PNEUMATIC CONTROLS

Contents

CHAPTER 1

INTRODUCTION TO PNEUMATIC CONTROL

The word 'Pneuma' means breath or air . Pneumatics is application of compressed air in automation. In Pneumatic control, compressed air is used as the **working medium,** normally at a pressure from 6 bar to 8 bar. Using Pneumatic Control, maximum force up to 50 kN can be developed. Actuation of the controls can be manual, Pneumatic or Electrical actuation. **Signal medium** such as compressed air at pressure of 1-2 bar can be used [Pilot operated Pneumatics] or Electrical signals [D.C or A.C source- 24V – 230V] can be used [Electro pneumatics]

1.1 Characteristics of Compressed Air

The following characteristics of Compressed air speak for the application of Pneumatics
•Abundance of supply of air
•Transportation
•Storage
•Temperature
•Explosion Proof
•Cleanliness
•Speed
•Regulation
•Overload Proof

1.2 Selection Criteria for Pneumatic Control System

•Stroke
•Force
•Type of motion [Linear or Angular motion]
•Speed
•Size
•Service
•Sensitivity
•Safety and Reliability
•Energy Cost
•Controllability
•Handling
•Storage

1.3 Advantages of Pneumatic Control

•Unlimited Supply
•Storage
•Easily Transportable
•Clean
•Explosion Proof
•Controllable (Speed, Force)
•Overload Safe
•Speed of Working Elements

Disadvantages
•Cost
•Preparation
•Noise Pollution
•Limited Range of Force
(only economical up to 25 kN)

1.4 General Applications of Pneumatic Control

•Clamping
•Shifting
• Metering
•Orienting
•Feeding
•Ejection
•Braking •Bonding
•Locking
•Packaging
•Feeding
•Door or Chute Control
•Transfer of Material
•Turning or Inverting of Parts
•Sorting of Parts
•Stacking of Components
•Stamping and Embossing of components

1.5 Applications in Manufacturing

•Drilling Operation
•Turning
•Milling
•Sawing
•Finishing
•Forming
•Quality Control

1.6 Structure of Pneumatic Control System

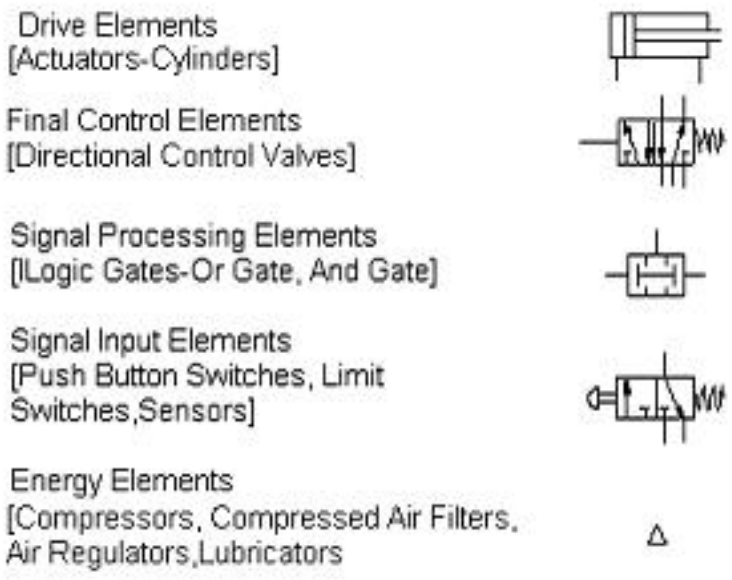


Figure 1.1 Structure of Pneumatic Control System

A typical Pneumatic control system comprises of the above groups of components. In direct actuation controls signal processing group is not required. In electro pneumatic Control signal processing can be carried out using combination of relays and contractors or using PLC. The final control valves are solenoid actuated in the case of electro pneumatic controls

CHAPTER 2

PNEUMATIC CYLINDERS

Drive Elements are Actuators – used to perform the task of exerting the required force at the end of the stroke or used to create displacement by the movement of the piston. Pneumatic Actuators can be classified as

•Single Acting Cylinders
  Conventional Cylinder with Spring Loaded Piston or
  Diaphragm type
•Double Acting Cylinders

2.1Symbolic Representation of Pneumatic Cylinders -Linear Actuators

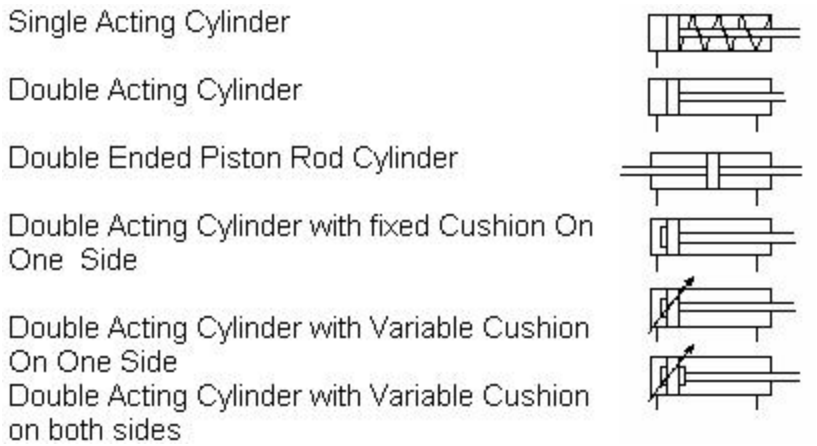


Figure 2.1

2.2 Single Acting Cylinder

•Single acting cylinder has one working port
•Forward motion of the piston is accomplished to due to supply of compressed air behind the piston.
•Return motion of piston takes place only due to built in reset spring placed on the rod side of the cylinder.
•Single acting cylinders are used for applications such as clamping, feeding, sorting, locking, ejecting, braking etc., where force is required to be exerted only in one direction..
•Single acting cylinder are usually available in short stroke lengths [maximum length up to 80 mm] due to the natural length of the spring.
Single Acting Cylinder exert force only in one direction.

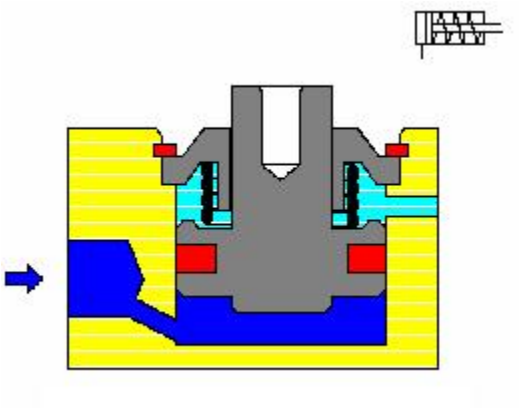


Figure 2.2 Single Acting Cylinder

2.3 Double Acting Cylinders

They are available in different constructions such as

•Conventional,
•Double ended piston rod type,
•Rod less type
•Tandem type
•Multi-position type and
•Rotary type..

Conventional Cylinders

•Double Acting Cylinders are equipped with two working ports- one on the piston side and the other on the rod side.
•To achieve forward motion of the cylinder, compressed air is admitted on the piston side and the rod side is connected to exhaust. During return motion supply air admitted at the rod side while the piston side volume is connected to the exhaust. Force is exerted by the piston both during forward and return motion of cylinder
•Double acting cylinders are available in diameters from few mm to around 300 mm and stroke lengths of few mm up to 2 meters

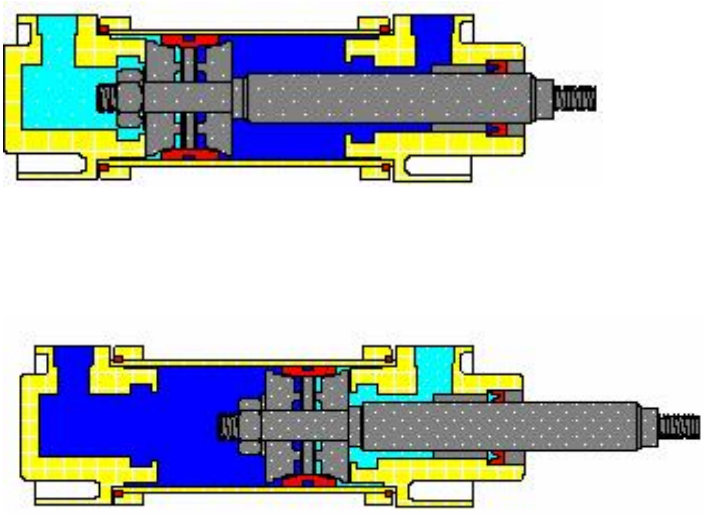


Figure 2.3 Double Acting Cylinder –Retracted and Advanced Positions

2.4 End Position Cushioning

•Pneumatic cylinders operates at much higher speeds than Hydraulic cylinders. Due to this, there is a tendency of the piston to ram against the end covers as the piston approaches the ends at high velocity especially in cylinder with large mass. This impact force can damage the cylinder as well as the piston due to repetitive action .
•All Double acting cylinders excepting for small sizes, are provided with end position cushioning arrangement.
•This arrangement decelerates the piston motion as it approaches the end of the stroke

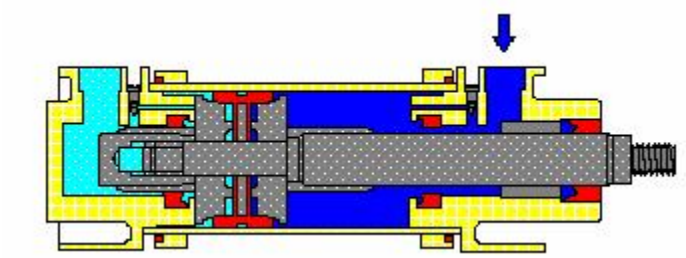


Figure 2.4 Double Acting Cylinder with Cushions

2.5 Tandem Cylinder

•Tandem cylinder is essentially a combination of two cylinders in tandem such that force derived from the first cylinder, supplements the force obtained by the second cylinder. More or less the force produced by a tandem cylinder is as twice as that of a conventional double acting cylinder of the same diameter.
•This type of cylinder is used where more force is to be generated and there is no scope for increasing the diameter of cylinder due constraint of space

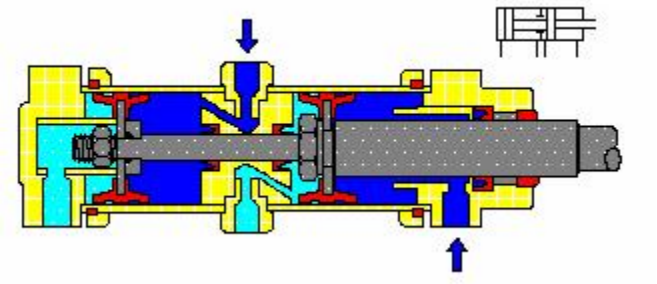


Figure 2.5 Tandem Cylinder

2.6 Rod less Cylinders

Different operational principals are used for the construction of Rod less cylinders:

1. Cable Cylinder
2. Sealing band Cylinder with slotted cylinder barrel
3. Cylinder with Magnetically Coupled Slide

Rod less cylinder have the following advantages:

•Available in long lengths –up to 4 m or even higher (as there is no buckling)
•Most ideally suited for stopping and fixing (Robotic application)
•Occupies less space as the extension of piston rod is not present

2.6.1 Rod less Cylinder with Magnetic Coupling

This cylinder has a hermetically sealed arrangement where piston is housed inside a sealed cylinder barrel. The piston is provided with number of annular ring magnets, radially polarised. An external sleeve which slides over the cylinder, is also provided with similar arrangement of ring magnets. Thus a magnetic coupling is established between the piston and slider. As the piston reciprocates due to supply of compressed air, the slider also reciprocates over the cylinder

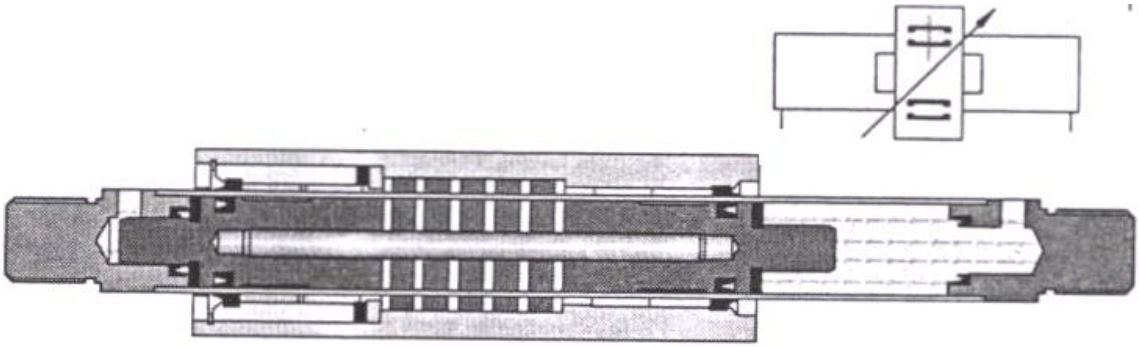


Figure 2.10 Rod less cylinder with Magnetic coupling

2.6.2 Rod less Cylinder- Mechanically Coupled

The cylinder barrel is provided with a slot across the entire length. The force is transmitted through a slide permanently connected to the piston. The connection from piston to slide is directed outwards through the slotted cylinder barrel. The slot is sealed by means of a sealing band, which seals the inside of the slot. The sealing band is guided between the piston seals and passed under the slide. A second metallic cover strip, covers the slot from the outside to prevent the ingress of dirt

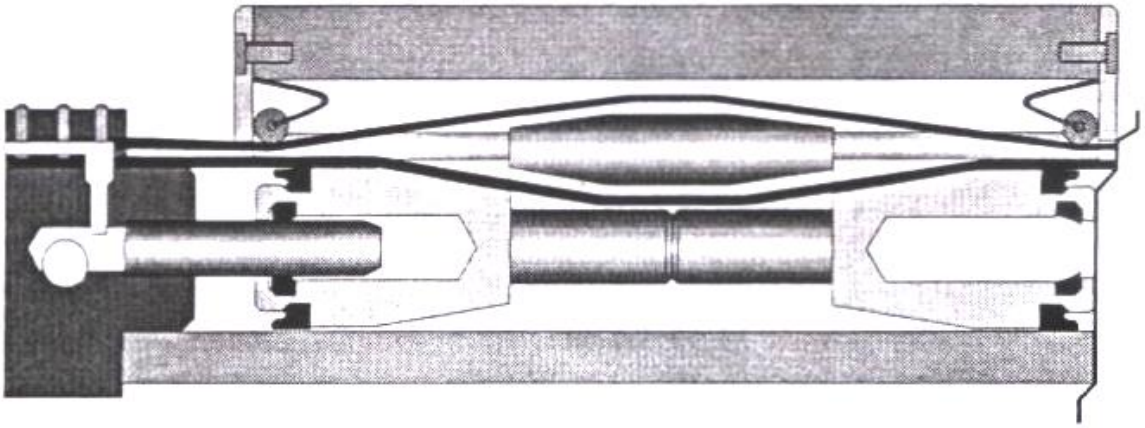


Figure 2. 12 Rod less Cylinder Mechanical Coupled

2.7 Rotary Actuators

•In order to achieve angular motion, Rotary Actuators are used. Rotary actuators are mainly available in two designs.

•Vane type Construction: Further these actuators are available with 180^0 rotation or 270^0 angle of rotation. These actuators can be used for low torque requirement up to 10 N-m.
•Rack and Pinion type construction: Can be used for angle or rotation close to 360^0. These actuators can develop torques up to 100-150 N-m depending on the diameter of the cylinder

2.7.1 Vane type Rotary Actuator

•A rotating vane connected to a shaft divides cylindrical chamber in to two compartments. Compressed air is alternately admitted and exhausted from the chambers. The compressed air pressure acting on the vane surface results in a torque. Hence rotary motion is obtained.

•The magnitude of the torque produced, depends on the surface area of the vane, air pressure and mean radius of the vane.

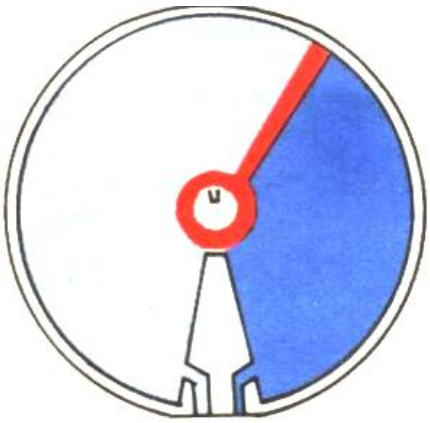


Figure 2.13 Vane Type Rotary Actuator

2.7.2 Rotary Actuator of Rack and Pinion Type

This is essentially a double acting cylinder with a rack arrangement provided on the piston rod and a pinion engages with this rack. Out put rotation of the pinion shaft can be used for obtaining angular motion from $0\text{-}360^0$. This type of rotary actuators are used for higher torque requirement up to 150 N-m.

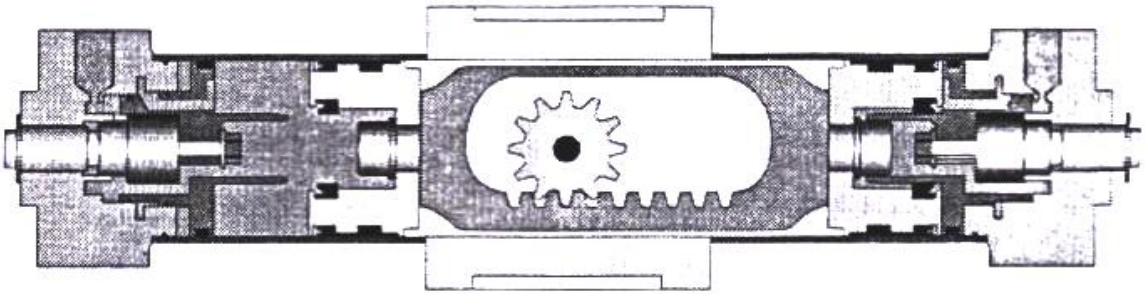


Figure 2.14 Rotary Actuator- Rack and Pinion Type

2.8 Cylinder Seals

•Cylinder seals of single cup or double cup type are often used for dynamic sealing between piston and cylinder walls.
•Single cup seals are used for single acting cylinder and double cup seals are used in Double acting cylinders

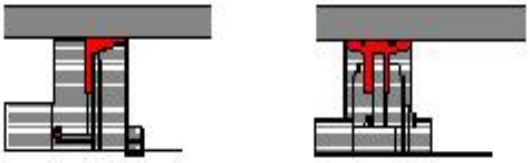


Figure 2.15 Single and Double Cup Seals

Sealing material such as Perbunan, Viton and Teflon are commonly used. Per bunan seals are used for temperatures in the range of -20^0 C to 80^0 C while Viton seals are used for high temperature range from -20^0 to 200^0 C. Teflon seals have applications at low temperature range -50^0 to 200^0 C

2.9 Mounting Arrangement for cylinders

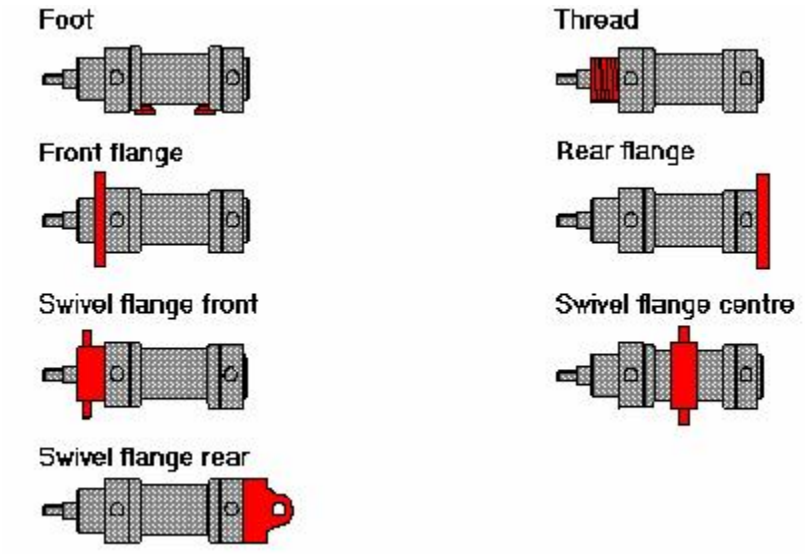


Figure 2.16 Mounting Arrangement of Cylinders

The type of mounting is determined by the manner of fitting the cylinder to fixtures and machines. Flange mounting arrangement is generally used for small cylinders. Large cylinders are usually foot mounted.

CHAPTER 3

Directional Control Valves

Directional Control valves are mainly used to change the direction of flow path of working medium or signal medium. They are used for admitting or exhausting working medium to the cylinder or from the cylinder for actuation of the cylinder. Also used to start or stop the pneumatic signal as well as for signal processing

Directional control valves are designated as per the following functions:

•Number of ports on the valves
•Number of switching positions
•Method of actuation
•Method of reset
•Design and constructional features

3.1 Symbolic Representation of Directional Control Valves

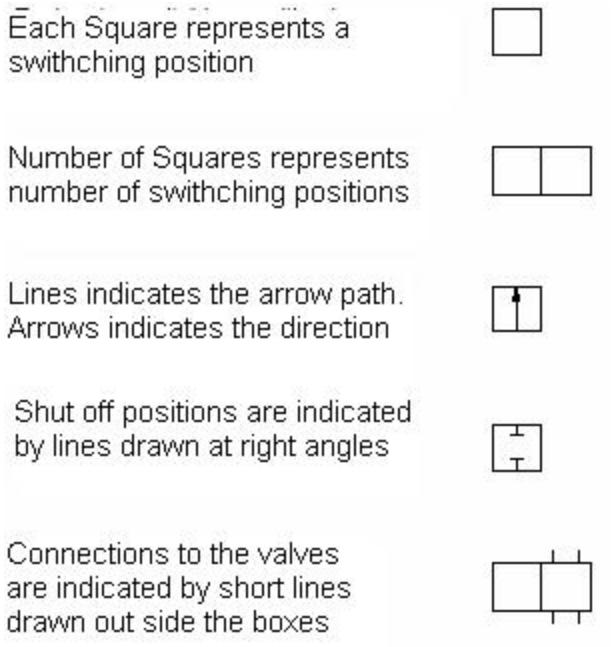


Figure 3.1 Symbolic Representation of Directional Control Valves

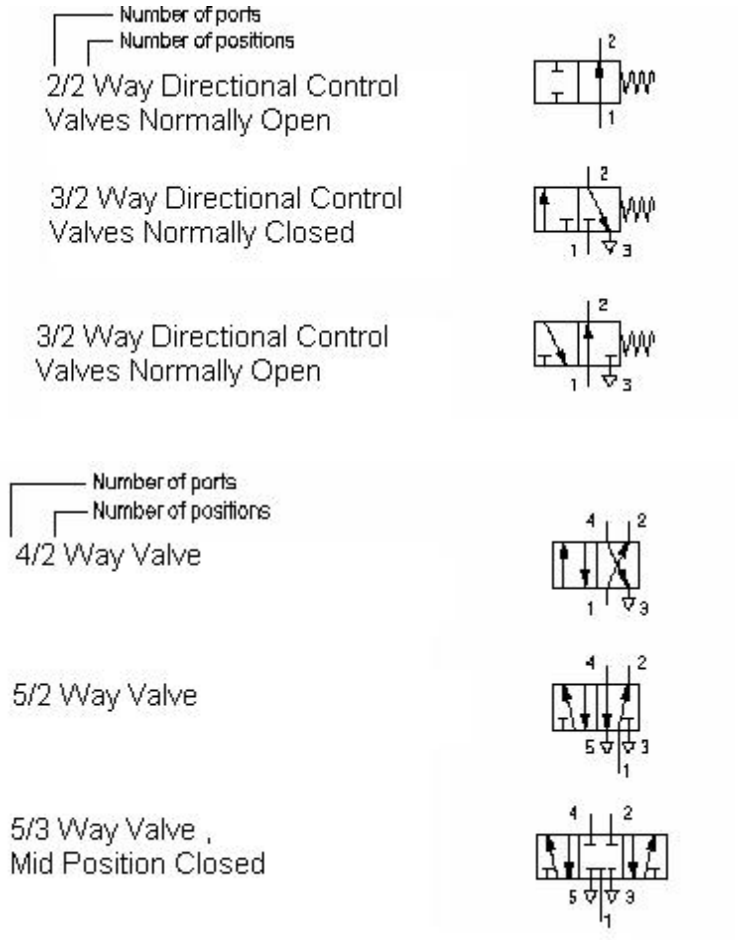


Figure 3.2 Symbolic Representation of Directional Control Valve

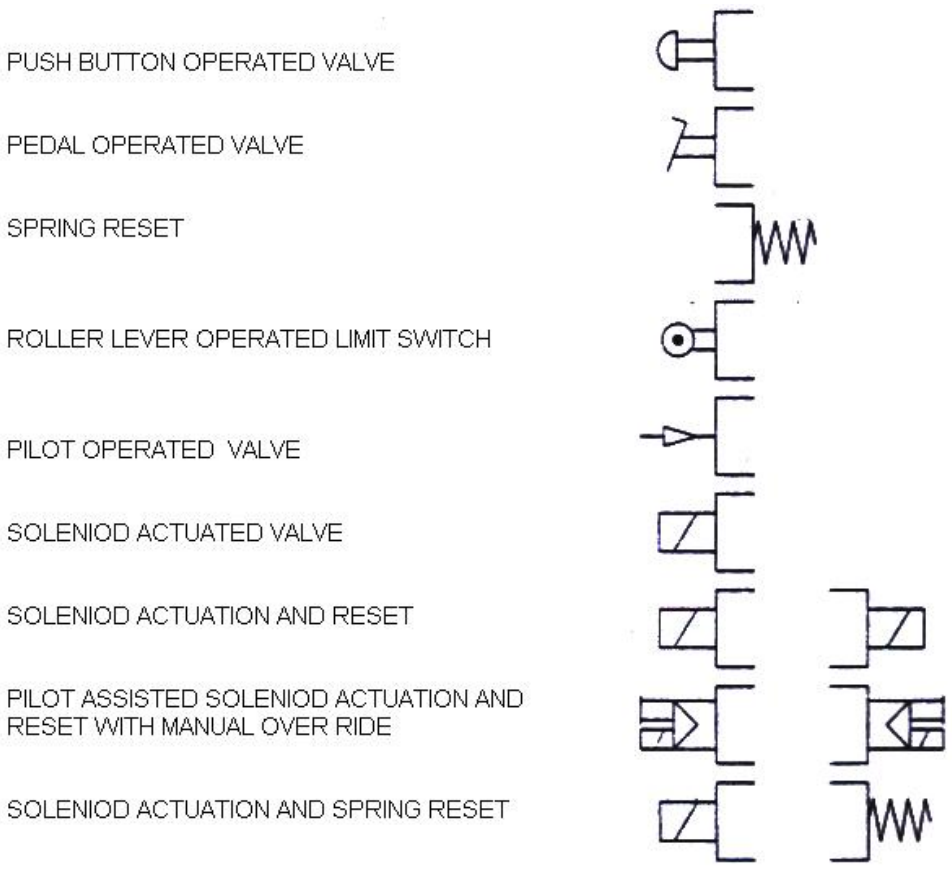


Figure 3.3 Method of Actuation and Reset of Directional Control Valves

3.3 Energy Elements

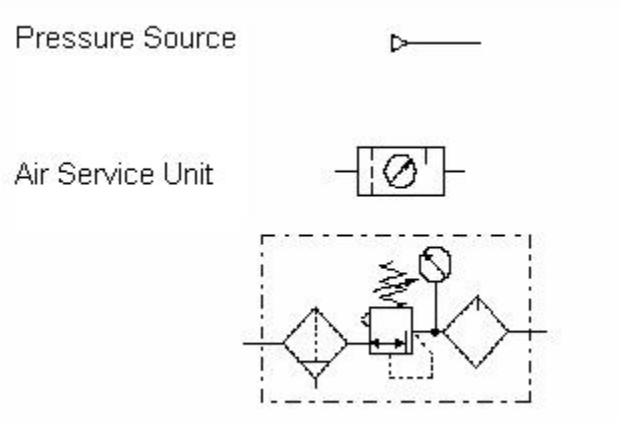


Figure 3.4 Symbols for Energy Elements

3.4 Port Marking of Direction Control Valve

As per IS 1219		As per IS 5599	
•Supply Port	A	Supply Port	1
•Exhaust Ports	R & S	Exhaust Ports	3 & 5
•Out put Pots	A & B	Out put Ports	2 & 4
•Pilot Port [Set]	Z	Pilot Port [Set]	14
•Pilot Port [Reset]	Y	Pilot Port [Reset]	12

3.6 Design and Construction Features of D.C. Valves

Directional Control Valves are available in the following types of constructions:

Poppet type of Valves
- Ball Seat Type [Pneumatic/ Solenoid actuation]
- Disc Seat Type [Pneumatic/ Solenoid actuation]

Slide Valves [Pneumatic/ Solenoid actuation]
Suspended Disc type of Valve [Pneumatic/ Solenoid actuation]
Plate of Valve [Manual actuation]

3.7 Selection Criteria of D.C. Valves

Selection of a particular design of D.C. valve depends on the following factors
•Actuation force
•Leak tightness
•Ease of servicing
•Sensitive to contamination by dirt
•Travel length of the valve stem
•Size
•Cost

3.8 3/2 Way- D.C. Valve N.C-Ball Seat Type

•These type of valves are often used as signal input valves, operated either with push button or with limit switches rollers, to interrogate the cylinder position
•A spring loaded ball initially blocks the supply ports 1. Out put port 2 is connected to exhaust port 3.
•On actuation, the plunger first isolates the exhaust port 3 and further descending of the plunger, the ball is pushed down wards, there by opening the supply port 1 to out put port 2.

