Pneumatics and Hydraulics

Input, Control and Processing elements

Dr. Ahmad Al-Mahasneh

Outline

- Valves

Valves

The function of valves is to control the fluid path or the pressure or the flow rate. Depending on design, these can be divided into the following categories:

1. Directional control valves.
    - Input/signaling elements
    - Processing elements
    - Control elements
    - Power elements.
2. Flow control valves.
3. Pressure control valves.

Directional control valves (DCVs)

- Directional control valves are devices which influence the path taken by an air stream.

- Normally this involves one or all of the following:

1. opening the passage of air
2. and directing it to particular air lines,
3. canceling air signals as required by blocking their passage
4. and/or relieving the air to atmosphere via an exhaust port.

Configuration and construction of DCVs

The directional control valve is characterized by:

- Construction type (Poppet or slide).
- Over Lapping (with or without overlapping).
- Number of controlled connections or ways (Ports): (1 way, 2 way, 2 ports, 3 ports, …)
- Number of switching positions:(2 positions, 3 positions, …)
- Method of actuation: Direct control (Manual, mechanical and solenoid) or Indirect Control (piloted control).
- Method of return actuation: (Spring return, air return,…)
- Special features of actuation: (Manually overrides, …)
- Size: (Port size, spool size,…)
- Switching time.
- Service life.

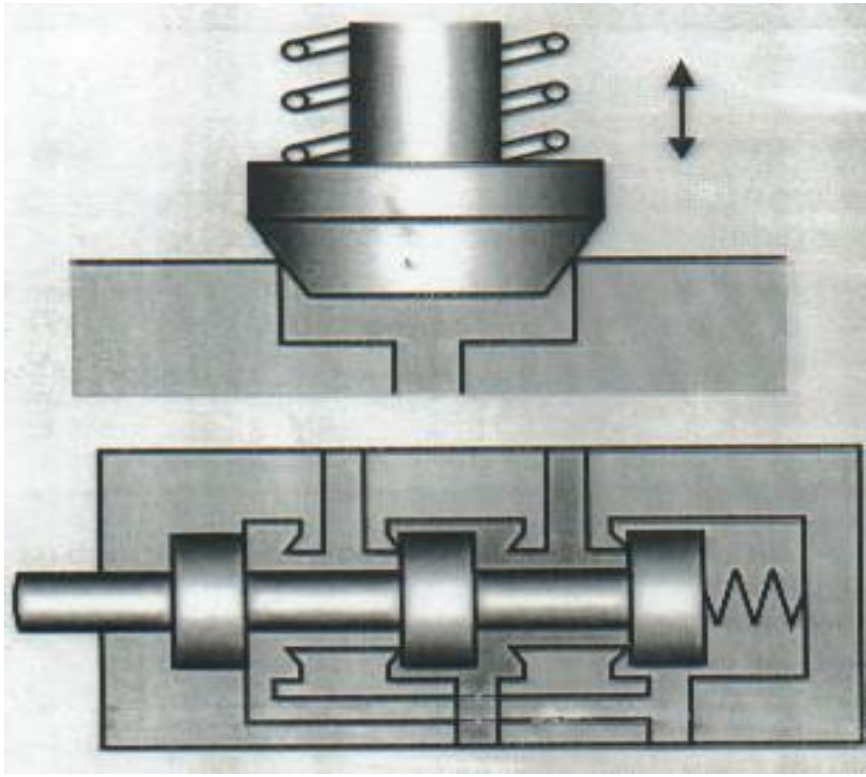
DCVs Construction type

- Poppet valves
- Slide valves

Poppet valves

With poppet valves the connections are opened and closed by means of balls, discs, plates or cones.

The valve seats are usually sealed simply using flexible seals.



Characteristics:

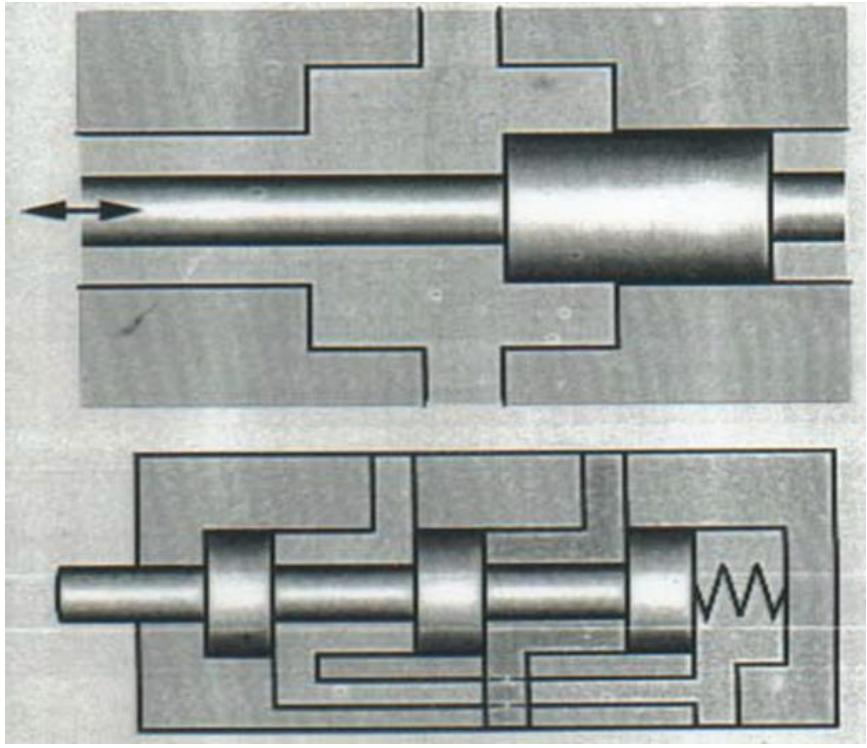
- Seat valves have few parts which are subject to wear and hence they have a long service life.
- Absolutely tight.
- They can switch quickly over short strokes.
- Insensitive to dirt and are robust.
- Need high actuating force (relatively high as it is necessary to overcome the force of the built-in reset spring and the air pressure).
- Can be actuated from one side only.

Slide valves

In slide valves, the individual connections are linked together or closed by means of spools or plate slide valves.

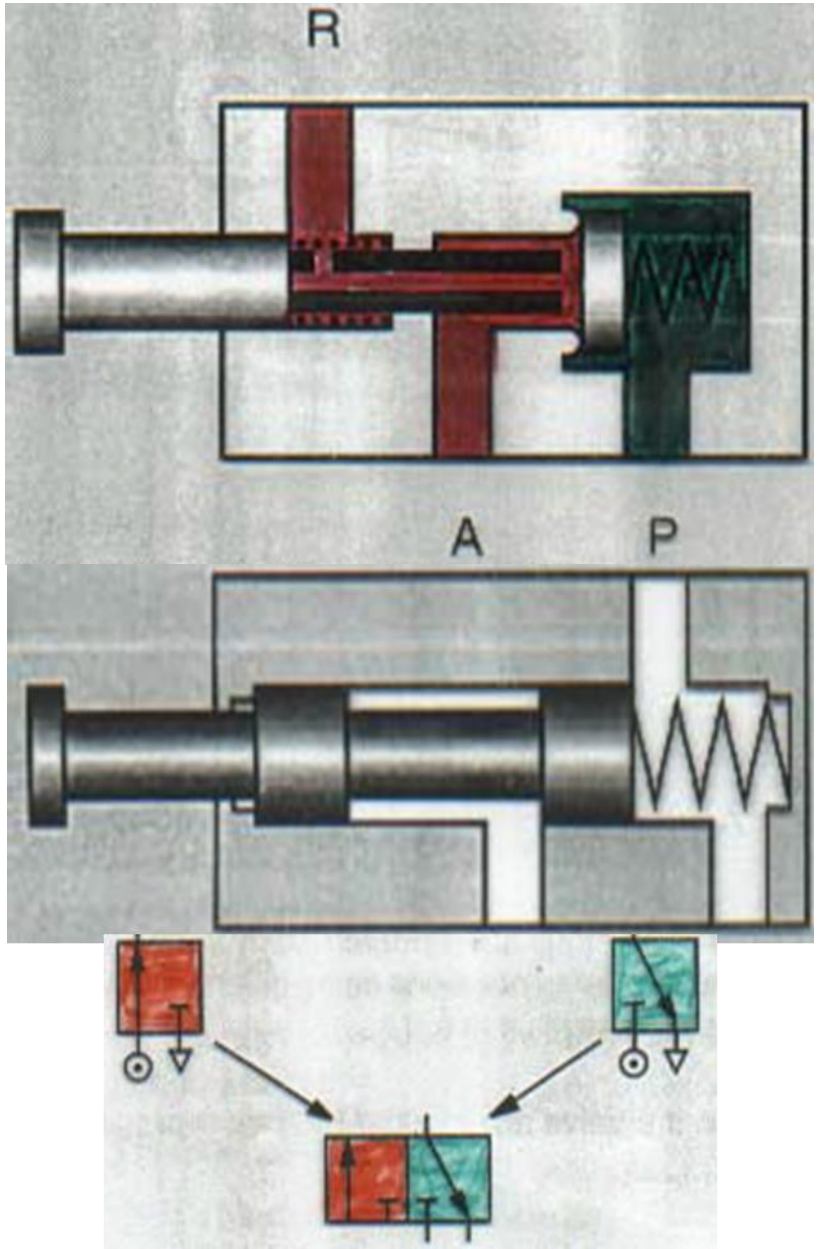
Characteristics:

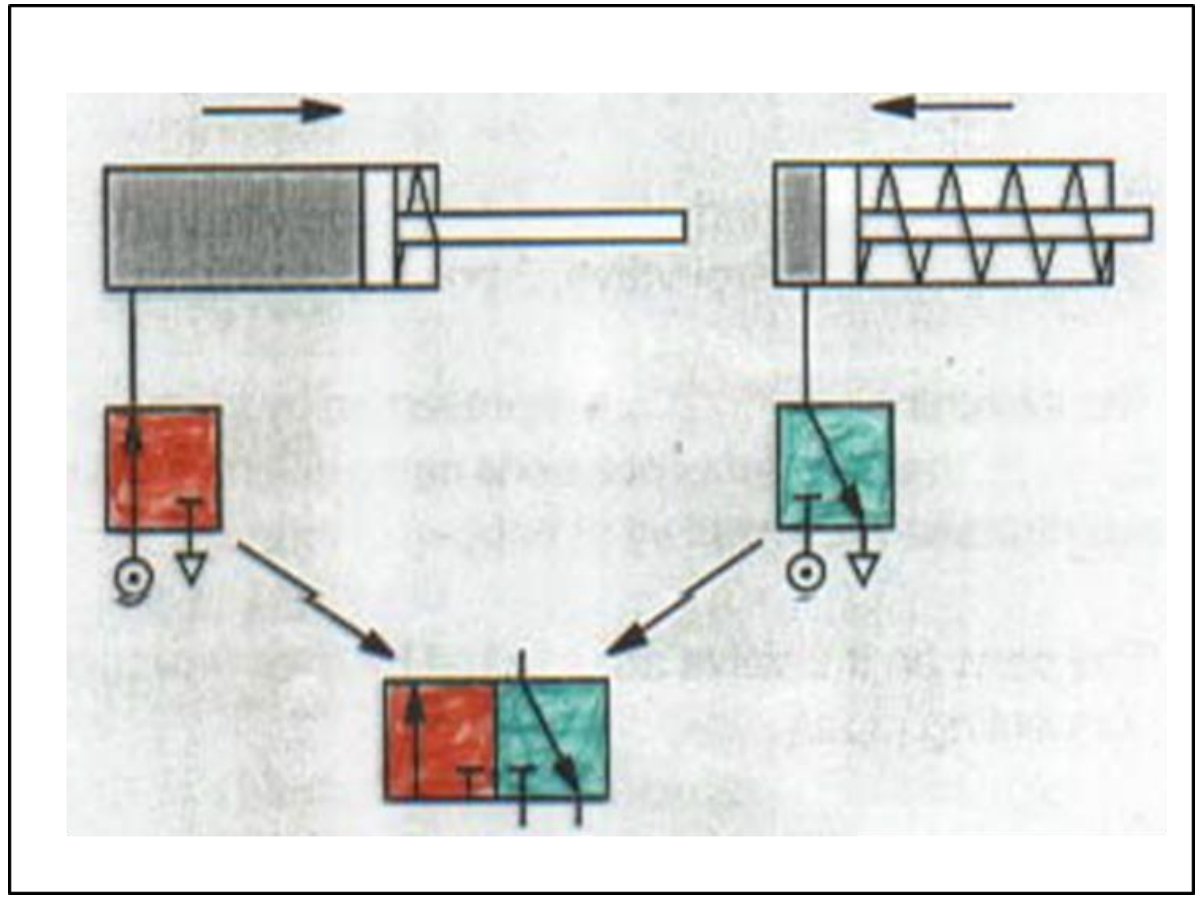
- Easy to produce.
- Compact size.
- Low actuating force required.
- Can be actuated from both sides.
- Long switching strokes.
- Limited tightness.
- Sensitive to dirt.

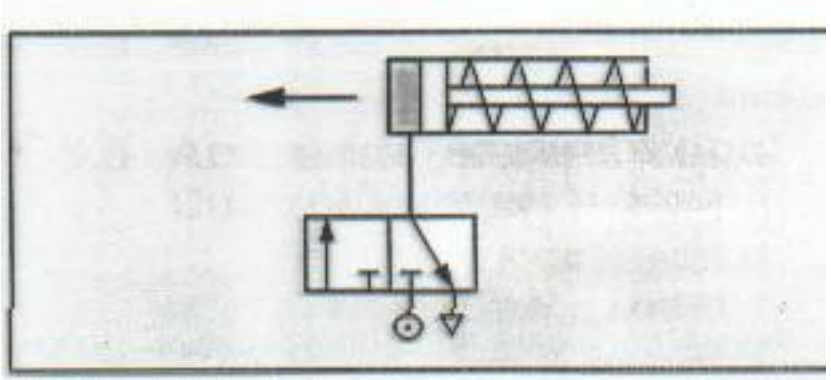


Overlapping

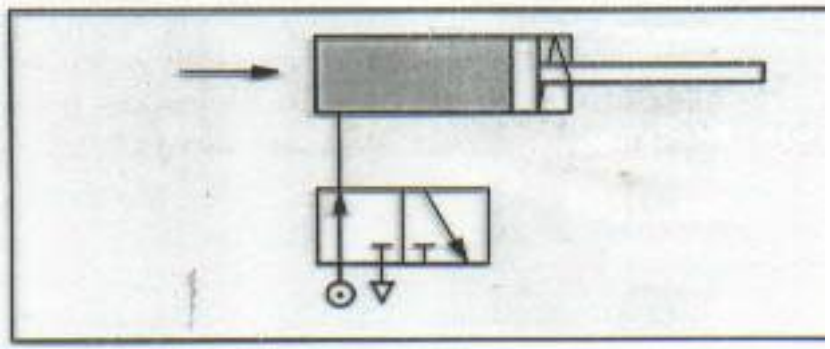
- The term overlapping describes the behavior of the valve during the switch over phase.
- With overlapping if during the switching phase ports A, P, and R are connected.
- Without overlapping, the connection of P to A after closing R.



