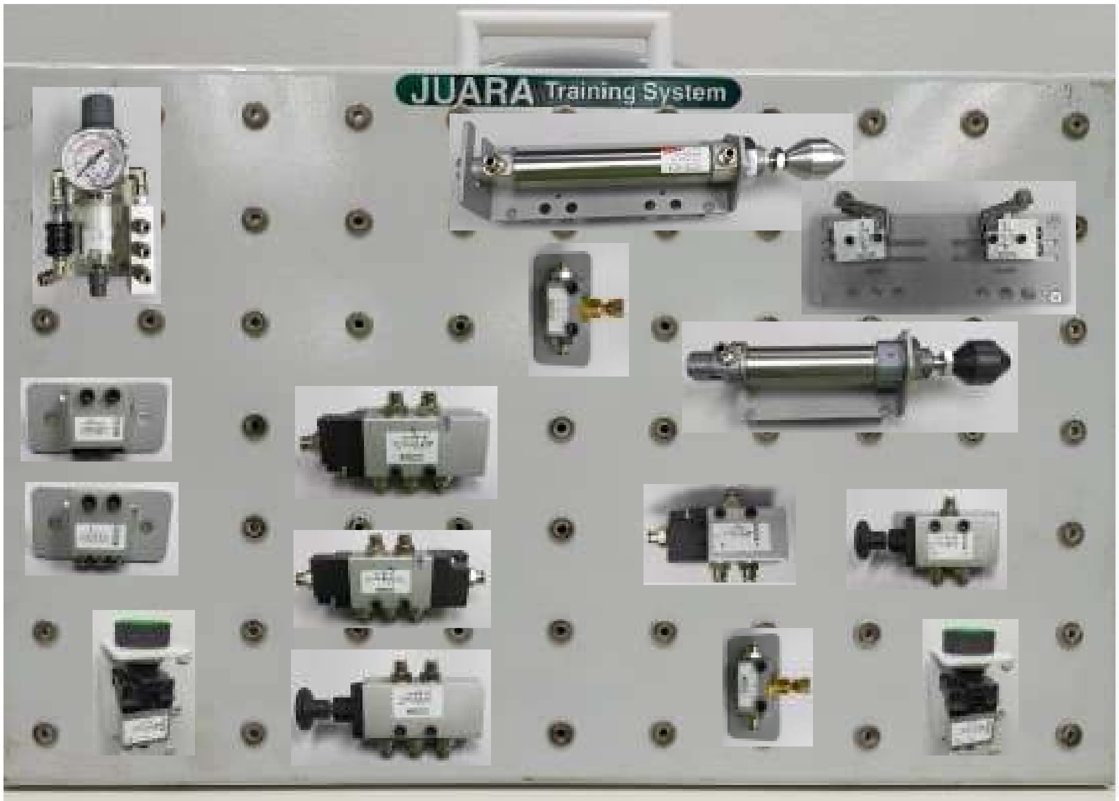
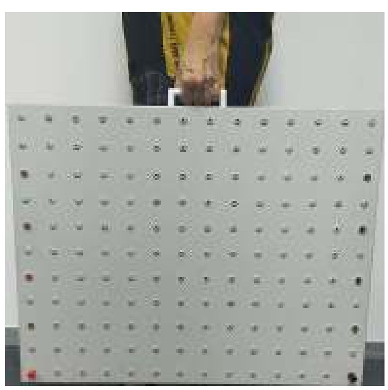
A GUIDE TO PNEUMATIC TECHNOLOGY



For JUARA micro Pneumatic Training Kit



JUARA TRAINING SYSTEM

PREFACE

Control technology is based on a logical approach whereby logical functions and their corresponding elements are used as building bricks or modules. This approach is reflected in our technical education.

The student should have access to a laboratory kit, so as to bring teaching to life and have an opportunity of trying out solutions of his own. The *Juara Training System* is designed to cater for this need. It is made up of sub-systems, which together or separately cover different modes of control. The basic kit, is all pneumatic within the normal pressure range (4 - 6 bar), which means that control is also pneumatic.

This guide sets out to suggest useful circuit exercises which will afford practice in connecting up a system according to a given diagram and which will also help the student to see how a general solution of a control circuit can be converted into a pneumatic system.

You will find Data Summaries describing the most important properties of the components. Each Data Summary also presents some of the typical applications of pneumatic cylinders together with their standard symbols and logical functions. It should be made clear, however, that this guide is not intended as an independent textbook of control technology.

The introductory exercises deal with simple situations involving the control of single-acting and double-acting cylinders. These are followed by examples of basic logic connections. Several experiments serve to show how moving parts logic can be used to build up circuits with special functions. The final exercises feature practical application in industry.

This guide also includes a number of experiments where the fluid circuit is incomplete, which gives the student a chance of completing it for himself and testing the result. The solutions to the problems will be available from the instructor.

A pneumatic control system is easy to understand, because it employs perceptible signals and simple components. Consequently, pneumatic experiments are to be recommended even at the commencement of teaching.

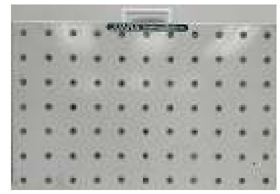
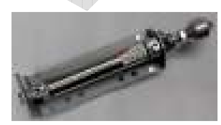
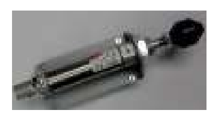
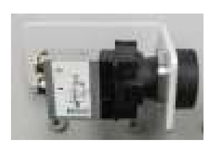
The best way to start on a problem is to put all the components you are going to use onto the training plug board. You should position them in such a way that you can take in the whole system more or less at a glance. Some of the experiments are accompanied by instructions concerning the positioning of the components, but otherwise, this is left to the student's own judgement.

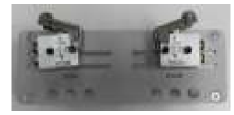
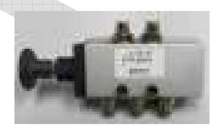
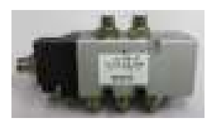
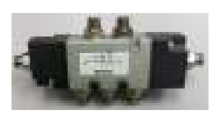
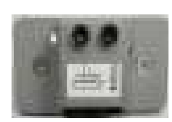
Lastly, a word of warning, air jets can injure sensitive parts of the body, such as eyes and ears. You should therefore make a habit of always evacuating the system via the main air supply valve when connecting or disconnecting the air lines to the side frames or components. It is ABSOLUTELY FORBIDDEN to point air jets at other people.

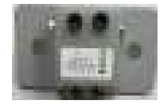
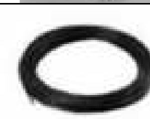
CONTENT

JUARA PORTABLE PNEUMATIC TRAINING KIT

COMPONENT LISTS

Part Number	Description	Qty	Photos
JTS97001	Plug board (550mm x 350mm) with	1	
JTS97002	Double acting cylinder c/w trip cam, 25 x 100mm Type of construction: crimped Material: anodized aluminum end-caps - stainless steel barrel and rod, aluminum piston - NBR/PU seals Stroke: 100 mm Bores: 25 mm Operating temperature: 0 to 80 C Operating pressure: 1 – 10 bar Fluid: filtered air without lubrication Speed: 10 – 1000 mm/sec (without load)	1	
JTS97003	Single acting cylinder c/w trip cam, 25 x 50mm Type of construction: crimped Material: anodized aluminum end-caps - stainless steel barrel and rod, aluminum piston - NBR/PU seals Stroke: 100 mm Bores: 25 mm Operating temperature: 0 to 80 C Operating pressure: 2 – 10 bar Fluid: filtered air without lubrication Speed: 10 – 1000 mm/sec (without load)	1	
JTS97004	3/2-way Push button N.C. + N.O. valve Construction: Poppet valve Material: aluminum body, brass plunger Seal: NBR Operating pressure: 2 – 8 bar Flow: 60 Nl/min Actuating force: 7 N Ports: cartridge dia 4mm Ambient temperature: 0 – 60 C	2	
JTS97005	3/2-way Push-pull knob valve Construction: Spool valve Operating pressure: 0.9 – 10 bar Flow: 700 Nl/min Actuating force: 6 N Ambient temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	

JTS97006	3/2-way roller / spring N.C. valve, 1 x 2 Construction: Poppet valve Material: Aluminum Seal: NBR Port: cartridge dia 4 mm Operating pressure: 0 – 10 bar Ambient temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	
JTS97007	3/2-way Pilot / spring, N.C. valve Construction: Spool valve Material: Aluminum body Flow: 700 Nl/min Min pilot pressure: 2.5 bar Operating pressure: 0.9 – 10 bar Operating temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	
JTS97008	5/2-way Push-pull knob valve Construction: Spool valve Operating pressure: 0.9 – 10 bar Flow: 700 Nl/min Actuating force: 6 N Ambient temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	
JTS97009	5/2-way Pilot / spring, valve Construction: Spool valve Material: Aluminum body Flow: 700 Nl/min Min pilot pressure: 2.5 bar Operating pressure: 0.9 – 10 bar Operating temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	
JTS97010	5/2-way Pilot / pilot valve Construction: Spool valve Material: Aluminum body Flow: 700 Nl/min Min pilot pressure: 2.5 bar Operating pressure: 0.9 – 10 bar Operating temperature: 0 – 60 C Fluid: Filtered air without lubrication	1	
JTS97012	Dual input AND valve Construction: Poppet valve Port: Cartridge 4 mm dia Operating pressure: 2 – 10 bar Operating temperature: 0 – 60 C Nominal flow rate: 100 Nl/min Fluid: Filtered air without lubrication	1	

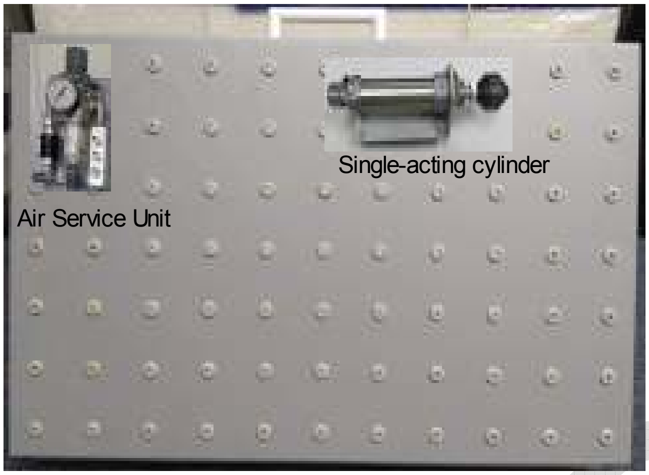
JTS97013	Shuttle valve (OR valve) Construction: Poppet valve Port: Cartridge 4 mm dia Operating pressure: 2 – 10 bar Operating temperature: 0 – 60 C Nominal flow rate: 100 Nl/min Fluid: Filtered air without lubrication	1	
JTS97014	Non-return (one-way) throttle valve Construction: Needle type Material: Al body, brass needle Seal: NBR Port: G1/8 Operating temperature: 0 – 80 C Operating pressure: 1 – 10 bar Nominal pressure: 6 bar	1	
JTS97015	Two-way Throttle valve Construction: Needle type Material: Al body, brass needle Seal: NBR Port: G1/8 Operating temperature: 0 – 80 C Operating pressure: 1 – 10 bar Nominal pressure: 6 bar	1	
JTS97016	Air Service Unit c/w shut-off valve and air manifold with 3 push-in, self-closing fitting with built-in check valve Construction: HDPE filtering element Operating temperature: -5 – 50 C Inlet pressure: 0.3 – 16 bar Outlet pressure: 0.3 – 10 bar Fluid: compressed air	1	
JTS97019	4mm equal Tee connectors	3	
JTS97020	4mm P.U. tube (25 m) 6mm P.U. tube (5 m)	1 roll	
JTS97021	Tube cutter	1	
JTS97022	Tube release tool	1	
JTS97024	Utility Box For storage of extra fittings and other accessories	1	

ASiP	Optional: AUTOMSIM Premium circuit design & simulation software c/w Pneumatic, Hydraulic, Electric and Digital Electronics Libraries **All the circuit drawings in this manual are created using this AUTOMSIM Premium circuit design and simulation software.* *The simulation circuit diagram of all the exercises (in executable file) is available upon request.* *However, teachers are advisable to have this software in order to create more circuit exercises for students at their own pace.*		
AIRCOMP	With noise lower than 70 dB, this air compressor is needed for practical pneumatic exercises in classroom environment. This machine is using auto-drain construction, which can make the output air more dry. It is portable and light weight. Specifications: Voltage: 220 – 240 50 Hz Power: 0.55 KW / ¾ HP Tank size: 24 Liter Max pressure: 8 bar Flow: 60 L/min / 2.1 CFM Speed: 1450 rpm Weight: 20 kg		

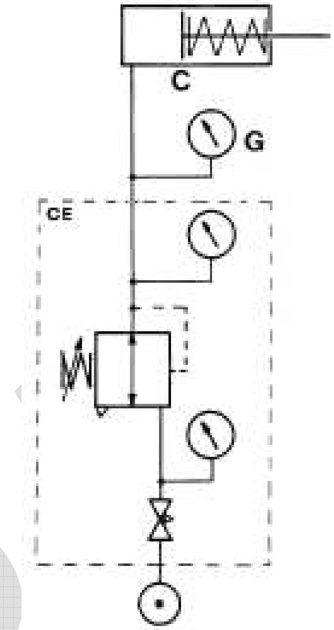
The above picture of the items shown are for illustration purposes and subject to changes without prior noticed.

F1 Behavior of a single acting cylinder with spring return

Procedure



Training panel



Position the air supply unit (CE), the single acting cylinder C, and the pressure gauge G with a pressure range of 0 – 3 bar as shown in the illustration.

Connect the input of the CE to the compressor.

This experiment requires an adjustable pressure.

Before going further with the experiment, pressurized CE and practice setting the pressure by turning the regulator knob. Finish by setting the pressure to zero.

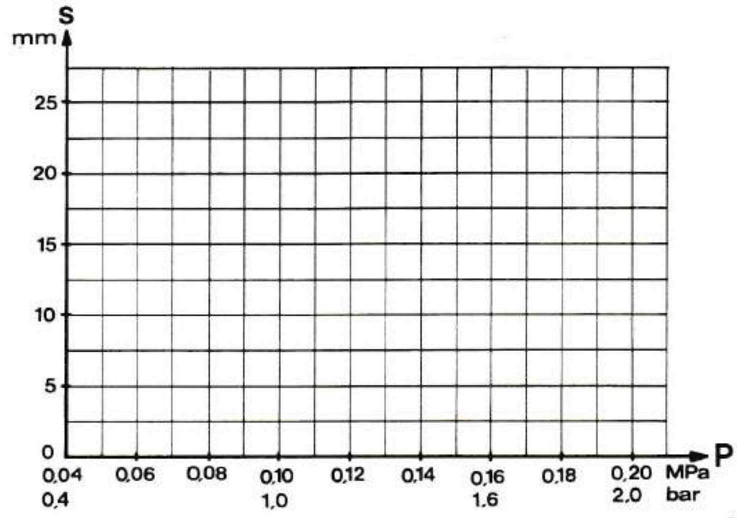
Now connect up the cylinder (C), and the pressure gauge (G) as shown in the circuit diagram.