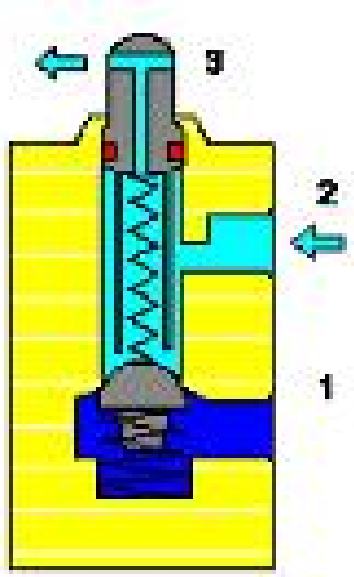


Figure3. 5 Ball Seat Type Directional Control Valve [NC]

•These type of valves are often used as signal input valve either push button operation or as limit switches to interrogate the cylinder position
•A spring loaded ball initially blocks the supply port 1 and out put port 2 is connected to exhaust port 3.
•On actuation, the supply port 1 is connected to out put port 2. The exhaust port 3 is isolated

3.9 3/2 Way Disc Seat Valve [Normally Closed]

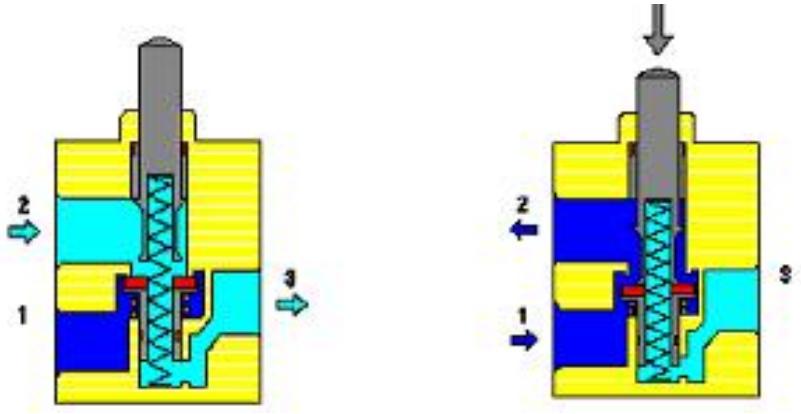


Figure 3.6 3/2 Way Disc Seat Valve [Normally Closed]

Comparison of Ball Seat and Disc Seat Valves

Ball Seat Valves
•They are inexpensive
•Relatively small size
•Insensitive to dirt
•Operated manually or mechanically

Disc Seat Valve
•Offers large area and hence lift required is very small
•Time of response is good
•Insensitive to dirt
•Can be actuated manually, mechanically, electrically or pneumatically

3.11 5/2 Way Suspended Disc Seat Type of Valve

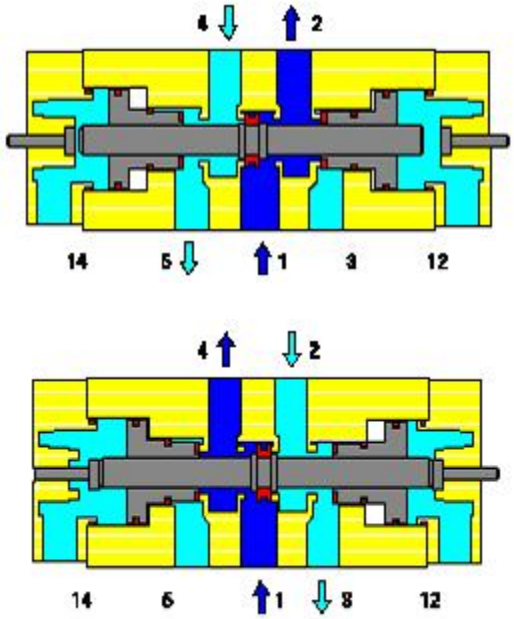


Figure 3.7 Suspended Disc Seat Directional Control Valve

These types of valves are widely used as it is insensitive to plugging by impurities, require low actuation force. A manual over ride is shown on both sides to manually set or reset the valves in case of signal locking. With pilot signal at pilot port 14, The valve communicates ports 4 to 5 and 1 to 2. With pilot signal at pilot port 12., ports of the valve 1 and 4 and 2 and 5 are communicated.. Used as final control element or for signal processing.

Chapter 4

Controlling of Pneumatic Cylinders

Pneumatic cylinders can be controlled by the following methods:

1. Direct control of Single or Double acting cylinder
2. Indirect Control of Cylinder with Single Piloted Final Control Valve
3. Indirect Control of Cylinder with Double Piloted Final Control Valve

In the indirect control actuation, a pilot signal from a 3/2 N.C. valve is used to activate pilot ports of final control valve.

4.1 Direct Control of Single Acting Cylinder

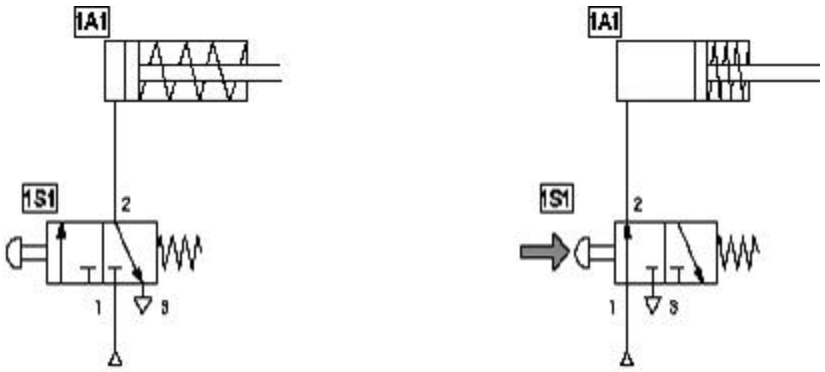


Figure 4.1 Direct Control of Single Acting Cylinder

Pneumatic cylinders can be directly actuated by actuation of final control valve, manually or electrically in small cylinders as well as cylinders which operates at low speeds where the flow rate requirements are less. When the directional control valve is actuated by push button, the valve switches over to the open position, communicating working source to the cylinder volume. This results in the forward motion of the piston. When the push button is released, the reset spring of the valve restores the valve to the initial position [closed]. The cylinder space is connected to exhaust port there by piston retracts either due to spring or supply pressure applied from the other port.

4.2 Indirect Control of Single Acting Cylinder

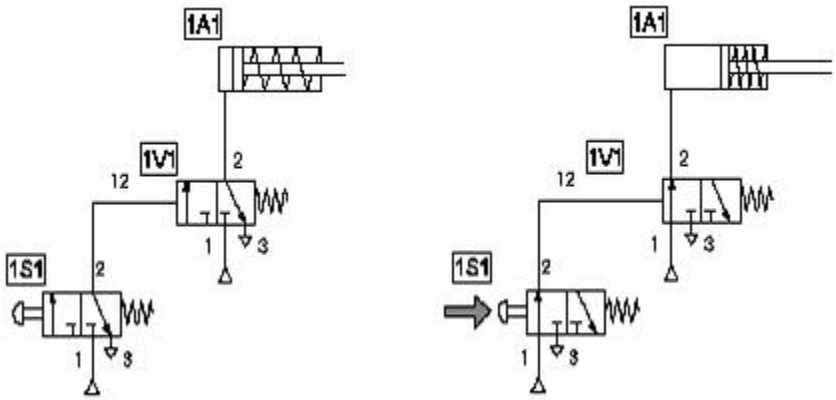


Figure 4.2: Indirect Control of Single and Double Acting Cylinders

Large cylinders as well as cylinders operating at high speed are generally actuated indirectly as the final control valve is required to handle large quantity of air. In the case of pilot operated valves, a signal input valve [3/2 way N.C type, 1S1] either actuated manually or mechanically is used to generate the pilot signal for the final control valve. The signal pressure required can be around 1-1.5 bar. The working pressure passing through the final control valve depends on the force requirement [4-6 bar]. Indirect control as permits processing of input signals.

Single piloted valves are rarely used in applications where the piston has t o retract immediately on taking out the set pilot signal -.suitable for large single acting cylinders.

4.3 Use Double Piloted Valve

Double piloted valve [Fig 3.3] is also called as the Memory valve
With the actuation of Forward push button, the out put signal activates the set pilot port [14] of final control valve. This results forward motion of the cylinder
Now even if this push button is released the final control valve remains in the actuated status as the both the pilot ports are exposed to the atmosphere pressure and the piston remains in the forward end position.

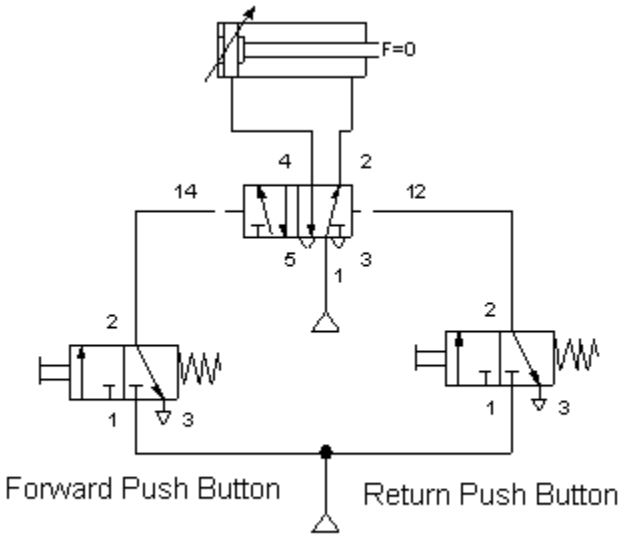


Figure 4.3 Use of Double Piloted Valve

In order to retract the cylinder, the Return push button is activated. This will convey reset signal from signal source to the pilot port of final control valve [12] . The piston retracts. Now even if the Return push button is released the status of the cylinder will not change.

4.4 Methods of Checking The End Positions

The following methods are commonly used to interrogate the end positions of piston in the cylinder:

1. Mechanically operated limit switches (Roller lever or idle return roller type)
2. Reed sensors, either with electrical or pneumatic out put [the piston is incorporated with ring magnet]
3. Electrical proximity switches
4. Pneumatic Signal generators

4.5 Use of Limit Switches

•S1 and S2 are the limit switches corresponding to home position and extended position
•Although they are located in the path of the movement of piston rod, normal practice is to represent the symbol of the limit switches on either side of the final control valve with out put signals connected to the pilot ports of the valve. The limit switches of Roller lever type are essentially 3/2 way ball seat or disc seat type of valves handling pneumatic signals. These are available with direct actuation type and internally pilot actuation type versions. Limit switches of idle return roller type are used for actuation only in one direction are used as signal elimination device in case of signal overlap.

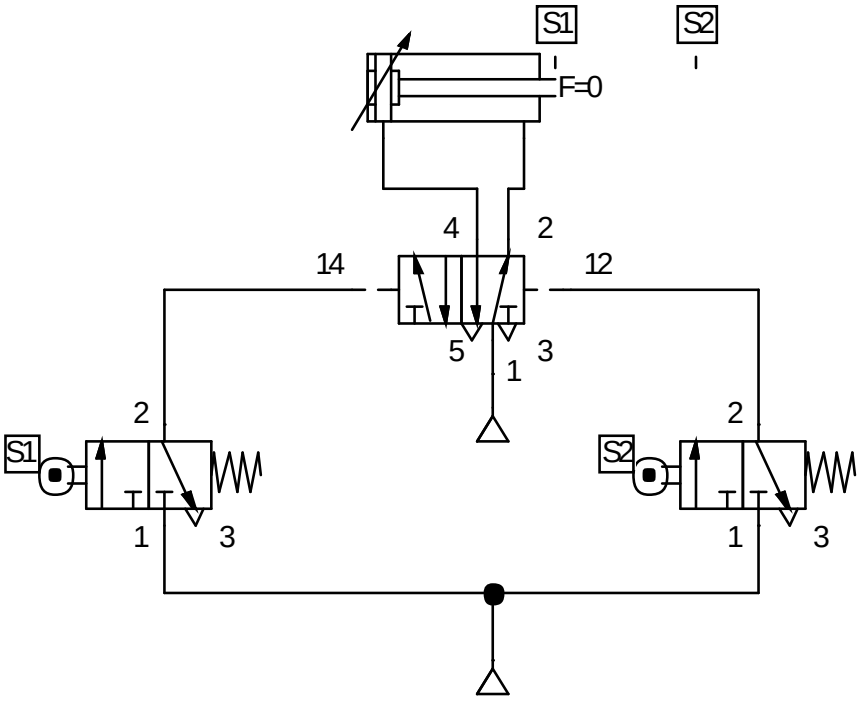


Figure 4.4 Use of Mechanically operated Roller lever Limit Switches

Example 4.1 : Pin Feeding Device

Pins are to be fed from a hopper to the next station one at a time using a Pneumatic Cylinder. Speed of the cylinder should be adjustable both during forward and return motion. The process of feeding should be initiated using a detent push push button. Develop a suitable Pneumatic control circuit .

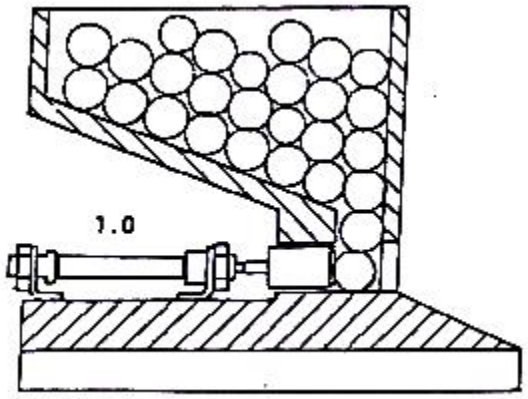


Figure 4.7 Pin Feeding Device

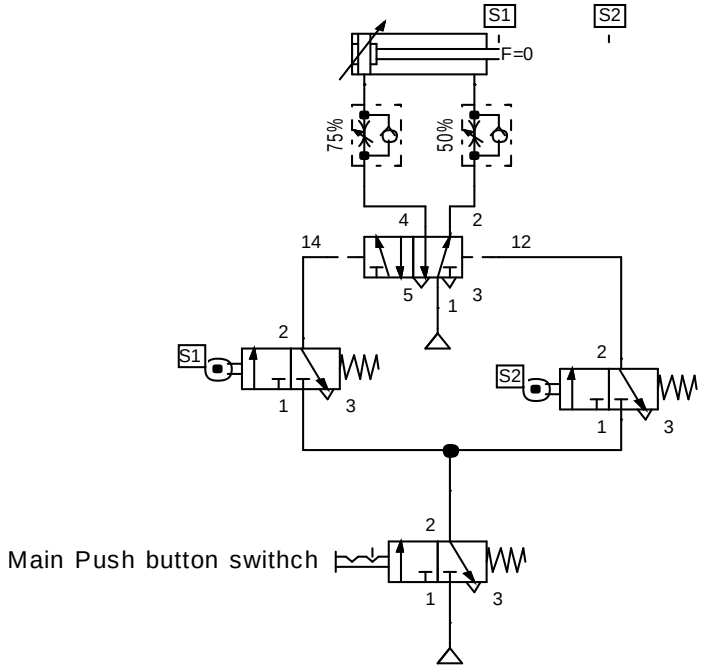


Figure 4.8 Pin Feeding Device

Exercise 4.1 : Rotary Indexing Table

Cans are required to be transferred from one conveyor to the other through a filling and capping station. A rotary indexing device is used which should be able to operate using a pneumatic cylinder with ratchet arrangement. The process should start on actuation of a push button operated valve. The process should stop when no cans are present from the incoming conveyor. The can sensor can be roller lever type of limit switch . Draw a suitable pneumatic control circuit.

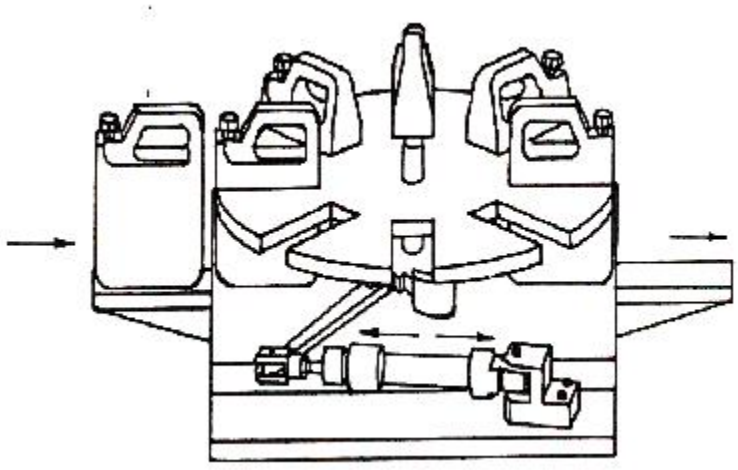


Figure 4.9 Rotary indexing device

CHAPTER 4A

SPEED CONTROL OF CYLINDERS

- It is always necessary to reduce the speed of cylinder from maximum speed based on selected size of final control valve to the nominal speed depending on the application
- Speed control of Pneumatic Cylinders can be conveniently achieved by regulating the flow rate supply or exhaust air.
- The volume flow rate of air can be controlled by using flow control valves which can be either Two way flow control valve or One way flow control valve

Flow Control Valves

- One way flow control valve is often used to achieve independent speed control of cylinder in the forward and return motion. This has a variable restrictor and a non return valve in parallel
- Two flow control valve is essentially a valve with variable restrictor which offers resistance to passage of air in both direction.

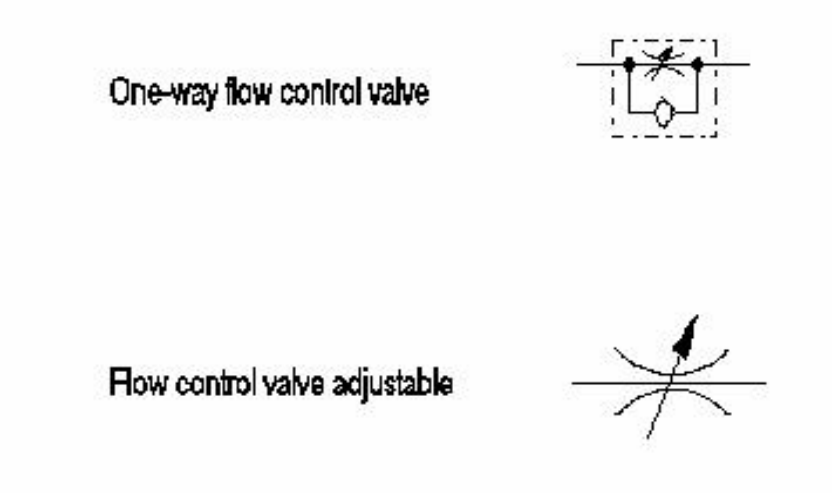


Figure 4A.1 Symbol for Flow Control Valves

One Way Flow Control Valve

- This valve is also called as the Throttle Relief Valve
- Generally used for Speed Control of Cylinder and is installed in the working pressure line, between the final control valve and the cylinder ports

- One way flow control valve has a needle and an orifice arrangement . A Non return valve in the form of an elastic diaphragm is secured to the bottom of the valve orifice. The diaphragm when subjected to air pressure from the top, seals against seat in the valve body and prevents any direct air flow to the down stream side. The compressed air has to necessarily pass through the flow control valve and under goes throttling. When the flow takes place form bottom to top, the diaphragm deflects upwards and allows air to pass directly to the down stream side of the valve, thus by passing the flow control valve.

- When Compressed air is admitted in the direction of throttling, [left to right] it exerts force above the diaphragm and holds it against the seat. This prevents by passing of air through the gap between diaphragm and seat.
- Then compressed air has to pass through the gap between needle and orifice of the valve which results in throttling

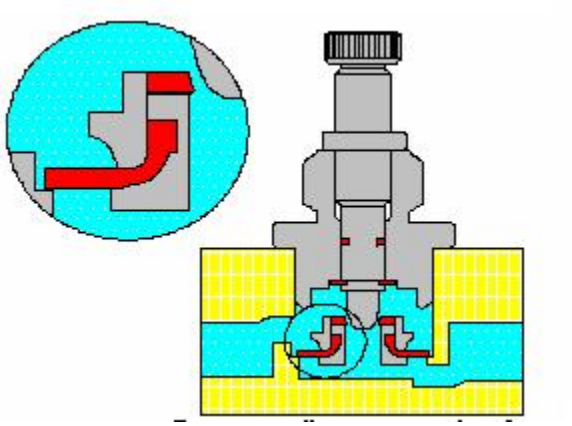


Figure 4A.2 One Way Flow Control Valve During Throttling

- When the flow takes place in the reverse direction, pressure exerted by the compressed air from the bottom of the diaphragm, opens it up against the seat and directly by passes the air without undergoing throttling

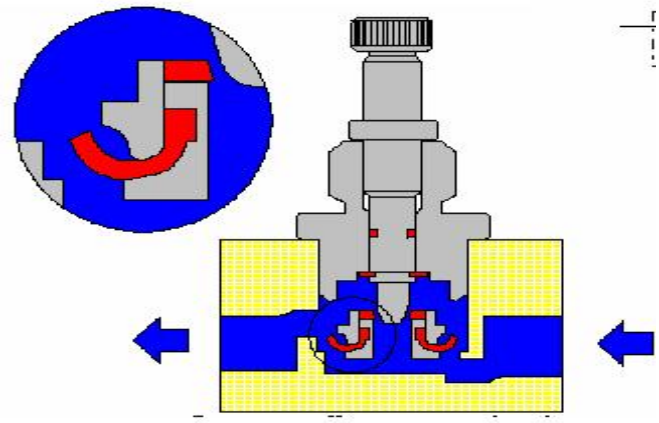


Figure 4A.3 One Way Flow Control Valve During Throttling

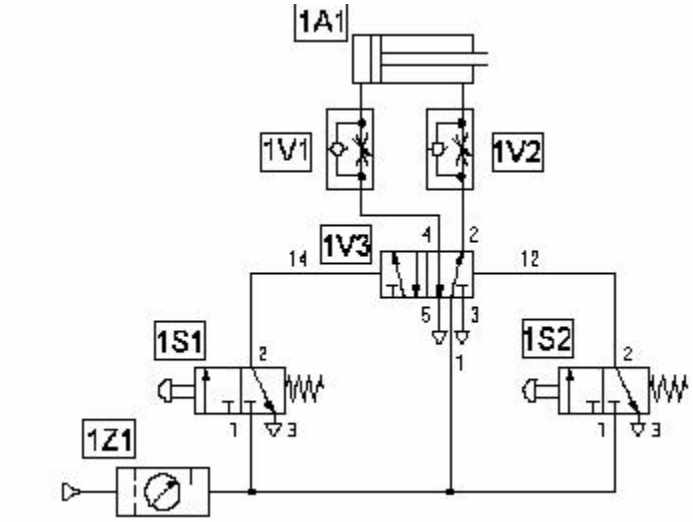


Figure 4A.4 Use of Flow Control Valve for Speed Control of Cylinder

Supply Air Throttling

Supply Air Throttling

- Supply air entering the cylinder through either of the working ports, undergoes throttling as the non return valve is closed in the direction of flow.
- During exhaust , the compressed air leaving the cylinder is by passed through the non return valve and escapes freely as it does not under go throttling
- Supply air throttling is used for single acting cylinder and small volume cylinder

Exhaust Air Throttling

- Supply air flows freely to the cylinder through the bypass passage of the non return valve. The supply air does not under go any throttling
- Exhaust air leaving the cylinder has to under go throttling as the non return valve is closed in the return direction
- The piston is loaded between two cushions of air
- Exhaust throttling should always be used for double acting cylinder
- Not suitable for small volume cylinders and cylinders with short strokes as effective pressure cannot build up sufficiently.

