HIGHER – HIGHER- HIGHER - HIGHER

Pneumatics

Name:_____

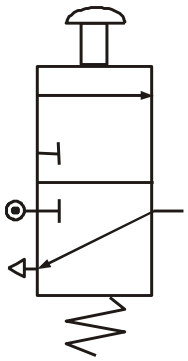
Teacher:_____

Engineering Science – Higher recap booklet

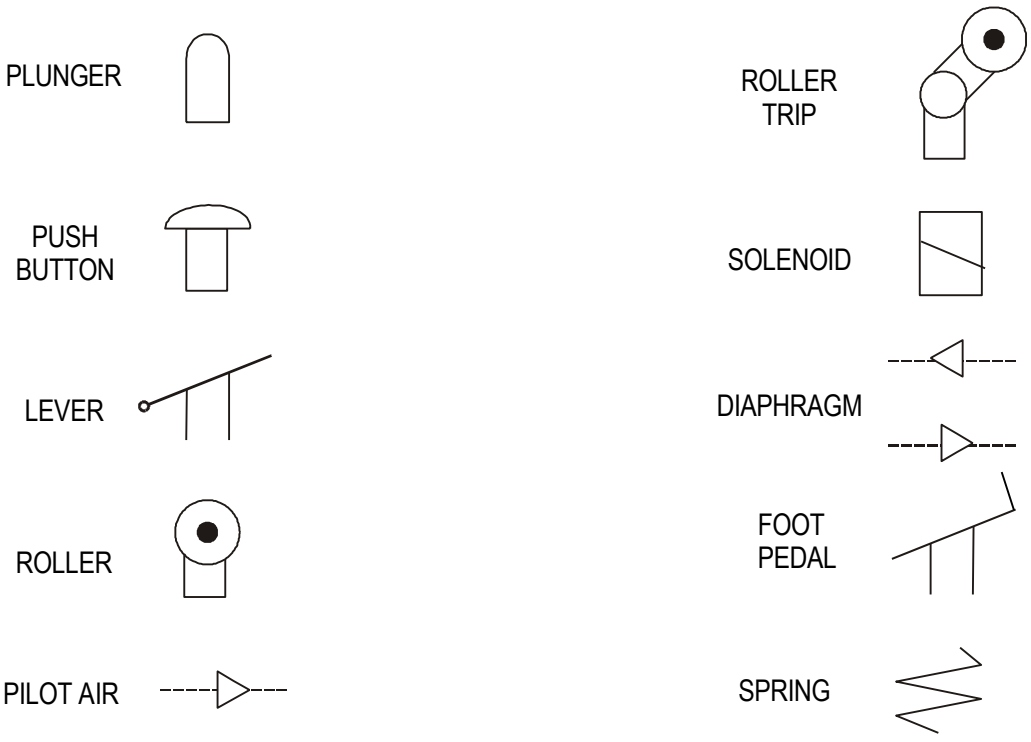
St Paul's Academy

Actuators

There are a number of different ways that we can operate a 3/2 valve. The most common way is by using a *push button*. By pressing the button, the valve changes to the actuated state and allows main air to flow through to other components. If we release the button, a spring inside returns the valve to its off state. The symbol for a push button, spring return 3/2 valve is shown below.

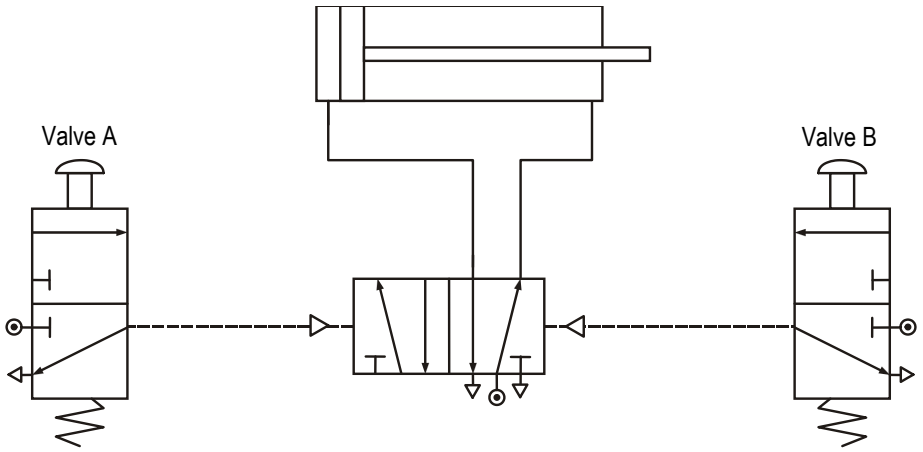


Below is a list of the most common types of actuators. They are always drawn onto the standard symbol for the 3/2 valve.



Pilot air

5/2 valves can be operated or actuated in the same way as 3/2 valves. However, the most common way of actuating a 5/2 valve is by *pilot air*. A pilot air 5/2 valve will change state when a brief air signal acts at either end of the valve. This signal is most often supplied from a 3/2 valve. In the example shown below, the button on valve A only needs to be pressed for a moment in order to change the state of the 5/2 valve. The 5/2 valve supplies the double-acting cylinder with air to make it outstroke.



Notice that the pilot airlines to the 5/2 valve are drawn as broken or dashed lines to distinguish them from the other air lines in the circuit.

Flow control valves

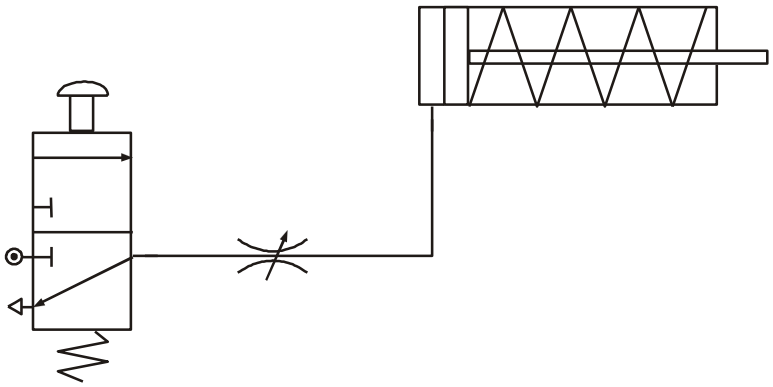
You should have noticed in the circuits you have built so far that the pistons move very quickly. Sometimes this can be dangerous or it may prevent the circuit from working properly. To slow down the speed of a piston we use a *flow control valve*.

There are two types of flow control valve available to us. The first type is called a *restrictor* (or sometimes a throttle valve). This valve works by reducing the amount of space that the air can flow through. We can adjust the airflow by turning the small screw on top of the valve. The symbol for a restrictor is shown below.

Figure 40

This restrictor slows down the flow of air in both directions. This means that using only one extra component can slow both the outstroke and instroke of a cylinder.