Vary the pressure between 0 – 2.5 bar. Noticed how the piston rods assumes different positions, depending on the supply pressure.

Owing to piston and piston rod friction and the relatively small piston area, the piston rod will presumably have a jerky movement.

Plot five or six widely distributed piston rod position (s) as a function of the input pressure (p). to eliminate as much of the piston friction as possible, the piston rod has to be pushed in and release a few times before each reading of p and s.

p MPa	s mm



A relatively linear relation is obtained piston rod position and pressure.

The spring force in N with the piston at minus (retracted) is obtained from F = p x A
Where p = the pressure in the plus chamber in kg/cm2 (bar), when s = 0 but has a value such that the piston rod begins to go plus at the slightest increase of p.

A = the piston area on the pressure side in cm2. (the cylinder has a label marked with the cylinder diameter and other particulars. Use this when calculating A).

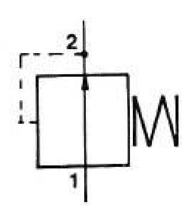
The spring force in the plus position (extended) is similarly obtained by inserting the value of p when s = 25mm.

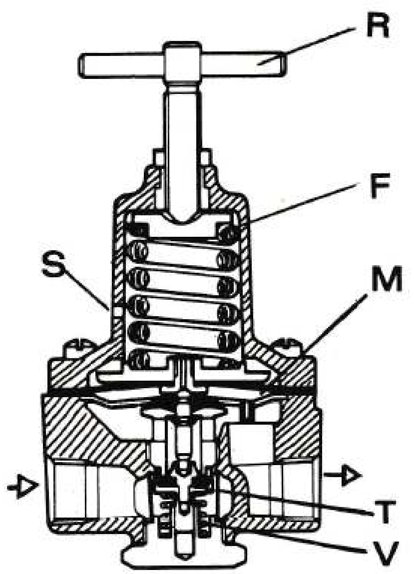
<u>Data Summary for experiment F1</u>

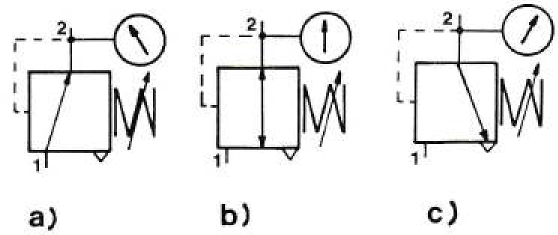
The task of a pressure regulator is to maintain a constant working pressure regardless of changes in the main pressure.

A pressure regulator may or may not have an exhaust from the secondary side (the outlet). A regulator with no exhaust cannot evacuate a working pressure (secondary pressure) greater than the pre-set value. The common practice is to use regulators with secondary evacuation (relieving type).

Right:
Non relieving
pressure regulator







Above: Relieving pressure regulator
a) secondary pressure too low
b) secondary pressure correct
c) secondary pressure too high
Note. In practice the symbol is always to be drawn as in fig. b.
The picture left is a cut-away drawing of the same regulator.
F = pressure control spring
M – diaphragm
R = setting knob
S = secondary exhaust vent
T = valve disc
V = valve spring

<u>The single acting cylinder</u>

A single acting cylinder can only work in one direction.

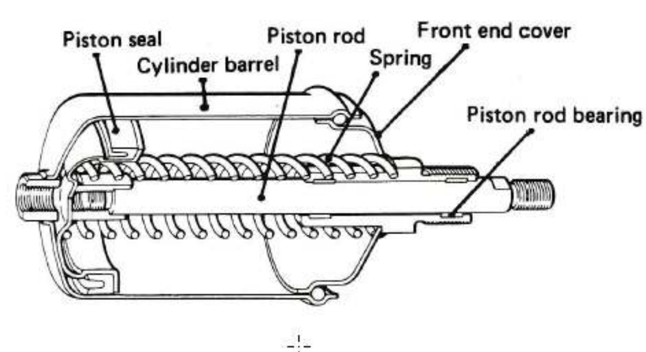
If the cylinder is not provided with a spring return, the piston has to be returned by an external load.

A single acting cylinder consumes only about half as much air as a double acting cylinder.

The built-in returned spring limits the stroke of the single cylinder to about 100 mm.

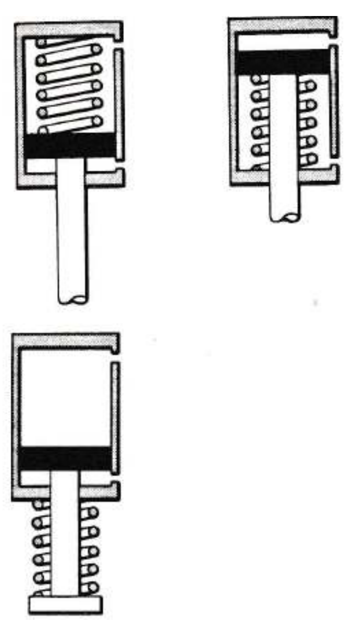
A single acting cylinder with a built-in returned spring is longer than the corresponding double acting cylinder.

EXAMPLES OF SINGLE–ACTING CYLINDERS



Cut-away drawing of a single-acting cylinder with spring return

Commonly used for clamping workpieces in small machine tools.



F2. CONTROL OF A SINGLE ACTING CYLINDER USING A UNISTABLE, NORMALLY CLOSED, 3/2 - WAY VALVE

2.1 PROCEDURE

Position the single acting cylinder (C1) and a mechanical operated, uni-stable 3/2-way directional control valve (V1) as illustrated in the diagram. The valve must be normally closed.

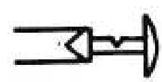
Connect the air supply from the air manifold. Set the pressure to about 5 bar and connect up as illustrated.

When the valve is unactuated, the piston will be in the minus position. The plus chamber will then be depressurized via exhaust port no. 3 of the valve.

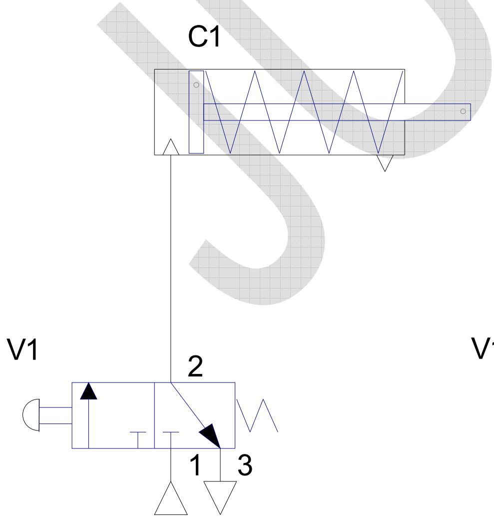
Now, if the valve is actuated, the right-hand square or position shows open connection between inlet port no.1 and outlet port no. 2 and the plus chamber of the cylinder will receive air. The piston rod of the cylinder will then go plus (extended position).

In term of logic, a valve of this kind is said to have a YES function.

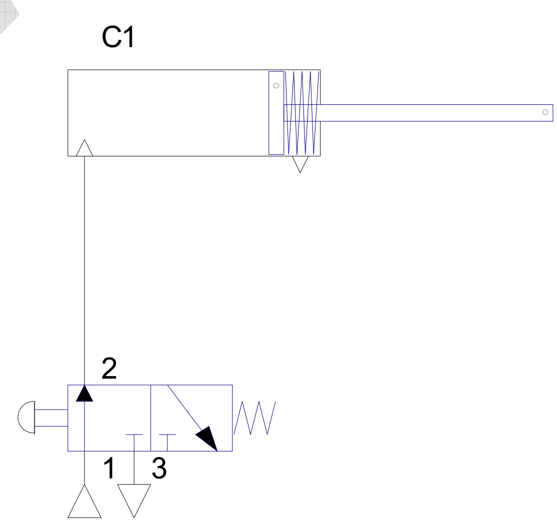
If you want to show that the valve can be locked in the actuated position, this can be indicated in the symbol by means of the designation for a detent. When the button is depressed, the catch drops into a recess to lock the valve in position.



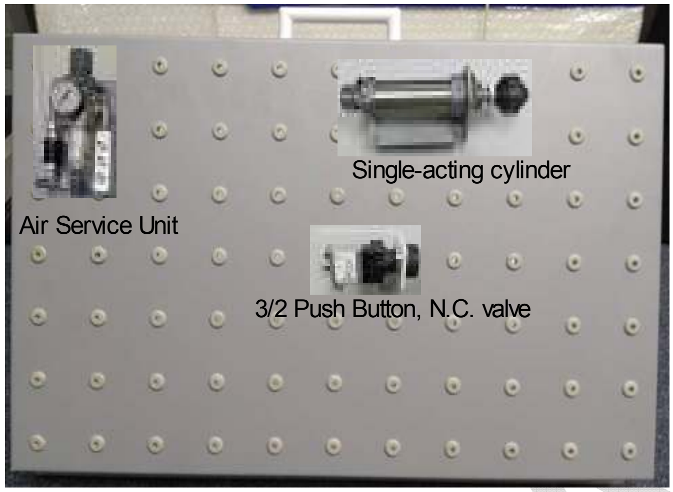
2.2 DIAGRAM



Unactuated



Actuated



Component layout on the training board

F3. CONTROL OF A SINGLE ACTING CYLINDER USING A UNISTABLE, NORMALLY OPENED 3/2 - WAY VALVE

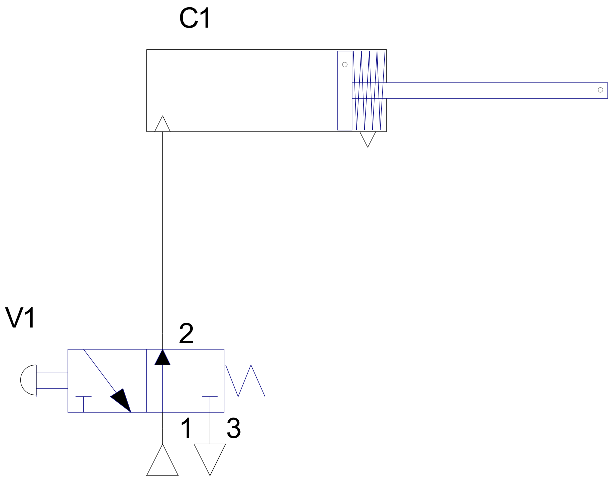
3.1 PROCEDURE

Reconnect the normally closed valve in exercise no. 1 by inverting the valve, i.e. supply air pressure to port 3 instead of port 1, so as to change the valve to a normally opened valve. Draw your own circuit diagram with the valve in the actuated position.

When the valve is unactuated, air is supplied to the plus chamber and the piston rod moves to the plus position. When the valve is actuated, the right-hand control square shows that inlet port no. 3 is closed, and the plus chamber evacuate the air through the exhaust port no. 1 of the valve. Then, the piston rod moves back to the minus position by the spring force in the minus chamber.

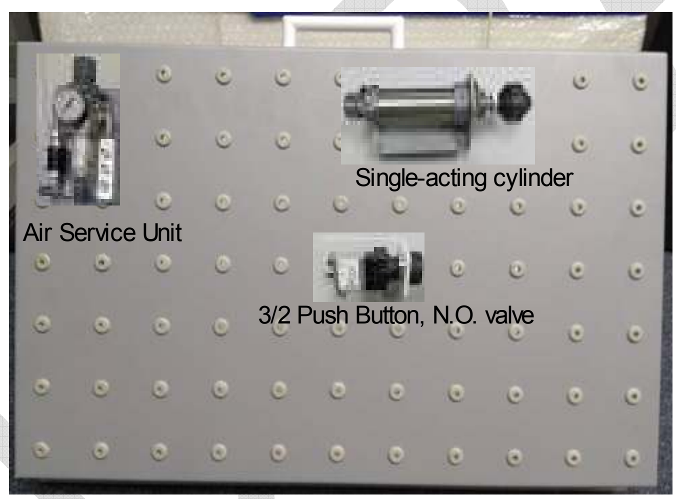
In logic, a valve of this kind is said to have a NOT function.

3.2 DIAGRAM



Unactuated

Actuated



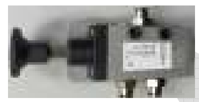
F4. CONTROL OF A SINGLE ACTING CYLINDER USING A BI-STABLE 3/2 – WAY VALVE

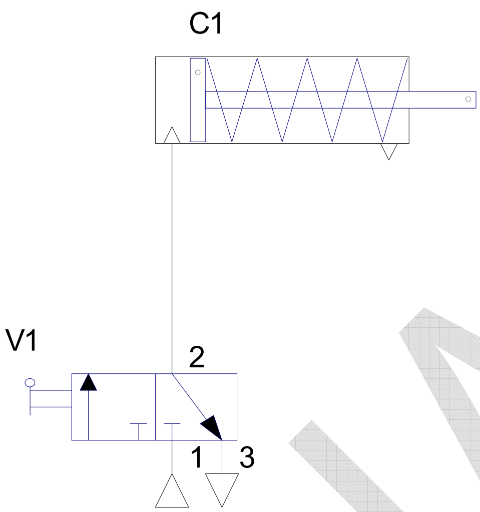
4.1 PROCEDURE

Replace the valve in exercise no. 2 with a 3/2 directional valve with a push-pull knob and connect up as illustrated in the diagram.

Pull or pull the knob and show that the piston rod moves to the plus position and remains in that position until the knob is reset again.

4.2 DIAGRAM



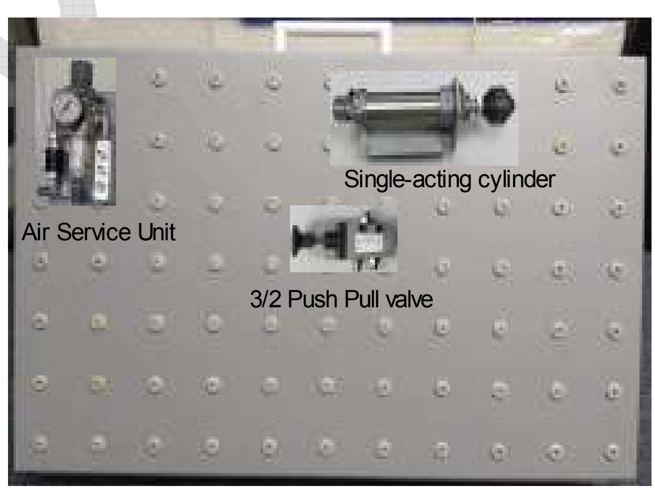


Valve in one of the stable position   Valve in the other stable position

This valve, then has two stable position, and it is therefore said to be of bi-stable or memory type.

Draw the diagram for the other stable valve position.

This valve can be used for instance, for start-stop function, i.e. in situations where the circuit is to be kept supplied with air for the duration of the work cycle.



F5. SERIES CONNECTION OF TWO NORMALLY CLOSED 3/2 DIRECTIONAL VALVES (Active AND function)

5.1 PROCEDURE

Complete the fluid circuit diagram. The cylinder is only to go plus if there is a pilot signal (logic “1”) both at push button A and at push button B. Connect up the system.

