UNIT –IV PART-A

PNEUMATIC SYSTEMS AND COMPONENTS

1. Under what conditions pneumatic systems are preferred?(Nov/Dec2012)

Pneumatics is study of mechanical motion caused by pressurized gases and how this motion can be used to perform engineering tasks. Pneumatics is used mainly in mining and general construction works. Pneumatic devices are used frequently in the dentistry industry across the world. On the other hand, hydraulics means use of pressurized fluids to execute a mechanical task. Hydraulics is frequently used in the concepts of turbines, dams, and rivers. Air brakes in buses, air compressors, compressed air engines, jackhammers, and vacuum pumps are some of the most commonly used types of mechanical equipment that are based on pneumatics technology. Commonly seen hydraulics based equipment types are hydraulic presses, hydraulic hoppers, hydraulic cylinders, and hydraulic rams. In the subsequent sections of this article, you will learn how a pneumatic system works, what its best features are, and its major advantages over hydraulic systems.

3. Name the different types of cylinder mountings.(Nov/Dec 2012)

Flange mounting: The flange can be attached to the head (item a) or to the base (b). In a, position B, the fastening screws must absorb the force from the piston, in a, position A, on the other hand only the withdrawal force.

Foot mounting: Here the fastening screws are subjected to shear (e, f). In e there is also a turning moment.

Mounting on end joint: Gives the cylinder freedom of movement in one (g) or in all planes (h). The centre of gravity is always at the end of the cylinder.

Trunnion mounting

Can be attached at any point along the length of the cylinder (i, k). A common design is pivoting at the centre of gravity of the cylinder.

4. **What is the function of air Filter and Dryer? (Nov/Dec 2012)**

i) The function of an air filter is to remove contaminants from air before it reaches the pneumatic components such as valves and actuators.

ii) The purpose of the dryer is to reduce the relative humidity and dew point of the compressed air from the compressor.

5. **When to use timer and relay? Why? (Nov/Dec2012)**

Their purpose is to control an event based on time. The difference between relays and time delay relays is when the output contacts open & close: on a control relay, it happens when voltage is applied and removed from the coil on time delay relays, the contacts can open or close before or after some time delay.

6. **What do you mean by logic control? (May/June2013)**

The logic control is a control based on logic functions like AND, OR, NOT etc. The components of logic control are sensors and switching elements called binary elements, i.e. at any moment they can be in one of the two states. "ON-OFF".

7. **What is a Ladder diagram? (May/June2013, 2014,) (April/May2015)**

The ladder diagram is a representation of hardware connections between switches, relays and solenoids etc., which constitute the basic components of an electrical control system. The left leg of the ladder connected to the power and the right to the ground.

8. **What is the function of quick exhaust valve? (May/June 2014)**

One quick exhaust valve is used in each port of the cylinder to ensure an increase in the speed of the rod in both directions. The use of a quick exhaust valve in a pneumatic system helps to increase cycling speed, in turn, that ensures a much smaller valve to be effectively used for the process.

9. **What are fluidic devices? (May/June2014)**

The term fluidics is normally used when devices have no moving parts, so ordinary hydraulic components such as hydraulic cylinders and spool valves are not considered or referred to as fluidic devices. A jet of fluid can be deflected by a weaker jet striking it at the side.

10. **State any four advantages of Pneumo-hydraulic circuits. (May/June2012)**

Over pneumatics, hydraulics is capable of moving heavier loads and having greater force, and since its working fluids are incompressible, it Pneumatic Drill have minimum spring actions. But at the same time pneumatics are cleaner, the system uses no return lines and gases are exhausted to the atmosphere.

11. **What is the function of pressure regulator in a pneumatic system? (April/May2015)**

The primary purpose of pressure regulators is to control pressure with close tolerances to ensure that compressed air in a pneumatic system is not wasted. Pressure regulating valves accomplish this by maintaining constant output pressure under various input pressures and output flows

12. **What is fluidics? (April/May 2015)**

Fluidics, *or* fluidic logic, is the use of a fluid to perform analog or digital operations similar to those performed with electronics. The physical basis of fluidics is pneumatics and hydraulics, based on the theoretical foundation of fluid dynamics.

Fluidics is the technology that utilizes fluid flow phenomena in components and circuits to perform a wide variety of control functions including sensing, logic and m more functions.

13. **Define FRL unit? (Nov/Dec2011)**

Air is not clean and hence contamination may result in pneumatic circuit. Also, due to time fluctuations, the receiver air pressure does not remain constant. Also, some parts of the Pneumatic system have to be lubricated for proper maintenance. For cleaning the air, regulating the pressure of air and lubricating pneumatic parts, three units 'Filter - Pressure Regulator - Lubricator' (Trio unit) are put together and this combined unit - Trio unit - is called FRL unit.

14. **What is the purpose of Shuttle valve in pneumatic circuit? (Nov/Dec2011)**

A shuttle valve is a type of valve which allows fluid to flow through it from one of two sources. Generally a shuttle valve is used in pneumatic systems, although sometimes it will be found in hydraulic systems

15. **What is a fast exhaust valve? (April/May 2012)**

A fast exhaust valve is used to vent cylinder quickly. It is primary used with spring return (single acting) pneumatic cylinders.

16. **How can you specify an air compressor? (April/May2008)**

Making the right choice of product, and supplier, will depend first and foremost on the actual application’s needs for a compressed air supply. That requirement has to be quantified in terms of compressor size, flow, pressure, air quality and usage patterns. These variables then need to be matched to the available types of compressor technology and their relative performance in terms of output, energy-efficiency and Total Cost of Ownership.

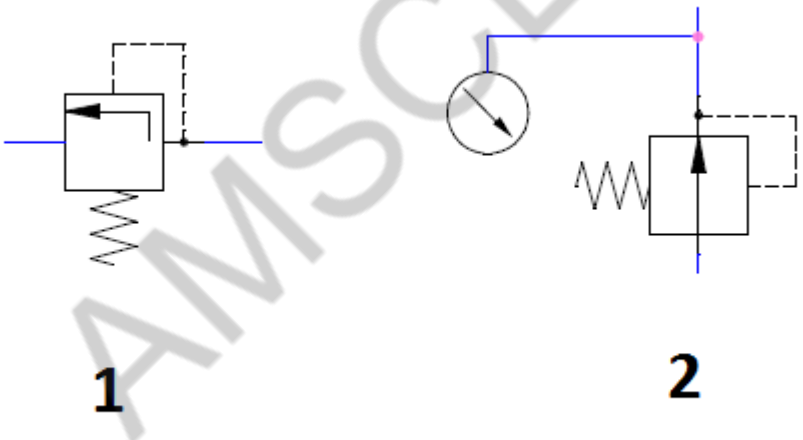
17. **What are the functions of FRL unit? (Nov/Dec 2009)**

Like pressure regulators, the lubricator function of an FRL unit ensures that the air is dosed with a small amount of lubrication oil to help pneumatic components work effectively. Lubricators ensure that the correct amount of oil is being used to reduce the friction between moving components.

18. **What are the basic components of pneumatic system? (Nov/Dec 2009)**

The main components of the compressed air production, transportation, and distribution system consist of air compressor, electric motor and motor control centre, pressure switch, check valve, storage tank, pressure gauge, auto drain, air dryer, filters, air lubricator, pipelines, and different types of valves.

