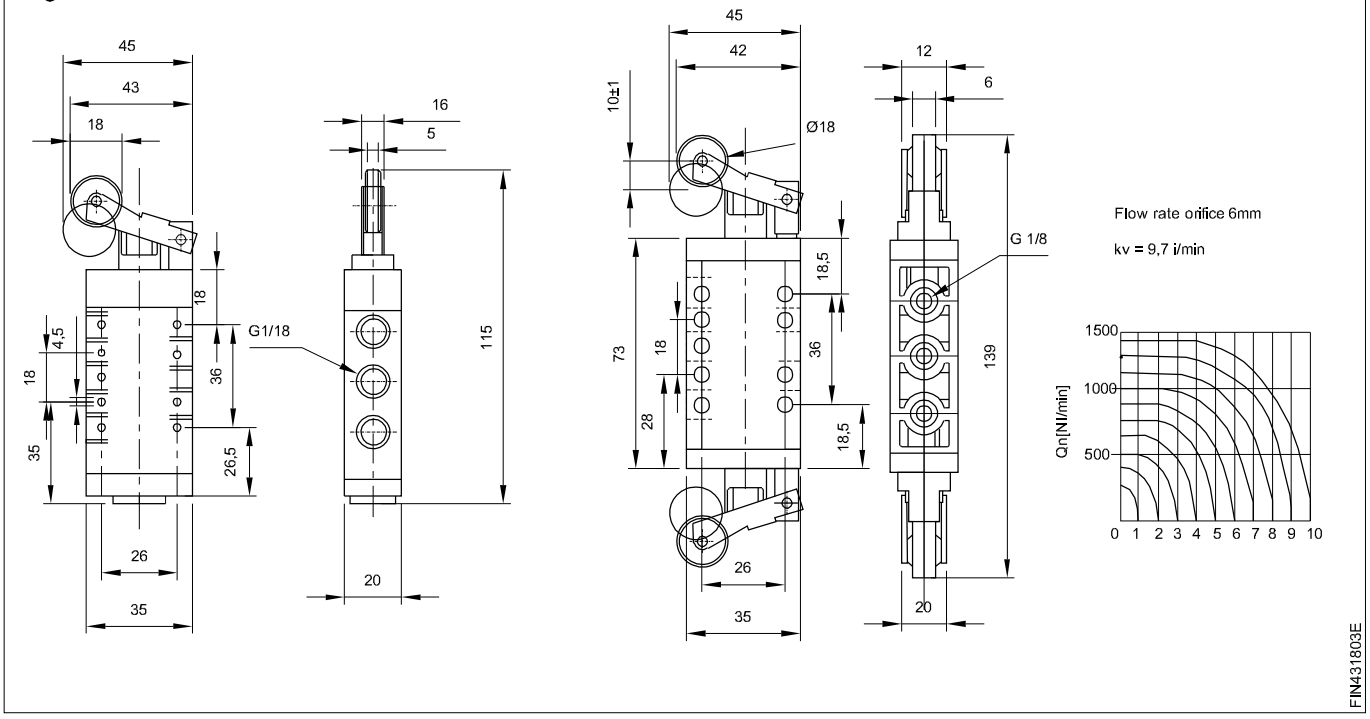
Fig 13

ROLLER LEVER VALVE

FIN431803D

Dimensional drawings

Fig 14



Pressure control valve

Objectives : At the end of this lesson you shall be able to

- **differentiate pressure relief valve, pressure reducing valve, pressure regulator and explain their function**
- **interprete counter balancing and sequencing.**

To control and regulae the pressure various pressure valve are used in hydraulics systems, like:

Classification of Pressure control valve

- Pressure relief valve.
- Pressure reducing valve
- Pressure regulator.

Pressure relief valve

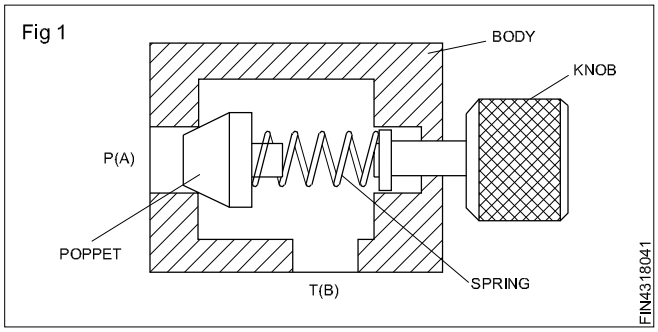
The pressure in the system is set and restricted by pressure relief valve. Pressure relief valve also help to remove excess amoung of oil from system to tank to overcome excess pressure.