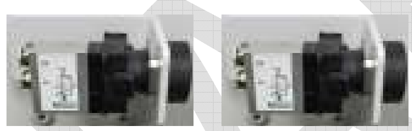
A function of this kind, where the output signal is conditional on all inlets having a signal, is termed an AND function.

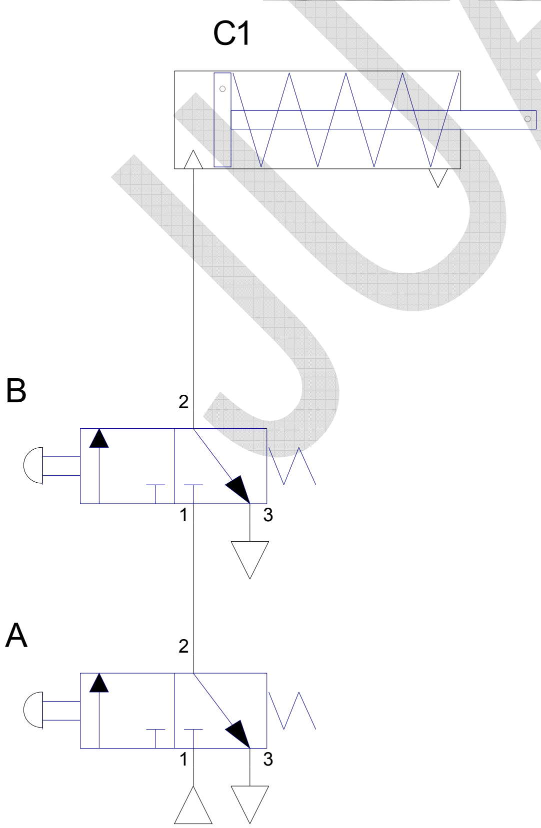
The AND unit is active, i.e. input and output signals are completely separate. This means that the output signal is not dependent on the pressure and power level of the input signal.

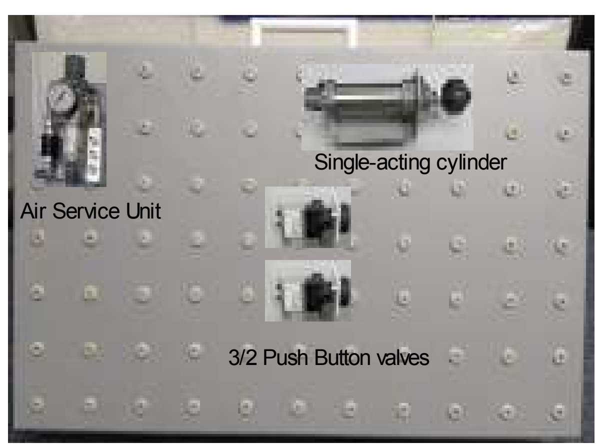
The distance between the valves must not be too long, because this can delay the air supply to the cylinder. The pilot lines can be made shorter by using the circuit shown in exercise 6.

This connection can be used in applications where two conditions have to be satisfied in order for something to happen. But the circuit must not be used for two-hand safety actuation, because the operator can actuate with only one hand by locking one of the valves. Demonstrate this by depressing one of the valves so that it stays in the actuated position (locked in position).

5.2 DIAGRAM







F6. PARALLEL CONNECTION OF TWO NORMALLY CLOSED 3/2 DIRECTIONAL VALVES (Active OR function)

6.1 PROCEDURE

Use the same components as in exercise 4, but connect according to the fluid circuit diagram.

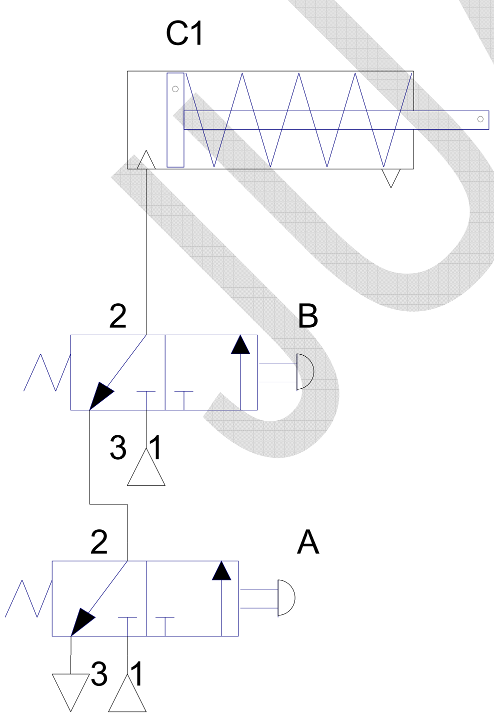
Show that with A or B or both inputs actuated, an output signal is obtained and the cylinder goes plus. A function in which the precondition for an output signal is that at least one input must have a signal (a logical "1") is termed an OR function.

An OR connection is obtained by connecting outlet port no. 2 of the first valve to exhaust port no.3 of the second valve. Unlike the series connection which uses only one air supply for the two valves, the parallel connection will require one supply for each valve (in other words two air supply is needed in this circuit connection).

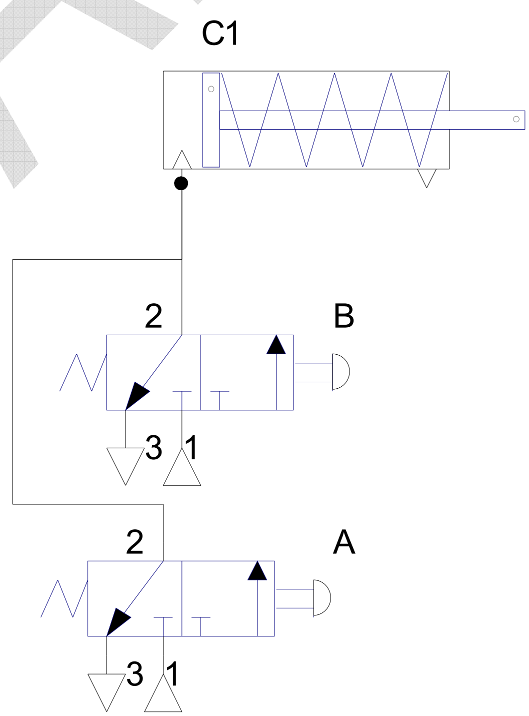
The valves must not be too far apart, because otherwise the air supply to the cylinder may be delayed. The pilot lines can be shortened by using the same circuit as in exercise 7.

Explain why the incorrect circuit does not work. If you cannot find the mistake by looking at the fluid circuitry diagram, you are sure to find it by connecting up and testing the circuit in practice.

6.2 DIAGRAM



Correct connection

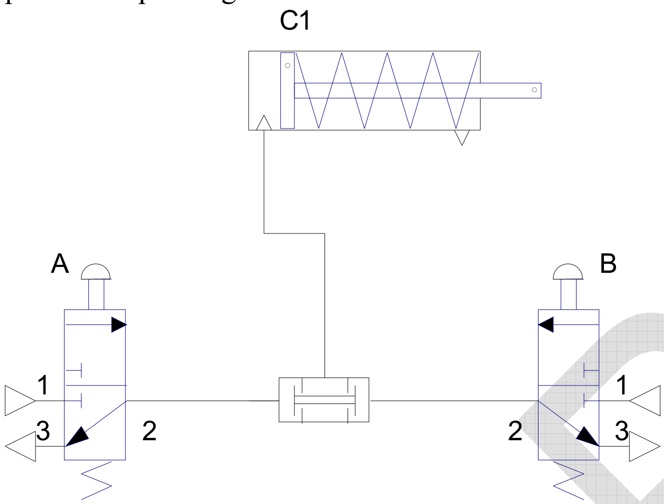


Incorrect connection

F7. PASSIVE AND - VALVE (DUAL PRESSURE VALVE)

7.1 PROCEDURE

Position the components as shown in the diagram and connect the tubes as indicated by the port numbers of the valves. Uni-stable 3/2 directional valves are used to give the AND valve pneumatic pilot signals.

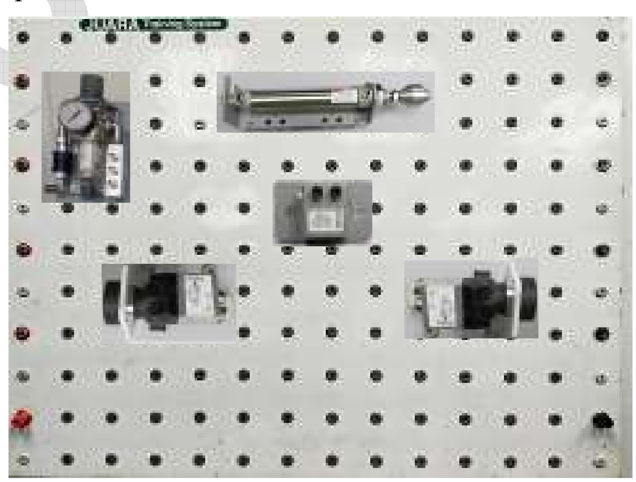


If valve A alone is actuated, the free double valve cone in the AND valve will take up a position blocking the input signal “1a”. Outlet port no. 2 of the AND valve can then be pressurized via control port “1b”.

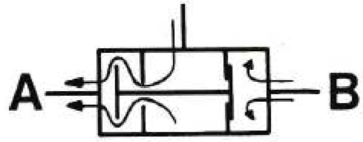
If valve B alone is actuated, input signal “1b” will be blocked and outlet port no. 2 will be depressurized via control port “1a”.

If both A and B valves are actuated, the free double valve cone will adopt a central position, whereupon outlet port no. 2 will receive air from both control port “1a” and “1b” and the cylinder piston rod will go plus.

If the control pressures are unequal, outlet port no. 2 will receive air from the pilot signal which has the lowest pressure.

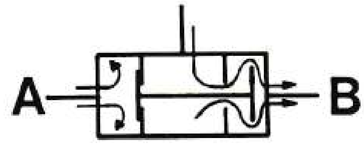


Component layout on plug board



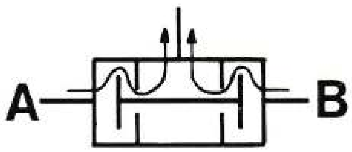
A = 0 B = 1

Control pressure to B only



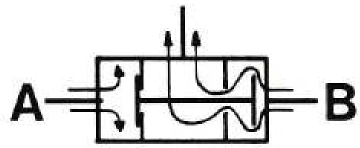
A = 1 B = 0

Control pressure to A only



A = B = 1

Control pressure to A <u>and</u> B



A = B = 1

Control pressure to A and B,

But $P_A > P_B$

Most control members have a small pin to show whether the outlet is giving a signal, so that the state of the signals can be rapidly checked and faults can be traced without disconnecting the tubes. This indicator pin projects when outlet 2 is pressurized. It is reset by hand.

The AND valve is passive, i.e. outlet pressure and control pressure are inter-dependent. Consequently when the AND condition is met, the output signal receives a pressure which is the lowest pressure. In an active unit the pressure of the outlet signal was dependent on the main pressure, and the control pressure only needed to be great enough for the unit to switch over, as in experiment F4.

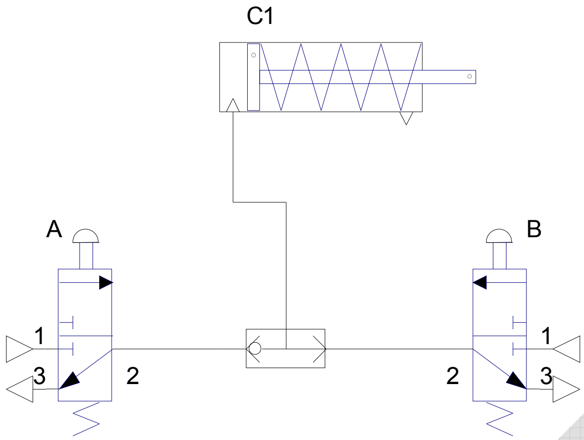
In practice, the use of AND valves make it possible for pilot lines to be made shorter than in the circuit.

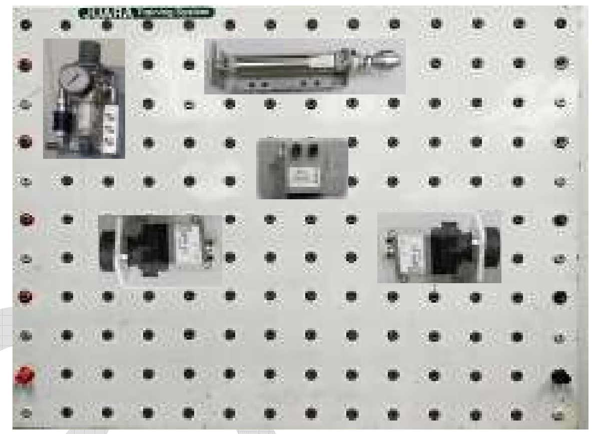
The AND valve requires air in the form of pilot signal, while the connection in F4 has manual input signals.

F8. PASSIVE OR VALVE (SHUTTLE VALVE)

8.1 PROCEDURE

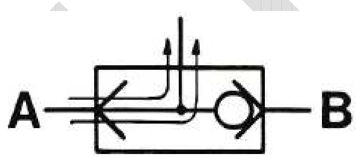
Substitute the OR valve with the AND valve used in exercise 6.



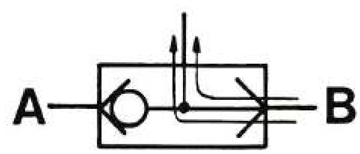


Component layout on plug board

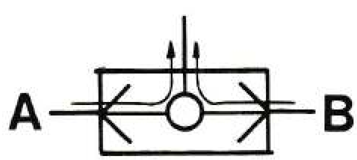
This valve can conceivably operate as a double non-return valve, so that a valve cone seals the control port which does not have a signal. If actuation is simultaneous, outlet port no. 2 will receive air from both the control ports or from the control port having the highest pressure.



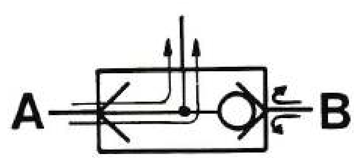
A = 1 B = 0
A alone has control pressure.



A = 0 B = 1
B alone has control pressure.



A = B = 1
$P_A = P_B$



A = B = 1
$P_A > P_B$

Thus, the piston rod of the cylinder will go plus if there is a control pressure in A or B or both.

Examine the signal state of the OR valve at the outlet by following the same procedure as in exercise 6.

The valve has no mains pressure connection, and its outlet pressure is therefore dependent on the control pressures. In other words, it is passive.

The OR valve demands pneumatic pilot signals, while the circuit in exercise 6 has a manual input signals.

INVERTING A VALVE

What is meant by "inverting a valve".

