Circuit simulation software

It is possible to use circuit simulation software such as that produced by Festo Didactic to investigate pneumatic circuits. Circuit simulation software is widely used in industry to design and model circuits and to test them to see if they work properly. This can save a lot of time and money.

We use simulation software in school for these same reasons but it also allows us to test circuits that we may not have all the equipment for.

Assignment 7

Using a pneumatic simulation software package, construct and test the following circuits. Make sure that you have built the circuit in exactly the same way as the ones shown. To test the circuit you need to press the 'play' button on the toolbar or select 'Start' from the 'Execute' menu. Now click on the 3/2 valve to see the circuit work.

1.

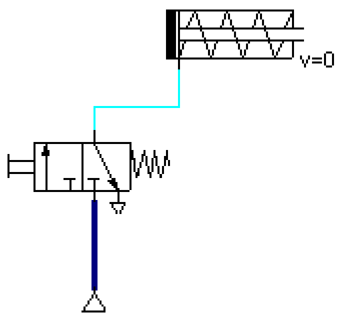

Figure 37

2.

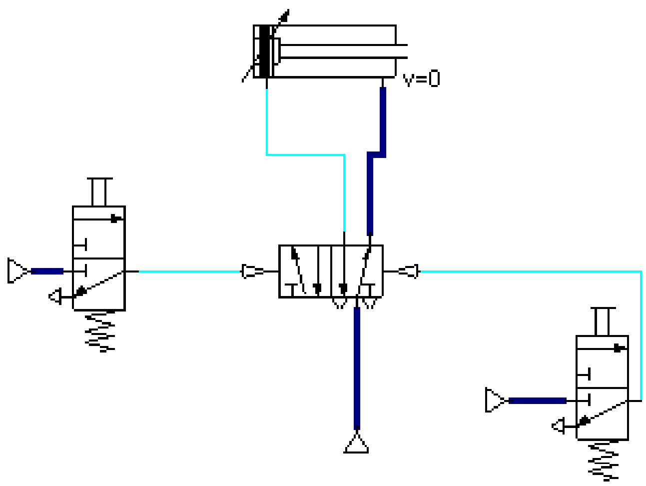

Figure 38

The software can be used for much more than just building and testing circuits. You can also see pictures of components, learn more about them and even see short films of them working. To do these things you go to the *Didactics* menu. Here you can select ‘Component Description’, ‘Component Photo’ or ‘Educational Film’.

An example of a component photo is shown below.

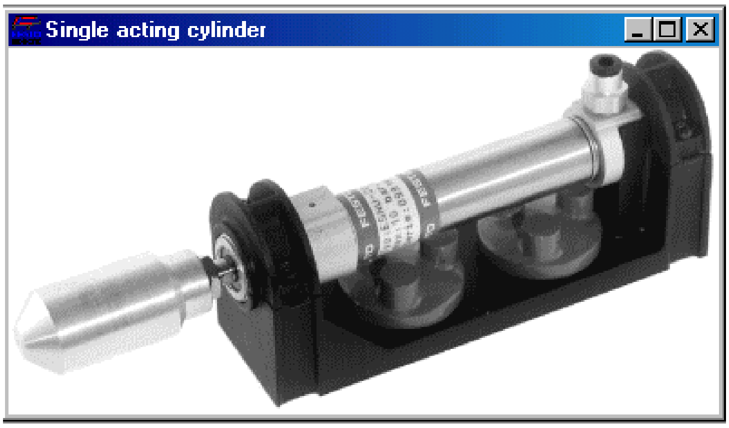

Figure 39

Take some time to select different components and view their descriptions and photos. It is also worthwhile looking at some of the video clips.

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.

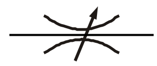

Figure 40

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.