In the circuit shown below, the restrictor is used to slow down the speed of the single-acting cylinder. We can adjust this speed by turning the small screw on the top of the restrictor.



The problem with this type of restrictor is that it always slows down the speed of the piston in both directions. In many cases, we would only want either the outstroke or the instroke to be slowed down. Also, if we study the piston movement very carefully, we sometimes find that it is quite jerky – not smooth as we would want it to be.

Unidirectional restrictor

To solve these problems we can use a component called a *unidirectional restrictor*. As its name suggests, it only slows down the air in one direction. The symbol is shown below.

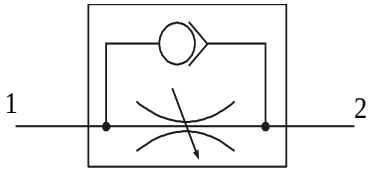
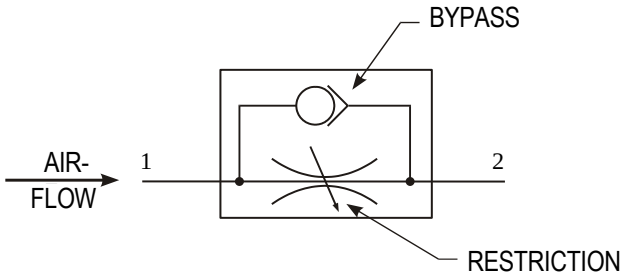
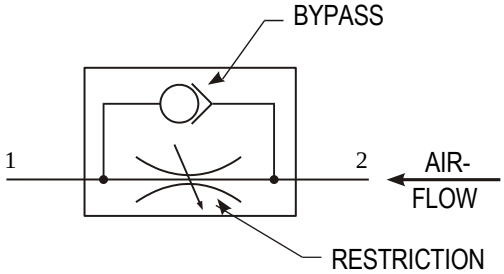


Figure 42

When air flows into port 1 of the restrictor, some of the air takes the bypass route. A small ball is blown against a valve and blocks this path. The air is then forced to go through the restriction and this slows down the airflow.

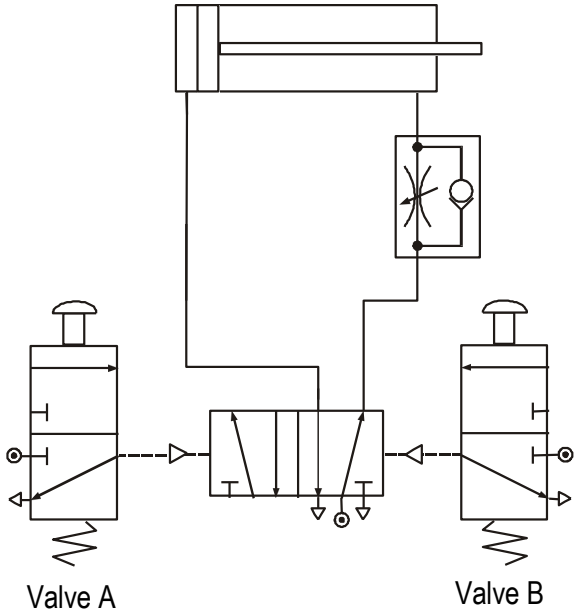


When air flows into port 2 of the restrictor, again some of the air takes the bypass route. This time, the ball is blown away from the valve and the air passes through unrestricted.



In pneumatics, unidirectional restrictors are much more useful to us. However, we must always be careful to insert them in the circuit the correct way round.

Remember our car park barrier. The attendant has complained that the barrier rises too quickly and is worried that this may damage it. Someone suggests changing the circuit to the one shown below.



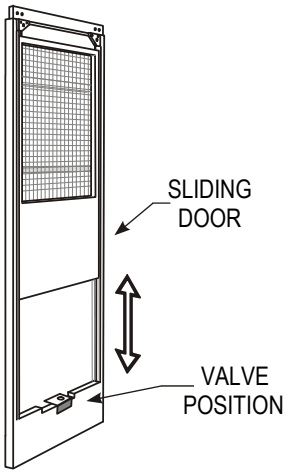
Study this circuit and take note of the position of the unidirectional restrictor. Is it where you expected? The restrictor is placed so that it slows down the *exhaust* air coming from the cylinder. When valve A is pressed, the 5/2 valve changes state and starts to supply the cylinder with air to make it outstroke. Air trapped on the other side of the piston escapes through the restrictor slowly. This makes the piston outstroke slowly.

We always restrict the exhaust air coming from a cylinder as this makes the piston move much more smoothly.

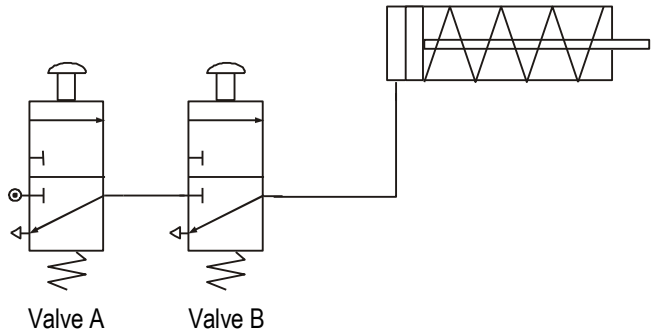
And control

Although pneumatic circuits are very safe, it is important to take safety precautions. AND control circuits can be used to help prevent accidents by ensuring that guards are in position before machines are switched on.

These circuits can also be used to stop a machine being switched on accidentally or to stop operators placing their hands in the machine when it is running.



AND control involves connecting 3/2 valves together in *series*. This means that the output from one valve becomes the input to another. Study the diagram below.



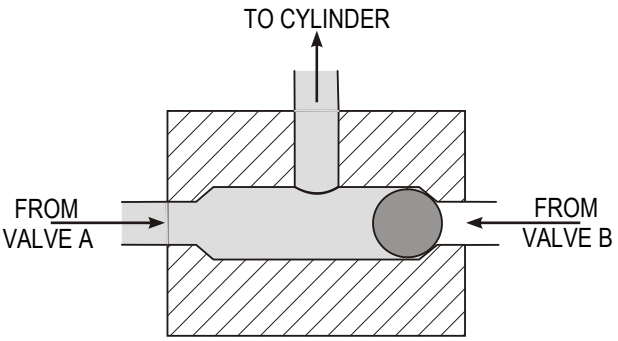
The single-acting cylinder will only outstroke when valve A *and* valve B are pressed at the same time. When the button on valve A is pressed, main air passes through and reaches valve B. The air cannot flow any further until valve B is pressed. This then supplies the cylinder with air and it outstrokes.

We can summarise how the circuit behaves in a *truth table*.

