Pneumatic Systems

Actuators & Valves

Source – Festo Textbook TP-101 Pneumatics Basic Level

Actuators & Valves

Actuators (Cylinders)

An actuator is an output device that converts supply energy (air or hydraulic) into useful work.

2 Types:

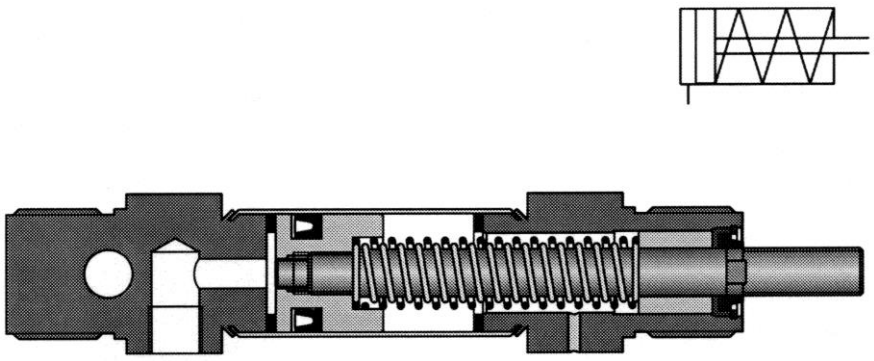
1. **Linear motion**
   - Single-acting
   - Double-acting
2. **Rotary motion**
   - Air motor
   - Rotary cylinder
   - Rotary actuator

Actuators & Valves

Actuators (Cylinders)

Single Acting Cylinders

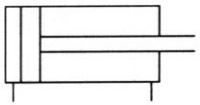
- Air is applied on only one end
- Work is produced in one direction only
- Piston rod is returned by a spring and/or external force
- Designed to return quickly under no-load
- Stroke length limited to natural length of spring typically < 80mm



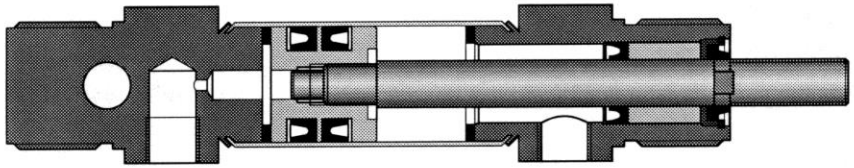
Actuators & Valves

Actuators (Cylinders)

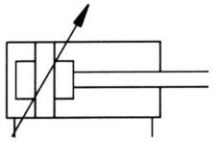
Double Acting Cylinders

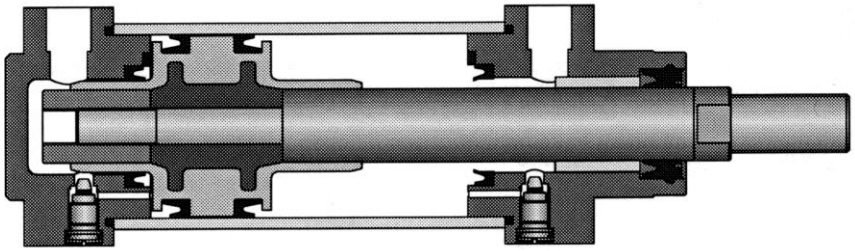


- No return spring
- 2 ports are used alternatively as supply and exhaust
- Work is produced in both directions
- Longer stroke lengths
- End position cushioning available for large loads



Double-acting Cylinder



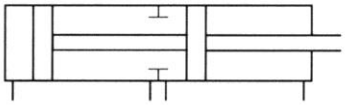


Double-acting Cylinder with end position cushioning

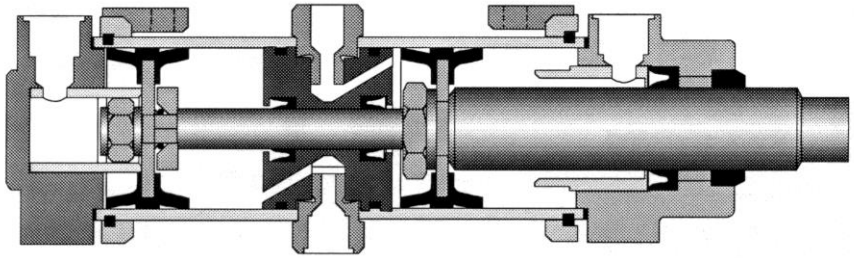
Actuators & Valves

Actuators (Cylinders)

