1. What are the properties of air to use in pneumatic System (Dec. 2009)

Air is one of the three states of matter. It has characteristics similar to those of liquids in that it has no definite shape but confirms to the shape of its container and readily transmits pressure.

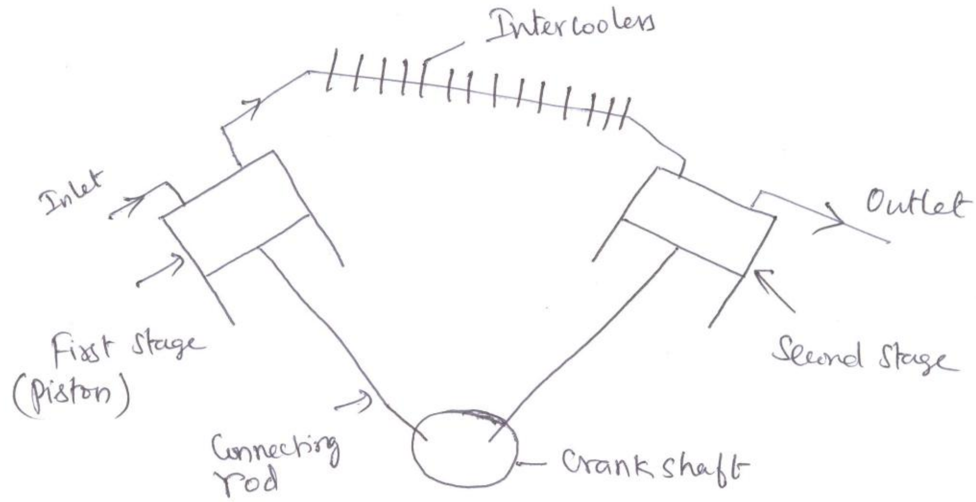
Air is a mechanical mixture of gases containing by volume approximately 78% of nitrogen and 21% of oxygen, and about 1% of other gases including argon and carbon dioxide.

Air is colorless, odorless, tasteless, and compressible and has weight.

- Air is available in unlimited quantities
- Compressed air is easily conveyed in pipelines even over longer distances
- compressed air can be stored
- Compressed air is clean. This is especially important in food, pharmaceutical, textile, beverage industries.
- Compressed air is fast. Thus, high operational speed can be attained
- Speeds and forces of the pneumatic elements can be infinitely adjusted.

2. Explain the working of a piston compressor with a neat sketch. (Dec. 2007, Dec. 2012)

A compressor is a machine that compresses air and gives high pressure air by reducing the volume. Air compressors are generally positive displacement units. They may be (i) Reciprocating piston
(ii) rotary screw and
(iii) rotary vane types.



A reciprocating compressor consists of one or more piston cylinder arrangement as shown above. The crank and connecting rod provides reciprocatory motion of piston from a electric motor.

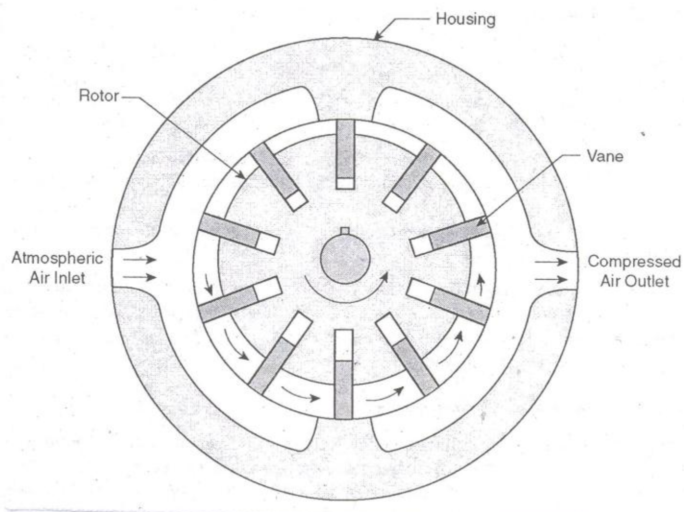
As the piston comes down, air is drawn in in the first stage and while piston moves up, air is compressed and forced thro' the outlet and fed into the inlet of second stage piston.

When air is compressed, it's temperature increases because of friction between the air molecules and the work done in compressing the air. So, before fed into the second stage air is passed through the intercoolers.

Normally in single stage compressers only 10 bar pressure be produced. Hence, if we need more than 10 bar multi stage compressor is required.

3. Discuss the construction and working principle of rotary Vane air Compressor. [Dec. 2011]

Vane Compressors are Smaller in physical size than piston compressors having comparable discharge, pressure and flow capabilities. The single stage vane compressors are capable of developing pressure upto 3.5 bar. By the multistage Vane compressor (Two Stage), the pressure can be developed upto 8 bar.



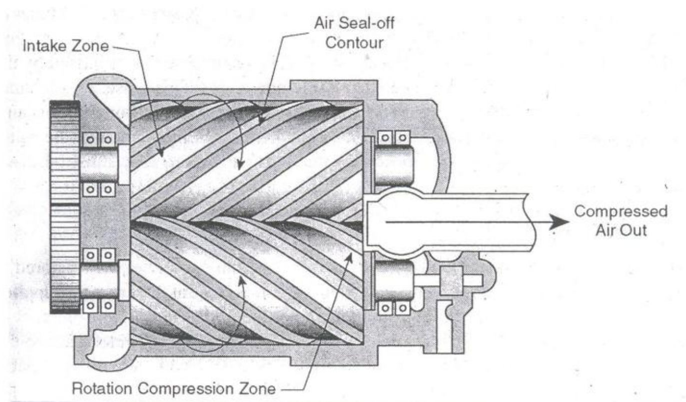
The compressor consists of a rotor with radial slots, mounted eccentrically to a Casing. The vanes are inserted in the slots of the rotor. As the rotor rotates, the negative Pressure (Vaccum) created by the vanes draws the air in. As the rotor continues, the vane compresses the air in the Space that gets progressively smaller. The air is compressed to the required pressure, discharged through the discharge Port, while vane approaching the discharge position.

4. With a neat sketch, explain the working principle of a screw compressor. [May 2012]

Screw compressors are basically classified as Dry screw compressor and wet screw compressor.

Dry screw compressor is constructed with two rotors, one with a concave profile (female) and other with a convex (male) profile. Both the rotors are driven and prevented from touching by a set of timing gears.

As the rotor revolves, vacuum area is created at the inlet and draws the air into the casing. The entered air is trapped between the rotors and casing and carried along until it is discharged.



The alternate design is a wet rotary screw compressor, which uses one screw that powers the other by contact. Here, to prevent the wear and reduce air temperature, oil is sprayed in the inlet chamber and is carried by the air particles.

5. Explain the constructional features of filter, Regulator and lubricator with neat sketches [Dec. 2007, May 2009, Dec. 2009, May 2008, May 2010, May 2011, Dec. 2011, May 2012, Dec. 2013]

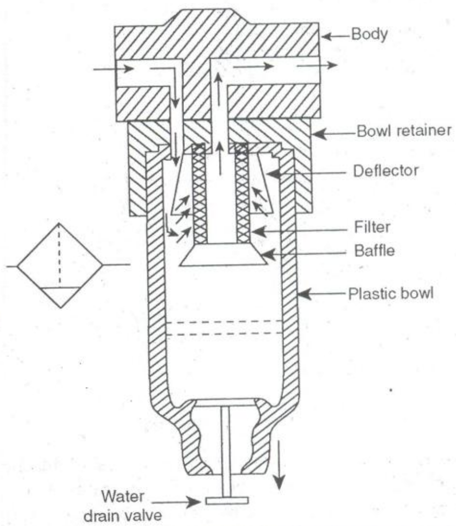
Air filter:

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

The components of air filter are

(i) Filter catridge - mostly made up of sintered brass or bronze.