VALVE A	VALVE B	CYLINDER
OFF	OFF	INSTROKE
ON	OFF	INSTROKE
OFF	ON	INSTROKE
ON	ON	OUTSTROKE

OR control

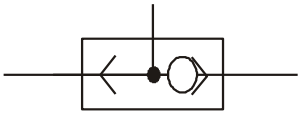
Sometimes we need to control a pneumatic circuit from more than one position. This can be done using OR control circuits. These circuits are quite simple but they need another component called a *shuttle valve*.



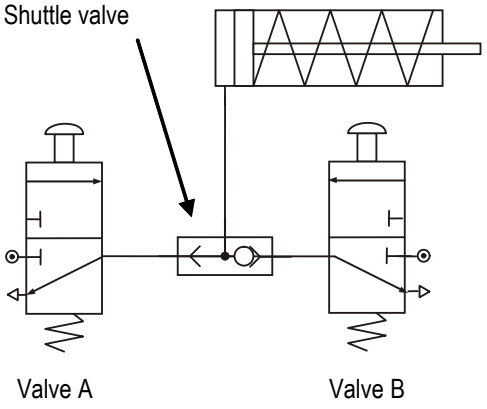
A shuttle valve is used to change the direction of air in a circuit. It has a small ball inside that gets blown from side to side. A picture is shown below.

When air is supplied from valve A, the ball gets blown across and the air is directed towards the cylinder. When air is supplied from valve B, the ball is blown to the other side and again the air flows into the cylinder. If air comes from both directions, air still manages to reach the cylinder, as this is the only path it can take.

The symbol for a shuttle valve is shown below.



OR control involves connecting 3/2 valves together in *parallel*. This means that either valve will outstroke the cylinder. Study the diagram below.



If the button on valve A is pressed, the ball in the shuttle valve is blown across towards B and the cylinder outstrokes. If the button on valve B is pressed, the ball is blown across towards A and the cylinder outstrokes. The circuit works if valve A *or* valve B is actuated.

We can summarise the behaviour of this circuit in a truth table.

VALVE A	VALVE B	CYLINDER
OFF	OFF	INSTROKE
ON	OFF	OUTSTROKE
OFF	ON	OUTSTROKE
ON	ON	OUTSTROKE

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5. Pneumatic circuits can be used to perform logical operations.

(*a*) Draw the symbols for exhaust and mains air on Valve (A) below.

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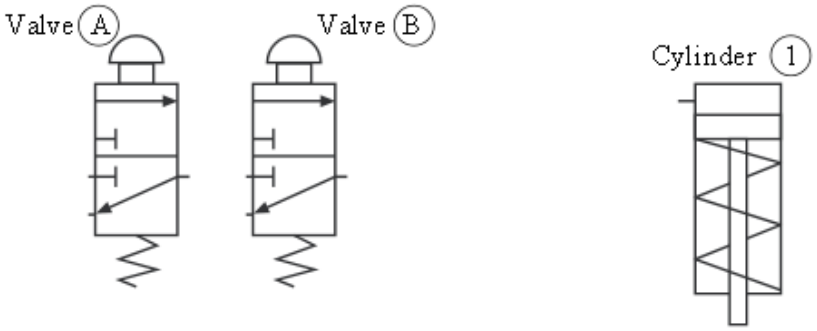
2 1 0	2 1 0

(*b*) Complete the piping of the pneumatic circuits below to give:

(i) **AND** control;



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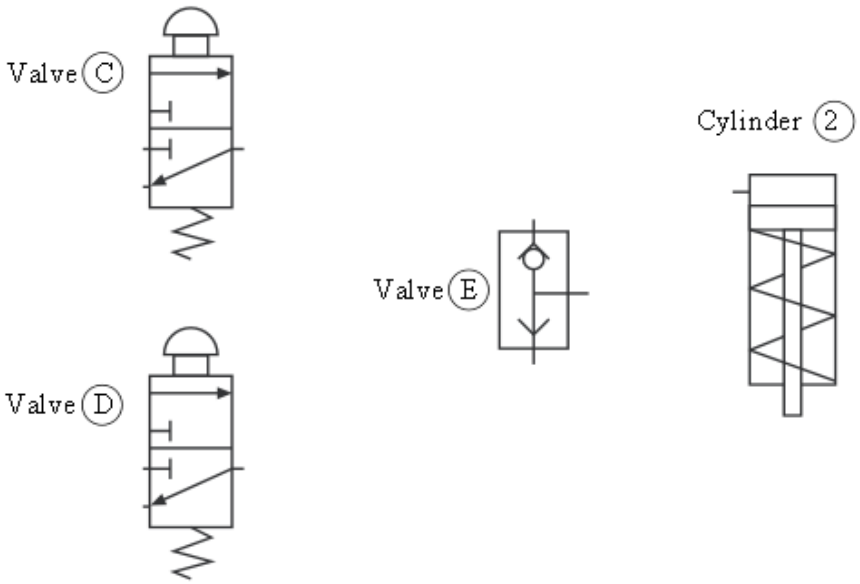
	2 1 0

(ii) **OR** control.



KU	RNA
	3 2 1 0

(*c*) State the **full name** of the following pneumatic components. (i)

(ii) Valve (D) _____

Valve (E) _____

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3 2 1 0 1 0	

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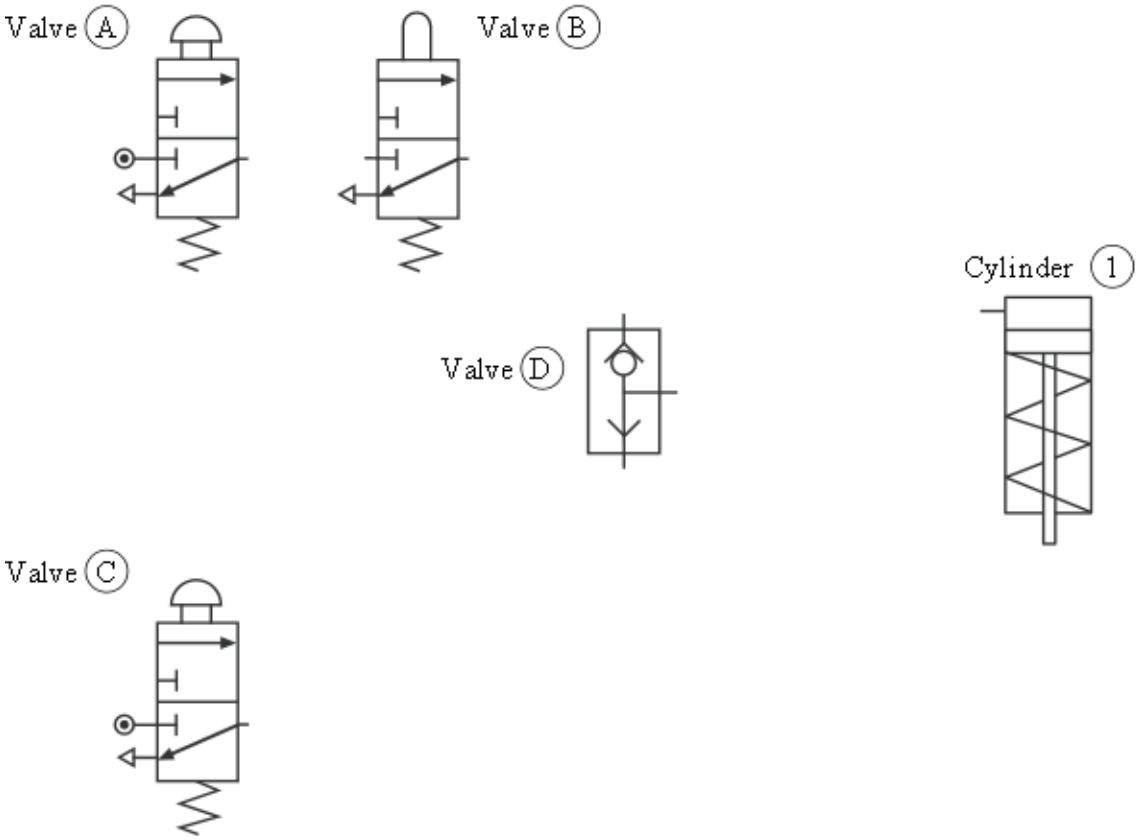
KU	RNA
	4 3 2 1 0