In this design incorporating a poppet valve, a seal is pressed against the inlet port P by a spring when the valve is in its normal position. The input pressure (P) acts on the surface of the sealing element generates the force.

$$F = p_1 A_1$$

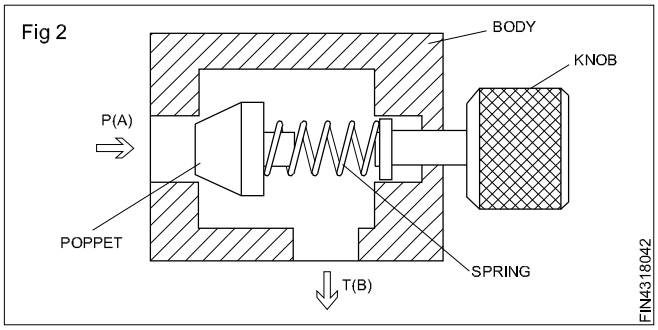
The Spring force by which the sealing element is pressed onto the seat is adjustable

Fig 1



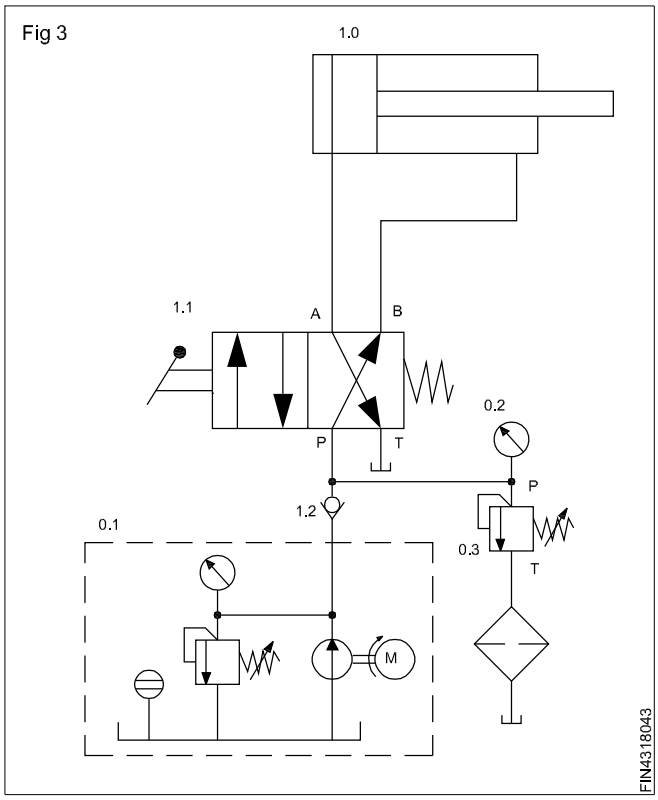
If the force generated by the input pressure exceeds the spring force, teh valve starts to open. This causes a partial flow of the liquid to the tank. If the input pressure continues to increase, the valve opens until the complete pump delivery flows to the tank.

Fig 2



The resistances at the outlet (tank line. filter) must be added to the force of the spring in the pressure relief valve. Application of PRV is shown in the Fig 3

Fig 3

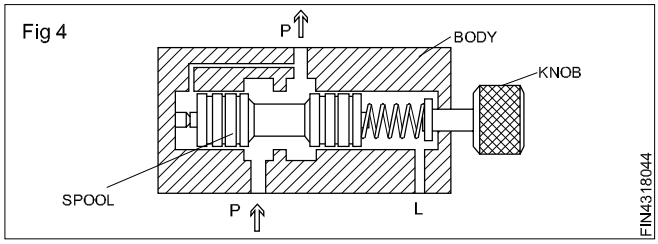


Pressure reducing valve (2 - way valve)

Pressure regulators reduce the inlet pressure to an adjustable outlet pressure. It is appropriate to use these in hydraulic system only if different pressures are required.

This valve is normally open. The outlet pressure (A) acts via a pilot on the left - hand surface of the pilot piston against an adjustable spring force. (Fig 4)

Fig 4



When the pressure rises at outlet A, the force at the left hand surface of the pilot piston becomes increases, the piston is displaced to the right and the throttle gap becomes narrower. This causes a pressure drop. In the case of slide valves, it is also possible to design the control edges in such way that the opening gap increases only slowly. This gives greater control precision. (Fig 5)

When the preset maximum pressure is reached, the throttle point closes completely. (Fig 6)

The pressure at the outlet A of the pressure regulator is less than the system pressure at P and constant. The piston rod of the cylinder is now in its forward end

