Feedback

Electro-Pneumatic Trainer - Tutor Notes & Workbook

36-200

- Computer Assisted Learning
- Electricity & Electronics
- Control & Instrumentation
- Process Control
- Mechatronics
- Robotics
- Telecommunications
- Electrical Power & Machines
- Test & Measurement

Technology Training for tomorrow's world

Electro-Pneumatics Trainer
Tutor Notes & Workbook

36-200

Feedback

Feedback Instruments Ltd, Park Road, Crowborough, E. Sussex, TN6 2QR, UK.
Telephone: +44 (0) 1892 653322, Fax: +44 (0) 1892 663719.
email: feedback@fdbk.co.uk website: http://www.fbk.com

Manual: 36-200 Ed01 072001 *Printed in England by FI Ltd, Crowborough*

Feedback Part No. 1160–36200

Notes

THE HEALTH AND SAFETY AT WORK ACT 1974

We are required under the Health and Safety at Work Act 1974, to make available to users of this equipment certain information regarding its safe use.+

The equipment, when used in normal or prescribed applications within the parameters set for its mechanical and electrical performance, should not cause any danger or hazard to health or safety if normal engineering practices are observed and they are used in accordance with the instructions supplied.

If, in specific cases, circumstances exist in which a potential hazard may be brought about by careless or improper use, these will be pointed out and the necessary precautions emphasised.

While we provide the fullest possible user information relating to the proper use of this equipment, if there is any doubt whatsoever about any aspect, the user should contact the Product Safety Officer at Feedback Instruments Limited, Crowborough.

This equipment should not be used by inexperienced users unless they are under supervision.

We are required by European Directives to indicate on our equipment panels certain areas and warnings that require attention by the user. These have been indicated in the specified way by yellow labels with black printing, the meaning of any labels that may be fixed to the instrument are shown below:

CAUTION -
RISK OF
DANGER

CAUTION -
RISK OF
ELECTRIC SHOCK

CAUTION -
ELECTROSTATIC
SENSITIVE DEVICE

Refer to accompanying documents

PRODUCT IMPROVEMENTS

We maintain a policy of continuous product improvement by incorporating the latest developments and components into our equipment, even up to the time of dispatch.

All major changes are incorporated into up-dated editions of our manuals and this manual was believed to be correct at the time of printing. However, some product changes which do not affect the instructional capability of the equipment, may not be included until it is necessary to incorporate other significant changes.

COMPONENT REPLACEMENT

Where components are of a 'Safety Critical' nature, i.e. all components involved with the supply or carrying of voltages at supply potential or higher, these must be replaced with components of equal international safety approval in order to maintain full equipment safety.

In order to maintain compliance with international directives, all replacement components should be identical to those originally supplied.

Any component may be ordered direct from Feedback or its agents by quoting the following information:

1. Equipment type	2. Component value
3. Component reference	4. Equipment serial number

Components can often be replaced by alternatives available locally, however we cannot therefore guarantee continued performance either to published specification or compliance with international standards.

CE DECLARATION CONCERNING ELECTROMAGNETIC COMPATIBILITY

Should this equipment be used outside the classroom, laboratory study area or similar such place for which it is designed and sold then Feedback Instruments Ltd hereby states that conformity with the protection requirements of the European Community Electromagnetic Compatibility Directive (89/336/EEC) may be invalidated and could lead to prosecution.

This equipment, when operated in accordance with the supplied documentation, does not cause electromagnetic disturbance outside its immediate electromagnetic environment.

ACKNOWLEDGEMENTS

Feedback Instruments Ltd acknowledge all trademarks.

IBM, IBM - PC are registered trademarks of International Business Machines.

MICROSOFT, WINDOWS 98, WINDOWS 2000, WINDOWS 95, WINDOWS 3.1 are registered trademarks of Microsoft Corporation.

Electro-pneumatic systems are used widely in industry and provide manufacturers with the ability to carry out complicated operations with great speed and accuracy. As the title implies two different power sources are used to drive and control a system.

First is electricity, which may be quoted as alternating current (ac) or direct current (dc) and is used to operate everything from washing machines, televisions, Street lighting, trains, and much of the machinery used in industry today.

Second is compressed air (pneumatic), which is air taken from the atmosphere we breathe and forced into a small space. We compress air every time we blow up a balloon or pump up a bicycle tyre. Compressed air is also used to inflate car tyres, operate dentist drills, bus/train doors, road drills, and many industrial machines. In an electro-pneumatic system the 'pneumatics' provides driving elements, which create the movement, required to perform a task, whilst the 'electrics' control the pneumatic equipment.

This training manual is designed to be used in conjunction with the 'Mechatronics Electra Pneumatics Tutor Kit' to provide a self-contained course that will be user friendly to the student.

Every section in this book contains information on a particular aspect of electro-pneumatics together with theoretical and/or practical activity to help you to develop your understanding of the subject.

Notes

TABLE OF CONTENTS

SECTION 1

Safety requirements when using pneumatics		13
What is pneumatics		15
Applications of pneumatics		17
History of pneumatics		19
Pascal's law		20
Concept of power transmission		21
Pressure		22
Effect of altitude on pressure		23
Comparison of pressure measurements		24
Introduction to basic pneumatics		25
The basic concept of a pneumatic system		26
Atmosphere		27

SECTION 2

Introduction to basic pneumatics		32
System layout		34
Compressed air equipment – selection guide		35
Factory air service system		36
Compressor types:	Reciprocating piston compressor (single-stage) and (two-stage) Rotary vane compressor	37
Air receivers		40
Pressure gauge		41
Pressure relief valve		42

SECTION 2 (continued)	Air preparation and conditioning		43
	Air drying		44
	Air dryers		45
	Air mains		48
	Correct air line installation		51
	Compressed air servicing		52
	Filter (with manual drain)		53
	Particle size		54
	Automatic drain unit (for filter)		55
	Pressure regulator		56
	Venturi action to transfer lubricant into the air system		58
	Lubricator and lubrication		59
	The concept of power transmission		61
	Cylinders:	Single acting, double acting Multi-position, magnetic sensing and rodless	37
	Cylinder cushioning (adjustable)		68
	Cylinder mountings		69
	Directional control valves		70
	Solenoid valves		80
	Various methods of sealing found on 5/2 way valves		85
	Port labelling for pneumatic valves		86
	Ports labelled to ISO 5599 (5 port valves only)		87
	Examples of labelling for 3 port valves		88
	Pneumatic symbols in accordance with ISO 1219-1		89
SECTION 3	Introduction		93

Contents

SECTION 4	Safety requirements when using electricity	100
	Formulae	103
	What is electricity	104
	Principles of electrical energy	105
	The electron theory	106
	Conductors	109
	Electron flow in a conductor	110
	Direction of current flow	111
	Current, voltage and resistance	112
	Ohm's law	115
	A basic electric circuit	117
	How electricity is produced via: Heat, Friction Chemical action, Light, Pressure and Magnetism	119
	Electrical symbols	126
	Pushbutton, toggle and roller-operated switches	127
	Modern relays	133
	Electrical switch notation	139
SECTION 6	Exercises and Operational procedures	153
	Circuit explanations and Question Papers	153
SECTION 7	Answers to Question Papers	317

Pages 11 and 12 are not used

Section 1

Safety requirements when using pneumatics

What is pneumatics?

Applications of pneumatics

History of pneumatics

Pascal's law

Concept of power transmission

Pressure

Introduction to basic pneumatics

The basic concept of a pneumatic system

Atmosphere

This page has intentionally

been left blank

Safety Requirements when using Pneumatics

General

With any type of engineering there is always potential hazards regarding health and safety requirements whilst working with pneumatics. In a controlled situation, pneumatic devices and systems are safe. However if they are used incorrectly, they can present serious hazards to the user.

Most hazards can be avoided by using a little logic and simple common sense. The following advice will help with the safety requirements required for pneumatics.

- ✓ Due to compressed air used with pneumatics being very powerful, it is important never to point a live airline at yourself or anyone else, as this can cause severe damage to the skin or eyes and can even be fatal.
- ✓ Safety goggles should be worn at all times to prevent anything being blown into your face, or someone else's. If a compressed air jet is pointed at the eyes this could cause a serious injury. Also all loose particles should be removed from workbenches before switching on the compressed air, as these can be blown up into the face by exhaust air from the pneumatic cylinders.
- ✓ Care needs to be taken with regard to open cuts to your skin. Make sure any open cuts, wounds, etc are covered with a plaster before commencing work with pneumatics and the compressed air supply. If this precaution is not carried out then compressed air can be forced through an open cut into the blood vessels and cause a similar illness to the 'bends' (as suffered by divers).

Safety Requirements when using Pneumatics

- ✓ Before using the pneumatic equipment and compressed air supply, make sure that all pipe work is secure. Loose pipes can whiplash violently if air is passed through them.
- ✓ Once the circuit is built, consult with your teacher to check that it is safe before commencing any further.
- ✓ Whilst using pneumatic equipment and compressed air you should never try to stop components in motion with your hands. Compressed air can store a great deal of energy, and pneumatic components can have very powerful movement.

What is Pneumatics?

Pneumatics is the use of compressed air to do a job of work. This may be work, which is repetitious, hazardous to operators, heavy, taking place in an unfriendly environment, needing accuracy, or speed of production.

The compressed air that is used as a medium of power is quite simply air that has been taken from the atmosphere and then put through a compressor to compress it to suitable pressure, a typical pressure that is used in modern factories is 6 bar (87 psi). Once the air is compressed, it should be passed through an after cooler, air receiver and air dryer to condition it.

The airline installation around the factory must also be designed and installed correctly for an efficient system, an efficient system is one that will deliver the required amount of air to the point of use without overloading the compressor and with the air clean and dry so that it does not create blockages in the pneumatic equipment. This is essential as pneumatic equipment is extremely reliable provided the air supplied to it is of good quality, a little investment at the production and conditioning stage will pay dividends at the machine (or process) due to less breakdowns.

What is Pneumatics?

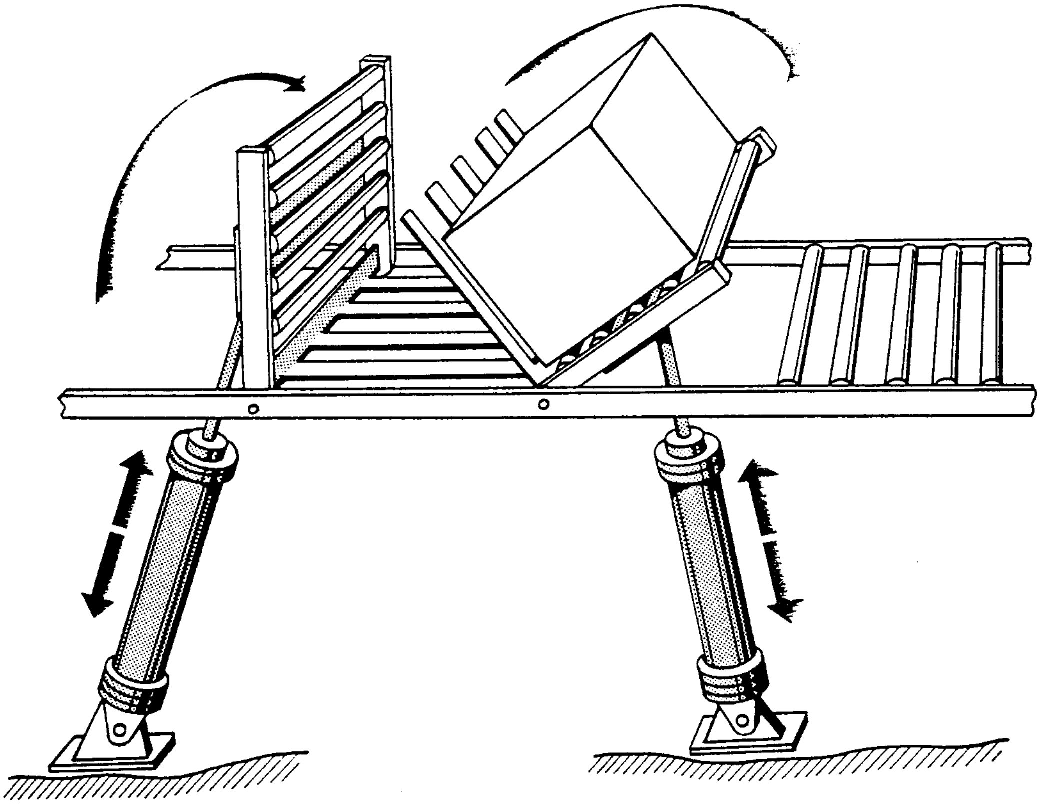
Pneumatics is widely used in most industries as a popular means of getting 'low cost automation' some examples being:

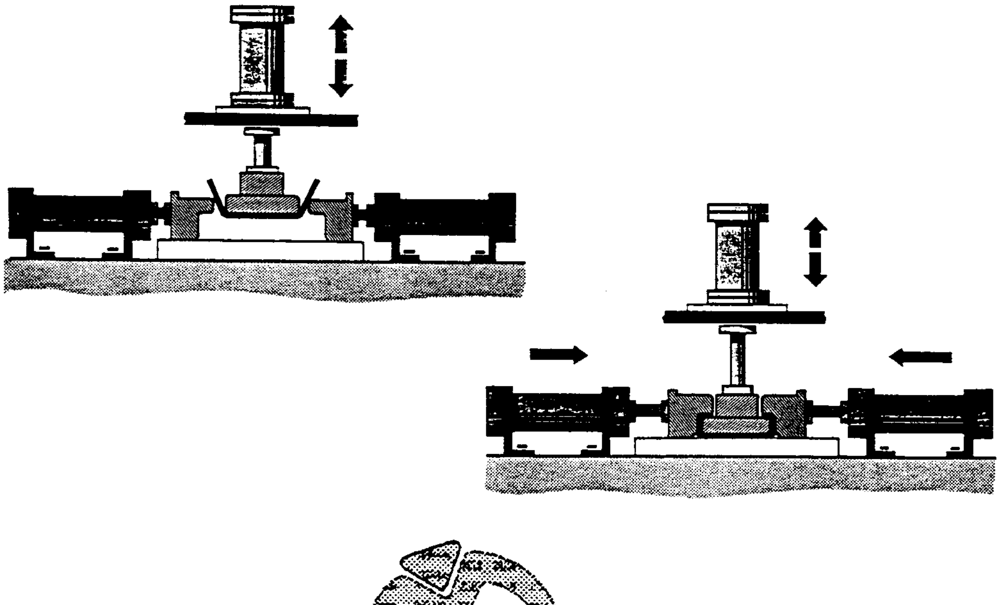
- Automobile manufacture, where it is used on robots for feed and gripper operations, also used on non-robotic operations for clamping, feeding, lifting and stamping, etc.

- Packaging machines, due to speed of operation, pneumatics is often used to do the work, with electronics performing the signal processing.

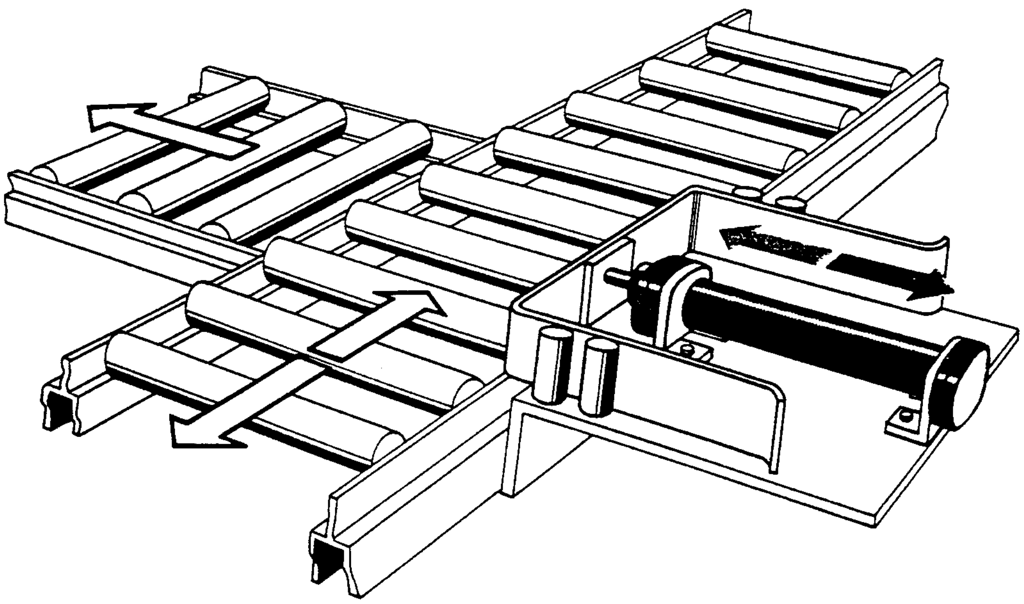
- Ammunition, gases, petrochemical manufacturing, and processing, due to the obvious dangers associated with sparks, etc. Pneumatics is often used in preference to electrics in these environments, (compressed air itself cannot cause a spark and sometimes special equipment is used that will not generate a spark on contact e.g. brass or stainless steel).

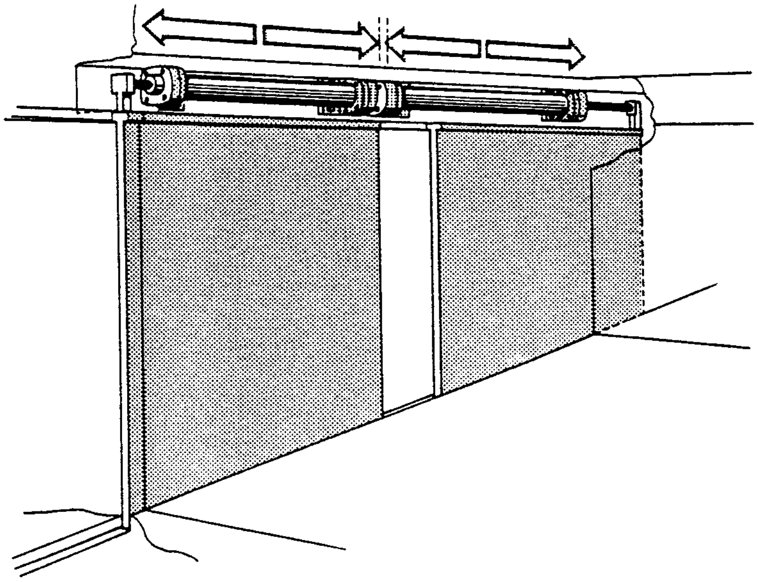
Applications of Pneumatics





Applications of Pneumatics





History of Pneumatics

Compressed air has been used as a medium of power for more than 2,000 years, its first recorded use being in the Grecian wars. In modern times pneumatics started in pumping stations in Paris, France and on tunnelling projects in the Alps. For industrial applications, as we think of them today, in factory automation, pneumatics really started in the 1950's and has been growing in use and stature ever since.

Today's equipment ranges from the ultra-miniature valves (some smaller than the size of a postage stamp) to larger valves (2½" and above) widely used in the process industry.

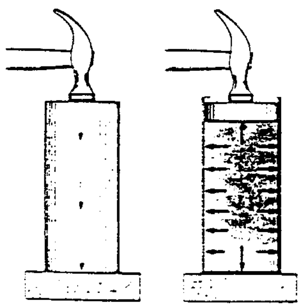
Recent developments have in numerous cases eliminated the need for lubricating the valves and cylinders (depending upon manufacturer and environment). It is important to remember that too much lubrication will cause more harm than too little, so if in doubt start by not lubricating and then increase the amount of lubricant rather than vice versa. The type and grade of oil used as a lubricant may differ according to the make of the equipment being used, and the ambient temperature(s) involved, always check with the equipment supplier, never guess.

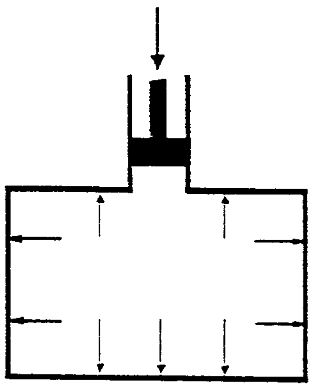
Pascal's Law

Transmission of force by fluids

When one end of a solid material bar is struck, e.g. with a hammer, the main force of the blow is transmitted straight through the bar to the opposite end. The direction of the blow determines the direction of the major force transmitted. The more rigid the bar, the less force is either lost in it, or transmitted at angles different to the direction of the blow.

When a force is applied to the end of a column of a confined fluid, that force is transmitted straight through the column to its opposite end, but also equally undiminished in every other direction, sideways, downwards, and upwards. Pascal's law defines this physical behavior. Pascal's discovery has opened the way to the use of confined fluids for power transmission and force multiplication.





Blaise Pascal (1623-1662) also discovered that pressure is equal to force per unit area, or the force divided by the area on which it acts. Pascal's law states that pressure applied to a static and confined fluid is transmitted undiminished in all directions and acts with equal force on equal areas and at right angles to them.

The Concept of Power Transmission

Power is the measure of a defined force moving through a given distance at a given speed. To understand this fundamental concept, the term force must now be explained.