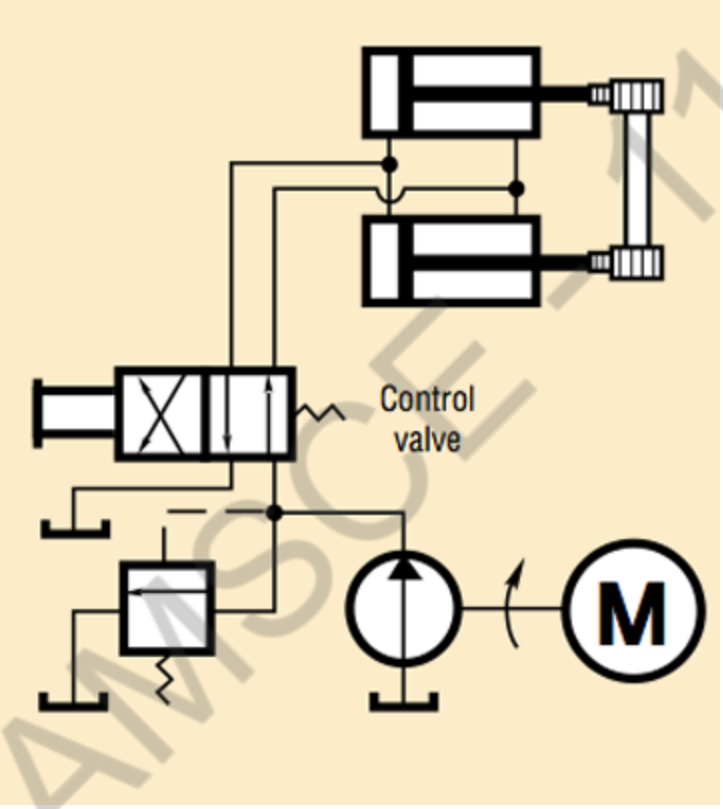
19. **Sketch the pneumatic symbol of pneumatic regulator (April/May2010)**



20. **List the components associated with PLC system (April/May2010)**

Programmable Logic Controllers (PLC) has three components. These three PLC components are: processor, power supply, and an input/output (I/O) section. The processor, or the brain of the PLC system, is a solid-state device designed to perform a wide variety of production, machine tool, and process-control functions.

21. Draw any one type of synchronizing circuit (April/May2010)



UNIT-IV

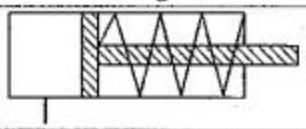
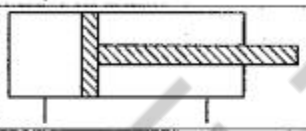
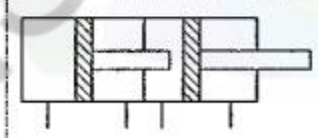
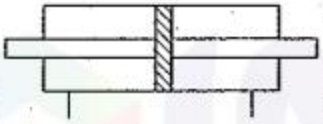
PART-B

1. Describe various pneumatic actuator with neat sketch (Nov/Dec2005)

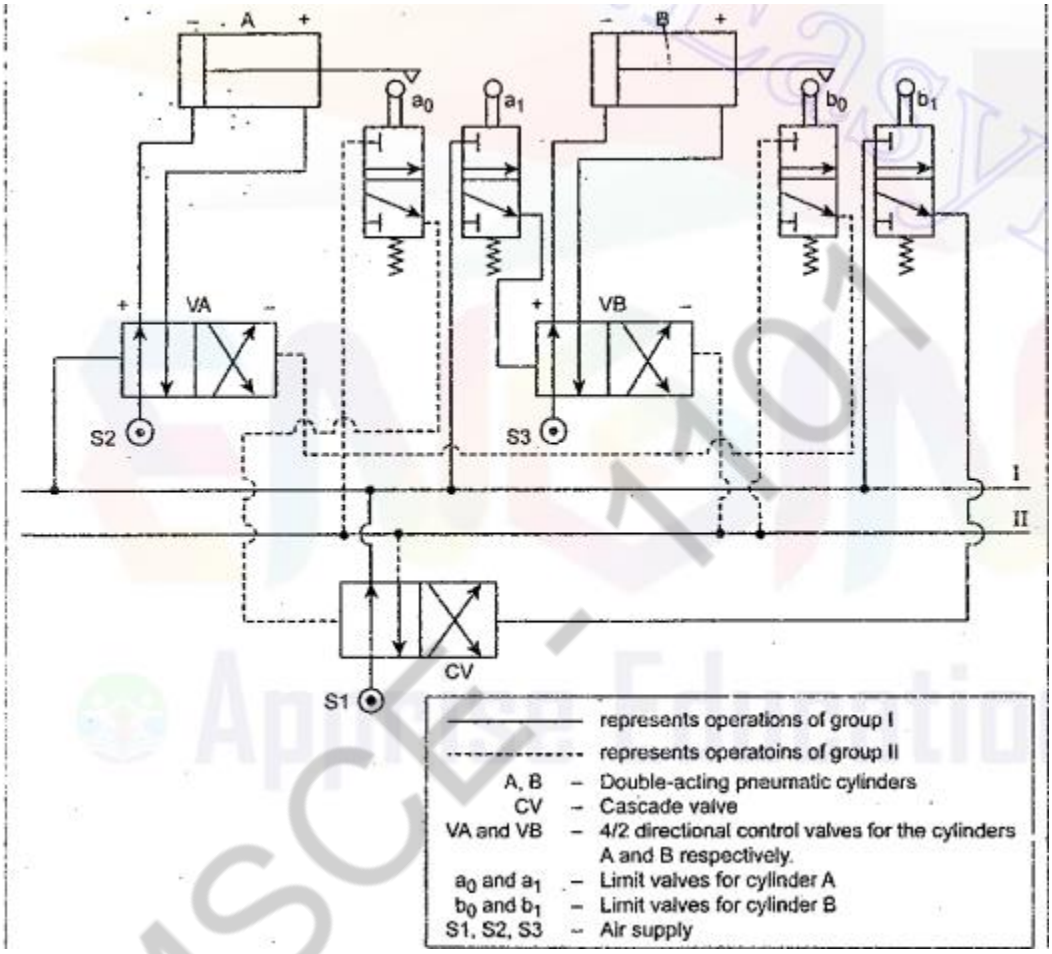
12.10. PNEUMATIC LINEAR ACTUATORS (PNEUMATIC CYLINDERS)

12.10.1. What are Pneumatic Cylinders ?

- ✓ *Pneumatic cylinders are the devices for converting the air pressure into linear mechanical force and motion.*
- ✓ The pneumatic cylinders are basically used for single-purpose applications such as clamping, stamping, transferring, branching, allocating, ejecting, metering, tilting, bending, turning and many other applications.

Sl.No.	Cylinder Type	Diagram	Description
1.	Single-acting cylinder		Air pushes the piston in one direction and the piston is returned by means of an external spring.
2.	Double-acting cylinder		The force exerted by the compressed air moves the piston in both directions.
3.	Cushion end cylinder		Cushioning is used in the end positions, to prevent sudden damaging impacts.
4.	Tandem cylinder		Here two cylinders are arranged in series so that the force obtained from the cylinder is almost doubled.
5.	Dual linear cylinder (Three position cylinder)		Similar to tandem cylinder, but the piston and rod assemblies of a dual actuator are not fastened together as in the tandem cylinder.
6.	Double-rod cylinder (Through rod cylinder)		It has piston rods extending from both ends of the cylinder. It produces equal force and speed on both sides of the cylinder.
7.	Telescoping cylinder		It is a two-stage, double-acting telescopic cylinder; for more details refer Section 6.6.2.

2. Develop an electro pneumatic circuit for the following sequence $A^+B^+A^-B^-$ where A and B stands for cylinders +indicate extension and – indicate retraction of cylinders (Nov/Dec2005)



☺ ***Solution :*** The solution to this design problem is very much similar to that of the previous problem. So the same procedure may also be followed for this problem.