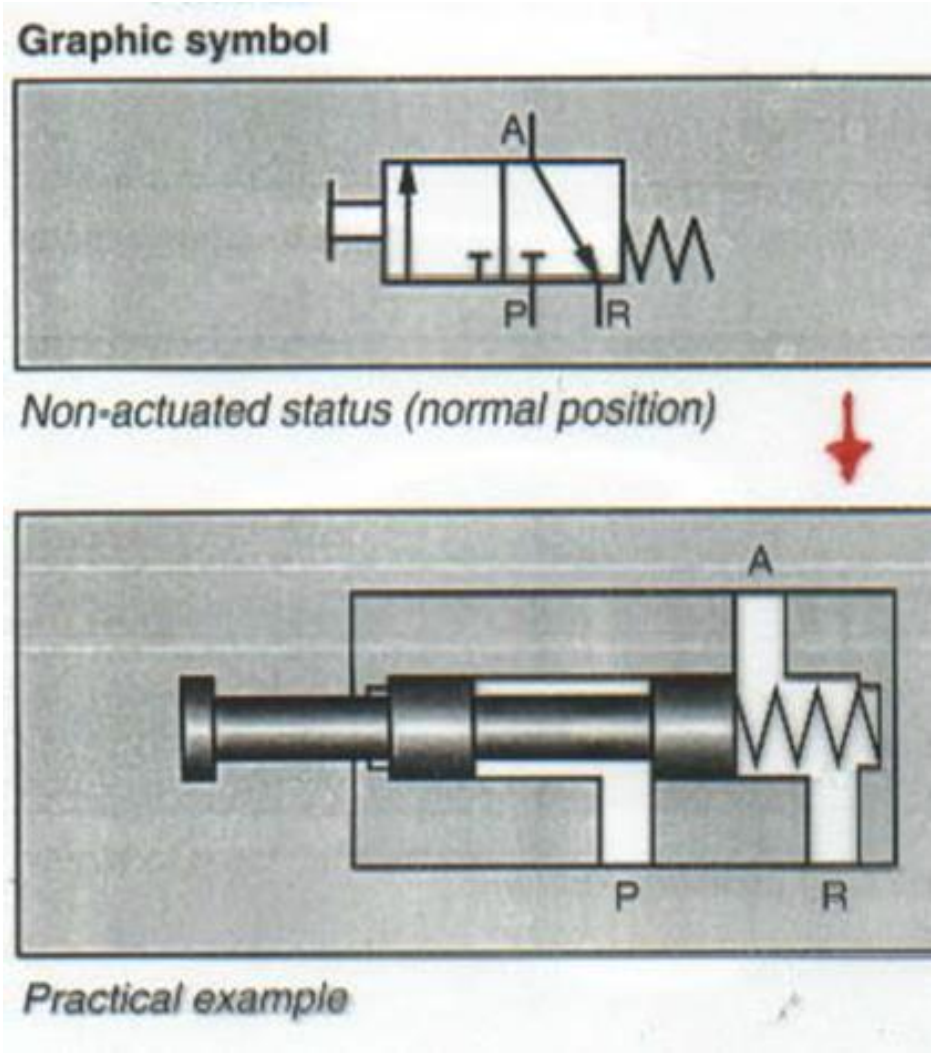


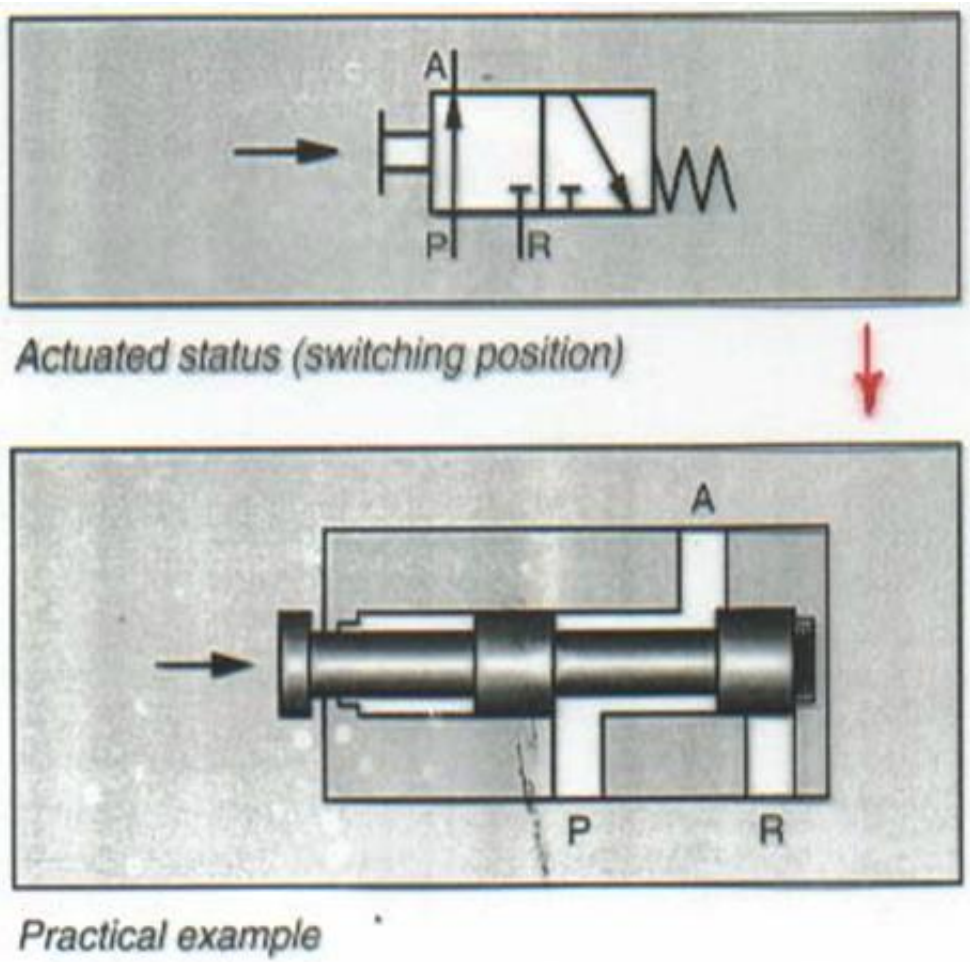


Position "Instroke"

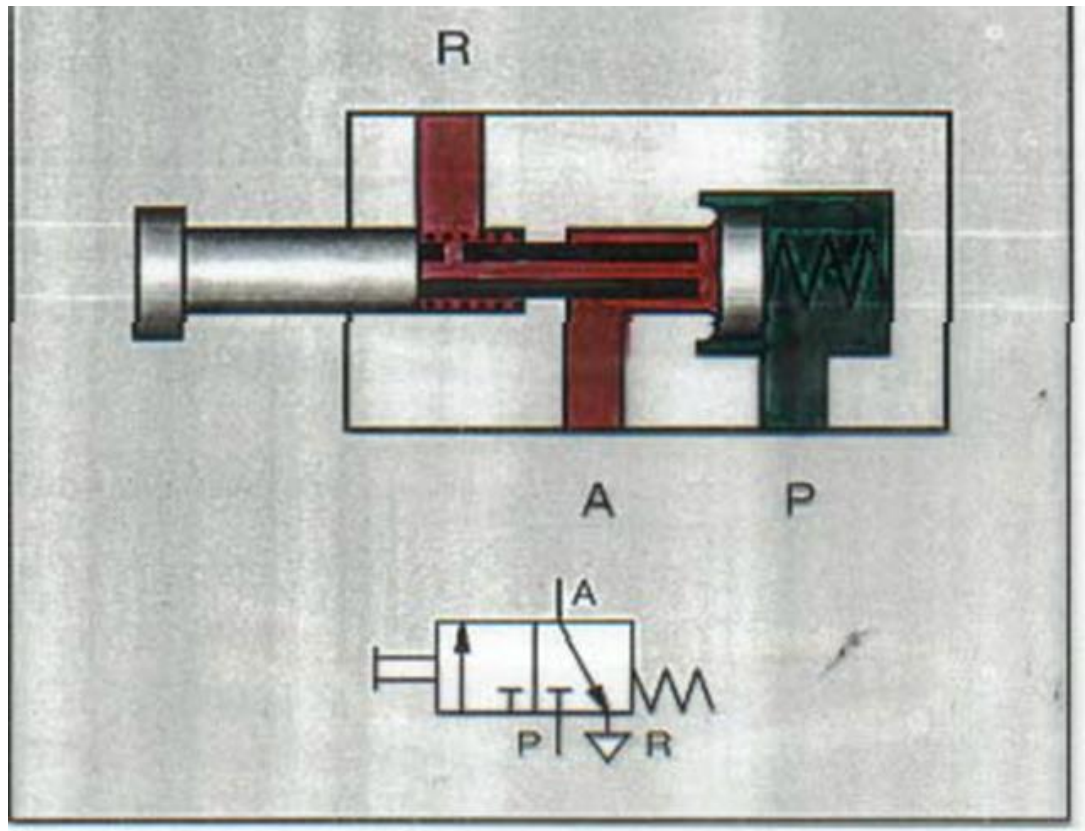


Position "Outstroke"





3/2 Directional Control Valve, Manual operated by push button, normally closed, return by spring, slide valve.



3/2 directional control valve, normally closed, plunger actuated, spring return, poppet valve

Graphical Symbols For Directional Control Valves

- Number of switching positions = Number of squares.
- Number of ports = Number of port marks (main ports only. No control ports are counted)
- Graphical symbols with additional lines = continuously adjustable valve.

Home positions

- Normal Position: The normal position on valves with existing reset, e.g. spring, refers to the switching position assumed by the moving parts of the valve, if the valve is not connected.
- Initial Position: The initial position is the switching position assumed by the moving parts of a valve after the valve has been installed in a system and the system pressure has been switched on and possibly also the electrical voltage, and with which the designated switching program starts.

Valve description

1. Number of ports.
2. Number of switching position.
3. Valve type.
4. Type of actuation.
5. Type of return.
6. Type of mid position sealing.
7. Construction type (If you can)

Valve description

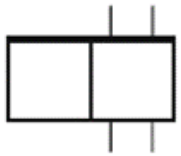
Valve switching positions
are represented as squares

The number of squares shows how many
switching positions the valve has

Lines indicate flow paths,
arrows shows the direction of flow

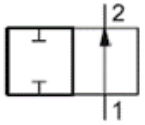
Shut off positions are identified in the boxes
by lines drawn at right angles

The connections (inlet and outlet ports) are shown
by lines on the outside of the box

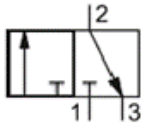


Number of ports
Number of positions

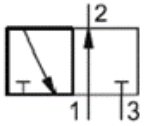
2/2 – Way directional control valve, normally open



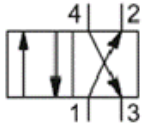
3/2 – Way directional control valve, normally closed



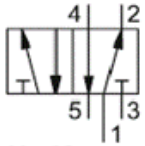
3/2 – Way directional control valve, normally open



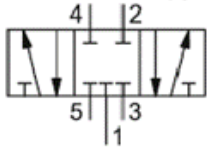
4/2 – Way directional control valve
Flow from 1 → 2 and from 4 → 3



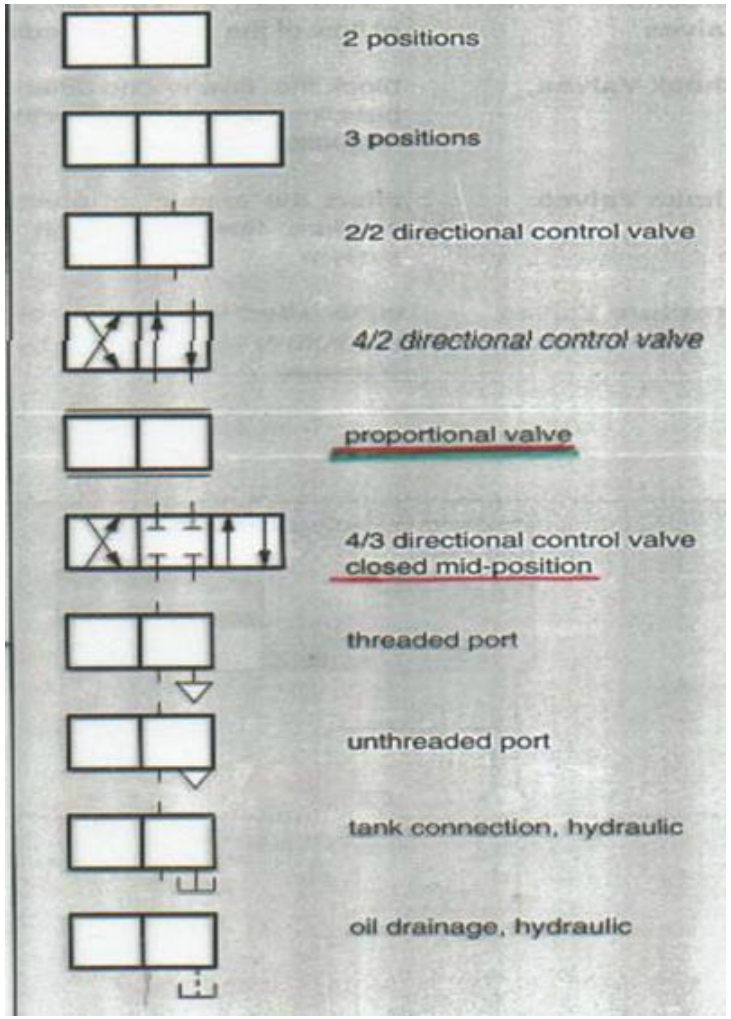
5/2 – Way directional control valve
Flow from 1 → 2 and von 4 → 5

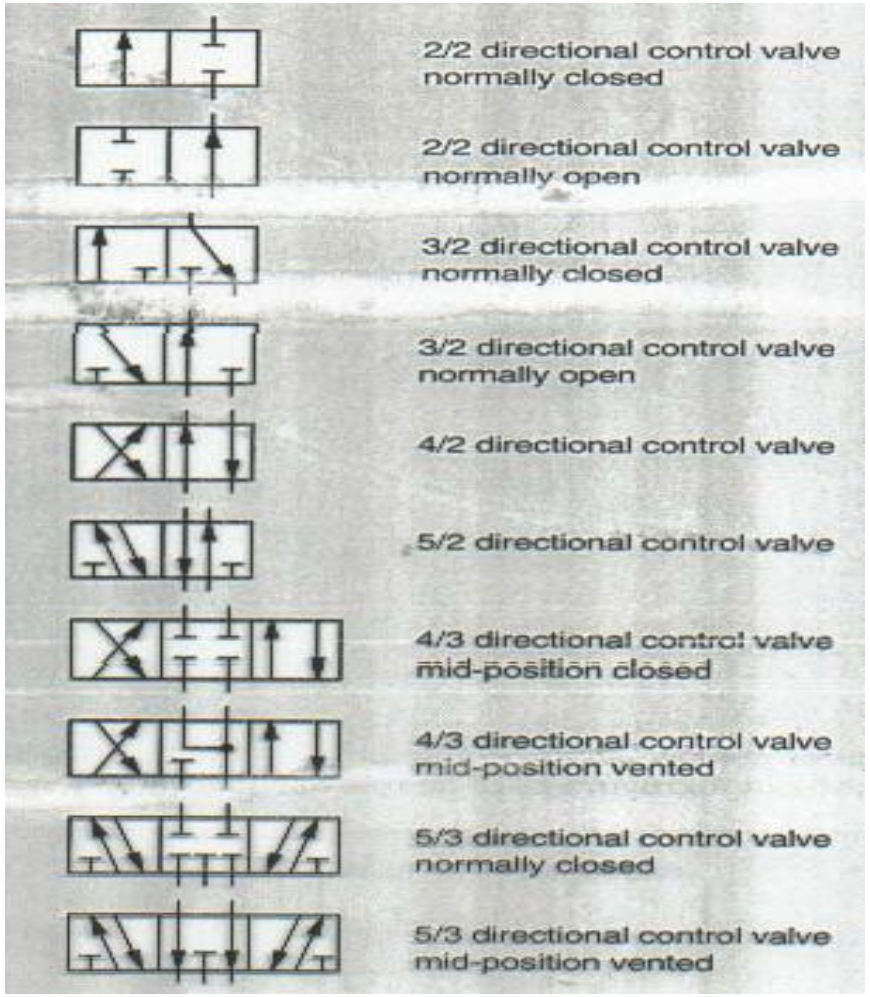


5/3 – Way directional control valve
Mid position closed



Valve description





Valve description

Port Designations	Letters	Digits
Working ports	A, B ...	2, 4 ...
Supply port	P	1
Exhaust/tank piping	R, S, T	3, 5
Hydraulic leakage ports	L	-
Pilot ports	X, Y, Z	10, 12, 14

Working lines

ISO 5599-3	Lettering System	Port or Connection
1	P	Pressure port
2, 4	A, B	Working lines
3, 5	R, S	Exhaust ports

Pilot lines

10	Z	Applied signal inhibits flow from port 1 to port 2
12	Y, Z	Applied signal connects port 1 to port 2
14	Z	Applied signal connects port 1 to port 4
81, 91	Pz	Auxiliary pilot air