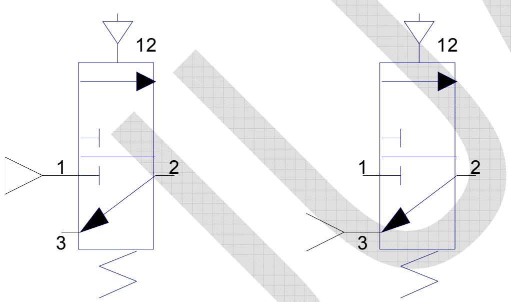
Inverting a valve simply means converting a normally open (N.O.) valve to become normally close (N.C.) or a N.C. valve to become N.O. See example below.

How do we "invert a valve".

By supplying changing the inlet pressure to port no 3 of a 3/2-way valve instead of port no 1.

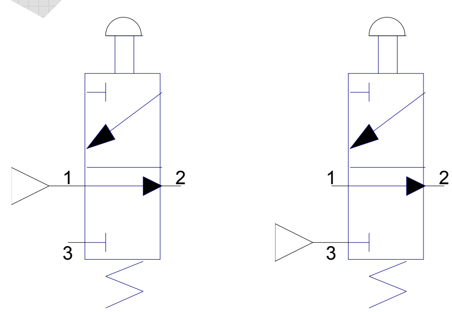
<u>Examples:</u>

3/2-way pressure control valve



Inverting a N.C. valve

3/2-way push button valve



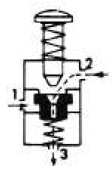
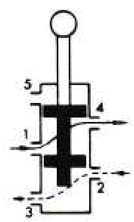
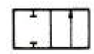
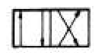
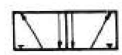
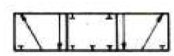
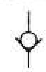
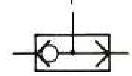
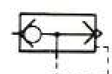
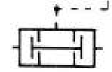
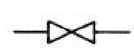
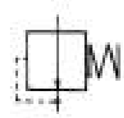
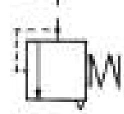
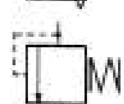
Inverting a N.O. valve

Data Summary for Experiment F2 – F8

Valves

Valves are used to control the direction, pressure and flow of air.

Valves can be classified according to their tasks or functions in the pneumatic circuit.

Valve group	Types			
	Structural classification		Functional classification	Symbols
1 Directional control valves	Poppet valve  **Unactuated control member**	Spool valve  **Unactuated control member**	2/2 directional valve	
			3/2 " "	
			4/2 " "	
			5/2 " "	
			5/3 " "	
2 Blocking valves	Non-return valve			
	Shuttle valve			
	Quick exhaust valve			
	Dual pressure valve			
3 Flow control valves	Throttle valve			
	Shut-off valve			
4 Pressure control valves	Pressure regulator			
	Pressure relief valve			
	Sequence valve			

19.

In experiment F 1 you used a pressure control valve (a pressure regulator with exhaust) to control the air pressure in the plus chamber of the single-acting cylinder.

In experiments F2 – F 6 you used a directional control poppet valve of the 3/2 type to control the single-acting cylinder.

Symbols and fluid circuit diagrams have to be drawn in compliance with ISO/DR 1219 and CETOP/RP3–1965. ISO stands for "International Organization for Standardization" and CETOP stands for "Comite' Europe'en des Transmissions Oleohydrauliques et Pneumatiques".

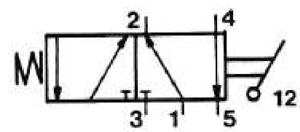
A symbol for a directional valve drawn as per above standards shows the following.

1. No. of ports (connections).
2. No. of distinct positions (indicated by the number of squares).
3. Control method (see opposite page).
4. Whether the valve is unistable (spring or pneumatic return) or bistable (of the memory type).
5. Whether the valve is unactuated ("spring" square connected) or actuated (control square connected).
6. Port connections in the actuated and unactuated positions.

Example

The symbol shown here tells us the following.

1. 5 ports.
2. 2 distinct positions.
3. Control: lever.
4. Unistable with spring return.
5. Actuated. Control square connected.
6. Inlet 1 connected to outlet 2.
   Outlet 4 connected to exhaust 5.
   Exhaust 3 blocked.

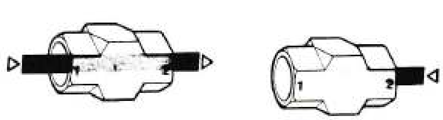


Unistable, actuated 5/2 directional valve.
(Read: "Five two directional valve".)

The dual pressure valve and the shuttle valve are classed as blocking valves because they block the air flow in one direction and let it through in the other.

The simplest form of blocking valve is the non-return valve, which blocks the air flow completely in one direction an admits it in the other direction with the least possible pressure loss.

Flow paths

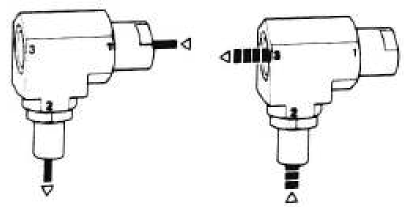


Non-return valve

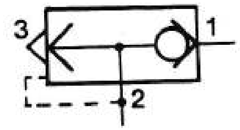
Symbol for non-return valve, showing that the valve opens when there is a particular difference in pressure (e.g. 25 kPa) between port 1 and port 2.

The quick exhaust valve is another blocking valve and is mainly used together with pneumatic cylinders when piston velocity has to be increased above the capability of the pilot valve controlling the cylinder. The quick exhaust valve is then connected to the cylinder chamber which is to be rapidly depressurized, so as to give the incerased velocity required.

Flow paths



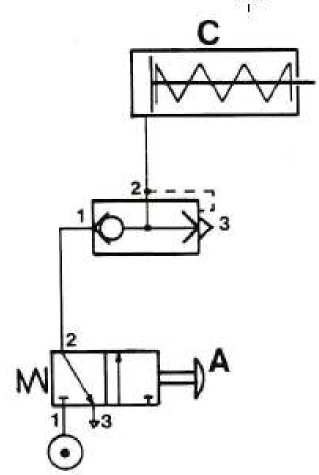
Quick exhaust valve



Symbol for quick exhaust valve

The fluid circuit diagram shows a connection of this kind. When A is actuated, the valve cone moves to the right and blocks the exhaust. The cylinder then moves plus. When the manual signal at A is discontinued, the pressure in the dotted line causes the valve cone to move over to the left, whereupon the cylinder is rapidly depressurized via the right-hand exhaust.

The quick exhaust valve has to be mounted directly onto or as close as possible to the cylinder.



MOVING PARTS LOGIC

The valves with OR and AND function used in the experiments belong to a new generation which has been evolved in response to new demands for control elements.

In the mid-1960s a great deal was expected of fluidics, a static fluid component which operates without moving parts and at low pressure and power levels. However, the fluidic elements has not become as widespread as had been expected, partly because control systems of this kind are easily disrupted and involve heavy losses of power. In addition, fluidics are at present relatively expensive, and so instead valves with moving parts have been developed which satisfy the demands of modern technology.

Developments have been influenced by the following requirments:

1. Small dimensions
2. Build-on facility and flexibility
3. Working pressures must be selectable to suit the rest of the system
   Pressure and power levels must not require amplification.
4. The units must be capable of performing basic logical functions and frequent composite functions such as memory functions
5. Ease of installation, trimming, fault location and operation
6. Low cost per function
7. Technical performance, e.g. long service life and short switching times
8. The valves must also be capable of serving as working elements at low power levels and with small cylinders.

F9. CONNECTION WITH NOR FUNCTION

A single acting cylinder is to be controlled by two 3/2 valves. Both valves must be of uni-stable function. The cylinder piston rod is not to remain in the plus unless both valves are unactuated.

9.1 PROCEDURE

The piston rod of the cylinder is to move plus if A or B or both are unactuated. A connection of this kind is said to have a NOR function, NOR being short for NOT OR. The connection can be made as per the following alternative fluid circuit diagrams.

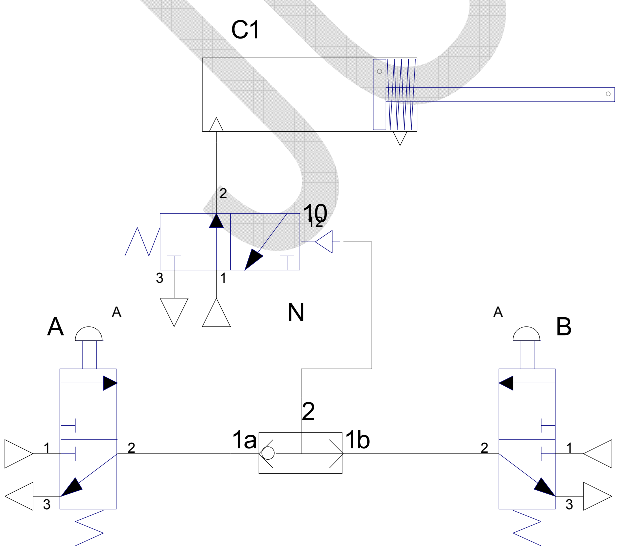
The NOT valve (N) employs pneumatic return. The rectangle which replaces the spring side with the number “12” means that the inlet pressure from port no. 1 acts on a smaller surface area than the pressure-controlled port “10” which acts on the whole valve surface. A control pressure > 0.5 times of the inlet pressure is needed for the valve to switch over (change position). The valve received its inlet pressure directly from the mains and is active.

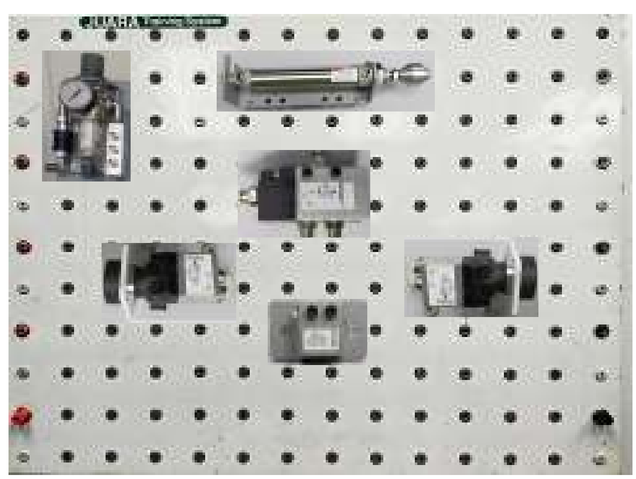
According to international standard the pilot lines must be dashed but can be drawn alternatively as continuous line. Assemble the circuits and show that functionally there is nothing to choose between them. One can also argue according to logical principles, as follows.

The piston rod of the cylinder must move plus if A and B are not actuated. We then obtain the following fluid circuit diagram.

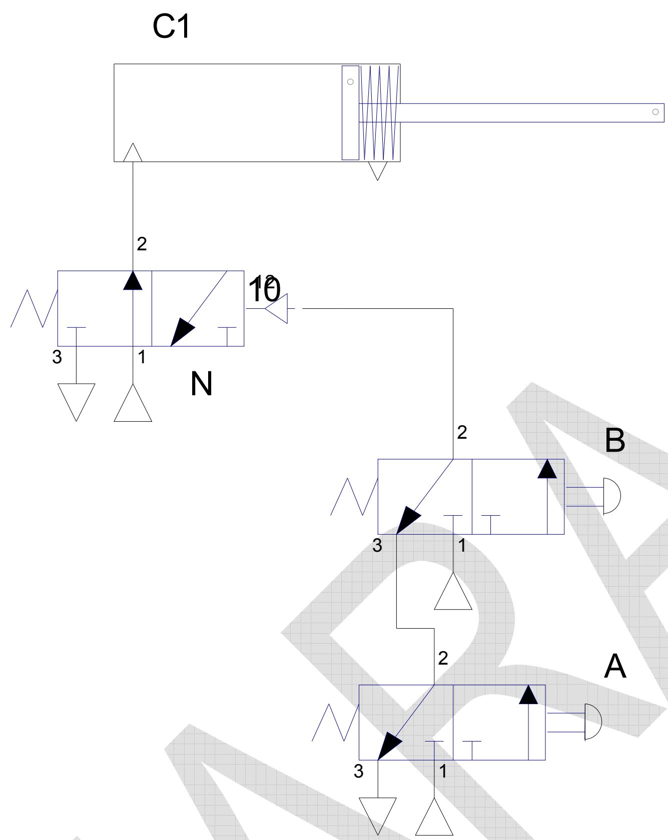
9.2 DIAGRAM

a). NOR connection using one OR and one NOT valve

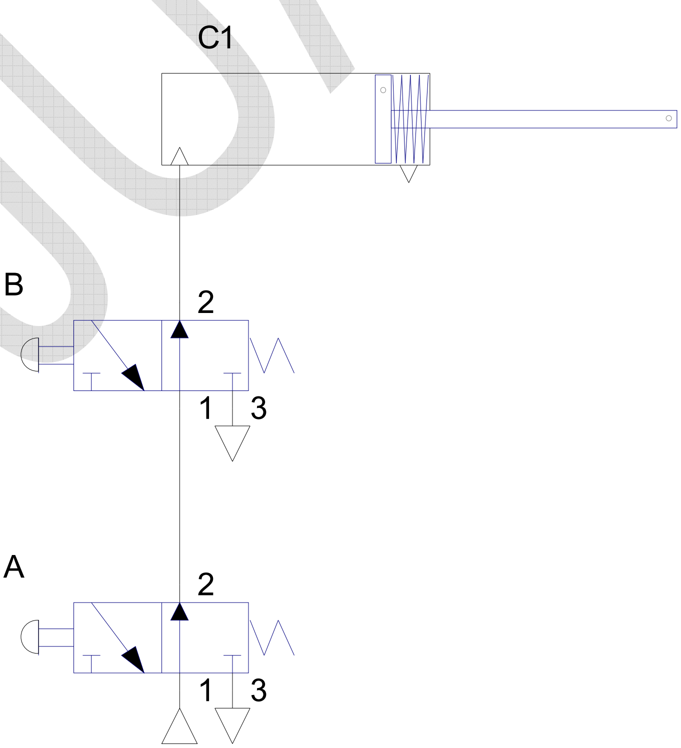




b). Alternative NOR connection using 3/2 valves.



c). NOR connection without a NOT valve.



F10. CONNECTION WITH NAND FUNCTION

Change the pre-condition of exercise 8 so that the piston rod of the cylinder will remain in the minus (retract) position only if both A and B are actuated.