Step 1 : Given sequence : $A^+ B^+ B^- A^-$

Step 2 : Grouping : $\underset{I}{A^+B^+}$, $\underset{II}{B^-A^-}$

Step 3 : Number of pressure lines = Number of groups = 2

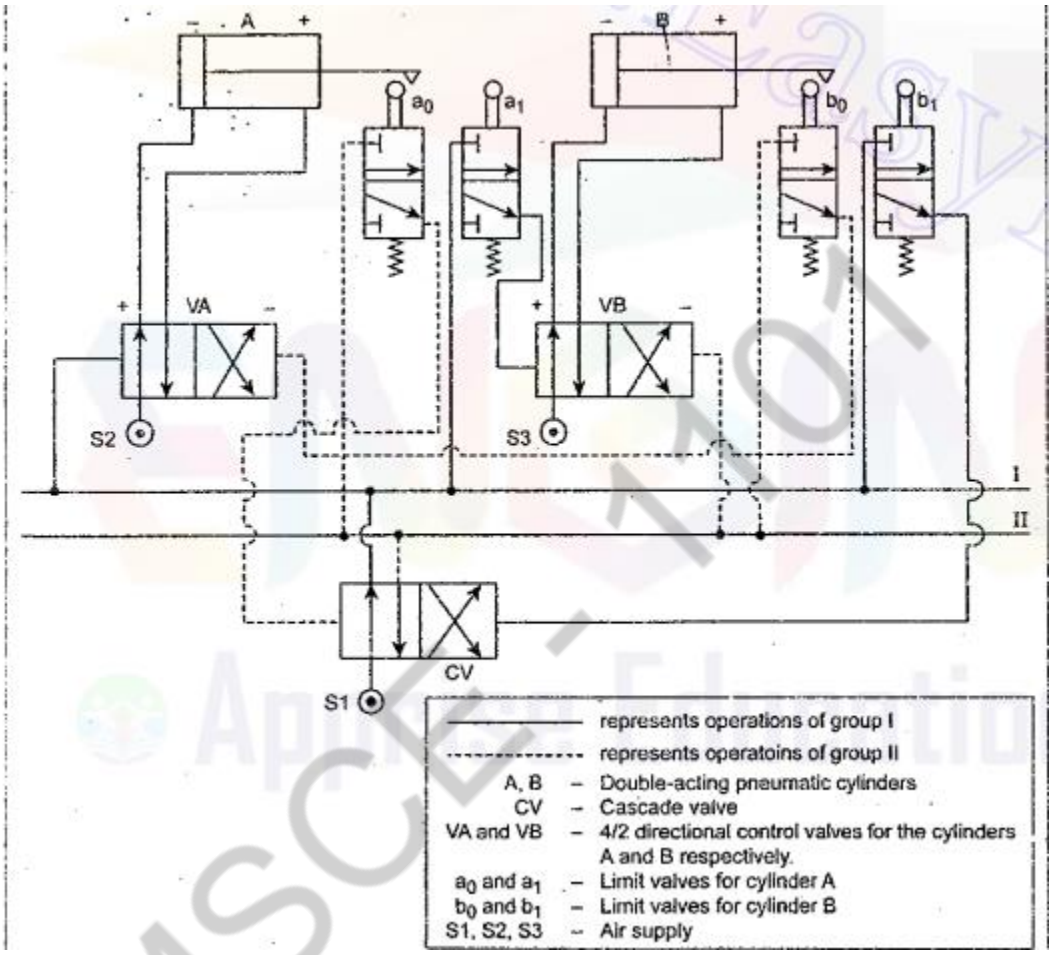
Step 4 : (*i*) Number of pilot operated 4/2 DC valve = Number of cylinders = 2

(*ii*) Number of limit valves = 2 × Number of cylinders = 2 × 2 = 4

(*iii*) Number of cascade valves = Number of groups – 1 = 2 – 1 = 1

Step 5 : The cascade circuit and their valve connections for the sequence $A^+ B^+ B^- A^-$ is drawn as shown in Fig.13.23.

3. Develop an electro hydraulic circuit for the following sequence $A^+B^+B^-A^-$ where A and B stands for cylinders +indicate extension and – indicate retraction of cylinders (Nov/Dec2005) (Nov/Dec2008)



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4. I) What are advantages of PLC? (April/May2005)

The PLCs replace electromechanical relays due to their following advantages :

1. PLCs are more reliable and faster in operation.
2. They are smaller in size and can be more readily expanded.
3. They require less electrical power.
4. They are less expensive when compared to electromechanical relays for the same number of control functions.
5. Hard-wired electromechanical relays lack flexibility. For instance, when system operation requirements change, then the relays have to be rewired.
6. PLCs have very few hardware failure when compared to electro-mechanical relays.
7. Special functions such as time-delay actions and counters, can be easily performed using PLCs.

ii) Explain the working principle of PLC with a neat block diagram (April/May2005)

15.8.1. Introduction

Programmable logic controller (PLC) is one of the important micro-processor based controller. As we aware, microprocessor has a tremendous impact on industrial control and instrumentation due to its high reliability and flexibility at the design and impiementation stages. The decreasing cost of microprocessors with increasing facilities in them are acting as catalyst in their widening scope of applications. In recent years, PLCs are being used in place of electro-mechanical relays or cam-operated logic controllers to control fluid power systems.

15.8.2. What is a Programmable Logic Controller (PLC) ?

- ✓ ***Definition :*** *A programmable logic controller (PLC) can be defined as a digital electronic device that uses a programmable memory to store instructions and to implement functions such as logic, sequencing, timing, counting, and arithmetic in order to control machines and processes.*
- ✓ In simple terms, a PLC is a user-friendly electronic computer designed to perform logic functions such as AND, OR, and NOT for controlling the operation of industrial equipment and processes.
- ✓ Thus a PLC consists of solid-state digital logic elements for making logic decisions and providing corresponding outputs.
- ✓ Basically, PLCs are designed as a replacement for hard-wired electro-mechanical relays to control fluid power systems.

15.9. MAJOR UNITS OF A PLC

A PLC consists of the three major elements, as shown in Fig.15.17. They are :

1. Central processing unit (CPU),
2. Programmer/monitor (PM), and
3. Input/output module (I/O).

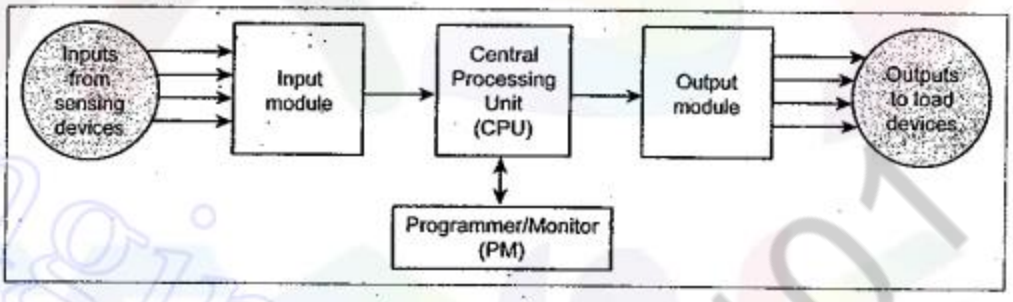

Fig. 15.17. Block diagram of a PLC

iii) How does a PLC differ from Microprocessor? (April/May2005)

PLCs are similar to general-purpose computers. But PLCs have certain features which are specific to their use as controllers. Some of the important features of PLCs are :

1. PLCs are rugged and designed to withstand vibrations, temperature, humidity, and noise.
2. The interfacing for inputs and outputs is inside the controller.
3. They are easily programmed and have an easily understood programming language. Programming is primarily concerned with logic and switching operations.

5. Explain with block diagram the components present in a PLC and give their functions (May/June2006)

15.9. MAJOR UNITS OF A PLC

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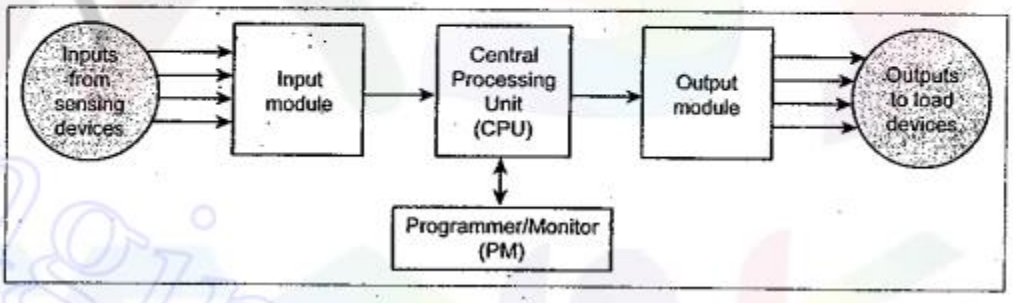


Fig. 15.17. Block diagram of a PLC

15.9.1. Central Processing Unit (CPU)

- ✓ The CPU controls and processes all the operations within the PLC, that's why this unit is referred as the 'brain' of the PLC.
- ✓ ***Function :*** The CPU (*i*) receives input data from various sensing devices such as switches, (*ii*) executes the stored program, and (*iii*) delivers corresponding output signals to various load control devices such as relay coils and solenoids.
- ✓ It consists a microprocessor with a fixed memory (ROM-'read only memory') and a variable memory (RAM–'random access memory').