Speed Control of cylinder

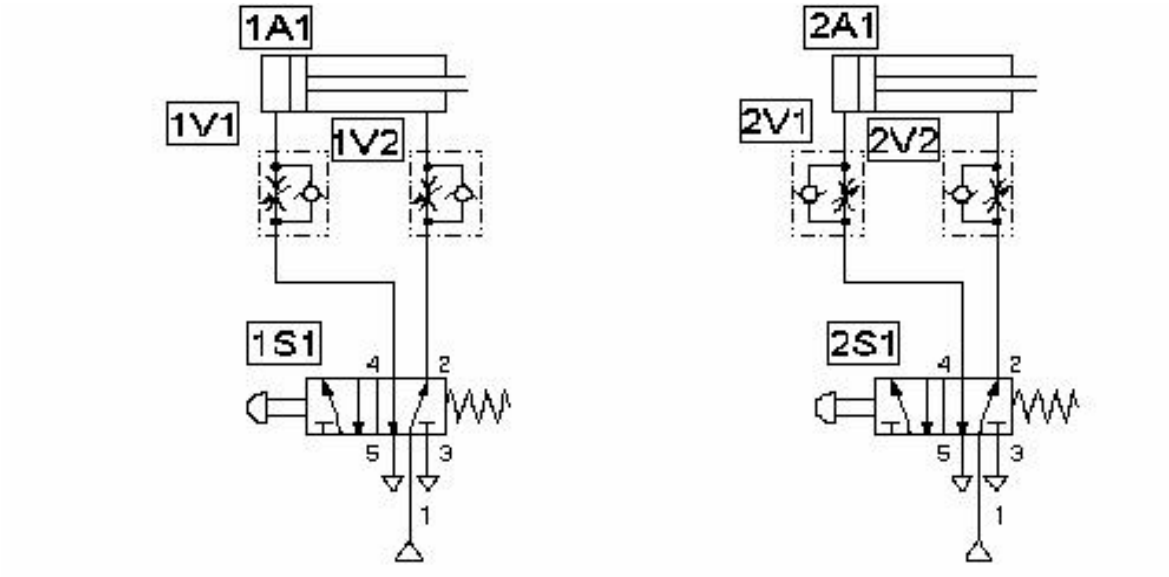


Figure 4A.5 Speed Control Valve

Stick Slip Effect

- There is a limitation is achieving smooth movement of cylinder with low speed setting of flow control valve. This results in jerky motion of piston which is called as the stick slip effect
- When the flow control valve is set for low flow rates, it takes considerable time for the supply air to build up to the required pressure [corresponding to the load]

behind the piston. Every time this pressure is reached, the piston jerks in the direction of motion which results in increase in cylinder volume. This further results in drop in pressure in the cylinder and the piston momentarily halts until the pressure build up takes place. This intermittent motion is called as the Stick Slip Effect

Quick Exhaust Valve

- In many applications especially with single acting cylinders, it is a common practice to increase the piston speed during retraction of the cylinder to save the cycle time
- This is carried out by incorporating a Quick exhaust valve.

- The Quick exhaust valve has essentially three ports
  Supply port 1, is connected to the out put of the final control element (Directional control valve). The Output port, 2 of this valve is directly fitted on to the working port of cylinder. The exhaust port, 3 is left open to the atmosphere

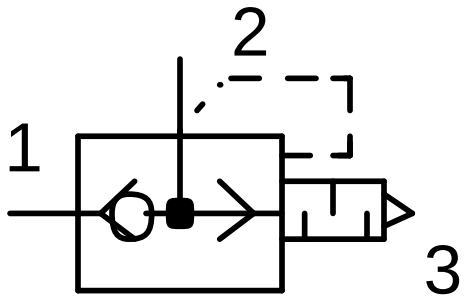


Figure 4A.6 Symbol for Quick Exhaust Valve

Forward Motion

During forward movement of piston, compressed air is directly admitted behind the piston through ports 1 and 2 Port 3 is closed due to the supply pressure acting on the diaphragm. Port 3 is usually provided with a silencer to minimise the noise due to exhaust.

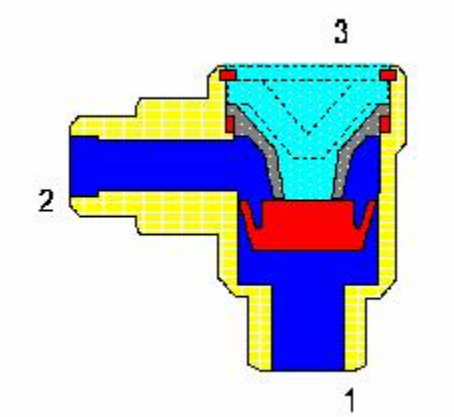


Figure 4A.7 Quick Exhaust Valve during Forward Motion

Return Motion

During return movement of piston, exhaust air from cylinder is directly exhausted to atmosphere through opening 3 (usually larger and fitted with silencer) .Port 2 is sealed by the diaphragm. Thus exhaust air is not required to pass through long and narrow passages in the working line and final control valve

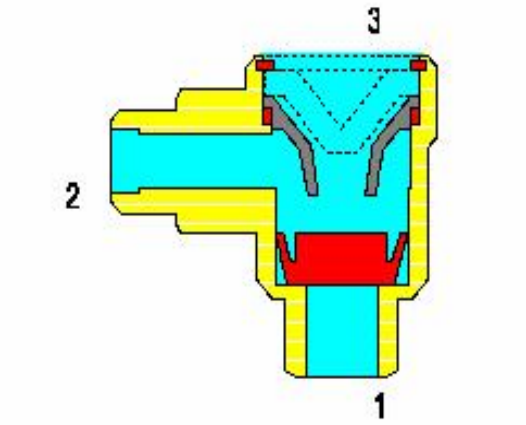


Figure 4A.8 Quick Exhaust Valve during Return Motion

Use of Quick Exhaust Valve

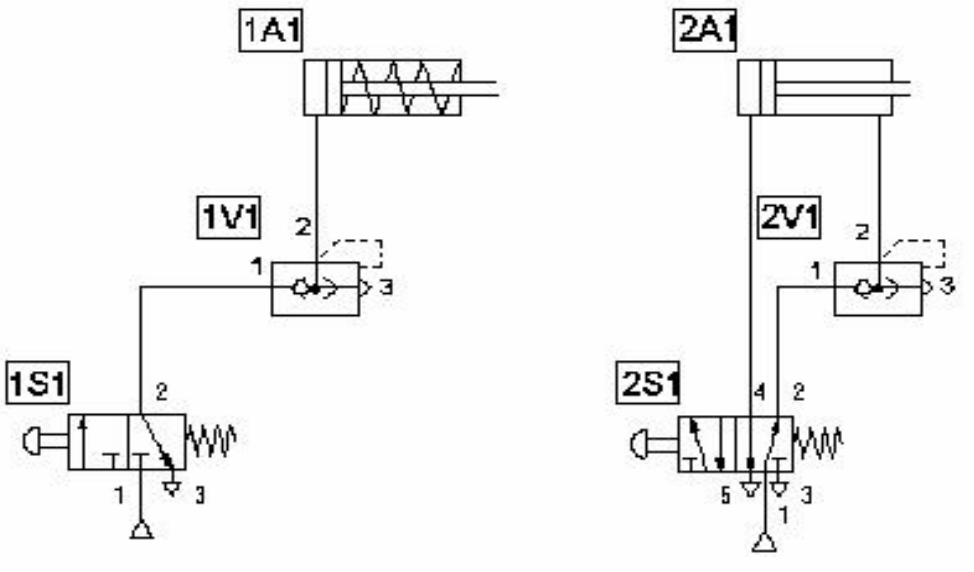


Figure 4A.9 Use of Quick Exhaust Valve

Example 4. 1

Liquid metal is drawn from a smelting crucible by a casting ladle and cast in moulds. The raising and lowering of the ladle is controlled by separate manual push buttons. The raising and lowering speed is separately adjustable . Design a Pneumatic control circuit for this application

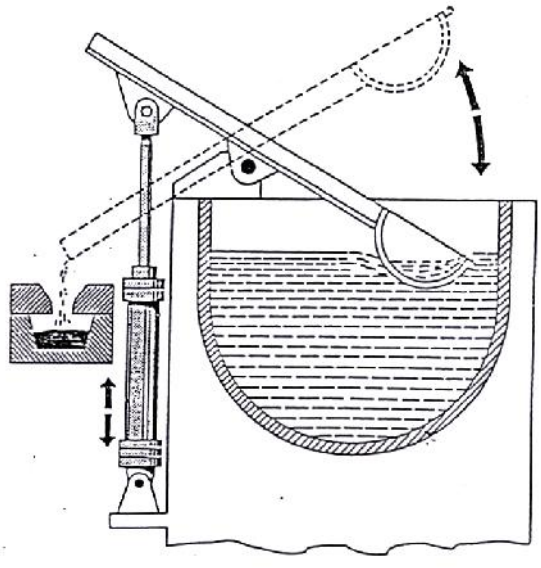


Figure 4A. 10 Casting Ladle Controlled by Cylinder

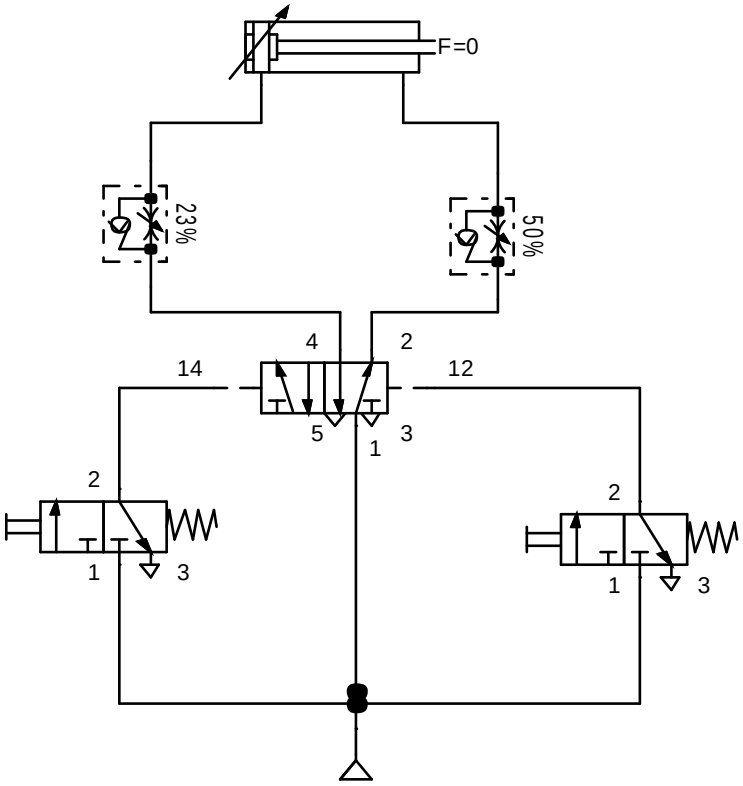


Figure 4A.11 Pneumatic Control for Casting Ladle

CHAPTER 5

SIGNAL PROCESSING DEVICES

To meet the requirement of various conditions in pneumatic applications, signal processing devices are often used. The following gates or valves are used, depending on the required conditions.

- OR Gate – Shuttle Valve – Used to select one of the two input signals
- AND Gate- Two Pressure Valve- To combine two input signals i.e to satisfy two conditions at the same time
- NOT Gate- 3/2 way, normally open, pilot operated Directional Control Valve- Used to negate the function

Shuttle Valve

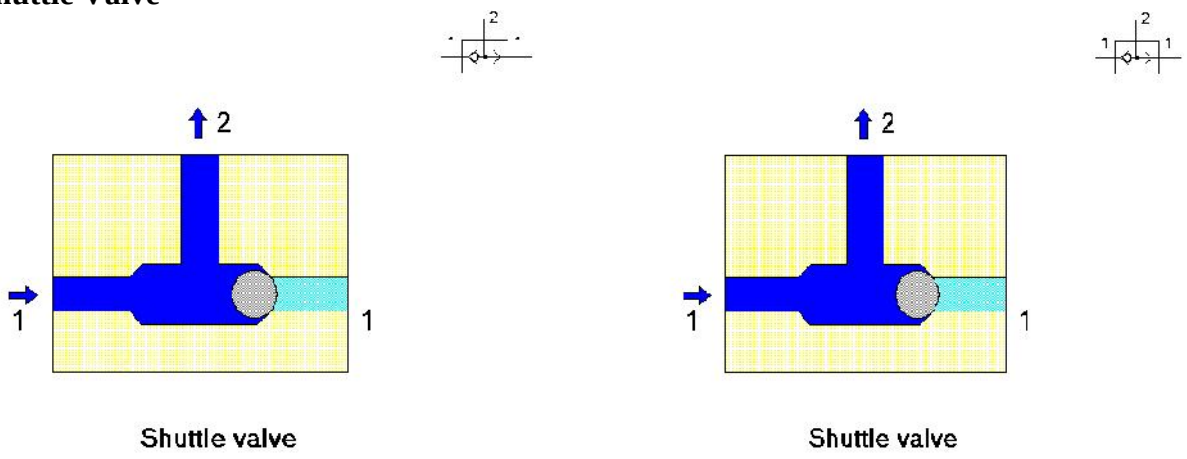


Figure 5.1 Shuttle Valve

- An Input Signal [1] can be applied on either side of the valve to obtain an out put signal at port 2. A small aluminum or plastic ball or spool is used as the shuttle which blocks the port opposite to the input signal.

OR Combination without Shuttle Valve

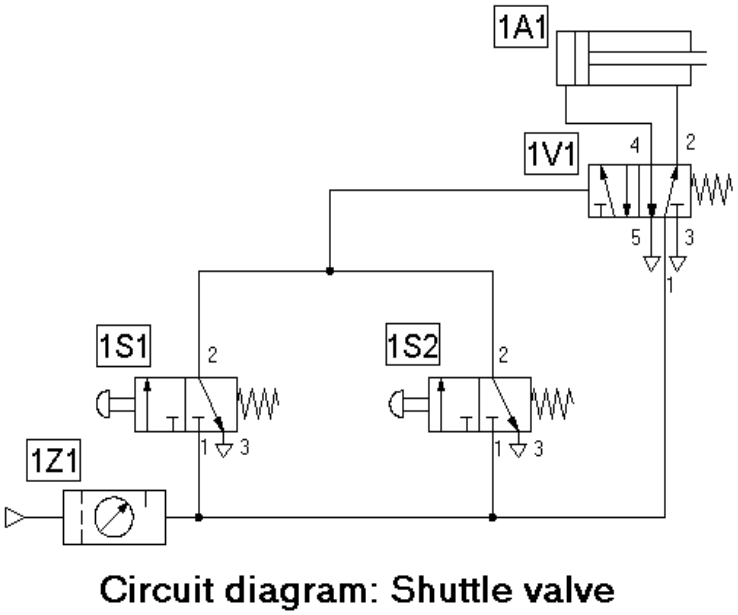


Figure 5.2 Circuit Diagram without Shuttle Valve

Use of Shuttle Valve

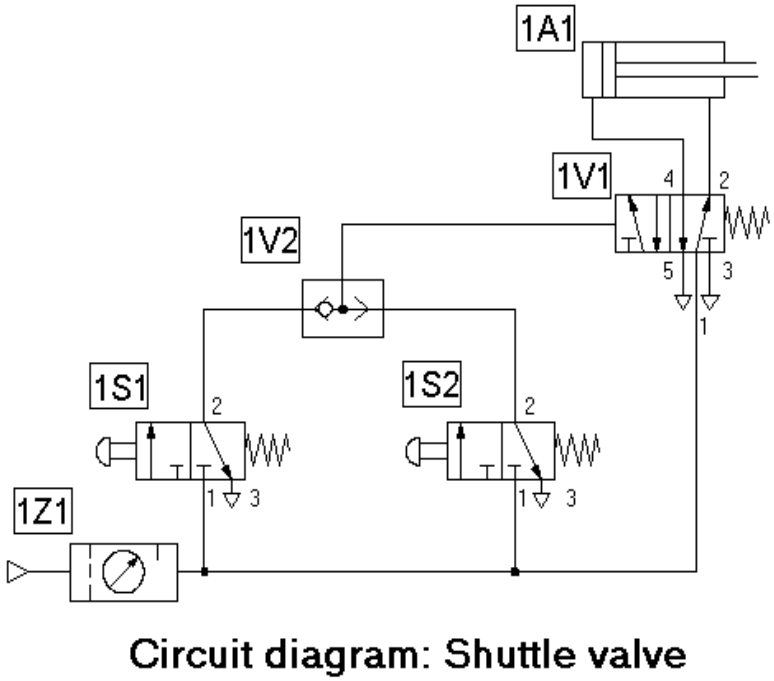


Figure 5.3 Circuit Diagram with Shuttle Valve

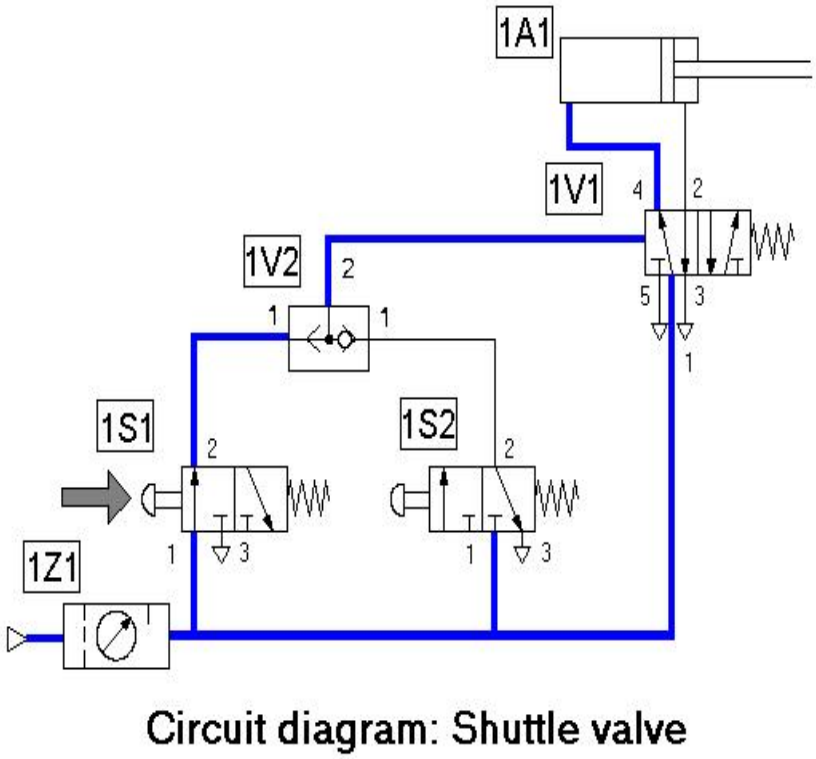


Figure 5.4 Circuit Diagram with Shuttle Valve (Actuated)

Two Pressure Valve

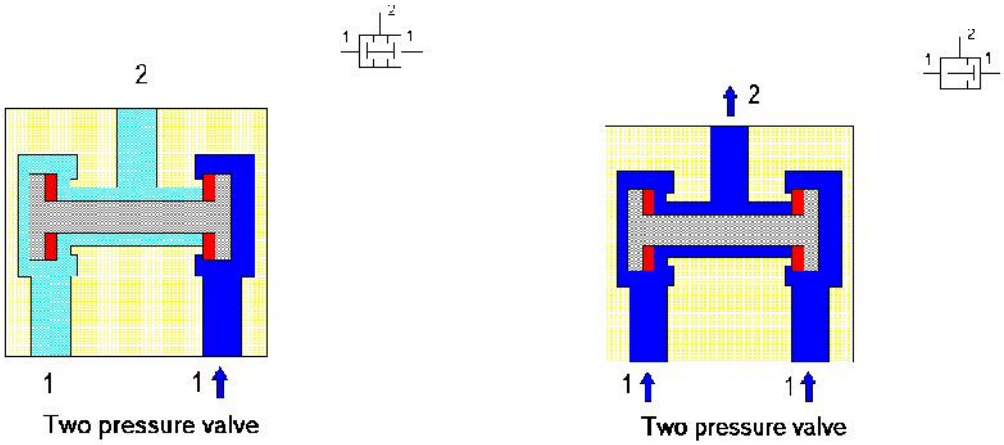


Figure 5.5 Two Pressure Valve

Input signal applied on any one side of the valve will block the signal passage on the same side of the port. If a second signal is applied on the opposite side at the same time, it will be communicated to the out put port.

And Gate Combination

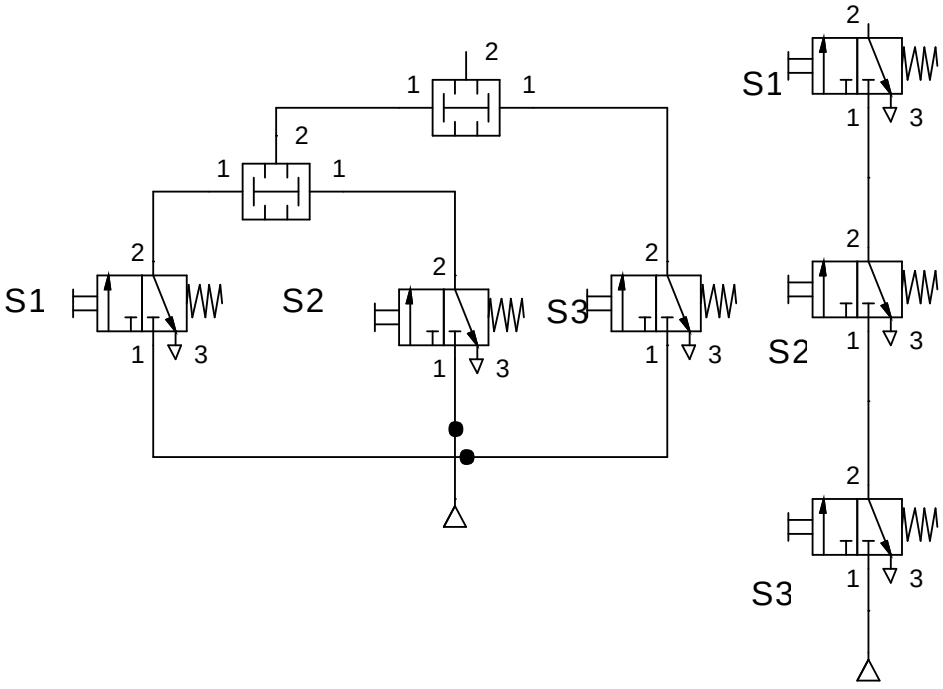


Figure 5.6 and Gate Combination

Use of Two Pressure Valve

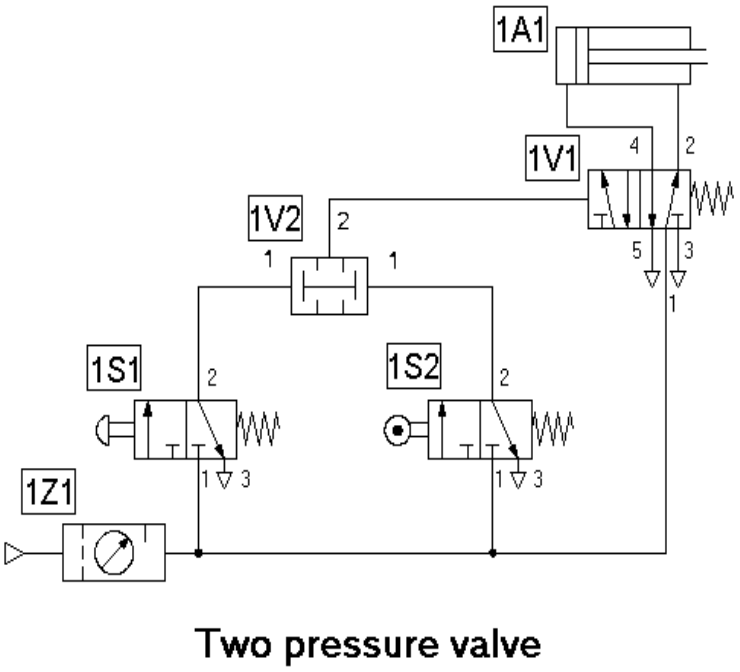


Figure 5.7 Two Pressure Valve

Use of Two Pressure Valve

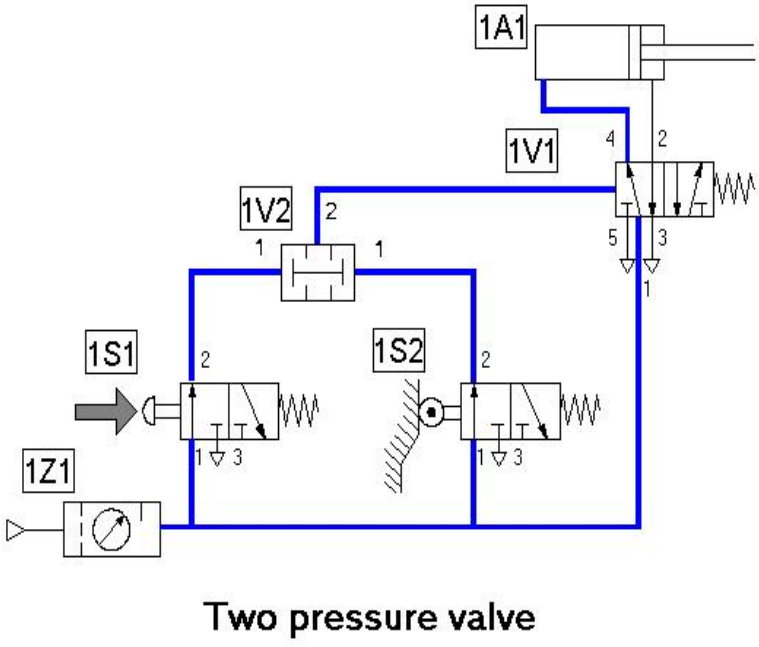


Figure 5.8 Two Pressure Valve

Not Gate

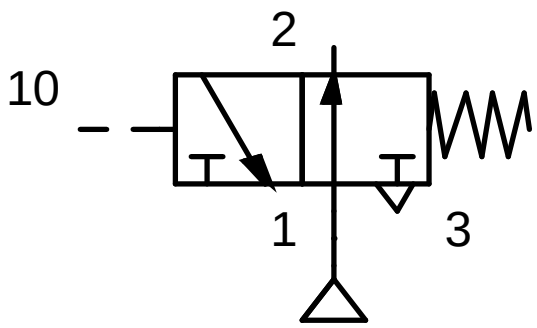


Figure 5.9 Not Gate

Not Gate is generally used to invert the signal status i. e to negate the signal. For example a normally closed timer or counter can be converted to normally open and vice versa
It is essentially a normally open 3/2 way, pilot operated directional control valve
Input signal is applied at pilot port 10 and out put is taken from port 2.