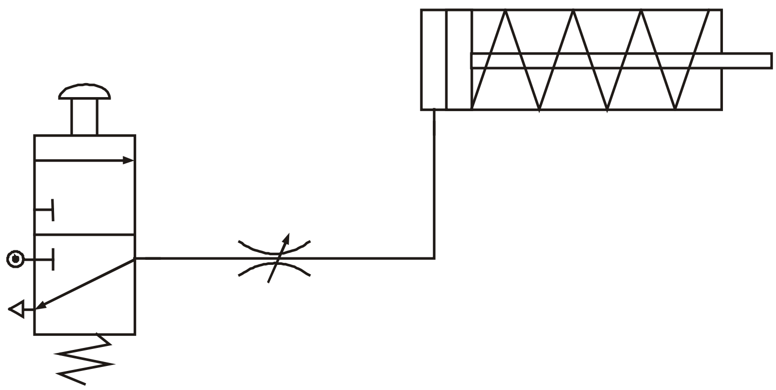

Figure 41

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.

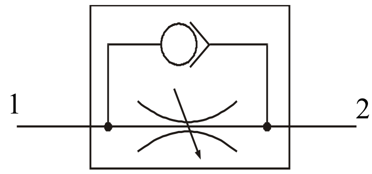

Figure 42

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.

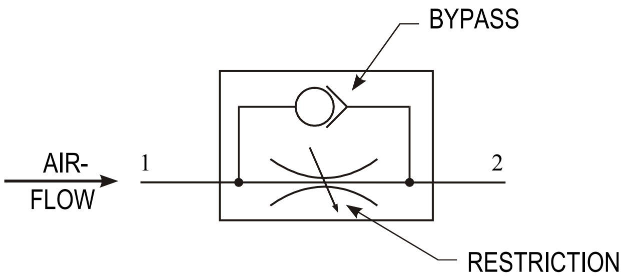

Figure 43

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.

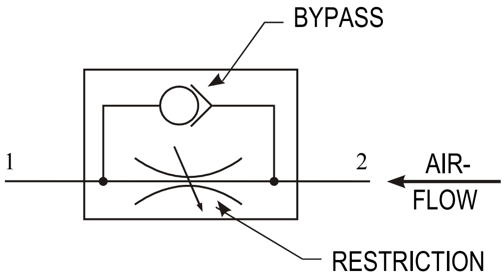

Figure 44

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.

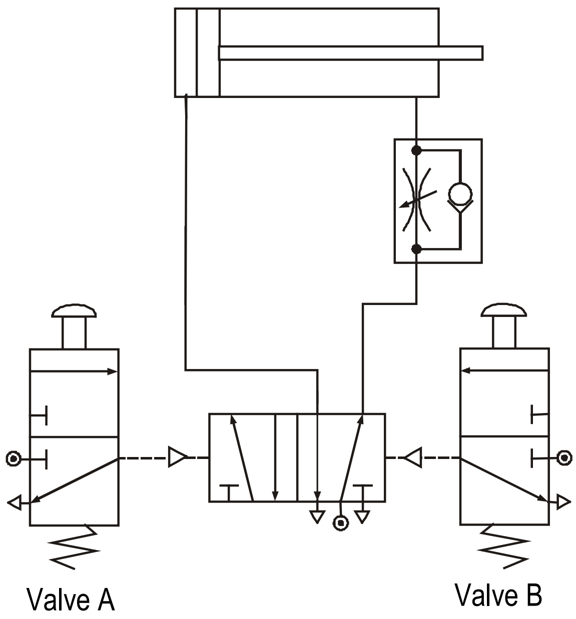

Figure 45

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.

Assignment 8

1. Build and test the circuit shown to raise the barrier slowly.
   (a) Why do we restrict the exhaust air to slow down the speed of the piston?

2. For safety reasons, the entrance door to a storeroom in a supermarket must open and close slowly. A double-acting cylinder is used to slide the door.