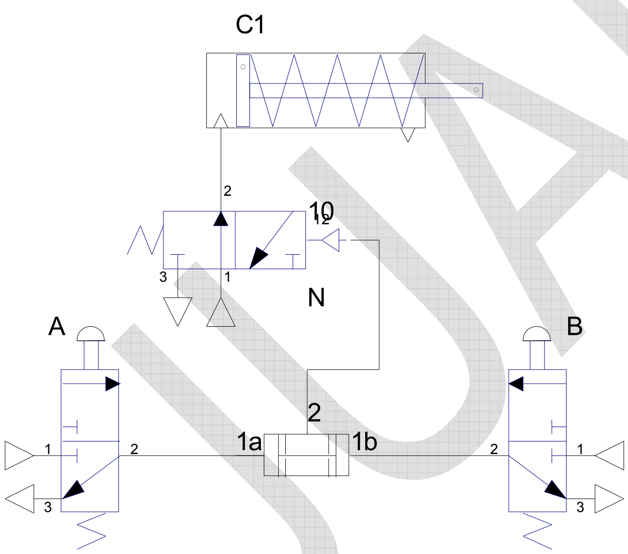
10.1 PROCEDURE

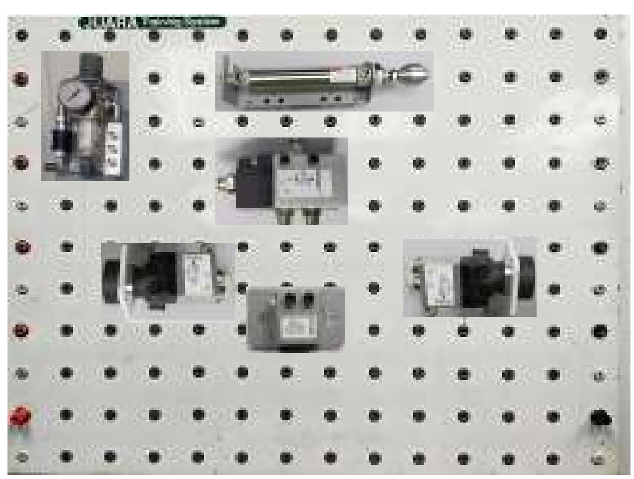
Thus the pre-condition for the piston moving plus is A and B are not actuated. A connection of this kind is said to have a NAND function, NAND being short for NOT AND. The connection can be made as per the fluid circuit diagram.

In the fluid circuit diagrams, both A and B must be actuated in order for the output signal to be "0" (piston rod in the minus position). This condition is also satisfied by the following diagram, with two normally open valves in an OR circuit. Thus it is sufficient for A not to be actuated or for B not to be actuated for the piston rod to move plus.

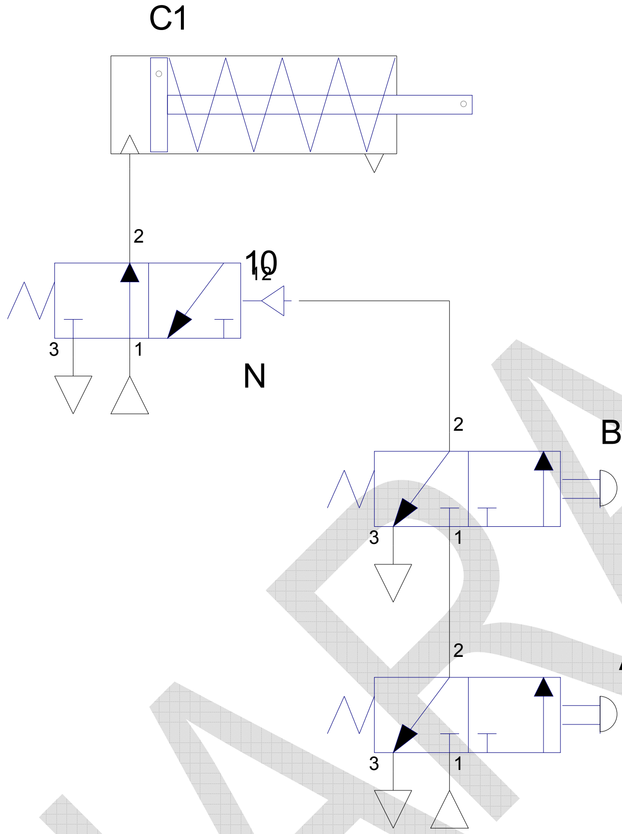
10.2 DIAGRAM

a). NAND connection using a passive AND valve and an active NOT valve.

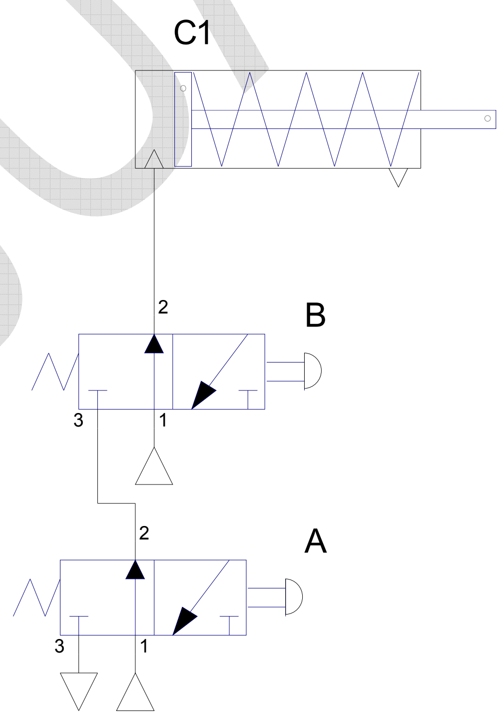




b). Alternative NAND connection using 3/2 valves, Complete the diagram.



c). NAND connection without a NOT valve.



F11. CONTROL OF A DOUBLE-ACTING CYLINDER USING MANUALLY CONTROLLED BISTABLE 5/2 VALVE

As a rule, double-acting cylinders are controlled by means of 5/2 valves.

One of the cylinder chamber receives air from one of the valve outlets, at the same time as the other chamber is evacuated via the other valve outlet.

11.1 PROCEDURE

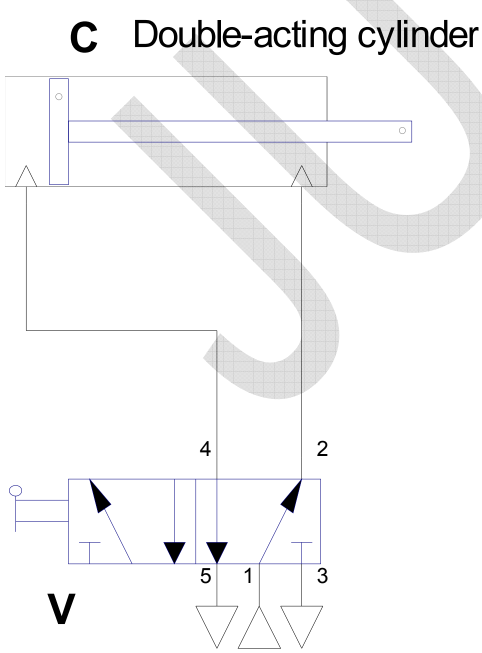
Connect up as per the fluid circuit diagram and test the connection without a silencer. Guide the piston rod to and fro and note the noise level of the exhaust air. Now, fit silencers to the exhaust ports and notice the great reduction in the noise level.

Throttle valves are fitted with silencers. Connect the entire throttle-silencing unit to the exhaust port of the valves with the throttle fully open (turn anti-clockwise), so that the throttle will not affect the work cycle.

In industry it is important for noise levels to be kept to a minimum, for purely hygienic reasons, all industrial installations should therefore be fitted with silencers whenever possible.

The arrowed rectangles in the piston indicates that the cylinder has adjustable cushioning at both the end positions.

11.2 DIAGRAM



Component layout on the training board

F12. ADJUSTMENT OF PISTON VELOCITY USING THROTTLE VALVES FITTED TO THE EXHAUST OF THE VALVES.

12.1 PROCEDURE

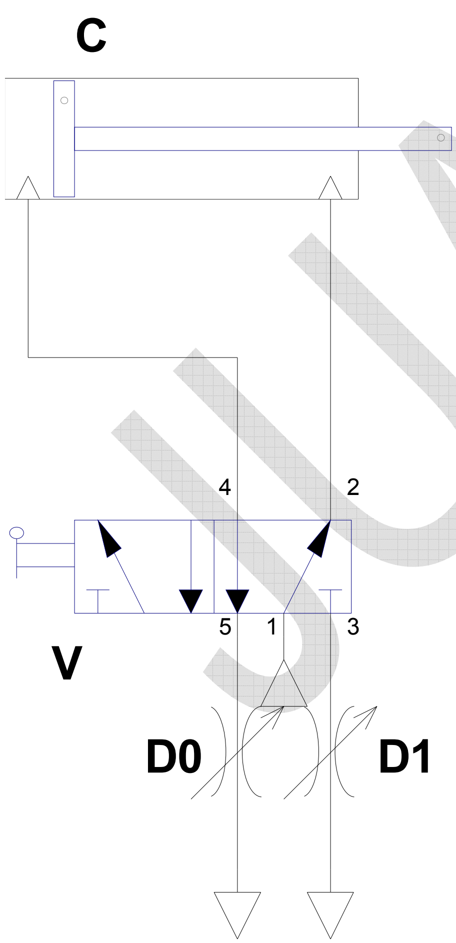
Start by reading the fact sheets under velocity control in the Data Summary section.

Use the same circuit as for exercise 10.

Test the possibility of controlling the piston rod velocity during the plus and minus movements by varying the throttles.

Note the term “power valve”, which will be used in the following to denote the directional valve supplying the cylinder or actuator with air (power).

12.2 DIAGRAM



Component layout on the training board

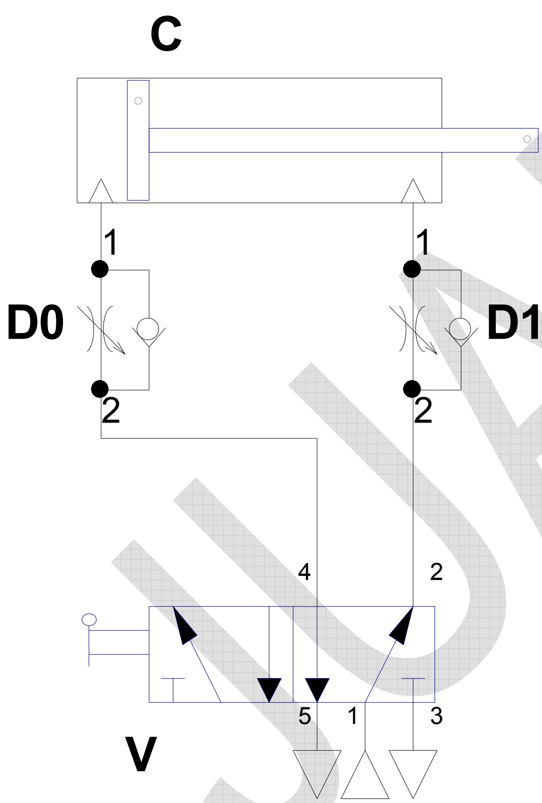
F13. ADJUSTMENT OF PISTON VELOCITY USING NON-RETURN THROTTLE VALVES IN THE CONNECTION PORTS OF THE CYLINDER.

13.1 PROCEDURE

Remove the throttle valves used in the previous exercise and fit the non-return throttle valves to the cylinder connection ports as shown in the fluid circuit diagram.

Note that the non-return throttle valves are positioned so as to throttle the exhaust flow, while the inlet flow can pass through the valve uninterrupted.

13.2 DIAGRAM



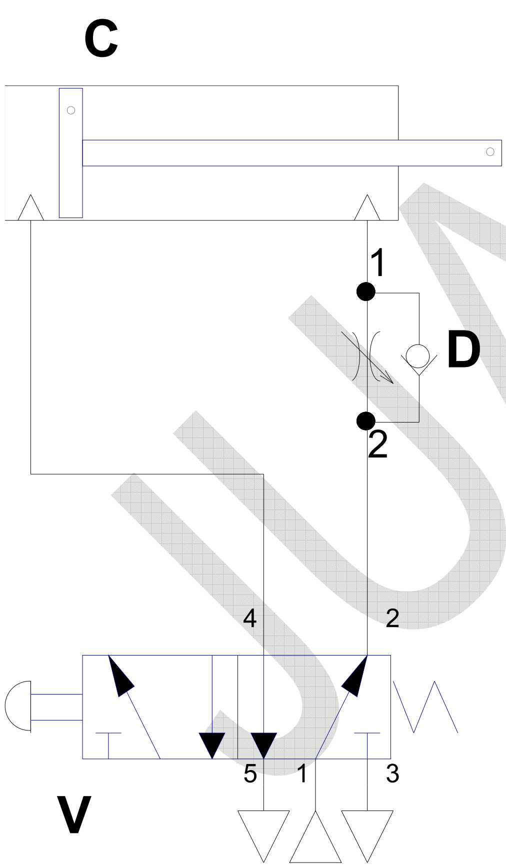
Component layout on the training board

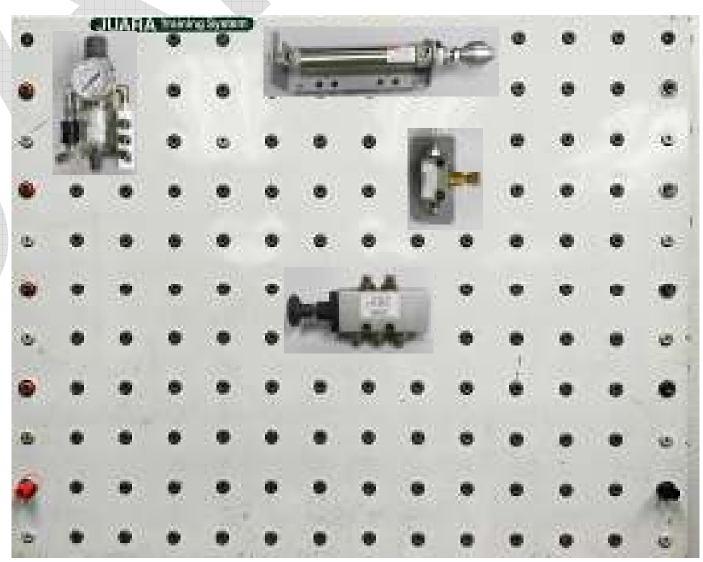
F14. CONTROL OF DOUBLE ACTING CYLINDER USING A MANUALY CONTROLLED UNI-STABLE 5/2 POWER VALVE

14.1 PROCEDURE

Connect up as per the fluid circuit diagram and manually operate the valve so that the cylinder moves to the plus position. When the manual signal is discontinued, the valve will be reset by the built-in return spring and goes back to its normal position whereby the minus chamber of the cylinder will receive full air flow via outlet port no. 4 and the free flow direction of the non-return throttle valve. The cylinder will then reverse and move to minus at its un-throttled velocity.