Grouping of Set and Reset Signals

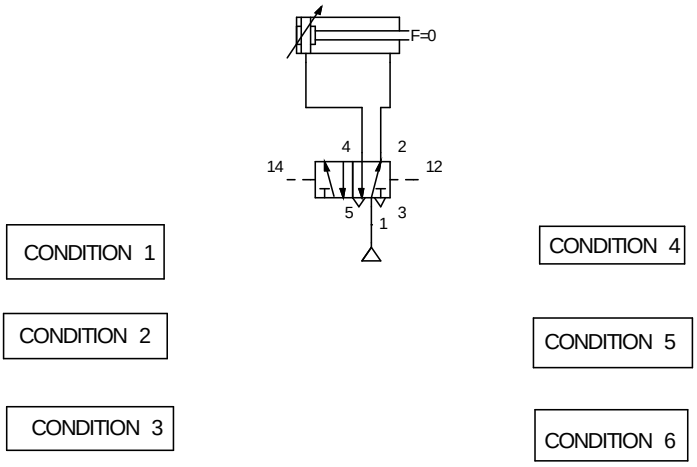


Figure 5.10 Grouping of Set and Reset Signals

Example 5.1 Clamping Device

The Clamping of workpiece must be possible slowly by manual control from two positions.
Unclamping must be carried out quickly and initiated by a further manual push button
Clamping must be possible only when the work pieces has been inserted
Unclamping must not be possible during the drilling operation.

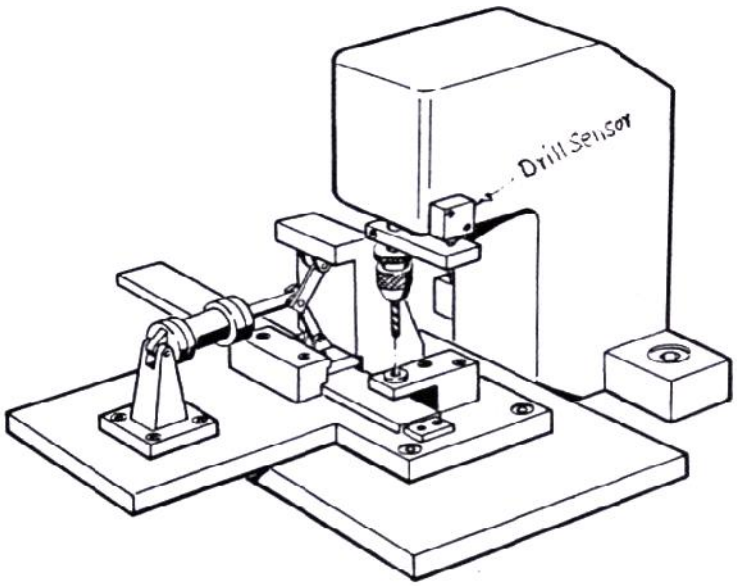


Figure 5.11 Clamping Device

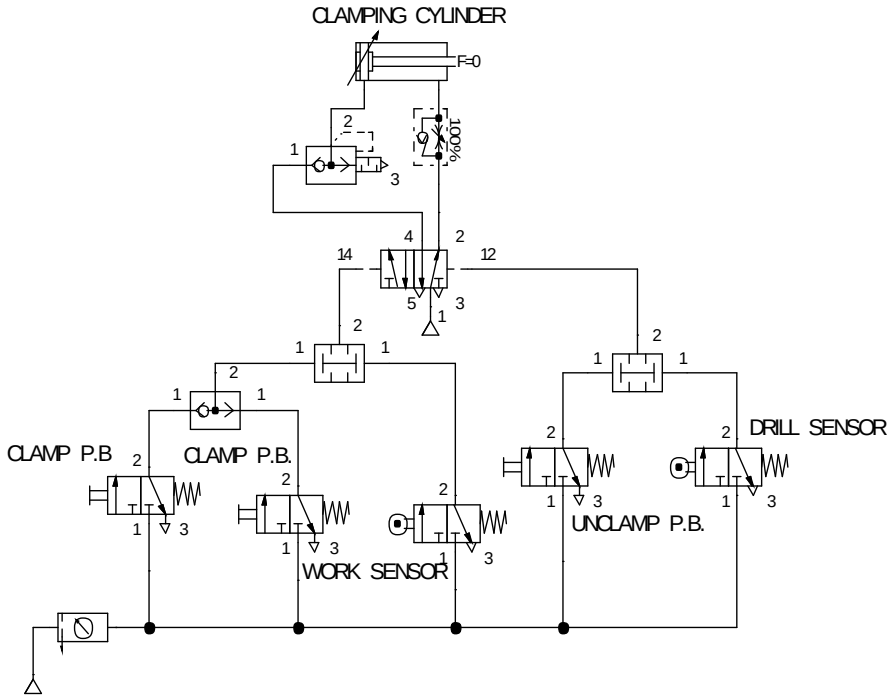


Figure 5.12 Clamping Device –Control Circuit

Example 2: Distribution of Balls

Billiards balls are distributed from a gravity magazine via distributor shafts by two packing stations for individual packing. The signal for the return stroke must be capable of being given by the machine operator by means of either a manual push button or a foot-operated valve. The advance stroke of the piston is triggered by the piston rod when the rearmost end of position is reached.
The piston must execute a return stroke only when balls are present in the gravity magazine.

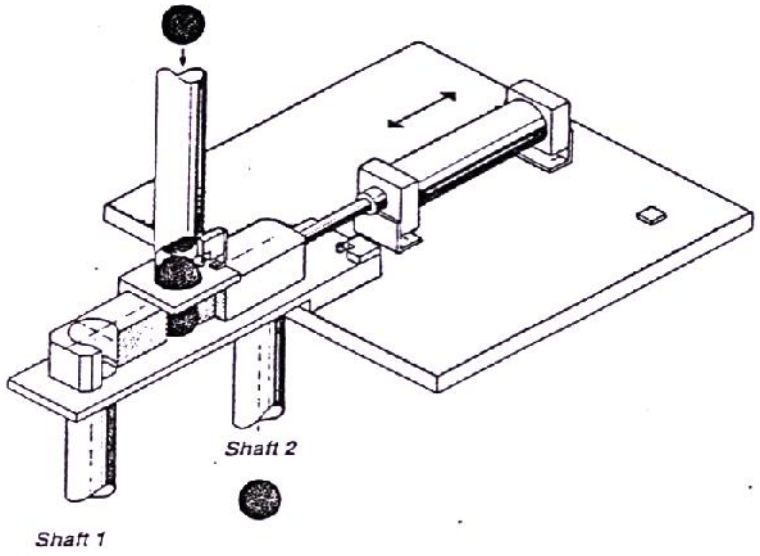


Figure 5.13 Distributions of Balls

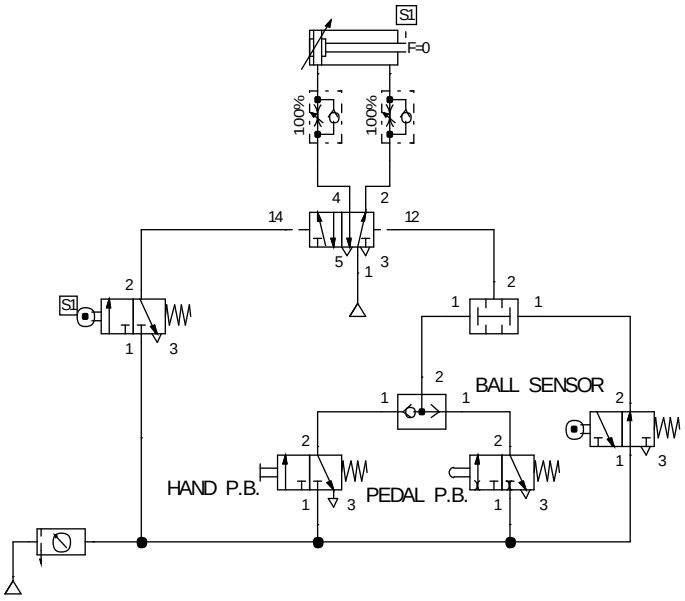


Figure 5.14 Distributions of Balls

Multi Position Cylinder

Normally we can get only two fixed positions [end positions] using a conventional cylinder. However It is possible to attain 3 to 4 positions using combinations of two cylinders of same or different lengths . The Cylinders are connected back to back using appropriate size of flange mountings. Piston rod of one of the cylinder is trunion mounted. This provides an economical solutions without going for elaborate electronic control

Both the cylinders Retracted

Ist Cylinder advanced and IInd Cylinder retracted

Ist Cylinder retracted and IInd Cylinder is advanced

Both Cylinder Advanced

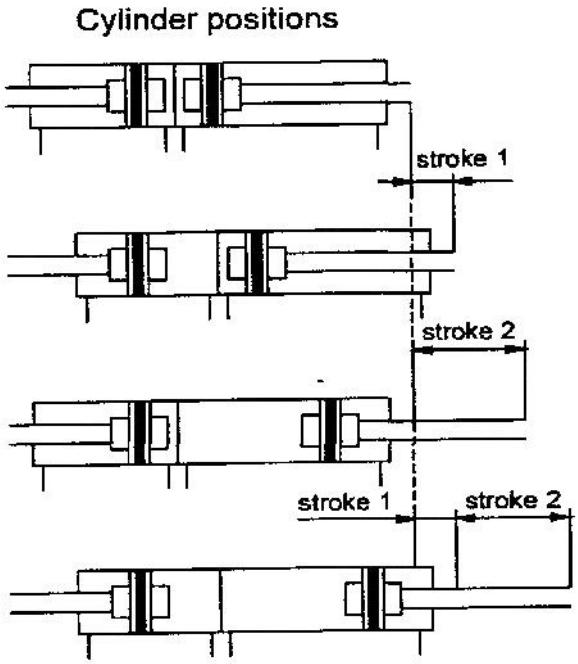


Figure 5.15 Multi position Cylinder Arrangement

Four positions can be obtained using combinations of two cylinders

Position	Displacement	Cylinder status
1	0	Both Cylinders retracted
2	L1 [Stroke length]	Ist Cylinder advanced & II Cylinder retracted
3	L2 [Stroke length	I st Cylinder retracted & II Cylinder advanced
4	L1+L2	Both the Cylinders advanced

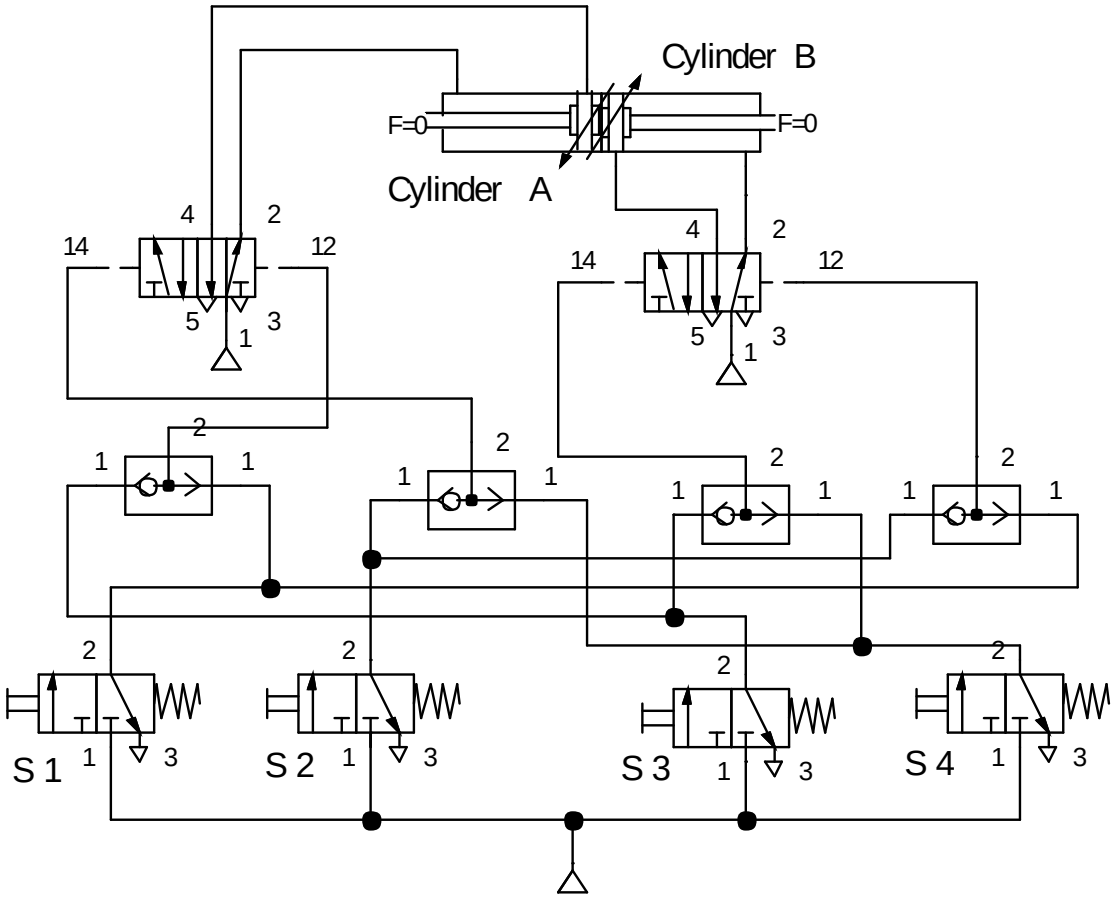


Figure 5.16 Pneumatic Control Diagram

CHAPTER 6

PRESSURE AND TIME DEPENDENT VALVES

Pressure Dependent Valves

The following Pressure Dependent Controls are often used in Pneumatic applications

- Pressure Sequence Valve
- Pressure Relief Valve
- Pressure Regulator

Pressure Sequence Valves

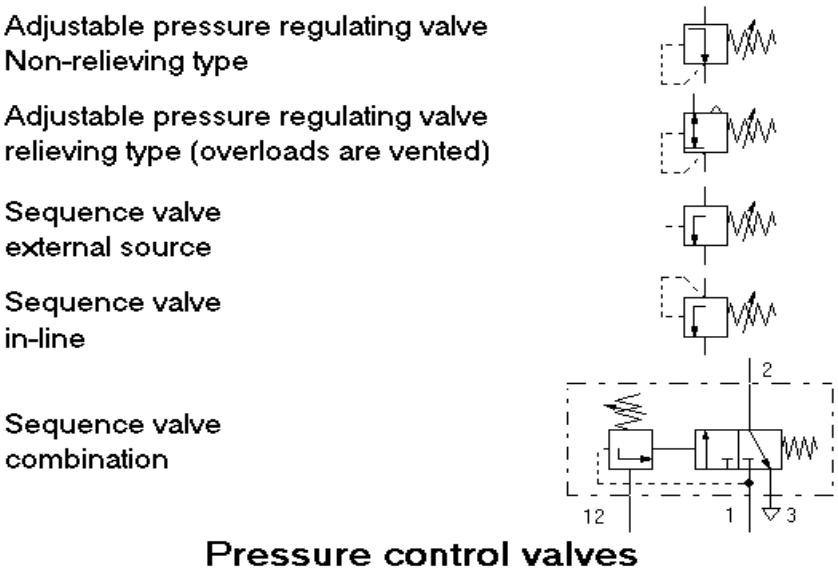


Figure 6.1 Pressure Control Volves

- Pressure Sequence valve is essentially a switch on or off valve
- Sequence Valve generates a pneumatic signal if the sensing pressure [signal input] is more than the desired set pressure
- This generated out put signal is used to control the movement of cylinder by using it as a set signal or reset signal to the final control valve to obtain forward or return motion respectively

- Used for applications such as bonding cylinders, clamping cylinder etc. to ensure desired minimum pressure in the cylinder
- This is a combination valve, having two sections. One of the section is a 3/2 directional control and the other a pressure control valve

Pressure Sequence Valve

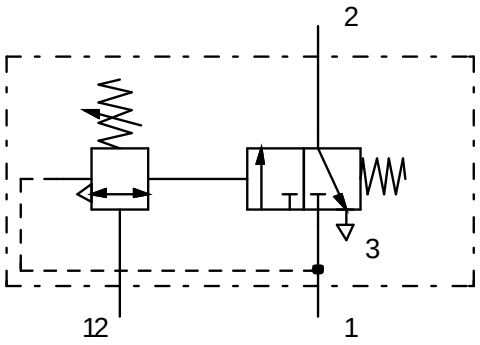


Figure 6.2 Pressure Sequence Valve

Sensing pressure signal is introduced at port 12
Manual adjustment of pressure setting is done with the help of a cap screw/knob which is spring loaded. Clock wise rotation of knob results setting for higher pressure setting and anticlockwise rotation of knob results in lower pressure setting.
The right section is basically a 3/2 directional control valve [NC] - pilot operated using pressure signal derived from left section.

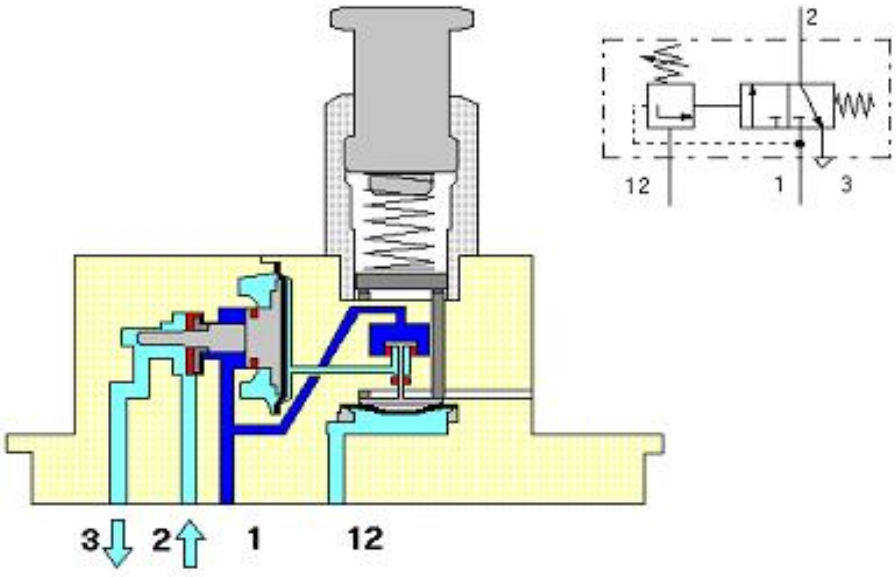


Figure 6.3 Adjustable Pressure Sequence Valve

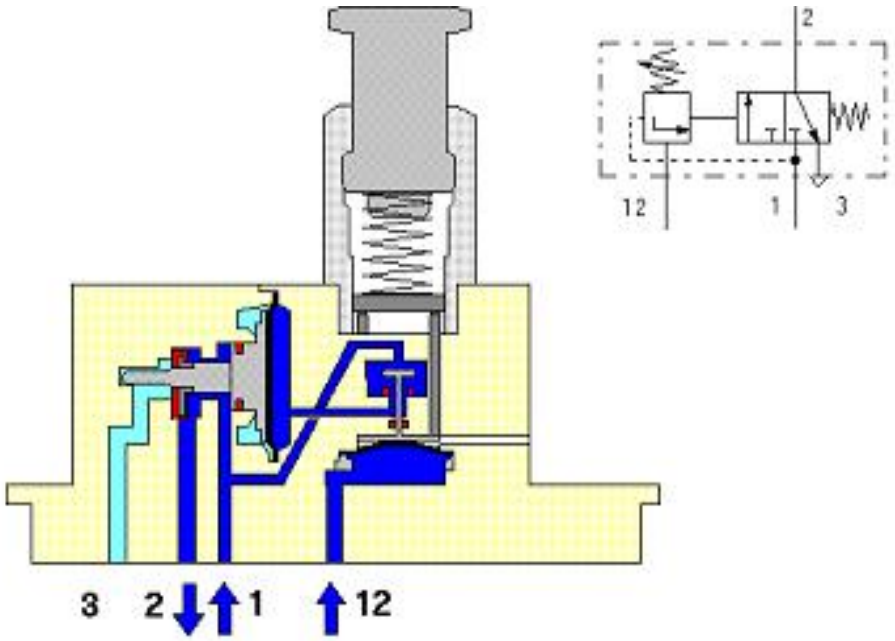


Figure 6.4 Adjustable Pressure Sequence Valve. Actuated

Pressure Sequence Valve Circuit

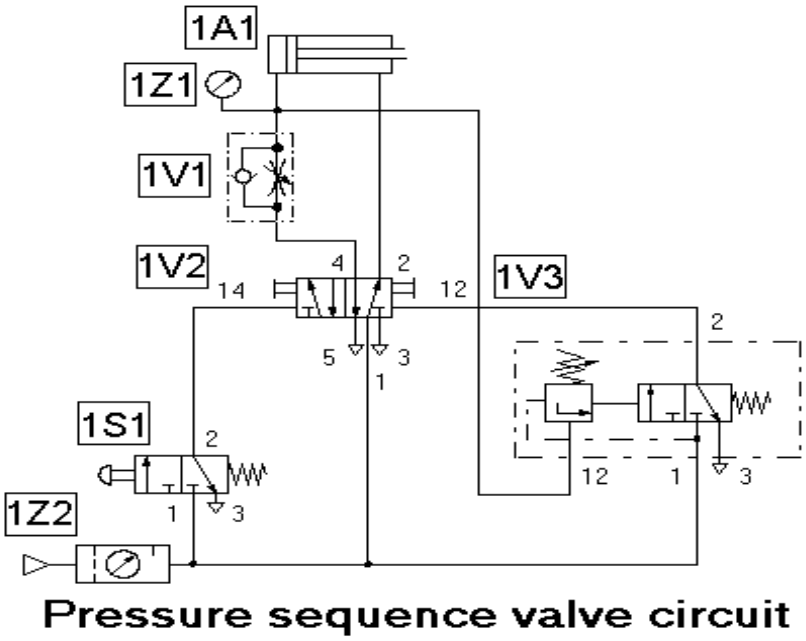
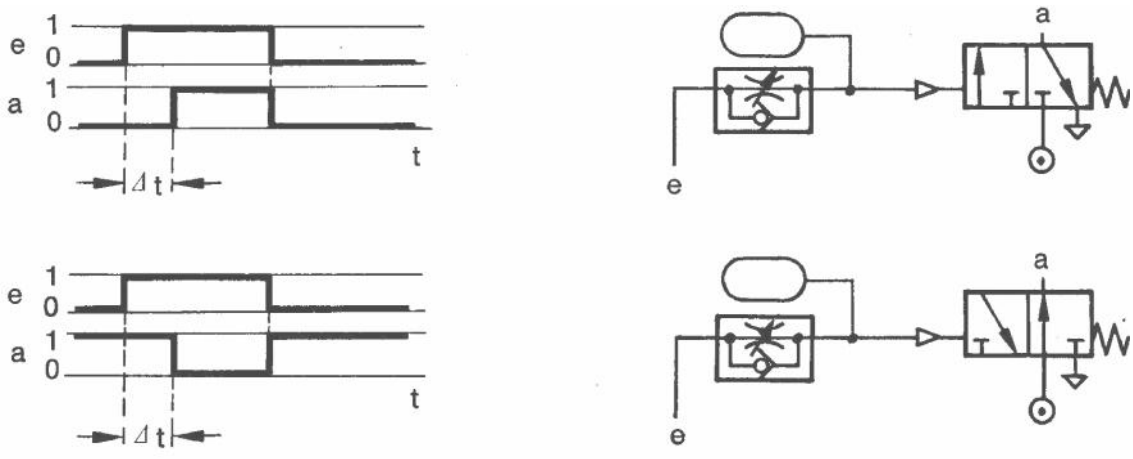


Figure 6.5 Adjustable Sequence Valve Circuit

Pneumatic Timers

- Pneumatic Timers are used to create time delay of signals in pilot operated circuits.
- Available as Normally Closed Timers and Normally Open Timers.
- Usually Pneumatic timers are On Delay Timers
  Delay of signals is very commonly experienced in applications such as
- Bonding of two pieces.
- Normally Open Pneumatic Timer are also used in signal elimination
- Normally Open Pneumatic Timers are used as safety device in Two Hand Blocks

Pneumatic Timers



ON DELAY TIMER NORMALLY OPEN AND NORMALLY CLOSED

Figure 6.6 Pneumatic Timers

Pneumatic Timers

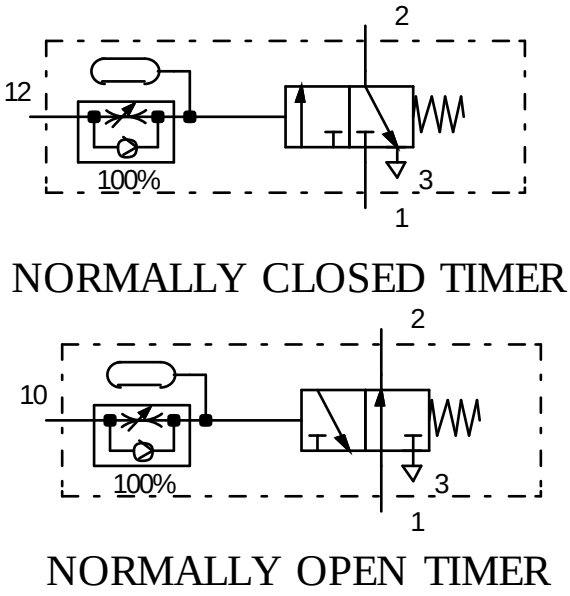


Figure 6.7 Pneumatic Timers

A Pneumatic Timer is a combination valve which consists of three parts

1. 3/2 way pilot operated directional control valve [NC or NO],
2. A one way flow control valve and
3. An accumulator

- Signal input is supplied at port 1 and delayed signal out put is taken at 2. A signal source is connected at port 1

Time Delay Valve [N.C]

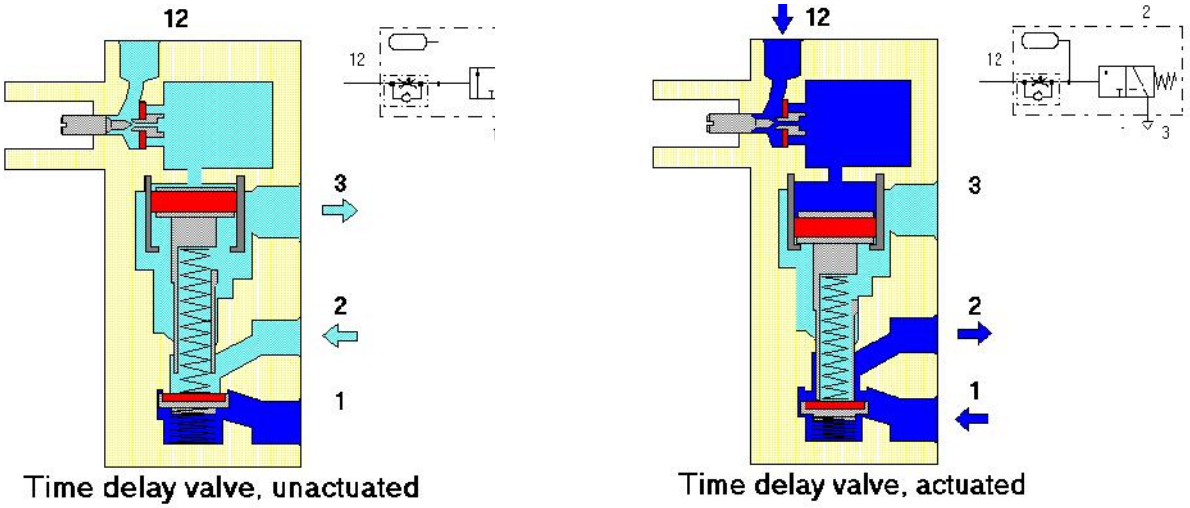


Figure 6.8 Details of Time Delay Valve [Normally Closed]