(ii) Deflectors



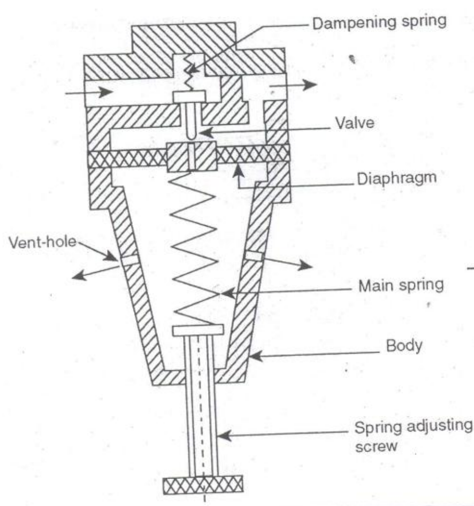
In the filter catridge, Contaminants of Size 5 to 50 microns are get removed. The air flow entering the filter is directed downward with a swirling motion that forces the moisture and the heavier particles to fall down. The deflector used here seperates most of the Contaminants. The finer particles move along air will be arrested when it passes through the catridge. At the bottom of the filter bowl, there is an on-off drain valve, which could be manually opened to drain the accumulated water and solid particles.

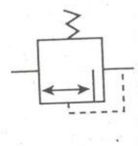
Pressure Regulator:

The main function of regulator is to regulate the incoming pressure to the system so that the desired air pressure is capable of flowing at a steady condition.

The parts of the regulator are

(i) A valve with Dampening Spring
(ii) Diaphragm
(iii) Vent hole
(iv) Spring adjusting screw



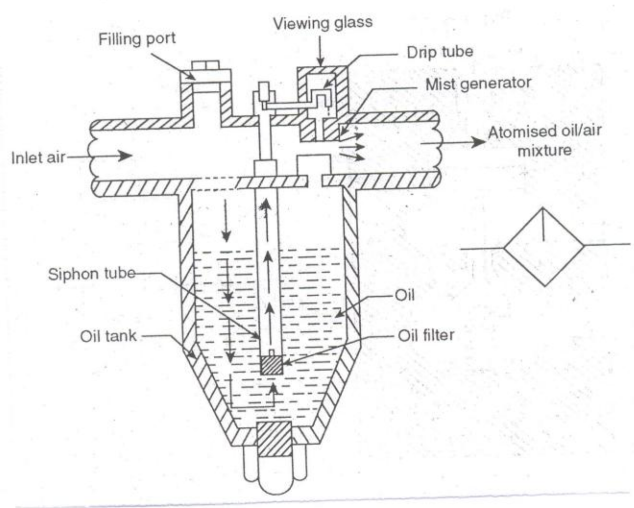


The valve has a metallic body with primary and secondary openings. The pressure regulation is obtained by opening the poppet valve to a measured amount for achieving the desired pressure level. This is done by an adjustable screw. This will move the diaphragm upward and thus will make the poppet to unseat, and allows the air to flow from primary to secondary side. The opening of the valve and there by the pressure of air flowing through it will be directly proportional to the compression of the spring underneath the diaphragm. Larger the opening, greater the pressure and vice versa. In many cases, the valve has two vent hole openings through which the compressor air is let out into the atmosphere, if the secondary pressure increases to a level not desired to the system. The spring at the other side of the poppet acts as a dampening device to stabilize the pressure.

Lubricator:

The function of the lubricator is to insert drops of oil into the air stream. A small amount of air from the main stream is diverted through the bowl pressure control valve into the bowl or reservoir.

Air pushes oil through the siphon tube past the adjustment screw to the drip tube. The drops of oil are then transferred through the center of the variable orifice and enters the mist-generator, mixing with the oil delivered by the drip tube. The air-oil mixture then rejoins the remaining air and continues toward its final destination.



6. What is the selection criteria for pneumatic components? [Dec. 2007, Dec. 2008, May 2013].

Pneumatic components serve the same purpose like hydralic components. Since the air pressure is low, components are lighter, less robust than hydraulic components. The compressibility of air is considered while selecting the components.

1) Selection of pneumatic cylinders] - Actuators
2) Selection of air motors]

3) Sizing of control valves] - Valves & pipes
4) Losses in pipes]

5) Selection of FRL] - Air prepatation unit.
6) Sizing of compressors]

1) Selection of pneumatic cylinders:

There are many physical similarities between pneumatic cylinders and hydraulic cylinder. But, because of low pressure used in pneumatics, Pneumatic cylinder has a lower force capabilities. Due to the

Compressibility of air, the speed of cylinder cannot be predicted accurately. The cylinder speed depends on the supply pressure, load on the cylinders, leakage and friction. As these factors are constantly changing, it is difficult to find the cylinder speed at best.

The main criteria for the selection of cylinders are

a) attainable piston force at specific operating pressure

b) Permissible buckling force of the piston rod

c) air consumption.

<u>Piston force:</u>

Load carrying capacity and distance to be travelled are the factors determining the selection of cylinders. A small percentage of piston force is used for overcoming friction and the remaining is used for taking load.

The effective piston force $= P \cdot \frac{\pi D^2}{4} - f$

where P - working pressure

D - Dia of piston

f - friction factor

<u>Permissible buckling force:</u>

The piston rod is the highest stressed part in an air cylinder. Due to this, the permissible load on piston rod is less than that provided by maximum working pressure. This load is calculated from the Euler's formula

$$F = \frac{\pi^2 E I}{L^2 S}$$

where E - Modulus of Elasticity

I - Moment of Inertia of rod

L - Equivalent buckling length

S - Factor of Safety.

The buckling length depends on type of cylinder mounting.

Air Consumption:

The air consumption of pneumatic cylinder depends on the application.

$$\text{Air Consumption}, Q = \frac{\pi}{4}\left[D_p^2 + (D_p^2 - D_R^2)\right] \times \text{Stroke} \times \text{Compression ratio} \times n$$

Where D_p - Dia of piston

D_R - Dia of piston rod

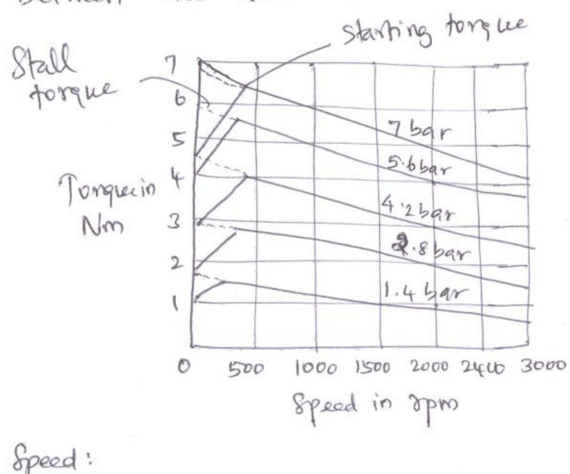
n - No. of cycles per minute.

2) Selection of air motor:

The Selection of air motors are based on performance characteristics called torque, Speed and power.

Torque:

The torque of the pneumatic motor depends on displacement pressure. Large motors produce more ~~torque~~ torque at a given pressure. When the load on air motor increases, Speed decreases until motor torque meets that load requirement. The influence of load can be reduced by installing Speed reduction gearing between the motor and load.