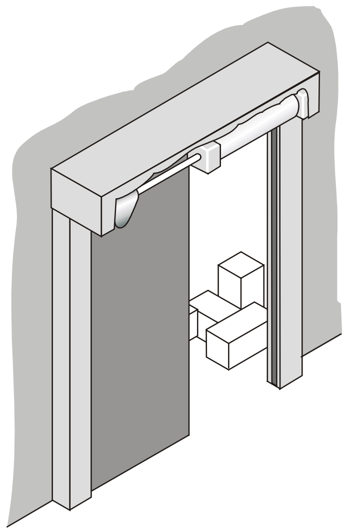

Figure 46

A simplified circuit diagram is shown below with some of the piping missing.

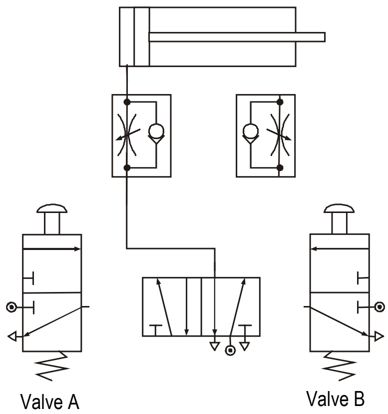

Figure 47

(a) Complete the diagram.
(b) Build and test the circuit.
(c) Explain why two restrictors are needed in this circuit.

3. Part of a manufacturing process involves dipping components into a chemical solution to prepare them before they are painted.

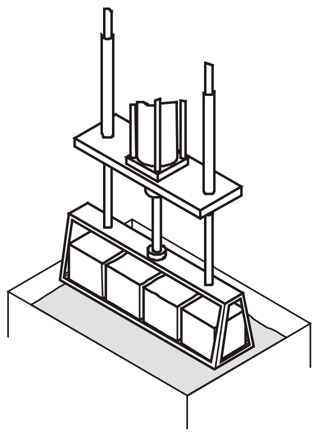

Figure 48

A double-acting cylinder controls the process and for safety reasons the cylinder must outstroke and instroke slowly.

(a) Using a computer simulation program, design a circuit that would solve this problem.
(b) Build and test your solution using components.
(c) How well does your circuit operate? Why is it important that the cylinder operates slowly?

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.

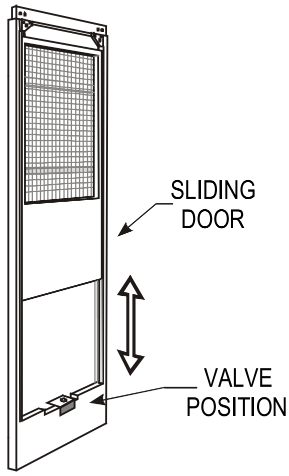

Figure 49

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.

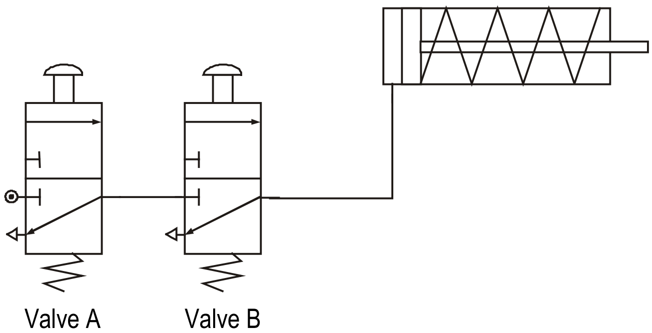

Figure 50

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

Figure 51

Assignment 9

1. A company logo is to be stamped onto boxes using a single-acting cylinder. To prevent accidents, the machine will only work when the operator has both hands on the start buttons. If either button is released, the machine will stop.