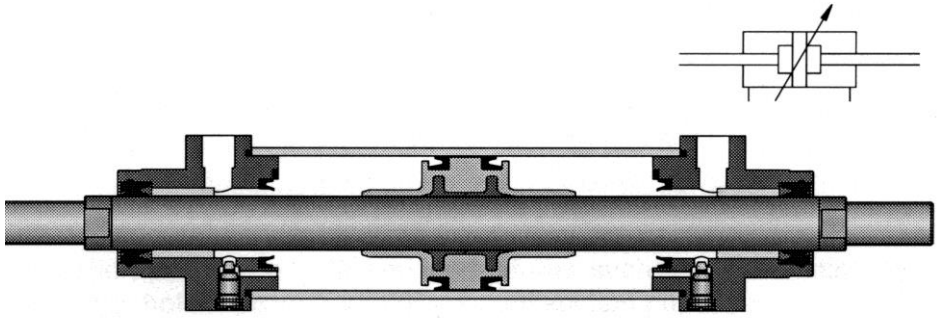
Double Acting Cylinders



- 2 double-acting cylinders joined to from a single unit
- Force is nearly doubled
- Used where large force is required but cylinder diameter is restricted



Tandem Double-acting Cylinder



Cylinder with Through Piston Rod

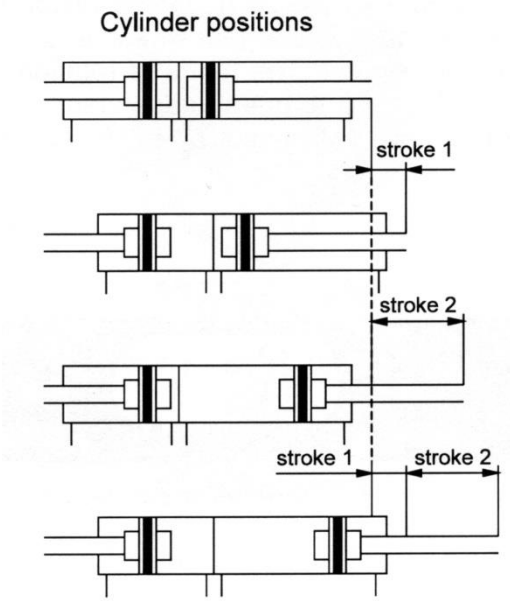
- Piston rod on both sides
- Forces equal in both directions
- Piston rod be hollow – can be used for compressed air or vacuum

Actuators & Valves

Actuators (Cylinders)

Double Acting Cylinders

- Two or more double-acting cylinders which are interconnected
- Each cylinder advances when pressure is applied
- Multiple positions can be obtained



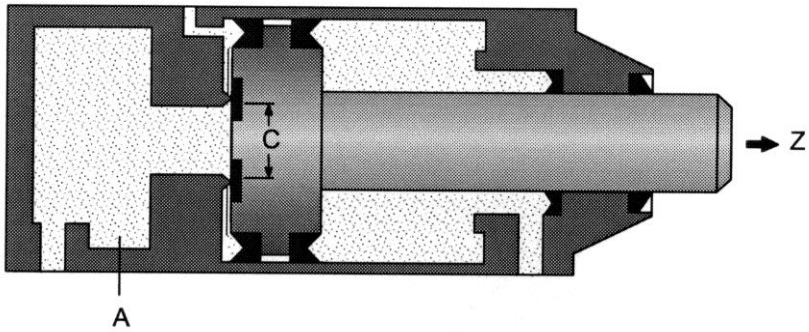
Multi-position Cylinders

Actuators & Valves

Actuators (Cylinders)