Force may be defined as any cause, which tends to produce or modify motion. Due to inertia, a body at rest tends to stay at rest, and a body in motion tends to maintain that motion until acted upon by an external force. Force is measured in Newton.

The concept of pressure must also be explained. Pressure is force per unit area and is expressed in Pascals (**Pa**). Both force and pressure are primarily measures of effort. A force may be acting upon a motionless object without moving the object, if the force is insufficient to overcome the inertia of the object.

Pressure

The force exerted on one square centimetre by a column of air that reaches from sea level to the outermost layer of the atmosphere is about 10.13 Newton. Thus at sea level the absolute atmospheric pressure is about 10.13.104 Newton per square metre. One Newton per square metre (**N/M^2**) is also called a Pascal (**Pa**), 10^5 Pa = 1 Bar. The absolute pressure at sea level is thus approximately 1 bar.

Work is a measure of accomplishment, for example, the piston of a pneumatic actuator exerts a force on an object over a given distance. Thus, work has been accomplished.

The concept of work, however, makes no allowance for time. The SI – unit of work is the Joule. 1 Joule (J) = 1 Newton metre (**Nm**).

Pressure

There are 3 methods (units) used to measure pressure:

1) Pounds per square inch (p.s.i.) – (imperial system)

2) Bar (atmospheres) – (metric system)

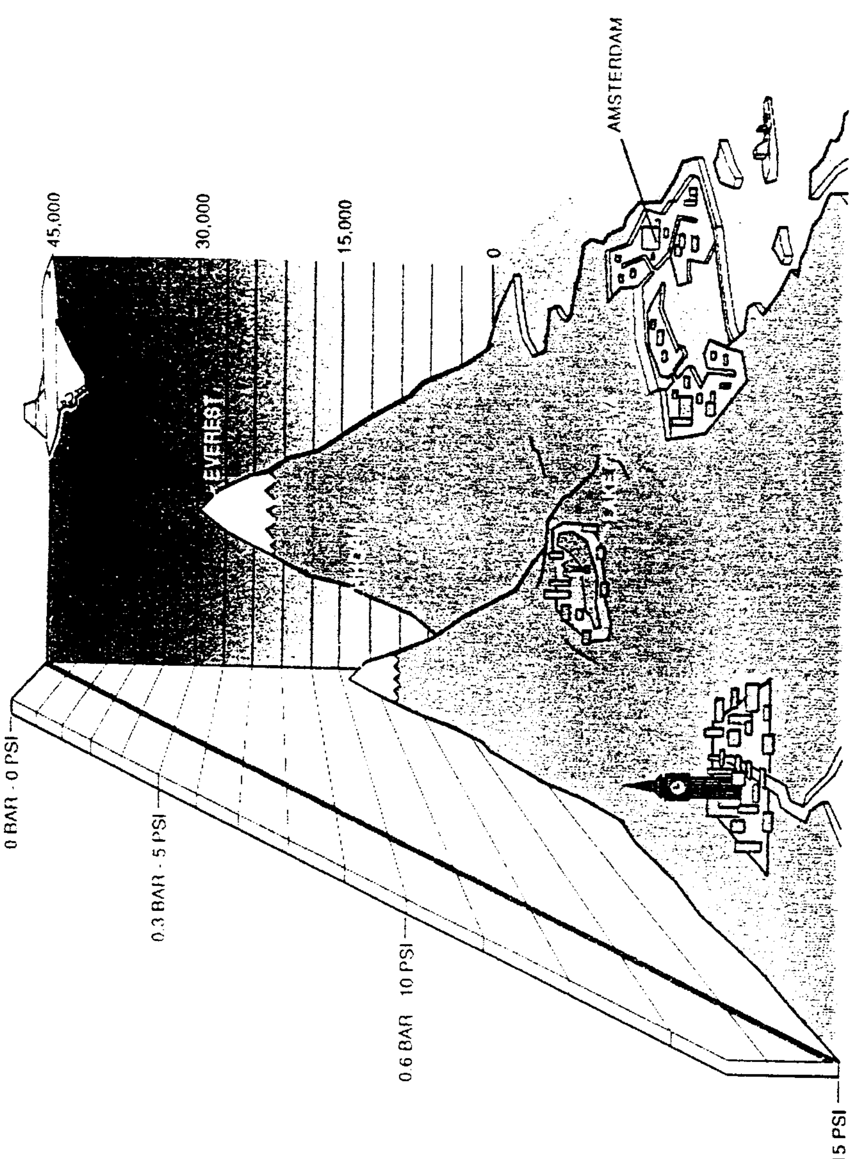
3) Pascal – (S.I. system)

The preferred method (and the most practical) is the "BAR".

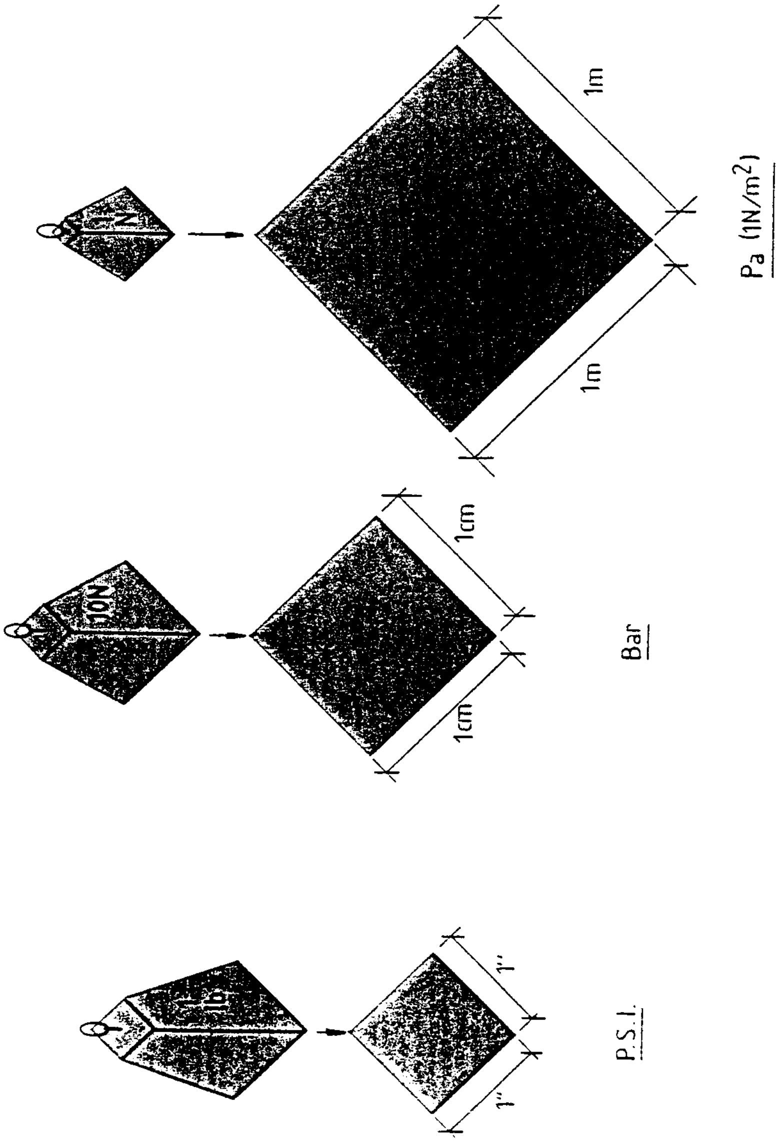
P.S.I. (lbf/sq. in)		BAR		Pascal
14,5	=	1	=	100,000 Pa (100 kPa) (10^5 Pa)

The component used to measure pressure is a gauge, a sample of which is shown below.

Effect of Altitude on Pressure

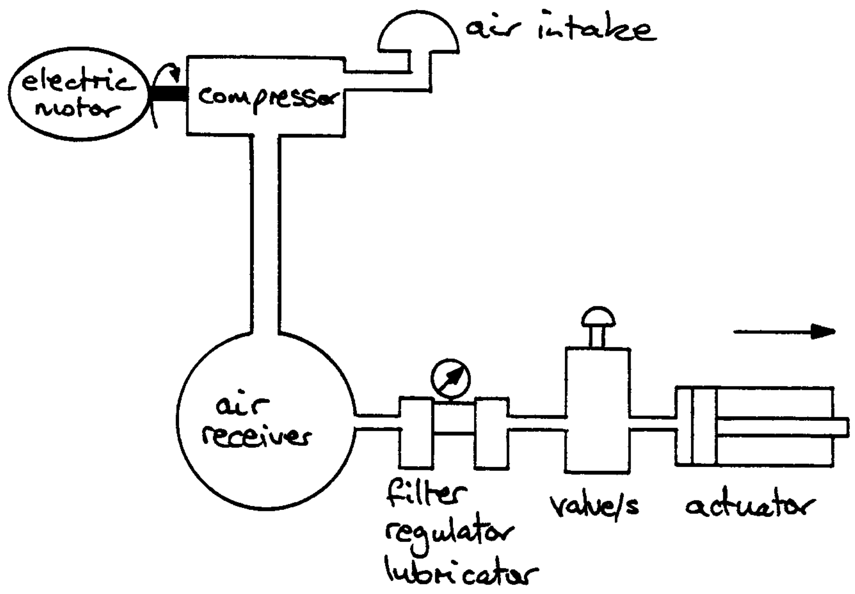


Comparison of Pressure Measurements



Introduction to Basic Pneumatics

Any system, which uses the energy stored in compressed air to do useful work, is called a **pneumatic system**. (The work 'pneumatic' comes from the Greek word for 'wind' or 'air').



In industry, atmospheric air is compressed by a special pump called a compressor, which is generally driven by an electric motor. The **compressor** forces the air into a strong storage tank called a **receiver**. What has happened is that the motor has used electrical energy. This energy has driven the compressor and most of the energy is now stored in the receiver as compressed air (energy conversion). We have in fact a tankful of energy, which can now do useful work.

The Basic Concept of a Pneumatic System

Pneumatics is the engineering science of pneumatic pressure, pneumatic potential energy production, and its use in linear and rotary actuators and finally the use of compressed air as a signal carrier for the achievement of logical sequential and combinational control. Such pneumatic systems may include:

- Compressors which convert available power from an electric motor or internal combustion engine to pneumatic power at the actuator.
- Valves that control the direction of air flow to the actuators or process logic signalling functions to achieve sequential control of pneumatic actuators.
- Pressure and flow control valves that control the level of power produced on the actuators and pneumatic motors.
- Actuators that convert potential energy of the compressed air into usable mechanical power output at the point required.
- Connectors that link the various system components to provide power conductors for the compressed air in motion or in a static condition.
- Sufficient quality conditioning and storage equipment, which ensure quality and cleanliness as well as lubrication of the compressed air to provide a trouble free working life for its actuators and valves.

Atmosphere

Atmosphere
|
Intake Filter
|
Compressor (intercooler)
|
After Cooler
|
Air Receiver
|
Air Dryer
|
Air Main Installation
|
Take off point for machine
|
ON/OFF Valve
|
Filter/Regulator/Lubricator
|
Valves (Pressure, Direction, Flow)
|
Actuators (Cylinders, Motors)

This page has intentionally

been left blank

Section 2

Introduction to basic pneumatics

System layout

Compressed air equipment – selection guide

Factory air service system

Compressor types: Reciprocating piston compressor (single stage) and (two stage)
Rotary vane compressor

Air receivers

Pressure gauge

Pressure relief valve

Air preparation & conditioning

Air drying

Air dryers

Air mains

Correct air line installation

Compressed air servicing

Filter (with manual drain)

Particle size

Automatic drain unit (for filter)

Pressure regulator

Venturi action to transfer lubricant into the air system

Lubricator and Lubrication

The concept of power transmission

Cylinders: Single acting, Double acting, Multi position, Magnetic sensing, and Rodless

Cylinder cushioning (adjustable)

Cylinder mountings

Directional control valves

Solenoid valves

Various methods of sealing found on 5/2 way valves

Port labeling for pneumatic valves

Ports labelled to I.S.O. 5599 (5 port valves only)

Examples of labelling for 3 port valves

Pneumatic symbols in accordance with ISO 1219-1

This page has intentionally

been left blank

Introduction to Basic Pneumatics

Compressed Air Production and Conditioning

- Compressors
- Receivers
- Dryers

Compressed Air Distribution and Airline Installation

- Installation criteria
- Pipe work

Service Units

- Filters
- Pressure regulators
- Lubricators

Power Components (Working Elements)

- Cylinders: Single Acting
  Double Acting
  Cushioning

Introduction to Basic Pneumatics

Directional Control Valves

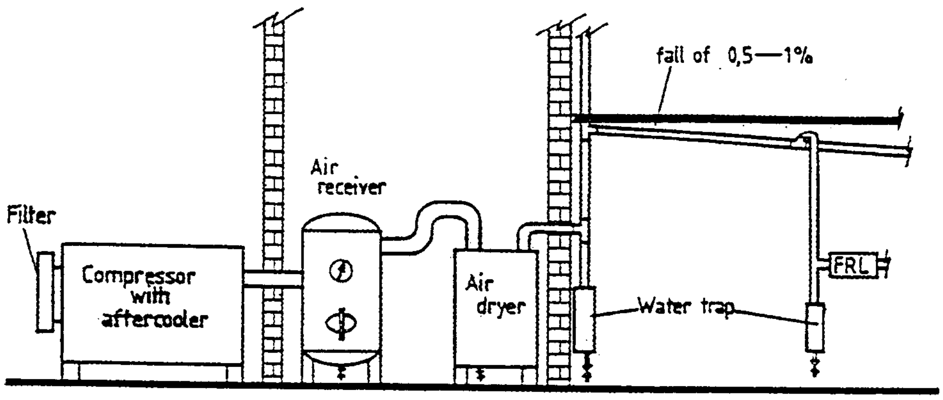
- Design, construction, and method of operation of:

  2/2 way, 3/2 way, 4/2 Way, 5/2 Way, 4/3 Way,
  5/3 Way, 5/4 Way

- Means of operations:

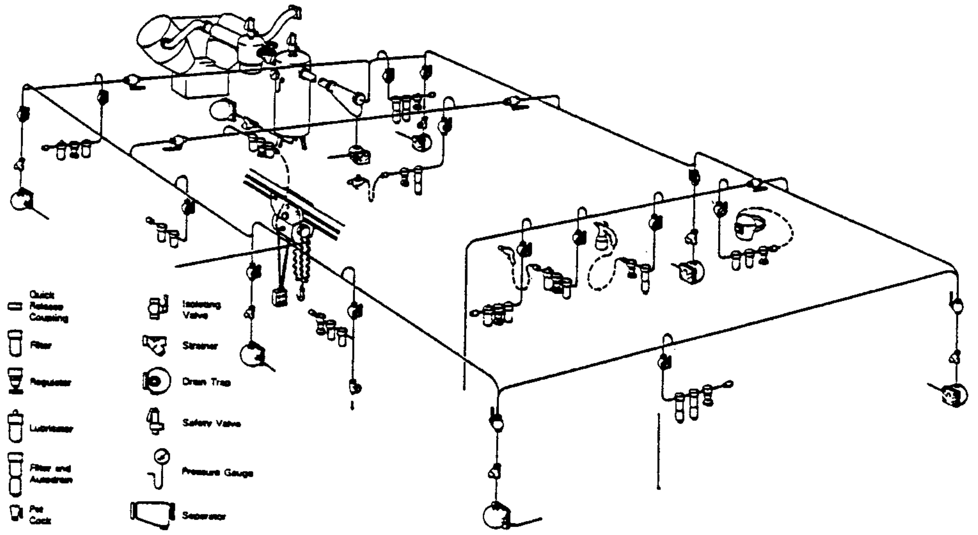
  Push Button, Foot Pedal, Pilot, Differential Pilot,
  Roller Lever, Idle Return Roller, Solenoid, Spring

System Layout

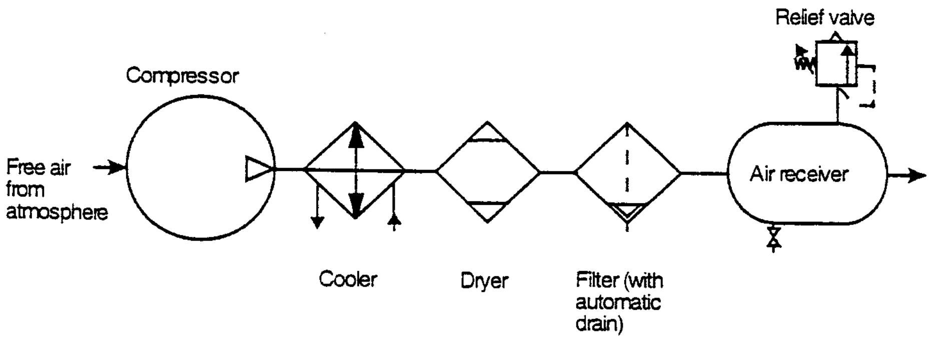


This diagram shows a typical system layout. Air is taken from the atmosphere into the compressor (the cooler the air the better) upon compression it is passed via an after cooler to the air receiver (ideally placed outdoors) once it has passed through the air receiver it is then dried before entering the airline installation. Compressed air pipe work should be run with a downhill gradient of 0,5 – 1,0% this will allow any condensation present to run downhill to the lowest point where it can be drained from the system. Air for use should ALWAYS be taken from the top of the air main and be passed through a service unit (FRL) to condition it correctly. Any dead legs should be fitted with water traps, wherever the air main rises it should do so via a tee (never an elbow or bend) with one side of the tee to a water trap (with drain cock).

Compressed Air Equipment – Selection Guide



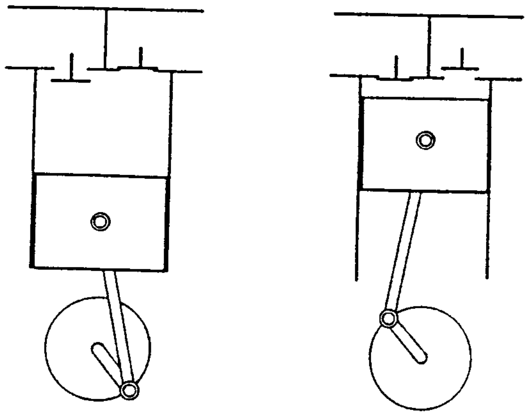
Factory Air Service System

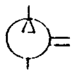


Compressed air for factory use, must first be conditioned to ensure that it is clean dry and cool before it is distributed to the working locations. Air plant like other fluid power systems can deliver useful results even when badly designed and poor quality, inefficient compressed air systems are not uncommon. However, careful attention to every feature of a system to give maximum efficiency and minimum maintenance, costs little more but results in much reduced running and maintenance costs.

Compressor Types

Reciprocating Piston Compressor (Single stage)





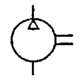
The unit consists of a piston connected via a conrod to a crankshaft, which can be driven, by either an electric motor or an internal combustion engine.

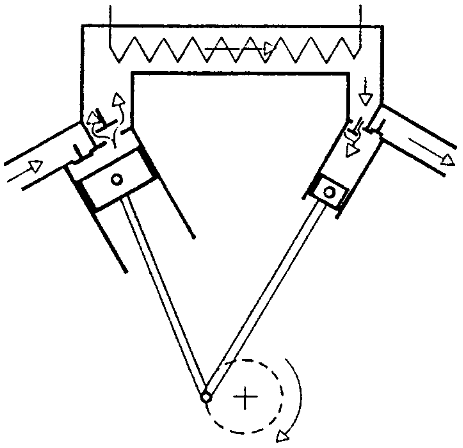
The piston reciprocates up and down the compressor chamber and as it does so, the inlet and outlet valves are opened and closed accordingly. As the piston goes down the outlet valve is closed and the inlet valve is open allowing atmospheric air to be drawn into the chamber at bottom dead centre (the largest chamber, volume) the inlet valve is closed the piston starts to rise in the chamber thus reducing the chamber volume, this increases the pressure of the air trapped in the chamber, at a certain predetermined pressure the outlet valve is opened and the pressurised air is passed through the compressor outlet and then onto the place of use.

The ISO/BS symbol for a compressor (regardless of make, size, model, etc) is shown in the top right hand corner.

Compressor Types

Reciprocating Piston Compressor (Two stage)



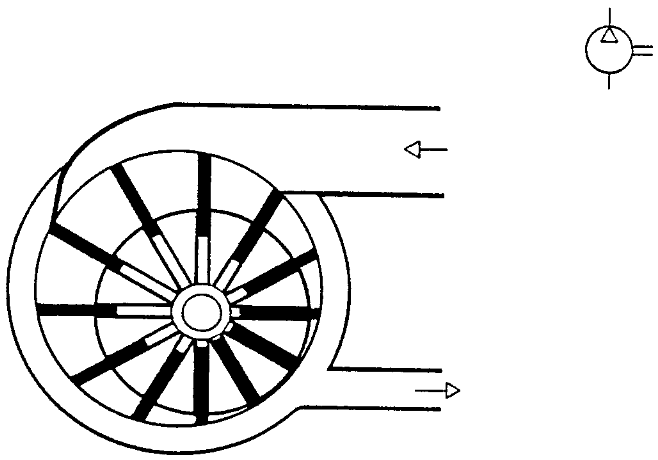


This unit is similar to the previous piston compressor but is has a second stage, this will allow the pressurised air from the first stage to enter the second stage as inlet air, this is then compressed again, subsequently the outlet pressure from the second stage is of a considerably higher pressure. The actual ratio of compression can vary from manufacturer to manufacturer but a 4:1 ratio is quite common. Therefore, if the first stage delivers 4 bar, then the second stage will deliver 16 bar (less any pressure drop associated with air leaks and/or friction losses within the compressor).