14.2 DIAGRAM





Component layout on the training board

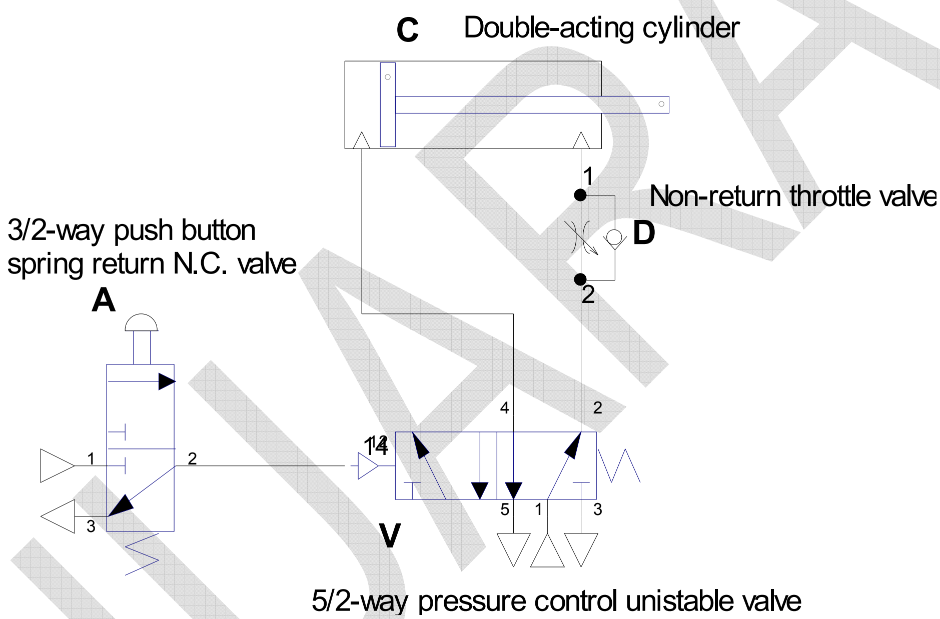
F15. REMOTE CONTROL OF PRESSURE-CONTROLLED UNISTABLE 5/2 POWER VALVE USING A PUSH BUTTON CONTROL 3/2 VALVE

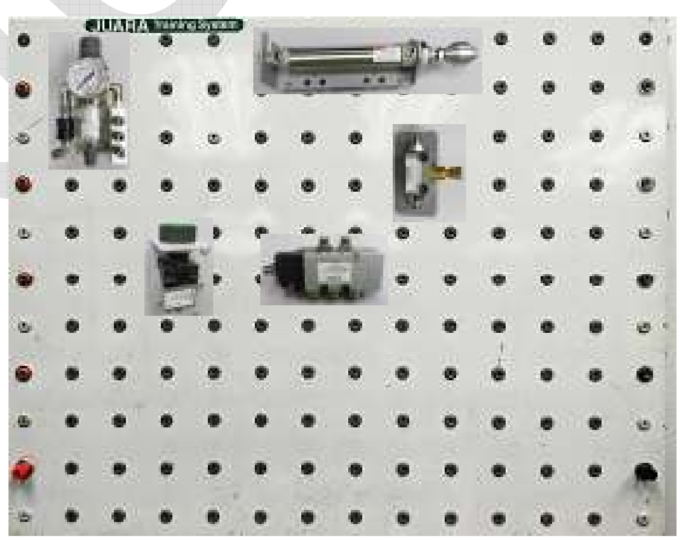
15.1 PROCEDURE

Replaced the 5/2 manually controlled power valves in exercise 13 with a pressure controlled (air pilot) uni-stable valve.

Add a push button control 3/2 uni-stable valve to the circuit as shown. Complete the fluid circuit diagram on this page so as to make the 5/2 power valve remote controlled. Draw the pilot line with a dashed line and number the ports of the valves.

15.2 DIAGRAM



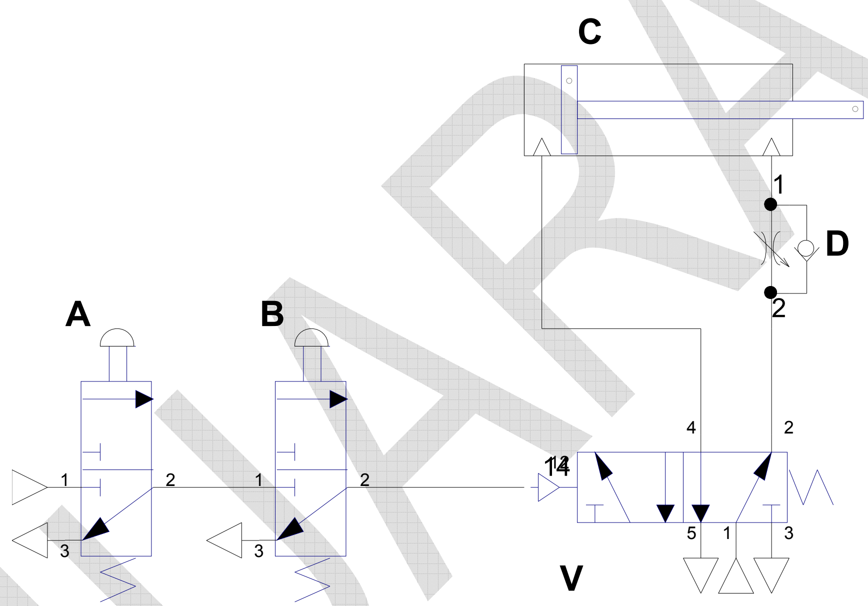

Component layout on the training board

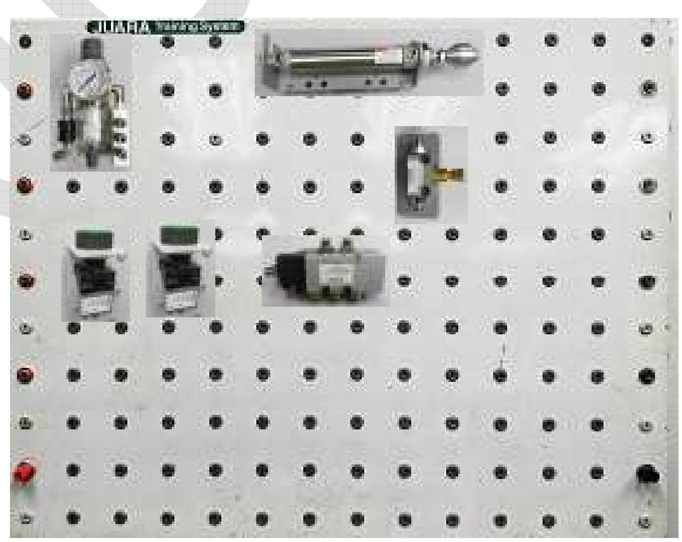
F16. REMOTE CONTROL OF PRESSURE CONTROLLED UNISTABLE 5/2 POWER VALVE USING TWO PUSH BUTTON CONTROL 3/2 UNISTABLE VALVE IN AN AND CONNECTION

16.1 PROCEDURE

Draw a complete fluid circuit diagram below (numbering all the connection ports) in which the control of the power valve gives an AND function. In other words, the power valve will only be actuated to make the cylinder move plus when both the push button valves are depressed.

16.2 DIAGRAM





Component layout on the training board

DATA SUMMARY FOR EXPERIMENTS F11- F16

Double-acting cylinder

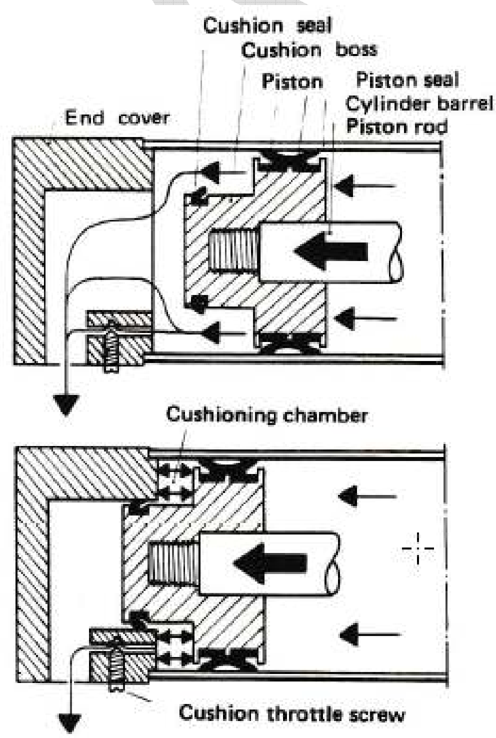
A double-acting cylinder can work in both directions. Theoretically, there is no limit to their potential stroke, but a limit is in fact imposed by various considerations, including the risk of buckling and bending.

The piston area on the piston rod side is less than on the other side, with the results that different piston rod forces are obtained in the plus and minus directions.

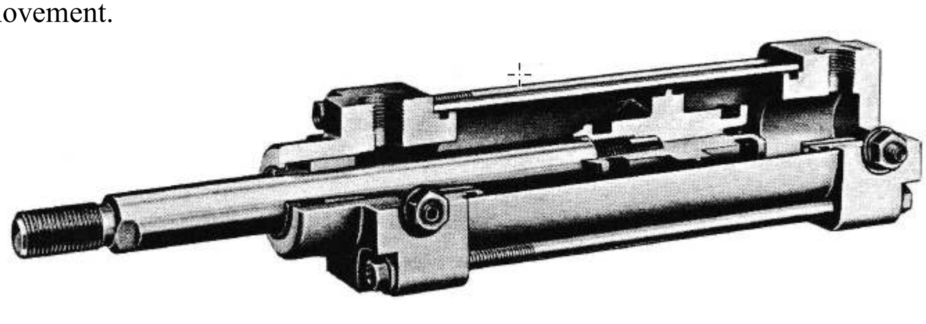
There are double-acting cylinders both with and without end position cushioning. If the cylinder sets large masses in motion and the piston is allowed to move as far as its end position (end cover), damage is liable to occur if the movement is not cushioned effectively.

The pictures on the right shows the most common principle of pneumatic end position cushioning. The upper picture shows the piston movement to the left before it has reached the cushioning position. The exhaust air is able to escape directly through the exhaust port.

In the lower picture, the piston has reached the cushioning position, i.e the cushion seal has entered and sealed between the cushion boss and the cylindrical surface of the end cover. The exhaust air is now only able to escape through the cushion throttle valve, and consequently the pressure in the cushion chamber increases.



The force which then acts on the piston – contrary to the direction of movement – serve as a cushioning. Note that the cushioning pressure only acts on the part of the piston area which comes outside the cushion boss, and that the mains pressure continues to act in the direction of the movement.



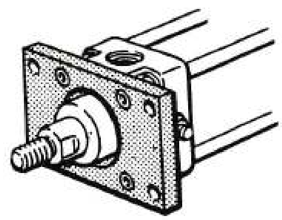
Cut-away drawing of a double-acting tie rod cylinder

The cylinder is intended for medium duty and is fitted with adjustable cushioning in both end positions.

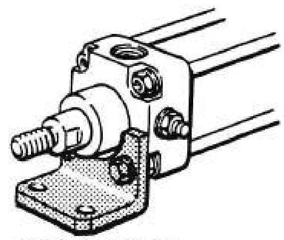
Cylinders of this kind are manufactured with standard diameters and strokes but are also available with optional strokes.

A number of optional cylinder mountings and piston rod adaptors are available for the cylinder, as illustrated below.

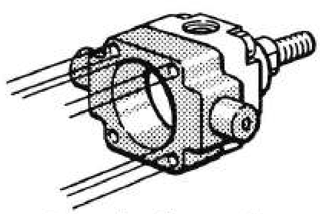
Cylinder mountings



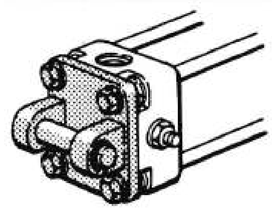
Flange
for fixed installation of the cylinder



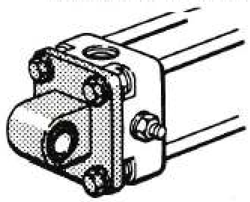
Angle brackets
For fixed installation of the cylinder



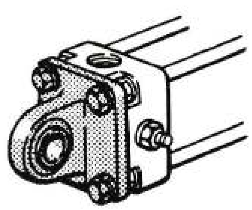
Central male trunnion
For flexible installation of the cylinder



Rear clevis with axle
For flexible installation of the cylinder



Rear eye
For flexible installation of the cylinder.
The bronze bushing of the eye is vulcanized in rubber, thus affording a certain elasticity of attachment.

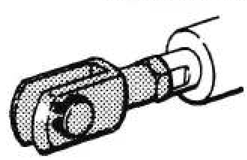


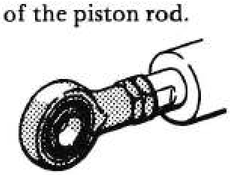
Rear ball joint eye
For flexible installation of the cylinder.
The eye is fitted with a ball joint.

Piston rod adaptors

Nuts
For fixed attachment of the piston rod.

Clevis with axle
For flexible attachment of the piston rod.

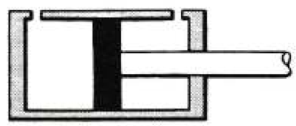


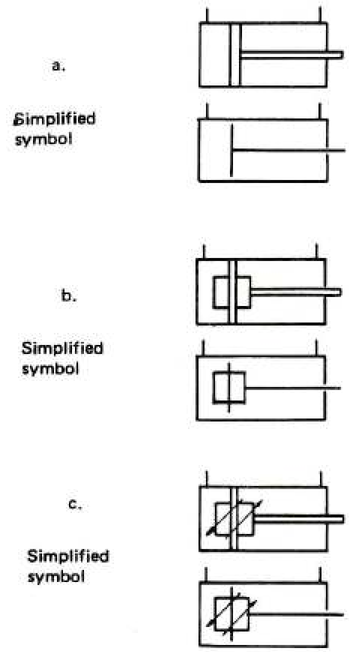


Ball joint eye for axle
For flexible attachment of the piston rod.

SOME COMMON TYPES OF DOUBLE–ACTING CYLINDERS

Normal design

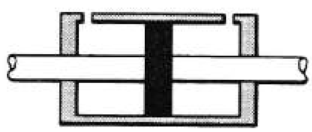


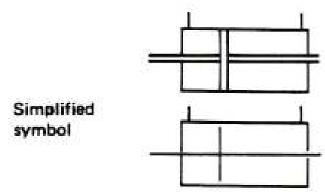


The symbols on the right show:

a. no cushioning in end positions
b. fixed cushioning in end positions
c. variable cushioning in both end positions

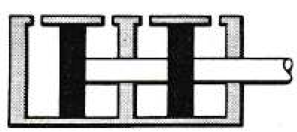
Through piston rod

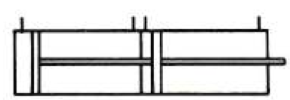




Exerts the same force in both directions. The piston rod position can be acknowledged at both ends of the piston rod.

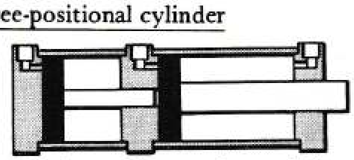
Tandem cylinder

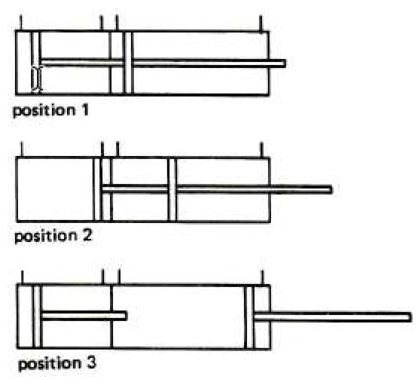




Its two pistons share the same piston rod.
This type of cylinder can exert twice the force of an ordinary double-acting cylinder without any increase in cylinder diameter. Instead the cylinder is enlarged axially.