Speed:

Theoretically air motor Speed is directly proportional to flow rate. Free Speed is the maximum Speed under no load conditions. Design Speed is the Speed at which rated power is reached. Manufacturers Specify the air consumption of each pneumatic motor under particular condition, free Speed and design Speed.

Power:

With a constant inlet pressure, the power of an air motor is zero at zero speed. Power increases with increasing speed until it peaks at around 50% of free speed.

3. Sizing of control valves:

Pneumatic valves are selected based on their pressure drop characteristic curves. However, flow co-efficient (C_v) a parameter that relates the pressure drop and the flow rate is commonly used.

$$C_v = \frac{Q}{6.98}\left[\frac{T}{\Delta p \cdot P_{out}}\right]^{1/2}$$

where Q = flow rate in m^3/min

Δp = pressure drop in bar

P_{out} = Down stream pressure in bar

T = Up stream Temperature in K.

Valve is selected from manufacturer's catalog with a C_v equal or greater than the calculated.

4. Pressure losses in pipes:

When air flows through the pipe, due to friction there is always a pressure drop in the outgoing air. A common formula for pressure loss calculation is

$$P_f = \frac{1600\, Q^{1.85} L}{P_{in} \cdot D^5}$$

where P_f = Drop in pressure

Q = volume of free air, m^3/sec

P_{in} = absolute pressure of air at entrance of pipe

D = Internal diameter of pipe, m.

L = length of Pipe line, m.

5. Selection of Filter, Regulator, Lubricator:

Filter:

Filters are rated according to the minimum particle size that will get trapped. 40-60 μm are adequate for most industrial applications, many point-of-use filters are rated at 5 μm. The finer ratings increase pressure drop through the filter, which equals to higher energy cost to compress the air.

Filter Manufacturers define the expected pressure loss and dirt holding capacity using curves related to pressure and flow.

If the filters are used to remove condensed water via Cyclone Seperators, these filters must be matched to the intended air flow rather than pressure drop.

Regulator:

While selecting a regulator for specific application, requires a choice among the styles - unbalanced poppet, balanced poppet, Seperate diaphragm chamber.

The Second Consideration becomes primary pressure Versus Secondary pressure.

Finally, desired air flow rate must be selected.

Regulators are also defined by body size and connection size. A larger body size will produce better setting sensitivity and less drop than smaller body model under the same set of operating conditions.

Lubricators:

Lubricators are generally selected based on pipe connection size, oil reservoir capacity and acceptable pressure loss versus flow rate. The pressure loss of lubricator is to be taken into account when setting the pressure regulator.

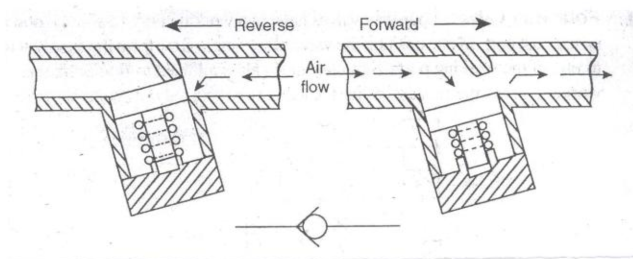
6. Sizing of Compressors:

Compressors must be sized to supply sufficient pressure and flow rate to the system under all expected conditions. Another important is the power required to drive the compressor.

7. Draw and explain the functions of pneumatic check valve. [May 2009]

A check valve shuts off against reverse flow and opens at a low cracking pressure in the forward direction. Metal body or light weight plastic body designs with suitable fittings are available.

As like hydraulic check valve, these valves function.



8. Describe the functions of air control valves. [Dec. 2010]

Air control valves are used to control

(i) the pressure
(ii) flow-rate and
(iii) Direction of air in pneumatic circuits.

Pneumatic pressure control valves are air line regulators that are installed at the inlet of each pneumatic circuit.

Flow control valves allow free flow in one direction and an adjustable or controlled flow in the opposite direction, as desired by the application.

Direction control valves are two-way, three-way and four-way control valves.

In addition to the above check valve and shut-off valves are used in the pneumatic circuits.

9. classify the various types of pneumatic actuators [Dec. 2010, Dec. 2011].

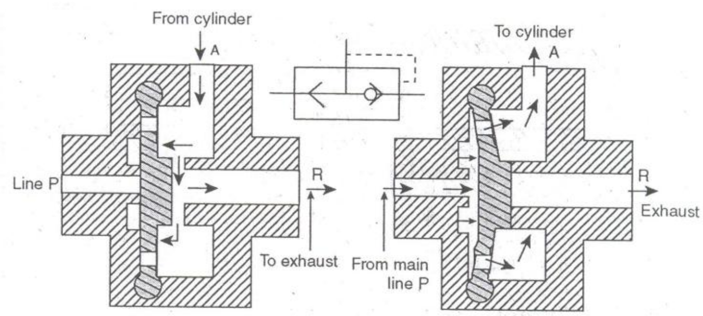
Pneumatic Actuator

- Linear Acutuator [Pneumatic cylinder]
  - Based on Application
    - Light duty
    - Medium duty
    - Heavy duty
  - Based on cylinder action
    - Single - acting
    - Double - acting
  - Based on cylinder's Movement
    - rotating type
    - Non rotating type
  - Based on cylinder Design
    - Through rod cylinders
    - Cushion end "
    - Tandem "
    - Double rod "
    - Telescoping "
- Rotary Acutator [Air Motor]
  - Continuous rotary air Motor
    - Gear motor
    - Vane motor
    - Piston motor
  - Limited rotation air Motor
    - Vane type
    - Piston type

10. Discuss the Construction and function of a quick exhaust valve with a diagram. [Dec. 2009]

Quick exhaust valve is a typical shuttle valve, used to exhaust the cylinder air to the atmosphere quickly.

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 exhausing air to the atmosphere quickly by using this special valve.



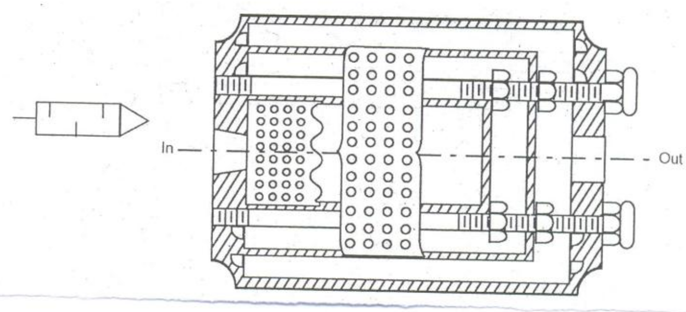
a) Air Quickly Exhausts to Atmosphere . b) Air Flows to Cylinder

When air is fed to the piston side of the cylinder, the air in the rod end of the cylinder exhausted quickly through this valve. The air flowing to the cylinder from DCV will pass through port 'P'. But the return air from cylinder is routed through 'R' without travelling through port 'P' and thus avoids DCV. So the resistance to the piston movement is eliminated to some extent and speed of cylinder is accelerated.