Situated between the two stages is an intercooler, this item as its title suggests is used to cool the temperature of the compressed air and thereby reduce the amount of water that it can hold, it is referred to as 'inter' due to its position a similar unit located downstream of the compressor would be called an aftercooler. Chilled water is passed through the coil of the cooler and compressed air passes around this, the air temperature is reduced in this process.

Compressor Types

Rotary Vane Compressor

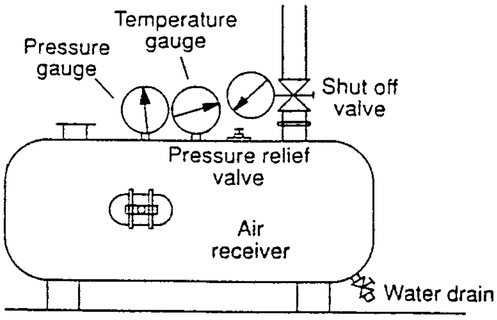


Vanes are located in slots within an eccentric shaft and as the shaft rotates the vanes are thrown out to the wall of the compressor chamber by means of centrifugal force. The lubrication within the compressor provides the seal between the vane/s and the chamber wall.

As the shaft rotates air is drawn in from atmosphere at the largest chamber volume (lowest pressure) and is trapped between two vanes, the shaft continues to rotate and in so doing the vanes are pushed in and the volume therefore reduces causing an increase in pressure until at the smallest volume (highest pressure) the air is released to the outlet of the compressor.

This type of compressor can be smoother in operation than the piston compressor however, the piston compressor will generally give a greater output (pressure and volume).

Air Receivers

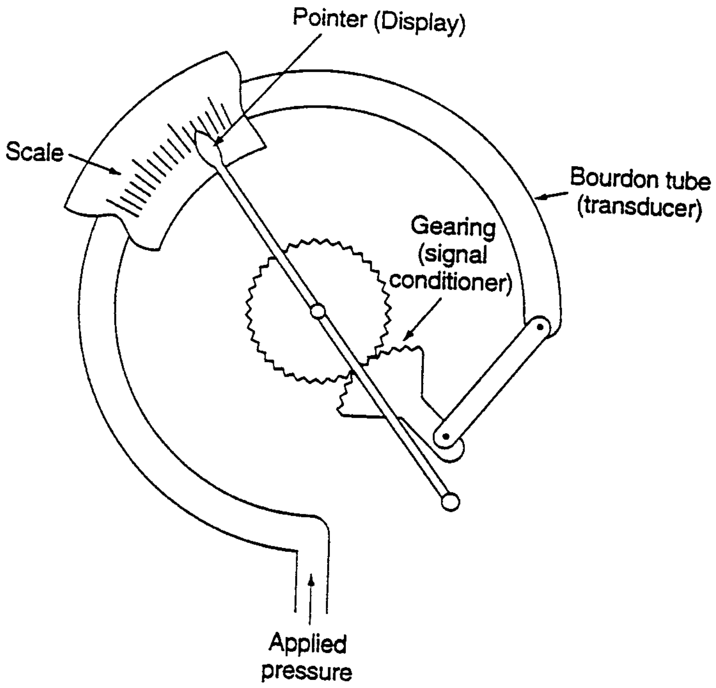


This item of equipment has a number of functions as follows:

- To hold a reserve of compressed air to assist the compressor when pressure peaks occur.
- To smooth out pressure surges coming from the compressor especially in the case of large piston compressors.
- To provide a large surface area to assist in the cooling of the air held within the receiver (ambient temperature outside the unit will be lower than the internal air temperature).
- To provide the relief of excess pressures that may occur in the compressed air system and have not been relieved elsewhere (SAFETY!).

To achieve best results the receiver should be fitted with a pressure gauge (showing internal air pressure) thermometer (showing internal air temperature) a drain cock (to drain condensation created within the unit). As a pressure vessel, it **MUST** be fitted with a pressure relief valve and a means of access for internal physical inspection. To comply with safety regulations any pressure vessel **MUST** be inspected at regular intervals.

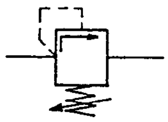
Pressure Gauge
(Bourdon Tube Type)

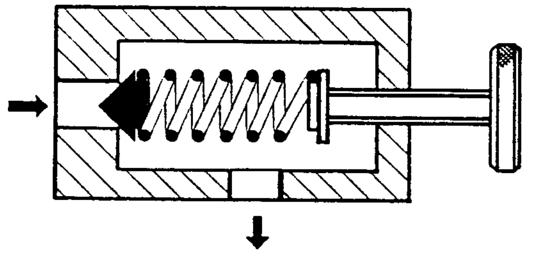


When air is supplied to the input of the pressure gauge it will attempt to straighten the Bourdon tube, as it does so the indicator, which is connected to the tube via a gear mechanism, will register the pressure on the gauge.

The amount of pressure determines the amount of movement in the Bourdon tube and subsequently the indicator. Gauges comes in various scales and face diameters wherever possible the scale used should be such that when the normal operating pressure is being read the indicator is at **12 o'clock** on the gauge face or as near as possible to it.

Pressure Relief Valve





All compressed air systems should be fitted with a pressure relief valve (PRV).

Air is fed into the pressure relief valve and at a pre-set pressure will overcome the spring and open the valve to allow the excess pressure to vent to atmosphere. The pressure that the valve switches at is determined by the adjustment of the screw against the large spring (the more force on the spring the higher the pressure required to overcome it). Once the spring is set the adjustment is then locked down to eliminate operators from re-adjusting the pressure required to relieve.

This valve is a **SAFETY** feature and **MUST** be treated accordingly.

Air Preparation and Conditioning

It is essential that the compressed air supply used to operate the pneumatic equipment, circuits and/or systems is of a good quality with particular emphasis on it being 'DRY'. Most problems on pneumatic circuits are in actual fact caused by poor quality air supply, this is usually because it is very wet and this in turn creates rust therefore 2 problems can be a direct result of water in the air. Other contaminants may be grit, pipe scale, swarf or oil (carried over from the compressor) with correct preparation and conditioning these problems can be reduced or totally eliminated. The costs incurred are low in comparison to the benefits achieved.

Intercoolers

The first stage of conditioning air is the intercooler this is a unit that fits between the stages of a twin (or multi) stage compressor (hence its name – inter). The function of an intercooler as its name suggests is to reduce the temperature of the air this is due to the fact that air can only hold a certain amount of water vapour at a given temperature the lower the temperature the less water vapour will be held, the remainder is deposited from the air in the form of condensation (water liquid) and can be drained from the system.

After Coolers

As their name implies this piece of equipment is situated after the outlet from the compressor like the intercooler, its function is to reduce the amount of water vapour present in the air by reducing the temperature.

Air Drying

On an average summers day a compressor delivering 600 cfm at 7 bar will deliver 32 gallons of water in 12 hours.

This amount can increase with higher humidity.

In excess of 50% can be eliminated by using an aftercooler.

A refrigerant dryer can then leave less than 2 gallons.

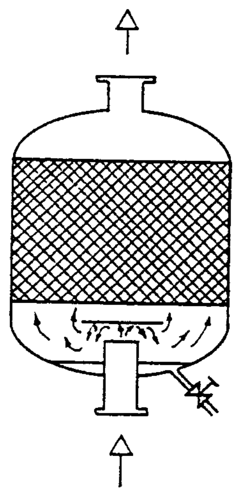
The power consumption of a refrigerant dryer is approximately 2% of that required to drive a matching compressor.

A dessicant (adsorber) dryer will leave less than 0,4 gallons but will cost 30 – 60% more than a refrigerant dryer.

Air Dryers

Air dryers fall into one of three different types distinguished by their method of operation as follows:

- Absorption
- Refrigeration
- Adsorption



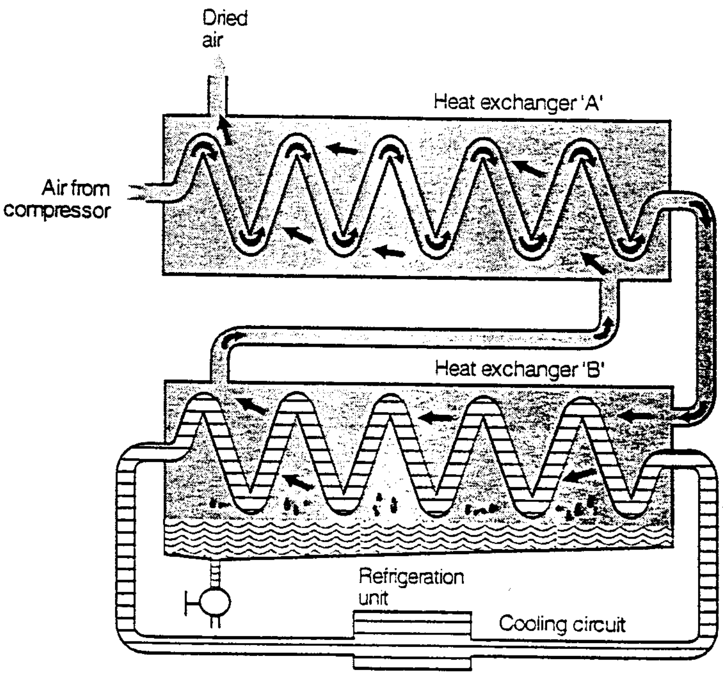
Absorption

This absorption dryer can be the least expensive unit on capital outlay but can also be the least convenient to use possibly with high running costs. This is due to the fact that it operates by passing the air through a tank filled with moisture absorption agent, this dries the air but eventually the agent will become saturated and will need replacing, this is done by isolating the dryer and taking the saturated agent out and replacing it with new agent, the saturated agent cannot be regenerated and therefore is thrown away. The frequency of this operation is dependent upon the original condition of the air, if it is very wet the agent will require changing frequently with the associated costs and inconvenience.

Air Dryers

Refrigeration

The refrigeration dryer gives better results than the absorption dryer but is more expensive to purchase. It operates on the principle of lowering the air temperature and therefore lowering the quantity of water vapour in the air.

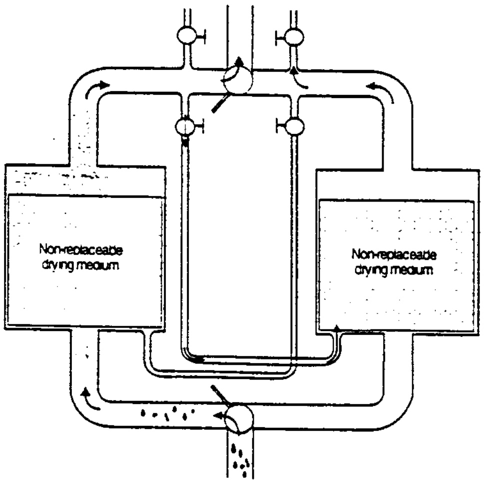


Air Dryers

Adsorption

The adsorption dryer gives the best results but is also the most expensive of the three types to purchase, however the air drying agent can be regenerated and does not have to be thrown away like the agent from the absorption dryers. To facilitate the regeneration of the drying agent (silica gel or similar) the adsorption dryers consist of two chambers of which one is in use at a time the second unit is incorporated into the system when the first chamber is saturated (shown by a visual indicator or gauge) the air is diverted through the second chamber and then the first chamber is isolated so that the drying agent can be regenerated (dried out) once this has taken place it is then ready to re-enter service which it will do when the second chamber is saturated. At this stage the air is again diverted this time back to the first chamber once this is complete the second chamber can again be regenerated.

Some applications are critical enough on the quality of the air that both adsorption and refrigeration dryers are used to give the best possible results.



Air Mains

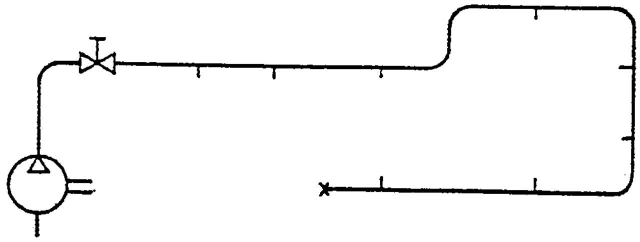
Pipe work

Airline installation and pipe work should always follow the accepted practices to assist with the removal of condensation from the system. All main pipe work should run at a gradient from the compressor thus allowing the water, which is heavier than the air to run along the bottom of the pipes to a point where it can be removed. Take off points for the air supply to machines, etc, should always come from the top of the pipe again water being heavier than air will remain in the pipe and not be taken through the outlet with the air. To reduce turbulence to a minimum, large radius fittings must be used wherever possible. When dropping pipe work to machines, drain legs should also be installed to eliminate as much water as possible before the air goes into the machine.

Generally, it is best to construct the pipe system as a closed loop around the area where the air consumption takes place. Branch lines are run from the loop to the different points of air consumption. In this way, a more uniform supply of compressed air is obtained for heavy intermittent consumption because the air is conducted to the relevant consumption point from two directions. The most suitable construction of an indoor pipe system naturally changes from case to case. The system of constructing the main line as a closed loop is still the best option in most cases.

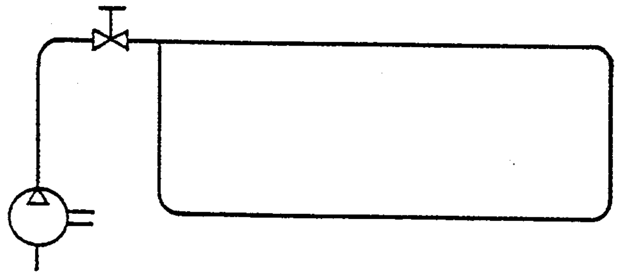
Air Mains

a.



Type a) This is a "Branch" main (or line) and is only suitable for short runs to one or two consumers if long runs are installed or a large number of consumers are connected to the system then the consumers at the end of the run will suffer from starvation of air (volume and/or pressure).

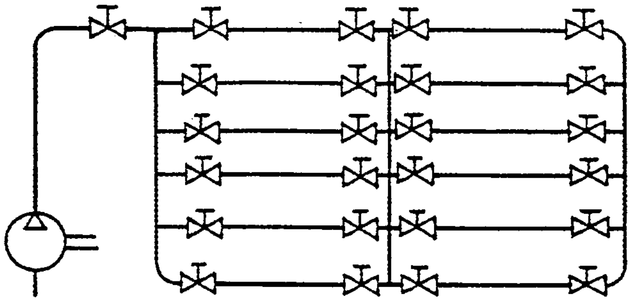
b.



Type b) This is a better design and is called a "Ring" main, the run of pipe is continued around to complete the ring, this allows the air to be more evenly distributed around the system (in both directions) therefore less potential of starvation occurring.

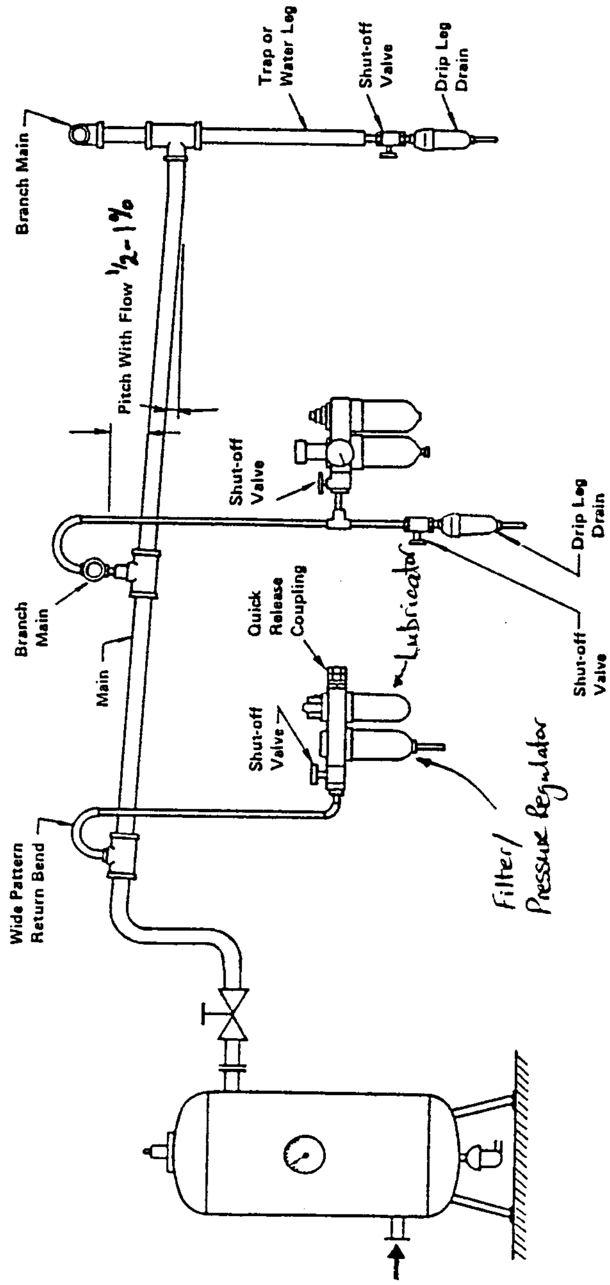
Air Mains

c.



Type c) The "Grid" main method is used wherever a large number of consumers are located within a close proximity and these consumers require large volumes of air to function correctly. It has also the advantage over both other systems that it is possible to isolate the individual parts of the system without closing the entire system down, for this to be possible each intersecting piece of pipe work has to be valved as shown. A typical example of where this system is used would be the automobile manufacturing industry in the final assembly areas where air tools are widely used.

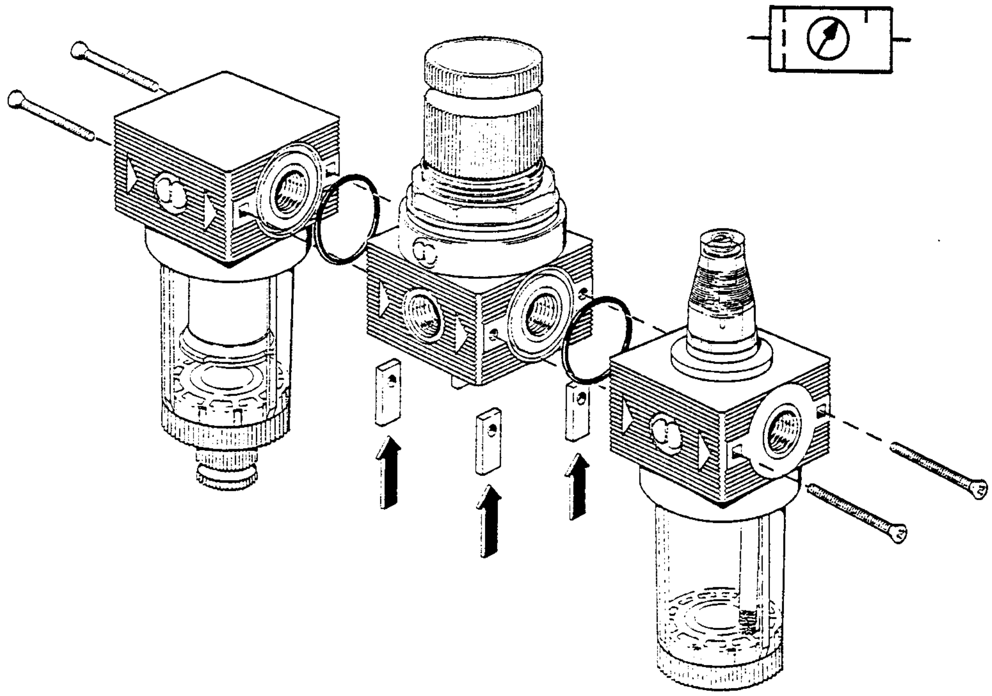
Correct Airline Installation



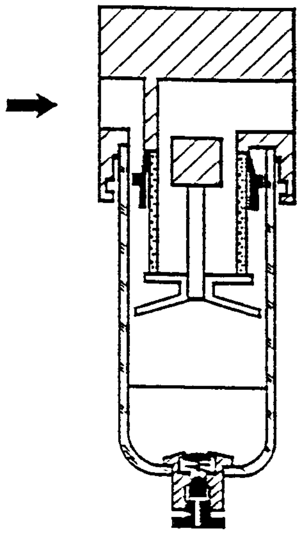
Compressed Air Servicing

The final stage of compressed air servicing or conditioning is a process carried out on the air supply directly before its point of use. This process is accomplished by three devices collectively called the air service unit sometimes abbreviated to FRL.

The air service unit consists of a filter, a pressure regulator, and sometimes a lubricator. To read off the adjusted system pressure a pressure gauge should also be attached to the pressure regulator.



Filter (with manual drain)



Filters are used in pneumatic systems primarily to remove solid particles of contamination (dirt, grit, rust, etc) as a secondary function they will also to a point remove moisture (water and oil carry over from the compressor).