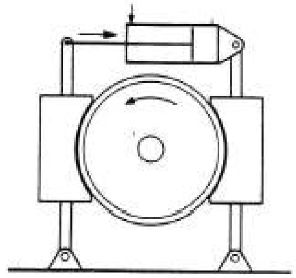
Three-positional cylinder



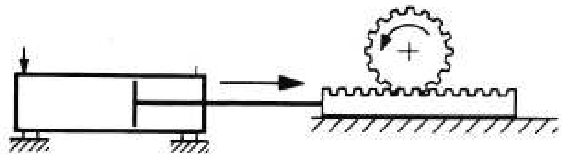


Several pistons have to be used if a cylinder is to be capable of adopting more than two distinct positions. This picture shows a cylinder with three distinct positions.

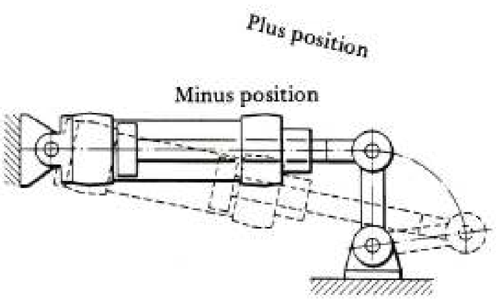
USES OF THE DOUBLE–ACTING CYLINDER



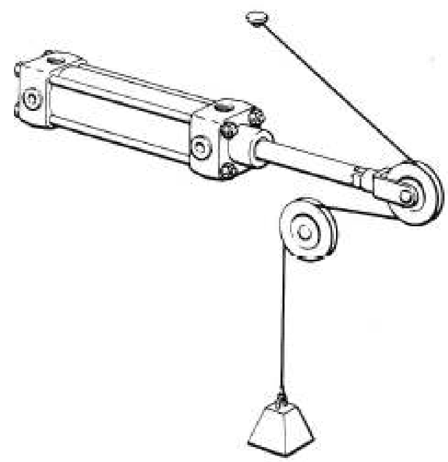
Braking



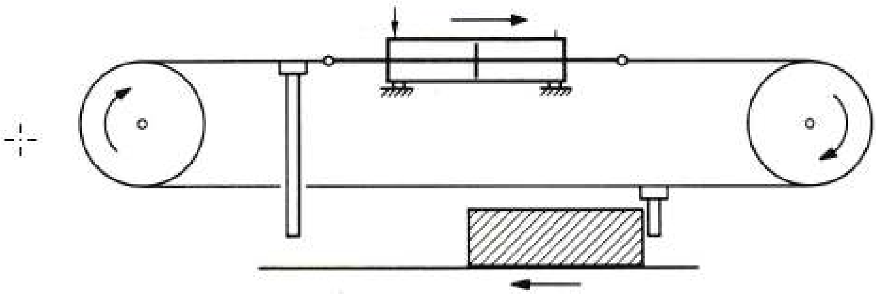
Conversion of linear to rotary movement



Swivelling

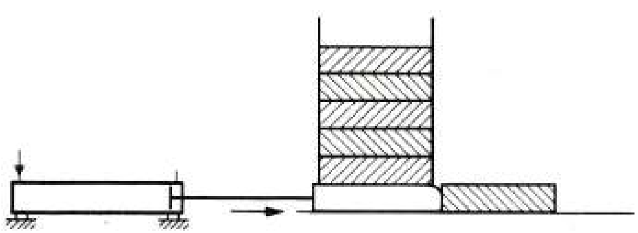


Changing the direction and magnitude of a force

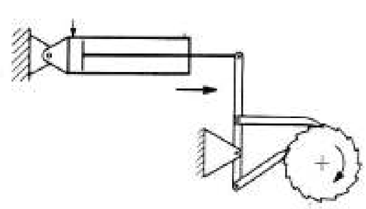


Positioning a part

USES OF THE DOUBLE–ACTING CYLINDER



Magazine feed

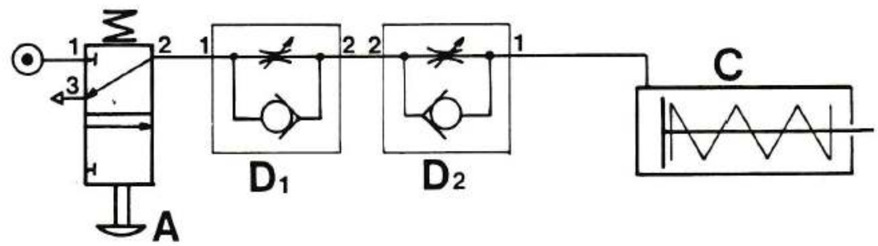


Ratchet with two pawls

<u>Velocity control</u>

The velocity of both single-acting and double-acting cylinders can be controlled by throttling the air flow.

The velocity of the single-acting cylinder cannot be controlled with the same precision as that of the double-acting cylinder, but this is not very important considering the limited stroke of the single-acting cylinder. The single-acting cylinder has only one connection, and throttling therefore has to be effected in the supply line to that connection. The illustration shows a velocity control arrangement with individual control in the plus and in the minus direction.



In the case of the double-acting cylinder, the rule is that the exhaust flow has to be throttled. Direct throttling of the inlet flow by means of throttle valves or indirect throttling of the same by means of small gauge airlines or undersize air filters cannot be allowed. An un-throttled supply flow is essential for cylinder performance. The exhaust flow can be throttled in two different ways, as shown in experiments F12 and F13.

Remarks concerning F12.
Throttling in the ports of the control valves demands separate exhaust port for the plus and minus movements and also requires ports which can be connected. Another requirement is that the valve must be capable of withstanding throttling in the exhaust ports without its function being disturbed.

A throttle valve is simpler and cheaper than a non-returned throttle valve. And can be fitted straight into the valve, which save fittings and simplifies assembly.

Control system s are tending more and more often to be prefabricated and mounted in cabinets, in which case the throttles can be included in the prefabricated control circuit. Cabinets can be locked to prevent undesirable alterations of the throttle settings.

Remarks concerning F13.
The non-returned throttle valve is place directly in the exhaust ports of the cylinder or as close to them as possible.

The supply flows pass through the non-return valve, in its flow direction, while the exhaust flow are forced through the throttles.

When dealing with small cylinders, variable loads and long supply lines between cylinders and control valve, this method gives better velocity control than with obtained with throttling in the exhaust ports of the power valve.

The method shown here cannot disrupt the functioning of the valve and is therefore universally applicable.

F17. MEMORY WITH NEUTRAL FUNCTION

17.1 PROCEDURE

Position the components as shown in the fluid circuit diagram and connect accordingly.

The diagram shows that the 5/2 power valve “V” is bi-stable.

A short pulse from S+ will cause V to switch over (the left square/position is connected). The cylinder then moves plus.

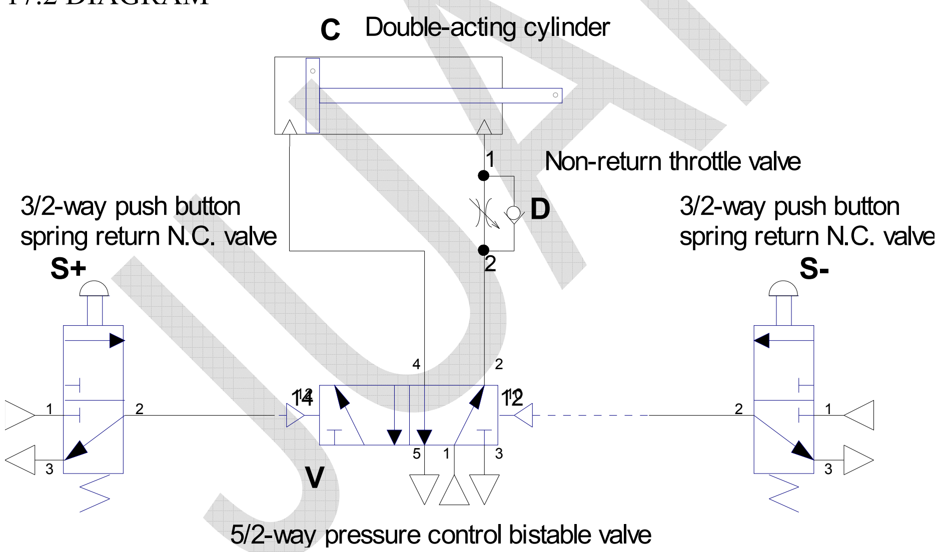
V remains in the position until a pulse from S- repositions it, whereupon the cylinder returns to its minus position.

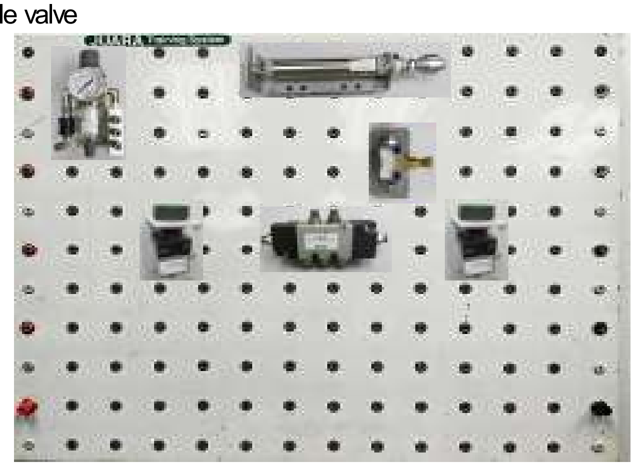
If an attempt is made to give simultaneous signals from S+ and S-, V will respond to the signal which arrives first. It will switch over as long as there is no signal on the opposite side.

A MEMORY of this kind is said to be neutral.

This valve is very commonly used both as a power valve and also in control systems.

17.2 DIAGRAM





F18. MEMORY FUNCTION GIVING PRIORITY TO S+

18.1 PROCEDURE

Add a NOT valve to the circuit diagram in exercise 16.

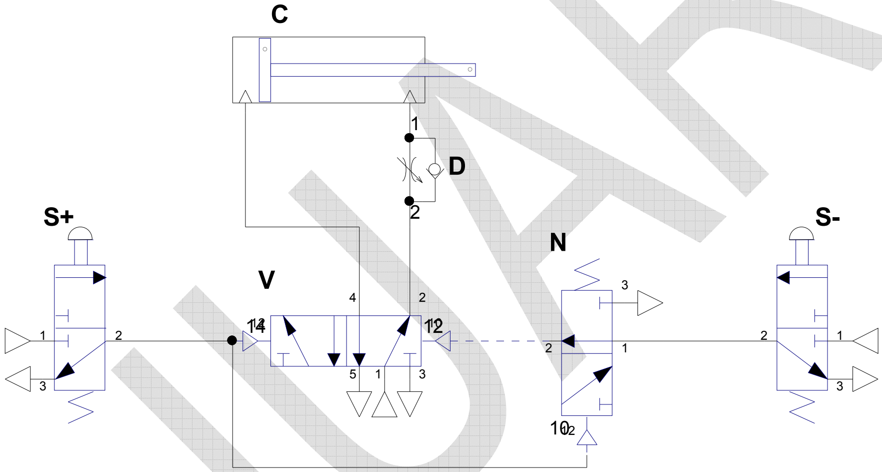
Note that a NOT valve is actually a normally open valve.

Connect up as per the fluid circuit diagram and show that if both S+ and S- are actuated simultaneously, the cylinder will always adopt the plus position, regardless of the order in which S+ and S- are actuated.

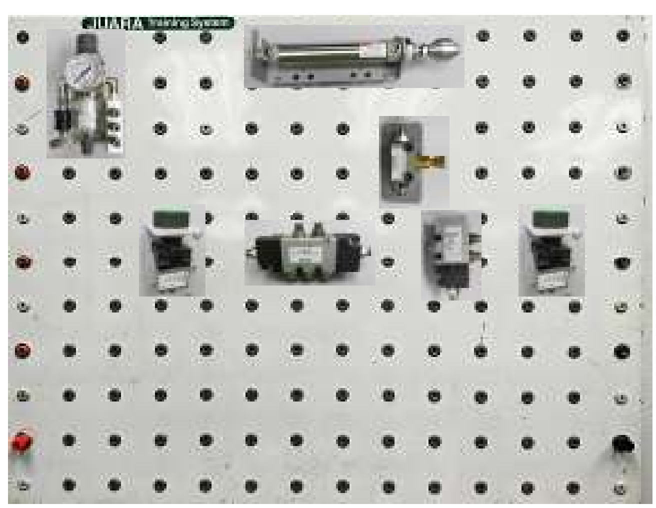
The memory is then said to be S+ dominant, or alternatively S+ is said to have priority.

The diagram shows that once S+ is actuated, the signal output from port no. 2 will actuate the NOT (3/2 normally open) valve making it close at this instance thus the signal from S- is blocked.

18.2 DIAGRAM



3/2-way pressure-control, normally open valve (NOT valve)



F19. MEMORY FUNCTION GIVING PRIORITY TO BASIC SETTING AND WITH THE S- INPUT DOMINANT

19.1 PROCEDURE

The fluid circuit diagram shows an S- dominant memory pneumatic circuit. Connect up as per the fluid circuit diagram and notice that S- is a normally open 3/2 valve, while the Y-valve is a logic element with YES function. The elements are connected here as a passive AND element.

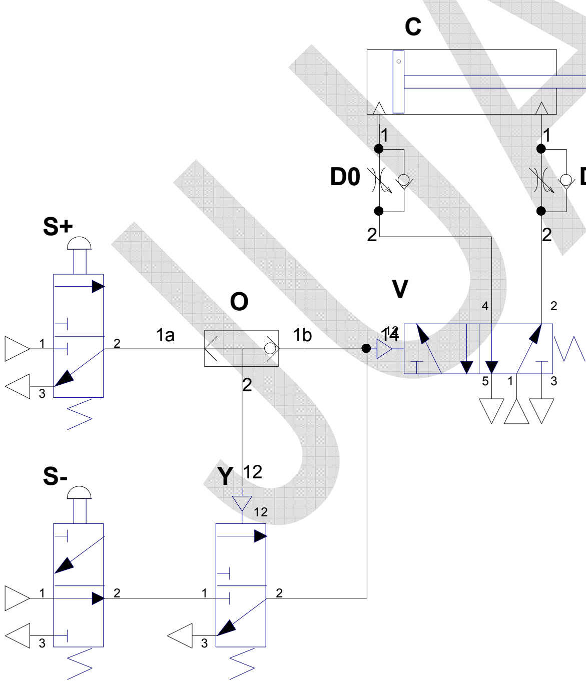
A pulse at S+ causes the YES valve (Y) to receive a pilot signal via the OR valve (O). The power valve (V) then receives a pilot signal via S- and Y, and the cylinder (C) moves plus.

The same signal is reconnected to Y and gives a holding signal. The pilot signal to V will therefore continue even after the signal from S+ has ceased.

When S- is actuated, the pilot line to V is depressurized regardless whether S+ has a signal or not. Thus S- is dominant (has priority).

The basic setting of V will always be that shown by the fluid circuit diagram, i.e. the spring square (normal position) will be connected when the pressure is turned on.