Fig 5

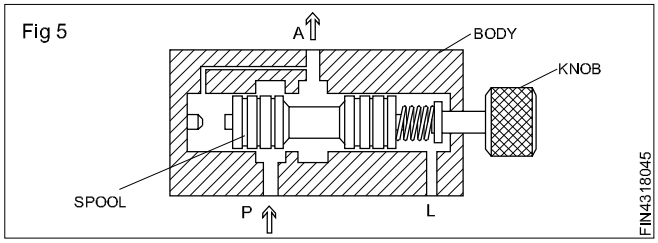
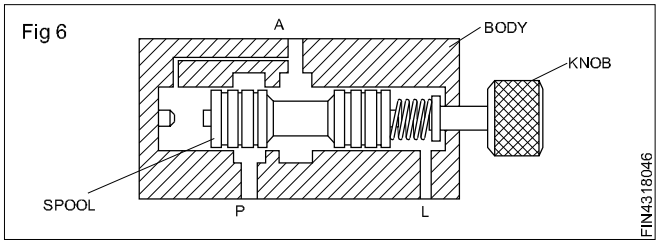
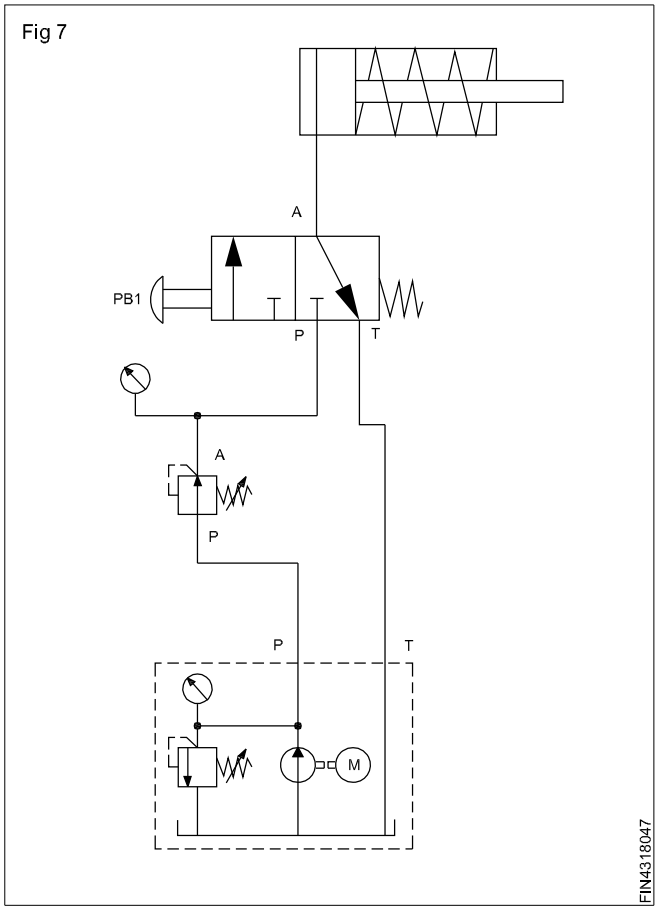


Fig 6



position. Application of pressure reducing valve is shown in the Fig 7

Fig 7

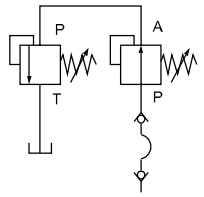


Pressure regulator (3- way Valve)

When the 2 - way pressure regulator close fully, then any impact vibration in cylinder will responsible to increase the output pressure above the set value which is not desirable. One method of rectifying this would be to install a pressure relief valve at the output.

The 3-way pressure regulator can be regarded as a combination of a 2- way pressure regulator (PR) and a pressure relief valve (PRV) (Fig 8)

Fig 8



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When the pressure at A raises the result of external conditions, this pressure acts via a pilot line on the left hand piston surface of the pilot piston against an adjustable spring force. Every pressure increase causes the throttle gap to become narrower, resulting in a pressure drop. (Figs 9 & 10)

Fig 9

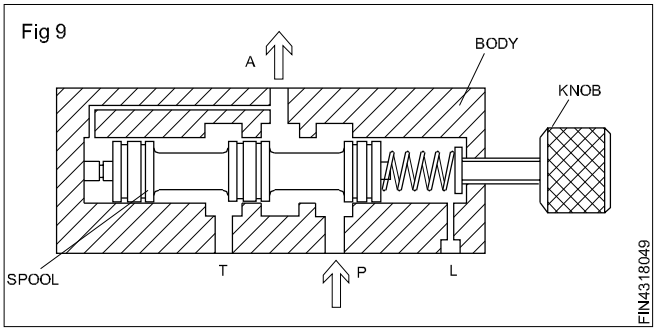

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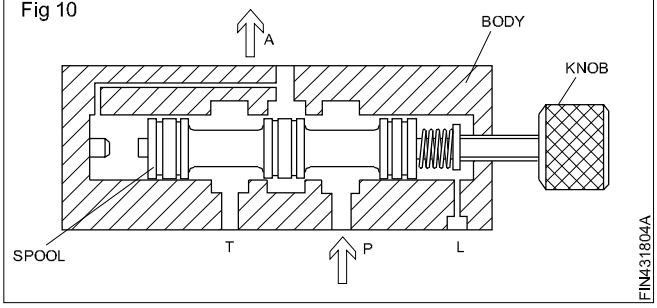
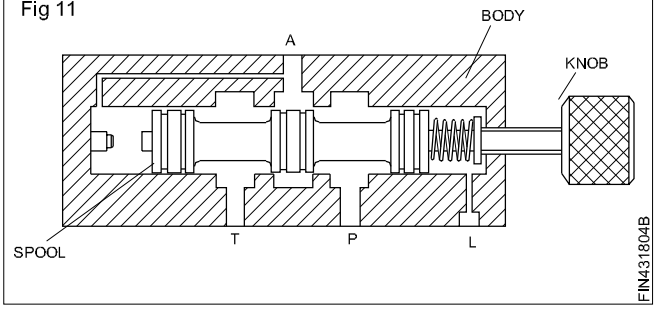
Fig 10



FIN431804A

When the maximum preset pressure is reached, the throttle point closes completely. (Fig 11)