15.9.2. Programmer/Monitor (PM)

- ✓ The programmer/monitor unit allows the user to enter the desired programme into the RAM.
- ✓ The programme which is entered in relay logic (in RAM) determines the sequence of operation of the system to be controlled.

15.9.3. Input/Output Module (I/O)

- ✓ This module interfaces between the fluid power system input sensing and output load devices and the CPU.
- ✓ ***Function :*** The purpose of the I/O module is to transform the various signals received from or sent to the fluid power interface devices (such as push-button switches, pressure switches, limit switches, solenoid coils, motor relay coils, and indicator lights).

ii) What is cascade control? Explain giving suitable example circuit. (May/June2006) (Ref.Q.No.2,3)

13.26.1. Cascade Method of Pneumatic Circuit Design

The cascade method is found to be the simplest and easiest method of designing pneumatic logic circuits.

13.26.1.1. Procedure

The following step by step procedure may be followed while using the cascade method.

Step1 : Each cylinders are given, for convenience, individual letters (say A, B, C, *etc.*). The given sequence is written first with '+' representing extension (forward) stroke of the cylinder and '–' representing retraction (return) stroke of the cylinder. (For example A^+, B^+, A^-, B^-, *etc.*)

Step 2 : The given sequence is split into minimum number of groups. The grouping can be done as below :

(*i*) The first group is split where the change in stroke occurs.

(*ii*) The second, third and subsequent groups are formed such that maximum of one change occurs within the group.

(*iii*) No letter should be repeated within any group.

(*iv*) The groups are identified by letters like I, II, III, *etc.*

Illustration : Let us assume the sequence $A^+ B^+ B^- C^+ C^- A^-$. This sequence can be splitted into three groups as shown below :

$$\underset{I}{\overline{A^+ B^+}}, \quad \underset{II}{\overline{B^- C^+}}, \quad \underset{III}{\overline{C^- A^-}}$$

Step 3 : Each group is assigned a pressure manifold line which must be pressurised only during the time the particular group is active.

$\therefore$ ***Number of pressure lines = Number of groups***

Step 4 : Selection of valves :

(*i*) Each cylinder is provided with a pilot operated 4/2 DC valve.

$\therefore$ ***Number of pilot control valves = Number of cylinders***

(*ii*) Limit valves are positioned at either end actuated by the piston rod to identify the extension and retraction of cylinders. The limit valves are denoted by a_0, a_1, b_0, b_1, *etc.*, where the suffix '0' corresponds to valves which are actuated at the end of return stroke and the suffix '1' corresponds to valves which are actuated at the end of forward stroke. Each cylinder requires two limit valves.

$\therefore$ ***Number of limit valves = 2 × Number of cylinders***

Each manifold line supplies air pressure to those limit valves within its particular group.

(*iii*) In order to pressurize the various manifold lines in the proper order, one or more group changing valves or cascade valves are used.

Step 5 : The valve connections are made as follows :

(*i*) The output of each limit valve is connected to the pilot input corresponding to the next sequence step.

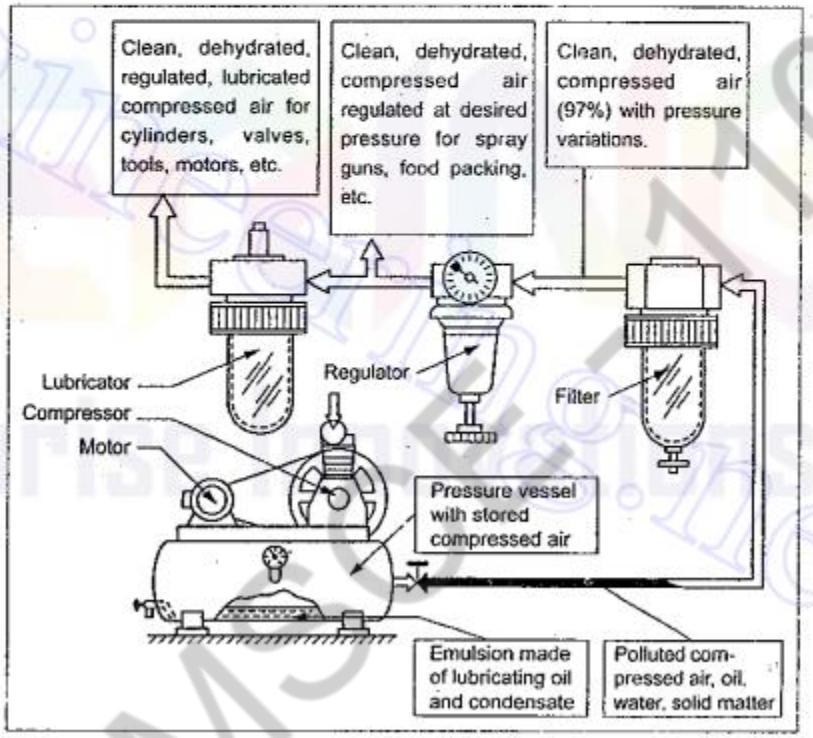
(*ii*) The limit valve corresponding to the last step of the given group is 'not' connected to the pilot actuation of the DC valve of next cylinder. Instead, it is connected to the pilot line of the group changing or cascade valve so as to pressurize the manifold of the subsequent group.

This manifold line is then connected to the pilot line corresponding to the first step of the next group.

6. I) Describe the operation of FRL unit (Nov/Dec2006)

11.9.5. FRL Unit

- ✓ In most pneumatic systems, the compressed air is first filtered and then regulated to the specific pressure and made to pass through a lubricator for lubricating the oil. Thus usually a filter, regulator, and lubricator are placed in the inlet line to each air circuit. These may be installed as separate units, but more often they are used in the form of a combined unit.
- ✓ The combination of filter, regular, and lubricator is often labelled as ***FRL unit*** or ***service unit.***
- ✓ Fig.11.11 illustrates the arrangement of a FRL unit.



- ✓ ***Composite symbol :*** Fig.11.12 illustrates how individual component symbols form a composite symbol of a FRL unit.

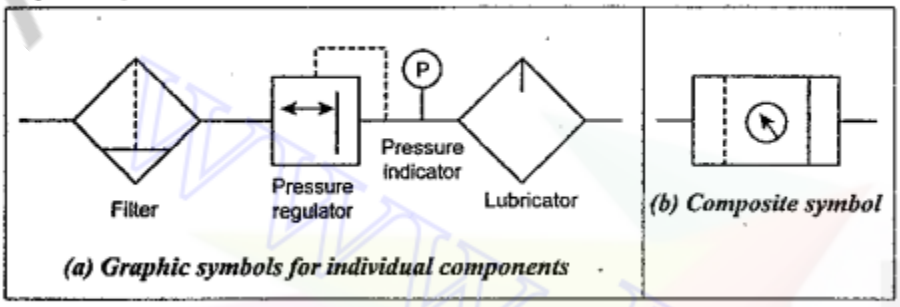


Fig. 11.12. FRL unit graphic symbol

ii) All the types of actuators used in pneumatics (Nov/Dec2006) (Ref. Q.No.1)

iii) Quick exhaust valve and silencer (Nov/Dec2006)

11.10. MUFFLERS (OR PNEUMATIC SILENCERS)

11.10.1. What are Mufflers ?

- ✓ ***Function :*** The function of muffler (also known as pneumatic exhaust silencer) is to control the noise caused by a rapidly exhausting air-stream flowing into the atmosphere.
- ✓ Noise created by air exhausting from an air system not only cause nervous tension and dissatisfaction among the operators, but also results in mental fatigue, lack of concentration, and inefficiency. This exhaust noises can be greatly reduced by installing a muffler at each pneumatic exhaust port.

11.10.2. Construction and Operation

The construction and operation of a typical pneumatic silencer is illustrated in Fig.11.13(*a*).