Valve description

Manually operated

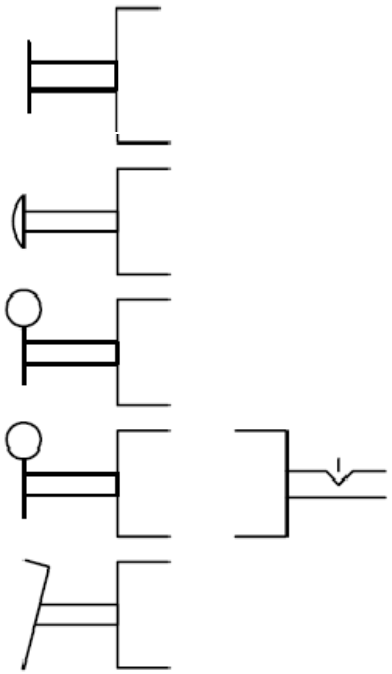
General

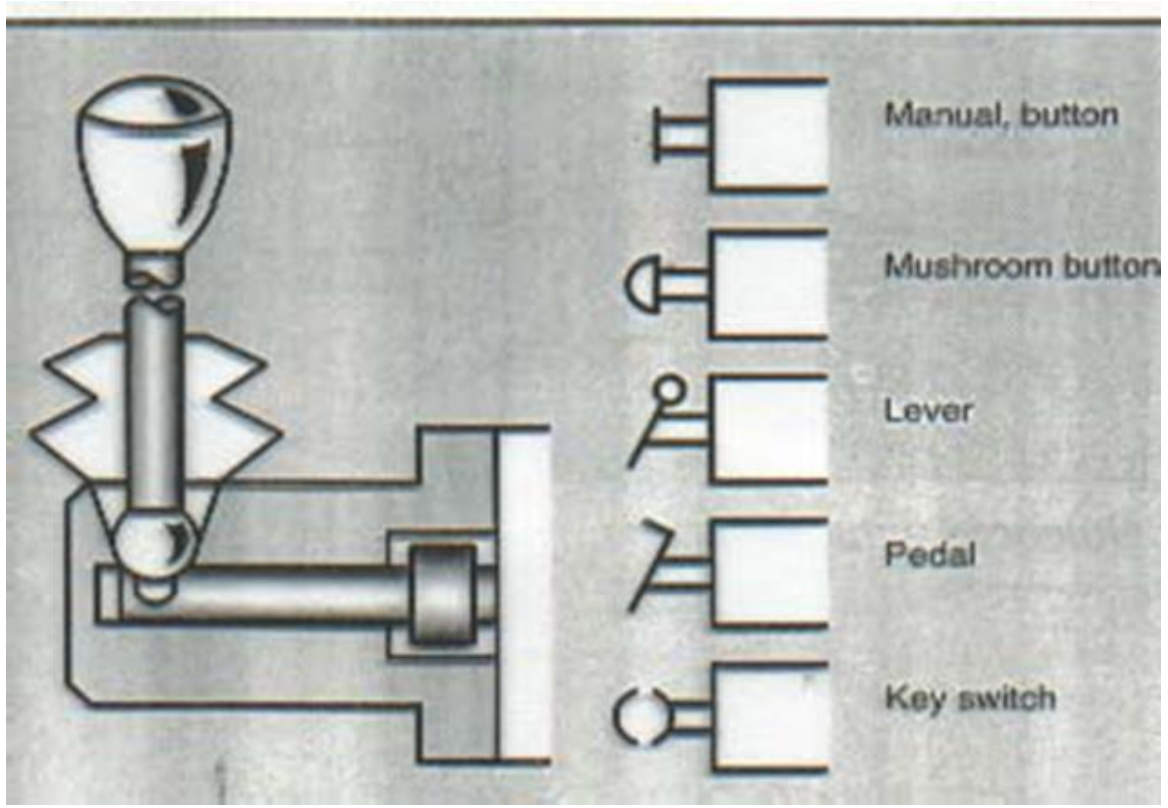
Pushbutton

Lever Operated

Detend lever operated

Foot pedal





Valve description

Mechanically operated

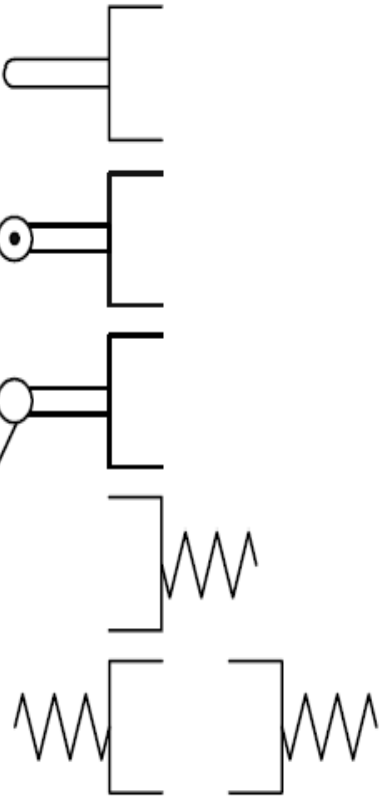
Plunger

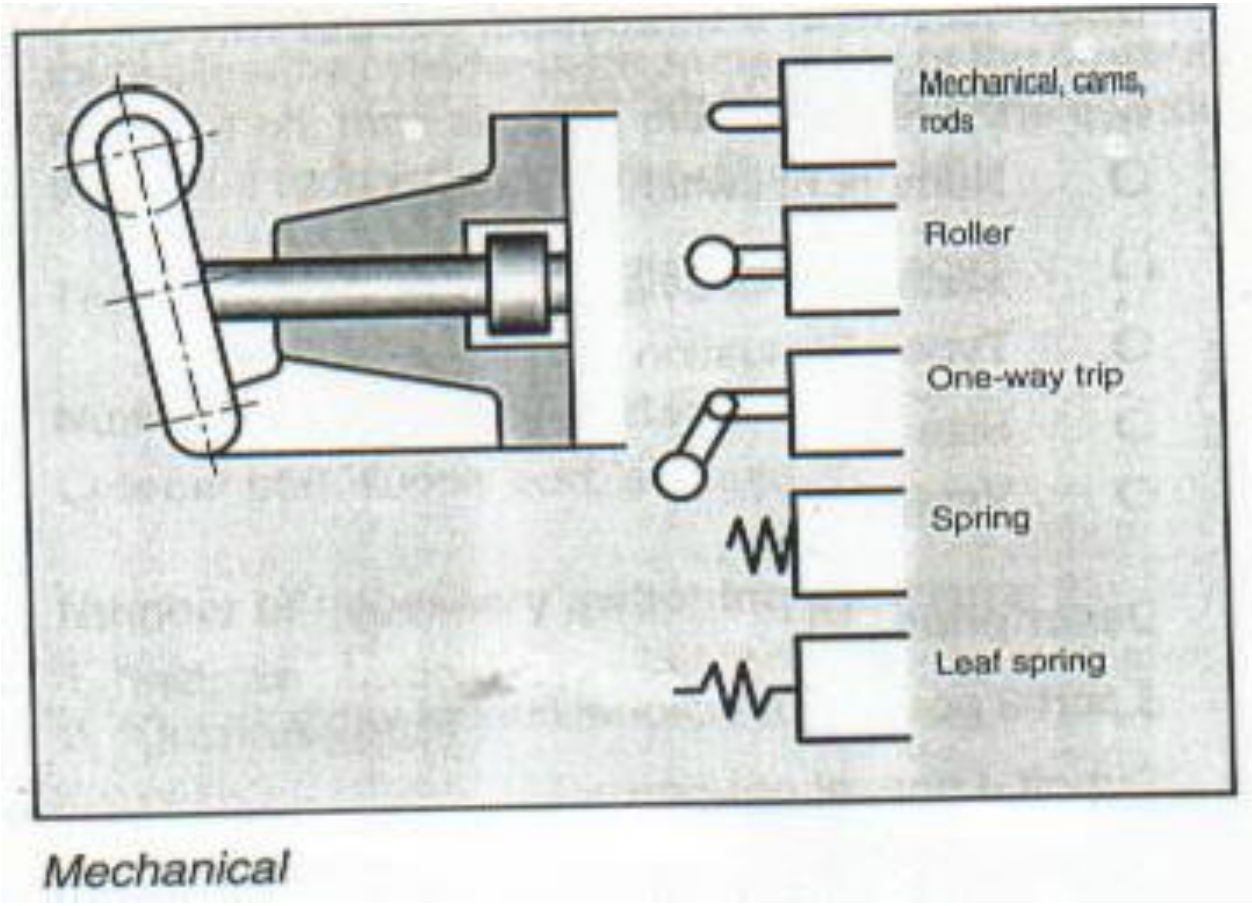
Roller operated

Idle return, roller

Spring return

Spring centred



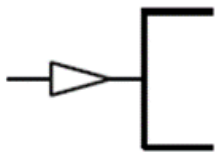


Mechanical

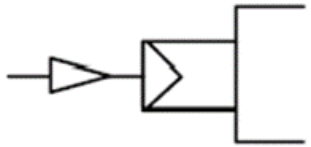
Valve description

Pilot operated

Direct pneumatic actuation

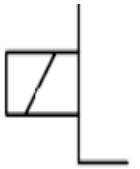


Indirect pneumatic actuation (piloted)