Fig 11



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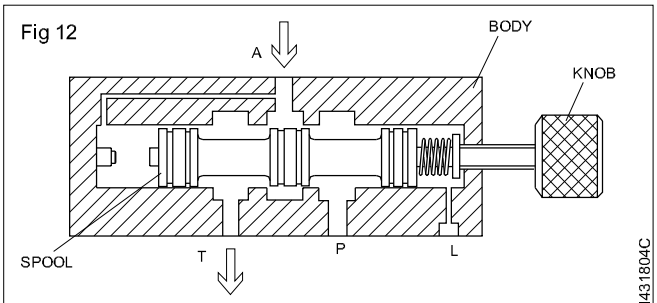
If the pressure rises above the preset value as the result of an external load at outlet A, the valve opens to allow from A to the tank port T (pressure - limiter - function). (Fig 12)

Example of pressure regulator is shown in the fig 13

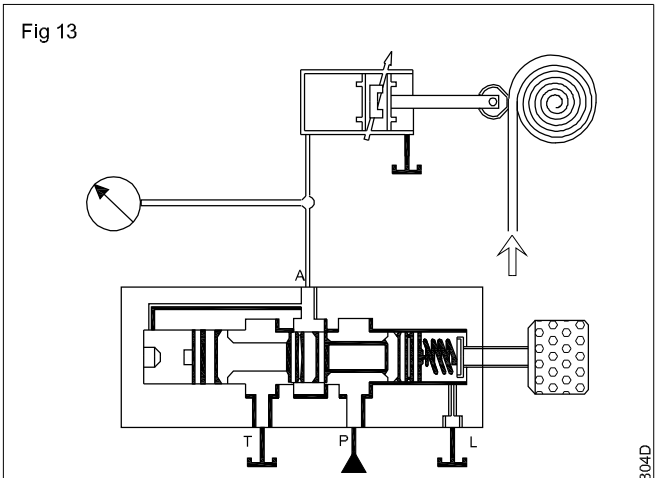
Pressure regulator help to maintain constant pressure in line and also safe the sytem from excess pressure, so you able to get approximate constant pressure in line.

Fig 12



FIN431804C

Fig 13



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Counter Balancing

Cylinders with external forces such as weight from a platen, machine members, or tooling acting against them will over r**un** when oil flowing out of them is not restricted. A meter - out flow control circuit is one way to control over running loads but it has one main drawback. A flow control's speed is fixed except for manual adjustment. Because flow is fixed, the actuator will continue at the same speed, even when working flow to it increases or decreases.

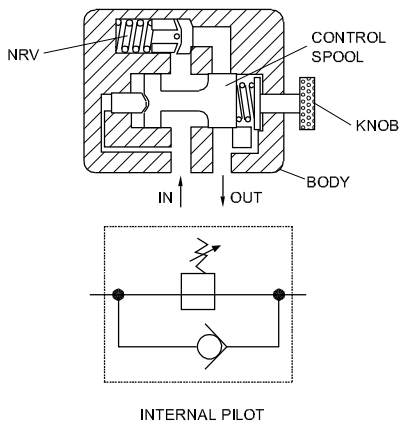
The valve which is used to create a back pressure against pushing or pulling types of load to maintain normal speed of cylinder is known as counterbalance valve.

A counterbalance valve keeps an actuator from running away regardless of flow changes because it responds to pressure signals, not flow. A counter balance valve is almost the same as a sequence valve. The figure of counter balance valve and symbols are shown in Fig 14

A counterbalance valve usually has a bypass check valve for reverse flow because its most common use is in controlling actuators with running away or overruning loads.

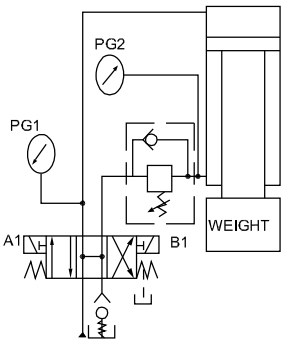
Fig 15 shows a vertically oriented cylinder with rod facing down and a load trying to extend it . To keep the cylinder from running away, the counterbalance valve must resist the load - induced pressure from the weight.

Fig 14



The load - induced pressure can be calculated and the counterbalance valve could be preset at 100 to 150 psi higher on a test stand.

Fig 15



In the centre position of directional control valve ports A and B are connected to tank in the center condition. There is no chance of extra pressure buildup in the pilot line while the circuit is at rest. If ports A or B? were blocked, pressure could not build and counterbalance valve will not open, not allowing the cylinder to drift.

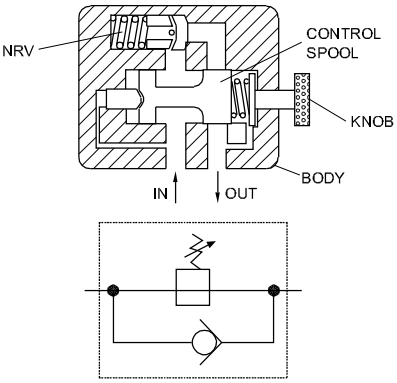
Press PB1 oil flows to the cylinder cap end. As pressure builds there, pressure also increases in the rod end. When pressure at the cylinder rod end reaches 100 to 150 psi above the load- induced pressure, the cylinder starts to extend as fast as the pump fils the cap end. When flow increases, cylinder speed increases and when flow decreases, cylinder speed increases and when flow decreases, cylinder speed decreases. Back pressure at the cylinder rod end is present during the entire extend stroke.

When PB2 is operated oil flows to rod end via check valve thus by passing the counterbalance hence piston retracts.