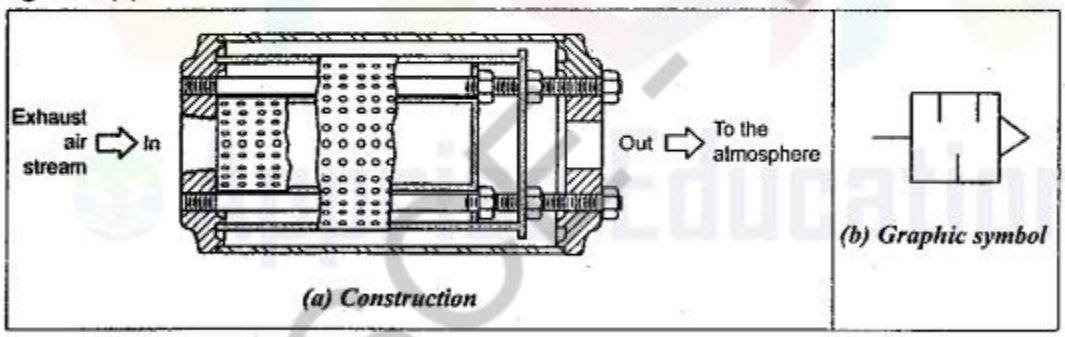


Fig. 11.13. Muffler

As shown in Fig.11.13 (*a*), the exhaust air stream enters one end, and passes out the another end after passing through a series of baffles. The baffle tubes are perforated with a large number of small holes. The outer shell acts as a barrier and helps guide the stream toward the exit to the atmosphere.

12.6. QUICK EXHAUST VALVE

12.6.1. What is a Quick Exhaust Valve ?

- ✓ A quick exhaust valve is a typical shuttle valve. *The quick (or fast) exhaust valve is used to exhaust the cylinder air to the atmosphere quickly.*
- ✓ It is basically used with spring return single-acting pneumatic cylinders to increase the piston speed of cylinders.
- ✓ The higher speed of piston in a cylinder is possible by reducing the resistance to flow of the exhausting air during motion of the cylinder. The resistance can be reduced by expelling the exhausting air to the atmosphere quickly by using a special valve. That's why this valve is known as a quick exhaust valve.

12.6.2. Construction and Operation

The construction and operation of a typical quick exhaust valve is shown in Fig.12.6. It consists of a movable disc and three ports—an inlet port (P), and exhaust port (R), and a cylinder port (A). Its working principle is very much similar to that of a shuttle valve.

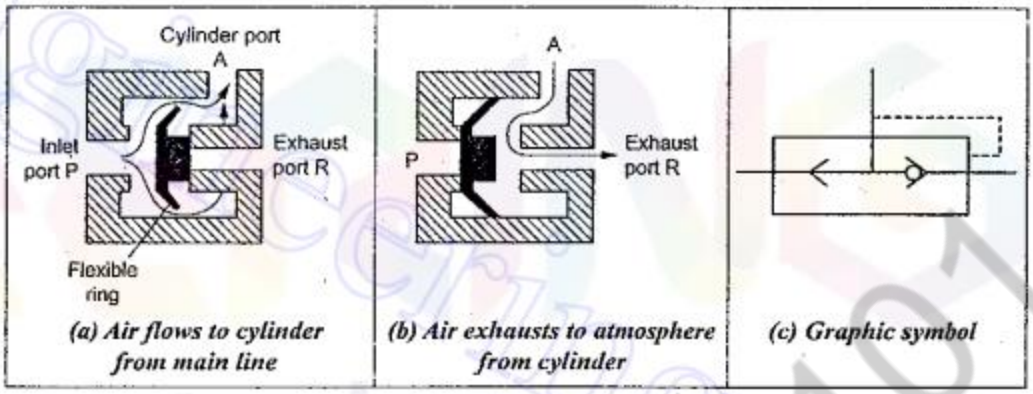


Fig. 12.6. Quick exhaust valve

When the air flowing to the cylinder from the DC valve is applied at port P, then the flexible ring covers the exhaust port R, whereby the compressed air passes from port P to the cylinder through port A (Fig.12.6(*a*)).

But the return air from the cylinder pushes the flexible ring to cover the inlet port P, whereby the exhaust air immediately expelled to the atmosphere (Fig.12.6(*b*)). Thus the resistance to piston movement is reduced considerably and the speed of the piston in the cylinder is accelerated proportionately.

7. Discuss the working principle of an air compressor (Nov/Dec2007)

11.3. PISTON-TYPE RECIPROCATING COMPRESSOR

- ✓ Piston compressors are the most commonly used compressors in the fluid power industry.
- ✓ The construction and working of a piston-type reciprocating compressor is very much similar to that of an internal combustion (IC) engine.

11.3.1. Construction

A typical piston-type reciprocating compressor consists of a cylinder, cylinder head, piston with piston rings, inlet and outlet valves, connecting rod, crank, crankshaft, bearings, *etc.* The arrangement of a basic single cylinder compressor is illustrated in Fig.11.2.

Inlet stroke : During the downward motion of he piston [Fig.11.2(*a*)], the pressure inside the cylinder falls below the atmospheric pressure and the inlet valve is opened due to the pressure difference. The air is drawn into the cylinder until the piston reaches the bottom of the stroke.

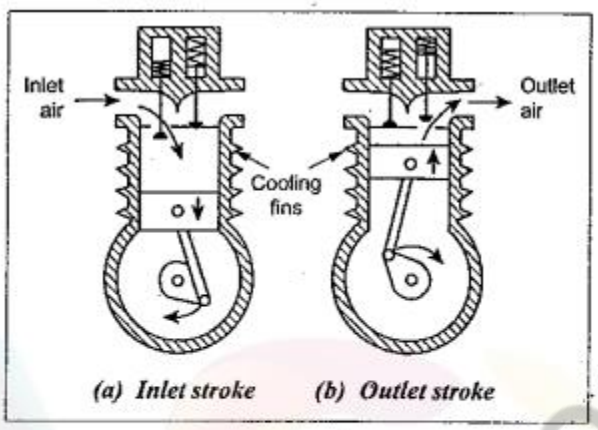


Fig. 11.2. Single cylinder compressor

Outlet stroke : As the piston starts moving upwards [Fig.11.2(*b*)], the inlet valve is closed and the pressure starts increasing continuously until the pressure inside the cylinder is above the pressure of the delivery side which is connected to the receiver. Then the outlet valve opens and air is delivered during the remaining upward motion of the piston to the receiver.

✓ To get the practical feel of a compressor unit, the simple view of a reciprocating air-compressor unit showing various external parts is presented in Fig.11.4.