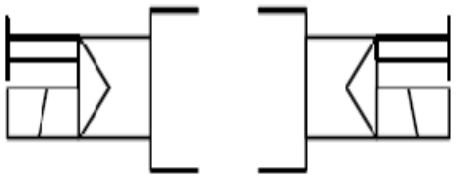
Electrical operated

Single solenoid operation

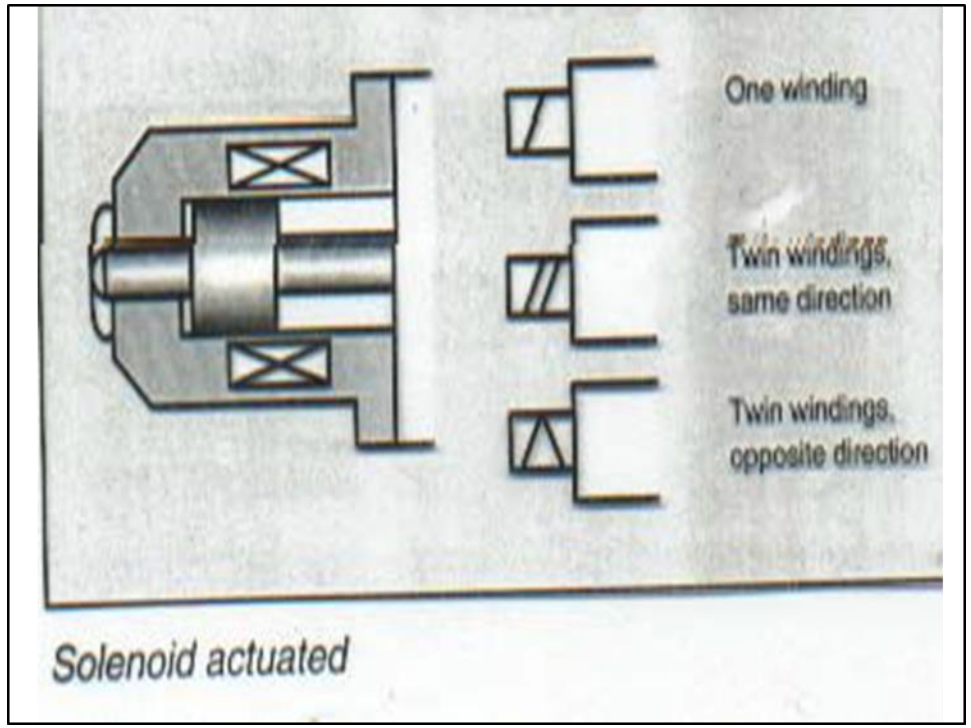


Double solenoid operation

Double solenoid and pilot operation with manual override

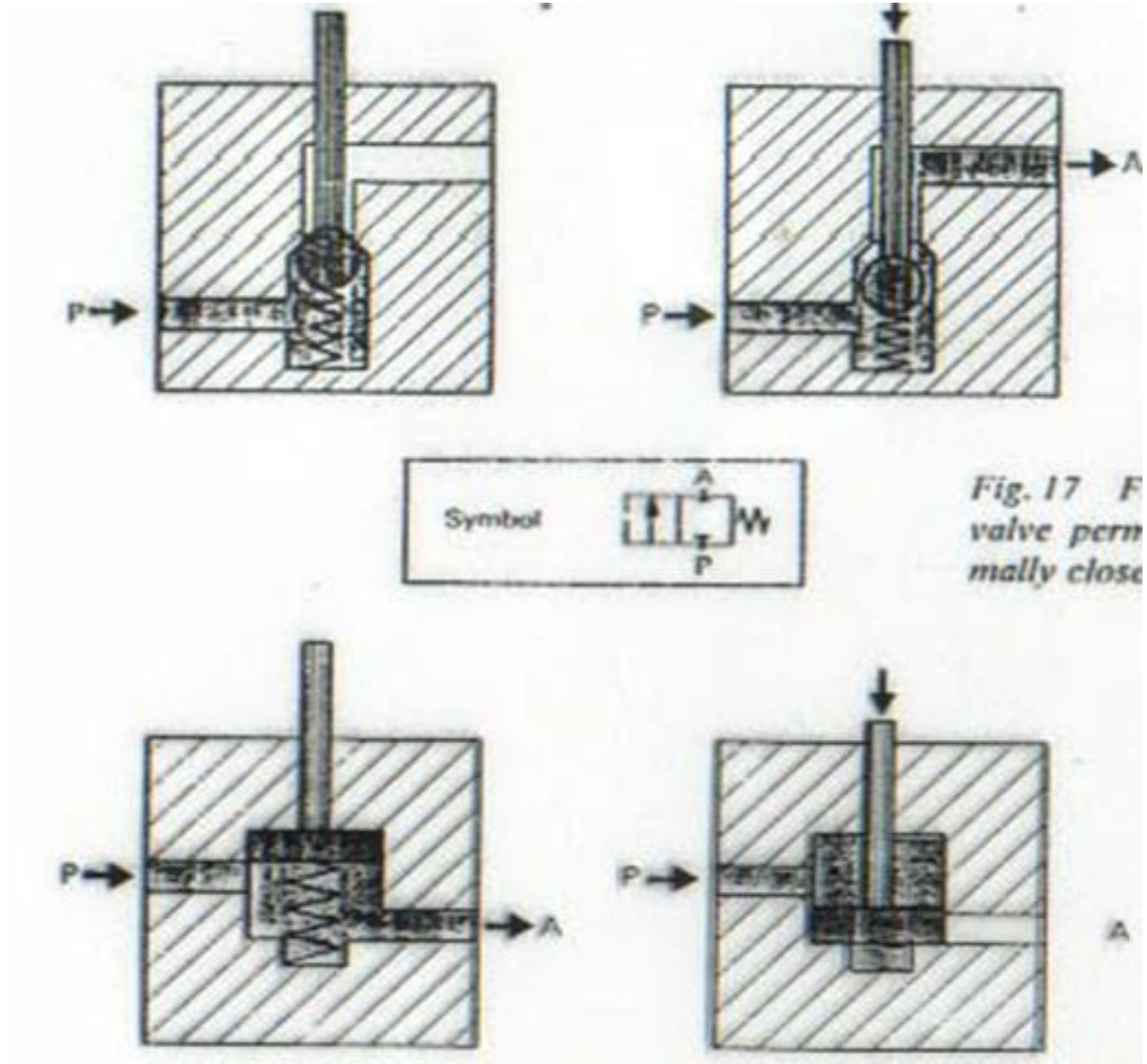


Valve description

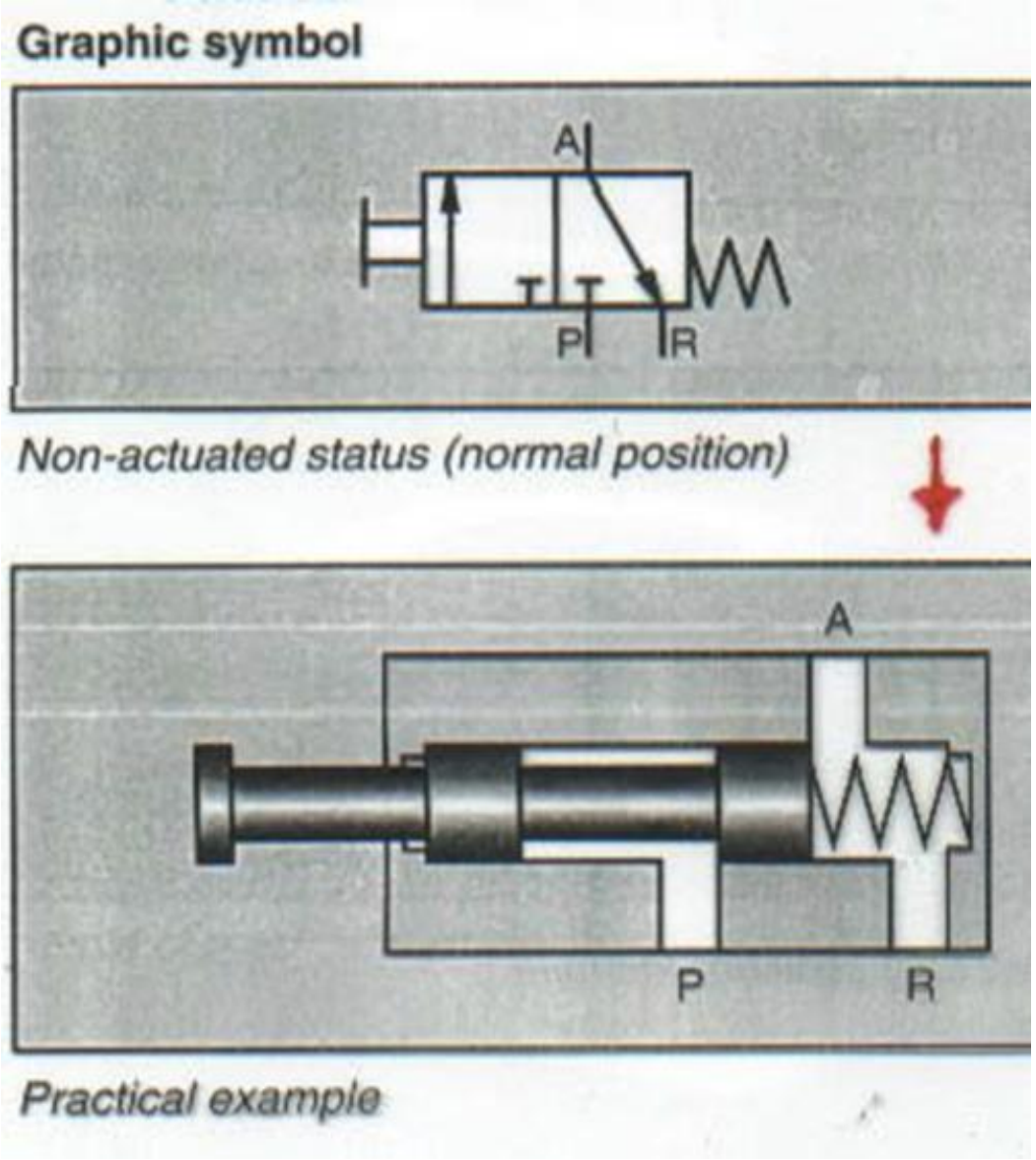


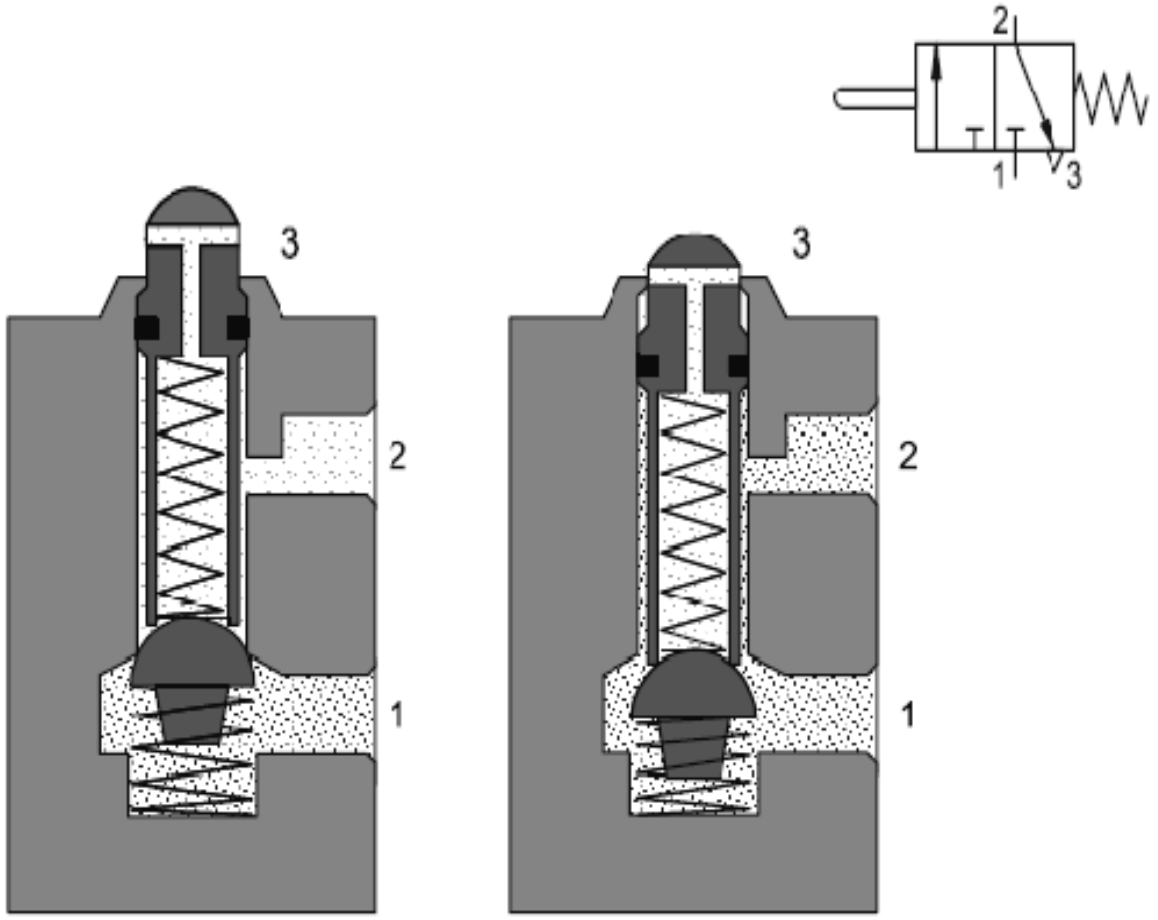
2/2 Directional Control Valve (On-Off Valve)

The 2/2-way valve has two ports and two positions (open, closed).
It is rarely used except as an on-off valve, since its only function is to enable signal flow through and cannot release the air to atmosphere once in the closed position in contrast to the 3/2-way valve.
The 2/2-way valve is normally of the ball seat construction.
This valve can be operated either manually, mechanically or pneumatically.

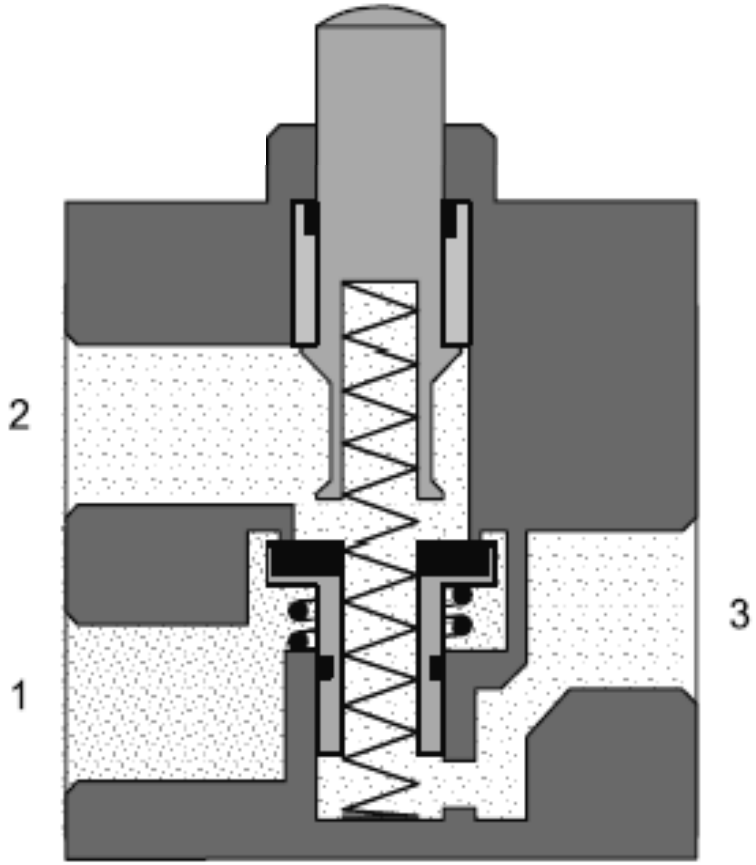


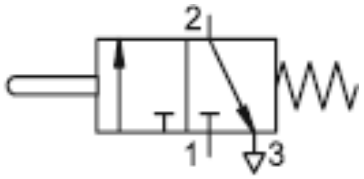
3/2 Directional Control Valve





3/2 Directional Control Valve





The valve shown here is constructed on the disc seat principle.

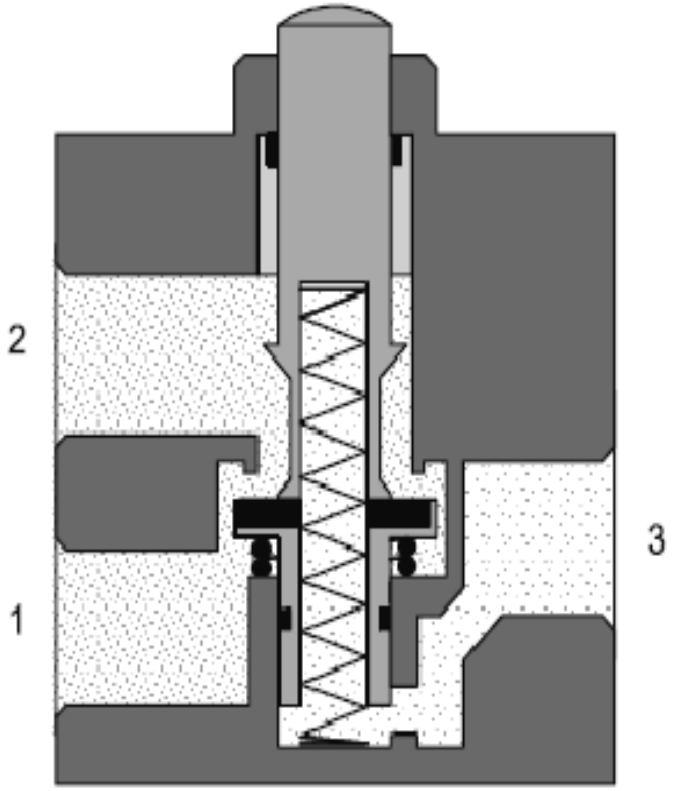
The sealing is simple but effective.

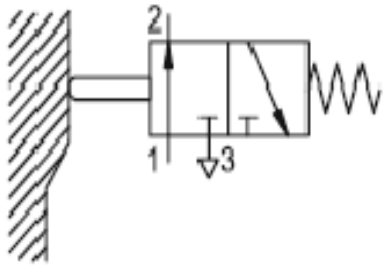
The response time is short and a small movement results in a large cross- sectional area being available for air flow.

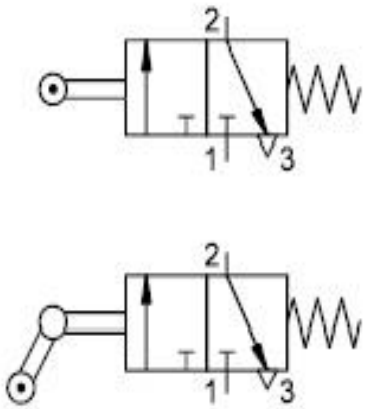
Like the ball seat valves, they are insensitive to dirt and thus have a long service life.

The 3/2-way valves are used for controls employing single-acting cylinders or for generating signals supplied to control elements.

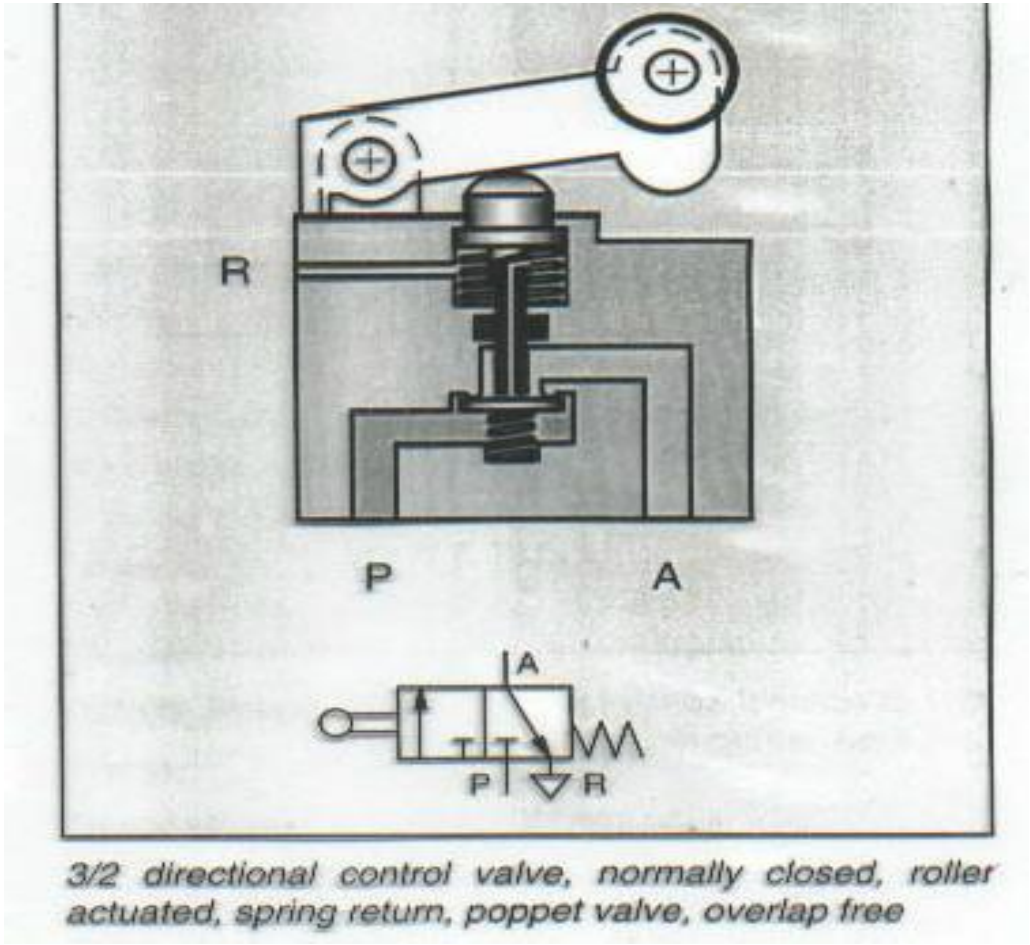
3/2 Directional Control Valve



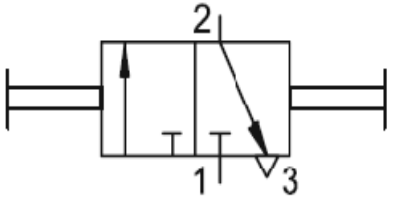


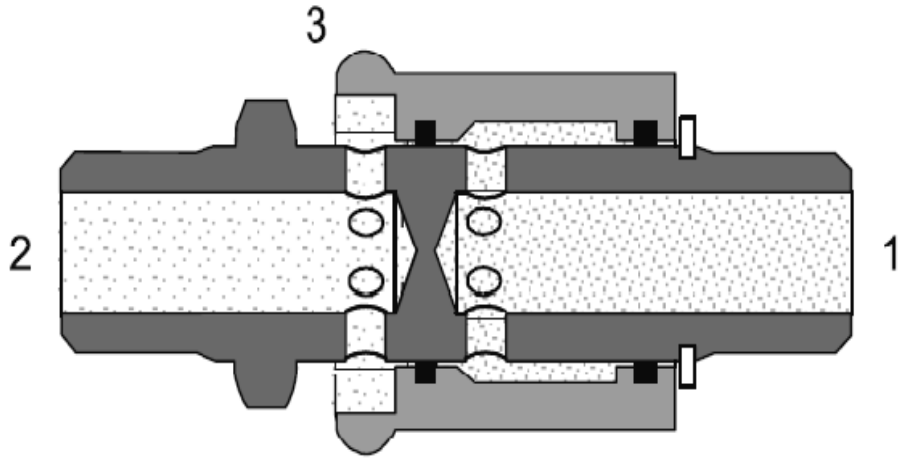


3/2 Directional Control Valve



3/2 directional control valve, normally closed, roller actuated, spring return, poppet valve, overlap free





3/2 Directional Control Valve

The construction of the valve is simple. Actuation is effected by displacing the grip sleeve lengthwise.

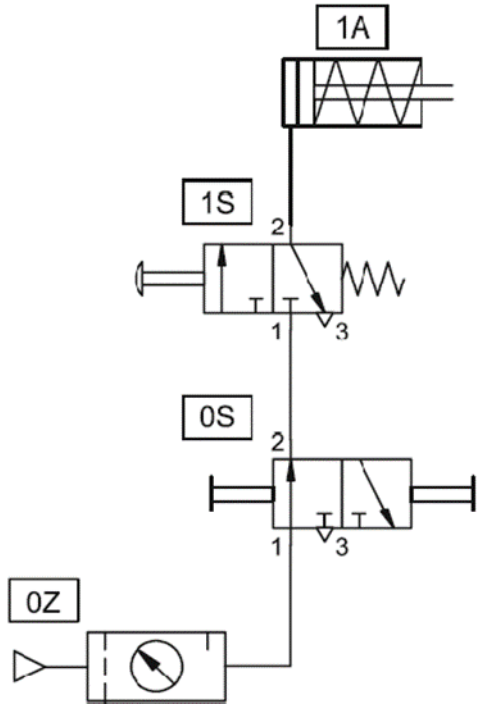
This valve is used as a shut-off valve, primarily for the pressurising and exhausting of control systems or system components.

In the actuated state, connection 1 and 2 are connected and the valve is switched to flow.

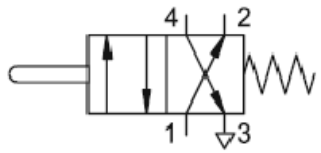
The valve is actuated either manually or mechanically.

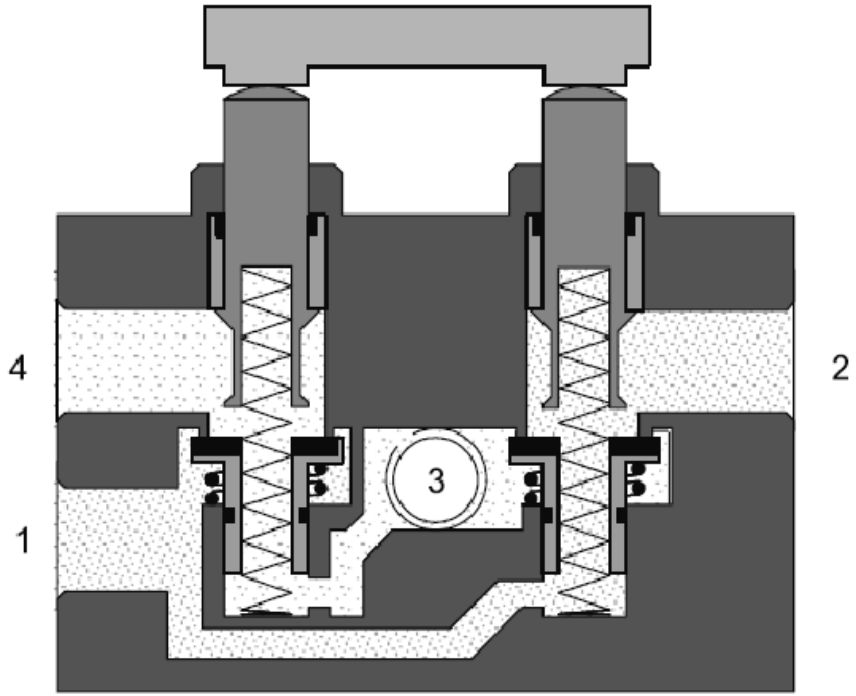
The actuation force required is dependent on the supply pressure, spring force and the friction in the valve.