Double Acting Cylinders

- High kinetic energy is obtained by increasing the piston speed
- Speed is between 7.5 m/s and 10 m/s
- Full piston surface is exposed to air
- Suitable for short stroke applications



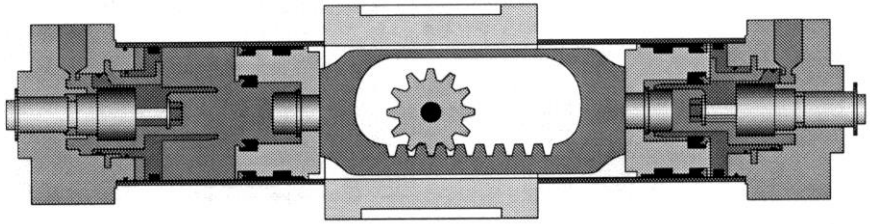
Impact Cylinder

Actuators & Valves

Actuators (Cylinders)

Rotary Cylinders

- Piston rod has a gear-tooth profile
- Piston rod drives a gear wheel which results in rotary movement
- Rotation varies from 45, 90, 180, 270 & 360 degrees
- Torque is dependant on pressure, piston surface & gear ratio
- 150 Nm are possible (110.6 lbf-ft)



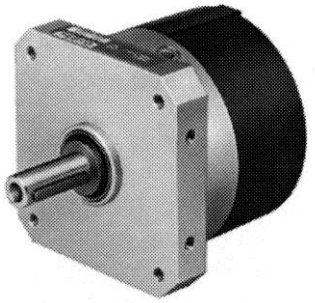
Rotary Cylinder

Actuators & Valves

Actuators (Cylinders)

Rotary Cylinders

- Force is transmitted direct to drive shaft via a vane
- Angular displacement infinitely adjustable from 0 to 180 degrees
- Up to 10 Nm (7.4 lbf-ft)



Rotary Actuator

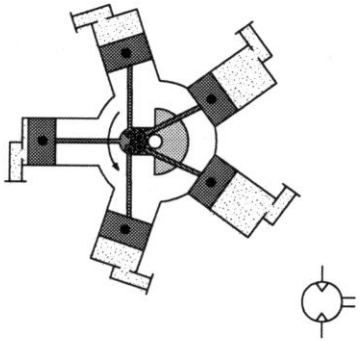
Actuators & Valves

Actuators (Cylinders)

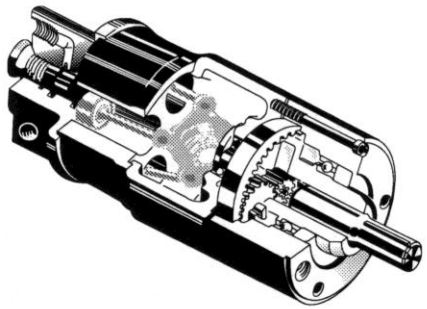
Air Motors

4 Types

1. Piston
2. Sliding Vane
3. Gear
4. Turbines (high flow)



Radial Piston



Axial Piston

Radial Piston

- Multiple cylinders connected to a crankshaft
- Power depends on # of cylinders, pressure, piston area, stroke and piston speed

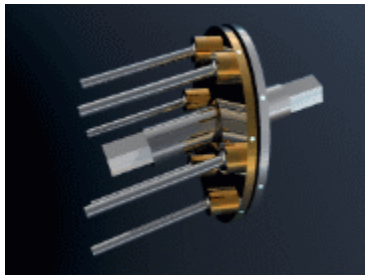
Axial Piston

- Multiple axially arranged cylinders (odd #)
- Force from cylinders is converted into a rotary motion via a *swash* plate
- Air is applied to 2 cylinders simultaneously, the balanced torque provides smooth running

Actuators & Valves

Actuators (Cylinders)