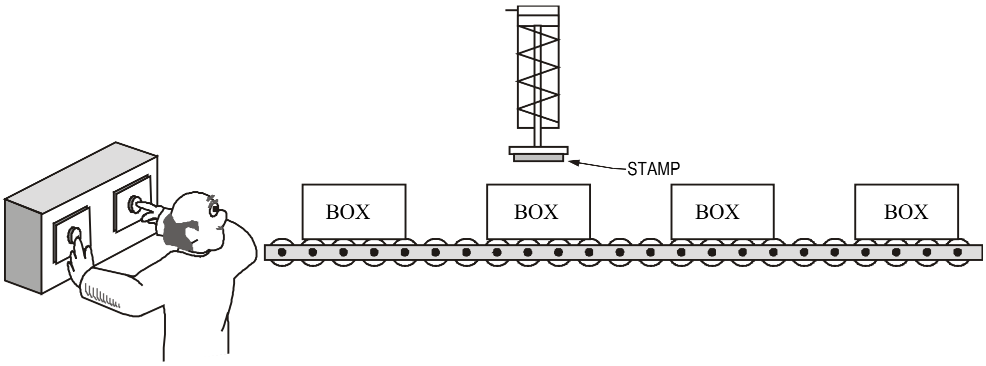

Figure 52

   (a) Design a circuit that would solve this problem.
   (b) Build and test your solution.
   (c) Draw a truth table of your results.
   (d) Explain how the circuit operates.

2. Sometimes the operator manages to jam the buttons on so that he can move some of the boxes on the conveyor belt. This is very dangerous and the manager wants the machine guarded. It should now only work when the guard is in position and the operator has both hands on the buttons.
   (a) Redesign the circuit to this specification.
   (b) Build and test your solution.
   (c) Explain how your solution works.

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.

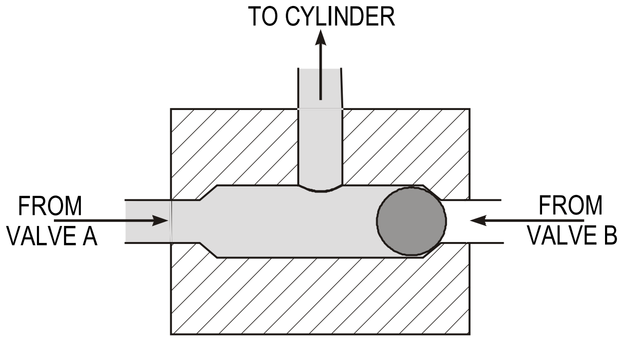

Figure 53

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.

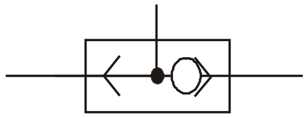

Figure 54

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

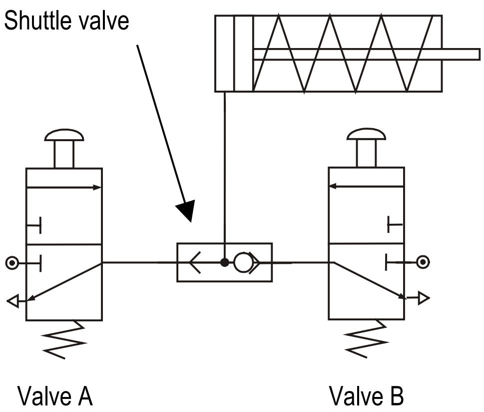

Figure 55

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

Figure 56

Assignment 10

1. Part of a production line involves a quality check. If goods are seen to be faulty then they are pushed off the conveyor by a single-acting cylinder. Two people are used to make sure that no faulty goods leave the factory. They operate the cylinder by pressing a button.