Application of Time Delay Valves

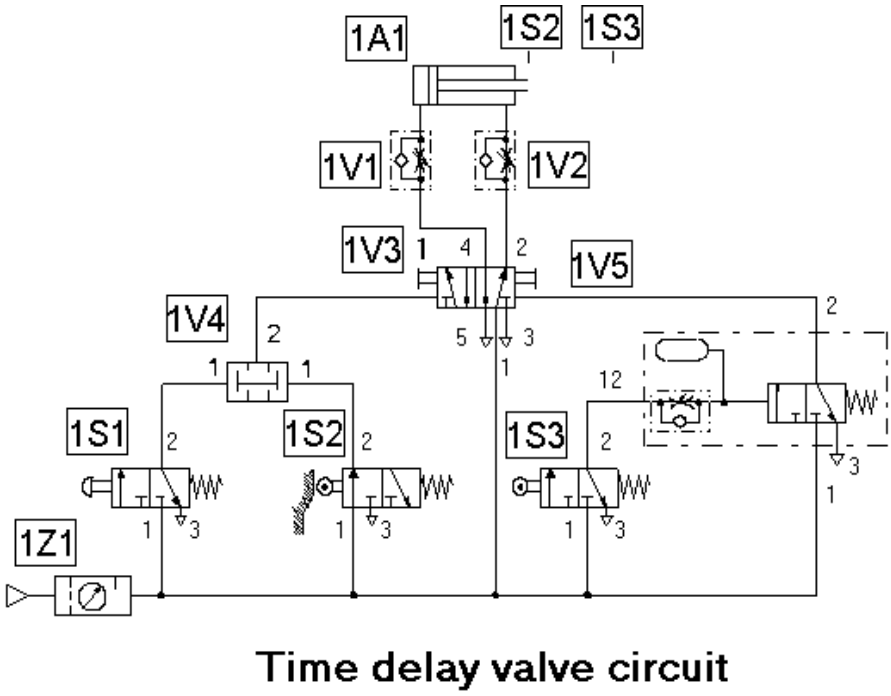


Figure 6.8 Time Delay Valve Circuit [N.C]

Ex.: 1 Use of Pressure Sequence Valve in Clamping Application

Work Pieces are to be **clamped** using a Pneumatic Cylinder. It is necessary that the piston advances on actuation of a Hand Push button only after the desired pressure is available in the working pressure supply. The piston should retract on releasing the same push button

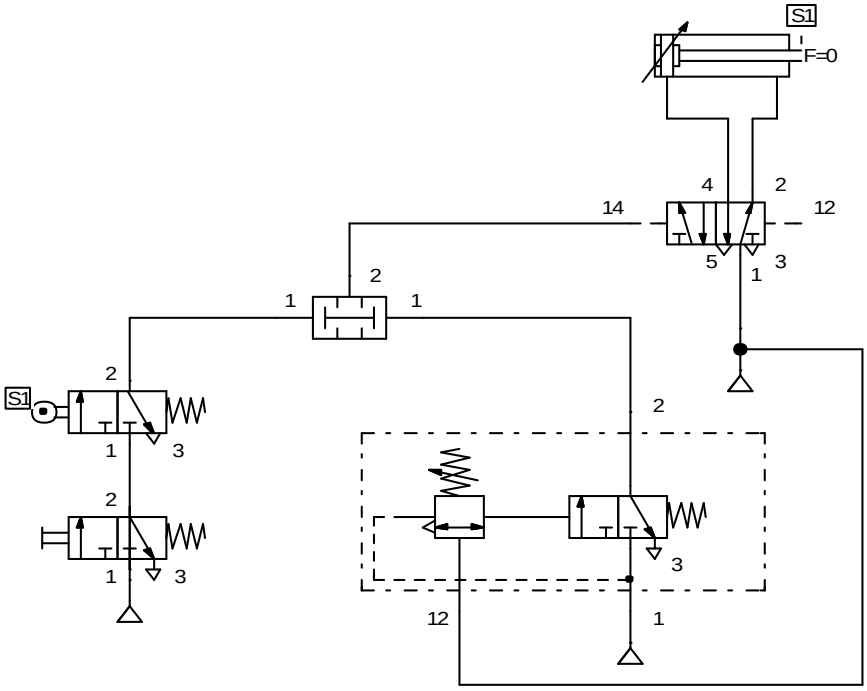
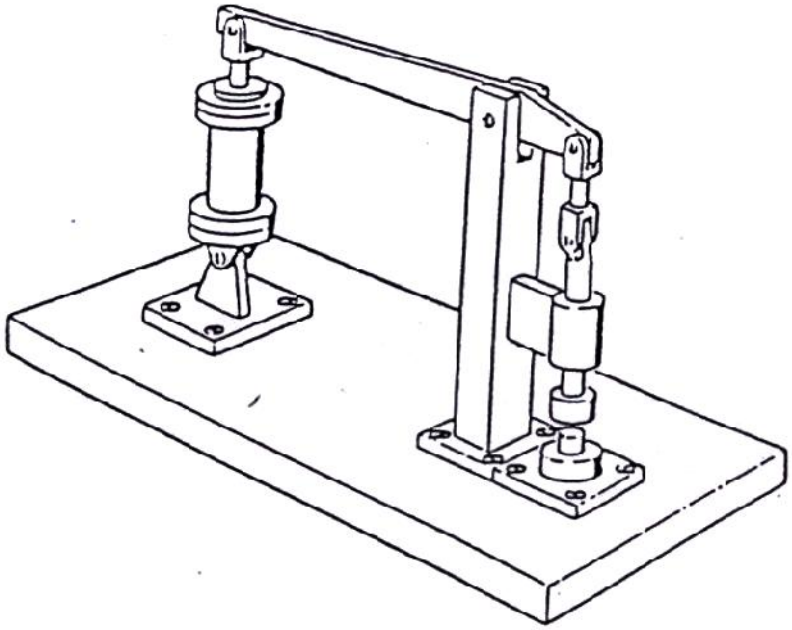


Figure 6.9 Use of Pressure Sequence Valve in Clamping Application

Exercise 2: Stamping of Badges

Badges are to be produced from a very thin metal sheet
A press with stamping die is available for this purpose . The double acting cylinder should extend when both push buttons S1 and S2 are pressed simultaneously.
The return stroke to occur automatically only after **preset pressure has been reached** in the cylinder at the forward end position[to get the consistent quality]
The cylinder should retract even if an Emergency push button S3 is pressed.



Example 3: Clamping Device

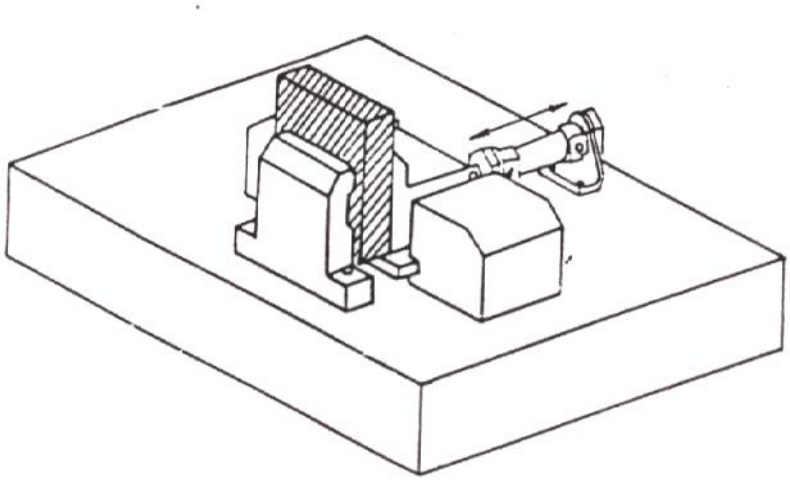


Figure 6.11 Clamping Device

A push button is to control the forward stroke. After the piton rod has reached the forward end position, the components are to be pressed together for 20 seconds. Then the piston rod should return to initial position automatically.
The return stroke must occur even if the start push button is still depressed.
A new start signal may only become effective after the initial position has been reached and after the push button has been released

Example 3: Clamping Device - Circuit

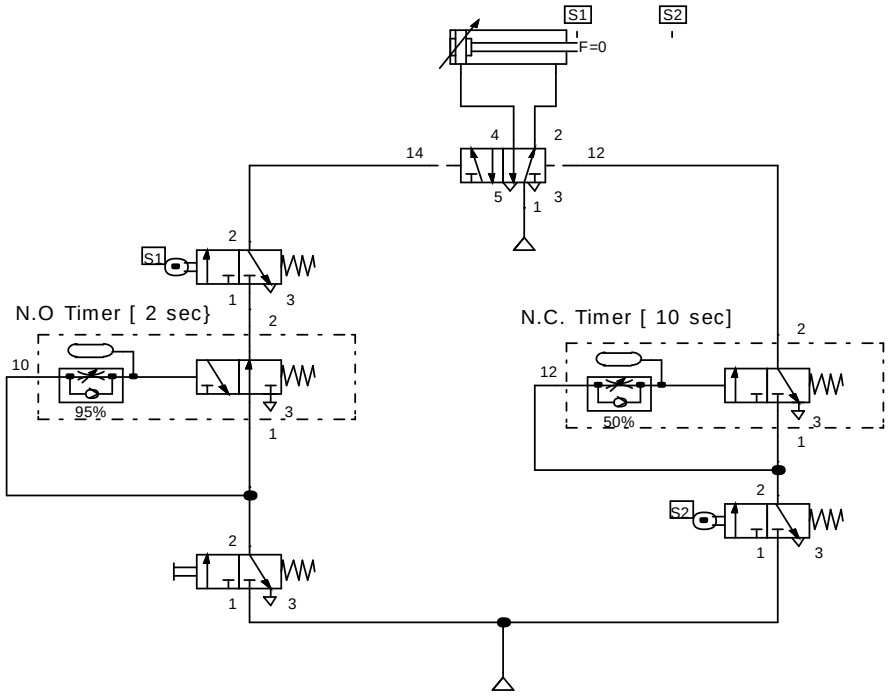


Figure 6.12 Clamping Devices – Circuit

Ex. 4: Two Hand Safety Block

A Pneumatic Cylinder has to advance on actuation of two push buttons simultaneously [both the hands of the operator are engaged]. The second push button is activated within short interval of time after actuation of first button.
/If any one of the push button is released, the piston of cylinder should Retract.

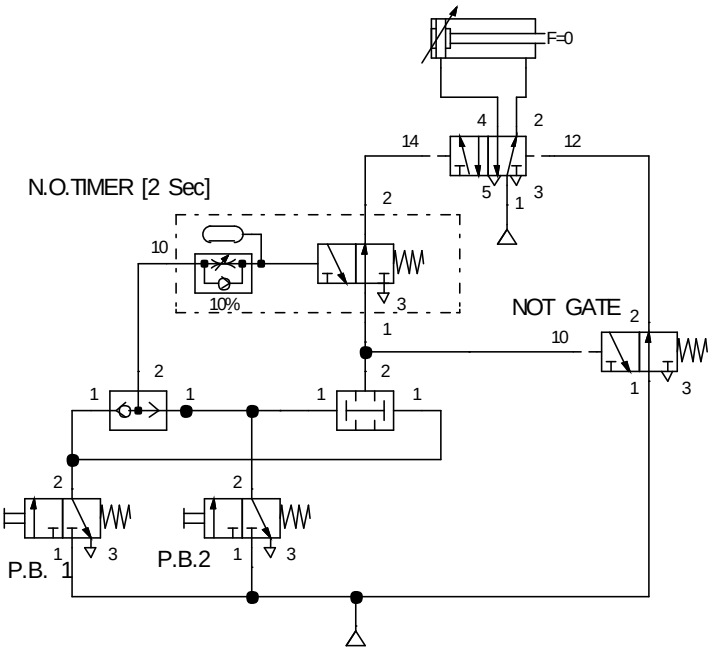


Figure 6.13 Two Hand Safety Block

Exercise 2: Stamping Device

Articles are to be stamped using a stamping device
By pressing two push buttons simultaneously, the movable stamping die is pushed down and the article is stamped .
After desired pressure is reached the die returns to its initial position even though the push buttons are still pressed
Next cycle should be possible only after the push buttons are released

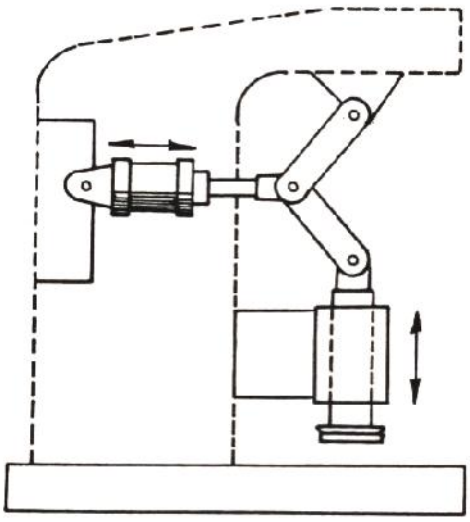


Figure 6.14 Stamping Device

Exercise 2: Bonding Application

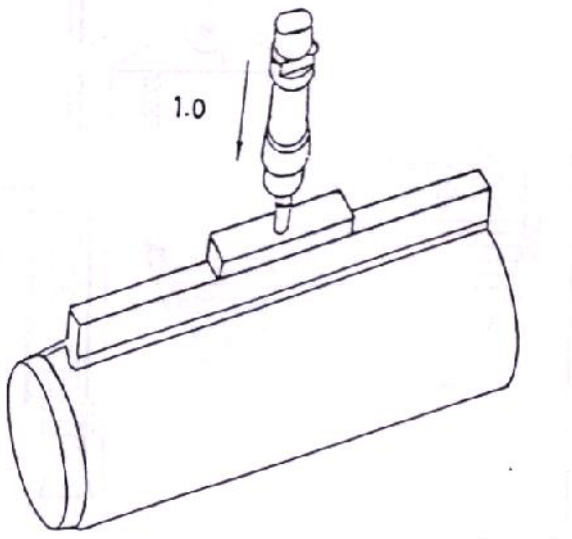


Figure 6.15 Bonding Application

Plastic Cylinders are to be bonded using a Pneumatic cylinder.
It is required that piston performs forward stroke on actuation of a hand push button
Return motion should take place after the piston reaches forward end position
cylinder attains full pressure of 6 bar and remains in that position for 10 sec
It should be possible to restart the forward motion only 20 sec after the piston reaches home position.

Development of Pneumatic Circuit

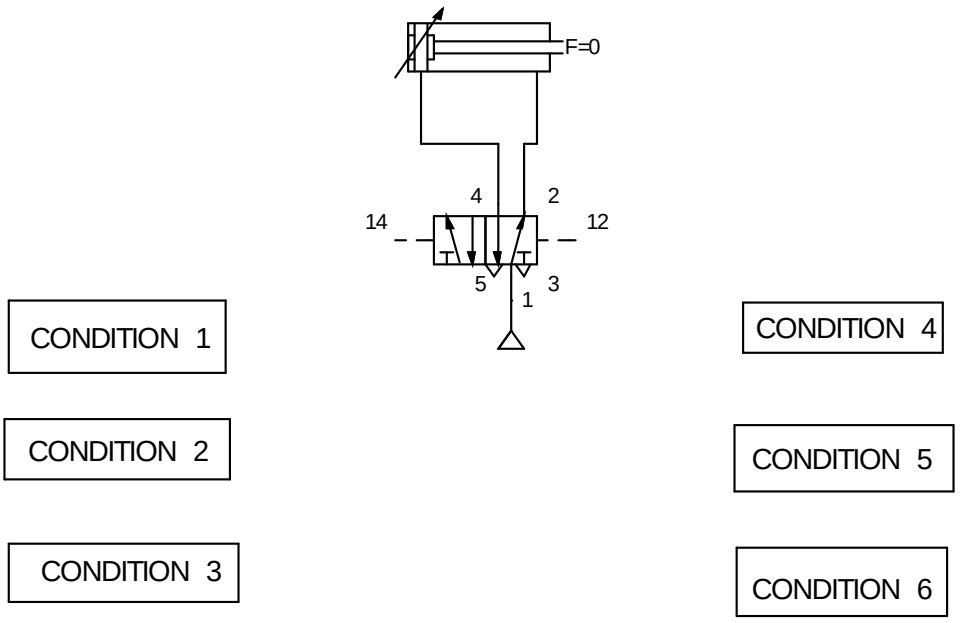


Figure 6.16 Development of Pneumatic Circuit

Bonding Application: Solution

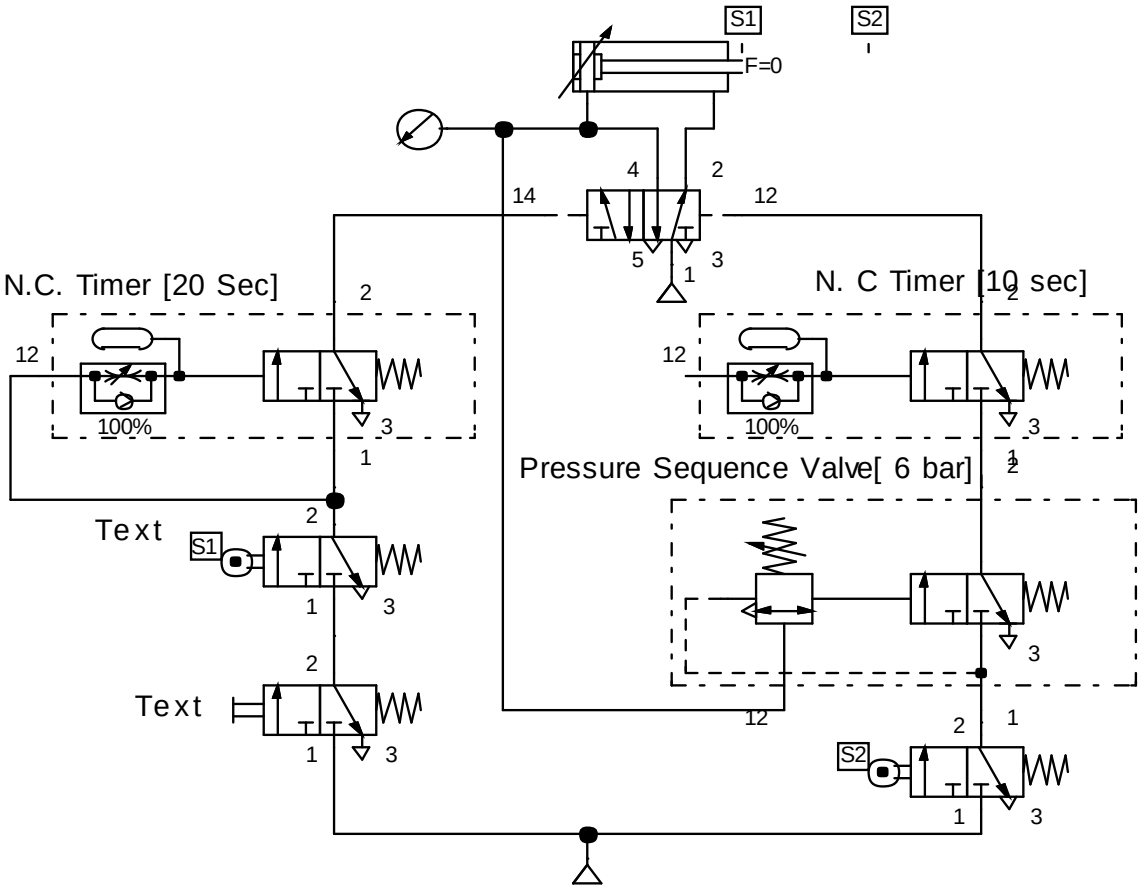


Figure 6.17 Bonding Application

CHAPTER 7

Coordinated Motion Control

In majority of the pneumatic applications more than one cylinder is used . The movement of these cylinders are coordinated as per the required sequence

- The activation of limit switches of different cylinders will provide set or reset signal to the final control valves for further controlling the movement of various cylinders
- The limit switches have to be arranged in the proper location with the help of motion diagram

Motion Diagram Step Displacement Diagram

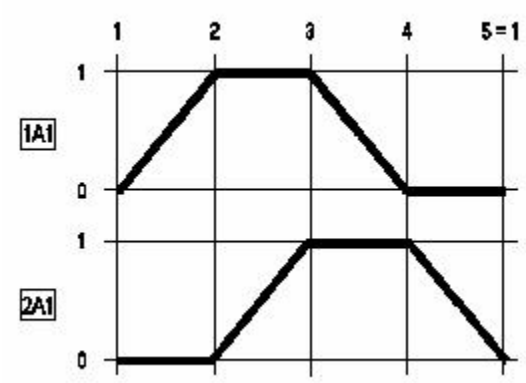


Figure 6.1 Motion Diagram –Displacement Step Diagram

- In order to develop control circuitry for multi cylinder applications, it is necessary to draw the motion diagram to understand the sequence of actuation of various signal input switches-limit switches and sensors
- Motion diagram represents status of cylinder position -whether extended or retracted
  in a particular step

Example: Coordinated Motion Control for a Stamping Application

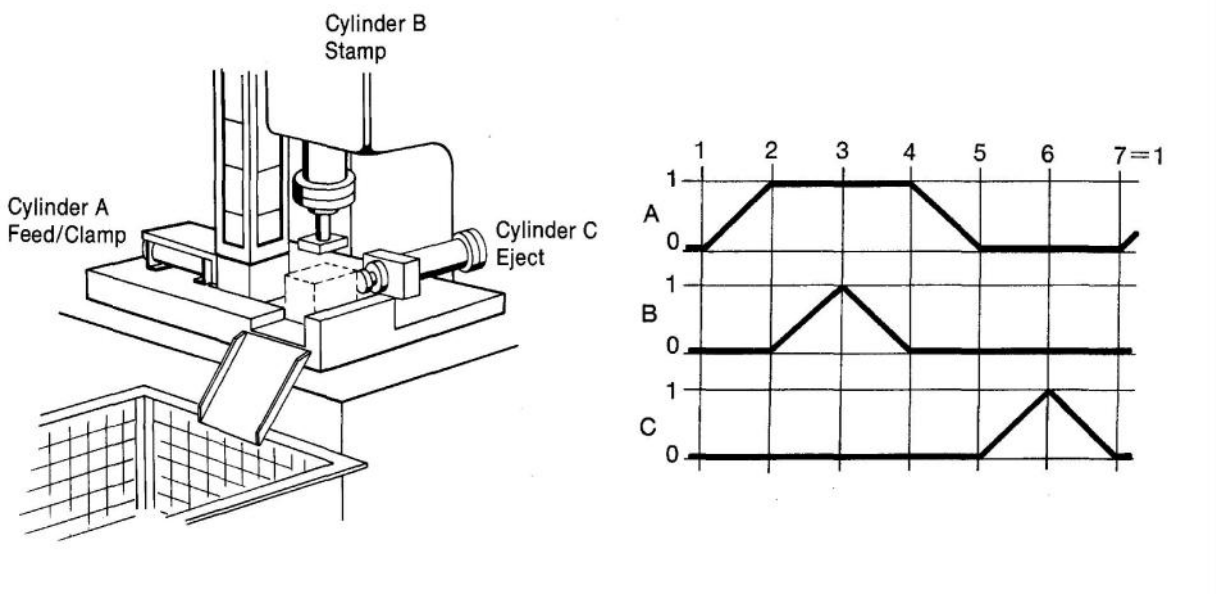


Figure 6.2: Clamping, Stamping and Ejection Application

Multi Cylinder Application with Two Cylinders A and B

Input Signals

- Cylinder A – Limit switch at home position ao
- Limit switch at home position a1
- Cylinder B - Limit switch at home position bo
- Limit switch at home position b1

Out put Signals

- Cylinder A advancing step is designated as A+
- Cylinder A retracting step is designated as A-
- Cylinder B advancing step is designated as B+
- Cylinder B retracting step is designated as B+

Designation of Signals

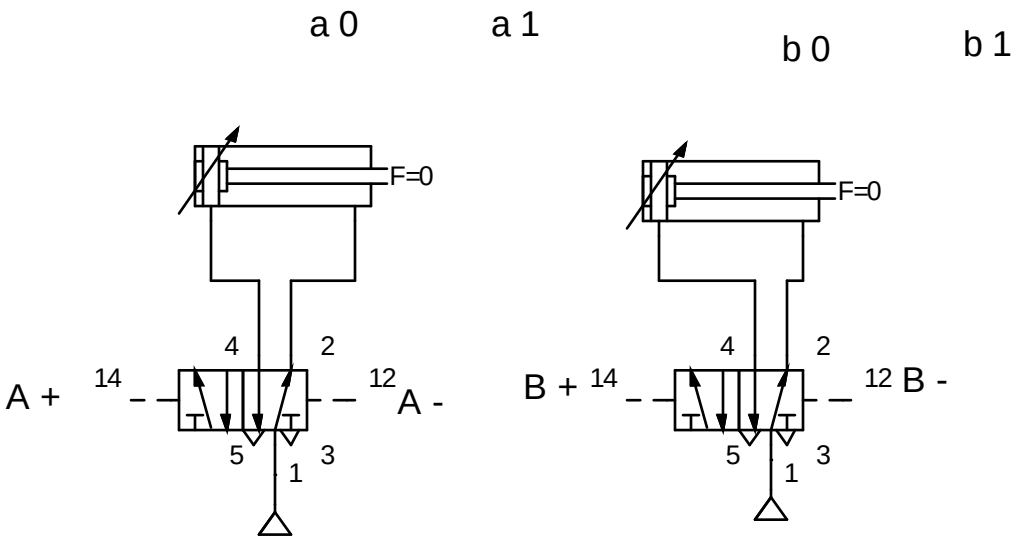


Figure 6.3 Designation of Signals

Sequential Motion of Cylinders

It is possible to have the following sequence of operation with **two** cylinders

Sequence	Example of Application
A+, B+, A-,B-	Lifting & Shifting / shifting of parts in two directions ,
A+, B+. B-,A-	Clamping & Stamping/Riveting
A+, A-, B+, B-	Feeding and Ejection of parts

Example 1: Lifting and Shifting

- Products are required to be transferred from lower level conveyor to higher level conveyor using two Pneumatic Cylinders
- Lifting Cylinder A lifts the product on receiving it at lower level
- Shifting Cylinder B shifts the product from the platform to the higher level conveyor