Air Motors



Swash Plate Animation

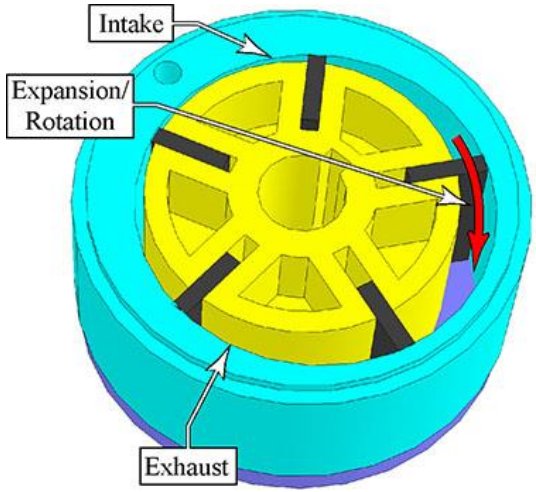
Actuators & Valves

Actuators (Cylinders)

Air Motors

Sliding Vane Motors

- Typically used for hand tools
- Compressed air enters chamber & transfers energy to the rotor
- Rotor consist of multiple vanes which are guided in slots
- Centrifugal force (and springs) slides vanes outward against outer wall
- Air chamber increases near exhaust port allowing air to expand
- Rotor speed typically 3000 – 5000 RPM
- Power range typically 0.1-17kW (0.14-24HP)



http://www.waterfront-woods.com/Projects/Images/RotaryCylinder-lo.jpg

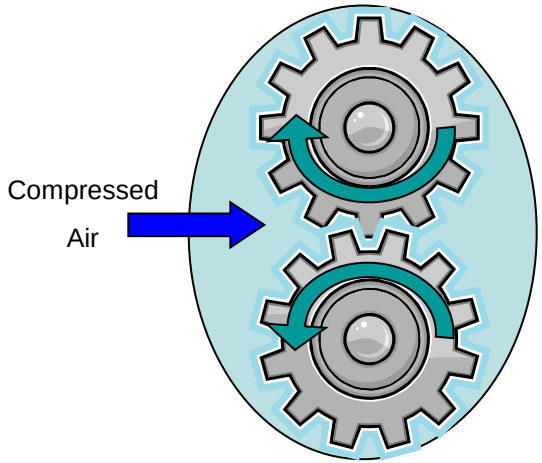
Actuators & Valves

Actuators (Cylinders)

Air Motors

Gear Motors

- Torque is generated by the pressure of the air against the teeth profiles of two meshed gear wheels
- One gear wheel is connected to the motor shaft
- High output power is possible ~ 44kW (60HP)



Actuators & Valves

Actuators (Cylinders)

Air Motors

Flow (Turbine) Motors

- Works like a flow compressor but in reverse
- Low power only
- High speed ~ 500,000 RPM
- Dentist drill

Characteristics of Air Motors

- Smooth regulation of speed & torque
- Small size
- Explosion proof
- Minimal maintenance
- Direction can be easily changed

Actuators & Valves

DC Valves

DC valves are devices which influence the path taken by an air stream.

Normal Position

- The position of the valve if it is not connected.

Initial Position

- The position of the valve once it has been installed in a system and pressure applied.

Construction Types

- Poppet valves
  - Ball seat
  - Disc seat
- Slide Valves
  - Longitudinal slide (spool)
  - Longitudinal flat side
  - Plate side

Actuators & Valves

DC Valves

Poppet Valves

Connections are opened and closed by means of balls, discs, plates or cones.

Long service life

Insensitive to dirt & robust

Actuation force is high because of reset spring and air pressure

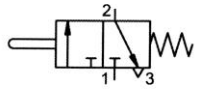
Slide Valves

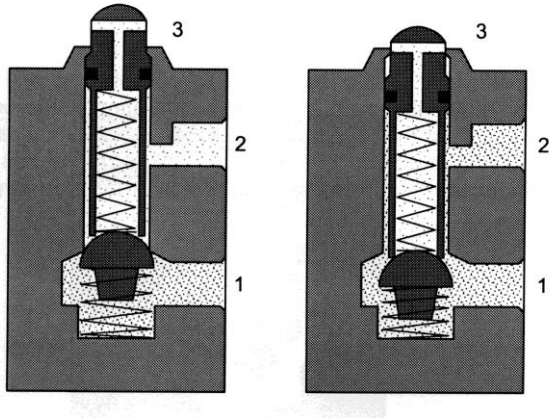
Individual connections are linked together or closed by means of spools, flat side or plate side valves.