Air enters the unit at the IN port (shown usually by an arrow indicating direction of flow) and is diverted into the bowl of the filter through a baffle plate, this causes the air to swirl and turbulence is created, due to centrifugal force the moisture droplets which are heavier than the air are thrown out of the air and drain down into the base of the bowl to be drained. In the meantime, the air has been passing through the filter element to the downstream (OUT) side of the unit. The filter element will filter solid particles from the air, this element is generally of a sintered bronze material and as a norm will have a pore size of 20 – 25 micron (micrometres) although a range of elements are available from 0,1 – 40 micron.

On low pressure systems where the tolerances are closer, the finer filters would be used with pre-filtration.

Particle Size

Dirt particles, grit, grime, etc. are measured in microns (or micrometres), µm

Industrial filters are generally 20 –25 µm, although other sizes are available.

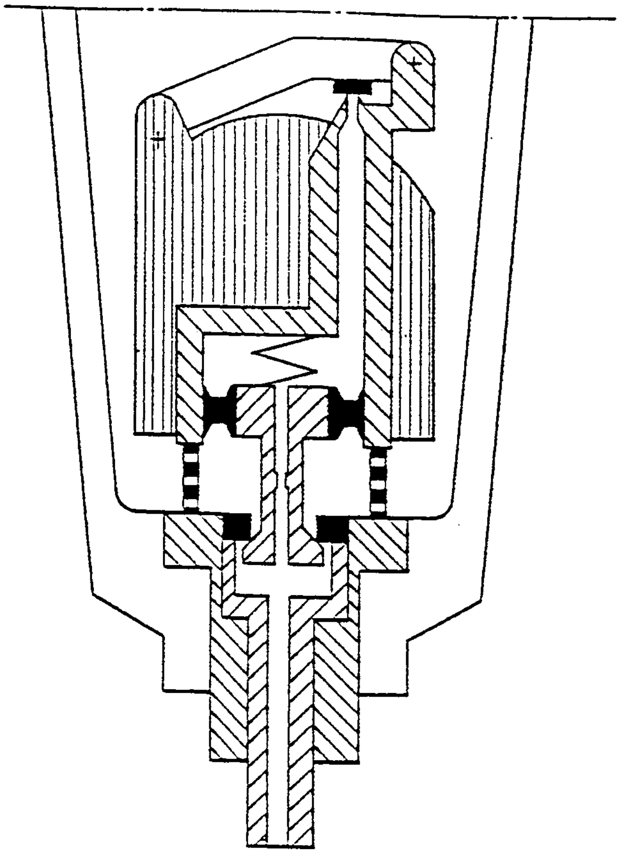
1 µm = 0,000039"

Comparisons:

- A grain of table salt is approximately 100 µm
- Limit of visibility for an unaided human eye is in the region of 50 µm
- A major contaminant is oil aerosol which is in the region of 0,01 – 0,8 µm

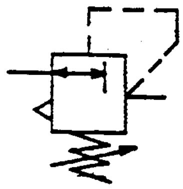
It is possible to clean air to 40,000 times cleaner than that which we normally breathe, with activated carbon filters.

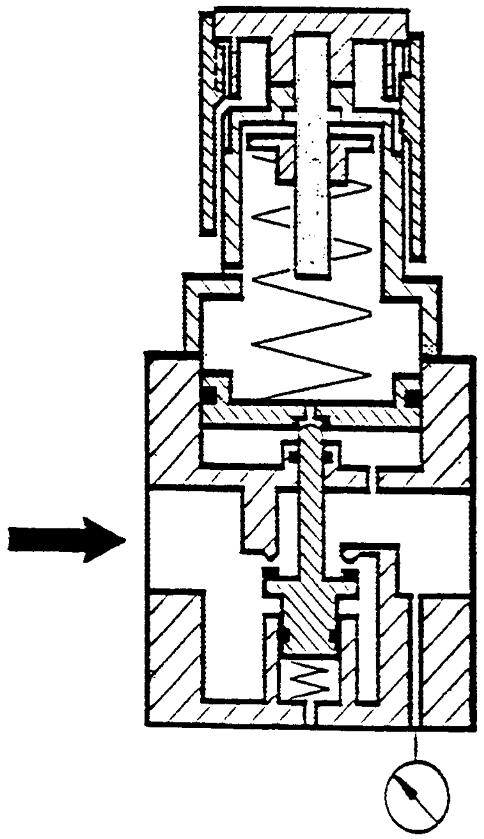
Automatic Drain Unit (for filter)



When moisture accumulates in the base of the filter bowl the float of the automatic drain will be lifted this allows the air pressure from the bowl to travel through the fine tube and operate the valve in the base this allows the moisture to be drained. When the moisture level drops, the float is lowered and eventually closes the air passage to the valve, which after a short period of time closes due to the in-built spring. The diagram shows a unit that can be retro-fitted into the filter bowl in place of the manual drain valve.

Pressure Regulator





A pressure regulator should be used on all pneumatic systems it is used to set a stable system pressure downstream on the unit.

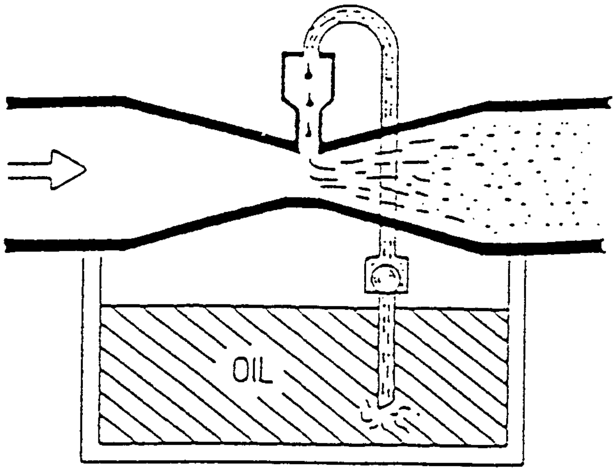
Pressure Regulator

The output (downstream) pressure is adjusted and set by means of the hand wheel on top of the unit, this in turn adjusts the force plate upon the large spring. The large spring pushes against the diaphragm plate, which in turn pushes against the poppet valve in the base. When air is supplied to the inlet of the unit it will travel through the poppet valve section to the outlet side, here there is a feed to the diaphragm plate. The air pressure can be indicated there is also a feed to the diaphragm plate. The air pressure will now oppose the spring at the diaphragm plate, as the air pressure rises the diaphragm plate moves against the spring and will eventually allow the poppet to close (no further passage of air through the valve). Once the air pressure on the outlet side of the valve drops the spring overrides and the diaphragm plate is moved again opening the poppet valve, more air flows through the valve until the pressure builds up again, switching the poppet. The poppet and diaphragm are therefore constantly moving up and down (opening and closing). If the excess pressure occurs on the outlet side of the valve it will move the diaphragm plate even further and allow the excess air to escape through the hole in the centre of the diaphragm plate and out through the body of the regulator to atmosphere.

By pushing the cap of the hand wheel in (down) the setting of the pressure regulator is locked.

Venturi Action to Transfer Lubricant Into the Air Stream

Air lubricants utilise the pressure difference caused by the compressed air as it streams through a Venturi tube.



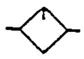
Transfer of lubricant is based on the Venturi principle, which states that different flow velocities produce different amounts of suction.

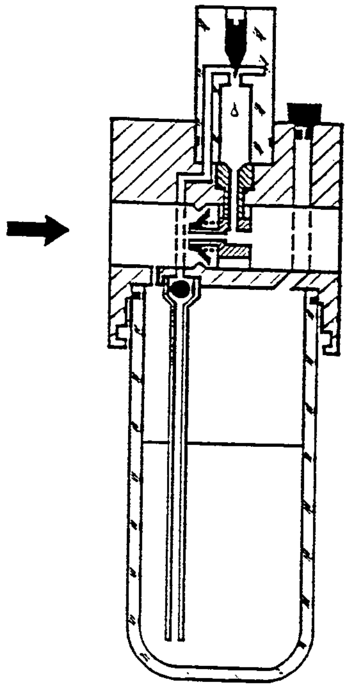
Oil mist lubricators use a self adjustable air diverter valve to divert more or less flow to the mist generator depending on the flow rate through the lubricator. Since these oil particles from this type of lubricator are so small, they stay air borne much longer and tend not to coalesce into larger droplets.

This is not the case with oil fog lubrication for this reason it is advisable to use predominantly oil mist lubrication for complex and diversified pneumatic systems.

Air line lubrication should be only light mineral oils, typically to ISO class VG10 per ISO 3448 (depending on manufacturer and ambient temperature).

Lubricator





Where required a lubricator may be fitted, although most good quality equipment on the market today will run on unlubricated air provided that the air is dry. A lubricator places small amounts of oil into the air as a fine atomised mist. This oil will coat the seals and surfaces and replace the original oils and greases that have been worn away or washed away by any water that is present in the air. Therefore, if the water can be eliminated then a lubricator is often unnecessary. Most systems with a lubricator fitted are in actual fact over lubricated, this can cause more harm than under lubrication.

The type and grade of oil will vary with the ambient temperature that the unit is being used in and also the manufacture of the lubricator therefore always refer to the manufacturers literature for the correct type and grade for your application.

Lubrication

Normal operating temperature range –5°C to +50°C lubricants should meet the following specification in order to give satisfactory lubrication.

1. Additives should be compatible with the materials from which the control elements are manufactured.

2. An anti-foam additive is desirable.

3. An anti-corrosion additive is desirable.

4. Pour point must be low enough to withstand low temperatures due to rapid expansion of air between valves and cylinders pour point should be no higher than –30°C.

5. Viscosity must be within the range of the lubricator such that it can readily pick up and carry suspension far enough to do the work.

   Viscosity best suited for pneumatic power and control are between 100 seconds and 350 seconds, Redwood scales 1 at 21°C recommended oils – Castrol AWS10, AWS32, Shell Tellus 15, 21, 27.

6. Volume required will vary with work done approximately 0.005cc/30 litres of expanded air.

7. Maximum travel through pipe of an oil mist is no more than 4.5m.

8. Any manifolds should not have an inside diameter greater than of the pipe supplying the air otherwise no lubrication will take place downstream.

The Concept of Power Transmission

Pressure Regulator with Pressure Gauge

A pressure regulator should be fitted after the filter. To be effective a pressure regulator **MUST** be fitted with a 'working' pressure gauge so that it is known what pressure the regulator has been set at. The pressure regulator is used to set a stable downstream pressure at a pressure, which is suitable for the system (too low a pressure means the system will not work too high a pressure means that air is wasted and possible the equipment could be damaged or at least its lifespan shortened). Ideally, a 1 bar (14.5 psi) pressure drop between upstream and downstream pressures should be achieved. A pressure regulator should **NEVER** be used as an on/off valve.

Working Elements

Components, which actually move in a circuit, are referred to as 'working elements' due to the fact that they are the items, which ultimately do the job of work. They are therefore the HANDS of a circuit. The working elements are then sub-divided into two groups 'cylinders' and 'motors' it is normally accepted that cylinders give linear motion while motors give rotary motion (although there are exceptions to this rule). The types and sizes of cylinders and motors are numerous (as are the manufacturers).

Cylinders

These can be divided into two groups known as:

- Single Acting Cylinders
- Double Acting Cylinders

These groups can then be further sub-divided into various types, which we will deal with later.

Principle of a Single Acting Cylinder

A single acting cylinder is so called because it is required to do work (to act) in ONE direction only, this direction is then air powered so that it may achieve the required task. The opposite direction is powered by a means other than air usually a spring but it may be by external mechanical force (e.g. if a single acting cylinder is used to lift a load vertically when the air which is providing a lift is exhausted then the cylinder will fall due to the load upon it). Single acting cylinders are generally available in sizes up to 100mm (4") bore and 100mm (4") stroke if sizes above these are required then a double acting cylinder is generally used.

The return spring is not designed to pull a load only to retract the piston. It is also possible to have a single acting cylinder where the spring extends the cylinder (retracted by air power). Single acting cylinders are mainly used for clamping, ejecting, lifting, feeding and locating, etc.

When air is passed into the cylinder via the inlet port, a force (F) is applied to the face of the piston. Assuming that this force being exerted is greater than any internal forces of the cylinder (friction, etc) then the piston will move, compressing the return spring, extending the piston rod.

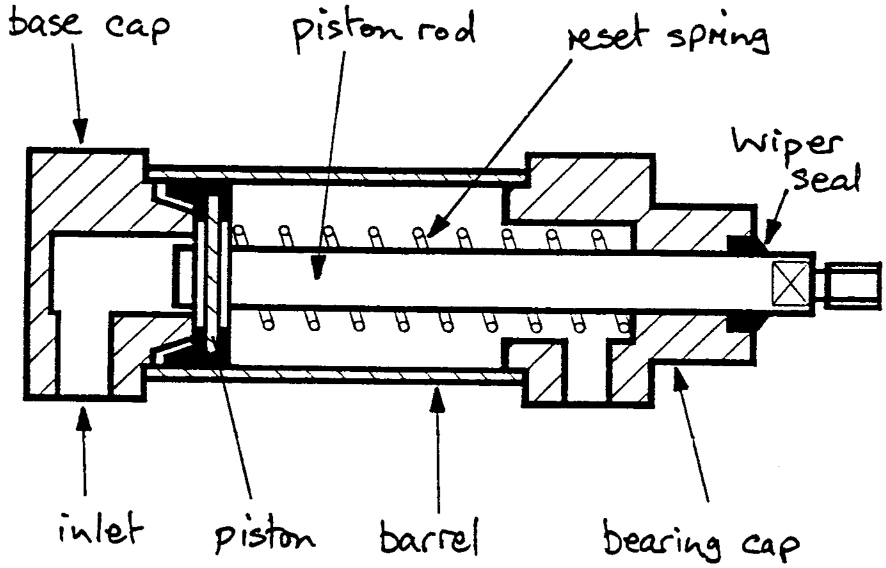
If the air is now allowed to escape from the rear chamber of the cylinder then the return spring will come into operation and retract the piston and piston rod to their original position.

The pressure applied and the surface area to which pressure is applied will determine the force, which acts upon the piston. The piston diameter will be equal to the internal diameter of the cylinder known as the bore.

Remember that: Force = Pressure x Area

Principle of a Single Acting Cylinder

The diagram below shows a single acting cylinder with spring return.



Principle of a Double Acting Cylinder

Double acting cylinders are required where the application calls for a cylinder to do work in both directions of travel (extend/outwards and retract/inwards). The cylinder is under air power during both extend and retract movements and therefore does not rely on springs or external mechanical force. Theoretically the stroke length is unlimited, in practice limits are placed on the stroke length due to factors such as buckling load which effect the piston rod when it is extended (if a side load is placed on the piston rod then it will bend (buckle) when this load reaches a certain level). Diameters up to 300mm (12") are readily available with some manufacturers offering cylinders in diameters greater than this. It is also very easy to achieve speed control with a double acting cylinder which can be another reason for choosing them.

When pistons travel at high speed the cylinder end caps can be damaged the same effect can also be the result of moving heavy loads, to overcome this problem end position cushioning is incorporated into the cylinder. The cushioning operates by closing the main exhaust path for the cylinder before the piston has reached the end of its travel, the remaining air is then allowed to exhaust through a small often adjustable aperture thus acting as a brake and slowing down the cylinder over the last part of the stroke. The cushioning has no effect when the piston starts to travel or through the main part of its stroke and cannot therefore be used as a means of performing speed control.

The range of double acting cylinders includes tandem, through-rod, multi-positioning, pancake, cable, impact, rotary, rodless, locking, non-rotating piston rod, oval and many special designs for specific applications. The materials used in manufacture are numerous with the popular cylinders being in aluminium, stainless steel, brass, etc.

Principle of a Double Acting Cylinder

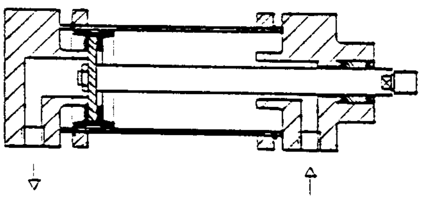
Cylinder seals also vary considerably according to manufacturer, application, and temperatures that the cylinders are to be used in, some examples being perbunan, nylon, teflon, and viton.

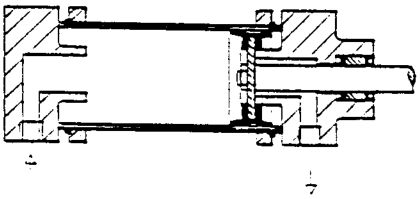
An extensive choice of cylinder mounting are also available to meet all requirements e.g. foot, thread and flange, swivel flange (front, rear and centre).

The diagram below shows the main component parts of a double acting cylinder.

When air is passed into the rear chamber of the double acting cylinder and the front chamber is connected to exhaust (via the DCV) the piston and piston rod will extend. If the flow remains to the rear chamber, the cylinder will stop at the end of its stroke and remain extended until the air flow is reversed (air passed to front chamber and rear chamber connected to exhaust). Once this has happened the piston and piston rod will now retract to the instroke position and remain there until the air flow is once again reversed.

Remember that: Force = Pressure x Area





Multi-Position Cylinders

By connecting two cylinders together (back to back) it is possible to get up to 4 positions from the unit when the cylinders are either fully instroked, fully outstroked or a combination of fully instroke on one cylinder and fully outstroke on the other.

If the two cylinders are of equal stroke length then the number of positions available will be 3, if the cylinders are of unequal stroke length then the number of positions is 4 e.g. if two cylinders are joined together back to back each having a stroke length of 200mm then position 1 is at 0mm (the datum) due to both cylinders being fully instroked. If either cylinder is fully extended then position 2 is 200mm forward of position 1 due to the fact that this is the stroke length of the cylinder, both cylinders being extended then position 3 is 400mm forward of position 1 due to each cylinder is 200mm stroke and there are two cylinders involved.

With one cylinder of 200mm stroke length connected to one cylinder of 400mm stroke length the datum would again be 0mm position 2 with the short stroke cylinder outstroked and the long stroke cylinder instroked would be 200mm forward of position 1, position 3 with the short stroke cylinder instroked and long stroke cylinder outstroked would be 400mm forward of position 1 the final position (4) would then be 600mm forward of position 1 as this is the total length stroke of both the short stroke (200mm) cylinder and the long stroke (400mm) cylinder.

Any number of positions may be selected in this method by adding more cylinders if all the cylinders are of differing stroke lengths then the number of positions will double with each additional cylinder.

Magnetic Sensing Cylinders

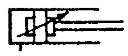
These cylinders have been developed to avoid the need for limit switches that operate upon physical contact. The piston of the cylinder contains a magnet(s) and this will then operate a reed switch that is attached to the outside of the cylinder barrel when the magnet of the piston passes the reed switch. The reed switches are also referred to as proximity switches or sensors. For this principle to operate the cylinder barrel must be made from a non-magnetic material, such as brass, stainless steel, or aluminium.

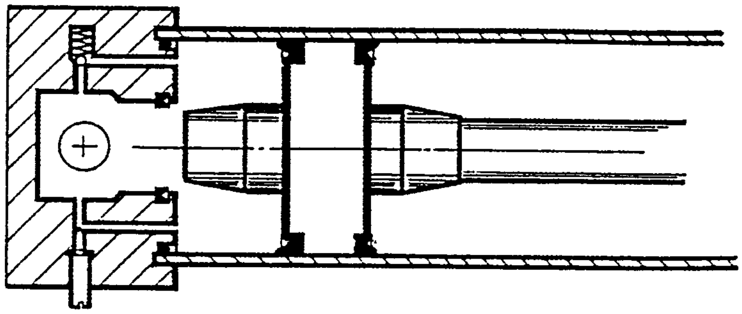
As the reed switch is fitted to the outside of the cylinder barrel (usually by means of tie rod mounting or straps) the possible problem of limit switches being mounted does not have to be considered, thus saving cost, space and time, when compared with conventional methods.

Rodless Cylinders

There are two quite different principles for the rodless cylinder, one method uses magnets built into the piston to pull an external carriage along the cylinder barrel as the piston is moved backwards and forwards. This method is not considered very suitable for moving heavy loads as the magnetic field can be broken if the carriage is overloaded, the piston would then be allowed to move backwards and forwards along the barrel without moving the carriage, subsequently achieving nothing, but nevertheless wasting energy. There are also size limitations on cylinders which operate on this principle presently the maximum diameter available is 63mm. With the second principle, cylinders of 100mm diameter and over are available. This version is more positive as the carriage and the piston are actually one unit and therefore it is impossible for the piston to move without the carriage. Because the piston and the carriage are one unit the cylinder barrel is split this spilt is then sealed with internal and external metal strips.