11. Write short note on Mufflers. [May 2013].

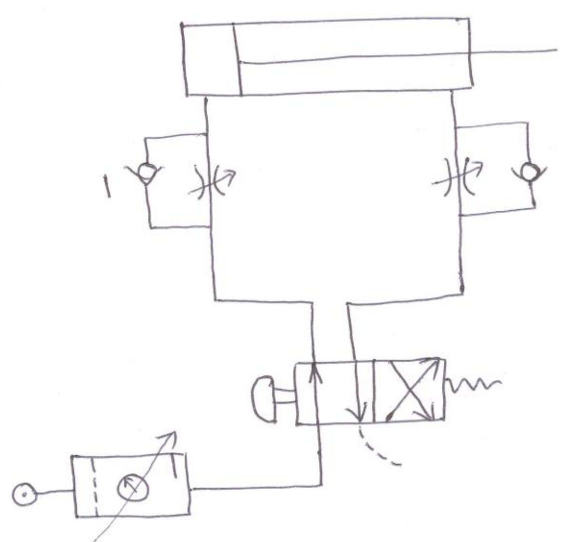
Muffler is an extra device to be attached to control the noise caused by a rapidly exhausting air-stream flowing into the atmosphere.

Noise created by 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 noise can be greatly reduced by installing a muffler at each exhaust port.



In the muffler, air stream enters at one end, passes through a series of baffles and passes out at the opposite end. The end at which the air enters is tapped for pipe connection while the opposite end is large enough to allow the exhaust air to flow without restriction to the atmosphere. The baffle tubes are perforated with a large number of small holes. The outer shell acts as a barrier and helps guide the air stream towards the exit.

12. Explain the working of a pneumatic speed control circuit. [Dec. 2007]



The motion and speed of double acting cylinder can be controlled by using flow control valves. In Pneumatics, meter-out flow control is preferred, because it provides a stabilishing back pressure on the piston which smoothes out the jumping motion of pneumatic actuator.

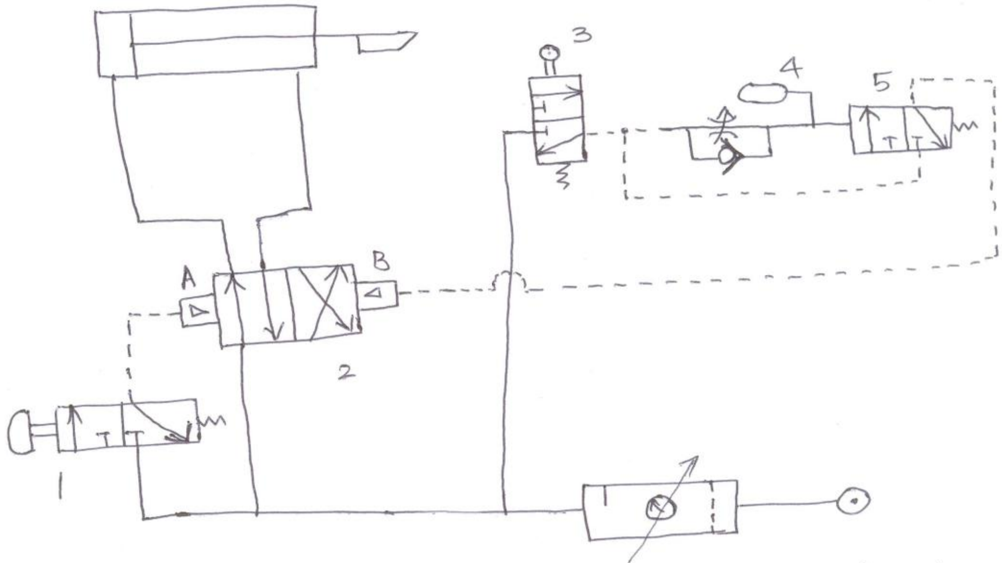
When the 4/2 DCV is operated, the air from FRL reaches the blank end of cylinder through check valve 1 and cylinder extends. The air in the cylinder ~~in the~~ rode side is to be exhausted through the flow control valve because the free flow is prevented by the check valve 2. Thus the speed of double acting cylinder is controlled during forward stroke.

When the 4/2 DCV is deactivated, air enters to rod end of cylinder through check valve 2 and air present in the blank end exhaust through flow control valve, free flow is prevented by check valve 1. Thus the speed of return stroke is controlled.

13. What is time delay circuit? Discuss with example [Dec.2007]

In certain engineering applications, for example, a pneumatic cylinder actuates a material handling platform. At the end of extension stroke, the platform has to wait for a predetermined time for material removal and then it has to return back. A time delay valve is an ideal solution for such applications.

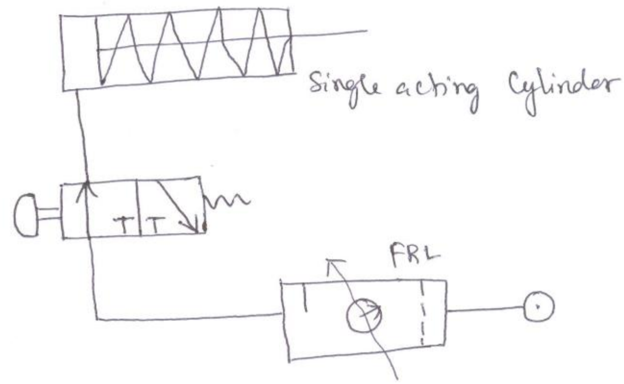
When the push button of 3/2 DCV (1) is actuated, the pilot signal goes to the portion 'A' of 4/2 way DCV (2). Now the cylinder extends and actuates the roller operated pilot valve (3). But it is connected to a time delay valve (4). So the valve (2) is not actuated immediately.



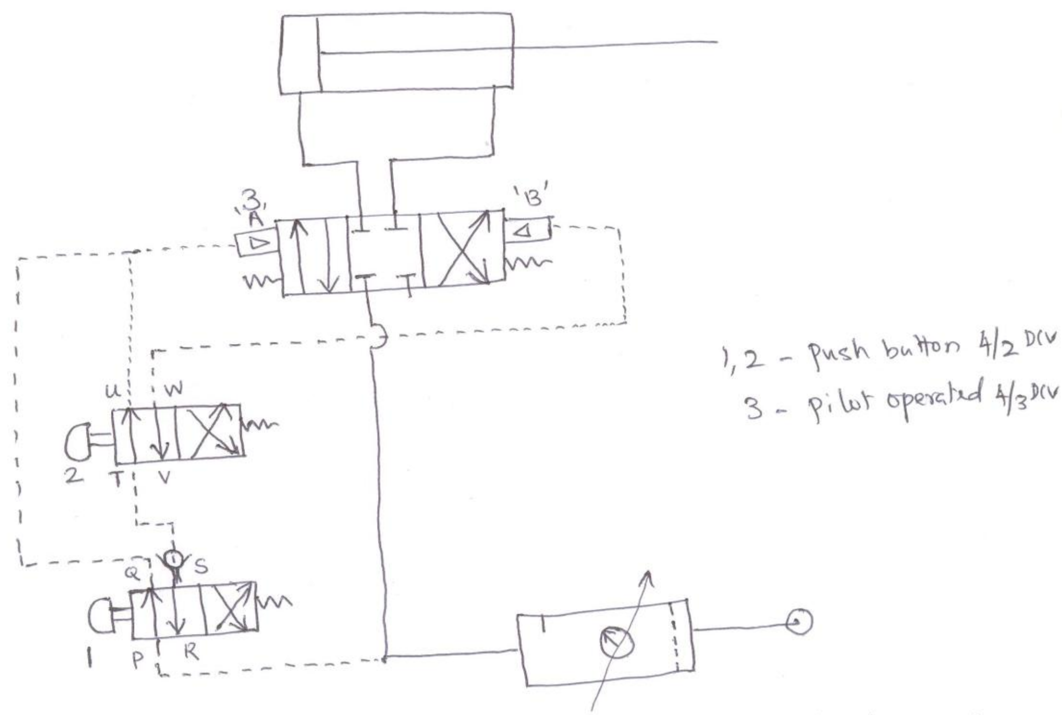
The air is accumulated in the reservoir (4) of time delay valve. When the pressure exceeds the 3/2 DC valve (5), the valve opens and the pilot signal is fed to the chamber (B) of 4/2 DCV. Now the cylinder returns. The return of the cylinder is delayed by a certain time which is required to ~~buildup~~ build up pressure in the reservoir.