Sequencing

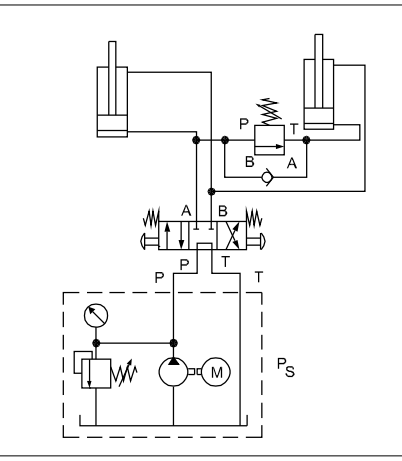
To operation of number of hydraulic actuators in desired steps sequencing is done. A sequence valve is the simplest mechanism to achieve desired steps. Fig 16 shows the sectional view and symbol of sequencing valve.

Fig 16



A balanced spool held in place by an adjustable - force spring blocks fluid at the hydraulic sequence valve's inlet. When pressure at the inlet reaches the spring setting, pressure in the internal pilot line pushes the spool up to allow enough flow to the outlet. A by pass check valve allows reverse flow without pressure sequencing. In this circuit 4/3 way valve is in neutral position Fig 17 so the pump flow is flowing into tank without any resistance.

Fig 17



In the actuated condition (Fig 18) the loaded cylcinder will complete it's stroke first then after no load cylinder start moving. This is the sequencing of actuation for cylinder with the help of pressure sequence valve.

In other actuated condition (Fig 19) cross connection of port in direction control valve, loaded piston will return back at faster speed as compare to the no load piston.

Fig 18

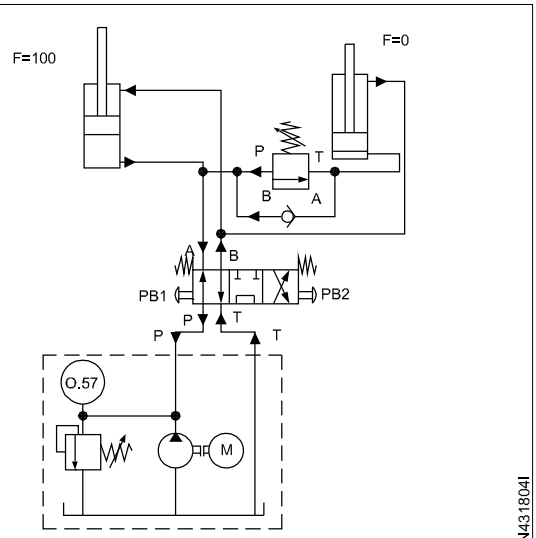
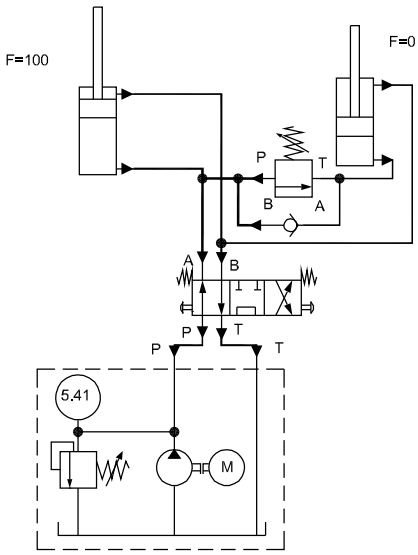


Fig 19



Electro- pneumatics

Objectives : At the end of this lesson you shall be able to
- **explain about the electro pneumatic control system**
- **list the basic electrical devices**
- **explain the operation of switches**
- **describe the purpose and constructional details of solenoid valves.**
- **explain purpose and operation of rela**y.

Introduction

Electro pneumatic control consists of electrical control systems operating pneumatic power system. In this solenoid valves, are used as interface between the electrical and pneumatic system. Devices like switches are used as feedback elements.

In electro pneumatics, the signal medium is the electrical signal either AC or DC source is used. Working medium is compressed air. Operating voltages from around 12v to 220 v are used. The final control valve is actuated by solenoid activation.

In electro pneumatic controls, mainly three important steps are involved.

Signal input devices

Signal generation such as switches and contactor, various types of contact and proximity sensors.

Signal processing

Use of combination of contactors of relay or using programmable logic controllers.

Signal outputs

Outputs obtained after processing are used for activation of solenoids, indicators or audible alarms.

Basic electrical devices

Basic electrical devices commonly used in the control of fluid power systems are

Manually actuated push button switches
Limit switches
Pressure switches
Solenoids
Relays
Temperature switches

Push button switches

A push button is a switch used to close or open an electric control circuit. They are primarily used for starting and stopping of operation of machinery. They also provide manual over ride when the emergency arises. Push button switches are actuated by pushing the actuator into the housing. This causes set of contacts to open or close.

Push buttons are of two types

Momentary push button

Maintained contact or detent push button

Momentary push buttons return to their unactuated position when they are released. Maintained (or mechanically latched) push buttons has a latching mechanism to hold it in the selected position.

The contact of the push buttons, distinguished according to their functions.

- Normally open (NO) type
- Normally closed (NC) type
- Change over (CO) type.