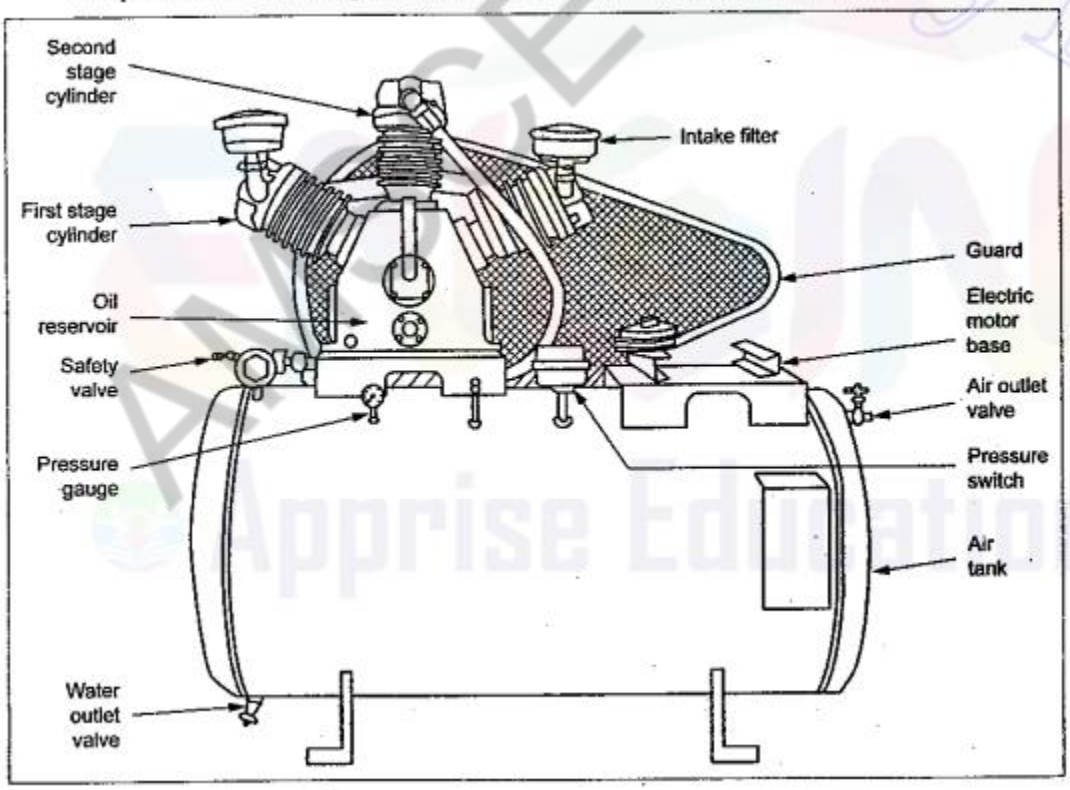


Fig. 11.4. Parts of reciprocating air compressor

ii) Discuss the function of FRL unit (Nov/Dec2007) (Ref. Q.No.6)

8. I) What are time delay circuits? Discuss with an example (Nov/Dec2007)

9.2.7. Timers

- ✓ Timers, also known as ***time-delay relays***, are time delay switches used to control the time duration of a working cycle.
- ✓ Timers are commonly applied in electrical control circuits when a time delay from the instant of actuation to the closing of contacts is required.
- ✓ These timers can be adjusted to change the dwell period for many machining operations. For example, in a drilling machine operation the timers provide a dwell, which allows the drill to pause for a predetermined time at the end of the stroke to remove the chips.
- ✓ The symbolic representation of the timers is shown in Fig.9.8.
- ✓ Fig.9.8(*a*) shows a normally open switch when energized closes after a predetermined time interval. Fig.9.8(*b*) shows a normally closed timer switch that is time opened when energized. Fig.9.8(*c*) shows the normally open timer switch that is timed when de-energized. Fig.9.8(*d*) shows the normally closed timer switch that is time close when de-energized.

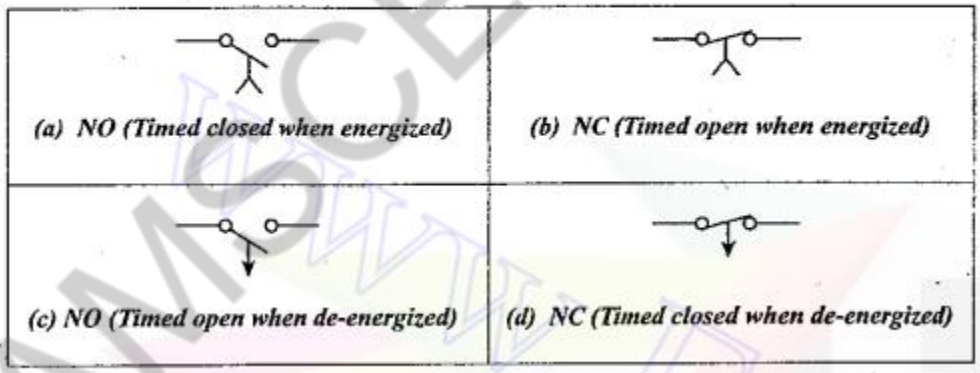


Fig. 9.8. Electrical timer symbols

ii) What are the selection criteria for pneumatic components? (Nov/Dec2007)

The various pneumatic components for a pneumatic system are selected based on the following criteria :

1. Work output required.
2. Maximum fluid pressure used in the system.
3. Speed of operation.
4. Life of the system.

9. I) What are advantages of fluidic system (Nov/Dec 2007)

15.2.2. Advantages of Fluidic Control Systems

The basic characteristics of using fluids to control themselves offer various advantages over the conventional alternate control methods. Some of the important advantages of fluidic control systems are given below :

1. Fluidic devices offer exceptional thermal and physical stability and ruggedness, when compared to electronic control systems. (Through the electronic logic control systems are widely used, they are affected by temperature, shock, vibration, and radiation.)
2. Fluidic devices are completely insensitive to radiation, even of extremely high levels.
3. Fluidic devices are not affected by severe vibration and shock.
4. Unlike hydraulic and pneumatic control components, fluidic devices are not susceptible to wear and tear. In other words, since fluidic components do not have any moving parts, they virtually do not wear out.
5. Simpler construction and easier maintenance.
6. Highly reliable functionality.
7. Relatively low cost.
8. Interfacing capability can be easily accomplished with fluidics. Fluidic components can be interfaced to control pneumatic, electrical, or other systems.
9. Since air is normally used as the working fluid within these devices, there are no problems of electrical noise, vibration, fatigue and contact contamination.
10. Since there is no arcing or sparking of switching elements, circuits employing fluidic devices can be operated quite safely in highly explosive or other dangerous environments.

ii) Explain the function of an air pressure regulator with neat sketch (April/May2008)

11.8.1. What are Air Pressure Regulators ?

- ✓ ***Function :*** The function of the air pressure regulator is to regulate the pressure of the incoming compressed air so as to achieve the desired air pressure at a steady condition.
- ✓ The compressed air leaving the compressor should be properly prepared before it goes into the circuit. The air should have the proper operating pressure for the circuit. Improper fluctuating pressure level in the piping system can adversely affect the operating characteristics of the system components such as valves, cylinders, *etc.* Therefore, air pressure regulators are fitted to ensure the constant supply pressure irrespective of the pressure fluctuations in the compressor unit.

It consists of diaphragm, valve, main and dampening springs, *etc.* Usually the diaphragm is made of oil-resistant synthetic rubber with a nylon cloth reinforcements.

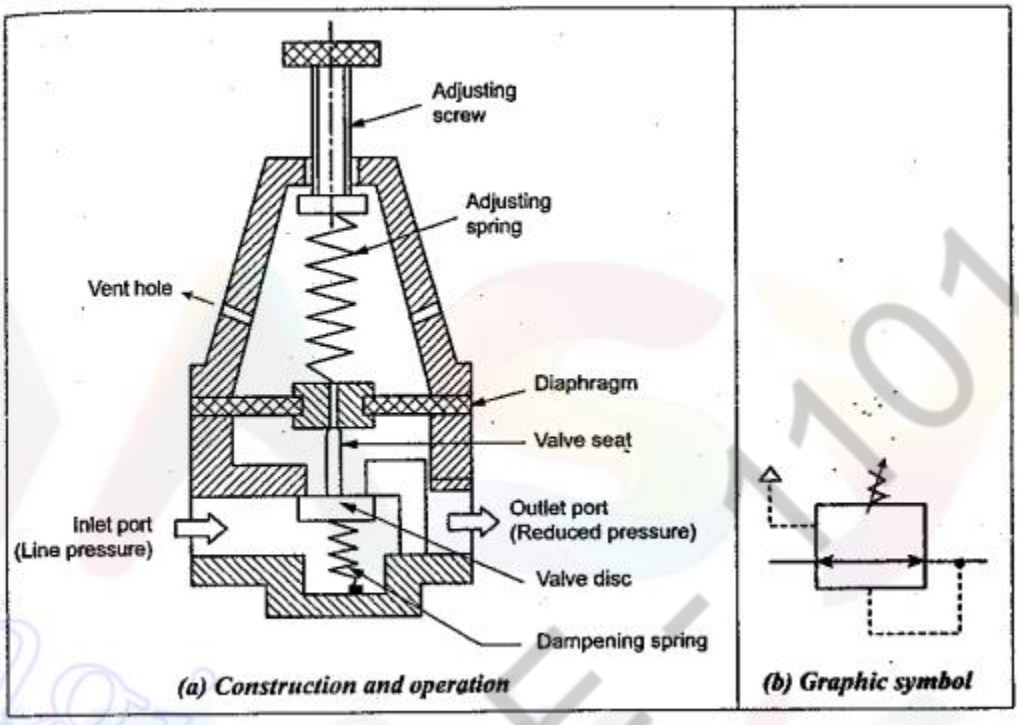


Fig. 11.9. Typical air pressure regulator

11.8.3. Operation

The diaphragm allows the proper amount of movement for opening and closing at the valve seat. When the adjusting screw is in the fully retracted position, the valve is closed. When the adjusting screw is turned to compress the adjusting and dampening springs, the valve is opened. Thus the air is allowed from inlet port to the outlet port.