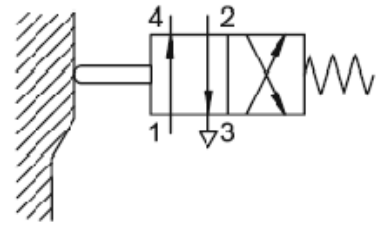
The actuation force limits the feasible size of the valve. The construction of the ball seat valve is very simple and compact.

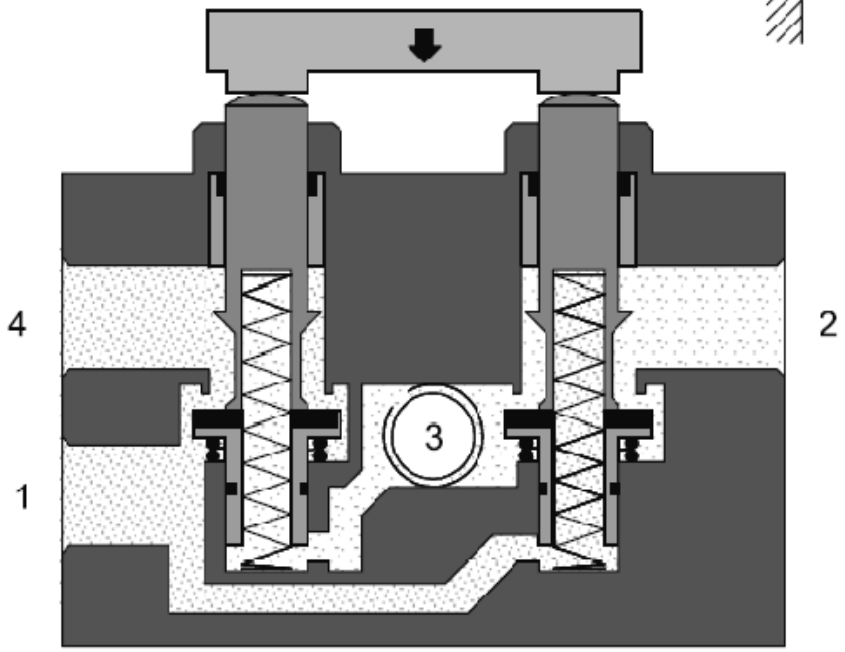


4/2 Directional Control Valve









4/2 Directional Control Valve

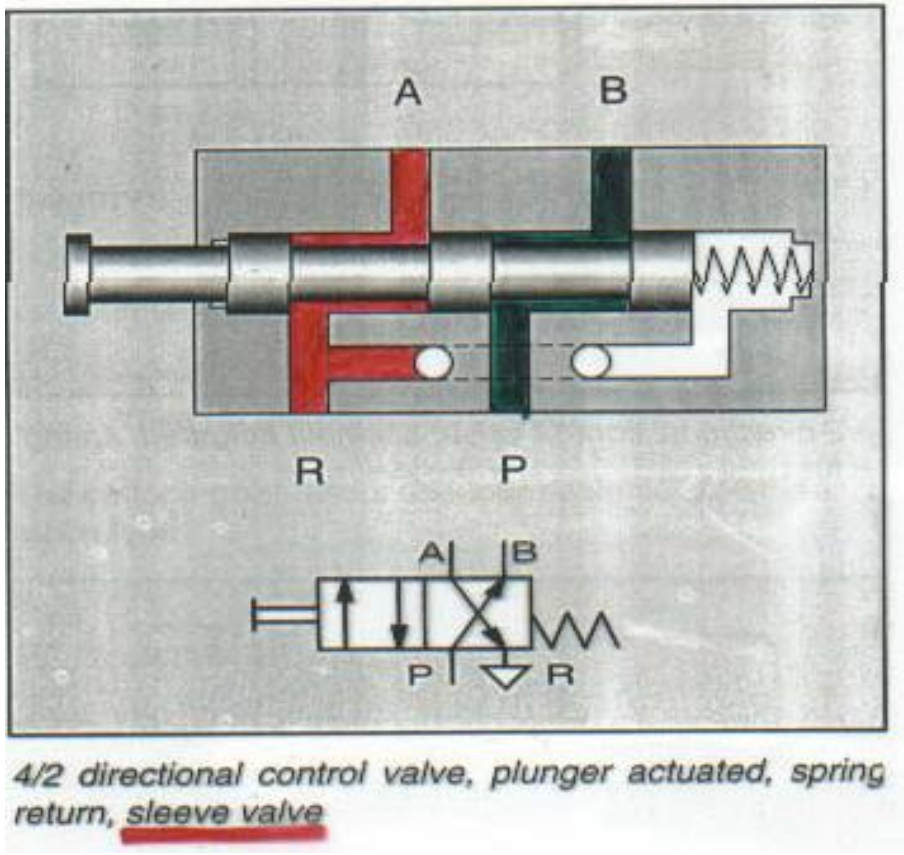
Actuation of the valve: When the two plungers are actuated simultaneously, 1 to 2 and 4 to 3 are closed by the first movement. By pressing the valve plungers further against the discs, opposing the reset spring force, the passages between 1 to 4 and from 2 to 3 are opened.

The valve has a non- overlapping exhaust connection and is returned to its start position by the spring.

The valves are used for controls employing double-acting cylinders.

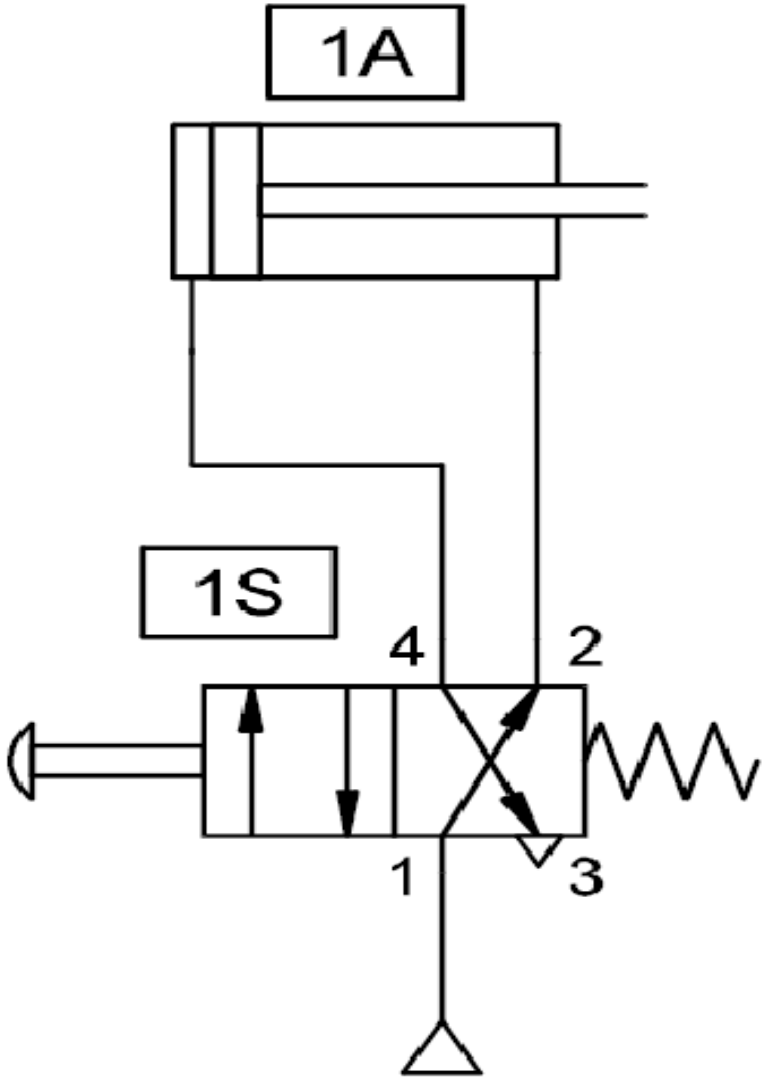
There are other actuating methods and types of construction available for the 4/2-way valve including push button, single air pilot, double air pilot, roller lever actuated, spool and sliding plate.

In the main, the 4/2- way valve is utilised in similar roles as the 5/2-way valve.

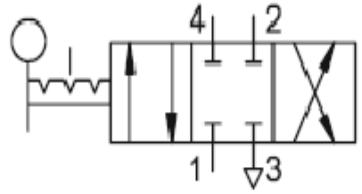


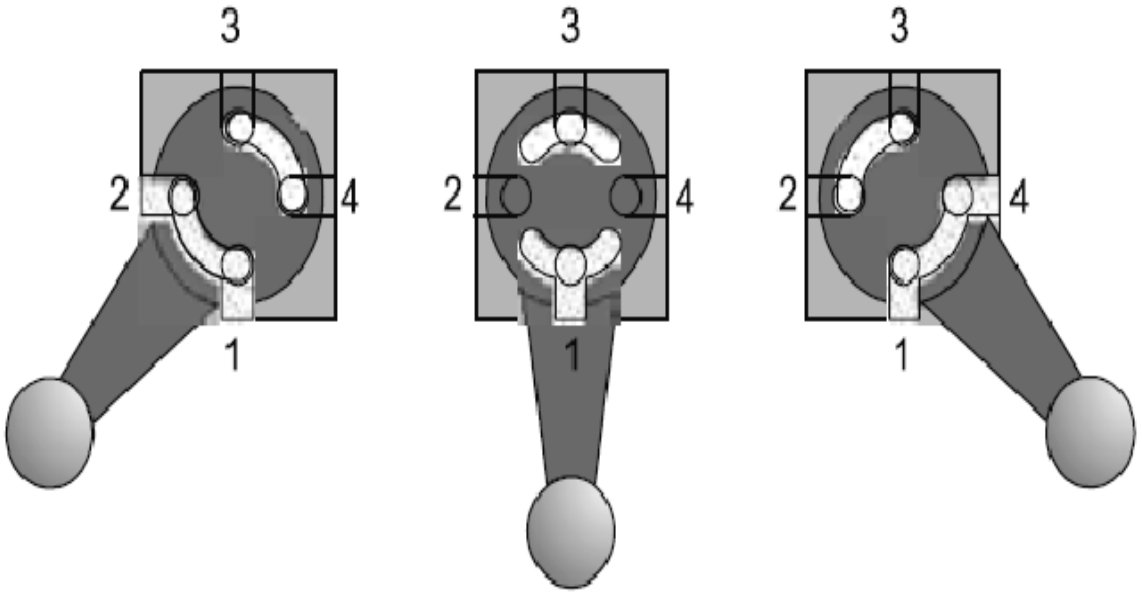
4/2 directional control valve, plunger actuated, spring return, sleeve valve

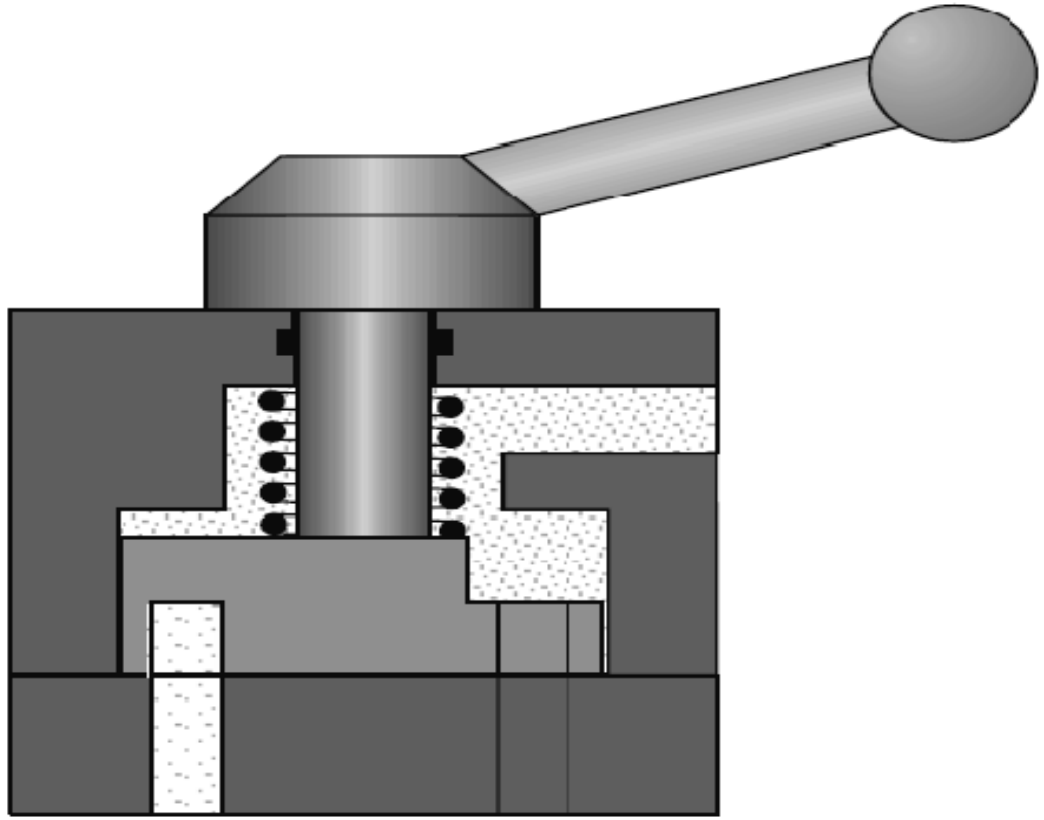
4/2 Directional Control Valve



4/3 Directional Control Valve



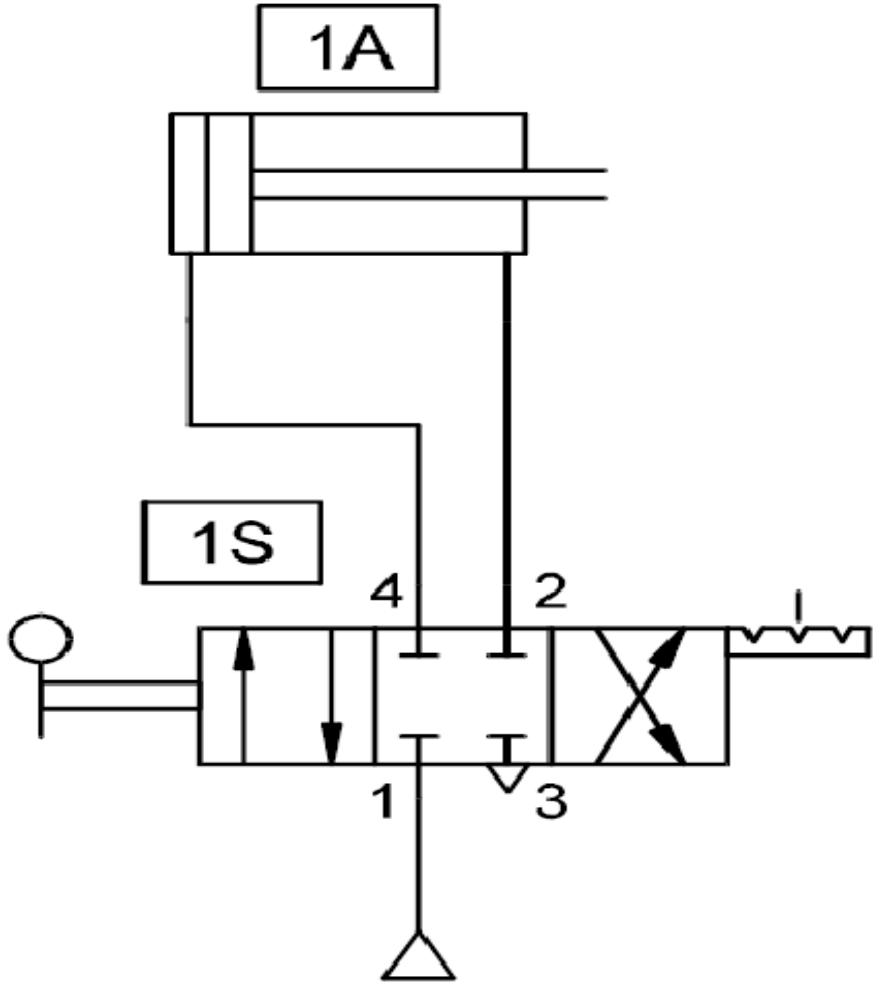




4/3 Directional Control Valve

In this circuit diagram the lines of the 4/3-way valve are closed in the middle position.