Actuators & Valves

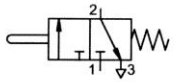
DC Valves

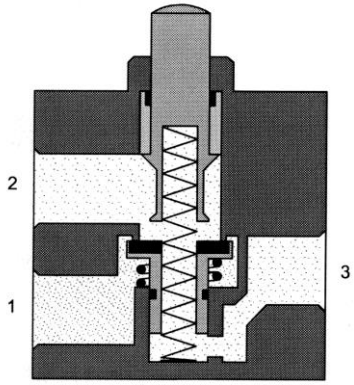
3/2 Way Valve

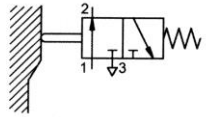


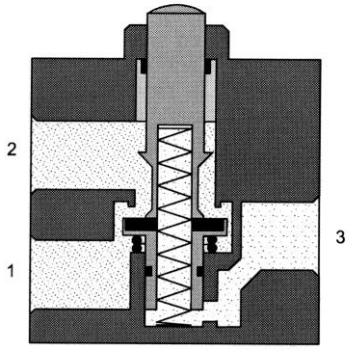


3/2 way valve
Normally closed,
ball seat







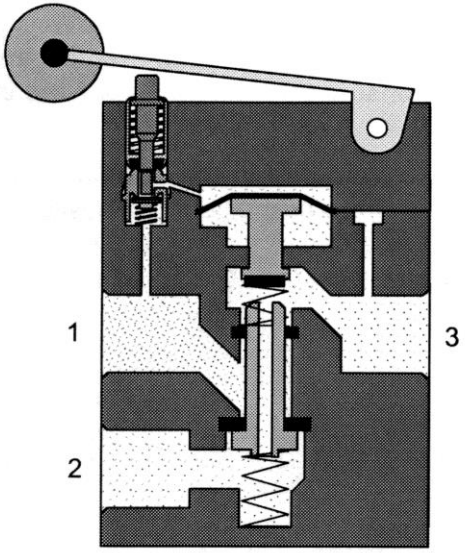


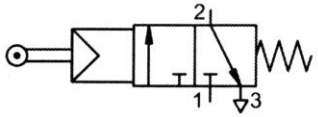
3/2 way valve
Normally closed,
disc seat

Actuators & Valves

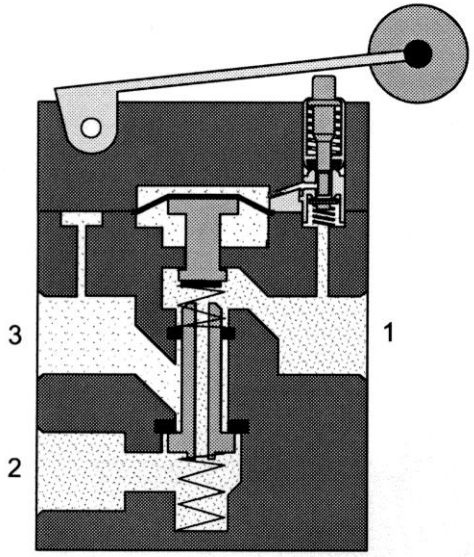
DC Valves

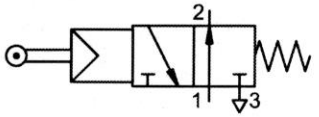
3/2 Way Valve





3/2 Way roller lever valve
internal pilot
normally closed



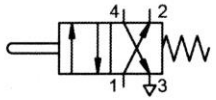


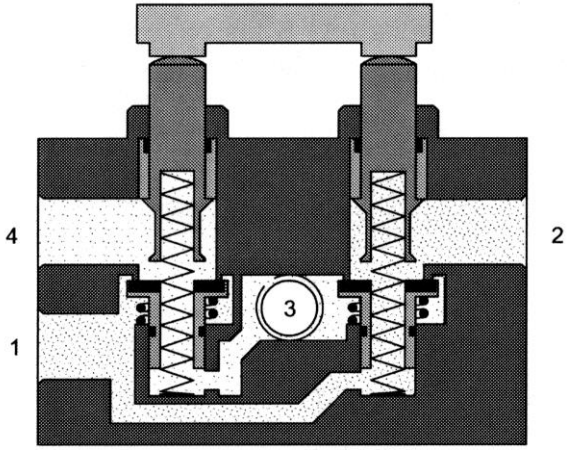
3/2 Way roller lever valve
internal pilot
normally open