The pressure of the outlet air depends upon the size of the valve opening that is maintained. This is determined by the compression of the adjustable spring. Higher the spring compression, more will be the amount of opening and hence more the pressure and vice versa.

The vent-holes are provided to let out the undesirable excessive outlet pressure, if any, into the atmosphere. The dampening spring is provided to act as a dampening device needed to stabilize the pressure.

10. I) What is meant by ladder programming? (April/May 2008)

- ✓ The basic form of programming commonly used with PLCs is ***ladder programming.***
- ✓ PLC programming based on the use of ladder diagrams involves writing a program in a similar manner to drawing a switching circuit.
- ✓ The ladder diagram consists of two vertical lines representing the power lines. Circuits are connected as horizontal lines. *i.e.*, the rungs of the ladder, between these two verticals.

ii) Draw the basic standard symbol that are used in ladder diagram, Also show rungs in a ladder diagram. (April/May 2008)

9.3.3. Details of a Ladder Diagram

Consider a typical ladder diagram as shown in Fig.9.9 for some application.

- ✓ ***Legs and Rungs :*** In Fig.9.9, the two vertical electrical power supply lines are called 'legs', and the horizontal lines containing electrical components are called 'rungs'.
- ✓ In ladder diagrams, always the power is connected to the left leg and the ground is connected to the right leg.
- ✓ It should be noted that always the switches should be shown in their unactuated (*i.e.*, open) mode in the ladder diagrams.

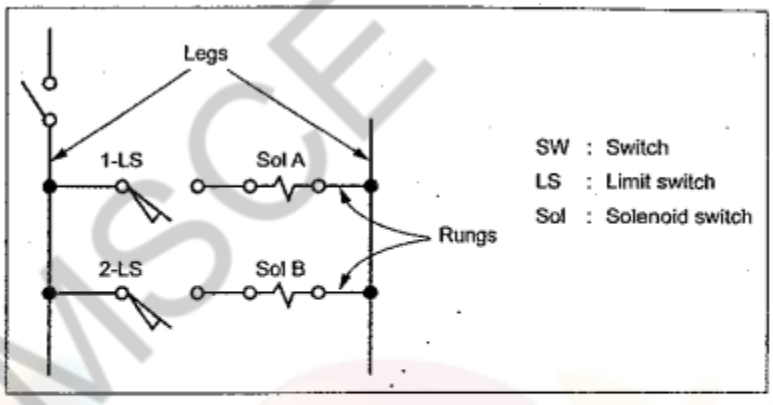


Fig. 9.9. Typical ladder diagram

- ✓ *Since the electric circuit diagram resembles to a ladder, this diagram is called a 'ladder diagram'.*
- ✓ ***Uses :*** Ladder diagrams provide a circuit designer with a practical means to examine input process and output functions to quickly plan the circuit layout design for a particular hydraulic or pneumatic application.

11. Draw and explain the function of an air filter (May/June2009)

11.7. AIR FILTERS

11.7.1. What are Air Filters ?

✓ *Functions :* The function of air filters is to remove all foreign matter and allow dry, clean air to flow without restriction to the regulator and then on to the lubricator.

✓ Filters are available in wide ranges starting from a fine mesh wire cloth (which only strains out heavier foreign particles) to elements made of synthetic materials (which are designed to remove very small particles).

✓ Usually in-line filter elements can remove contaminants in the 5 to 50 μm range.

11.7.2. Factors Affecting Selection of Filters

While selecting the filters, the following factors at least should be taken into account :

1. Size of particles to be filtered from the system.
2. Capacity of the filter.
3. Accessibility and maintenability.
4. Life of the Filter.
5. Ability to drain the condensate.

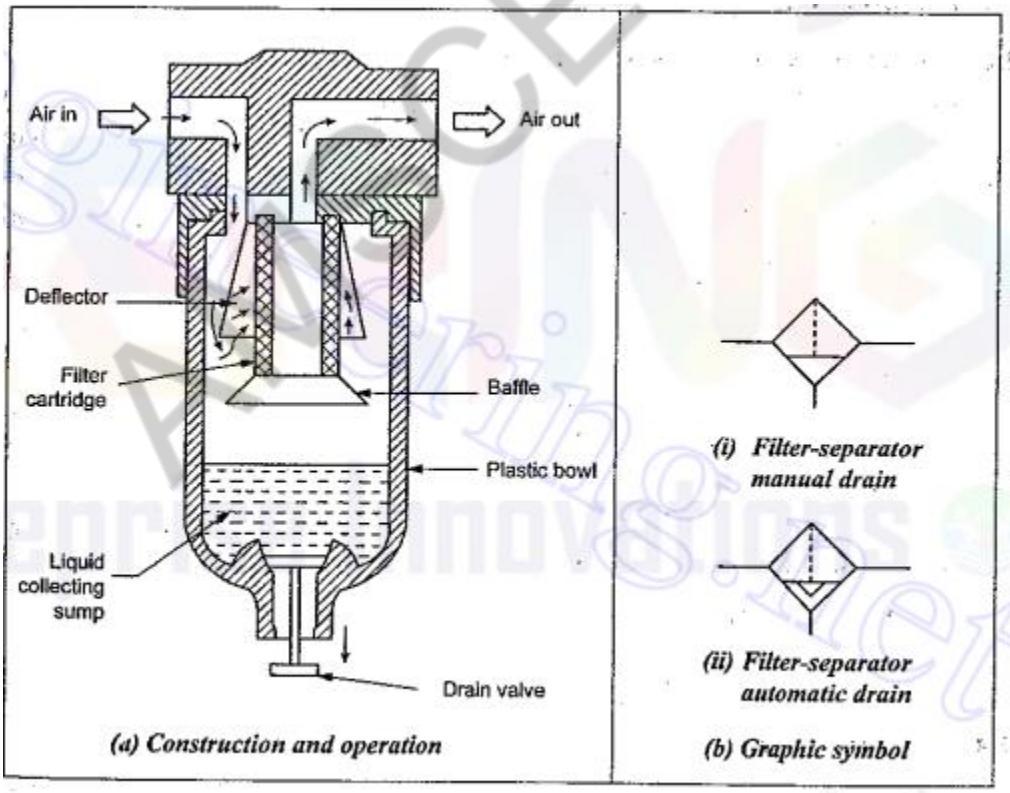


Fig. 11.8. Typical air-filter system

It consists of the filter cartridge, deflector, plastic bowl, baffle, water drain valve, *etc.*

11.7.4. Operation

The air to be filtered is allowed downward with a swirling motion that forces the moisture and the heavier particles to fall down. The deflector used in the filter mechanically separates the contaminants before they pass through the cartridge filter. The filter cartridge provide a random zig-zag passage for the air flow. This type of air flow arrests the solid particles in the cartridge passage.

The water vapour gets condensed inside the filter and is collected at the bottom of the filter bowl. Also heavier foreign particles that are separated from the air are collected at the bottom of the bowl. Then the accumulated water and other solid particles at the bottom of the filter bowl are drained off with the use of an on-off drain valve located at the bottom of the filter bowl.

11.7.5. Graphic Symbol

Fig.11.8(*b*) shows the graphic symbol for an air-filter.

ii) Draw and explain the function of pneumatic check valve (May/June2009)

12.3. CHECK VALVES

12.3.1. What are Check Valves ?

- ✓ Check valves are the most commonly used and the simplest type of directional control valves.
- ✓ ***Functions :*** The check valves are used :
  - (*i*) to allow free flow of compressed air in only one direction, and
  - (*ii*) to prevent any flow of compressed air in the opposite direction.
- ✓ Since check valves block the reverse flow of the fluid, they are also known as ***non-return valves.***

12.3.2. Construction and Operation

The sectional view and ANSI symbol of pneumatic check valve are shown in Fig.12.1(*a*). The construction and operation of a typical pneumatic check valve is illustrated in Figs.12.1(*b*) and (*c*).