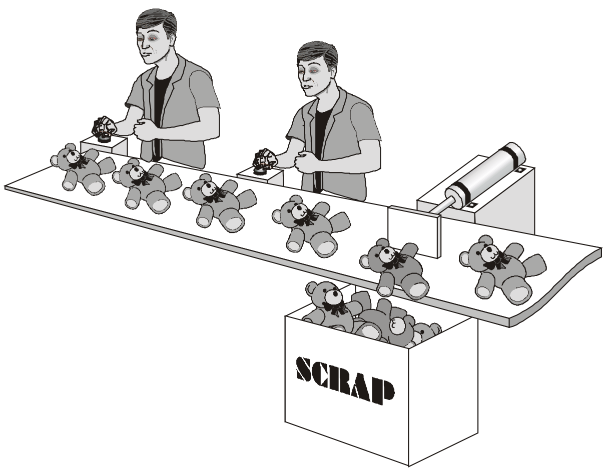

Figure 57

(a) Design a circuit to solve this problem.
(b) Build and test your solution.
(c) Draw a truth table of your results.
(d) Someone has suggested changing the shuttle valve to a T-piece. Why is this not a good idea? (You might want to build this circuit to investigate.)

2. A bus door is operated by pneumatics. The door is operated by a single-acting cylinder and controlled by a 3/2 valve. In an emergency, there should be a second valve that allows passengers to open the doors.

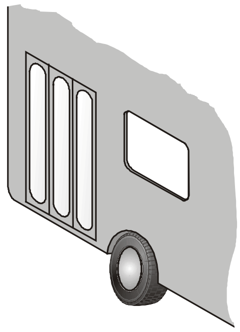

Figure 58

(a) Design a circuit to solve this problem.
(b) Build and test your solution.
(c) Explain your choice of actuators.

3. A pneumatic circuit has been devised for use in operating a sliding door. It must be possible for the door to be opened or closed from both the inside and outside. The speed of the door should be controlled when opening and closing.
   (a) A diagram of the components is shown below with some of the piping missing. Complete the diagram.

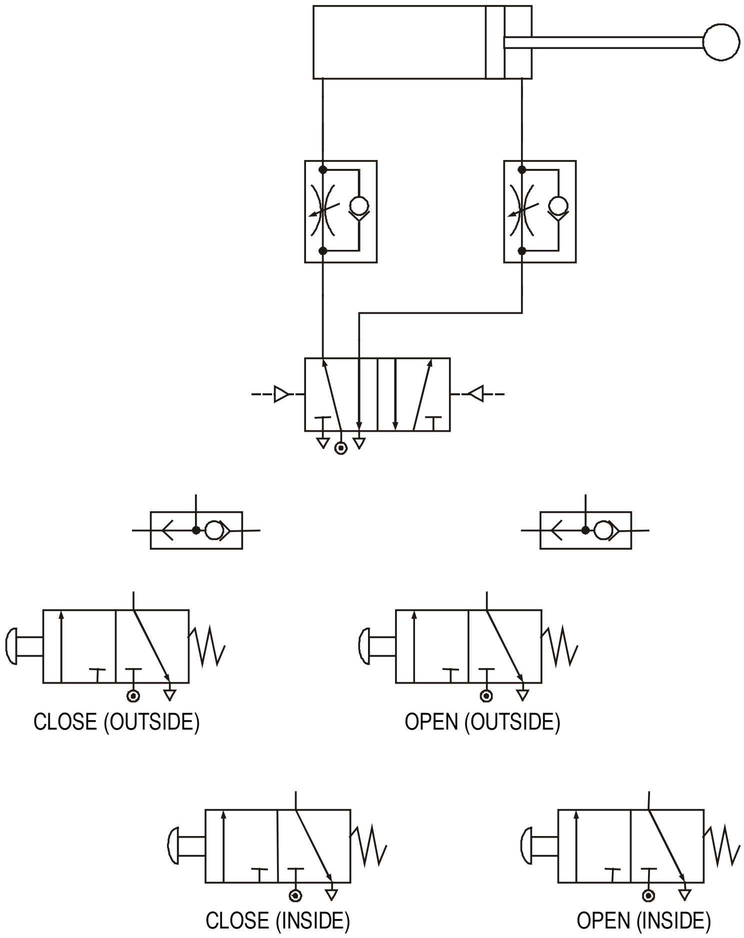

Figure 59

   (b) Build and test the solution.
   (c) Name all of the components used.
   (d) What type of control does this circuit use?