Actuators & Valves

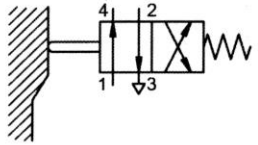
DC Valves

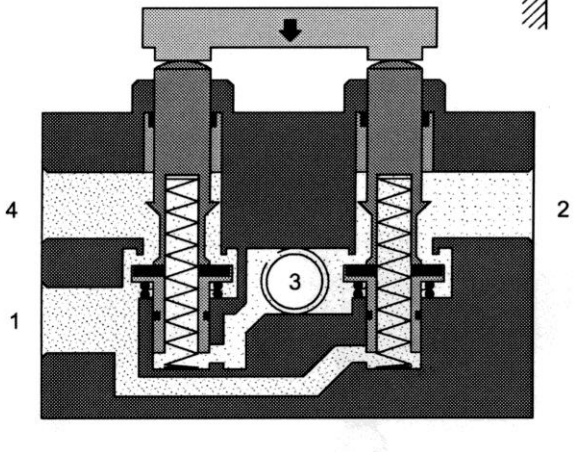
4/2 Way Valve





4/2 way valve
disc seat



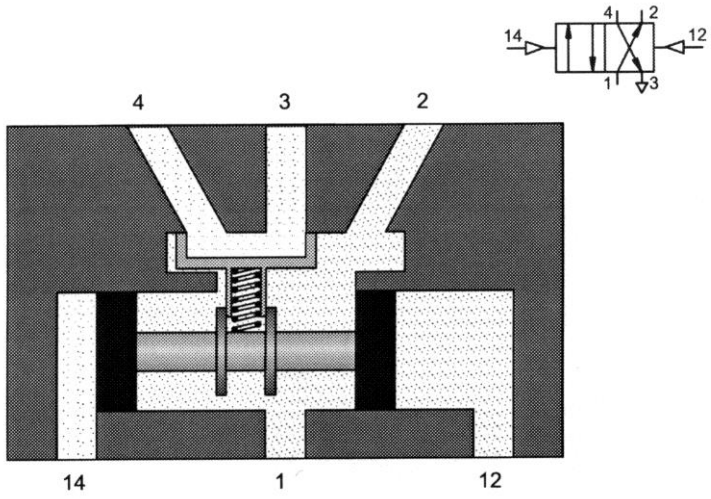


4/2 way valve
disc seat

Actuators & Valves

DC Valves

4/2 Way Valve

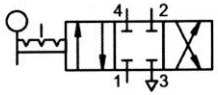


4/2 way double pilot valve

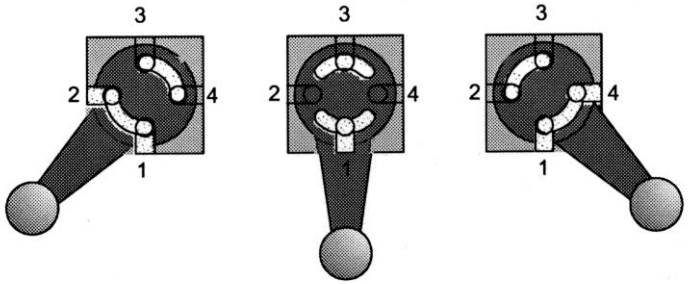
Longitudinal flat side

Actuators & Valves

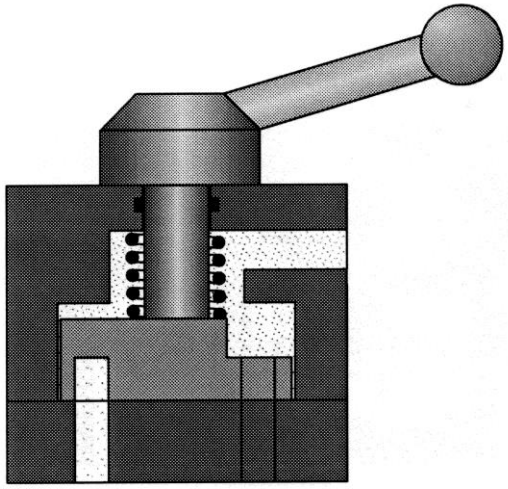
DC Valves



4/3 Way Valve

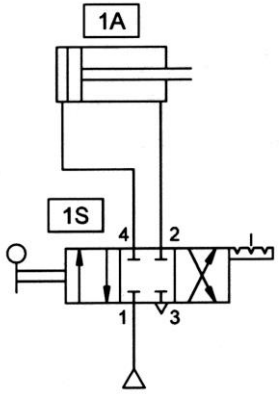


4/3 way plate slide valve