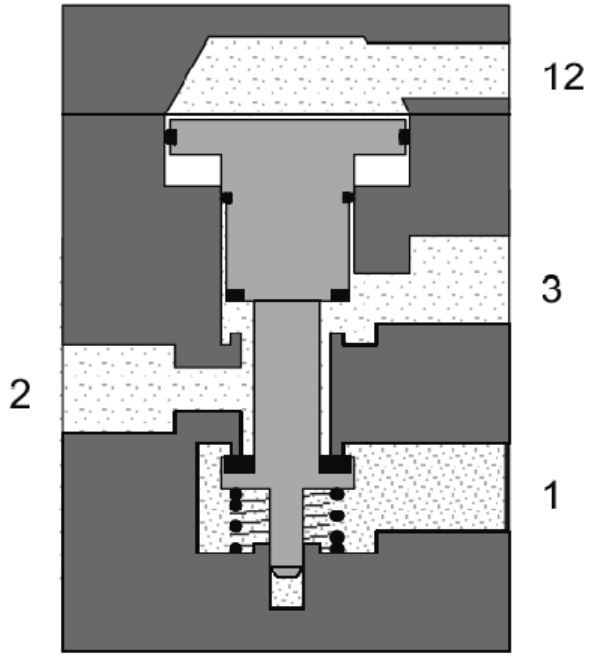
- This enables the piston rod of a cylinder to be stopped in any position over its stroke range, although intermediate positions of the piston rod cannot be located with accuracy.
- Owing to the compressibility of air, another position will be assumed if the load on the piston rod changes.

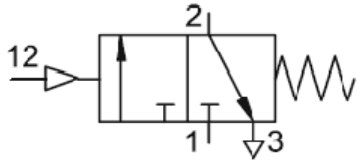


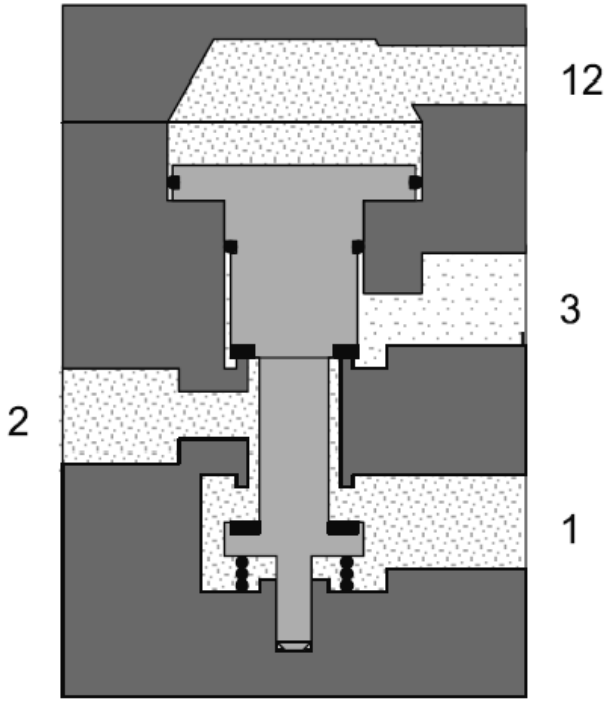
Indirect Control (Piloted Operated)

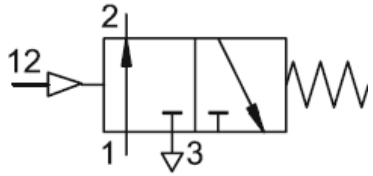
- Piloted valves are not actuated directly but they are controlled by a pressure signal. The main valve is actuated by the pressure of the medium to be controlled. The purposes of piloted valves are:
- Reduce the actuating force (also with large diameter).
- Minimum pressure necessary.
- Allow the use of smaller solenoid size.
- (Note: the piloted valve has a longer switching time than with directly actuated valves).

Indirect Control (Piloted Operated)

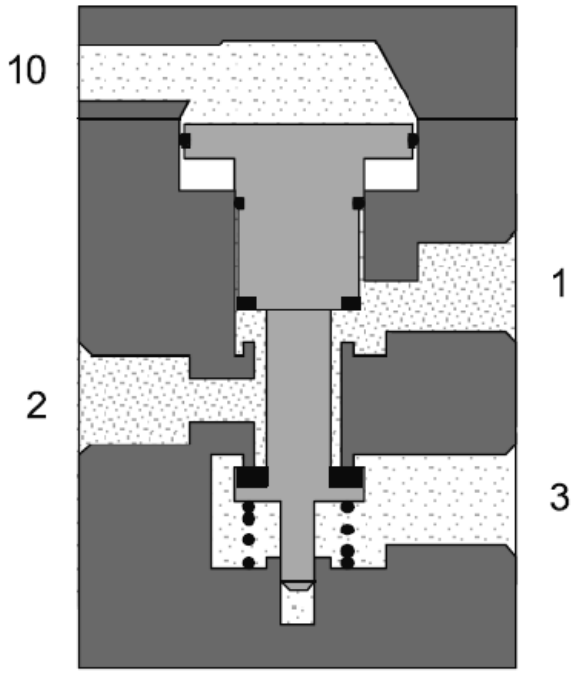


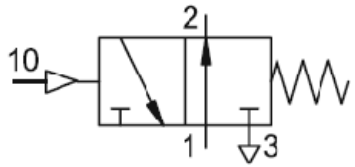


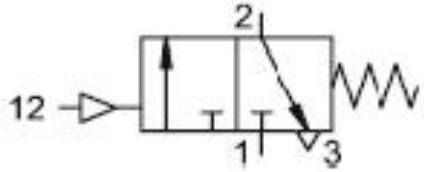




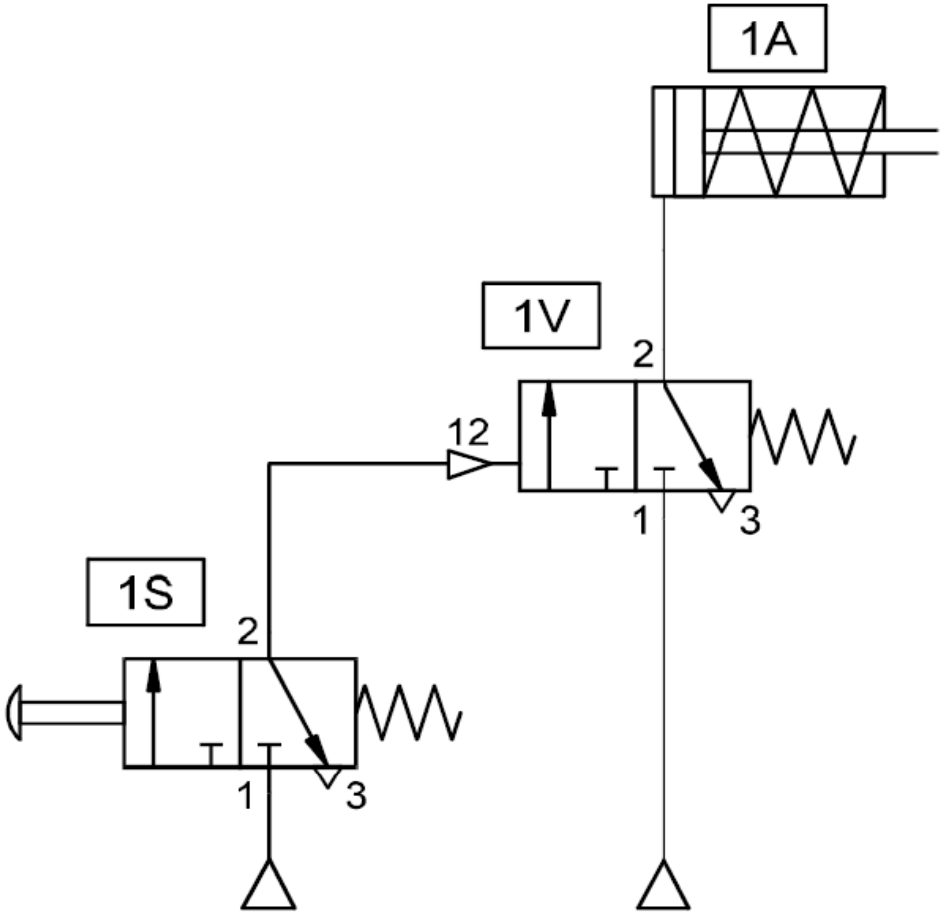
Indirect Control (Piloted Operated)

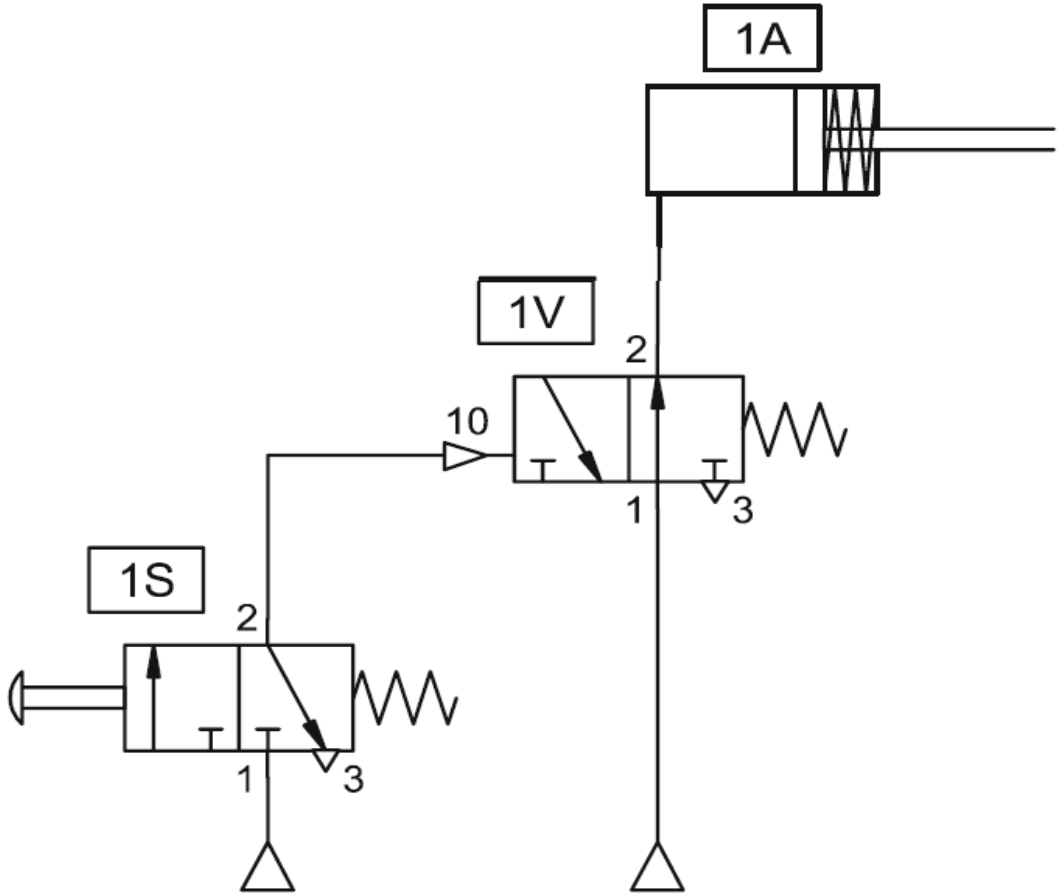




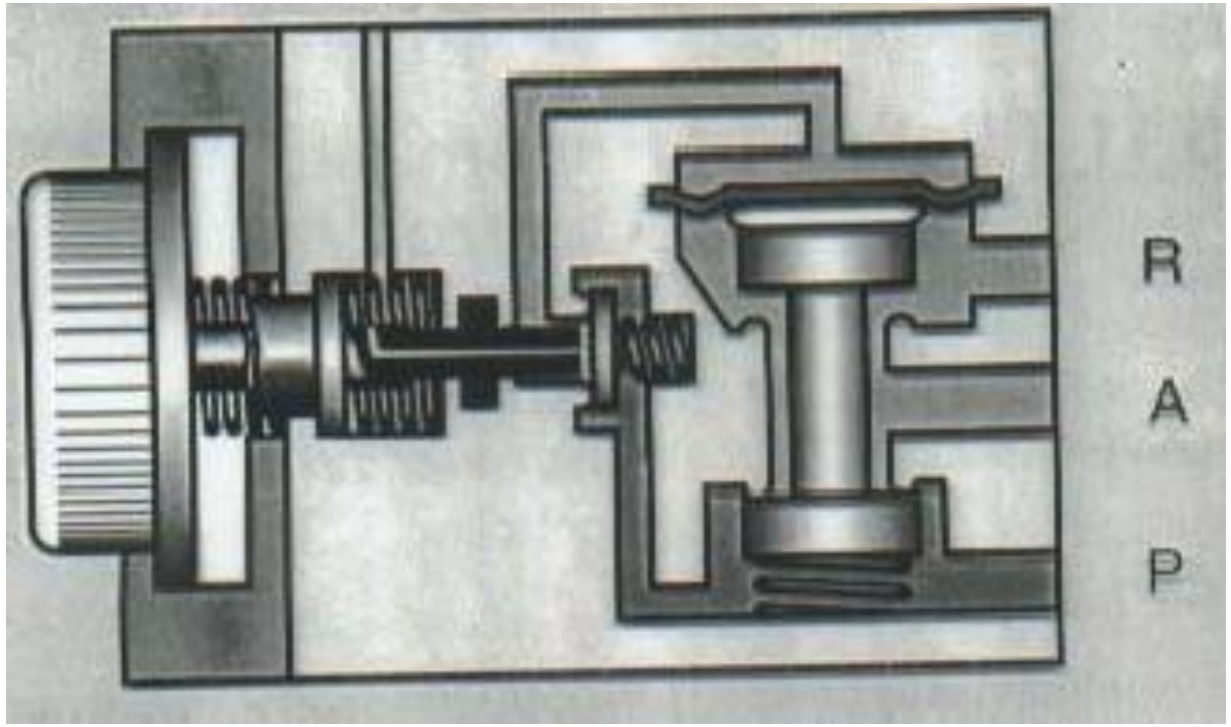


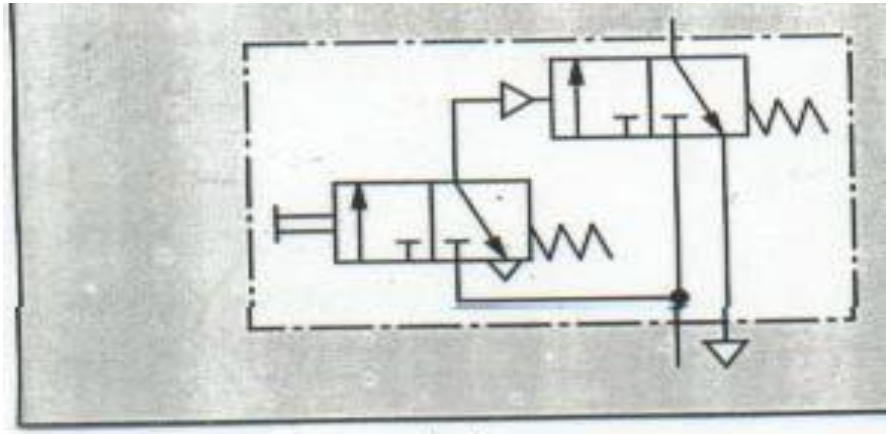
Indirect Control (Piloted Operated)



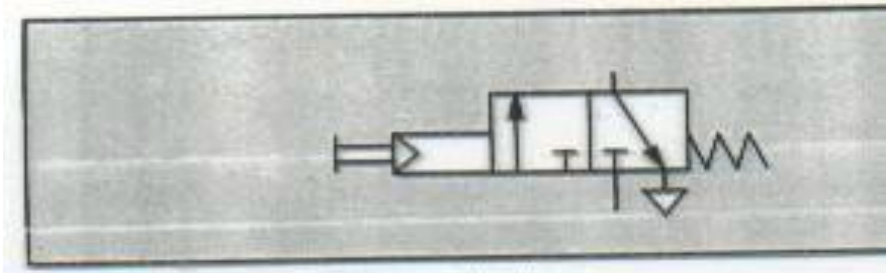


Indirect Control (Piloted Operated)