5. A control gate in a gas pipeline is operated by a pneumatic cylinder.

The gate must operate when **both** valves (A) **and** (B) are actuated **or** when valve (C) is pressed.

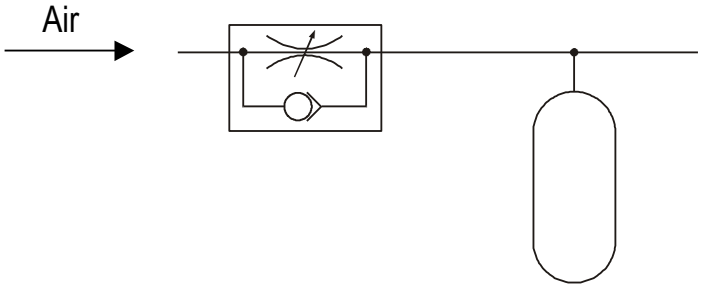
(*a*) Complete the piping of the pneumatic circuit below.



Time delay

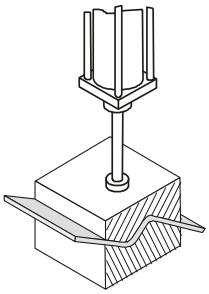
Sometimes in a circuit we want a pause or delay before something else happens. To create a delay we need to use two components – a unidirectional restrictor and a reservoir.

A reservoir is simply an empty container, just like an empty bottle. The bigger the reservoir, the longer it takes to fill up with air. To make the delay longer we use a unidirectional restrictor in front of the reservoir. This slows down the air so that the reservoir takes even longer to fill. The length of time it takes to fill creates the delay.

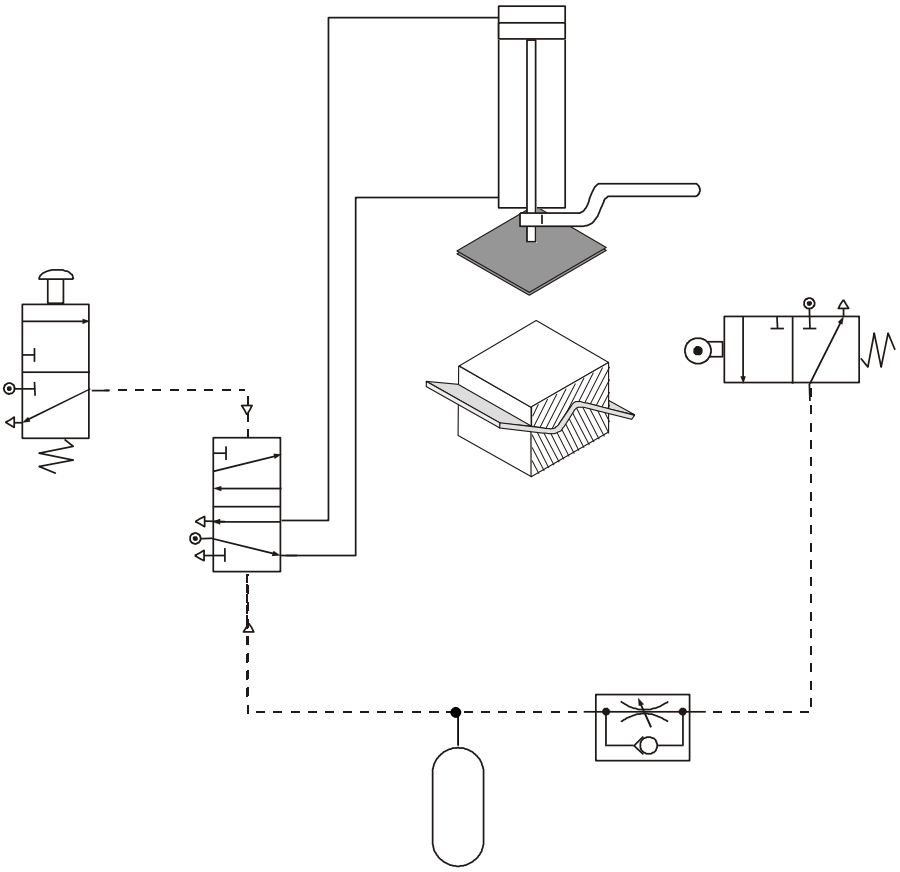


We can change the length of a delay by changing the size of the reservoir or adjusting the restrictor.

Time delays can be very useful in clamping operations when objects need to be held in place by a cylinder for a specific amount of time to glue or set.