By turning two discs channels are connected with one another.

A double acting cylinder can be made to stop in any position.

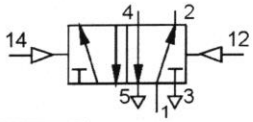


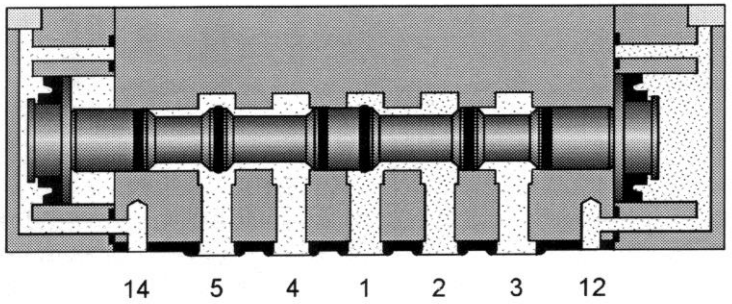
Actuators & Valves

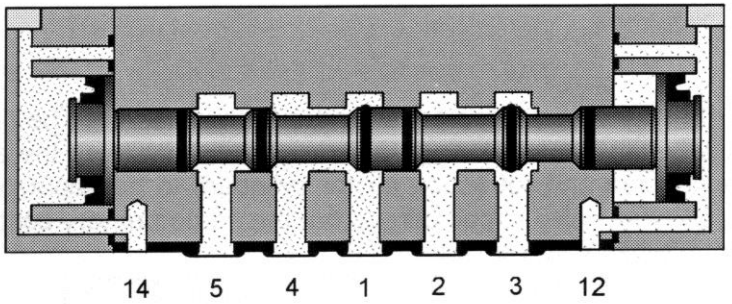
DC Valves

5/2 Way Valve

- Used primarily as a control element for the control of cylinders
- Actuating force is low because there are no opposing forces due to compressed air or springs
- Sealing can be a problem
- Replacement to the 4/2 way valve
- Allows exhaust of both extension and retraction air for cylinders to be separately controlled