Cylinder Cushioning (adjustable)

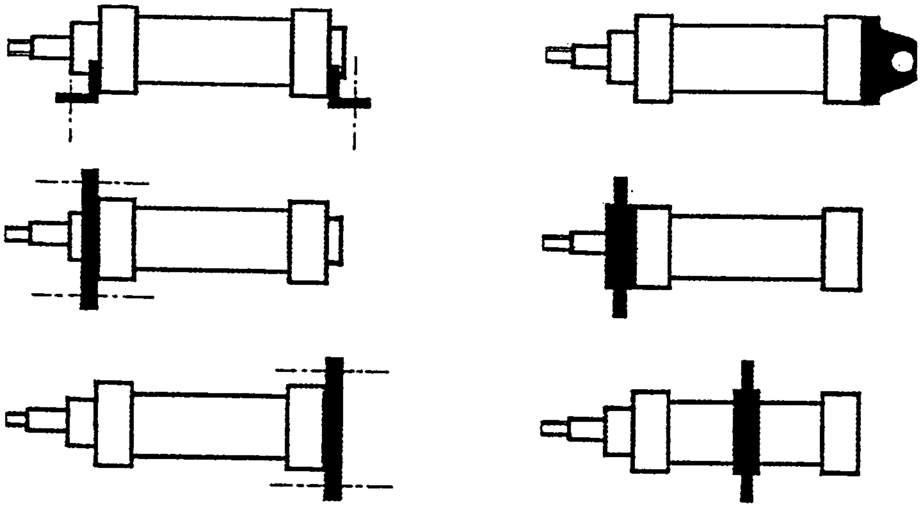




Double acting cylinders are commonly cushioned to avoid damage to the unit at the ends of its stroke. This cushioning is a means of applying a brake using the compressed air already contained in the cylinder chamber. This diagram shows an example of a cylinder retracting and just about to enter the cushion.

Either side of the main piston there is a cushioning piston of a smaller diameter, this cushioning piston locates in the main port of the cylinder approximately 15 – 20mm before the end of stroke, thereby blocking the main exhaust path and trapping a small volume of air in the cylinder chamber, this air can now only escape via a small passageway with an in-built throttle. The rates of escape for the air can therefore be controlled by this throttle, thus slowing down the speed of the cylinder travel for the distance that the cushions are operational. When the control valve is switched, the air is fed into the chamber at full flow (direct onto the face of the cushioning piston also via the check valve and in-built throttle to the face of the main piston).

Cylinder Mountings



This diagram shows some of the more common methods of cylinder mounting it is not however intended to illustrate the complete range available.

Foot (top left) shown as external but often the same brackets can be reversed for internal mounting. Front and rear flange (centre and bottom left) generally used for short strokes or where the cylinder is operating in a vertical mode.

Trunnion mounts: Rear (top right) front (centre right) and centre (bottom right) these mounts are generally used where the cylinder/s is/are travelling through an arc during the piston rod extension and retraction (e.g. when the component connected to the piston rod has to travel over centre).

Directional Control Valves

Directional control valves, control start, stop, and the direction of the air flow. They are characterised by their number of ports and the number of position that they can switch to. For example, the designation 3/2 way valve means a directional control valve, which has 3 ports and 2 switched positions, whereas a 4/3 way valve is a directional control valve with 4 ports and 3 switched positions. Each position that a valve may switch to is shown in its symbol by means of a square. Inside the squares, wherever a line touches the perimeter of the square is a port; these ports are not always connectable (tapped). The ports will normally consist of supply (1), output/s (2, 4, 6, etc) and exhaust/s (3, 5, 7, etc).

External to the squares in the symbol will be shown the operating mechanism(s) these can range from manual (push button), through mechanical (roller lever and idle return roller lever) to pneumatic (pilot) and electrical (solenoid) or indeed combinations of these operating mechanisms are also possible.

The most commonly used valves are 3/2 way but the following are also available: 2/2, 4/2, 4/3, 5/2, 5/3, 5/4, 6/3, etc.

DIRECTIONAL CONTROL VALVES

MANUALLY OPERATED	MECHANICALLY ACTUATED	PILOT ACTUATED	ELECTRICALLY ACTUATED
Push Button	Roller	Pneumatic	Solenoid, direct
Key Switch	One-way Roller		Solenoid, internal pilot
Lever	Plunger		Solenoid, ext. pilot
Rotary Lever			Solenoid, manual override
Lever with Detent			
Foot Pedal			

Directional Control Valves

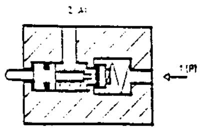
The directional control valve can be spilt into two distinct design principles:

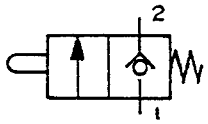
- Poppet (or seat)
- Spool (or slide)

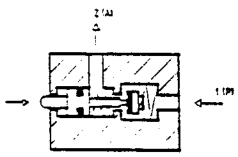
The poppet (or seat) is where the seal operates against a face (seat). The spool (or slide) is when the seal travels through the body of the valve on a spool (or slide). There are differing characteristics for each design along with their advantages and disadvantages, subsequently it is now quite popular to integrate both design principles without disadvantages.

Directional Control Valves

2/2 way Plunger Actuated Poppet Valve







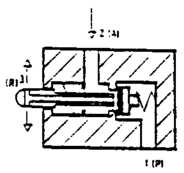
This valve is actuated by means of a plunger and reset by means of the internal spring to its 'normal' condition, which in this case is CLOSED, subsequently the valve is described as being of the 'Normally Closed' type. The term closed relates to what is happening to the supply port in this condition.

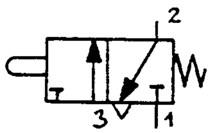
Therefore in the unoperated condition (top) the spring assists the supply air in keeping port 1 (P) closed, the output air cannot escape back through the valve as port 2 (A) is also closed, presuming both air pressures are equal the spring will give favour to port 1 (P) if however the supply air at port 1 (P) was eliminated the output air could overcome the spring and travel back through the supply port.

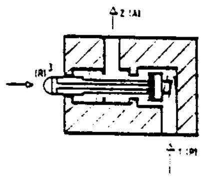
When the valve is actuated the plunger is depressed and comes into contact with the poppet seal, further travel then opens the valve allowing the air from the supply port 1 (P) to travel through to the output port 2 (A) or vice versa. Upon releasing the plunger, the valve resets to its normal condition (closed) due to the internal springs.

Directional Control Valves

3/2 way N/C, Plunger Actuated, Spring Reset, Poppet Valve







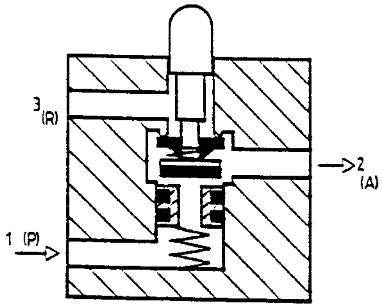
This valve is similar to that shown previously however it has been modified by drilling through the centre of the plunger to create an exhaust facility thereby converting the valve from a 2/2 way to a 3/2 way. The exhaust port in this valve is not threaded and therefore it cannot have a silencer or fitting connected to it.

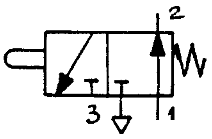
In the unactuated condition, the supply is blocked and the output is open to exhaust, once the plunger is actuated, it contacts the main poppet closing the exhaust, further movement of the plunger then opens the supply to output. The valve remains in this condition until the plunger is released, when the springs will reset the valve to its 'Normally Closed' condition.

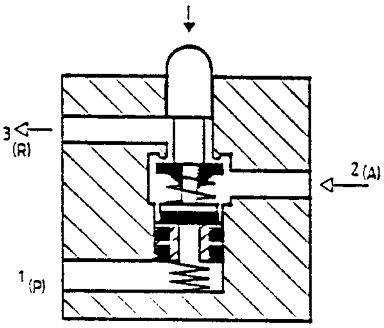
Port configuration:	Supply	1 (P)
	Output	2 (A)
	Exhaust	3 (R)

Directional Control Valves

3/2 way N/O, Plunger Actuated, Spring Reset, Poppet Valve







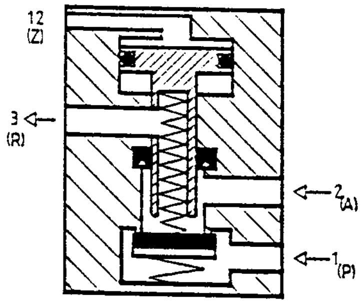
This valve is of a larger size than the two previously shown and subsequently the exhaust facility is through the valve body and is a threaded port, this will allow the fitting of a silencer or other fitting.

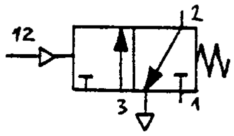
In the unactuated condition the supply air is allowed to travel through the valve to the output, thus the valve is OPEN and therefore termed of the 'Normally Open' type.

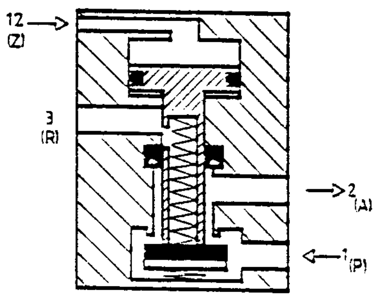
In the unactuated condition the supply, port 1 (P) is connected to the output 2 (A) with the exhaust 3 (R) being internally blocked. When the plunger is actuated, the poppet closes the supply and on further travel opens the output to exhaust. When the plunger is released, the valve resets to its normal condition 'open' and the output at port 2 (A) is re-instated.

Directional Control Valves

3/2 way N/C, Pilot Actuated, Spring Reset, Poppet Valve





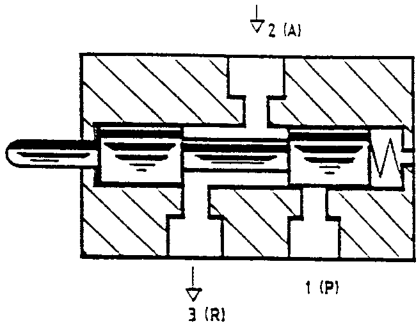


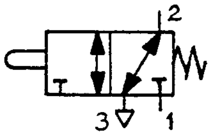
When the valve is not actuated, the poppet is blocking the supply 1 (P) and the output 2 (A) is connected to the exhaust 3 (R). The valve is therefore 'Normally Closed'.

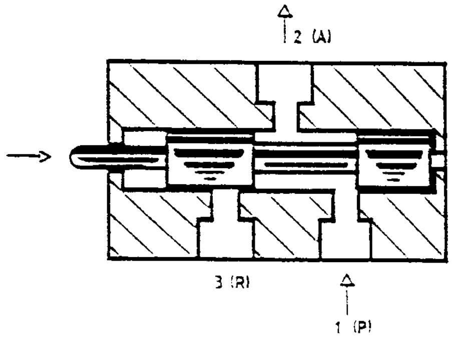
To operate the valve a pneumatic signal (pilot) has to be applied to port 12 (Z) this will depress the piston (at the end of the plunger) and close the connection of the output 2 (A) to the exhaust 3 (R) further movement of the plunger will then open the supply 1 (P) through to output 2 (A) the valve remains in this condition until the pilot is removed and the springs will then reset the valve to its 'normal' condition in this case closed.

Directional Control Valves

3/2 way, Plunger Actuated, Spring Reset, Spool Valve





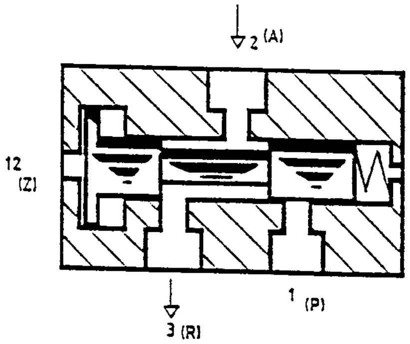


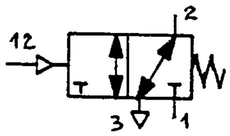
With a spool valve, it is a common feature that the valve can be used for either 'Normally Closed' (N/C) or 'Normally Open' (N/O) operation. In this case we are showing the valve being used for N/C operation to reverse the operation to N/O it is only necessary to reverse the connections at ports 1 (P) and 3 (R).

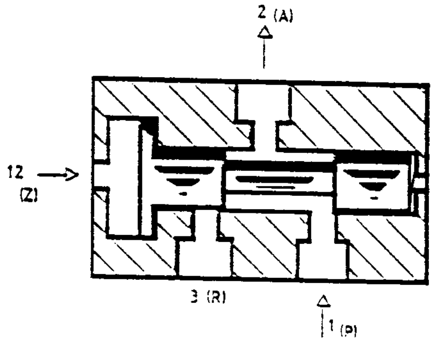
As shown (N/C) in the unactuated condition the supply 1 (P) is blocked by the land of the spool and the output 2 (A) is connected through to exhaust 3 (R) once the plunger is actuated the spool (which it is connected to) travels through the valve and the supply is connected to the output and the exhaust is blocked, upon release of the plunger the valve resets to the closed condition.

Directional Control Valves

3/2 way, Pilot Actuated, Spring Reset, Spool Valve



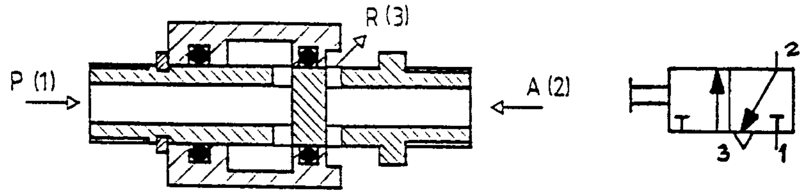


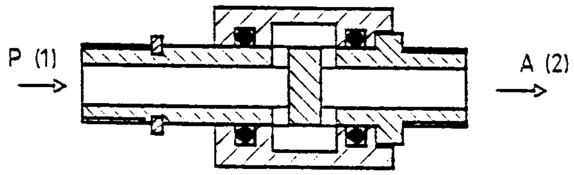


The operation of this valve is similar to that of the valve featured on page 77 but the valve is of the **spool** design and can therefore be used for 'Normally Closed' operation (as shown) or by changing the supply 1 (P) and exhaust 3 (R) connections it can be used for 'Normally Open' operation.

Directional Control Valves

3/2 way Hand Slide Valve





This valve is a 3 port 2 position manually operated (in both directions) directional control valve (DCV). In its unoperated condition (top) the slide is across to the left this blocks the supply air P (1) and opens the output air A (2) to exhaust R (3).

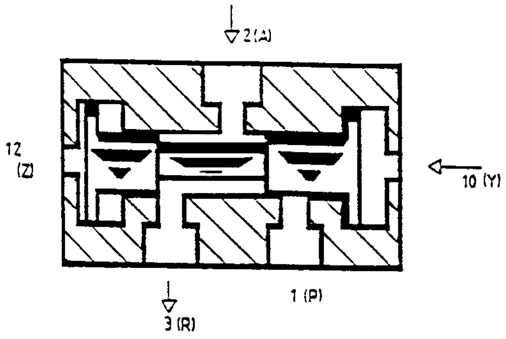
When the slide is moved to the right (bottom) the supply air P (1) is connected through to the output port A (2) and the exhaust R (3) is blocked.

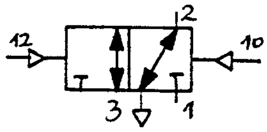
As there are no springs in the valve the slide will remain in the last position that it is placed until such time that it is repositioned manually.

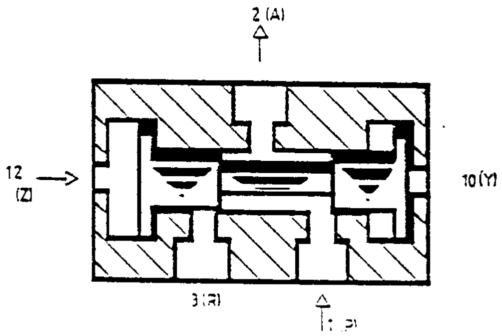
This type of valve is ideal as the mains ON/OFF valve in a pneumatic system.

Directional Control Valves

3/2 way Double Pilot Valve







This valve is a further adaptation of the unit shown previously where the spring return has been replaced by the second pilot 10 (Y) thus making the valve a double pilot type.

When a signal is placed on port 10 (Y) the supply 1 (P) is closed and the output 2 (A) is opened to exhaust 3 (R). The valve will remain in this condition even when the signal is removed. To reverse the valve it is necessary to place a signal at port 12 (Z) this will open the supply to output and close the exhaust, again the valve will remain in this condition even when the signal is removed.

Due to the valve remaining in a selected position, even when the signals are removed this type of valve is commonly called a 'Memory' or 'Bi-stable' valve.

Solenoid Actuated Valves

A solenoid actuated valve consists of a spool, body and either one or two solenoids depending upon the application. The spool is deflected by the solenoid allowing air under pressure to flow from port 1, to either port 2 or 4 and subsequently connecting the alternative port to exhaust.

De-energising the solenoid allows the spool to return by spring pressure to its initial position, in the case of single solenoid valves.

In the event of a signal being removed from a double solenoid (two position) valve, the valve will remain in that position, until the opposite signal is applied (memory).

In the event of an electrical fault, the solenoids can be operated manually if necessary (manual override).

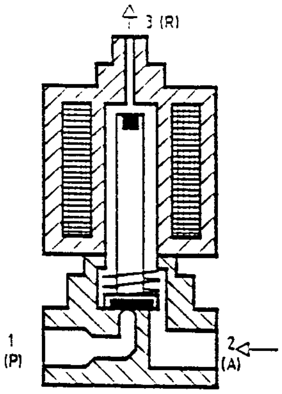
Solenoid Actuated Valves

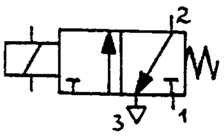
Electrical Control

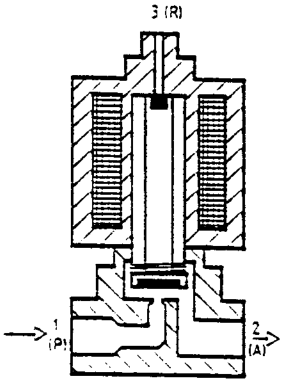
An increasing proportion of pneumatic valves are being actuated electrically, this gives an ideal interface between electrical and/or electronic control systems and the muscle of pneumatics. The interfacing component is the solenoid. Solenoids are available in numerous formats e.g. low wattage, explosion proof, with LED to indicate the switching condition, various voltages, etc.

It should be remembered that solenoid valves are used to provide an interface between the electrics/electronics and the pneumatics, they are NOT used to speed up the operation, in fact they will normally slow down the operation due to the fact that there are two functions involved (to switch the solenoid and then to switch the valve).

3/2 way Normally Closed (N/C) Solenoid Actuated Spring Reset Poppet Valve



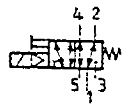


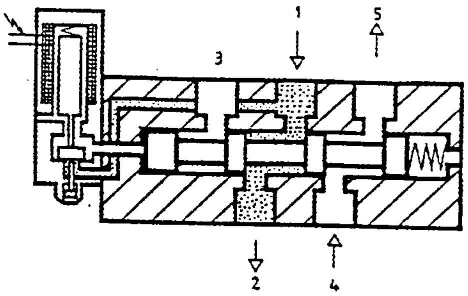


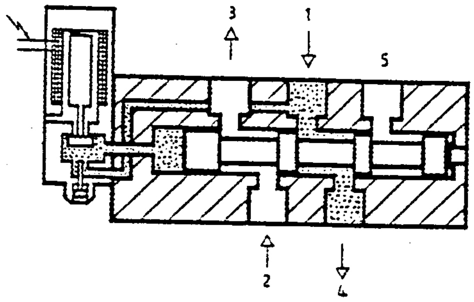
This directional control valve is actuated electrically via a solenoid coil. This version is of the Normally Closed type. When the valve is unactuated (no current applied) the supply is closed with the output open to exhaust which is through the solenoid coil and exhaust ports 3 (R) at the head of the coil. When an electrical current is applied to the solenoid a magnetic field is created and the plunger (armature) is lifted against the spring this opens the supply port 1 (P) through to the output 2 (A) with the exhaust 3 (R) closed by the seal in the end of the armature. The valve is reversed when the magnetic field is broken by removing the current from the solenoid and the spring reseating the armature closing the supply and opening the exhaust port.

Note: This valve is of the direct actuating type and would normally only be used for low power applications.

5/2 way Solenoid Actuated Spring Reset Spool Valve





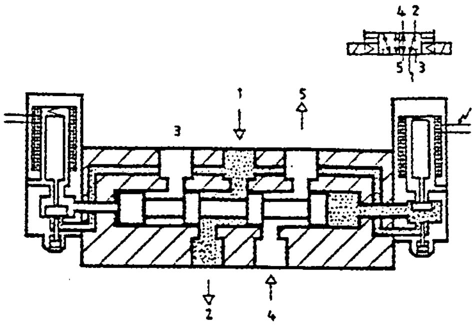


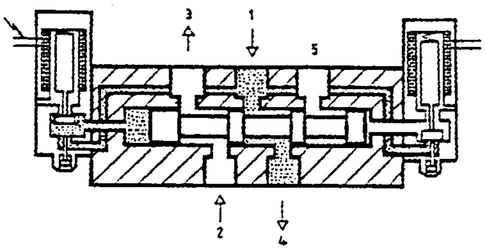
Without electrical current being fed to the solenoid the valve is in the condition shown in the top diagram flow paths are 1 to 2, 4 to 5 and exhaust 3 is blocked. Supply air is fed internally from port 1 to the servo valve, which in turn is operated by the solenoid.