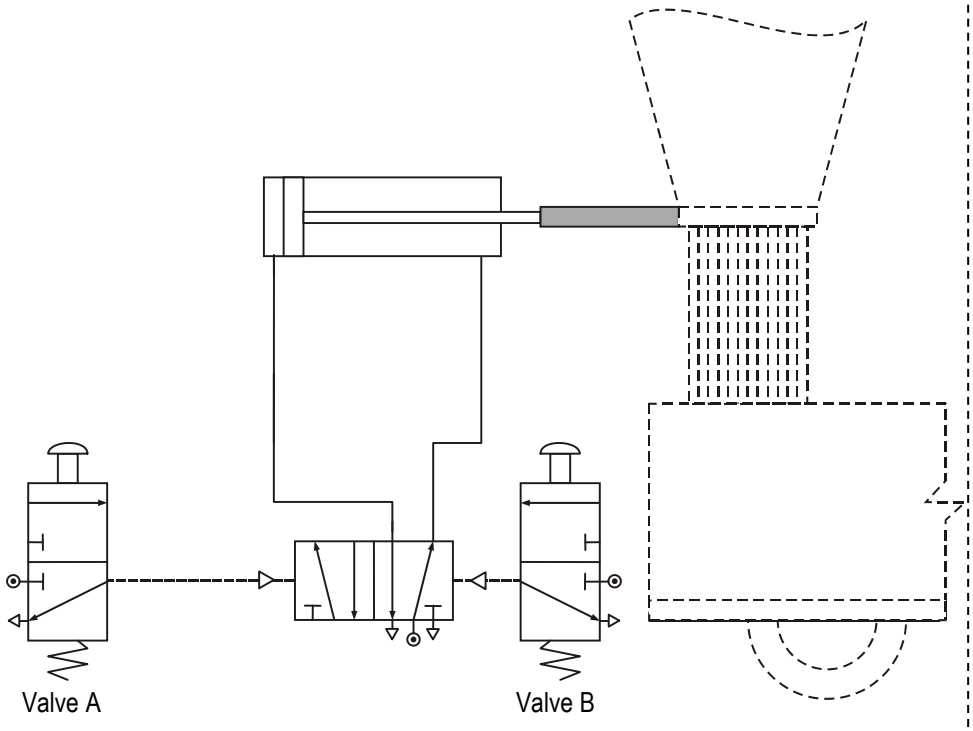
In this type of example the delay has to occur before the cylinder would instroke. Study the circuit diagram.



When the push button is pressed, the 5/2 valve changes state and the cylinder outstrokes. As it outstrokes, it pushes the former together and the hot plastic sheet is pressed into shape. As this happens it also actuates the roller. Air now flows through the restrictor and starts to fill up the reservoir. Once the reservoir is full, the 5/2 valve changes state and the cylinder instrokes, ready for the process to begin again.

Assignment

1. Sand is fed into a hopper from above. When the hopper is full, the operator presses the button and a double-acting cylinder slides open the door. This lets the sand fall into a wagon underneath. The operator now presses the other push button, but there must be a short delay before the hopper door closes to ensure that all the sand has emptied out. Study the circuit diagram.



(a) Which two components are needed to create a time delay?

(b) Insert these components into the circuit diagram. Simulate your solution to ensure that it works properly.

(c) What other improvements would you make to this circuit?

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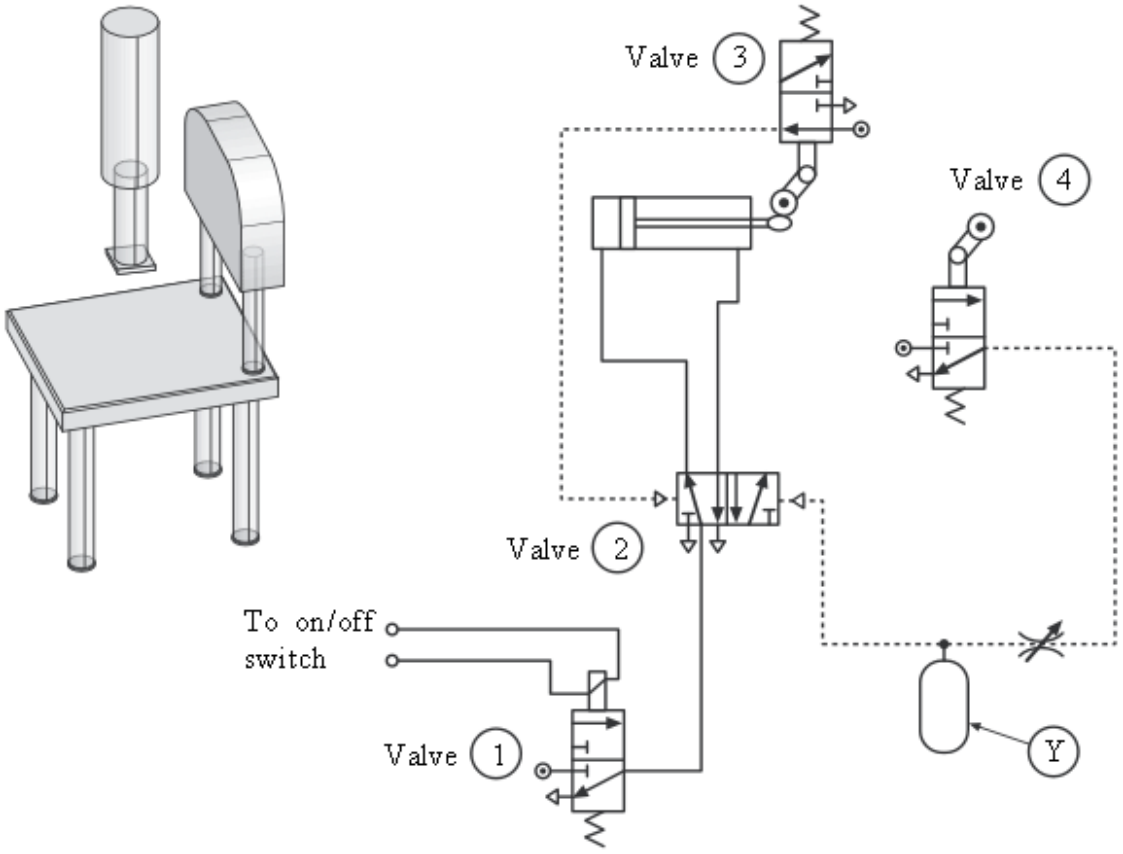
4. A test rig in a furniture factory is operated by the pneumatic circuit shown below.



(*a*) Describe, using appropriate terminology, how the pneumatic circuit operates.

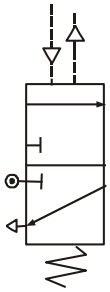
When Valve (1) is actuated

5
4
3
2
1
0

Air bleed

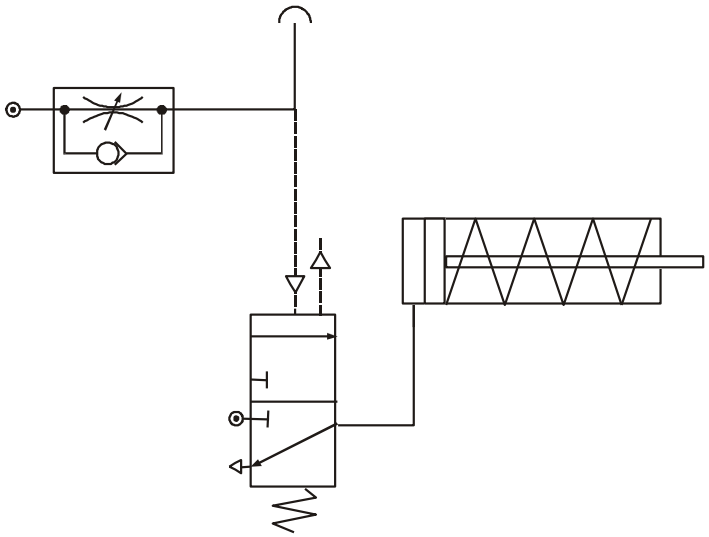
Sometimes with pneumatics we find that the actuators on valves can get in the way of the circuit. Also, some actuators need a big force to make them work and this is not always possible. There are different ways to overcome these problems and one of the most common is to use an *air bleed*.