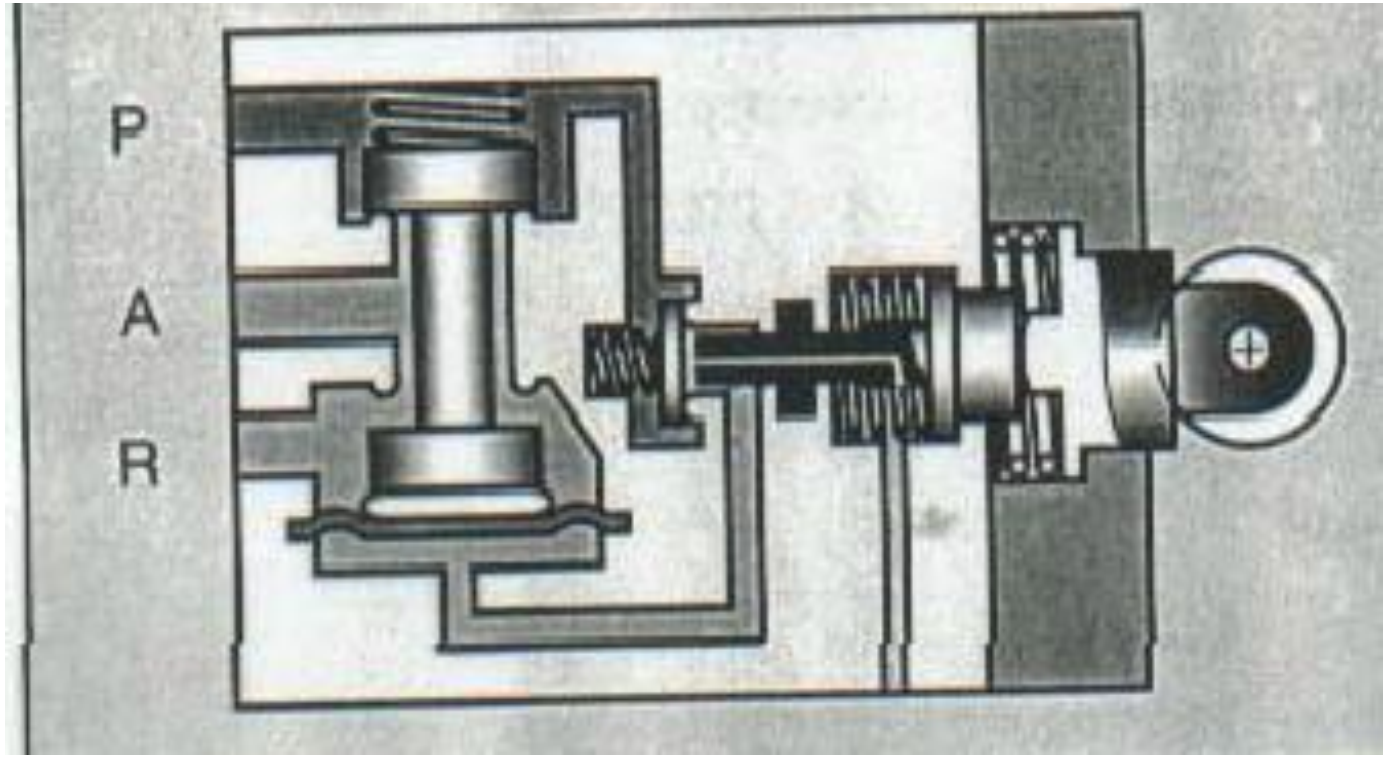


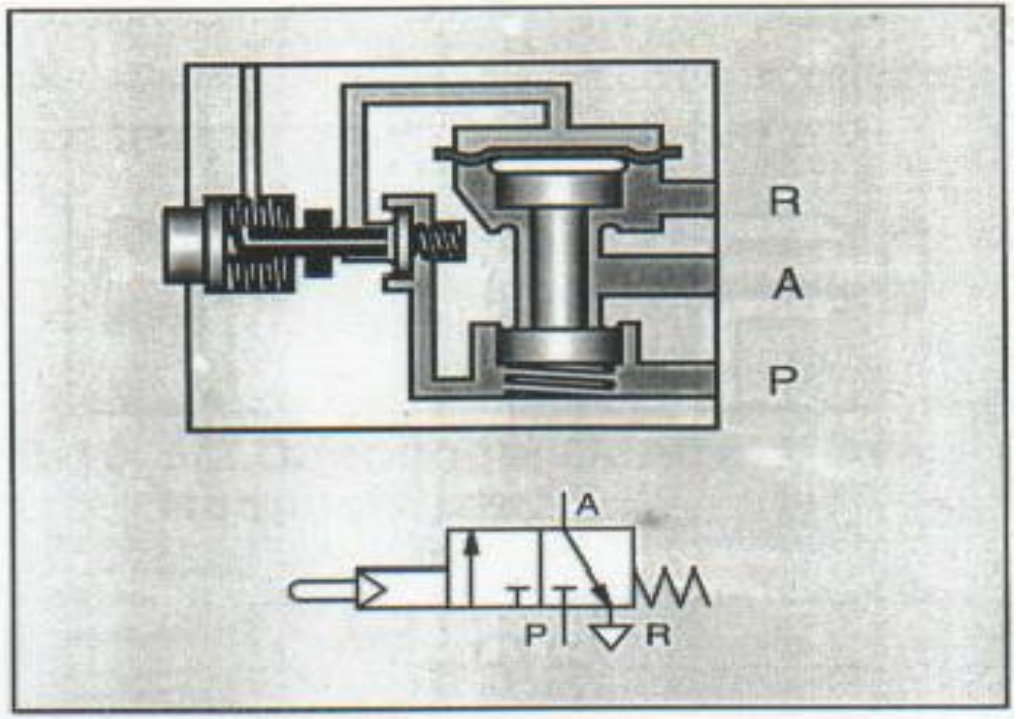
Detailed graphic symbol



Simplified graphic symbol

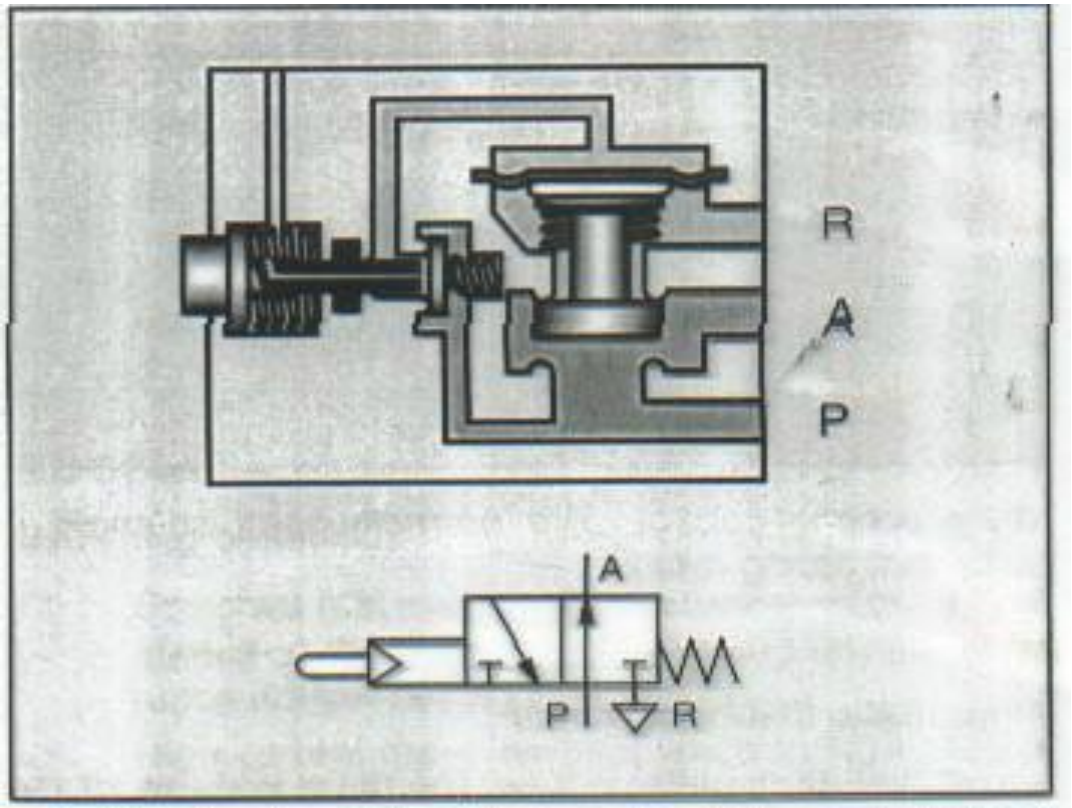
Indirect Control (Piloted Operated)



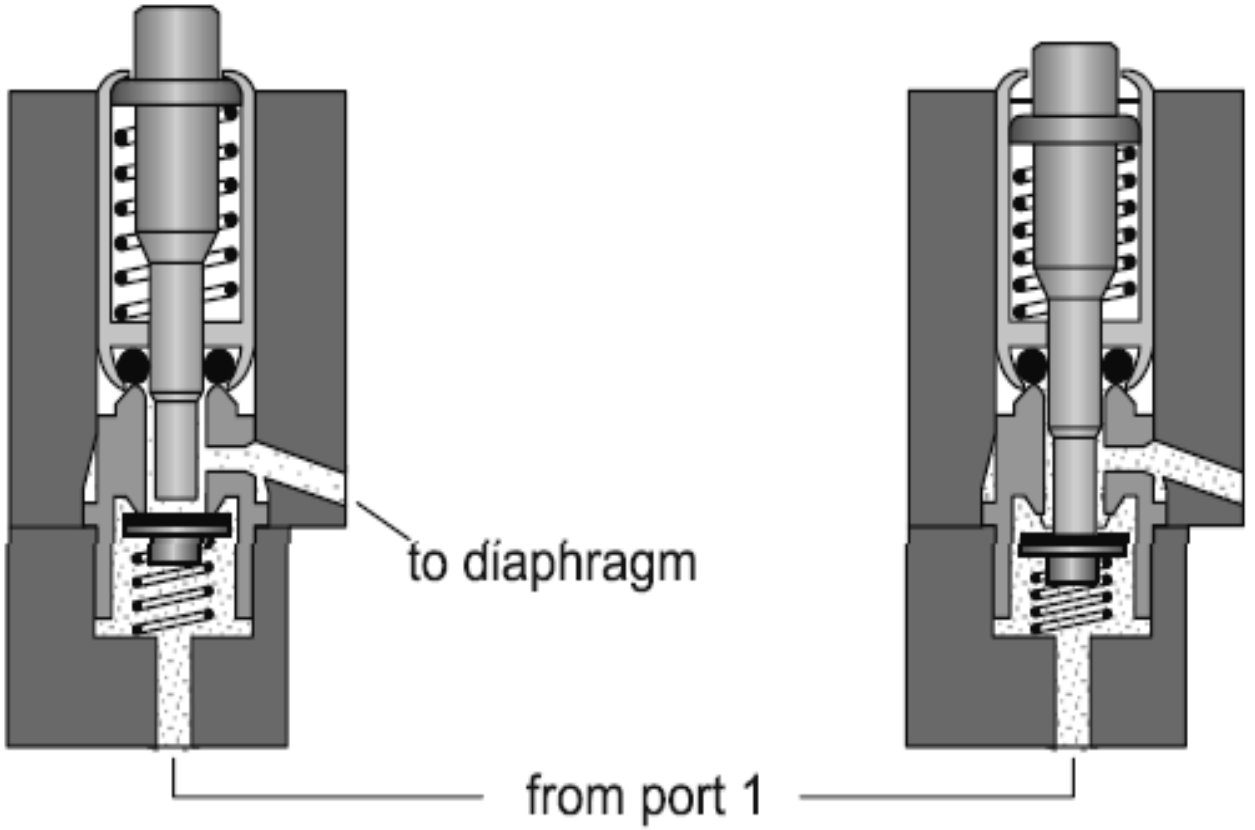


3/2 directional control valve, normally closed, mechanically actuated, piloted, spring return, poppet valve, not overlap free

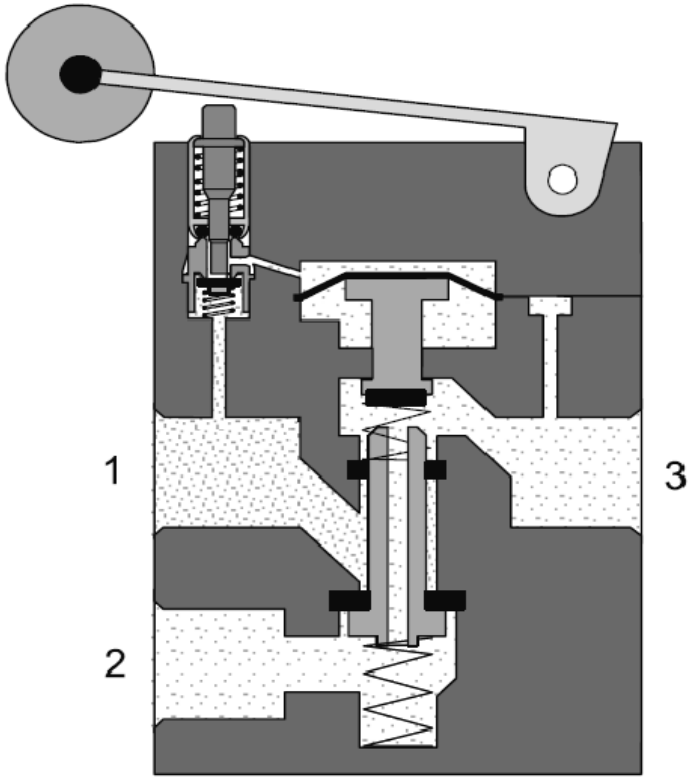
Indirect Control (Piloted Operated)

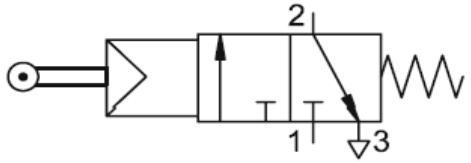


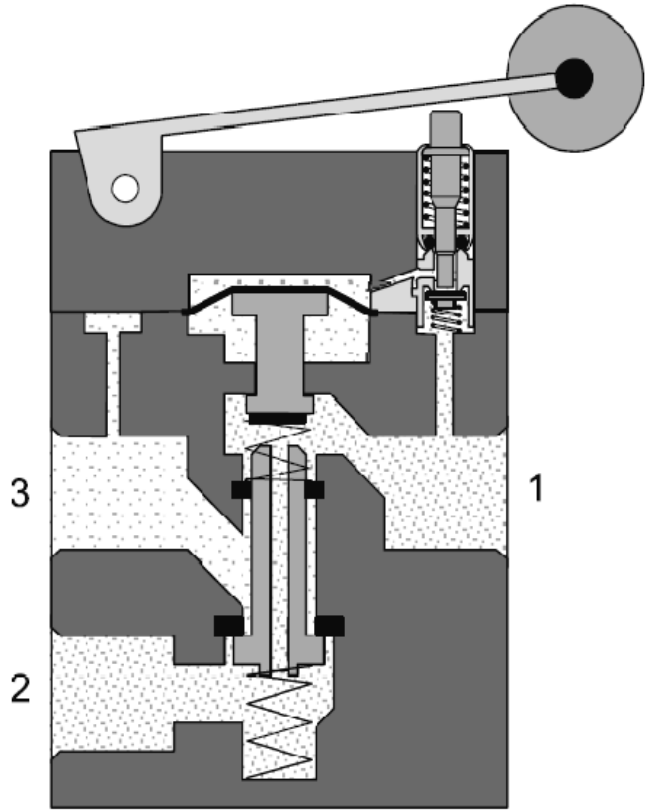
3/2 directional control valve, normally open, mechanically actuated, piloted, spring return, poppet valve, not overlap free

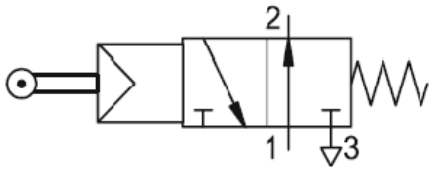


Indirect Control (Piloted Operated)

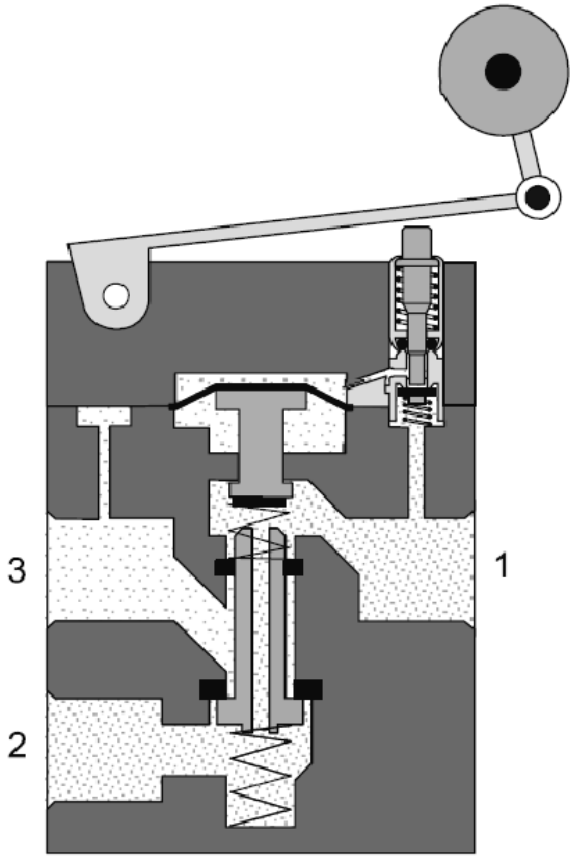


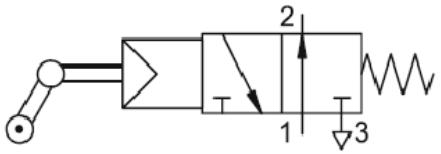


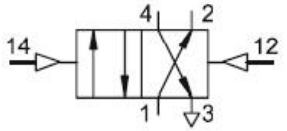


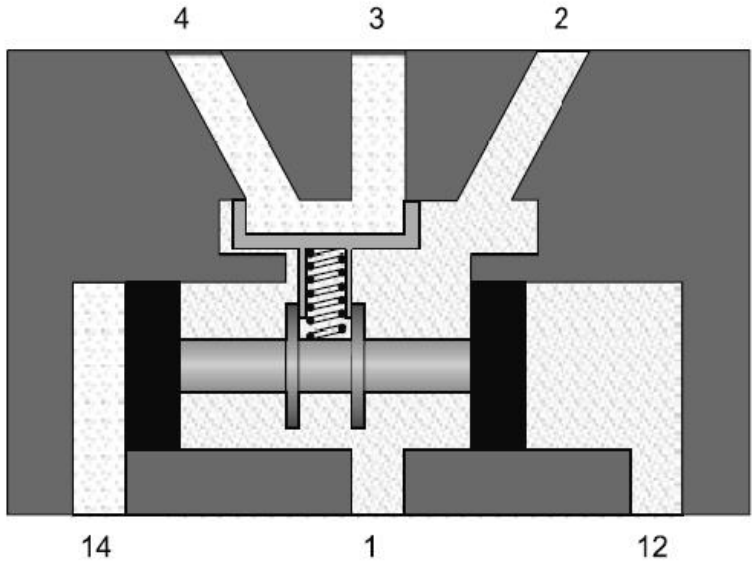


Indirect Control (Piloted Operated)