When the solenoid is energised the armature is lifted against the spring and this allows air to pass through the pilot section onto the end of the spool moving it to the right (against the main spring) this gives the connections 1 to 4, 2 to 3 and exhaust 5 is now blocked. The valve stays in this position while the solenoid is energised, when it is de-energised the air from the end of the spool is exhausted out of the pilot section via the solenoid (the pilot section is a 3/2 way valve in its own right).

The valve shown has a manual override facility incorporated into the servo section.

5/2 way Double Solenoid Spool Valve



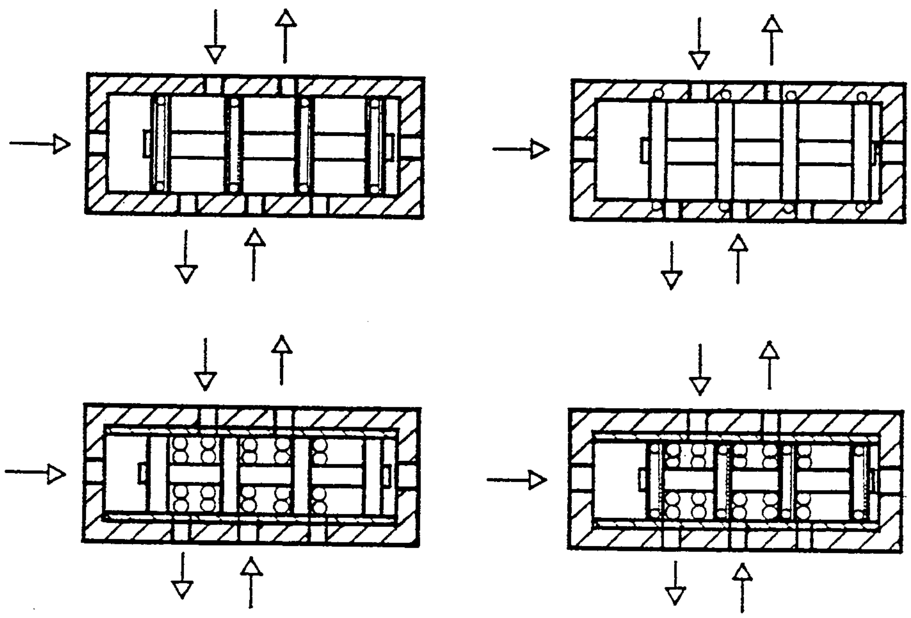


With the right hand solenoid actuated (top diagram) the spool moves to the left and give connections 1 to 2, 4 to 5 and exhaust 3 is blocked (this is effectively a 12 signal and is sometimes marked on the valve as such). When the solenoid is de-energised the spool remains in this position due to the friction between the spool and valve body (MEMORY valve).

To get an output at port 4 the left hand solenoid must be energised moving the spool to the right and giving the connections 1 to 4, 2 to 3 and exhaust 5 is now blocked (14 signal) the solenoid can then be de-energised and the spool will remain in the right hand position.

A manual override facility exists on both solenoids this means that the valve can be set and/or reset without the electrical supply being present (this can be a useful feature during commissioning, maintenance or resetting after Emergency Stop).

Various Methods of Sealing Found on 5/2 way Valves



The method of sealing will be dictated by the valve manufacturer and will differ widely. Shown in this diagram are a selection of some of the more popular methods.

Port Labelling for Pneumatic Valves

The diagrams covering valves contained within this manual, include port labelling. At the time of production an I.S.O. (International Standards Organisation) standard exists **(I.S.O. 5599)** for port labelling in relation to ***5 port valves only*** as follows:

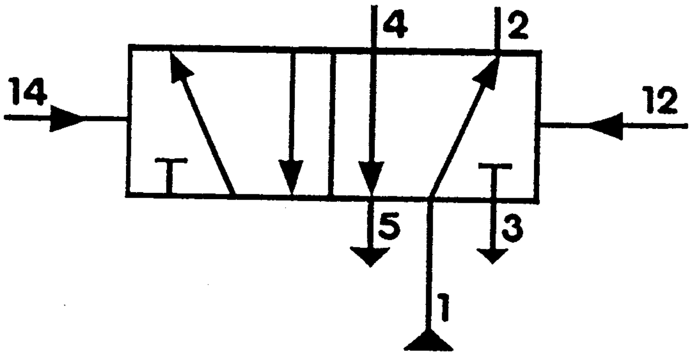
Supply	-	1
Outputs	-	2, 4
Exhausts	-	3, 5
Signals	-	12, 14

This standard is for 5 port valves only, at the present time there are NO laid down standards for other pneumatic valves be they directional control, pressure control or flow control.

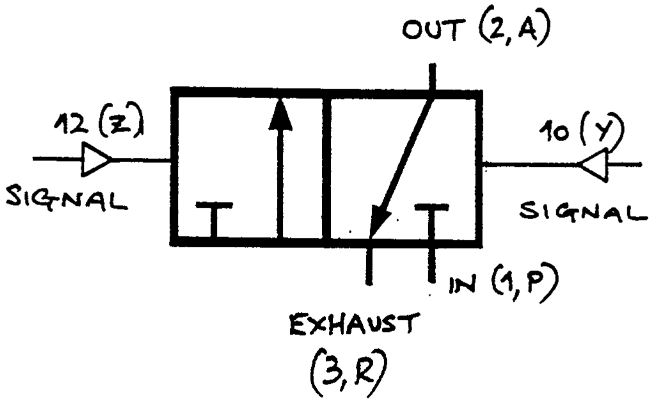
We have therefore in this manual used the two most popular methods of port labeling for valves other that 5 port that is letters and numbers. 4 port valves are labelled with letters as this is in the main how this type of valve will appear in practice, this type of valve is also less common now than in previous years. The numbers used follow the same pattern as the I.S.O. 5599 standard with the letters following the system as follows:

Supply	-	P
Output/s	-	A, B
Exhaust/s	-	R, S
Signal/s	-	Z, Y

Ports Labelled to I.S.O. 5599 (5 Port Valves ONLY)

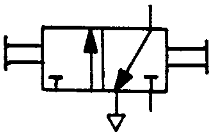


Examples of Labelling for 3 Port Valve/s

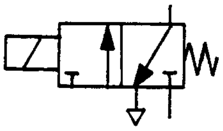


Pneumatic Symbols in Accordance with I.S.O. 1219-1

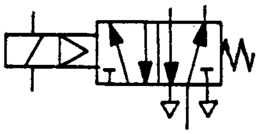
In all the exercises in this manual, the following pneumatic symbols are used in the circuit diagrams.



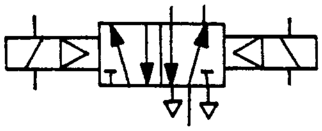
3/2 way directional control valve with manual operation



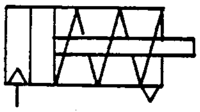
3/2 way directional control valve solenoid operated spring return



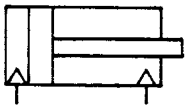
5/2 way directional control valve solenoid operated spring return



5/2 way directional control valve double solenoid operated



Single acting cylinder, spring return



Double acting cylinder

This page has intentionally

been left blank

Section 3

Introduction

This page has intentionally

been left blank

Introduction

These exercises and solutions have been designed for use on 'practical' courses where the participants are required to 'put theory into practice' by designing and constructing working circuits to meet with the requirements of typical industrial applications. They are progressive from very simple through to more complex and should cover the needs of most electro pneumatic courses. The circuits contained within the solutions are designed in such a way that they can be constructed from equipment widely available on the market and are not intended to be manufacturer specific.

Important Note:

At the time of publication an international standard (I.S.O. 5599) exists this standard covers amongst other things the port labelling of 5 port valves as follows:

Supply port	=	1
Output ports	=	2, 4
Exhaust ports	=	3, 5

There is no standard (at time of production of these exercises) for the other types of valves available in pneumatics and therefore where 3 port valves are used the ports are labelled as follows:

Supply port	=	1 (P)
Output port	=	2 (A)
Exhaust port	=	3 (R)

Introduction

The DIN system has been used for labelling the electrical connections and identifying components as follows:

Open contacts	=	3, 4
Closed contacts	=	1, 2
Change over contacts	=	1, 2, 4

Solenoids	=	Y
Relays	=	K
Switches	=	S
Sensors	=	B

This page has intentionally

been left blank

This page has intentionally

been left

Section 4

Safety requirements when using electricity

Formulae

What is electricity

Principles of electrical energy

The electron theory

Conductors

Electron flow in a conductor

Direction of current flow

Current, voltage and resistance

Ohm's law

A basic electric circuit

How electricity is produced via: Heat, Friction, Chemical action, Light, Pressure, and Magnetism

Electrical symbols

Push button, toggle, and roller operated switches

Modern relays and types

Electrical switch and notation

This page has intentionally

been left blank

Safety Requirements when using Electricity

General

With any type of engineering there is always potential hazards regarding health and safety requirements whilst working with electrical systems.

Care must be taken at all times to avoid personal injury and/or damage to you, plant, or equipment. In a controlled situation, electrical devices and systems are safe. However, if they are used incorrectly, they can present serious hazards to the user.

Most hazards can be avoided by using a little logic and simple common sense. The following advice will help with the safety requirements.

- ✓ Due to electricity being very powerful, it is highly important never to let it come into contact with any fluids, so as to avoid electrical shocks.
- ✓ Whilst a low voltage system is relatively safe, as far as serious electrical shock is concerned, high voltages of short duration are present under certain conditions with some components and whilst a fatality is very unlikely. A shock from such a source could produce a reflex action in the arm, which could easily lead to injury through uncontrolled physical contact with other parts of the machine and/or equipment.
- ✓ Make sure all equipment is switched "off" before setting up any circuits. If the equipment is not kept switched "off" whilst setting up the circuits this could cause a short circuit and lead to blown fuses, etc.

Safety Requirements when using Electricity

- ✓ Never try to undertake any kind of servicing or interfere with any part of the electrical system unless you have adequate understanding of the consequences of your action.
- ✓ If the electrical power supply is not disconnected and the circuit is live make sure that any action taken cannot initiate subsequent operations that could endanger you or other people near you.
- ✓ Switch 'off' all equipment before making or breaking any electrical connections.

Safety Requirements when using Electricity

HAZARDS ASSOCIATED WITH ELECTRIC CURRENT

Currents more than 50 mA (0.05A) can be lethal to humans if the path is across the heart!!

Human (and animal) bodies are conductors of electricity, electric current can cause burns and muscular cramp. If the current flows across the heart, the result is "cardiac flutter" which causes failure of the heart and breathing.

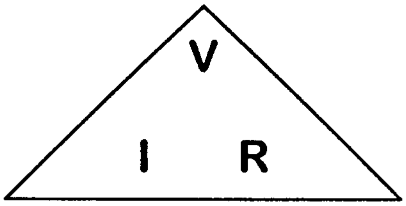
Therefore, protective measures must be observed in practice to avoid accidents.

Effects of current on humans:

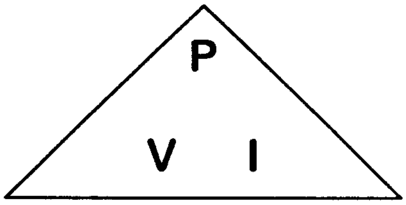
0.3 mA	-	Sensitivity level
1 mA	-	Fright shock
10 mA	-	Muscular cramp
30 mA	-	Human is stunned
50 mA	-	Cardiac flutter (possible death)

Be aware that many domestic appliances in the home are protected by a 13 amp fuse, so therefore offer no protection to humans.

Formulae

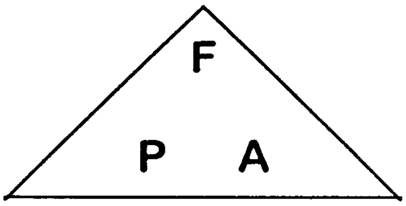


V = Voltage (volts)
I = Current (amps)
R = Resistance (ohms)



P = Power (watts)

Pneumatic equivalent:



F = Force (newtons)
P = Pressure (bar)
A = Area (m^2)

What is Electricity?

The Oxford English Dictionary defines electricity as:

> **"A peculiar condition of the molecules of a body developed by friction, chemical action, heat or magnetism."**

Generally speaking, electricity can be described as being the flow of electrons from atom to atom in a conductor.

Principles of Electrical Engineering

Electricity is a form of energy. It is encountered in the form of heat, light, magnetic or chemical action. It has always been difficult for humans to detect the presence of electricity although electrical energy is put to use in a wide range of installations and machines.

Distinctions are already found in the electrical components used in electrical systems. Almost everyone makes daily use of electricity or electronics in some form or other for example switching on lights, domestic appliances, televisions, computers, vehicle lights, etc.

In all of these cases, electricity must be present. It is irrespectful of whether energy is supplied from a battery or power station.

We know all things consist of atoms. Each atom has a nucleus, the electrons circle around the nucleus. Atoms are minute and invisible to the human eye. Their diameter is approximately 1/10,000,000 mm. The diameter of the nucleus is about 1/10,000 of the diameter of the entire atom. The diameter of an electron is approximately 1/10 of the diameter of the nucleus.

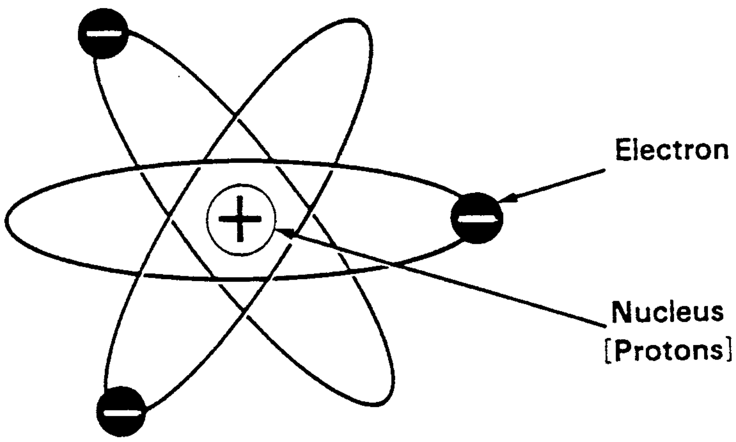
The Electron Theory

Matter is composed of atoms and the atom is the smallest independent unit in the composition of any substance. Although its structure varies in different materials, its basic pattern is always the same.

Every atom has a nucleus composed of positively charges protons, orbiting around the nucleus are negatively charged electrons. Atoms are normally in an electricity-balanced state with the positive charge of the protons in the nucleus equaling the negative charge of the orbiting electrons.

Protons are positive charges (+)
Electrons are negative charges (-)

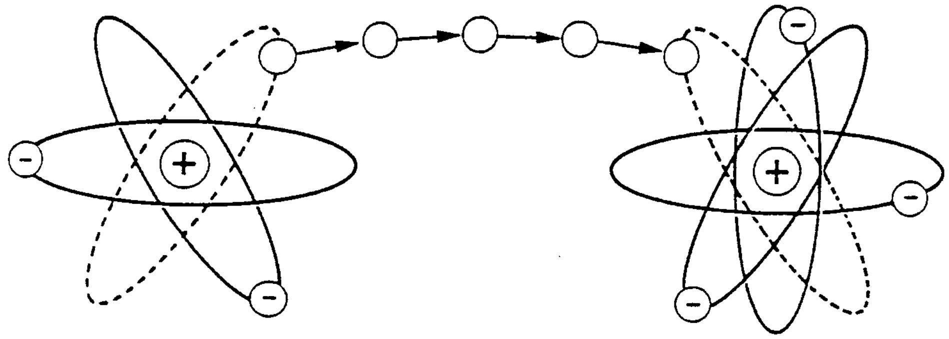
When an atom is in this electrically balanced state it has the same number of protons and electrons and is said to be electrically neutral.



The Electron Theory

Under certain conditions, an electron can be persuaded to change partners so to speak and be made to detach itself from one atom and take up an orbit around another nucleus of an adjoining atom.

When this happens it can be seen that the atom giving up the electron is now unbalanced (because it has too few electrons) and becomes positively charged. Conversely, the atom receiving the electron had one too many electrons and becomes 'biased' to a negative charge. Neither of them is in a state of electrical balance.



Too few electrons = **Positive charge**   Too many electrons = **Negative charge**

The Electron Theory

It is important at this stage to understand what happens next in the atoms concerned as they endeavor to reinstate their respective balanced structures. The atom positively charged needs to attract a negatively charged electron, the atom negatively charged with too many electrons must dispense with one of them to re-establish its former electrical equilibrium.

In other words	Like charges repel Unlike charges, attract

"LIKE CHARGES" ⊕ ⊕ ⊖ ⊖ repel each other

"UNLIKE CHARGES" ⊕ ⊖ attract each other

Conductors

A material in which electrons can be persuaded easily to transfer from one atom to another by the application of some external force is known as a conductor.

Copper is widely used in electrical systems as a good conductor of electricity and a brief look at the atomic structure of the material shows why this is so.

In every atom of copper, there are 29 protons and an equal number of electrons in orbits around the nucleus, which conform, to a regular pattern represented by the diagram.

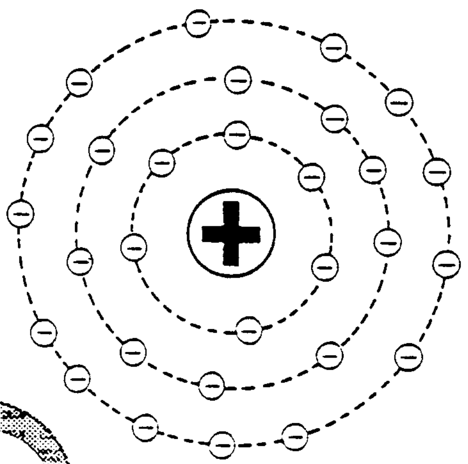
Most of the electrons travel in four clearly defined orbits but there is one which travels around in an exclusive path on the very outside quite apart from all the others.

The fewer electrons in the outer ring the easier they can be dislodged and persuaded to join an adjacent atom.

So, that copper with its solitary electron in the outer ring has the necessary characteristics to make it a good conductor.

As a general rule elements with four or less electrons orbiting in the outer ring make good conductors of electricity whilst those with more than four are poor conductors and are referred to as insulating materials.

An atom of Copper has
29 Protons and 29 Electrons



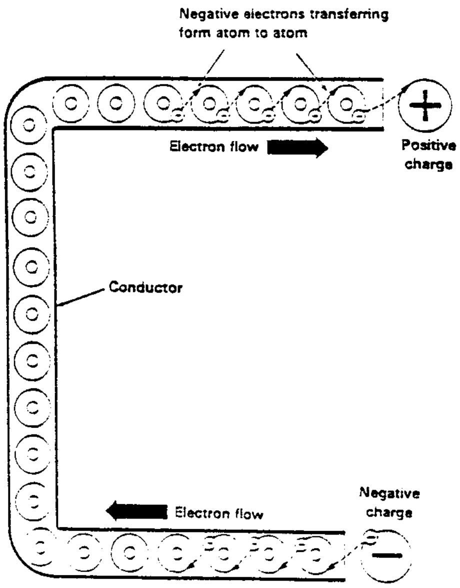
Electron Flow in a Conductor

It is now possible at this point to see what happens in a conductor e.g. a length of copper wire – when it has a positive (+) charge at one end and a negative (-) charge at the other.

For ease, the diagram below shows only a few atoms with only the single electron in the outer ring. In reality, copper wire contains billions of atoms and electrons.

What happens is that a negative electron in the wire at the positively charged end is attracted to the electron hungry positive charge. (NB a positive atom is short of electrons). This then leaves an atom in the wire short of an electron which means that it is positively charged. Therefore it attracts an electron from its neighbour, the neighbour then collects an electron from the next atom along the wire and so on.

The end result is a movement of electrons along the wire from the negative end to the positive end. This flow will continue as long as the positive and negative charges are sustained at each end of the wire.



The flow of electrons is called a **CURRENT.**

Direction of Current Flow

There are two descriptions for the direction in which current flows within an electrical circuit.

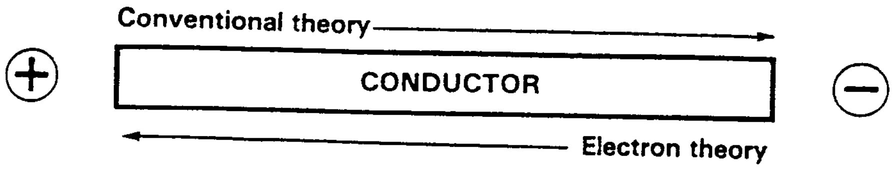
1) Conventional theory- Current flows from positive to negative.

2) Electron theory - Electrons flow from negative too positive.

Both of these theories are correct and both can be used.

Although both theories are correct, the conventional theory is the one, which is generally accepted and will be used throughout this manual for convenience and consistency.

Current flow in a conductor



Current, Voltage and Resistance

Below are the ingredients, which are necessary for an electric circuit.

CURRENT
(Amperes)

VOLTAGE
(Volts)

RESISTANCE
(Ohms)

ELECTRIC CIRCUIT

Current, Voltage and Resistance

There are three interdependent factors, which are all variable. These need to be considered in any electrical circuit - current, voltage and resistance.

Current

We have already established that current is the flow of electrons through a conductor.