19.2 DIAGRAM



Component layout on the training board

F20. NEUTRAL MEMORY CONNECTION WHERE BOTH OUTPUTS RECEIVE A ZERO SIGNAL WHEN BOTH INPUTS ARE ACTUATED SIMULTANEOUSLY

20.1 PROCEDURE

According to the fluid circuit diagram, the connection incorporates six logic elements, two of which have a YES function while two others have a NOT function and the remaining two have an OR function. Pilot signals are obtained from two manual 3/2 valves.

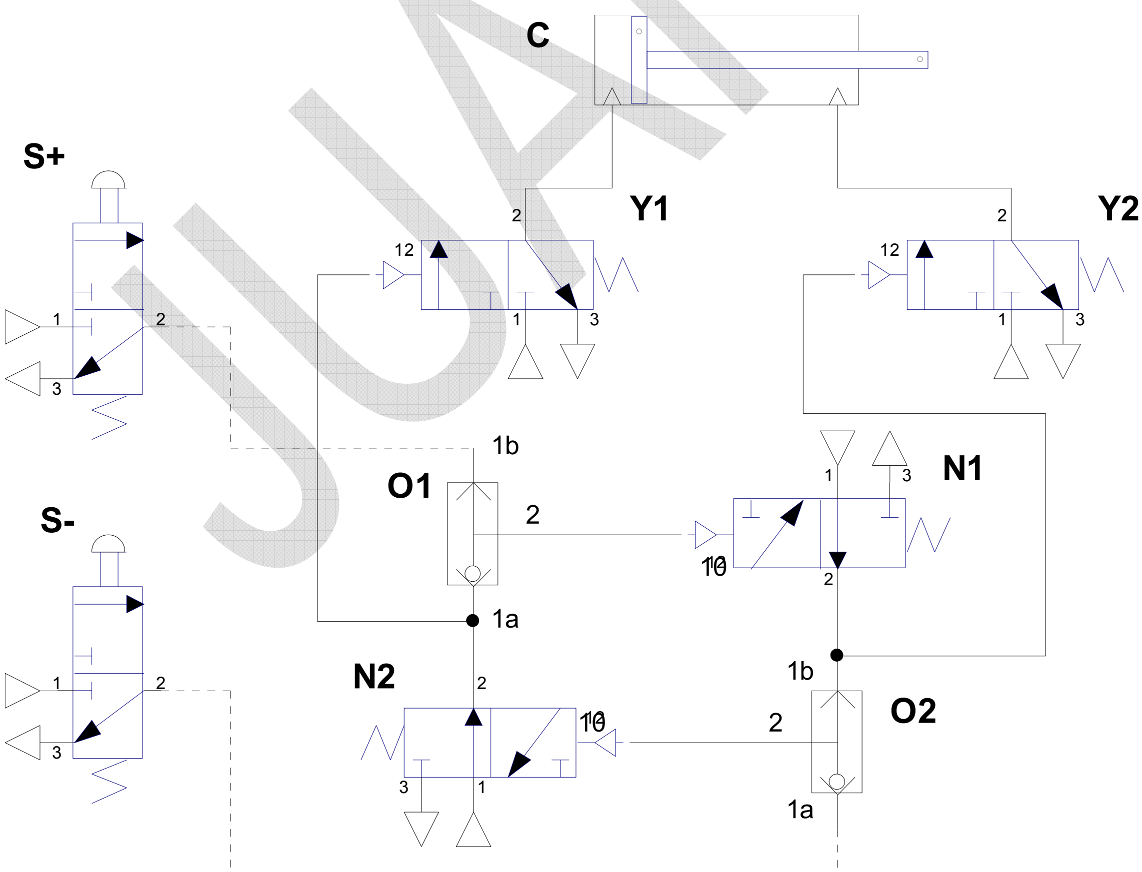
Notice that in the initial situation, Y1 and N2 are actuated, i.e. their control squares are connected.

When S+ is actuated, N1 receives a pilot signal, whereupon Y2 and N2 lose their signals. As a result, Y1 and N1 receives a pilot signal via N2 and the signal at S+ can then be removes.

Thus following the pulse to S+, the circuit has been altered in such a way that Y1 has a signal but not Y2, and subsequently the piston moves plus.

If both S+ and S- are actuated, both Y1 and Y2 are deprived of their signals, whereupon the piston rod can be moved manually (both chambers of the cylinder depressurized).

20.2 DIAGRAM



F21. WORK CYCLE WITH MANUAL START OF PLUS MOVEMENT AND AUTOMATIC RETURN

21.1 PROCEDURE

Pull out the piston rod to the plus position and place valve S1 in such a way that the roller is actuated by the disc on the piston rod end. Now connect up the circuit as shown in the diagram.

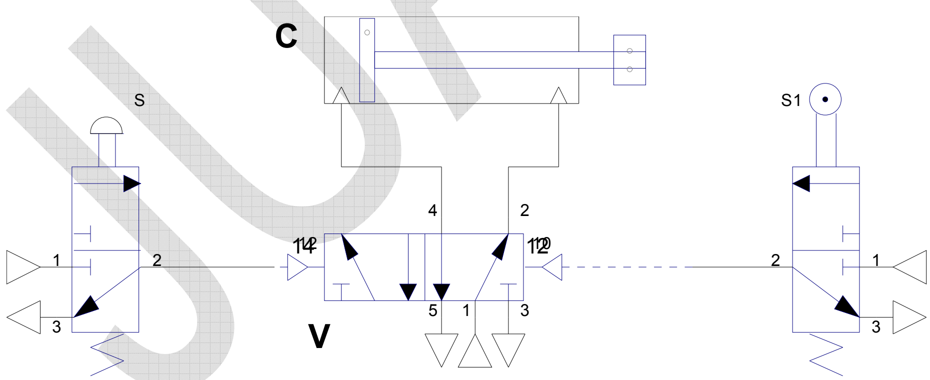
Let us call the cylinders C1, C2, C3......... and the signal valves S1, S2, S3 ....., the figures indicating the cylinders to which the valves belong. If there is only one cylinder in the diagram, it will be denoted by a letter C without any number.

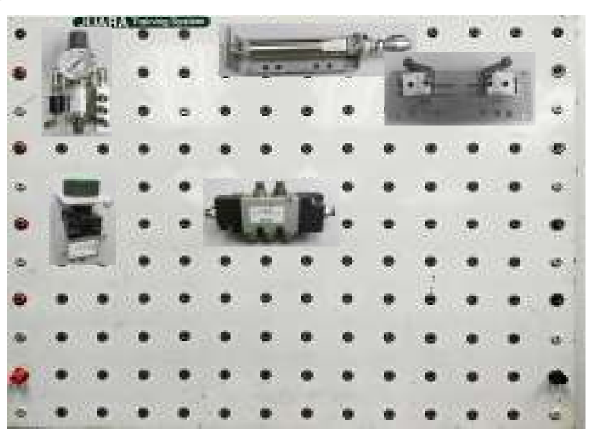
We will adopt a logical approach to the two positions of the cylinder (piston rod), terming the minus position “0” (logical zero) and the plus position “1” (logical one). We will insert the figures as an index to the signal valves.

If, therefore we have a cylinder C, the signal valve in the minus and plus position respectively should be designated as S0 and S1. The corresponding designations for C1 will be S1-0 and S1-1 respectively.

When the start valve (S) is actuated, the power valve (V) receives a pilot signal to the left and the cylinder (C) moves to its plus position, where S1 is actuated. V now receives a pilot signal to the right, and the cylinder moves to its minus position, wher it remains until S is actuated again.

21.2 DIAGRAM





F22. AUTOMATIC WORK CYCLE PROVIDED WITH A START-STOP VALVE

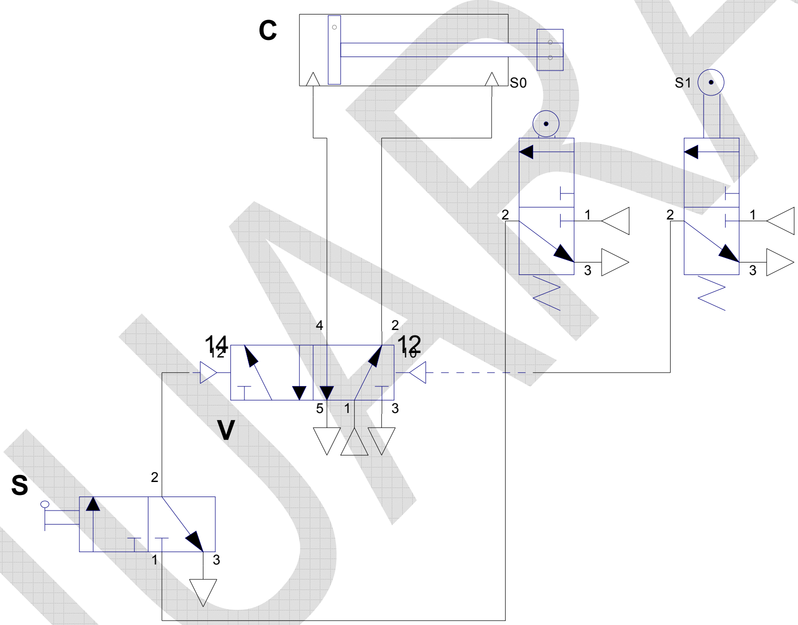
22.1 PROCEDURE

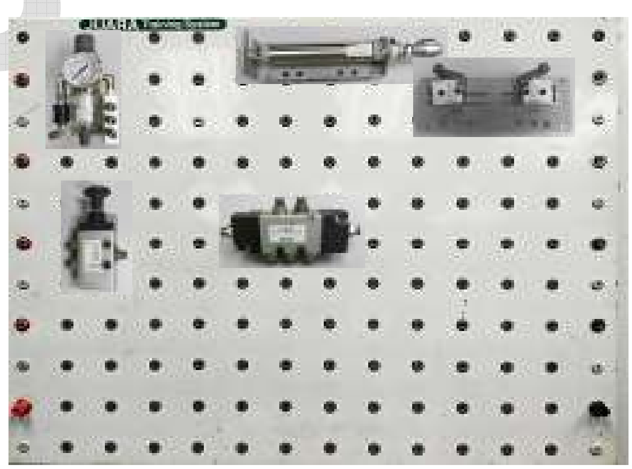
Reference to the circuit diagram in exercise 20, add a signal valve (S0) at the piston rod minus position so that the roller arm of the signal valve is actuated by the disc on the piston rod when the later is in the minus position.

Replace the manual unistable start valve with a bistable 3/2 valve with a turn switch.

In the initial situation S0 is actuated, and the control square must therefore be connected. When the START-STOP valve is put in the START position, the cylinder will automatically move to and fro until the valve is set in the STOP position, whereupon the piston will complete its double stroke and come to rest in the minus position.

22.2 DIAGRAM





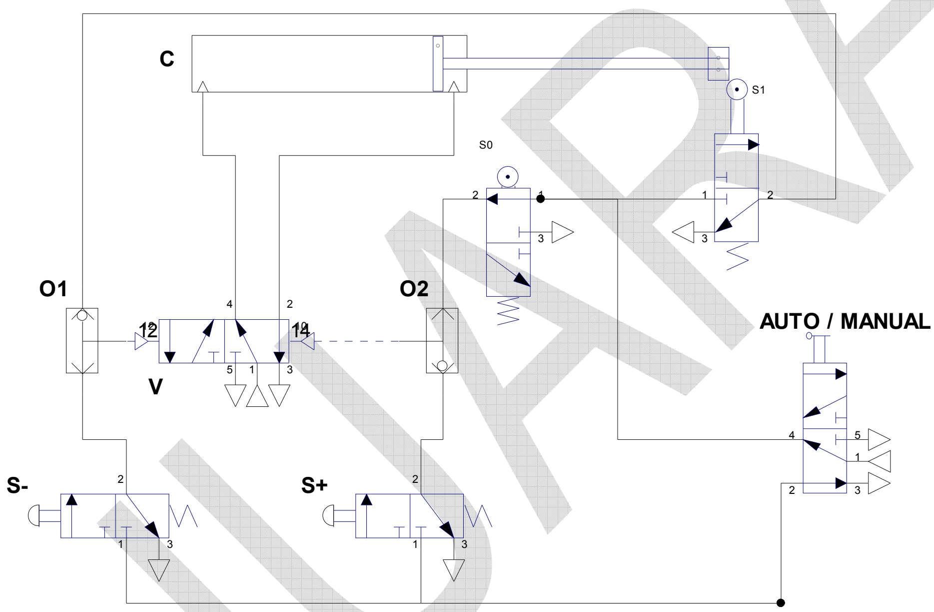
F23. MANUAL OR AUTOMATIC CONTROL OF A DOUBLE ACTING CYLINDER

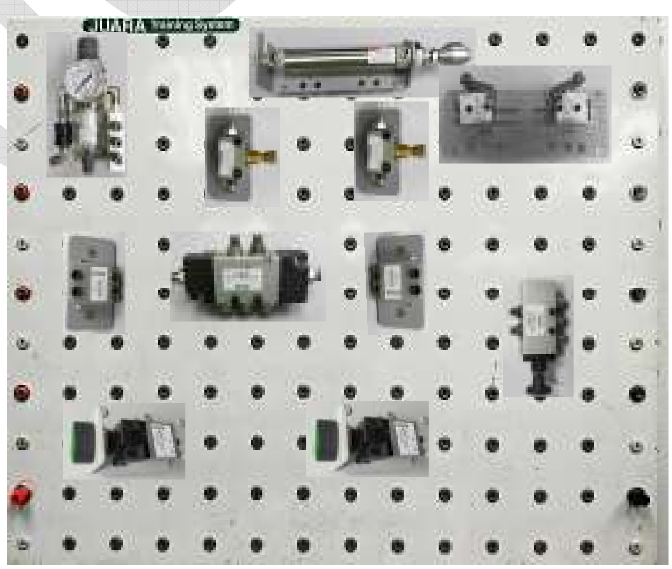
It is often desirable for both manual and automatic control of a cylinder-driven device to be possible. Thus the power valve must be controllable via mechanically or manually operated pilot valves. The control system therefore has to be doubled and supplemented with a control selection valve.

23.1 PROCEDURE

Start by placing all the components included in the fluid circuit diagram in suitable positions on the training board. Use a bistable manual 5/2 valve as a MANUAL - AUTO switch-over valve (push-pull operated). If connected in accordance with the fluid circuit diagram, this valve will give a manual cycle when pressed and an automatic cycle when pulled.

23.2 DIAGRAM





F24. AUTOMATIC WORK CYCLE PROVIDED WITH EMERGENCY STOP

24.1 PROCEDURE

A bi-stable 5/2 valve is to serve as a START - EMERGENCY STOP. When the valve is set to START, a cylinder is to perform an automatic reciprocating movement. When the valve is set to EMERGENCY STOP, the work cycle is to curtailed and the cylinder is to move immediately to the minus position and remain there.

Draw the pneumatic circuit diagram by using the components given below. Test the fluid circuit diagram afterwards and show that the given requirements are satisfied.

24.2 DIAGRAM