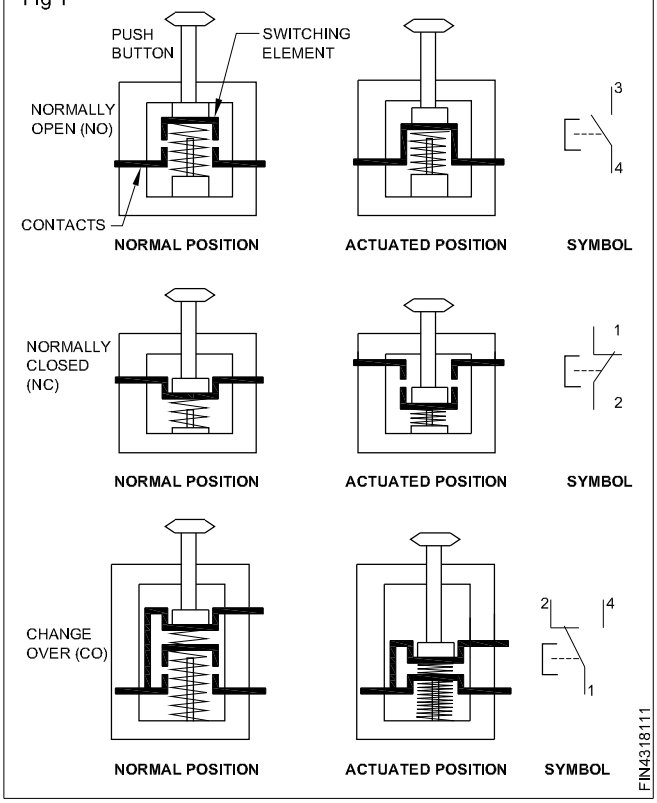
The cross section of various types of push buttons in the normal and actuated positions and their symbols are given in the fig 1. In the NO type, the contacts are open in the normal position, inhibiting the energy flow through them. But in the actuated position, the contacts are closed, permitting the energy flow through them. In the NC type, the contacts are closed in the normal position, permitting the energy flow through them. And, the contacts are open in the actuated position, inhibiting the energy flow through them. A changeover contact is a combination of NO and NC contacts.

Type of devices	**Terminal numbers**	
	Normally closed contacts	**Normally open contacts**
Push buttons and relays	1 and 2	3 and 4

Limit switches

Any switch that is actuated due to the position of a fluid power component (usually a piston rod or hydraulic motor shaft or the position of load is termed as limit switch. The actuation of a limit switch provides an electrical signal that causes an appropriate system response.

Fig 1



Limit switches perform the same function as push button switches. Push buttons are manually actuated whereas limit switches are mechanically actuated.

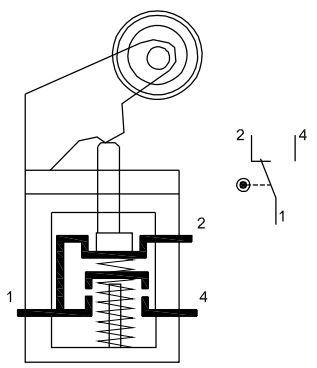
There are two types classification of limit switches depending upon method of actuation of contacts

Lever actuated contacts

Spring loaded contacts

In lever type limit switches, the contacts are operated slowly. In spring type limit switches, the contacts are operated rapidly. Figure 2 shows a simplified cross sectional view of a limit switch and its symbol.

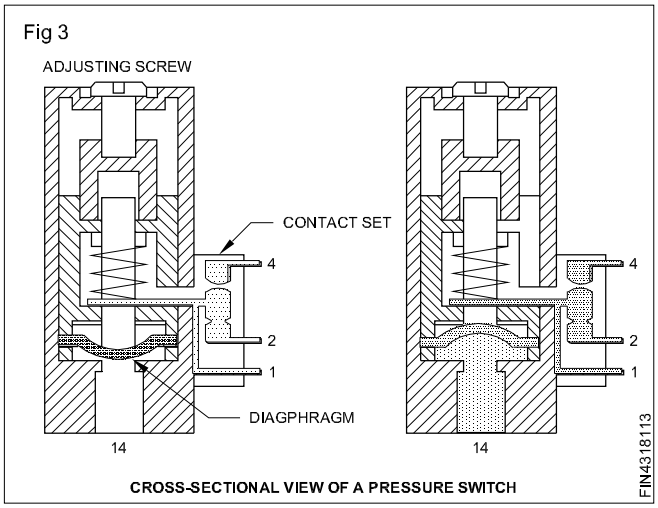
Fig 2



CROSS SECTIONAL VIEW OF A LIMIT SWITCH

A **pressure switch** is a pneumatic - electric signal converter. Pressure switches are used to sense a change in pressure, and opens or closes an electrical switch when a predetermined pressure is reached. Bellow or diaphragm is used to sense the change of pressure. Bellows or diaphragm is used to expand or contact in response to increase or decrease of pressure. Figure. 3 shows a diaphragm type of pressure switch. When the pressure is applied at the inlet and when the pre-set pressure is reached, the diaphragm expands and pushes the spring loaded plunger to make/break contact.

Fig 3



CROSS-SECTIONAL VIEW OF A PRESSURE SWITCH

Temperature switch

Temperature switches automatically senses a change in temperature and opens or closes an electrical switch when a predetermined temperature is reached. This switch can be wired either normally open or normally closed.