An air bleed is simply an open pipe that allows the air in the circuit to escape. This air must be at a low pressure, otherwise the pipe would 'wave' about and be dangerous. Air bleed circuits rely on a component called a *diaphragm valve*. This valve is capable of detecting small changes in air pressure. The valve works in the same way as other 3/2 valves; it is only the actuator that is new to us. The symbol is shown below.



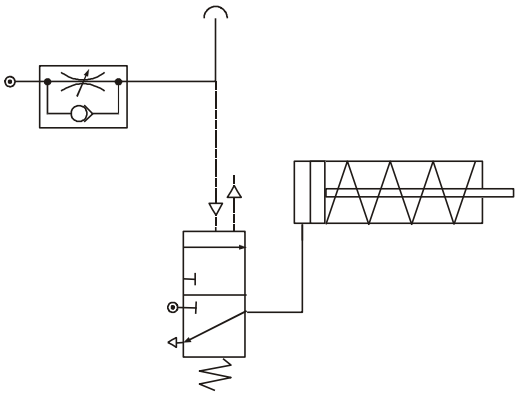
The diaphragm is a piece of rubber stretched inside the valve. When air flows into the top of the valve, the rubber expands much in the same way as when a balloon is blown up. When the diaphragm expands, it presses down inside the valve and changes its state.

The signal to the diaphragm comes from an air bleed. When the air bleed is blocked, air is diverted back towards the diaphragm. This actuates the 3/2 valve and the cylinder outstrokes. Notice that the airflow to the air bleed passes through a restrictor. This slows down the air before it is allowed to escape.



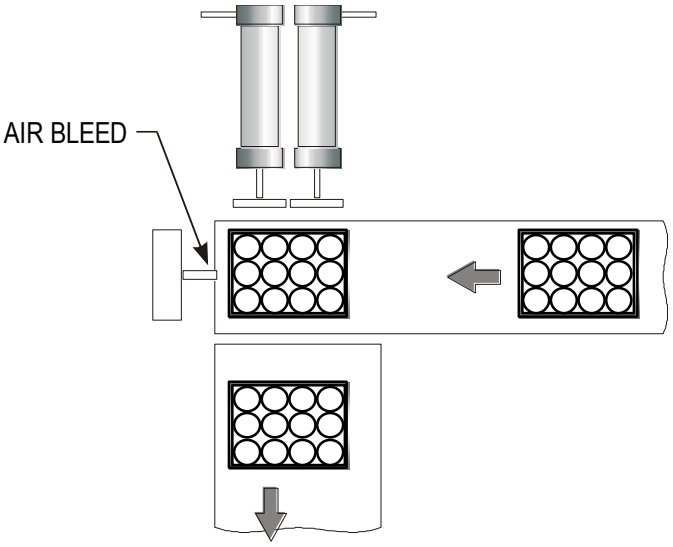
Assignment 12

1. The manufacturer of crystal ornaments wants to print a 'Fragile!' warning on every box before it leaves the factory. A simple pneumatic machine will stamp the boxes, which vary in size and weight. The packages are not spaced regularly on the conveyor belt and so the printing should only take place when a package is in the correct position. A possible solution is shown.



(a) Explain why an air bleed is used to sense the position of the boxes.

2. Crates containing cans of beans are moved to the dispatch area by a series of conveyor belts. The crates are quite heavy and **two** single-acting cylinders are needed to push the crates from one belt to another.



(a) Design a pneumatic circuit to solve this problem. Draw it in the box above.
(b) Why are pneumatics often used in food production lines?

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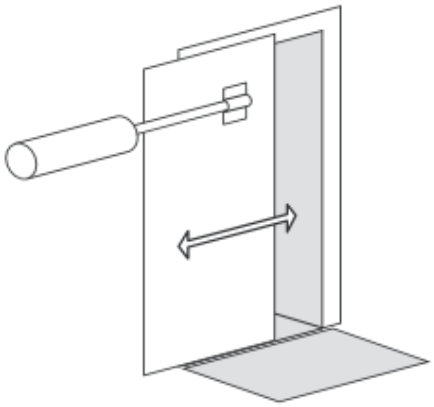
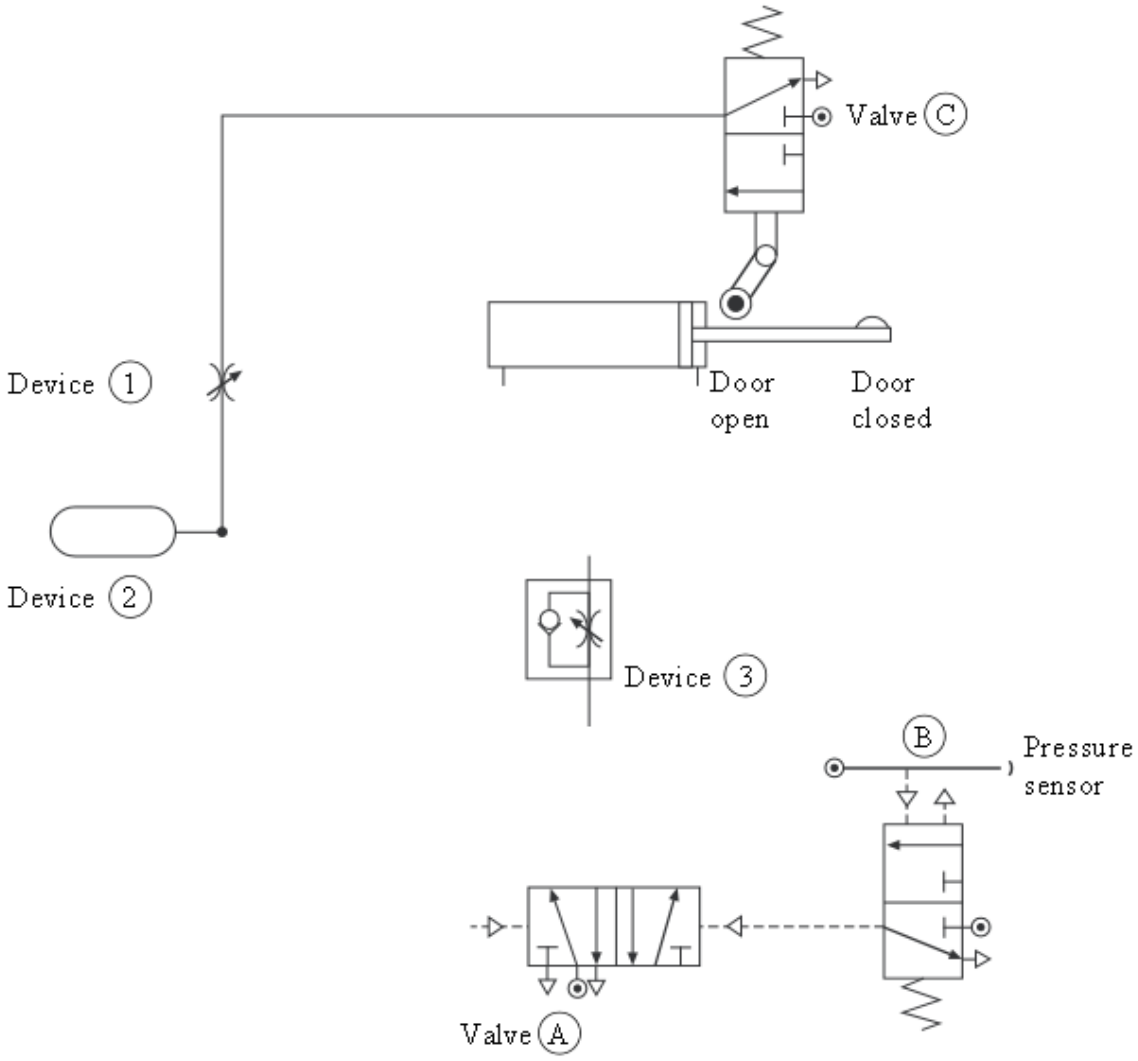
3. A pneumatic circuit is used to control the operation of an automatic door.