14. What is pneumatic circuit? Draw the control of single acting pneumatic cylinder circuit. [May 2011]

Pneumatic circuits are similar to the hydraulic. One main difference is that no return lines are used in pneumatic circuits because the exhaust air is released into the atmosphere. Also no input device is shown, because most pneumatic circuits use a centralized compressor as their source of energy.



15. Design a circuit with air pilot control of a double-acting cylinder [Dec. 2007].



The circuit is a two hand safety control circuit, designed for safety of the operator by requiring two hand operation of machines.

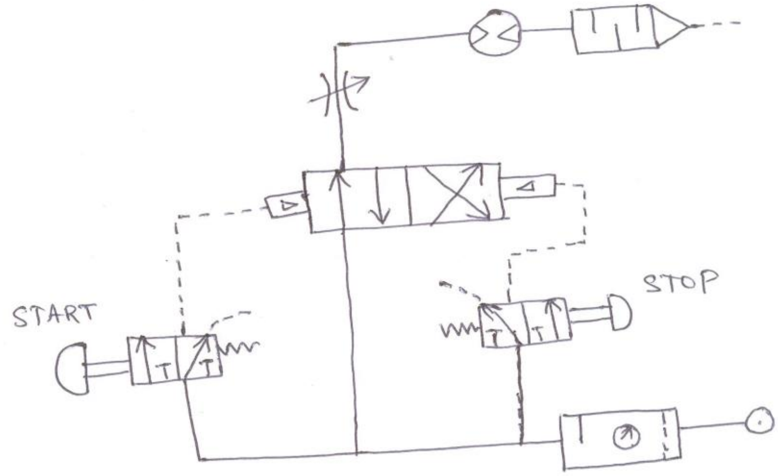
If 1 and 2 push button are pressed, pilot air will reach champer 'A' of 4/3 DCV '3' and cylinder extends.

If both button of the valves 1 and 2 are released, through P-S, T-W, Pilot air will reach champer 'B' of 4/3 DCV '3' and cylinder retracts.

If valve 1 alone pressed, pilot air passes thro P-Q and vented through U-V of valve 2, no actuation in valve 3, hence no strokes in double acting cylinder.

If valve 2 alone pressed, pilot air passes thro P-R, check valve, T-U and through Q-R vented to atmosphere.

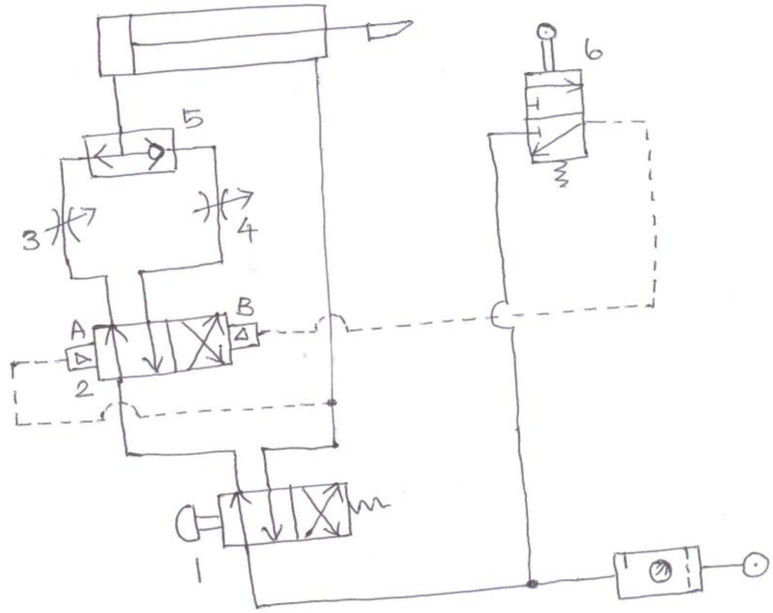
16. Explain with a circuit diagram how is the control of an air motor is acheived. A flow control valve is used to adjust the speed of motor. [Dec. 2007)



when the START push-button valve actuated, the air pilot valve shifts and supplies air to the motor. When the STOP push-button valve is actuated, the air pilot valve shifts into its opposite mode and shut off the supply air to the motor. The flow control valve in the main line to the air motor is used to adjust the speed of the motor.

17. A Double acting cylinder is required to provide the following operation: Fast extension till the mid stroke, Slow extension till the end of stroke and rapid return. Develop a pneumatic circuit employing a shuttle valve and Suitable flow Control and other valves (May 2010)

otherwise Two-step Control System.



Initially, the cylinder is fully retracted. Valve '2' is in its left mode 'A'. When the push button '1' is pressed, air flows through valve 2, flow control valve 3, Shuttle valve 5 and make the cylinder extend. Here the flow control valve 3 will permit more fluid than the flow control valve '4' hence initial extension is a speedy one. During extension, the cam operated valve '6' will get energized, will make the valve '2' is actuated to its right mode 'B'. Then the air flow goes through the flow control valve 4, Shuttle valve 5 and reach cylinder's Blank end and continue extension stroke with slower speed. Because the flow control valve 4 permits lesser fluid than flow control valve 3. When push button 1 is released, fast retraction of cylinder will take place.

18 Design and draw a sequential circuit for the operation of two cylinders A and B for $A^+ B^+ B^- A^-$ using cascade method. [Dec. 2008, Dec. 2010, May 2011, Dec. 2011, Dec. 2013]

Step 1: Sequence is $A^+ B^+ B^- A^-$

Step 2: Minimum No. of groups, No letters should be repeated in a group.

$\underbrace{A^+ B^+}_{I}, \underbrace{B^- A^-}_{II}$ ∴ 2 groups.