Temperature switches can be used to protect a fluid power system from serious damage when a component such as a pump or strainer or cooler begins to malfunction.

Solenoids

Electrically actuated directional control valves form interface between the two parts of an electro pneumatic control. The most important tasks of electrically actuated DCVs include.

Switching supply air ON or OFF

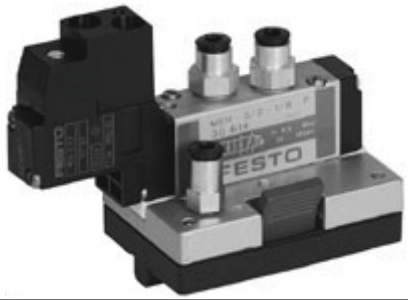
Extension and retraction of cylinder drives.

Electrically actuated directional control valves are switched with the aid of solenoids. A solenoid is like a coil of the relay. When it is energized, it will switch on the valve, similar to turning on the hand lever of a normal valve.

They can be divided into two groups

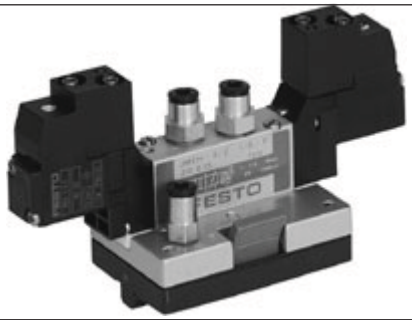
- Spring return valves (single solenoid valve) only remain in the actuated position as long as current flows through the solenoid (fig 4)

Fig 4



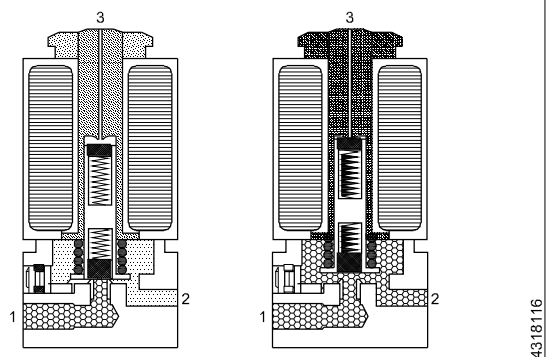
- Double solenoid valves (double solenoid valve) retain the last switched position even when no current flows through the solenoid (fig 5)

Fig 5



In the initial position, all solenoids of an electrically actuated DCVs are de - energized and the solenoids are inactive. A double valve has no clear initial position, as it does not have a return spring. The possible voltage levels for solenoids are 12V Dc, 12V Ac, 12V 50/60 Hz, 24V 50/60 Hz, 110/120V 50/60 Hz,220/230V 50/60 Hz

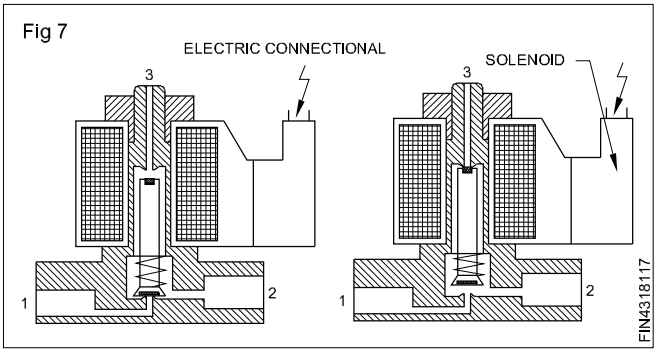
Fig 6



CROSS SECTIONAL VIEW OF A 3/2 SINGLE SOLENOID VALVE

3/2 way singal solenoid valve, spring rectors : The cross sectional view of 3/2 way single solenoid valve in the normal and actuated positions are shown in fig 6. In the normal position, port 1 is blocked and port 2 is connected to port 3 via back slot (details shown in the circle) when the rated voltage is applied to coil, armature is pulled towards the centre of the coil and in the process the armature is lifted away from the valve seat. The compressed air now flows from port 1 to port 2, and ports 3 is blocked. When the voltage to the coil is removed, the valve returns to the normal position. Fig 7 shows 2/2 solenoid operated valve.