We measure it in AMPERES, as this is the rate of flow of the electrons. One ampere is the electrical circuit equivalent to approximately 6.25 trillion (6.25×10^{18}) electrons passing a given point in one second. The symbol used to illustrate this within circuit diagrams is **I**.

Voltage

This is the force required to maintain a flow of current in a conductor. The amount of current flowing in a given conductor will depend upon the potential difference (P.D.) between the charges at each end of the conductor.

Voltage is a potential force and can be present without current, but on the other hand, current cannot exist without voltage. For example, a storage battery may have potential difference between its positive (+) and negative (-) terminals although no current carrying devices are connected to the terminals.

The unit of measurement used is a **VOLT** and the symbol used is to show this is **V**.

Current, Voltage and Resistance

Resistance

All conductors offer some resistance to a flow of current. Resistance is caused primarily by two main factors:

1) The reluctance of individual atoms to part with an electron.

2) The multitude if collisions caused by electrons moving along the conductor.

The second phenomenon also creates heat.

The unit of measurement used for resistance is an **OHM** and the symbol used to show this is **Ω**, as in the Greek letter 'omega'.

Ohm's Law

Ohm's law expresses the relationship between current, voltage, and resistance in a conducting circuit.

It states that if a potential difference (voltage) of one volt is applied to a conducting circuit a current of one Ampere will flow if the resistance of the circuit is one Ohm.

Representing this mathematically $V = IR$

Where V = Voltage
I = Current
R = Resistance

Thus when any two values are known the third can be established by using one of the three available formulae:

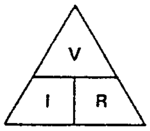
$V = IR$ (Volts = Current multiplied by Resistance)

$I = \frac{V}{R}$ (Current = Volts divided by Resistance)

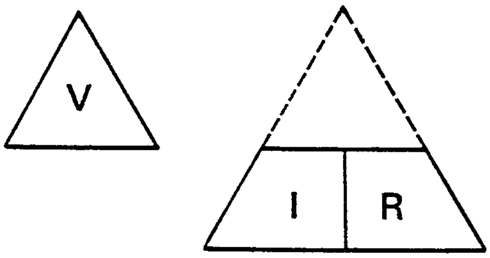
$R = \frac{V}{I}$ (Resistance = Volts divided by Current)

Ohm's Law

It is possible to represent Ohm's Law graphically in the form of a triangle:

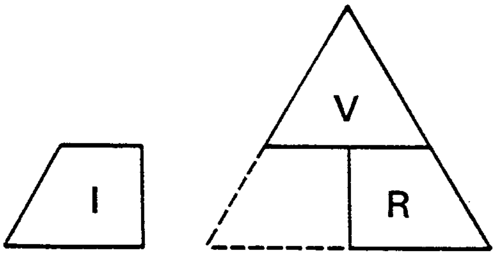


Remove the symbol to be found and the position of the two remaining symbols indicate the procedure.



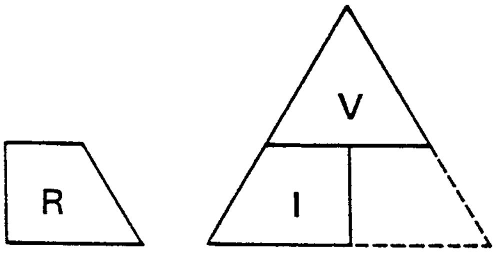
$V = IR$

V = Current multiplied by resistance



$I = \frac{V}{R}$

I = Voltage divided by resistance



$R = \frac{V}{I}$

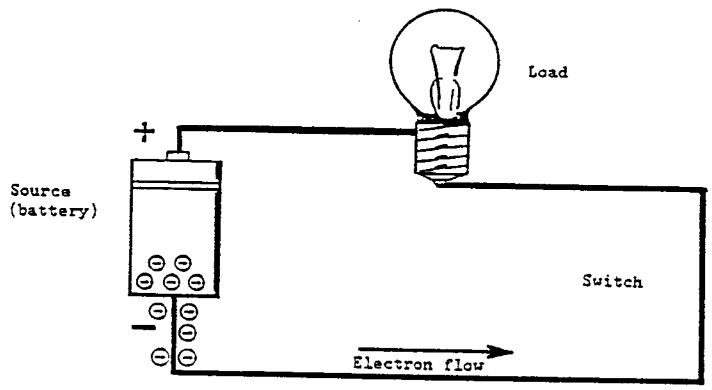
R = Voltage divided by Current

A Basic Electric Circuit

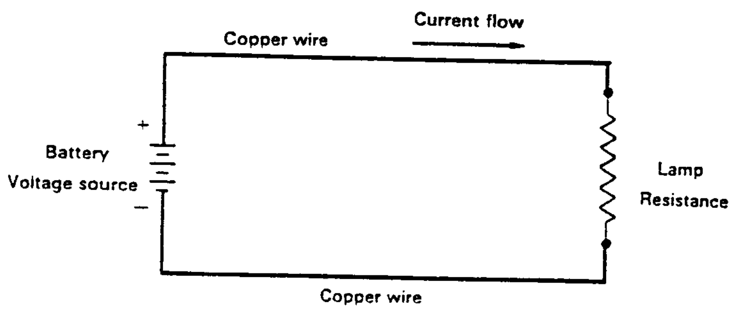
There are three main ingredients, which are essential in every conducting electric circuit:

1) A voltage source – e.g. a battery
2) Conductors – e.g. copper wire to connect the circuit
3) Resistance – such as an electric lamp

The conductors themselves contribute a small part of the total resistance in a circuit but it can be ignored at this stage.

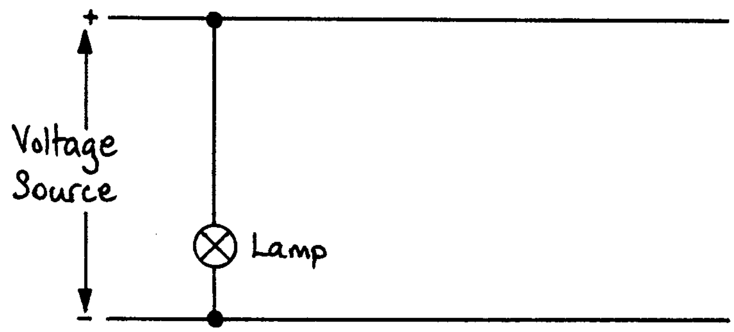


Using symbols, the circuit above is represented as:-



A Basic Electric Circuit

All the electrical circuits shown in the practical exercises comply with the DIN standard, which is the most commonly used throughout Europe. Using this standard the two electrical circuits shown on the previous page would be drawn as below:



How Electricity is Produced

The six sources of external energy, which are capable of separating the negative electrons from the positive nucleus of an atom, are: Heat, Friction, Chemical Action, Light, Pressure, and Magnetism.

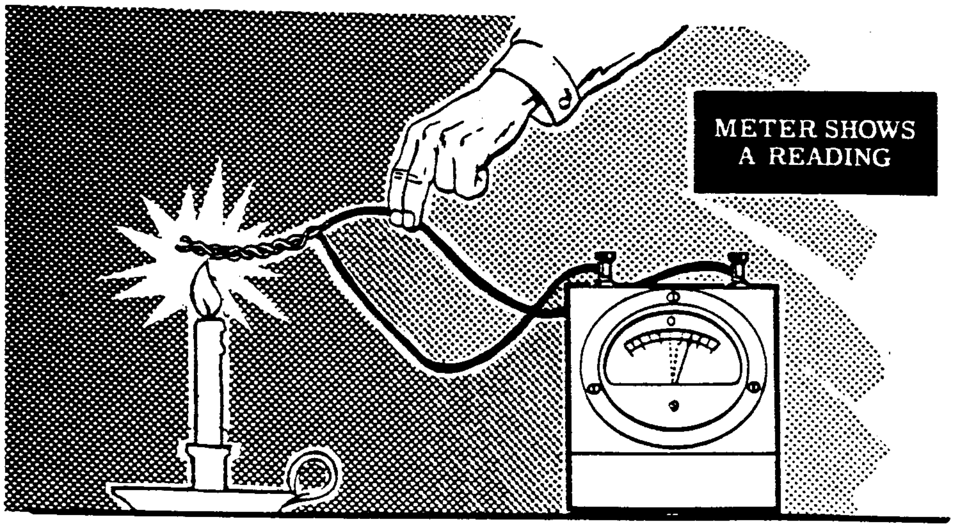
How Heat Produces Electricity

The first source of external energy, which can separate electrons away from their parent atom, is Heat and the most common way of using heat for this purpose is to apply it to the junction of two dissimilar metals. If an iron wire and a copper wire are twisted together to form a junction for instance and if that junction were heated an electric charge will result.

The amount of this charge will depend on the difference in temperature between the junction and the opposite ends of the two wires. The greater this temperature difference the greater the charge.

A junction of this type is called a "thermo-couple". It will produce electricity for as long as heat is applied to it.

In practice, however thermo-couples are more efficient than twisted wires, they are constructed of two pieces of dissimilar metal riveted or welded together.



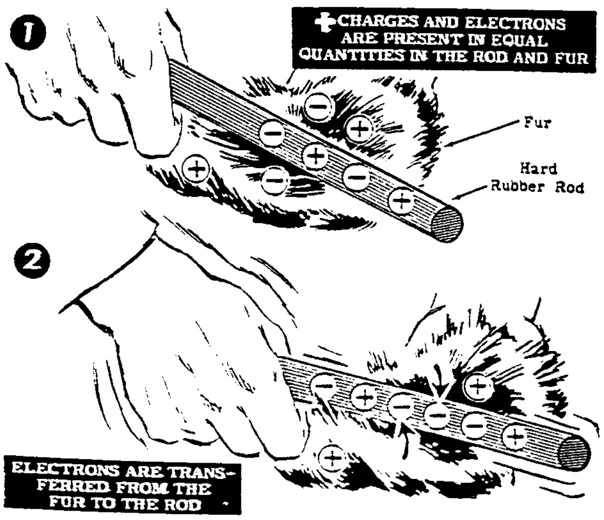
How Friction Produces Electricity

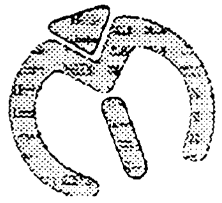
The second source of external energy, which can separate electrons away from their parent atom, is Friction.

If you rub two different materials together, electrons may be forced out of their orbits in one material transferred to the other material and retained there. The material, which captures electrons, acquires of course a negative charge and the material, which loses electrons, acquires a positive charge.

The resulting distribution of electric charge is known as "static electricity". Both materials retain the static charges they have acquired because of friction until (as you will learn in a moment) something occurs to "discharge" them.

Materials which easily acquire a charge of static electricity include glass, amber, hard rubber, waxes, flannel, silk, rayon and nylon. When a hard rubber rod is rubbed with fur the fur loses electrons to the rod, the rod becomes negatively charged and the fur positively charged. When a glass rod is rubbed with silk the glass rod loses electrons it then becomes positively charged and the silk negatively charged.



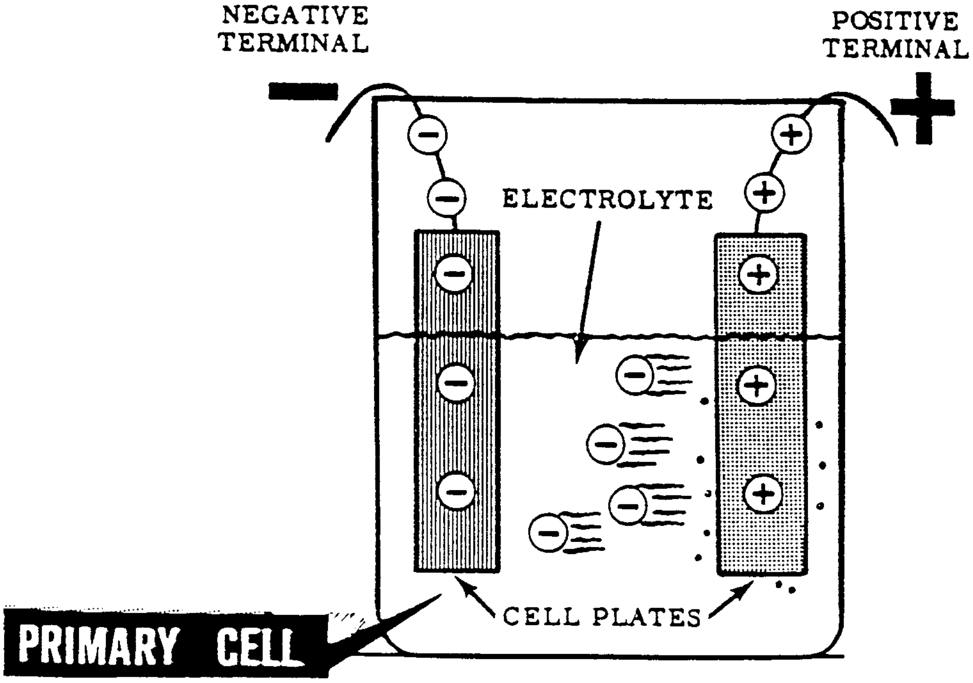


How Chemical Action Produces Electricity

The third source of external energy, which can separate electrons away from their parent atom, is Chemical Action. The particular kind of chemical action that takes place in "electric cells" and "batteries" is put to practical use in the production of electricity.

Batteries are used for emergency and portable electric power. Whenever you use a flashlight or portable wireless equipment, you will be using batteries. Batteries are the main source of power for present day submarines. In addition, there is a wide variety of equipment, which uses cells or batteries either as normal or emergency power. "Dead" batteries are a common type of equipment failure and such failures can be very serious.

Cells and batteries require care and maintenance in exactly the same way as the other equipment on which you will work. Even though you may use only a few cells or batteries if you find out how they work, where they are used and how to care for them properly you will save time and in many cases a lot of hard work.



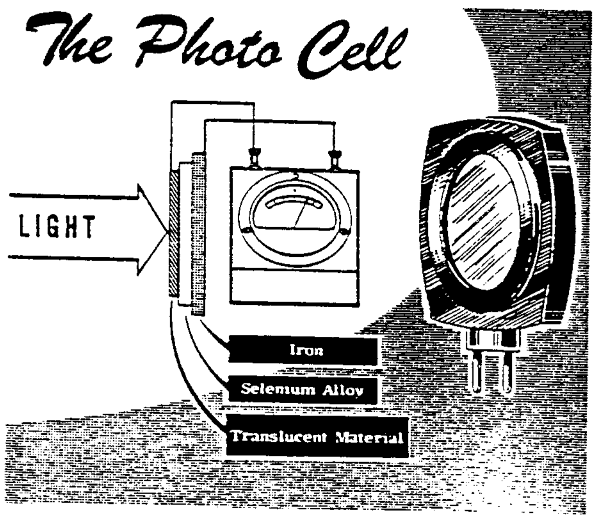
How Light Produces Electricity

The fourth source of external energy, which can separate electrons away from their parent atom, is Light.

The most useful way in which light can be used to produce electricity is in a special kind of cell containing photosensitive material, which has the property of developing an electric charge when light strikes it.

Such a "photo cell" is a kind of metallic sandwich shaped like a disc and composed of three layers of different material. One outside layer is made of iron the other is a film of semitransparent material, which allows light to pass through it. The inside layer of the sandwich is made of an alloy of selenium.

When light is focused on the selenium alloy through the translucent film an electric charge is created between the film and layer of iron. A meter connected across these layers will measure the amount of charge created. Such a cell forms the exposure meter used by a photographer to measure the amount of light present in the studio.



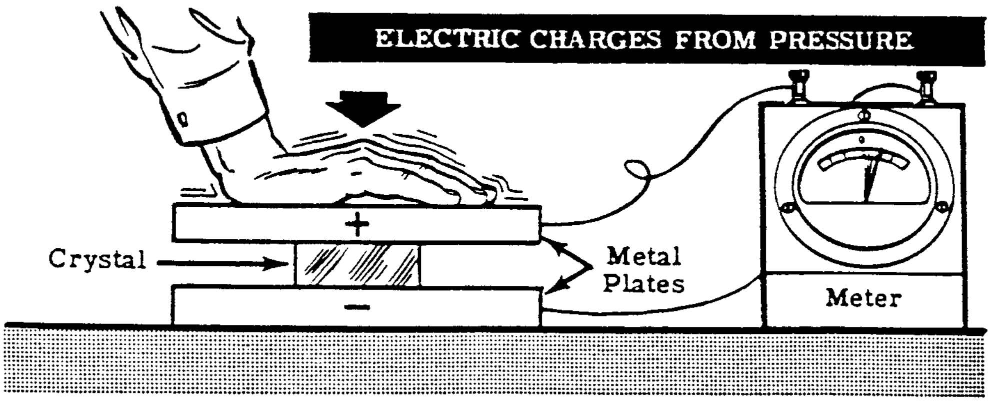
How Pressure Produces Electricity

The fifth possible source of external energy used to separate outer orbit electrons away from their parent atom is Pressure.

Whenever you speak into a telephone or any other similar type of microphone the pressure waves of the sound energy, which your voice generates, make a diaphragm move. This diaphragm movement can be used to give rise to an electric charge in the following way.

There exists in nature certain materials whose crystals develop an electric charge when pressure (as from a moving diaphragm) is exerted on them. Quartz tourmaline and Rochelle salts are examples. If a crystal from one of these materials is placed between two metal plates and pressure is exerted on the plates in the manner illustrated (rather improbably of course!) in the diagram below an electric charge will be created between the plates. Its size will depend on the amount of pressure exerted.

It is also possible to convert electrical energy back into mechanical energy by placing an electric charge on the plates of such a device. The crystal will then expand or contract by a small amount depending on the amount and type of the charge applied and the mechanical energy so created can also be put to use.



How Magnetism Produces Electricity

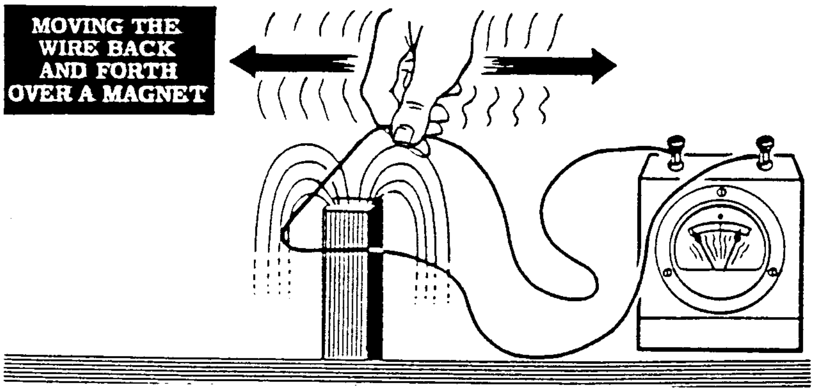
The sixth (and by far the most commonly used) source of external energy, which can separate electrons away from their parent atom, is Magnetism.

Magnetism itself however, is not used as the direct source of this external energy. Large quantities of electric power are produced in big machines called "generators" as the result of an action which takes place between the wiring of the generator and some powerful magnets placed in a special way inside it.

The generator itself has also to be driven of course and this may be done by waterpower, by an internal combustion engine or by a steam turbine. In turn burning oil may either produce the steam needed to drive this turbine or coal to heat a conventional boiler or it may come from a modern nuclear reactor.

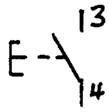
In any case, the action is indirect. Energy is used to make the generator turn. When it turns, it makes use of the properties of magnetism to produce the source of external energy you need to separate electrons away from their parent atoms and so make it possible for electric current to flow.

However, magnetism itself is central to the whole enormously important process. Therefore, you must now learn what magnetism is and how it can be used to produce an electric charge.

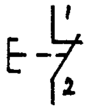


Electrical Symbols

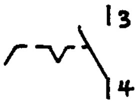
In all the exercises in this manual, the following electrical symbols are used in the circuit diagrams.



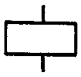
Push button switch with Normally Open contacts



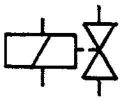
Push button switch with Normally Closed contacts



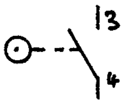
Toggle switch with Normally Open contacts



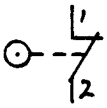
Relay coil



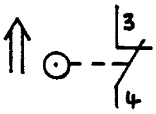
Solenoid valve coil



Roller operated limit switch with Normally Open contacts



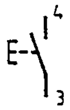
Roller operated limit switch with Normally Closed contacts

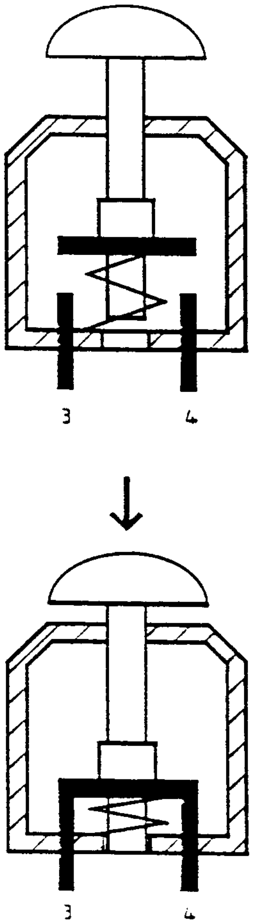


Roller operated limit switch with Normally Open contacts "Held Operated"

Lamp

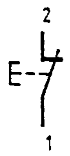
Push Button Switch with Normally Open (N/O) Contacts

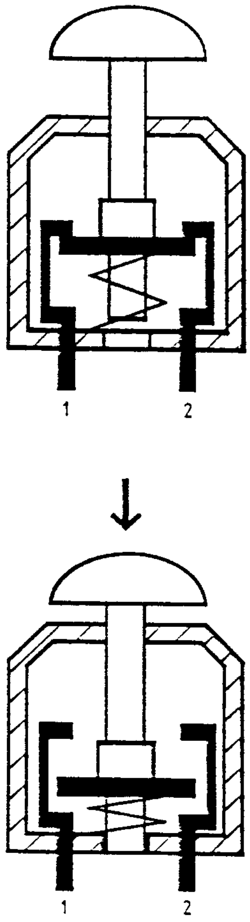




The push button is an electrical input device. When the push button is operated the contacts are actuated and reversed from their Normally Open condition to a switched condition, which closes the contacts, this allows current to flow. After the push button is released, it returns to its original position by means of the internal spring thereby breaking the current flow.