- Lifting cylinder retracts
- Shifting cylinder retracts

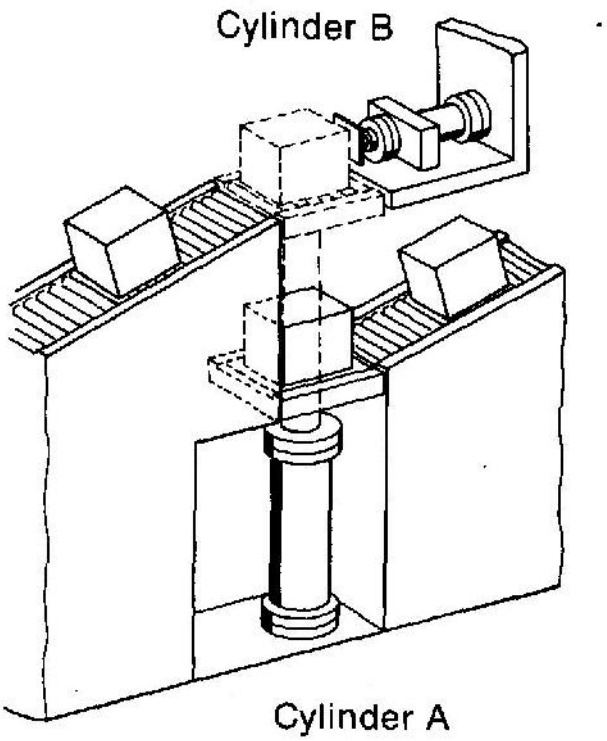


Figure 6.4 : Schematic of Lifting and Shifting Application

Motion Diagram Lifting and Shifting

- Motion and Control Diagrams are shown for Lifting and Shifting Application: A+,B+,A-,B-
- Signal 1.2 –Start Signal
- Signal 1.3- Extended position limit switch for cylinder B
- Signal 2.2- Extended position limit switch for cylinder A
- Signal 2.3-Home position limit switch for cylinder A

- NO SIGNAL OVER LAP

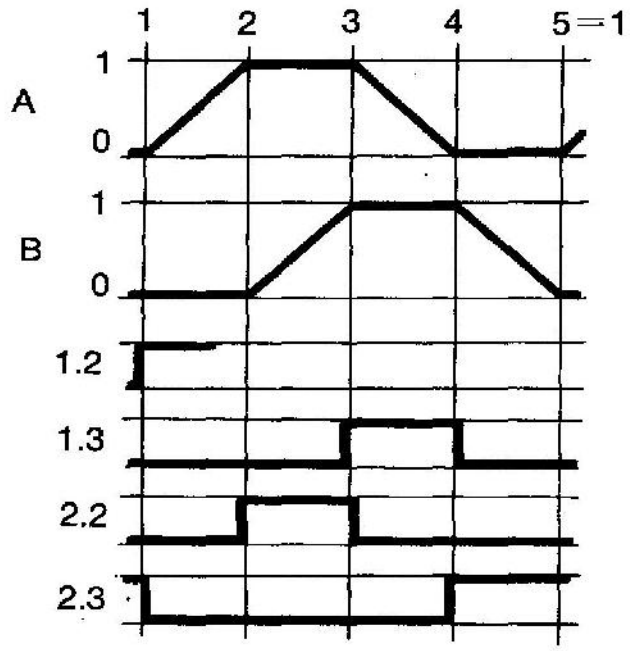


Figure 6.5 Control Diagram

Lifting and Shifting

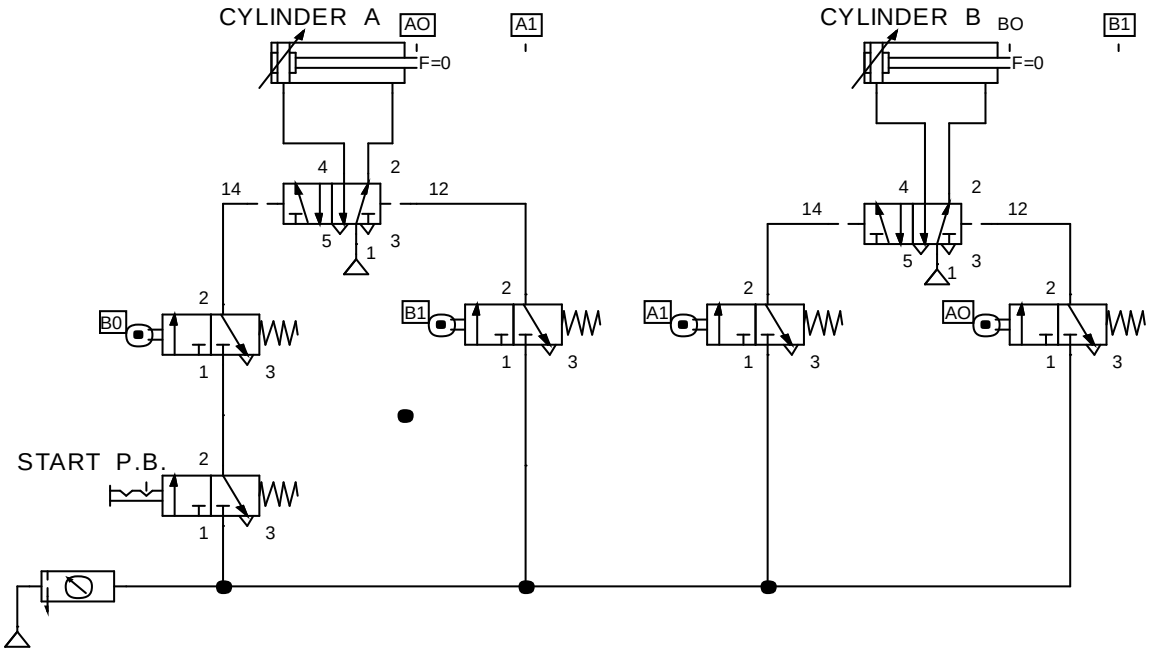
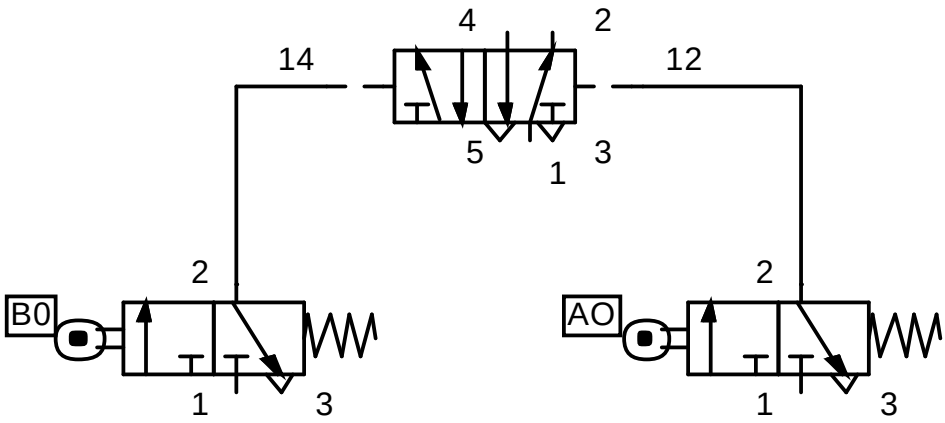


Figure 6.6: Pneumatic Circuit Diagram for Lifting and Shifting

Signal Overlap

Signal Overlap can occur when simultaneously two active signals appear on both set and reset pilot ports of Final Control Valve. This is due to the required sequencing of cylinder. At the start, both signals ao and bo appear at the same time. This will not result in any change.



6.7. Illustration of Signal over lap

Multi Cylinder Applications Signal Elimination

On analyzing the status of **set** signal and **reset** signal for final control valve for different cylinders, it is observed that both set and reset signals could be present simultaneously at any instant of time, depending on the sequential operation of the cylinder. This does not permit further change in status of the valve. This situation is termed as signal over lap. To overcome this problem signal elimination techniques are used as listed below:

- **Use of Idle return lever limit switches**
- Use of N.O Timers
- Use of Cascading with the help of reversing valves
- Use of Stepper Sequencer modules

Example 2: Clamping and Riveting

- Sheet metal components are to be riveted using two Pneumatic Cylinders. A Clamping cylinder (A) first advance and clamps the sheet metal parts.
- While the parts are clamped a second cylinder (B) advance and performs riveting operation
- The riveting cylinder retracts and finally clamping cylinder retracts

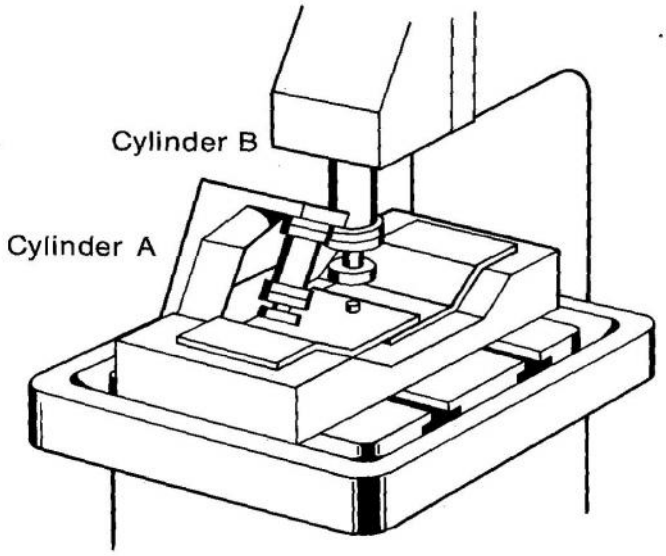


Figure: 6.8 : Clamping and Riveting Using Pneumatic Cylinders

- Control Diagram is drawn below the motion diagram represents the status of various signals- the limit switches used to interrogate the piston position
- Signals 1.4 and 1.3 correspond to home position and extended position limit switches of cylinder A respectively
- Signals 2.2 and 2.3 correspond to home position and extended position limit switches of cylinder B respectively

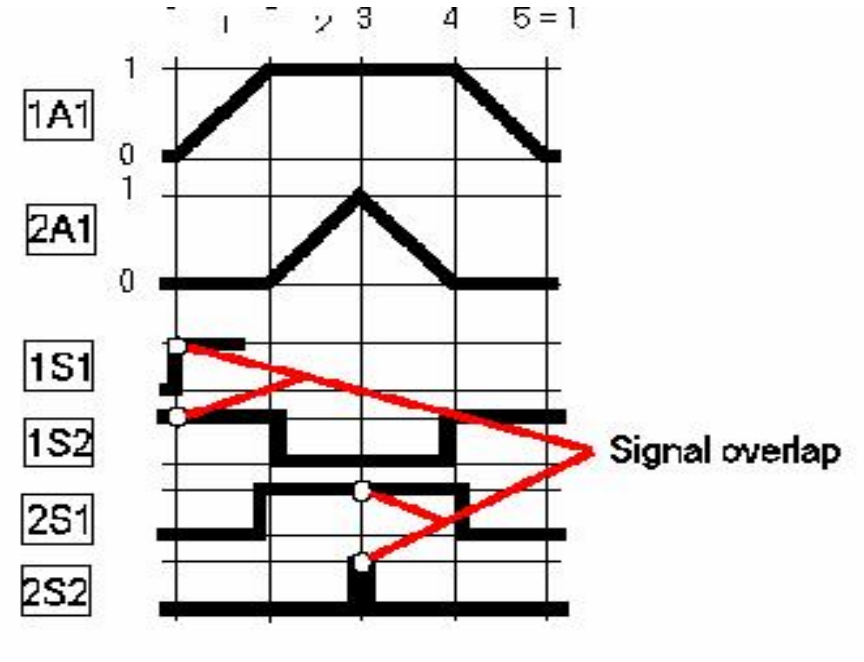


Figure 6..9 Control Diagram for Sequence A+,B+,B-, B-

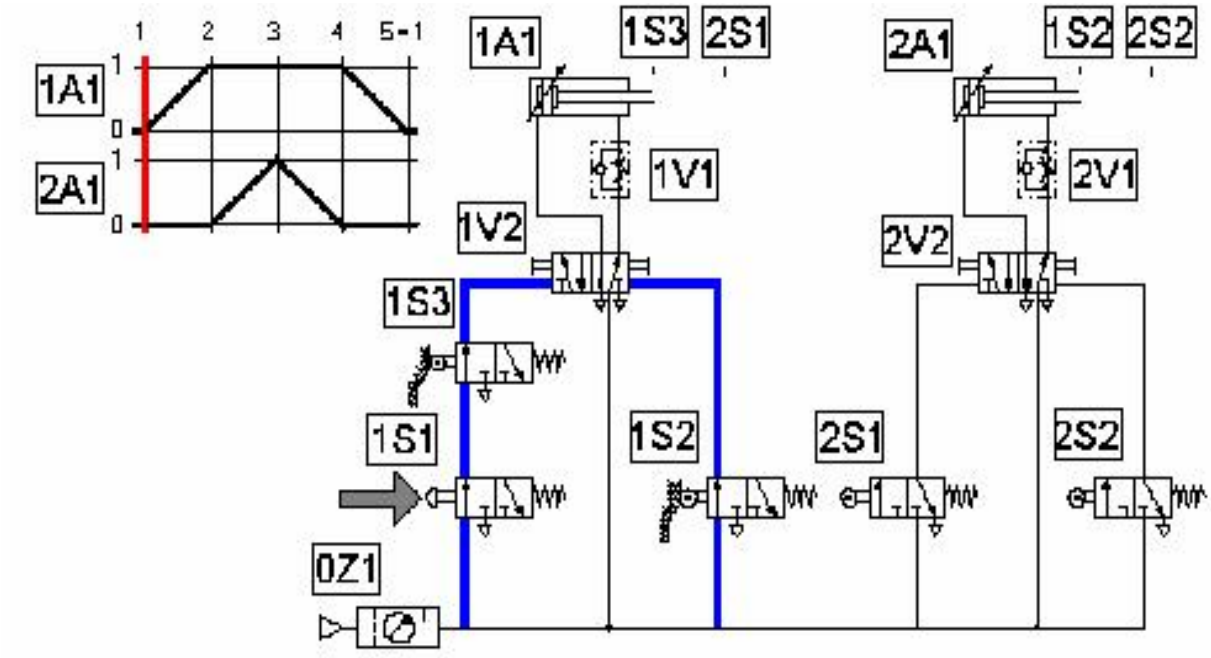


Figure 6. 10 Pneumatic Control Circuit and Control Diagram

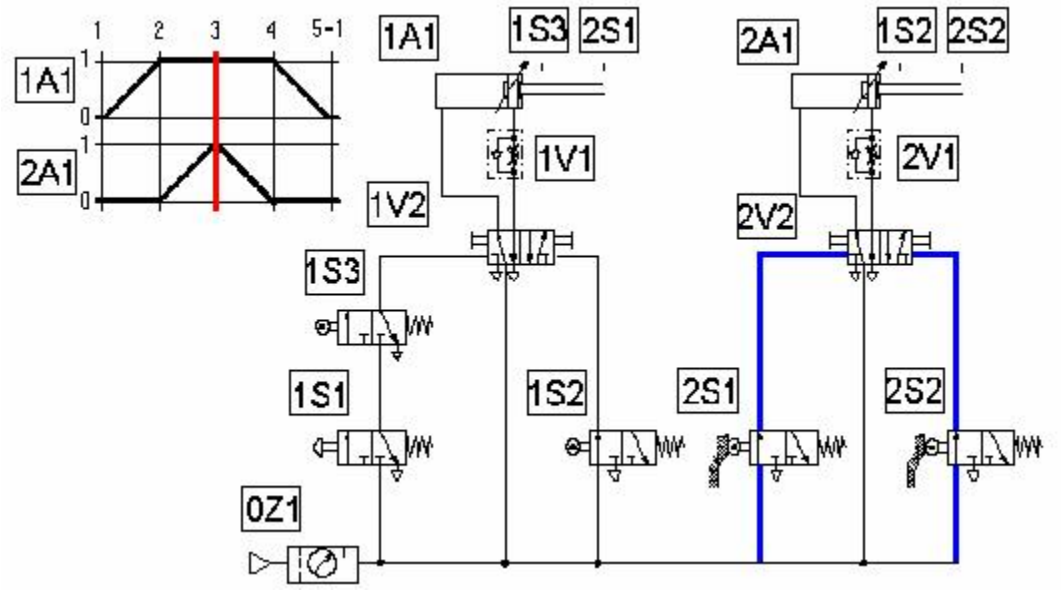
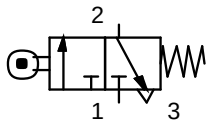
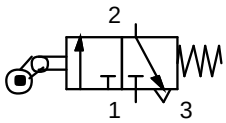


Figure 6.11 : Signal Over Lap at Step 3

Use of Idle Return Roller Limit Switch



ROLLER LEVER LIMIT SWITCH



IDLE RETURN ROLLER LIMIT SWITCH

Figure 6.12: Limit Switches

- Roller Lever type Limit Switch gives mechanical signal which can be sensed in both direction movement of piston rod cam
- Idle Return Roller Limit Switch gives mechanical signal due to actuation of roller only in one direction. This is conveniently used in **Signal Elimination**

Use of Idle Return Roller Limit Switches for Signal Elimination

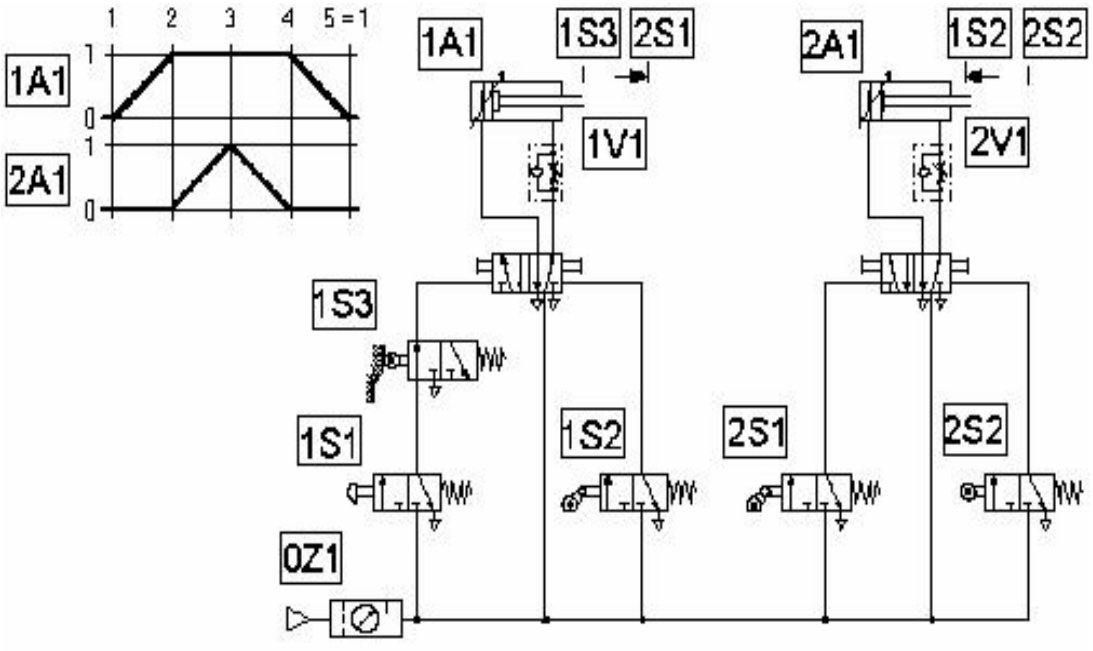


Figure 6.13 Use of Idle Return Roller Limit Switch

Exercise for practice:

Develop Pneumatic control Circuit for Sequence of Operation A+,A-, B+,B-
Using Control Diagram to find out the signal overlap status.

CHAPTER 8

Cascading Method of Signal Elimination

Reversing Valves [Double piloted 5/2 way or 4/2 way] .These are signal processing valves which are used to change over from one signal to next signal
Depending on the presence of set or reset signal at the reversing valves, output change over takes place from port 4 to port 2 of the valve
There is no need to examine exact step where signal over lap occur in the circuit

Reversing Valves

When an input limit switch signal, S1 is generated , it is used to activate a Final Control valve. This results in activation of a corresponding cylinder which is followed by activation of a limit switch S2. This limit switch signal cancels the first input signal S1 using a reversing valve and the same process continues

Conditions for Cascading

- Number of signal inputs [from limit switches] must be equal to number of output signals [pilot signals to final control valves]
- Each input signal is assigned to a particular out put signal
- It should be possible to store an out put signal even when the corresponding input signal is no longer present
- Only one out put signal may exist at any one point or it must be possible to eliminate any specific output signal
- The input signal should be effective in the same required sequence
- No. of reversing valves required are (n-1), where n is total number signals from limit switches or signal groups

Designation of Signals

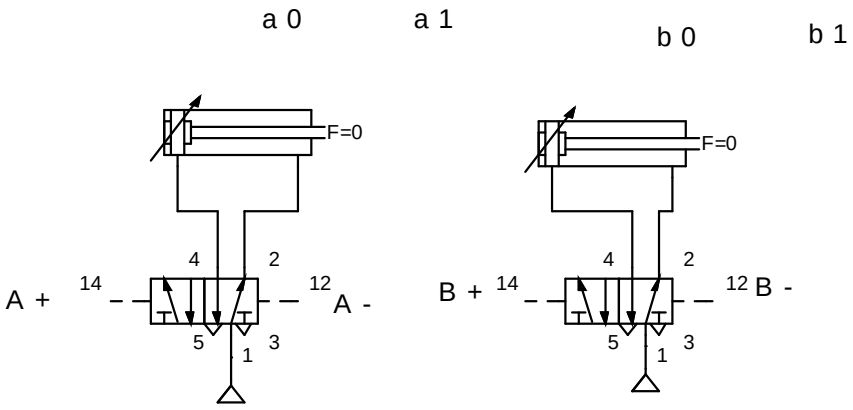
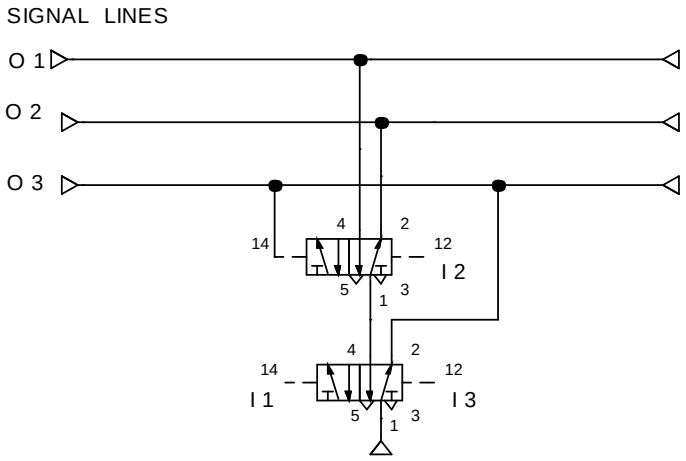


Figure 8.1. Designation of Signals From Limit Switches

Cascading Stages



I 1,I 2, and I 3 are Input Signals

O1,O2 and 03 are Out put Signals

Figure 8.2: Cascading Stages

Development of Cascade Stages

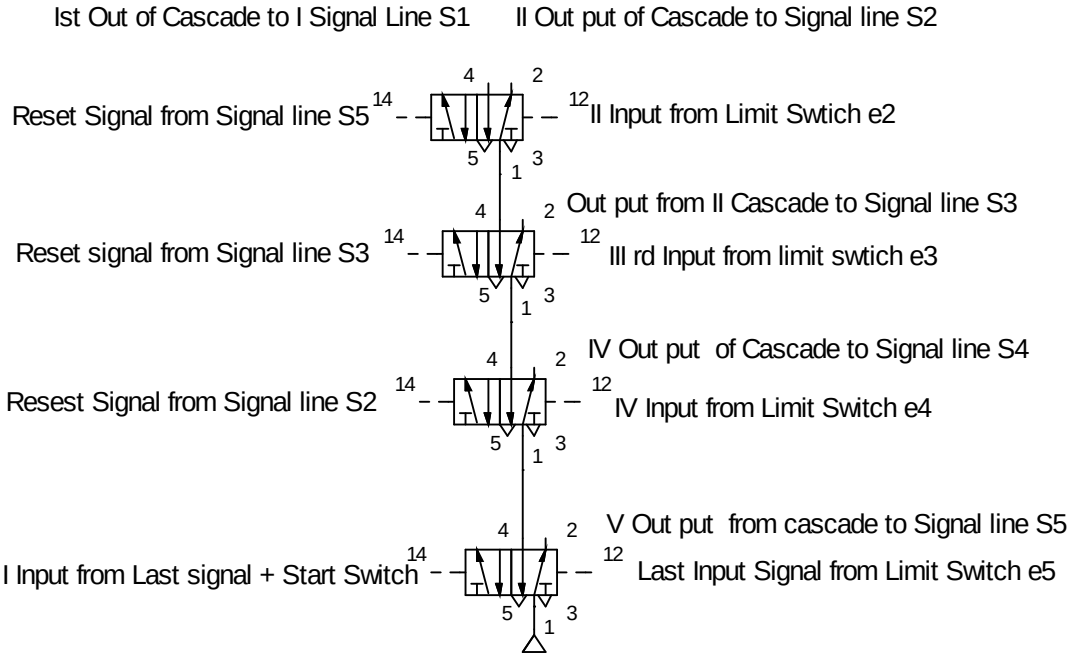


Figure 8.3 Input Signals to Cascade Stages

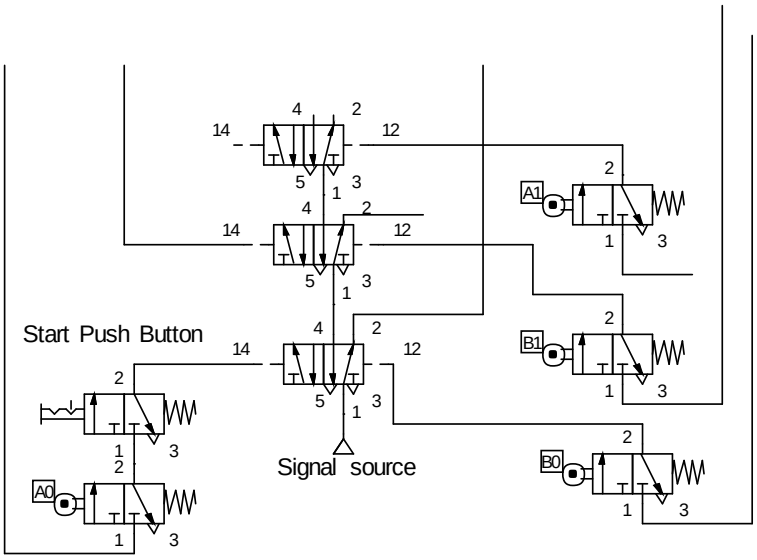


Figure 8.4: Arrangement of Cascading Reversing Valves and Input Signals

Two Cylinder Co- Ordinated Motion Control [A+,B+,B-,A-]

- Sequence of operation
  A+,B+,B-,A-
- Signal Groups
  [a1][b1][b0][a0]
- Last signal (a0) + Start signal is used to initiate the motion This will be input signal to o last stage of cascade

Grouping of Signals

- Total number of cascade stages can further be reduced by grouping of signals.
- While grouping of signals, care should be taken not to include more than one output signal from the same cylinder.
- Total number of cascade stages will be one less than number of signal groups.