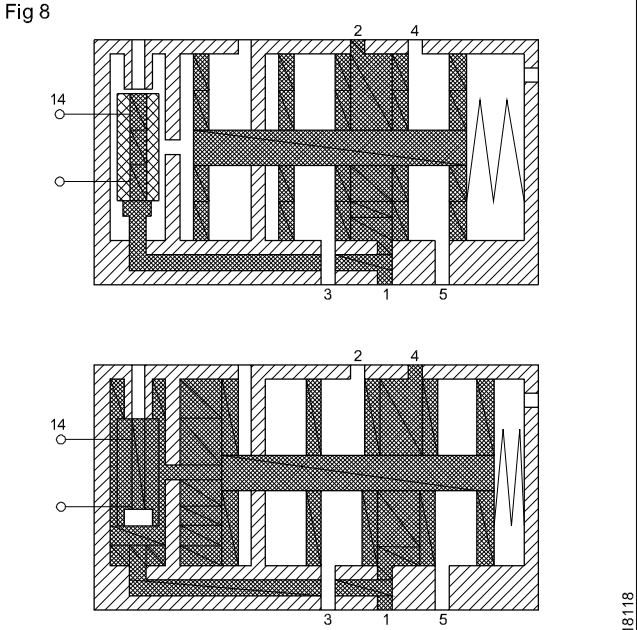
Fig 7



5/2 way single solenoid valve, spring return

The cross section view of 5/2 way single solenoid in the normal and actuated positions are shown in figure 8. In normal position, port 1 is connected to port 2, port 4 is connected to port 5, and port 3 is blocked. When the rated voltage is applied to coil 14, the valve is actuated through an internal pilot valve. In actuated position, port 1 is connected to port 4, port 2 is connected to port 3, and port 5 is blocked. The valve returns to the normal position when the voltage to the armature coil is removed. This type of valves is normally used as final valve to control double acting cylinders.

Fig 8

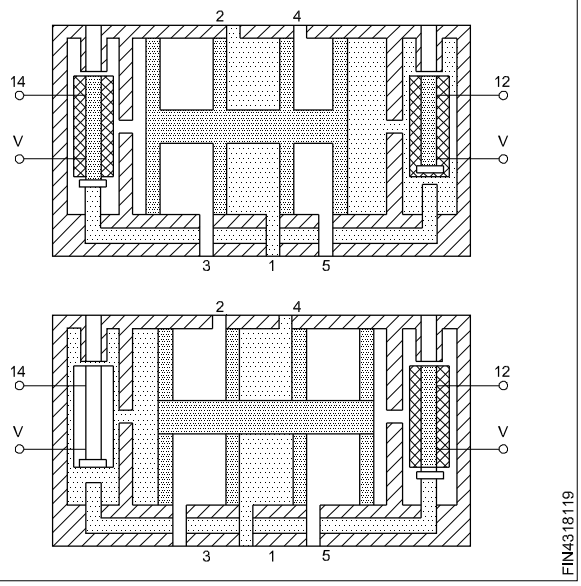


CROSS SECTIONAL VIEW OF A 5/2 WAY SOLENOID OPERATED VALVE

5/2 way single double solenoid valve

The cross section view of 5/2 way double solenoid in the normal and actuated positions are shown in the fig 9 when the rated voltage is applied to coil 14, the valve is actuated to a one switch in position with port 1 connected to port 4, port 2 connected to port 3, and port 5 blocked. When the rated voltage is applied to the coil 12, the valve is actuated to the other switching position with port 1 connected to port 2, port 4 connected to port 5 and port 3 blocked.

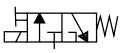
Fig 9



The symbols for the various solenoid/pilot actuated valves are given in table 1

Fig 10

TABLE 1

SYMBOL	DETAILS
	3/2 WAY SINGLE SOLENOID VALVE (SPRING RETURN)
	3/2 WAY PILOT OPERATED SINGLE SOLENOID VALVE (SPRING RETURN)
	5/2 WAY SINGLE SOLENOID VALVE (SPRING RETURN)
	5/2 WAY DOUBLE SOLENOID VALVE
	5/2 WAY PILOT OPERATED DOUBLE SOLENOID VALVE (SPRING RETURN)

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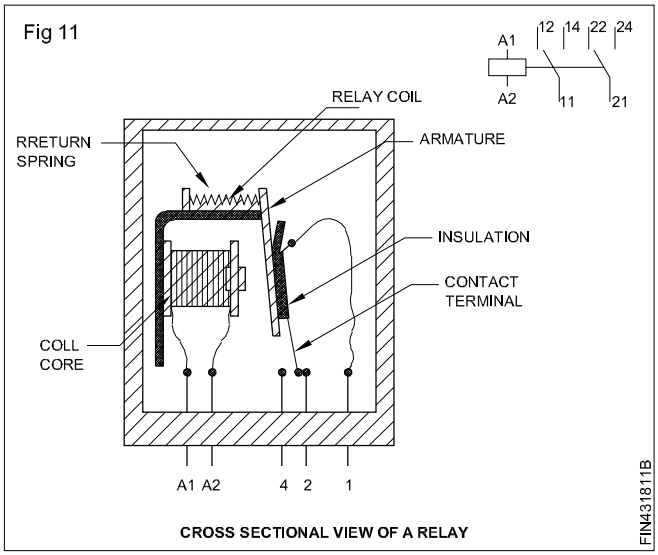
VARIOUS SYMBOLS FOR DCVs

Relay

A relay is an electro magnetically actuated switch. It is a simple electrical device used for signal processing. Relays are designed to withstand heavy power surges and harsh environment conditions. When a voltage is applied to the solenoid coil, an electro magnet field results. This causes the armature to be attracted to the coil core. The armature actuates the relay contacts, either closing or opening them, depending on the design. A return spring returns the armature to its initial position when the current to the coil is interrupted. Cross sectional view of a relay is shown in fig 11.

A large number of control can be incorporated in relays in contrast to the case of a push button station. Relays are usually designated as K1, K2, and K3 etc. Relays also possess interlocking capability that is an important safety feature in control circuits. Interlocking avoids simultaneous switching of certain coils.

Fig 11



CROSS SECTIONAL VIEW OF A RELAY