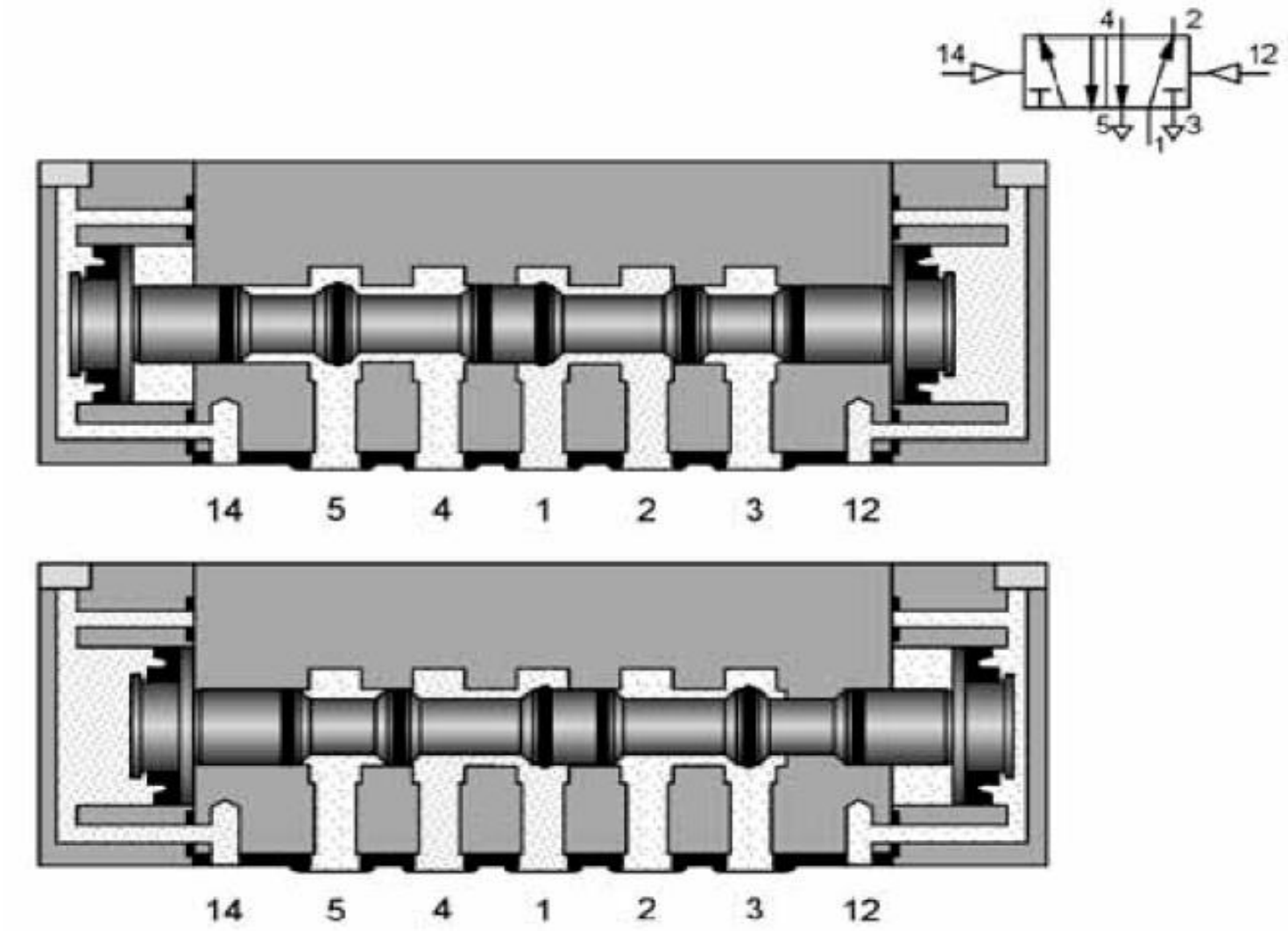






- Memory Function.
- Impulse Operated.

5/2 Directional control valve

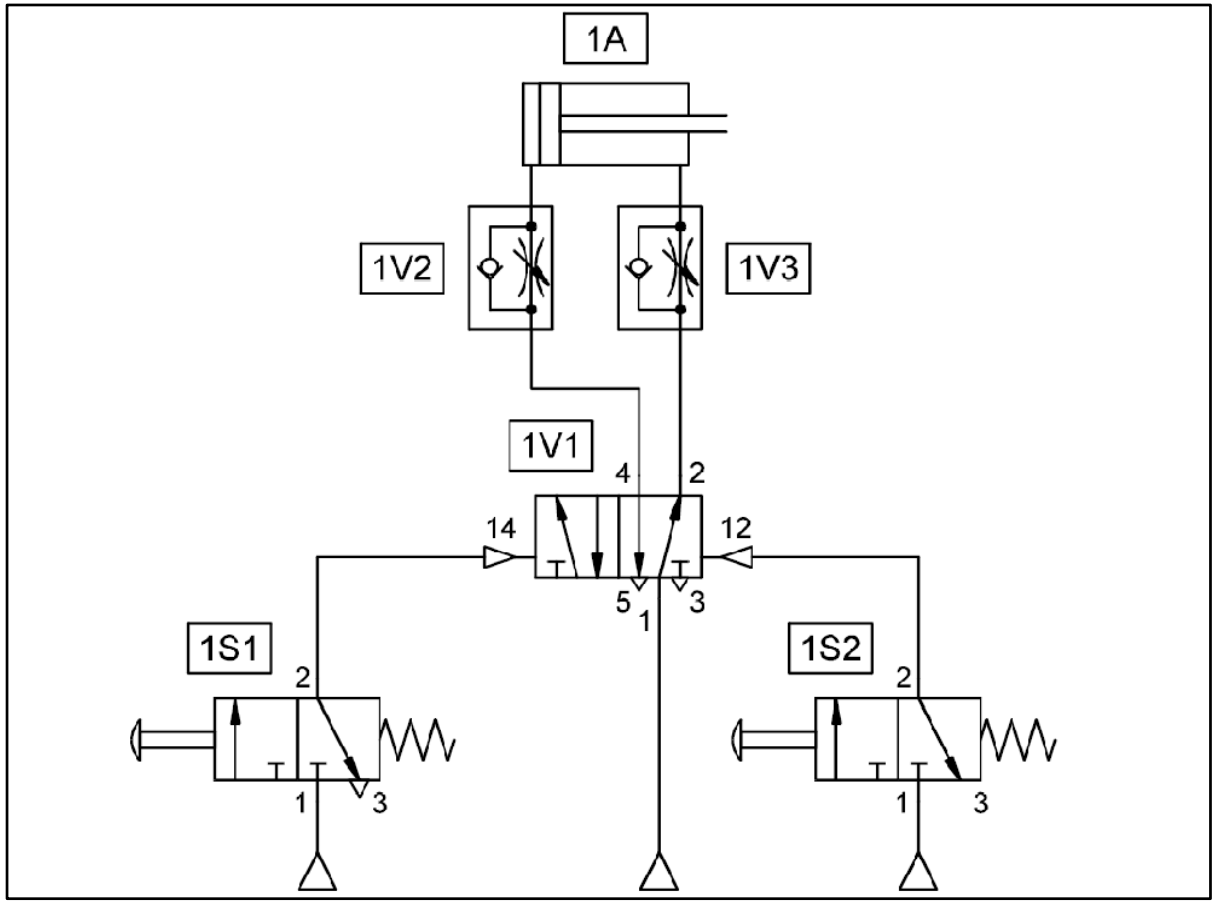


5/2 Directional control valve

In general the 4/2-way valve is replaced by the 5/2-way valve.

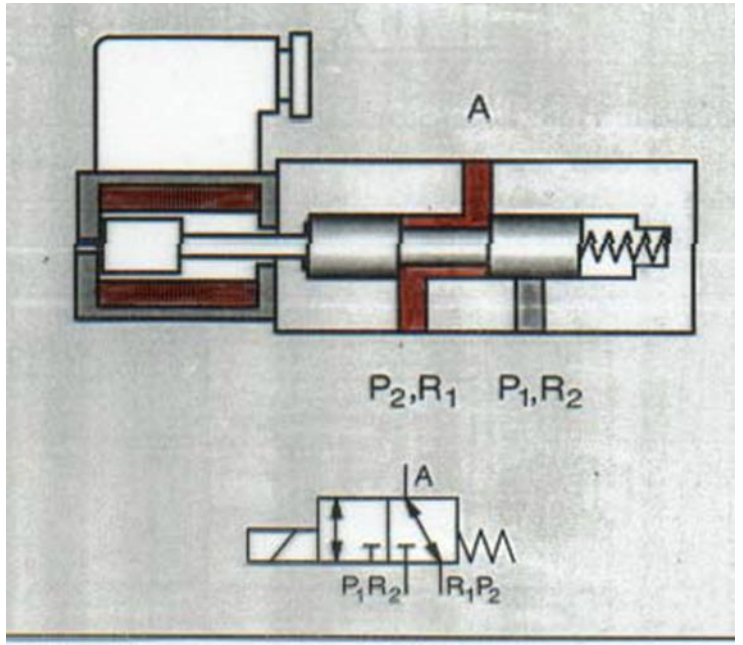
The 5/2- way valve has advantages in passage construction and allows the exhaust of both extension and retraction air for cylinders to be separately controlled.

The 5/2-way valve circuit carries out the same primary control functions as the 4/2-way valve circuit



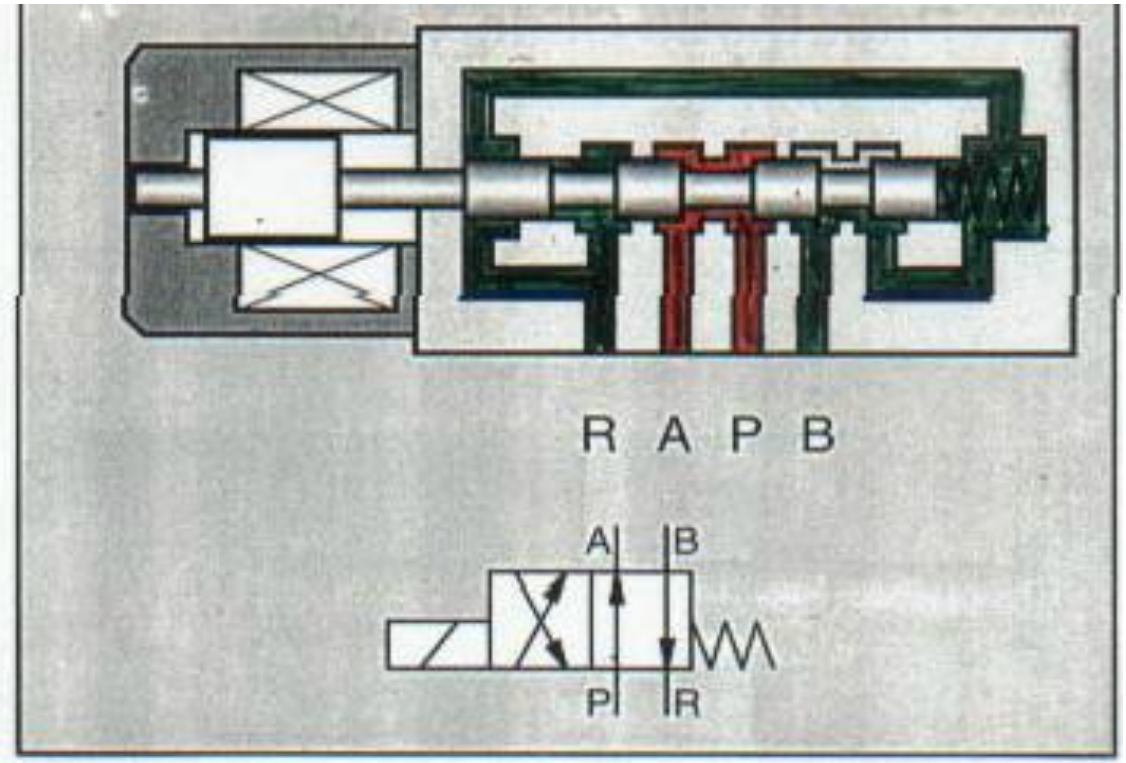
Solenoid valve

- A very common way to actuate a spool valve is by using a solenoid, illustrated in the following figure.
- As shown, when the electric coil (solenoid) is energized, it creates a magnetic force that pulls the armature in to the coil. This cause the armature to push the spool of the valve.
- Solenoid switching behavior depends on excitation type.

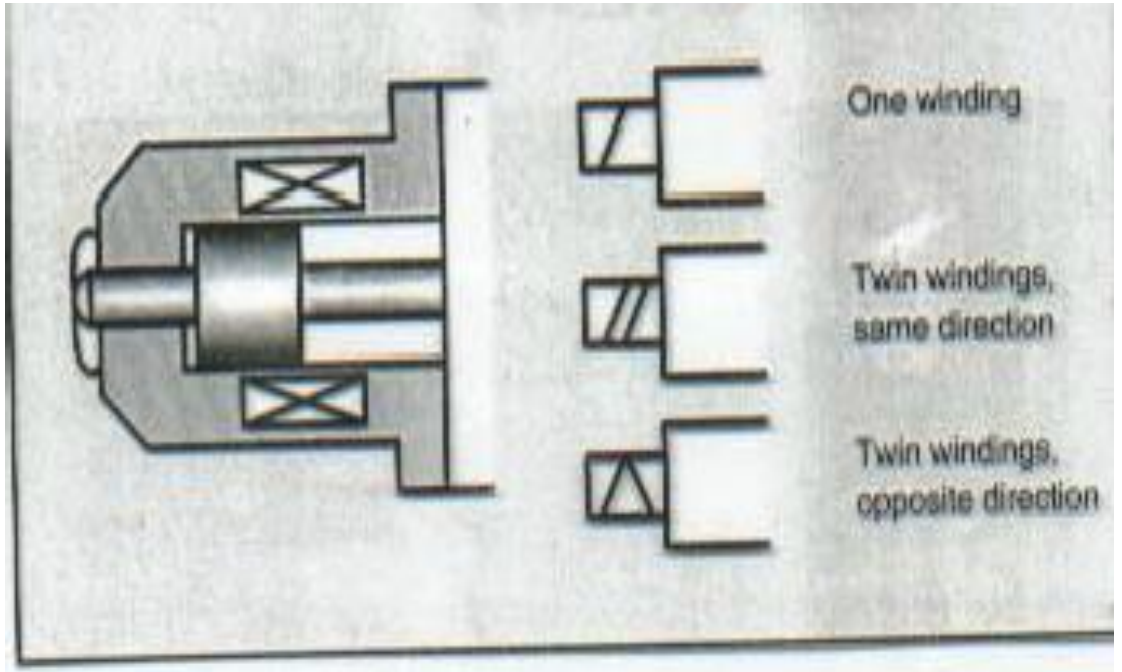


3/2 directional control valve, normally open, solenoid actuated, spring return

Solenoid valve



4/2 directional control valve, solenoid actuated, spring return



Solenoid actuated

Solenoid Valve Electrical Characteristics

- Operating time for attraction and release.
- Supply: DC or AC.
- Power consumption: hold on power and inrush power.
- Protection methods: against accidental contact, water proof, pressure proof.
- Duty cycle (%).

DC Solenoid Characteristics

- Slower switching on and off (Self Inductance).
- Cut-out spikes.
- Smooth attraction.
- Safe against overload even with blocked armature.
- Bulkier than AC solenoid.
- Longer life.
- Resistance is equal to the ohmic resistance of the coil.
- Need freewheeling protection circuit.

AC Solenoid Characteristics

- Switching Fast and hard (due to reduced resistance at the moment of switching on, the reactance net yet having developed).
- High current drain when the armature is blocked.
- Smaller than DC solenoid.
- Eddy current and hysteresis losses.
- Total resistance consists of the ohmic resistance and reactance.
- Cannot be operate by direct current.
- Shorter life time.
- Noisy.

AC Solenoid Characteristics