Example 8.1 Clamping and Stamping ;Application

Required Sequence: **A+,B+,B-,A-**

Cylinder Sequence [A+ , B+] [B-, A-]

Signal Sequence [a1, b1] [bo, ao]

Signal Groups S1 S2

Circuit for Sequential Motion A+,B+,B-,A-,

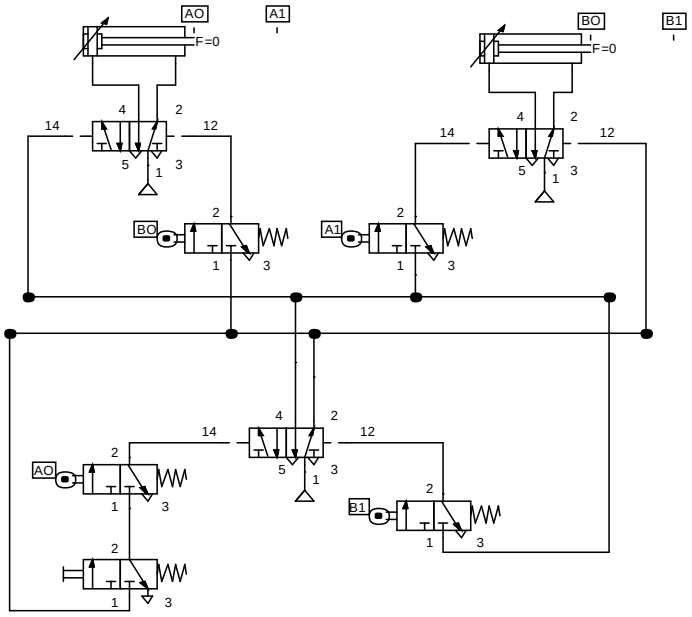


Figure 8.5 : Circuit Diagram for Sequence A+,B+., B-, A+

Example 2

Required Sequence: A+,A-,B+,B-

Cylinder Sequence [A+],[A- ,B+], [B-]

Signal Sequence [a1] , [ao ,b1],[bo]

Signal Groups S1 S2 S3

Circuit for -Sequence Motion A+,A-,B+,B-

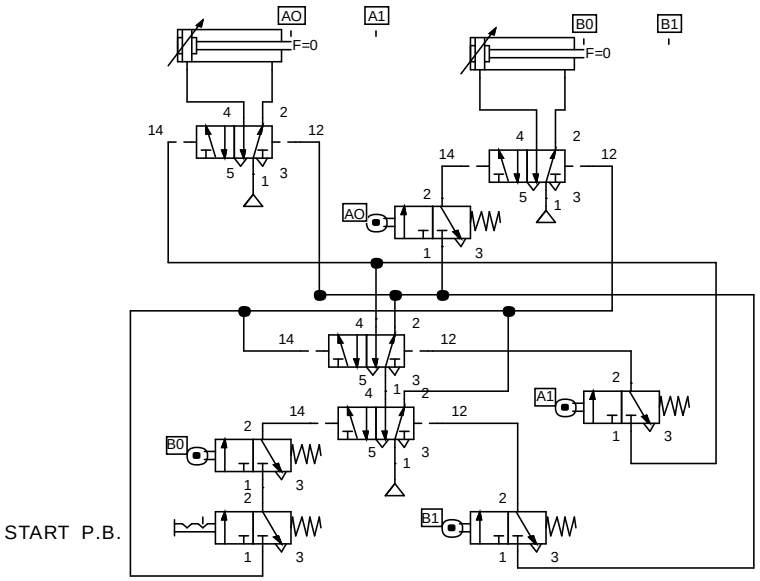


Figure 8. 6 : Circuit Diagram for Sequence A+.A-, B+, B-

CHAPTER 10

Electro Pneumatics

Electro Pneumatic control integrates pneumatic and electrical technologies, is more widely used for large applications. 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 12 V to 220 Volts are often used. The final control valve is activated [setting] by solenoid actuation

The resetting of the valve is either by spring [single Solenoid]or using another solenoid [Double solenoid Valve] . More often the valve actuation/reset is achieved by pilot assisted solenoid actuation to reduce the size and cost of the valve

Control of Electro Pneumatic system is carried out either using combination of Relays and Contactors or with the help of Programmable Logic Controllers [PLC]

A Relay is often is used to convert signal input from sensors and switches to number of out put signals [either normally closed or normally open] .

Signal processing can be easily achieved using relay and contactor combinations

A Programmable Logic Controller can be conveniently used to obtain the out puts as per the required logic, time delay and sequential operation.. Finally the out put signals are supplied to the solenoids activating the final control valves which controls the movement of various cylinders. The greatest advantage of electro pneumatics is the integration of various types of proximity sensors [electrical] and PLC for very effective control. As the signal speed with electrical signal, can be much higher, cycle time can be reduced and signal can be conveyed over long distances.

In Electro pneumatic controls, mainly three important steps are involved:

1. Signal input devices -Signal generation such as switches and contactor, Various types of contact and proximity sensors
2. Signal Processing – Use of combination of Contactors of Relay or using Programmable Logic Controllers
3. Signal Out puts – Out puts obtained after processing are used for activation of solenoids, indicators or audible alarms

Symbols of Switches - Contactors

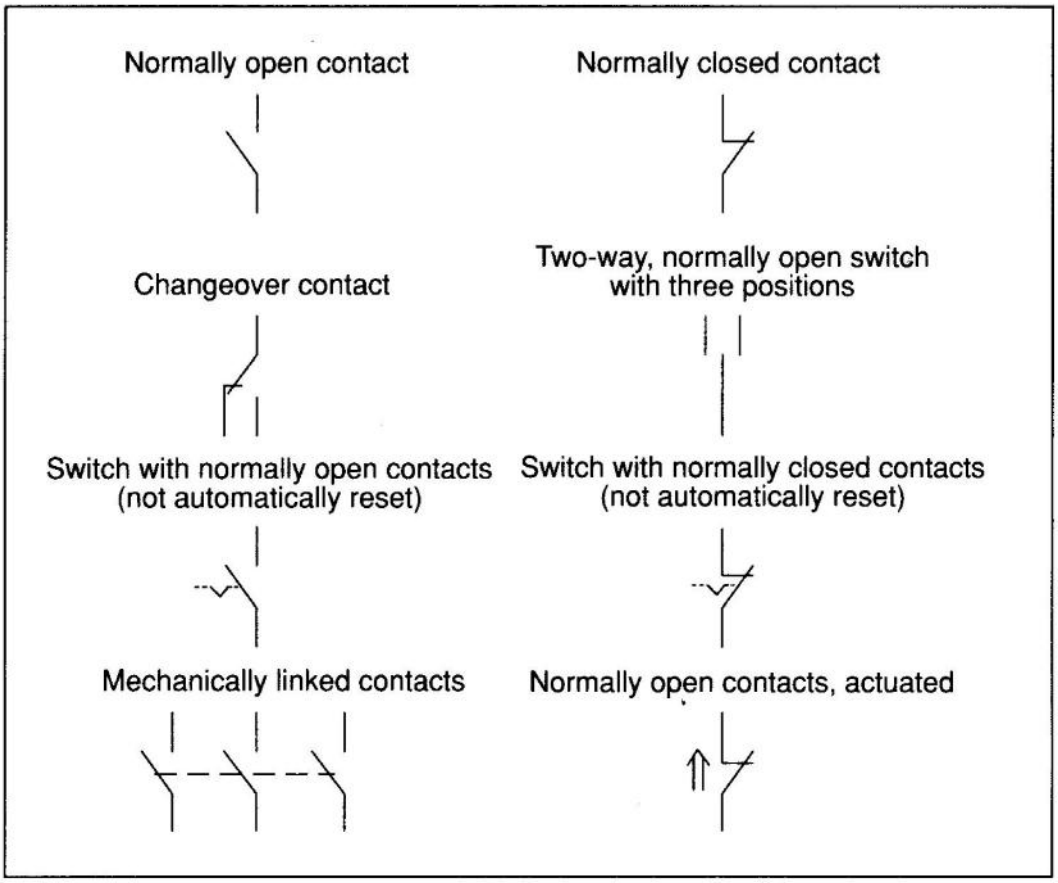
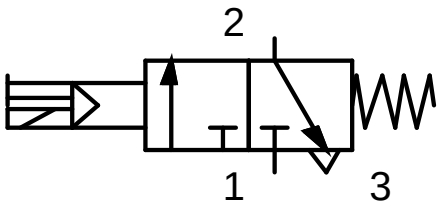
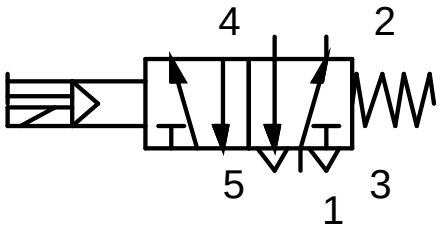


Figure 9.1 Symbols for Switches and contactors

Symbol- Single solenoid Valves



Single Solenoid Valve- Pilot assisted



Double Solenoid Valve- Pilot assisted

Figure 9.3 Symbolic Representation for Solenoids and Relays

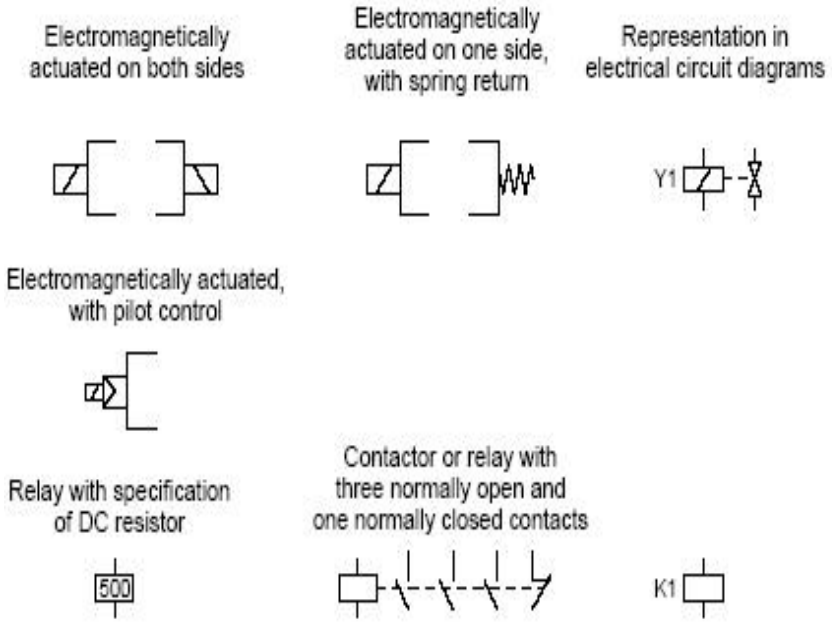


Figure 9.4. Symbols of Solenoid Valves and Relays

Types of Relays

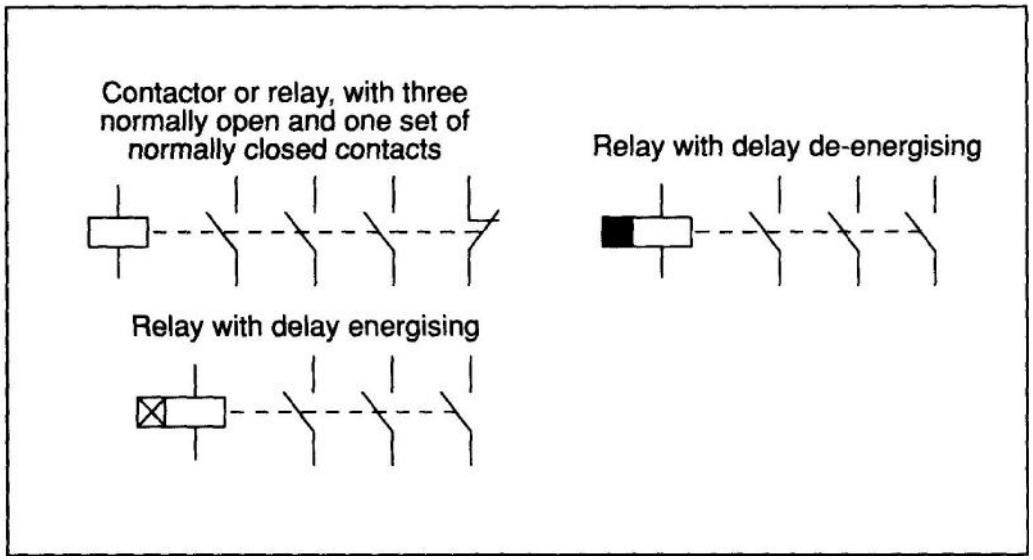


Figure 9.5 Types of Relays

Signal flow in Electro Pneumatic Circuit

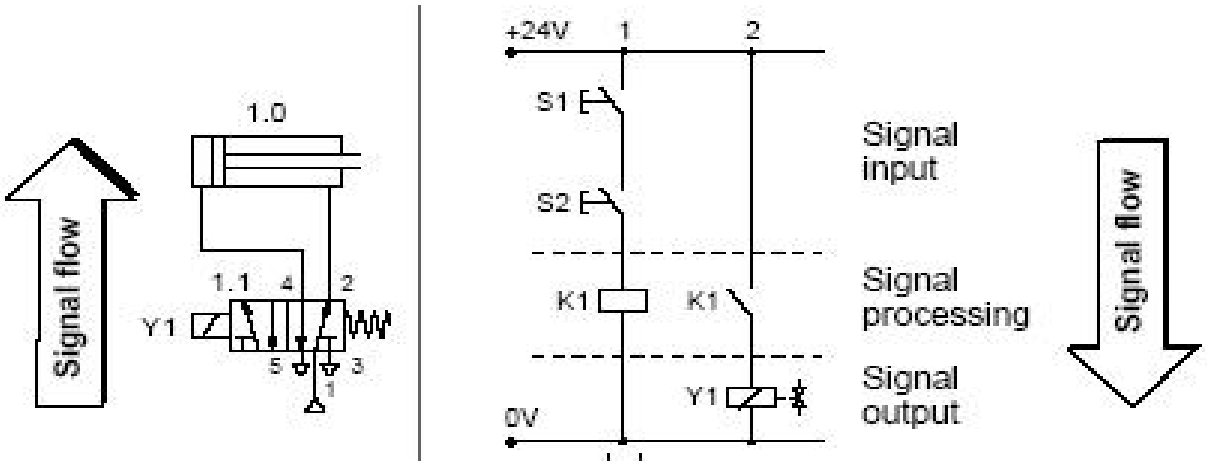


Fig 9.6 Signal Flow in Pneumatic and Electrical Control Circuit

Control of Double Acting Cylinder

Indirect Action of Double Acting Cylinder Using a Relay

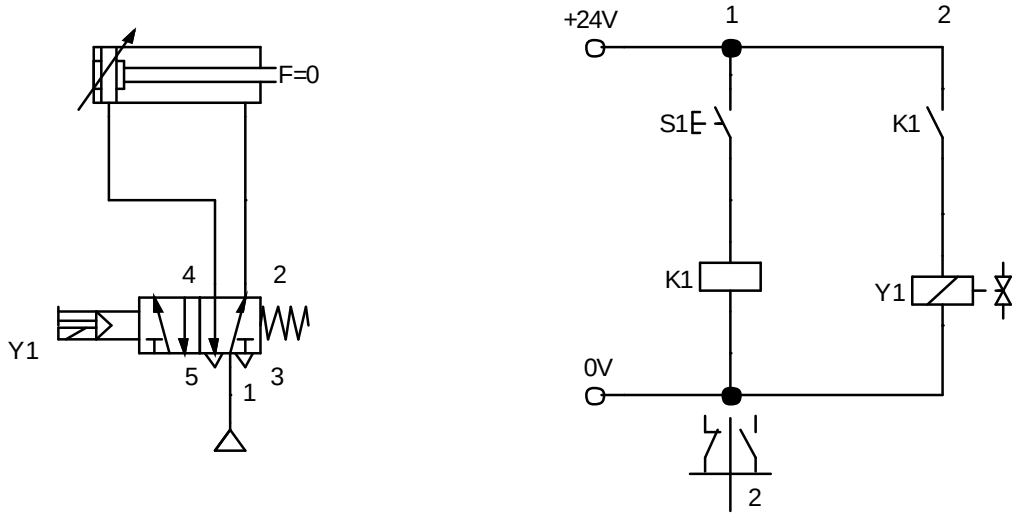


Figure 9.7 Control of Cylinder Movement indirectly using Relay

Indirect Actuation of Double Acting Cylinder for Forward and Return Motion

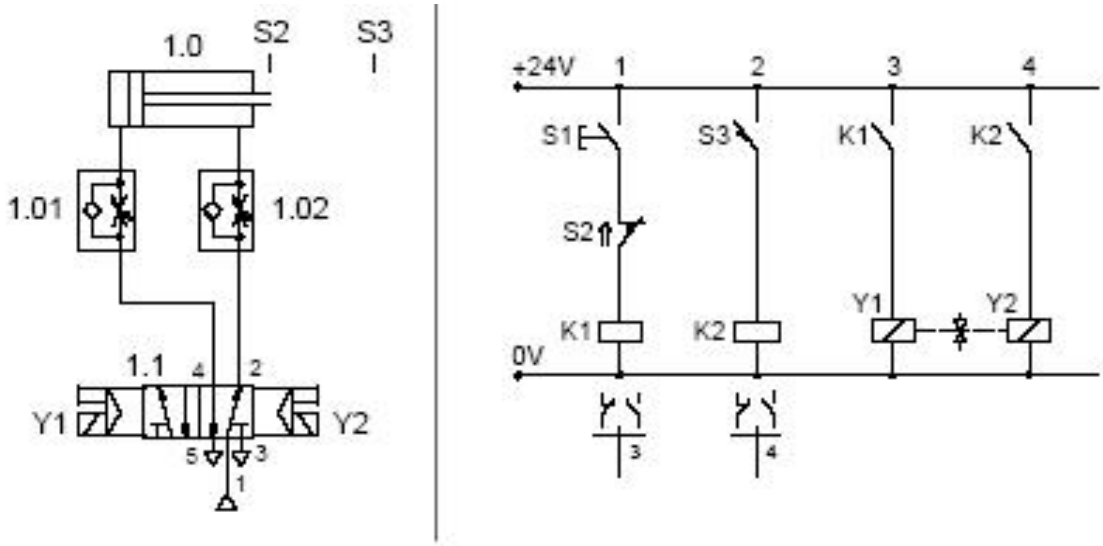
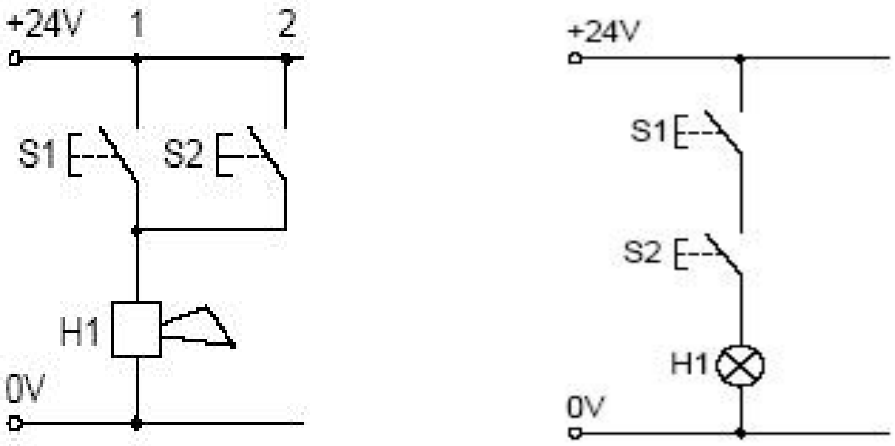


Figure 9.8 Indirect Control of Double Acting Cylinder With continuous Reciprocating Motion

Logic Circuits



OR Logic Circuit **AND Logic Circuit**

Figure 9.9: OR and AND Logic Circuit

Magnetic Reed Switches

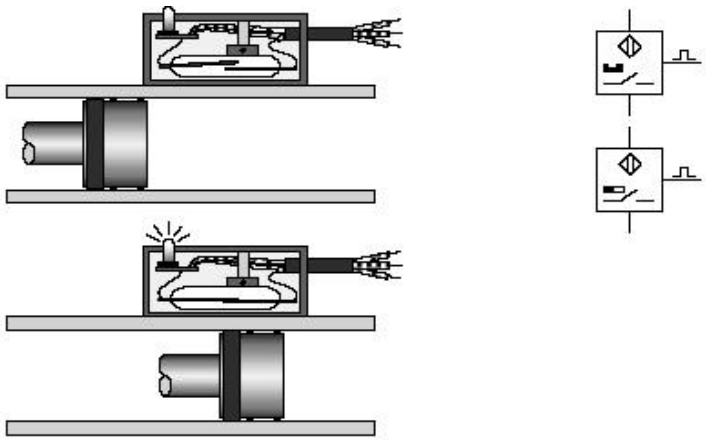


Figure: 9.10 : Magnetic Reed Switches

•Magnetically operated Reed Switches consists of electrical contactors in a sealed glass tube. The terminals of the contactors are taken out through an indicating lamp. The glass tube is encapsulated in a housing filled with epoxy resin. It is necessary to have a magnetic ring incorporated in the piston, so that when the piston is in the proximity of reed switch ,the contactor will get closed and out put is available at the terminal

Electro Magnetic Relay

Relay is essentially a electromagnetic switch, operated at low voltage,
Relay has a relay coil and several contactors
Commonly 24V D.C source is used for relay coil and contactor circuit
Relay contactor out puts either NO or NC can be conveniently used for signal processing

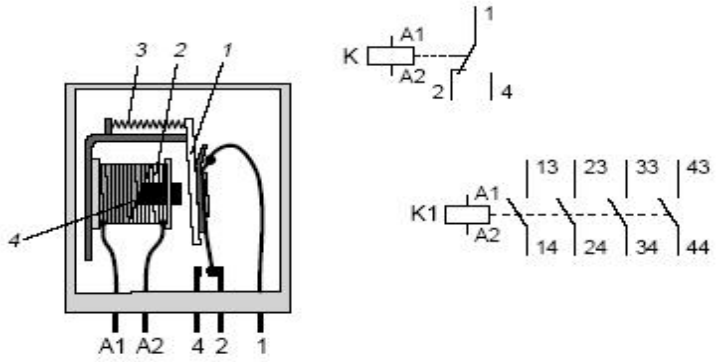
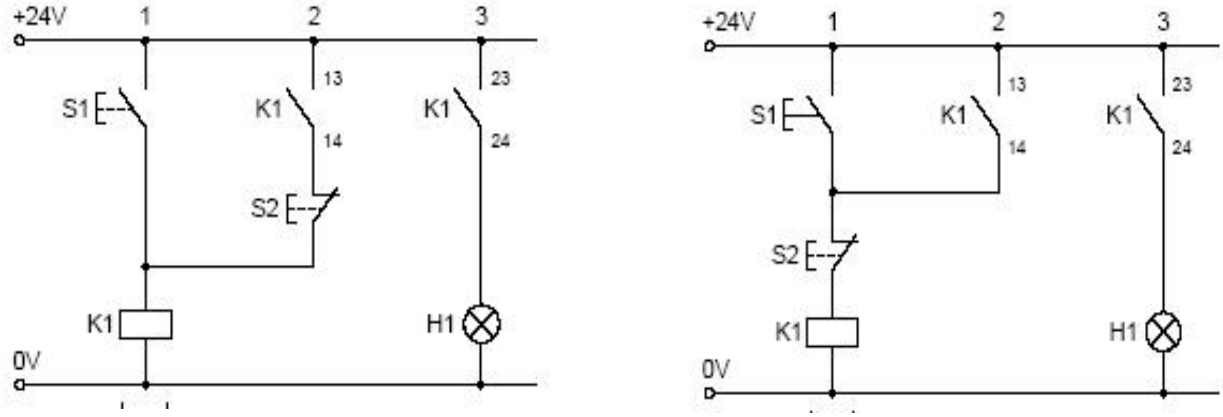


Figure 9.11 Electro Magnetic relay with Symbol for multiple contactor

Holding Circuits



Dominant On circuit **Dominant Off circuit**

Figure 9.12 Holding Circuits

Pilot Assisted Solenoid Valve

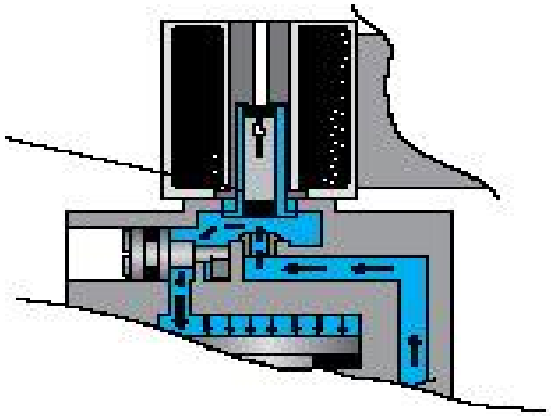


Figure 9.13 Pilot Assisted solenoid Valve

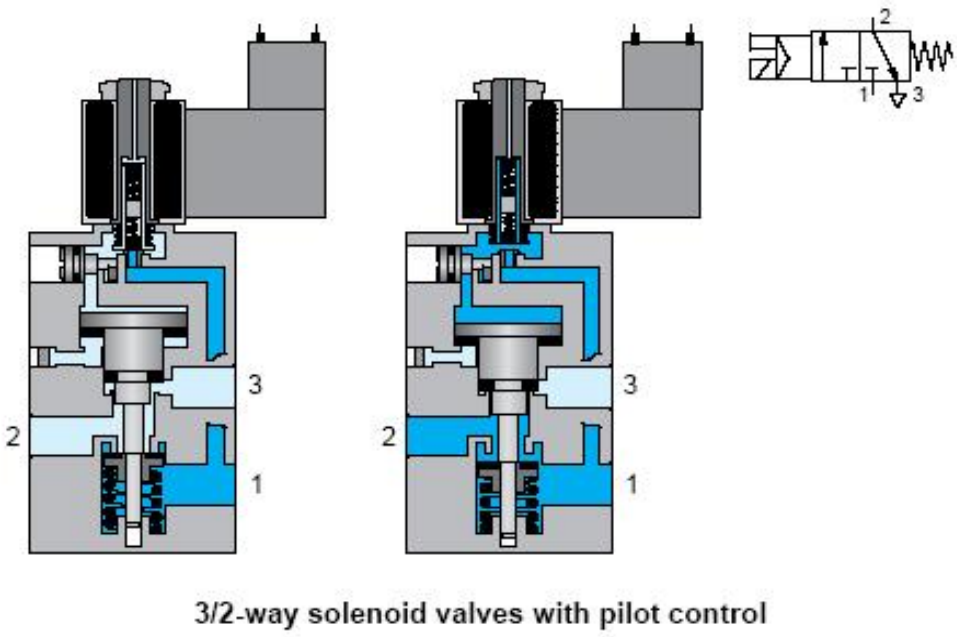


Figure 9.14 3/2 Way Pilot Assisted Single Solenoid Valve [Normally Closed]

Use of Proximate Sensor to Interrogate the End Positions of Piston

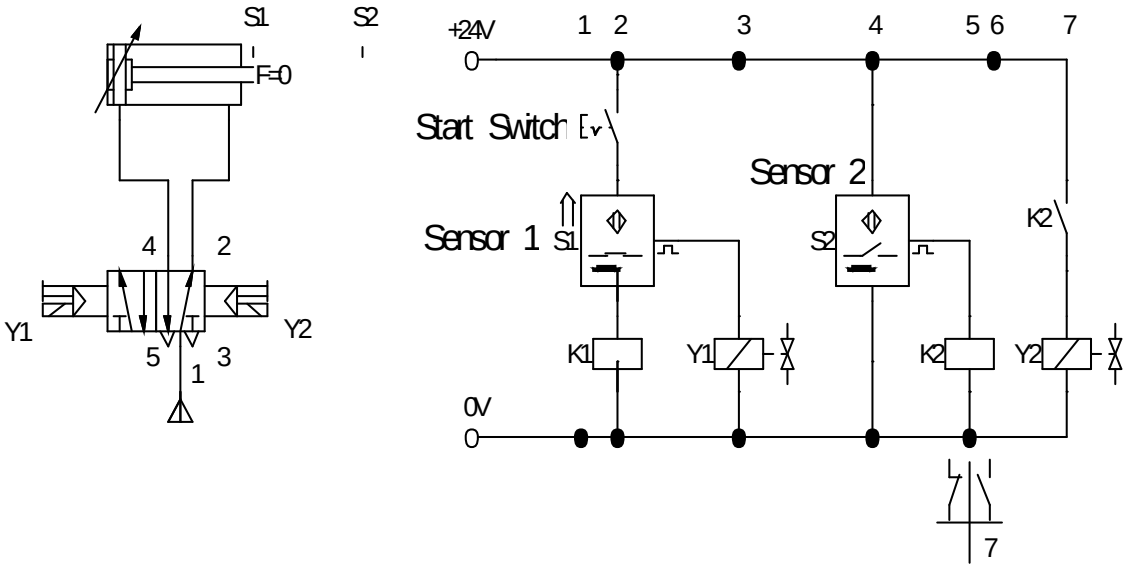


Figure 9.15 Example with Single Solenoid Valve Control

A Double acting cylinder is to be controlled using by a final control valve **with single solenoid and spring reset**

•The piston is required to advance on actuation of a manual detent push button switch and should continuously reciprocate from home to forward end position. The operation should stop after release the detent push button.