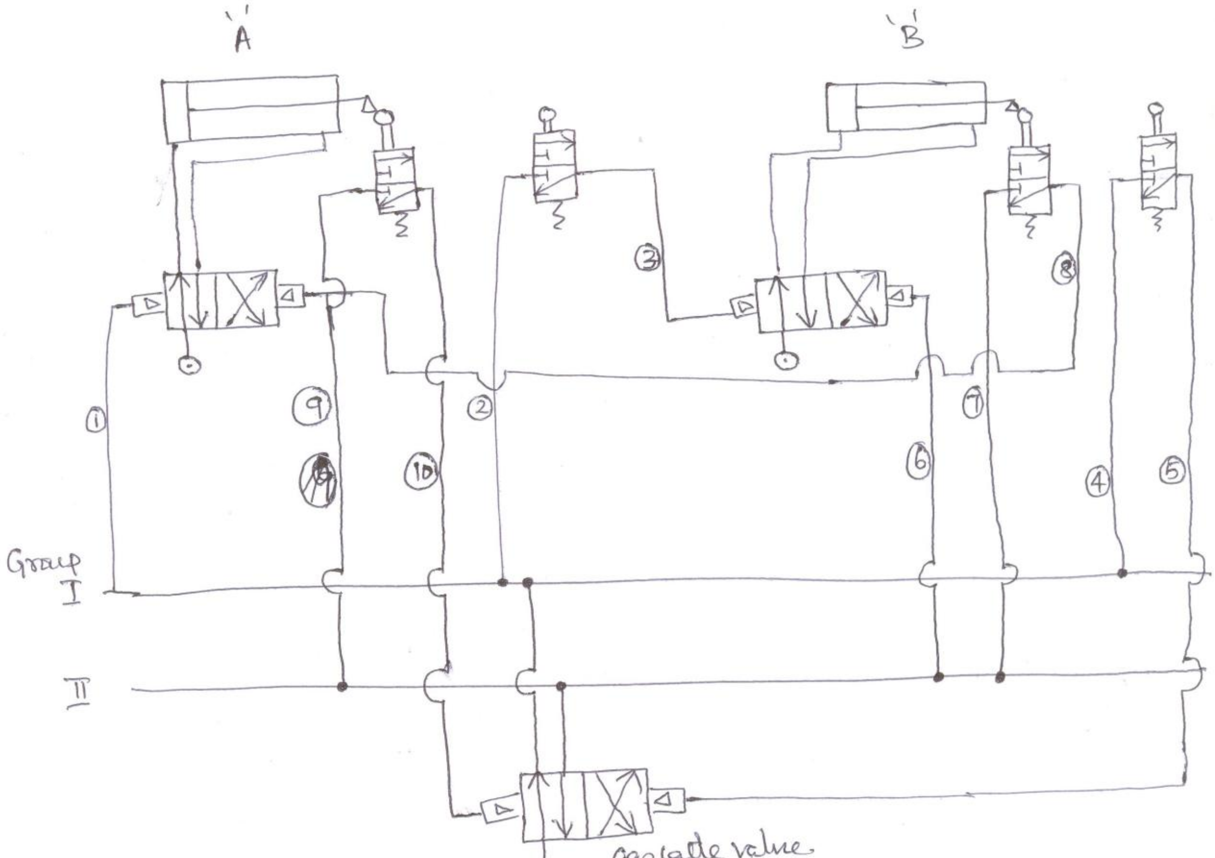
Step 3: No. of pressure line = No. of groups = 2

Step 4: Selection of valves

a) Each cylinder is provided with a 4/2 DCV, Here, 2. 4/2 DCVs

b) No. of Limit valves = 2 × No. of cylinders = 2 × 2 = 4.

c) No. of Cascade valves = No. of groups − 1 = 2 − 1 = 1.

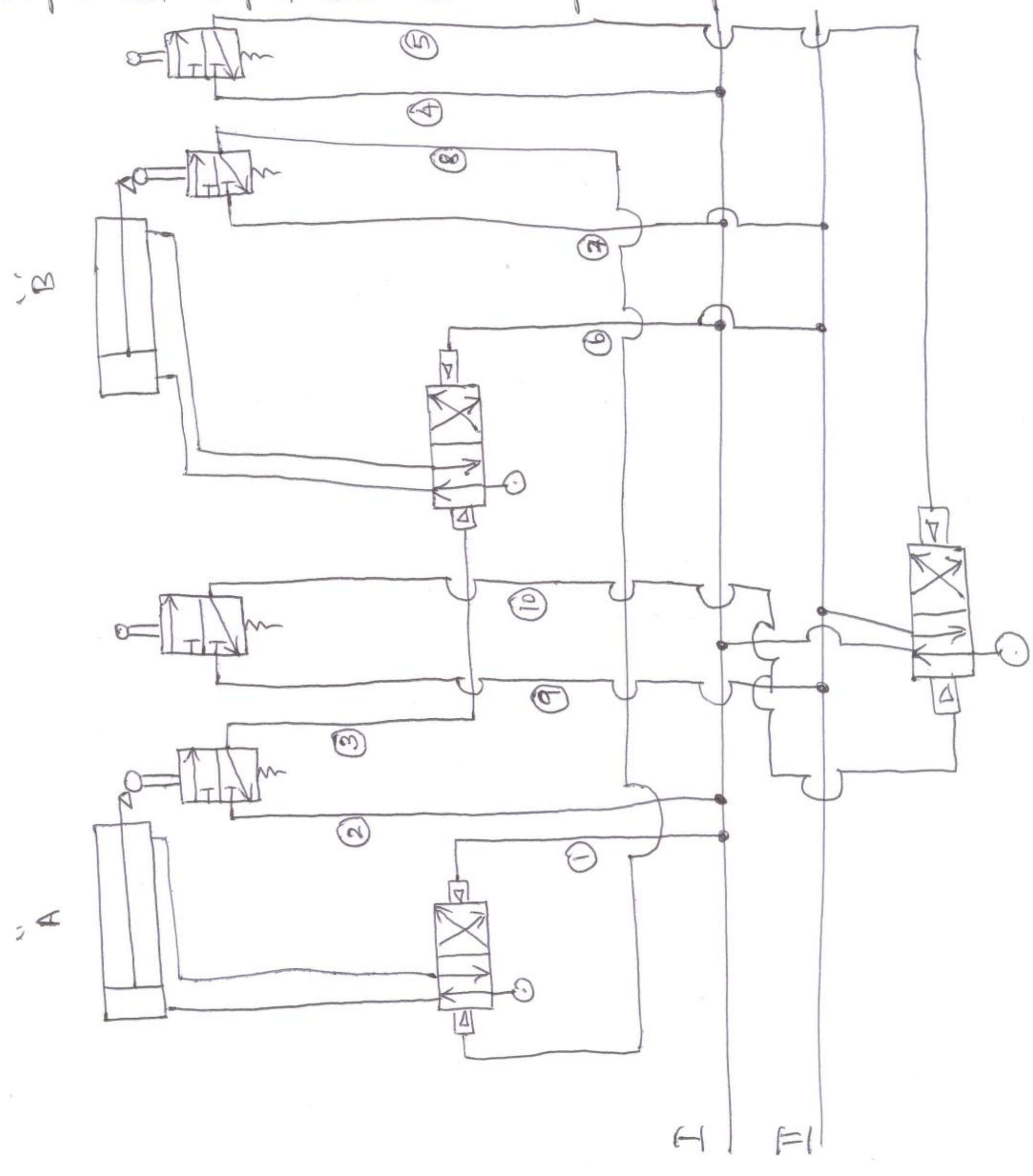


1. Make all components like cylinders A & B, DCVs, Group lines, Cascade valve
2. The order of line connections are indicated by numbers encircled at the left of each line.

19. Valve bodies are to be marked with letters P, A, B and R. The valve bodies are placed in the holder Manually. Cylinder 'A' stamps the letters in the body and returns. Cylinder 'B' pushes the parts from the holder in to the basket and returns to its initial position. Design a pneumatic Sequential Circuit for the above operation using ~~cade~~ cascade (May 2012).

1. Sequence of operation is $A^+ A^- B^+ B^-$
2. Grouping $\underbrace{A^- B^+}_{I} \quad \underbrace{B^- A^+}_{II}$

step 3 and Step 4 are as like previous problem.



20. Design and draw a Sequential circuit for a Surface grinding machine / shaping machine ram reciprocation / Drilling machine using cascade method. [Dec. 2010, May 2011, Dec. 2011]

Here for these cases cylinder 'A' may be used for holding the workpiece, cylinder 'B' may be for the operation.

Hence Sequence of operation is $A^+ B^+ B^- A^-$.

This is answered in problem (Q.No.) 18.