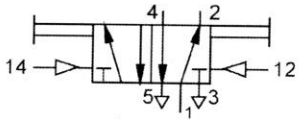




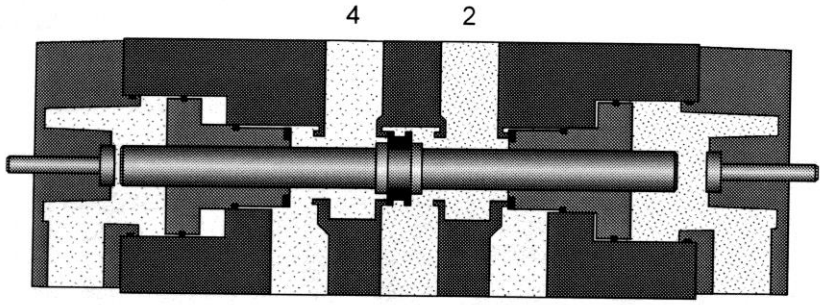
Actuators & Valves

DC Valves

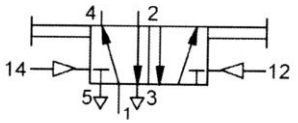
5/2 Way Valve

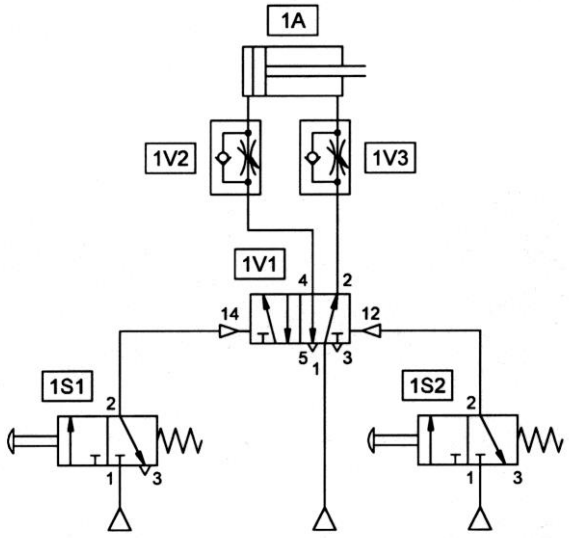


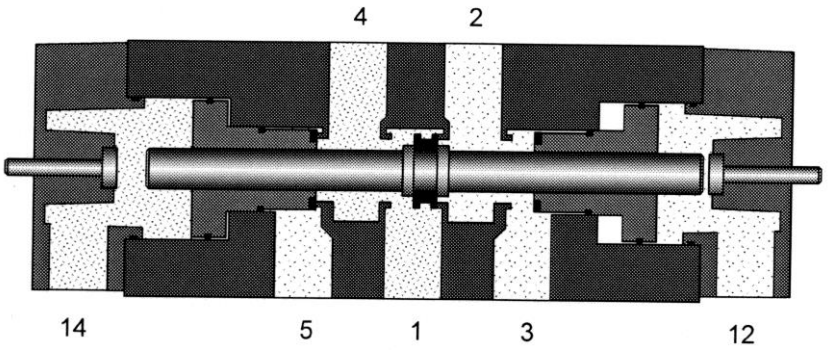
- Alternate method of sealing
- Small switching movement
- Memory position



5/2 way double pilot valve
suspended disc seat





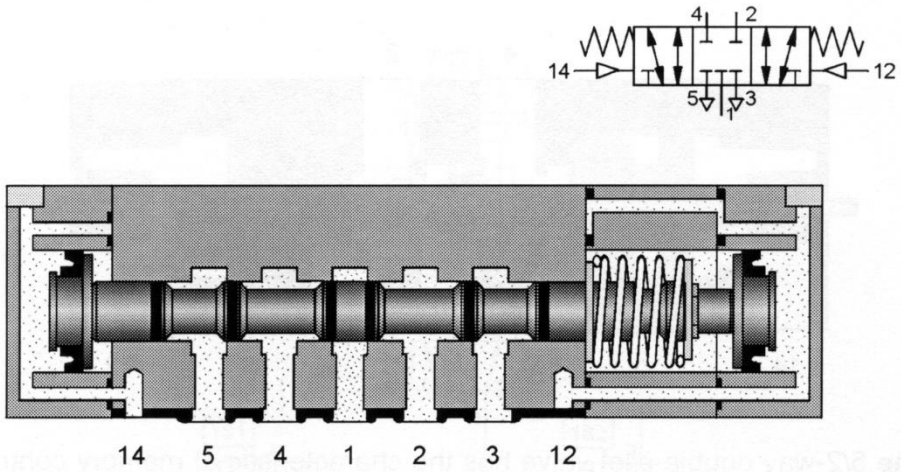


Actuators & Valves

DC Valves

5/3 Way Valve

- Double acting cylinders can be stopped anywhere in it's stroke
- Spring centred



5/3 way valve

Longitudinal side