•Holding circuit can be used for this purpose

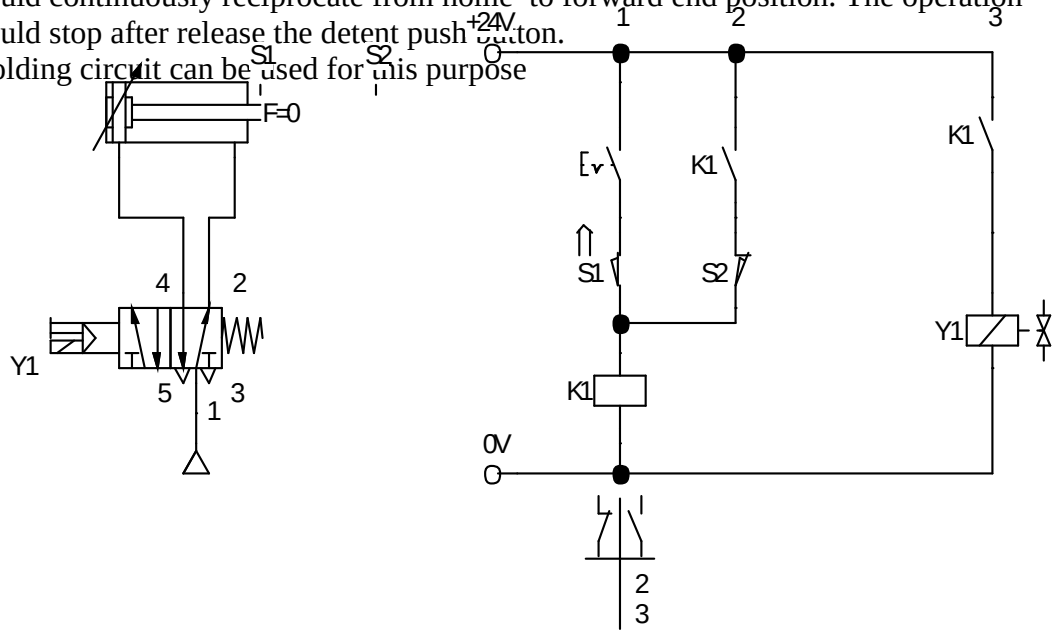


Figure 9.16 Electro pneumatic circuit for Single Solenoid

CHAPTER 10

Compressed Air Production, Preparation and Distribution

Compressed air required for a Pneumatic Control System is produced and conditioned using the following equipments which is termed as the Energy Elements:

- Air Compressor and Accessories
- Air Preparation
- Air Regulation
- Air Lubrication

Energy Elements

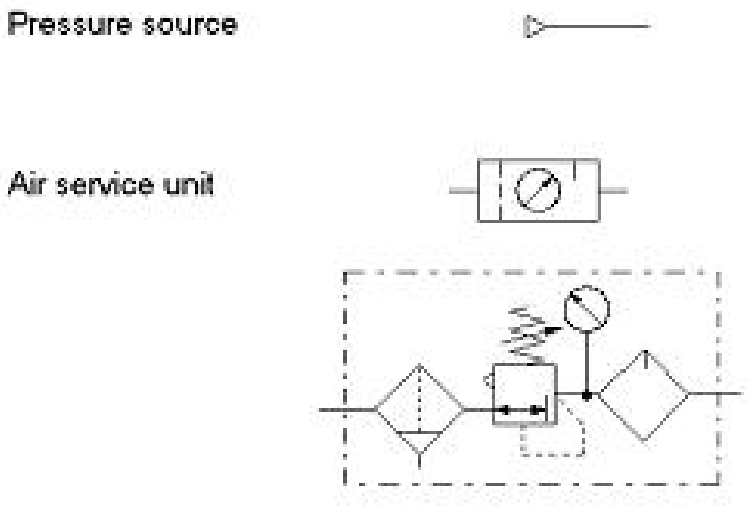


Figure 10.1 Symbol for Air Service Unit

Air Compressors

Air compressor used for generation of compressed air is selected on the basis of desired delivery pressure and flow rate.
The following types of compressors are used depending the required flow rate of air and maximum delivery pressure

- Piston type or Reciprocating Compressors
- Rotary type compressors- Vane type or Screw type
- Centrifugal type compressors
- Axial flow type compressor

Types of Air Compressors

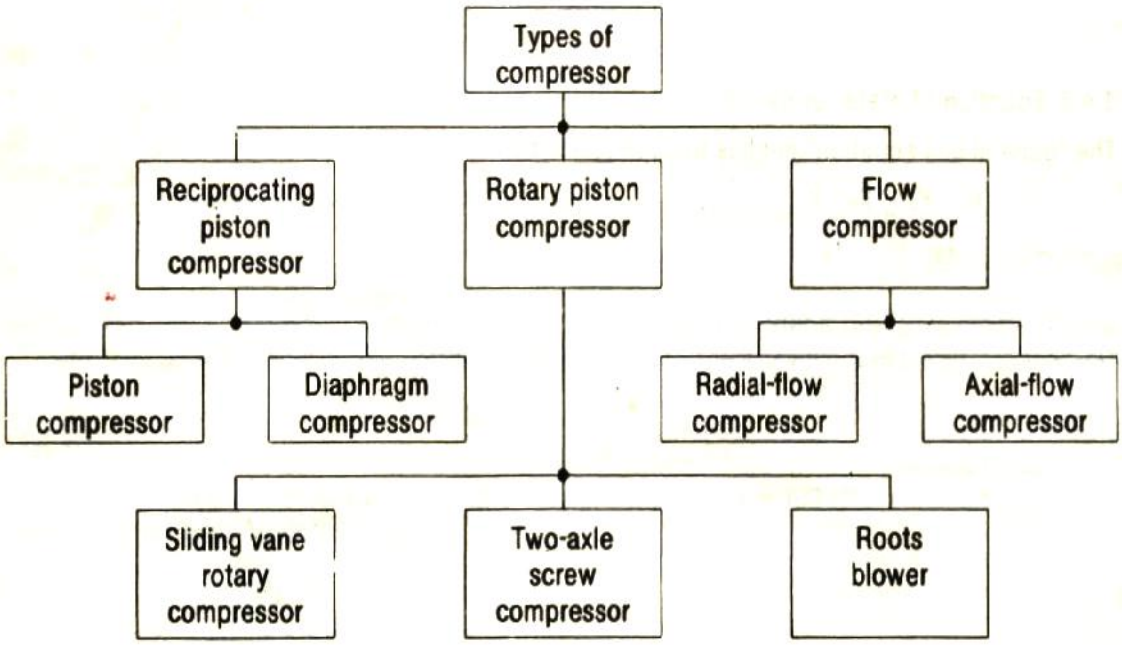


Figure 10.2 Types of Air Compressors

Piston Type –Reciprocating Compressors

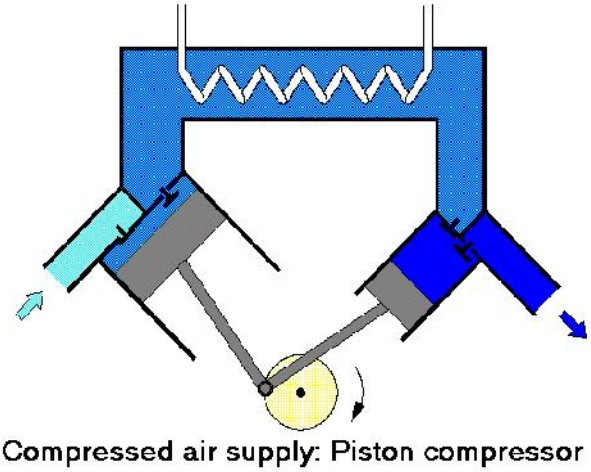


Figure 10.3: Reciprocating Compressor

Reciprocating Compressors are preferred for delivery pressure up to 8 bar with relatively low flow rate. Single or Two stage compression with inter cooling between stages is commonly used for air flow rate up to 20,000 cubic meters.

Diaphragm Type Compressor

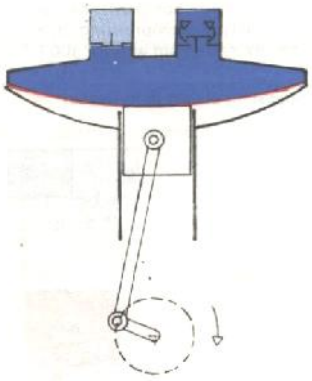


Figure 10.4 Diaphragm Type Compressor

Compression takes place in the space separated by the diaphragm .The advantage of this Compressors the totally oil free compressed air can be produced. Suitable for Food and Pharmaceutical industries.

Screw Compressor

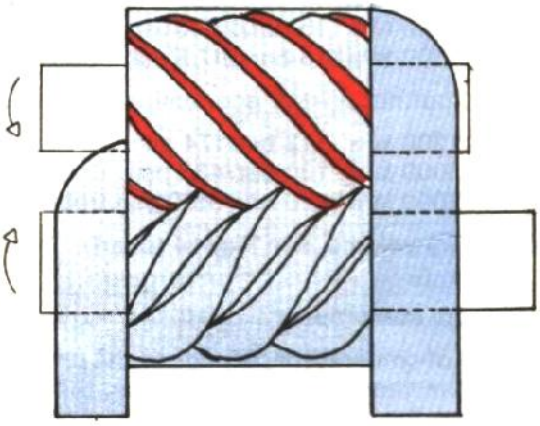


Figure 10.5 Screw Compressor

Screw compressor are used for moderate flow rates and moderate pressures up to 8 bar and flow rates up to 15,000 cubic meters. It has greatest advantage of noise free operation compared to piston type compressors as well as low energy consumption.

Vane Type of Compressor

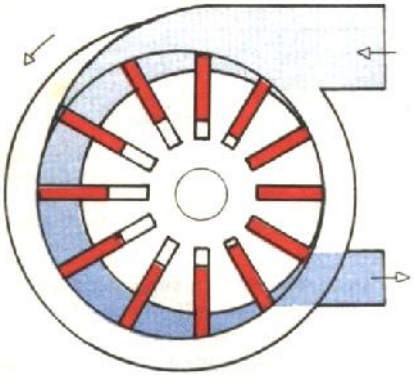
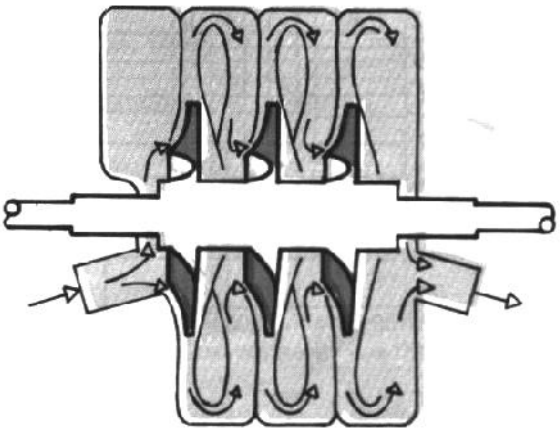


Figure 10.6 Vane Type Rotary Compressor

It is a rotary compressor suitable for moderate pressure ratio and moderate flow rates

Centrifugal Compressor

Figure 10.7 Diaphragm Type Compressor



Centrifugal compressors are ideally suited for large flow rates and low pressure ratio of around 4 per stage. Used only in large installation

Compressor Air System

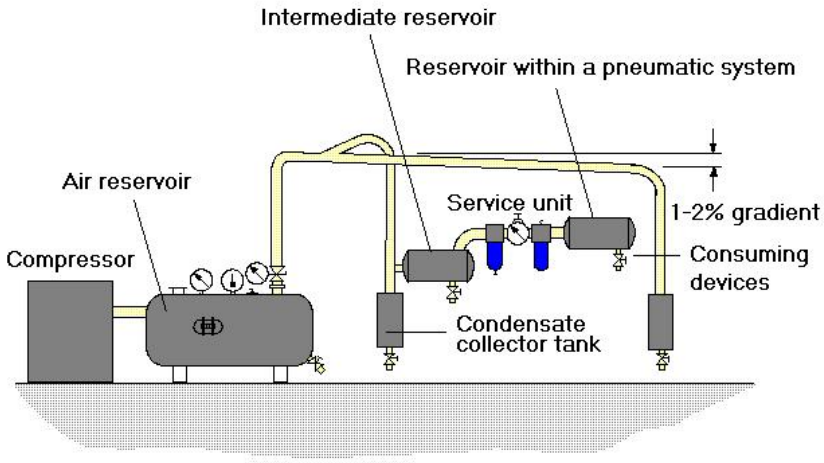


Figure 10.8

The following accessories are used in a typical Air compression system

- •Air Pre filter
- •After Cooler
- •Air Receiver
- •Air Drying system: Adsorption type, Absorption type,Refrigeration type or using semi permeable membranes

Commonly Adsorption Driers are for used for large air flow capacities and for dew point up to –40 deg C

Air Receiver

Compressed Air Receiver is the most important accessory of air compression system from the point of storage of energy, Horizontal or Vertical Receivers can be used depending on available floor space. Air receivers should be equipped with delivery line, Safety valve, Drain cock, Pressure gauge. Drain connection located at the bottom of the Receiver is very important as the condensate collected in the Receiver should be periodically drained either manually or automatically.

Compressed Air Filter

In compressed air filter, dust and moisture are arrested outside the filter element as the air flows from out side to inside.
Available in various grades from 100 to 2 microns
Usually porous sintered bronze or ceramic filter elements are used.
Denser water particles which is collected on the outer surface of the filter element, gets separated due to gravity and collects in the transparent bowl. This is periodically drained with the help of manual drain cock. or automatic drain arrangement

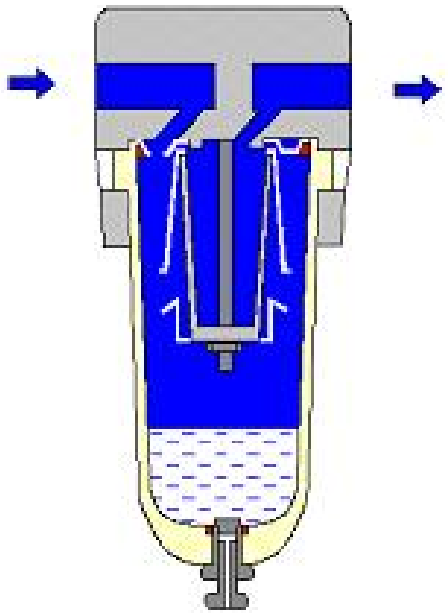


Figure 10. 9 Compressed Air Filter

Maintenance of Filters

Care should be taken to see that the condensate level is always below the filter element so that re entrapment of water in compressed air does not occur

Periodically the pressure drop across the filter should be monitored to check excessive clogging of filter pores by dust. Some design of filters are provided with visual indicator which indicates permissible contamination. When the indicator show red signal, it is high time that the filter element is cleaned or replaced
Filter element is often cleaned with kerosene or soap water and compressed is air blown in the opposite direction to purge out the dust clinging to the pores

Compressed Air Regulator

The Compressed Air Regulator serves two functions. The main function of the compressed air pressure regulator is to maintain constant down stream pressure in the air line, irrespective of variation of upstream pressure
In Vent type Regulators , if there is sudden surge or rise in pressure on the down stream side of the Regulator [may be due to sudden closure of valves], the equipment is safe guarded from excess pressure by venting out the air through vent holes in the Pressure Regulator

Construction of Regulator

The Pressure Regulator has a spring loaded metallic diaphragm provided with an aperture A spring loaded plunger rests on the aperture. A valve disc is connected at the top of the plunger, rests on valve seat, either opens or closes the air passage from primary supply line to the down stream secondary line. The regulator body below the diaphragm houses the main spring and an external knob to adjust the required pressure setting . The body is provided with vent holes

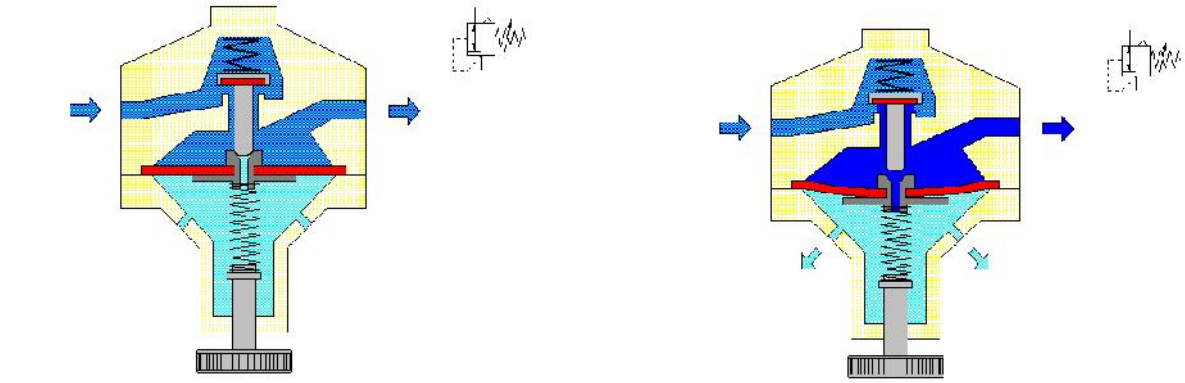


Figure 10. 10 Compressed Air Regulator [Vent Type]

When the primary pressure on the upstream side of the Regulator is more than the pressure setting of the Regulator, the pressure exerted by the primary pressure above the diaphragm deflects it slightly downwards. This results in down ward movement of the

plunger. A valve disc at the top of the plunger closes the supply passage until the pressure above the diaphragm falls below the spring setting of the regulator.

This result in deflection of the diaphragm upwards followed by upward movement of plunger which further opens the supply line passage. The repeated movement of the plunger and opening of closing of the valve disc results in an equilibrium setting for a given pressure
During periods when the sudden closure of valves on the down stream side takes place ,the secondary line pressure is momentarily is more on the diaphragm thereby the diaphragm deflects down wards The diaphragm deflects to a greater extent such that the bottom of the plunger cannot close the aperture on the diaphragm there by relieving excess pressure from secondary line to escape through aperture and vent holes

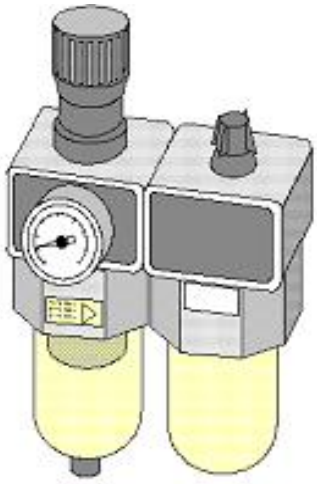
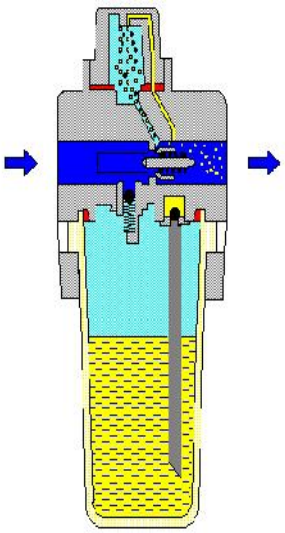
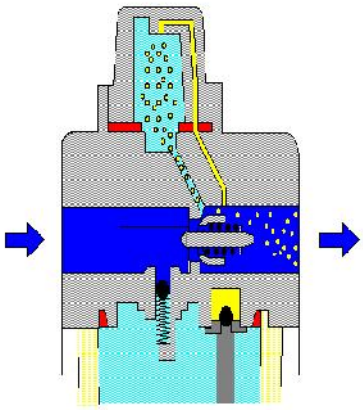


Figure 10.11. Compressed Air Service Unit

Compressor Air Lubricator



Air lubricator



Air lubricator

Figure 10.12. Compressed Air Lubricator

Lubrication of moving parts of cylinder and valves is very essential in Pneumatic system For this purpose Compressed Air Lubricators are used ahead of each Pneumatic equipment
Correct grade of lubricating oil usually with kinematic viscosity around 20- 50 centi-stokes should be used.
Low pressure is created at the throat portion of the venturi due to flow of air taking place in the Lubricator. This low pressure will assist automatic suction of the lubricating oil from the oil bowl to the drip chamber where drop by drop of oil is diffused in to air stream

Typical feature of any compressed air lubricator should incorporate the following:
•Automatic suction of oil from oil bowl due to suction created by the venturi portion
•Transparent Drip Chamber for visual observation
•Non return valve to prevent back flow of air from secondary to primary side of lubricator
•Non return valve arrangement to prevent air loss during opening of oil bowl to replenish the lubricating oil during operation without interruption
•Regulating screw for adjustment of oil feed rate in to air
•Transparent oil bowl with Oil filling cap

Operation
•Number of oil drops lets should be around 10 to 20 drops per 1000 lit of air .
•It is necessary to diffuse the lubricating oil in to compressed air in the form of fog or mist
•The Lubricator should be preferably located not more than 5 m from the pneumatic equipment

Compressed Air Distribution

Proper distribution of compressed air is very important to achieve good performance .Some important requirements to be ensured are
•Piping Lay out [Open Figure 10.13 or Closed Loop Fig 10.14],Suitable number of drain valves at diagonally opposite corners
•Piping Design [Diameter of pipe for given flow, pressure drop, number and type of fitting and absolute pressure-Using Nomograms]
•Slope of the main horizontal header from compressor [1:20]
•Take off branches from the top of horizontal headers with U or at 45 deg
•Provision of accumulator with drain cock at the bottom of all vertical headers
•Air service unit connected at right angles to vertical headers

Open Type Distribution System

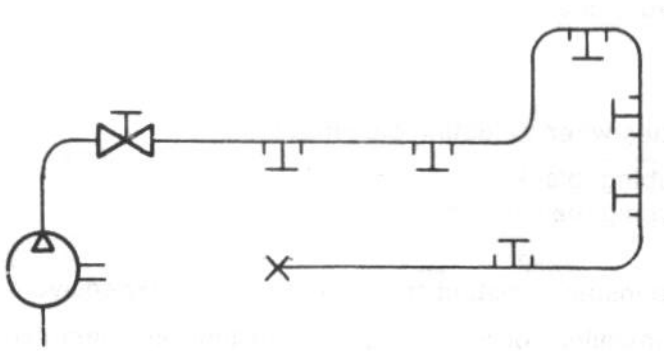


Figure 10.13 Open Distribution System

This type of distribution can adopted for an existing buildings lay out. However the terminal pressure keeps on reducing up to the last terminal due to pressure drop in the piping.

Closed Loop Distribution System

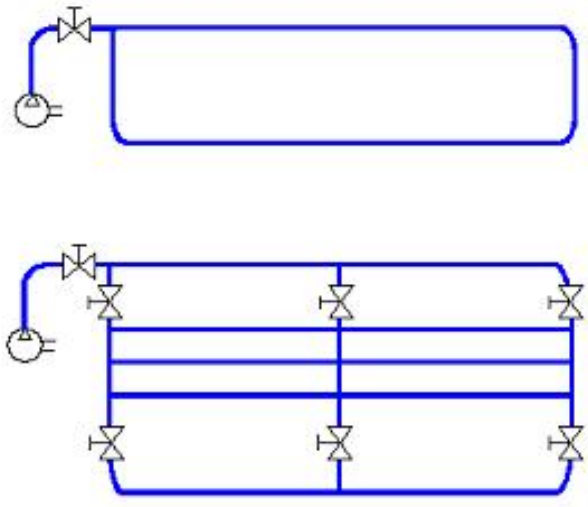


Figure 10.14 Closed Loop Distribution

Pressure drop is uniform and as it closed loop, the terminal pressures are the same in all the outlets. Proper planning of lay out the building is required for using this type of distribution system.

References :

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3. ‘ Fluid Sim P ‘ V3.6, Simulation Software Festo Didactic Product

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