21. Design an electropneumatic circuit using cascade method for the following sequence. $A^+ B^+ B^- A^- C^+ C^-$ [May 2009, Dec. 2012, May 2013]

Step 1: Sequence is $A^+ B^+ B^- A^- C^+ C^-$

Step 2: $A^+ B^+ / B^- A^- C^+ / C^-$

$\underbrace{C^- A^+ B^+}_{I} \quad \underbrace{B^- A^- C^+}_{II}$ 2 groups

Step 3: No. of pressure lines = 2

Step 4: Selection of valves

a) There are 3 cylinders, hence 3 4/2 DCVs

b) No. of limit valves = 3x2 = 6

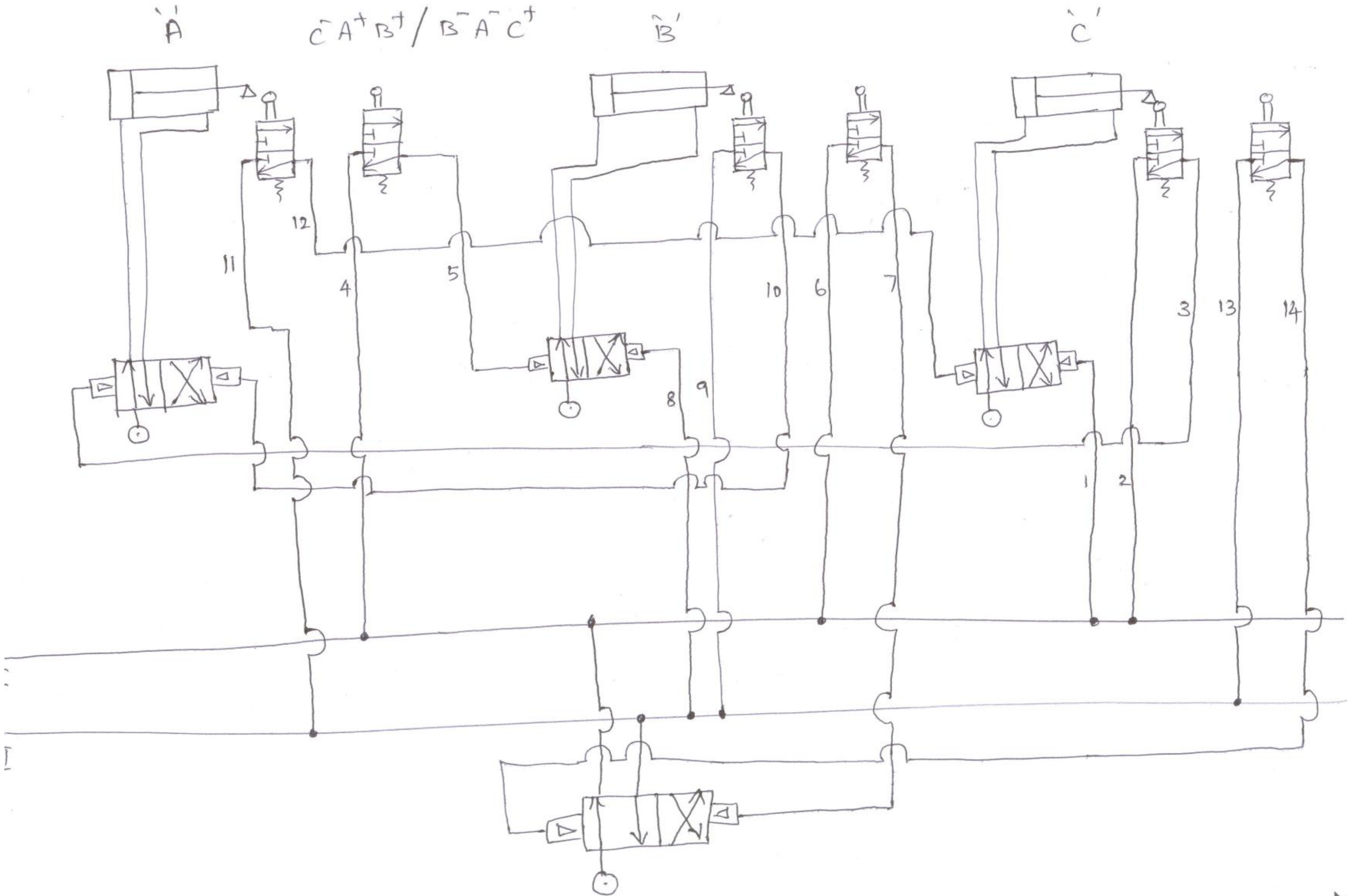
c) No. of cascade valves = No. of groups − 1 = 1.

22. Design and Draw for $A^+ B^+ C^+ C^- B^- A^-$. [Dec. 2011]

Step 1: Sequence is $A^+ B^+ C^+ C^- B^- A^-$

Step 2: $\underbrace{A^+ B^+ C^+}_{I} \quad \underbrace{C^- B^- A^-}_{II}$

Step 3 and Step 4 are same as previous problem.



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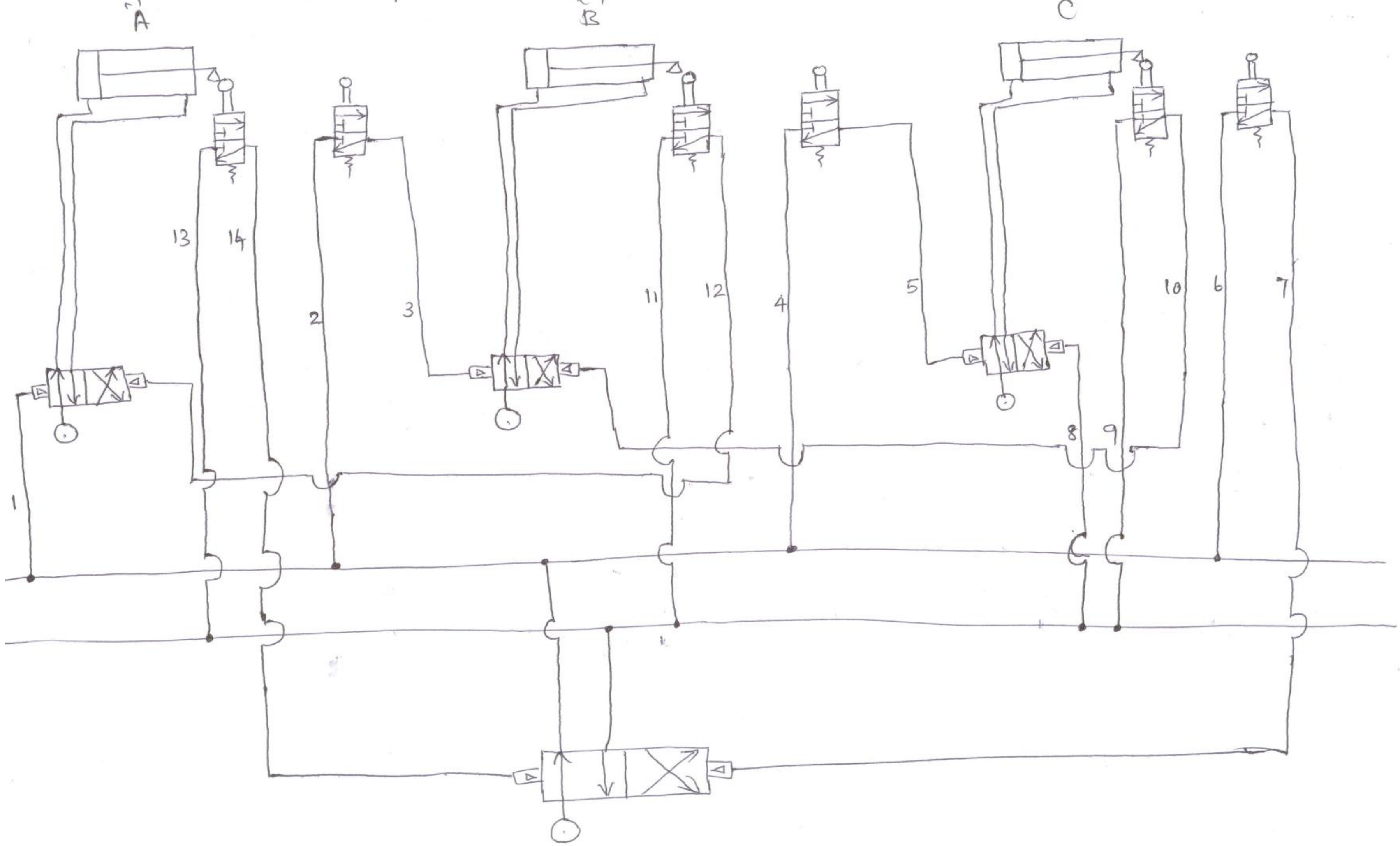
$A^+B^+C^+ / C^-B^-A^-$



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23. What are the factors considered during the installation of pneumatic System? [Dec. 2007]

The air compressor, Source of pneumatic power, is positioned at a distance away from the main use due to noise problem and reasons related to machine safety.