When a person steps on to the pressure sensor, the piston will instroke and open the door. After an 8 second delay, the piston will automatically outstroke and slowly close the door.

(*a*) Complete the piping of the pneumatic circuit below.



	3
	2
1	1
0	0

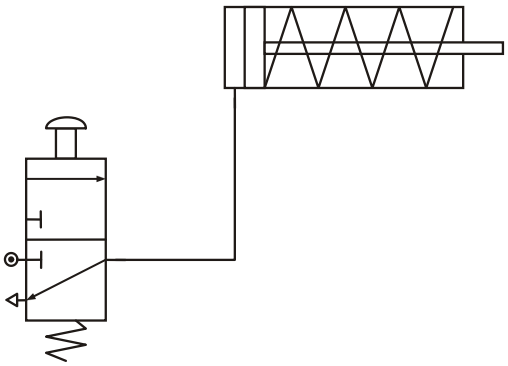
Automatic circuits

Automatic circuits are commonly found on production lines. They help to speed up production and make sure that the goods are all manufactured to the same standard. There are two types of automatic circuit: semi-automatic and fully automatic.

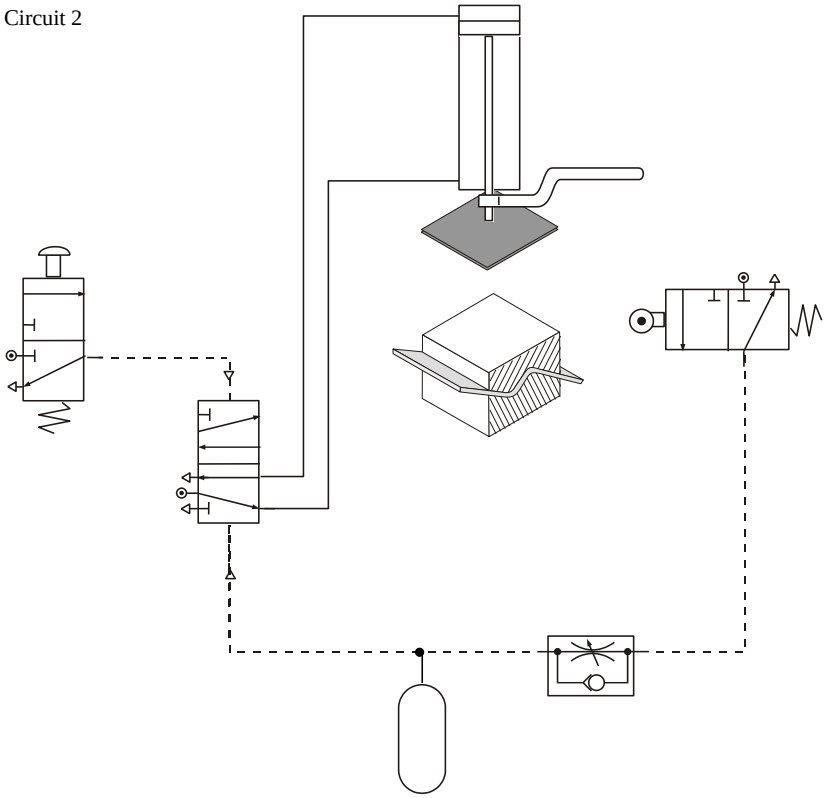
Semi-automatic

A semi-automatic circuit is one that completes a process once it has been started, usually by a human operator. We have come across semi-automatic circuits already in the course. You should recognise the two circuits shown below.

Circuit 1



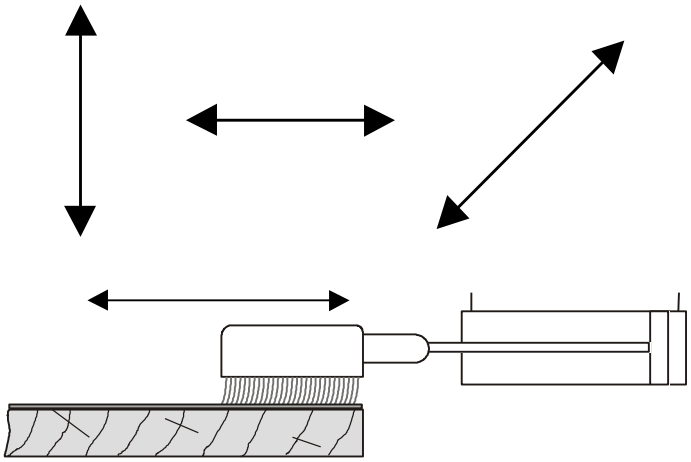
Circuit 2



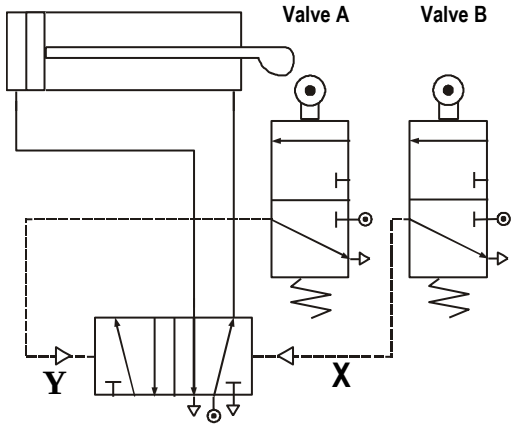
Fully automatic

A fully automatic circuit is one that continues to work, performing a task over and over again. It does not stop or wait for input from an operator. These circuits make use of actuators such as a roller trip and plunger to detect the position of the piston as it instrokes and outstrokes.