As shown in Fig.12.1(*b*), when flow is in the forward direction, the compressed air pressure pushes the disk seal and thus the valve allows free flow. Instead, if flow is attempted

in the opposite direction as shown in Fig.12.1(*c*), the compressed air pushes the disk seal in the closed position. Hence no flow is permitted in opposite direction.

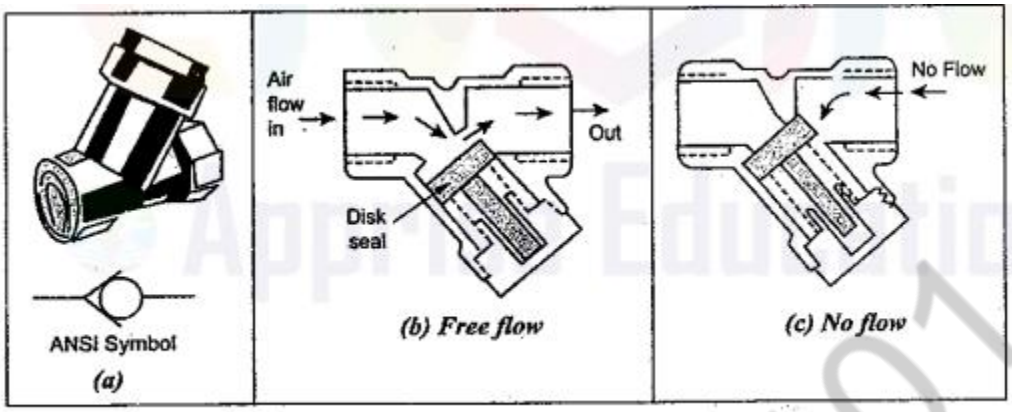


Fig. 12.1. Pneumatic check valve

12. Design a pneumatic circuit for the following sequence using cascade method A+B+B-A-C+C- (May/June2009)

☺ ***Solution :*** The steps involving during the design of this circuit is explained as below :

Step 1 : Given sequence is $A^+ B^+ B^- A^- C^+ C^-$

Step 2 : The given sequence can be initially splitted into three groups as

$$\underset{\text{I}}{\underline{A^+ B^+}}, \quad \underset{\text{II}}{\underline{B^- A^- C^+}}, \quad \underset{\text{III}}{\underline{C^-}}$$

In order to keep the number of groups minimal, the C^- can be assigned to group I. So the ideal grouping is as follows :

$$\underset{\text{I}}{\underline{C^- A^+ B^+}}, \quad \underset{\text{II}}{\underline{B^- A^- C^+}}$$

Step 3 : Number of pressure lines = Number of groups = 2

Step 4 : Selection of valves :

(*i*) Number of pilot operated 4/2 DC valve = Number of cylinders = 3

Thus three cylinder actuation—VA, VB, VC—are provided.

(*ii*) Number of limit valves = 2 × Number of cylinders = 2 × 3 = 6

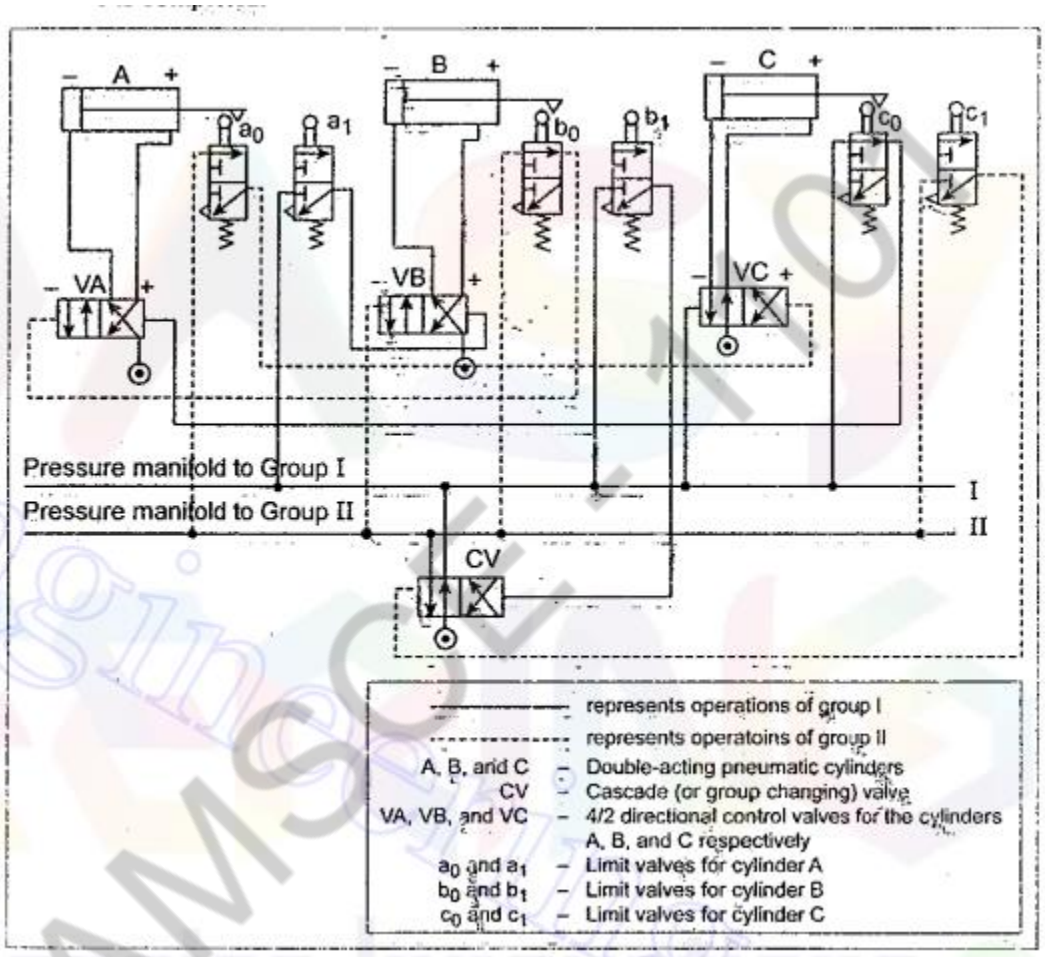
Thus six limit valves—$a_0, a_1, b_0, b_1, c_0, c_1$—are provided.

(*iii*) Number of cascade (or group changing) valves = $\left\{ \begin{matrix} \text{Number of} \\ \text{groups} \end{matrix} \right\} - 1 = 2 - 1 = 1.$

So for this circuit, only one cascade valve is sufficient.

Step 5 : The valve connections are made as follows :

(*i*) The cascade valve CV is shifted to its left envelop flow path configuration so that the pressure manifold to group I is pressurized. First line I is connected directly to the pilot line (–) of 4/2 DC valve VC. So retraction of C (C^-) starts when group I is pressurized.



At the end of retraction of C, the limit valve c_0 is actuated. Now the pressure from manifold line I passes through c_0 to the pilot line (+) of 4/2 DC vale VA. As a result, cylinder A extends (A^+) and actuates limit valve a_1. Pressure then passes from manifold line I through a_1 to the pilot line (+) of 4/2 DC valve VB; this causes cylinder B to extend (B^+) and actuates limit valve b_1. Thus the sequencing of Group I is completed.

As a result, cylinder A retracts (A^-) and actuates limit valve a_0. Pressure then passes from manifold line II through limit valve a_0 to the pilot line (+) of 4/2 DC valve VC; this causes cylinder C to extend (C^+) and actuates limit valve c_1.

(*iii*) Now the pressure from limit valve c_1 shifts the cascade valve CV to its left envelop flow path configuration and thus the pressure manifold I is pressurised again. Thus the automating sequencing of $C^-A^+B^+B^-A^-C^+$ can be achieved.