The pneumatic air from this Source point to end use point is taken through pipe lines and it has been observed that pipe fittings and joints are mostly responsible for drop in pressure.

During pneumatic System installation, the pressure drop between compressor point and end user point should be kept low is the important consideration.

Installation of Compressor:

✓ The intake pipe should be as short as possible with a direct connection to the unit from the outside air.

✓ The open end of intake pipe should be in such a way that it should prevent rain and dirt from entering.

✓ The piping should be sloped away from the compressor to prevent the condensate or oil drainage back to the compressor.

Installation of FRL Unit:

✓ The filter is installed upstream from the other components and normally installed in each branch.

✓ Regulators are installed at branches which require a specified pressure setting.

✓ Lubricators are installed at the downstream end of FRL and placed close to the equipment that they serve.

Installation of pipe lines:

✓ To ensure water and unwanted foreign matter, filters will be provided, will be seperated out at this stage.

✓ For ease of inspection, install the main air such that it can be accessed from all sides.

✓ If possible do not embed the lines in brick work or narrow ducts

✓ Horizontal air lines should be sloped one or two percent towards the flow direction.

✓ Branch lines should be started from top of the main line.

Installation of pneumatic cylinder:

✓ The cylinder should be perfectly aligned for efficient and trouble free operation.

✓ To increase ~~lifee~~ life of cylinder, proper support should be placed at the end of rod and exactly in line with the centre line of the cylinder.

✓ Tie rods connecting the end covers should be tightened with equal tension to avoid strain on the rods.

24. Determine the actual power required to drive a compressor that delivers air at 3.5 standard m^3/min at 8 bar gauge pressure. The overall efficiency of the compressor is 74 %. [Dec. 2008]

Given Data:

$Q = 3.5\ m^3/min$

$P_{out} = 8$ bar, gauge pr.

$P_{out\,(abs)} = 8+1 = 9$ bar $= 900$ kpa

$\eta_o = 74\ \%$

Asked Data:

Actual power required to drive the compressor.

Solution:

Atmospheric air at inlet, $P_{in\,(abs)} = 1$ bar $= 100$ kpa

WKT, Theoritical power $= \dfrac{P_{in}\,Q}{17.1}\left[\left(\dfrac{P_{out}}{P_{in}}\right)^{0.286} - 1\right]$

$= \dfrac{100 \times 3.5}{17.1}\left[\left(\dfrac{900}{100}\right)^{0.286} - 1\right]$

$= 17.9$ KW

∴ Actual power $=$ Theoritical power ~~×~~ / η_o

$= 17.9$ ~~×~~ / 0.74

$=$ ~~13.25 KW~~ 24.19 KW

25. A rotary vane air motor has a displacement volume of 80 cm³ and operates at 1750 rpm using 700 kPa. Calculate the standard m³/min rate of consumption and kW power output of the motor. Assume temperature remains constant. [May 2008]

<u>Given Data:</u>

$V_D = 80\ cm^3 = 80\times10^{-6}\ m^3/rev$

$N = 1750\ rpm$

$P = 700\ kPa$; Assume $T_1 = T_2$

<u>Asked Data:</u>

(i) Q_1

(ii) kW power output of motor.

<u>Solution:</u>

$Q_2 = V_D \times N$

$= 80\times10^{-6}\times1750$

$= 0.14\ m^3/min$

standard air consumption, $Q_1 = Q_2\cdot\left(\frac{P_2}{P_1}\right)\left(\frac{T_1}{T_2}\right)$

$P_2 = 700\ kPa\ (gauge) + 100\ kPa = 800\ kPa\ (abs)$

$P_1 = $ Standard air $= 100\ kPa\ (abs)$

$Q_1 = 0.14\left(\frac{800}{100}\right)\cdot 1$

$= 1.12\ m^3/min$

$$kW\ power = \frac{V_D\,(m^3/rev) \times P\,(kPa)_{gau} \times \omega\,(rad/sec)}{6.28}$$

$\omega = \frac{2\pi N}{60}$

$= \frac{2\times\pi\times1750}{60}$

$= 183.17$

$$= \frac{80\times10^{-6}\times700\times183.17}{6.28}$$

$= 1.634\ kW$

26. A 75% efficient compressor delivers air at 680 kPa and a volume of 7.6 m³/min. Calculate the cost of electricity per year if the efficiency of electric motor ~~during~~ driving the compressor is 95% and the compressor operates ~~at~~ 2500 hr/year. The cost of electricity is Rs. 5/kWh. [Dec. 2009]

Given Data:

$\eta_{o\,\text{compressor}} = 75\%$

$P_{out\,(gauge)} = 680\ kPa = 780\ kPa\ (abs)$

$Q = 7.6\ m^3/min$

$\eta_{motor} = 95\%$

Compressor operating time = 2500 hr/year

Cost of electricity = Rs. 5/kWh.

Asked data:

Cost of electricity per year

Solution:

Yearly cost = power rate × time per year × Unit cost of electricity

To find power

WKT,

$$\text{Theoritical power (kW)} = \frac{P_{in}\,Q}{17.1}\left[\left(\frac{P_{out}}{P_{in}}\right)^{0.286} - 1\right]$$

$$= \frac{100 \times 7.6}{17.1}\left[\left(\frac{780}{100}\right)^{0.286} - 1\right]$$

$$= 35.53$$

Actual power (kW) = Theoritical power / η_o = 35.53 / 0.75

= 47.37 kW

$\eta_{Motor} = 95\%$

Power required to drive the compressor = 47.37/0.95 = 49.87 kW

∴ Yearly cost = 49.87 × 2500 × 5

= Rs. 6,23,350/- year

27. How is the economic cost of energy losses in pneumatic systems calculated? Explain [Dec. 2009]

Efficiency of operation and costs are the main related parameters while designing any system. A low efficiency compressor requires more electric power to operate, which increases the system operating costs. Though the atmospheric air is free but not compressed air.

The components in the systems are wasting the energy due to ~~frictional losses as below~~

1. Efficiency of compressor
2. Efficiency of electric motor driving the compressor
3. leakages in the pipe lines
4. Losses due to to friction in valves and actuator.

In addition frictional wear of components will lead some energy losses.

The cost of energy losses due to friction and air leakage in pneumatic systems to be determined.

Yearly cost = Power rate x time per year x Unit cost of electricity.

⇒ Power rate will be influenced by efficiency of compressor, Motor and pressure range.

⇒ operating time of compressor per year

⇒ Unit cost of electricity are the factors to calculate economic cost of the pneumatic system.