Automatic circuits produce reciprocating motion. This is motion up and down like the needle on a sewing machine. It can also be left and right, or forwards and backwards along a straight line. We can represent reciprocating motion by arrows like these: For example, a polishing machine requires the reciprocating motion of a double-acting cylinder.



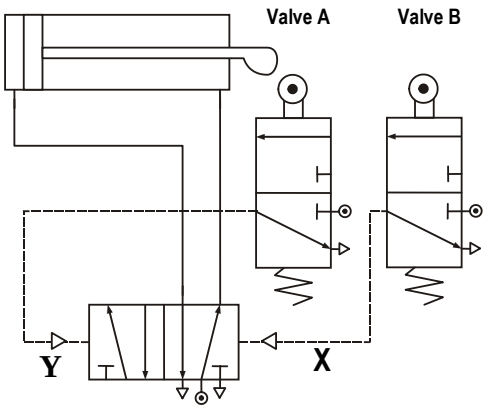
The pneumatic circuit is shown below.



As the piston instrokes, it trips valve A and the 5/2 valve changes state and the piston is sent positive. When it is fully outstroked, it trips valve B and the 5/2 valve returns to its original position, allowing the piston to instroke. The process begins all over again and continues to operate.

Assignment 13

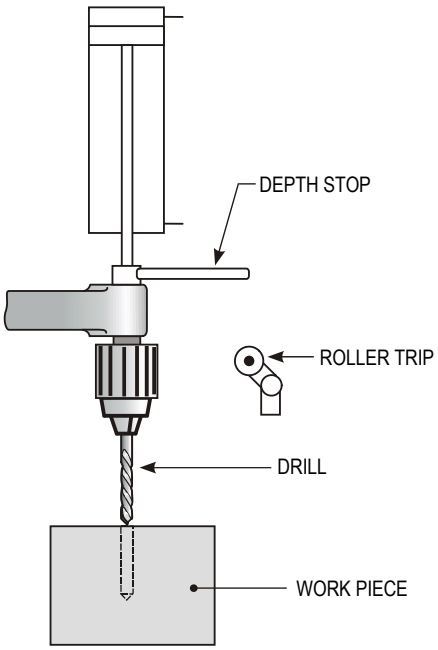
1. Simulate the circuit for the polishing machine.



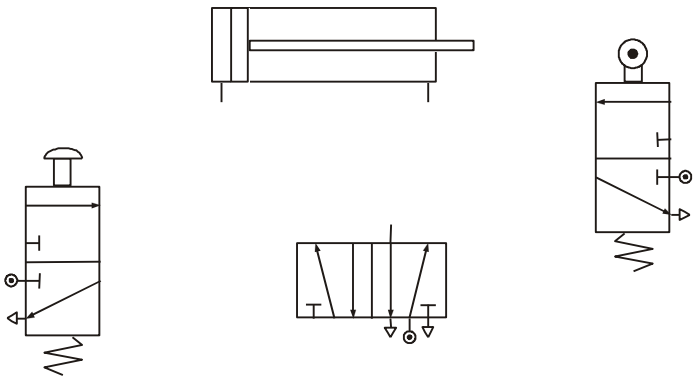
   (a) You should have noticed that the only way to stop the circuit is to turn off the main air supply. It would be much better if we could use a lever-operated 3/2 valve to do this. It has been suggested that the valve be placed at either point X or point Y. Try both positions and record what happens.

   (b) Which position do you think is better and why?

A small company that makes spice racks wants to automate some of its production. To begin with, a drilling operation is to be controlled by a pneumatic cylinder. An operator will start the sequence and then the drill will be lowered automatically into the wood. Once the hole has been drilled to the correct depth, the cylinder should automatically instroke ready for the process to start again.



A layout of all the components needed is shown with the piping missing.



   (a) Complete the diagram in pencil.
   (b) Name each component.
   (c) The cylinder outstrokes far too quickly and the drill bits keep breaking. Alter the circuit so that the cylinder outstrokes slowly.

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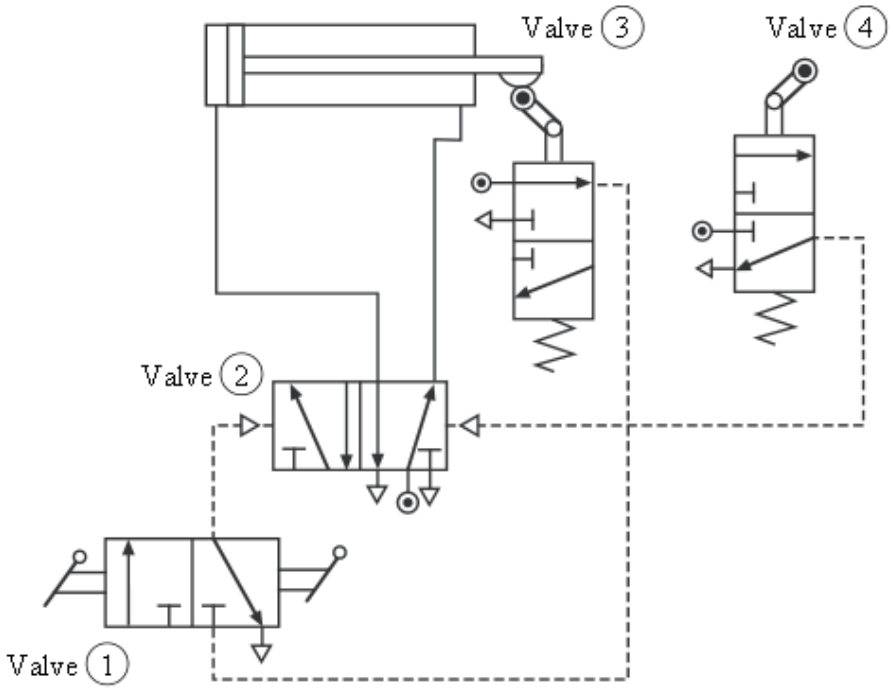
3. A road drill is operated by using the pneumatic circuit shown below.



(*a*) State the **full name** of Valve (2).

_____ **3 2 1 0**

(*b*) Describe the operation of the circuit as it outstrokes the piston rod.

_____

_____

_____ **3 2 1 0**

_____

_____

A solenoid actuated, 3/2, spring return valve was inserted into the circuit to stop the drill if the operator let go.

(*c*) Sketch the solenoid actuator below. **1 0**