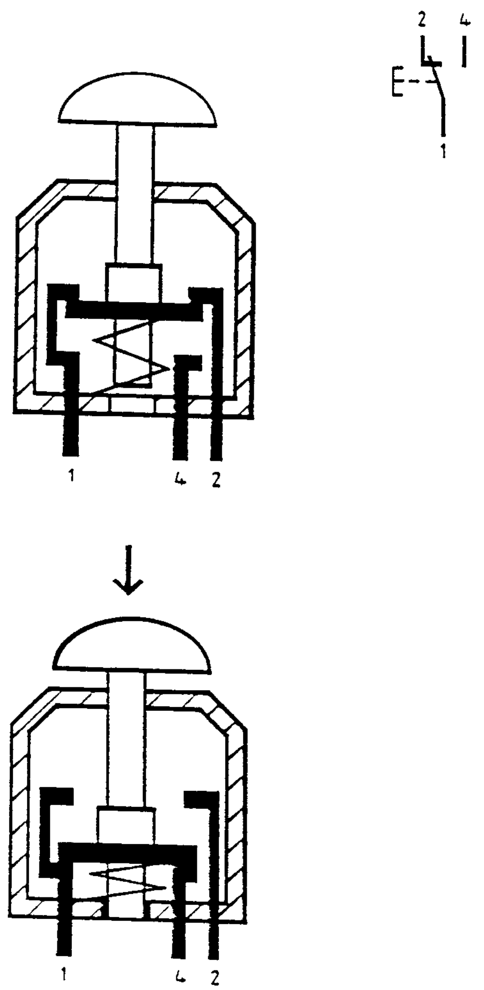
Push Button Switch with Normally Closed (N/C) Contacts





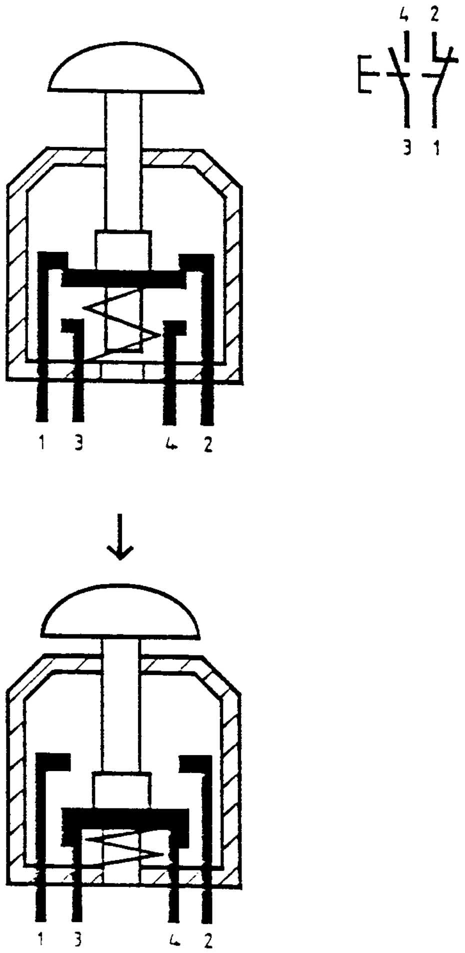
The push button is an electrical input device. When the push button is operated the contacts are actuated and reversed from their Normally Closed condition to a switched condition, which opens the contacts, this stops the current flow. After the push button is released, it returns to its original position by means of the internal spring this closes the contacts and allows current to flow once again.

Push Button Switch with Change Over Contacts



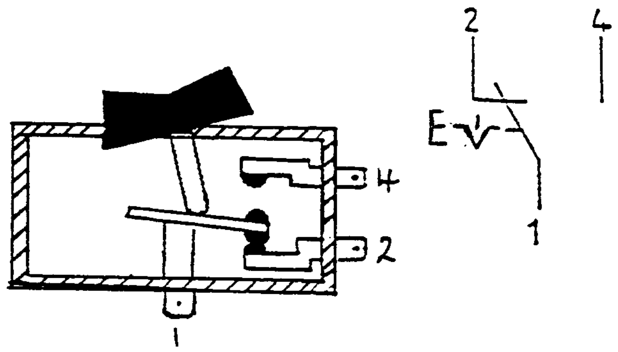
The push button is an electrical input device. When the push button is operated the contact is switched from its normal condition (current flow from 1 to 2) to its actuated condition (current flow form 1 to 4) thus one circuit is opened and the other is closed. The contacts remain in this condition until the push button is released when the internal spring resets the contact to its original condition.

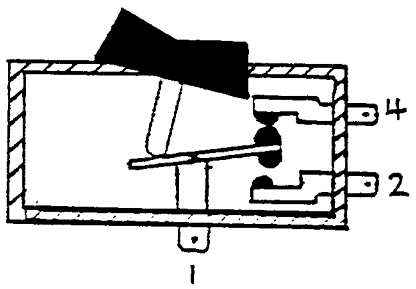
Push Button Switch with Open and Closed Contacts



The push button is an electrical input device. When the push button is unoperated, the contacts 1 and 2 are connected (closed) allowing current flow, at this time contacts 3 and 4 are isolated (open) and current will not flow across them. Upon operation of the push button the contacts are reversed 1 to 2 are opened (breaking the current flow) and 3 to 4 are closed (current flow possible). After releasing the push button, the contacts are returned to their original condition by means of the internal spring.

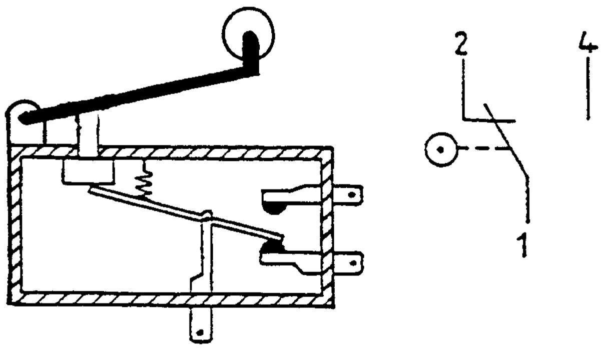
Toggle Switch with Change Over Contacts

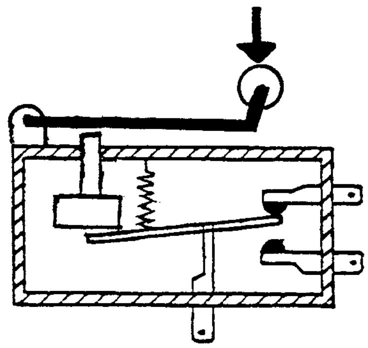




The toggle is an electrical input device. When the toggle is operated the contact is switched from its normal condition (current flow from 1 to 2) to its actuated condition (current flow from 1 to 4) thus one circuit is opened and the other is closed. The contacts remain in this condition until the toggle is operated to its initial position resetting the contacts to their original condition.

Roller Operated Limit Switch with Change Over Contacts





The limit switch is an electrical input device. When the roller is unoperated, the contacts 1 and 2 are connected (closed) allowing current flow, at this time, contacts 1 and 4 are isolated (open) and current will not flow across them. Upon operation of the roller the contacts are reversed 1 to 2 are opened (breaking the current flow) and 1 to 4 are closed (current flow possible). After releasing the roller, the contacts are returned to their original condition by means of the internal spring.

Modern Relays

In 1837, when Samuel Morse, using the electromagnet invented by J. Henry in 1824 first made his "writing telegraph" operate, the birth of the relay took place. Anyone talking of *relays* in those days – the days of the mail coach – would however have been thinking of a change of horses.

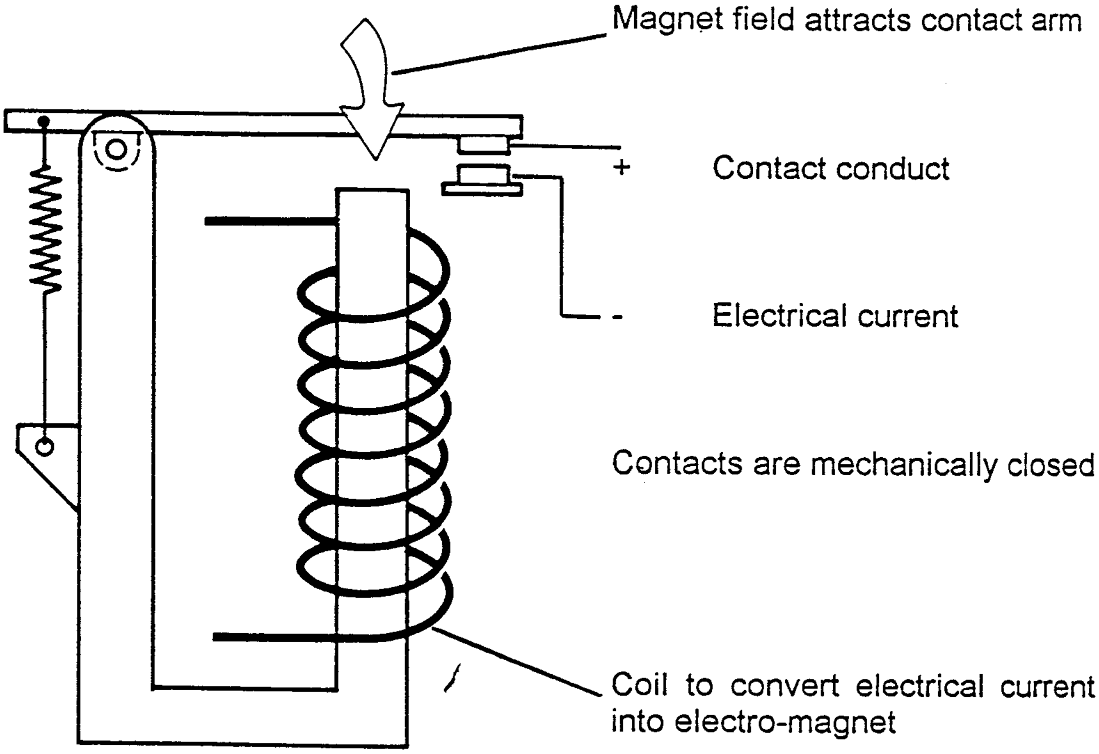
Today there are an estimated 25 billion relays in operation worldwide (approximately five for every person on earth). These relays carry out switching control and monitoring functions in electrical systems, devices, and equipment at around 25 million per second.

Signals applied to the coil can be amplified in the contact circuit by a factor of up to 10^5 or reduced by up to 10^{-10}. Time delays lasting from milliseconds to many hours can be achieved as well as branching the signal over several contact circuits.

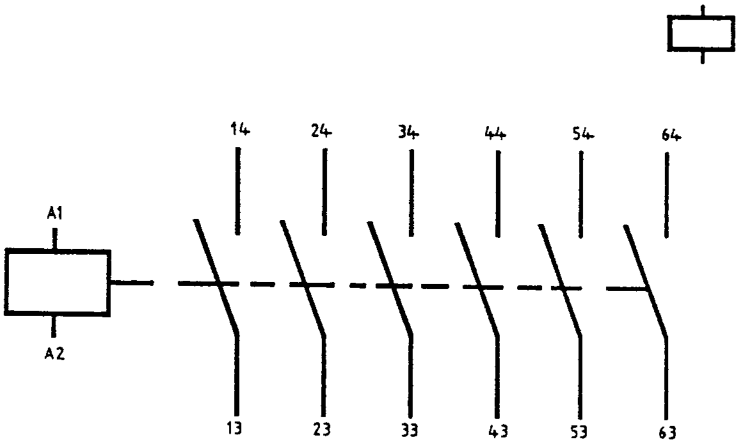
Conventional relays have a four-part function:

1) To convert electrical current into a magnet flux.
2) Convert magnet flux into a force.
3) Conduction of mechanical energy.
4) Conduct electrical current via the contact.

Modern Relays

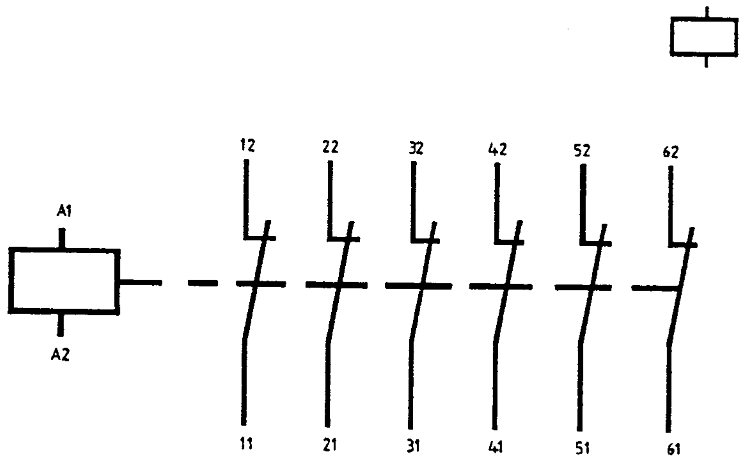


Relay with Normally Open Contacts



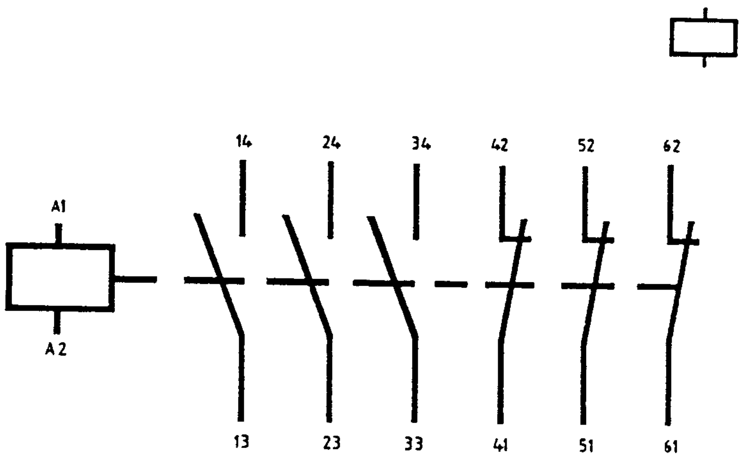
A relay is an electrical signal processing device. After applying voltage to the coil contacts (A1 and A2) electric current flows through the armature winding and a magnetic field is produced. The armature is thus pulled into the core of the coil and contact set is then actuated (switched). The contacts of this relay are Normally Open and therefore switch to a Closed condition, all contacts are actuated even if they are not utilised in the circuit. When the voltage is removed from the coil the magnetic field is released and the armature and contact set return to their original positions thus the contacts are reset to Open condition.

Relay with Normally Closed Contacts



The function of this relay is similar to the unit featured previously however the contacts are in the opposite condition (Normally Closed) when the relay is unactuated.

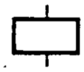
Relay with Normally Open and Normally Closed Contacts

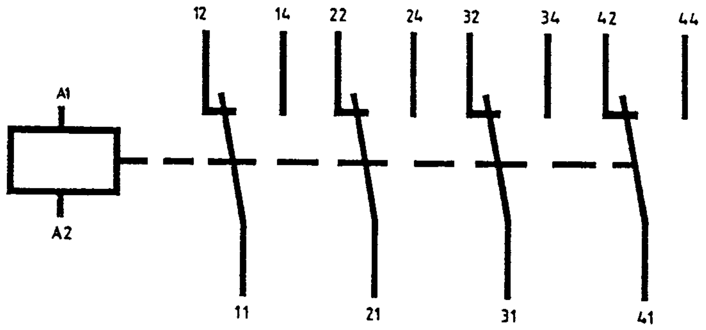


The function of this relay is similar to the units featured previously however it has a combination of Normally Open and Normally Closed contacts.

It should be noted that the closed contacts are identified with contact numbers 1 and 2 and the open contacts are identified by the contact numbers 3 and 4. The prefix to these numbers in each case denotes which contact it is in the contact set e.g. 13 and 14 is the first contact and has Normally Open condition.

Relay with Change Over Contacts



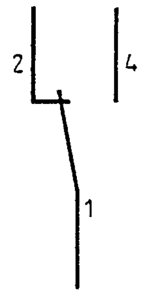


When a voltage is applied to the coil contacts (A1 and A2) current flows through the armature and a magnetic field is established. The armature is subsequently pulled into the core of the coil and the contact set is actuated (switched).

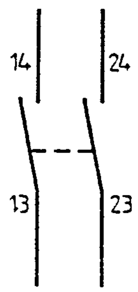
The contacts of this relay are of the Change Over type this means that when the relay is **NOT** actuated the flow path is contacts 1 to 2 in each case, when the relay is actuated (energised) the contacts change over and the flow path is then switched resulting in 1 to 4 in each case. The contacts remain in this condition until the coil is de-energised they are then returned to their original condition (1 to 2 in each case).

Electrical Switch Notation

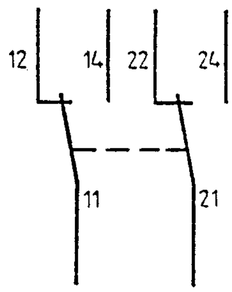
SPST
Single Pole
Single Throw



SPDT
Single Pole
Double Throw



DPST
Double Pole
Single Throw



DPDT
Double Pole
Double Throw

This page has intentionally

been left blank

Section 5

Tutor Kit

Tutor Layout

Tutor List

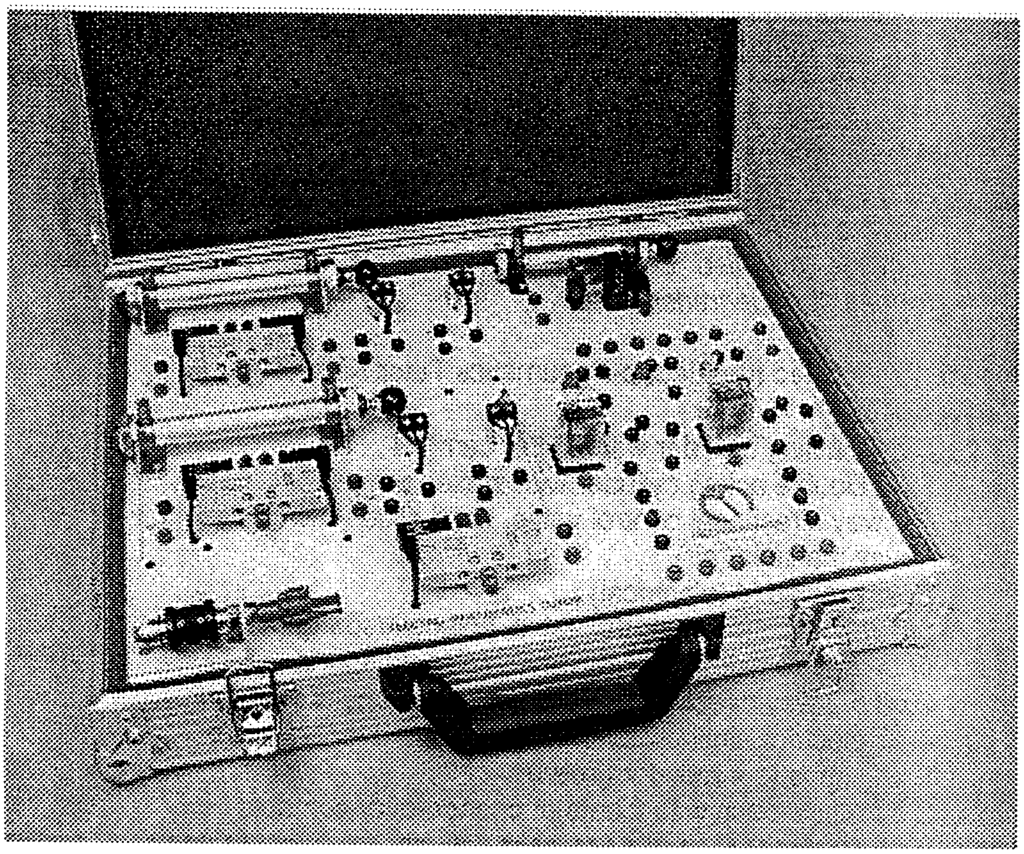
Exercises

Initial Start Up of Tutor Kit

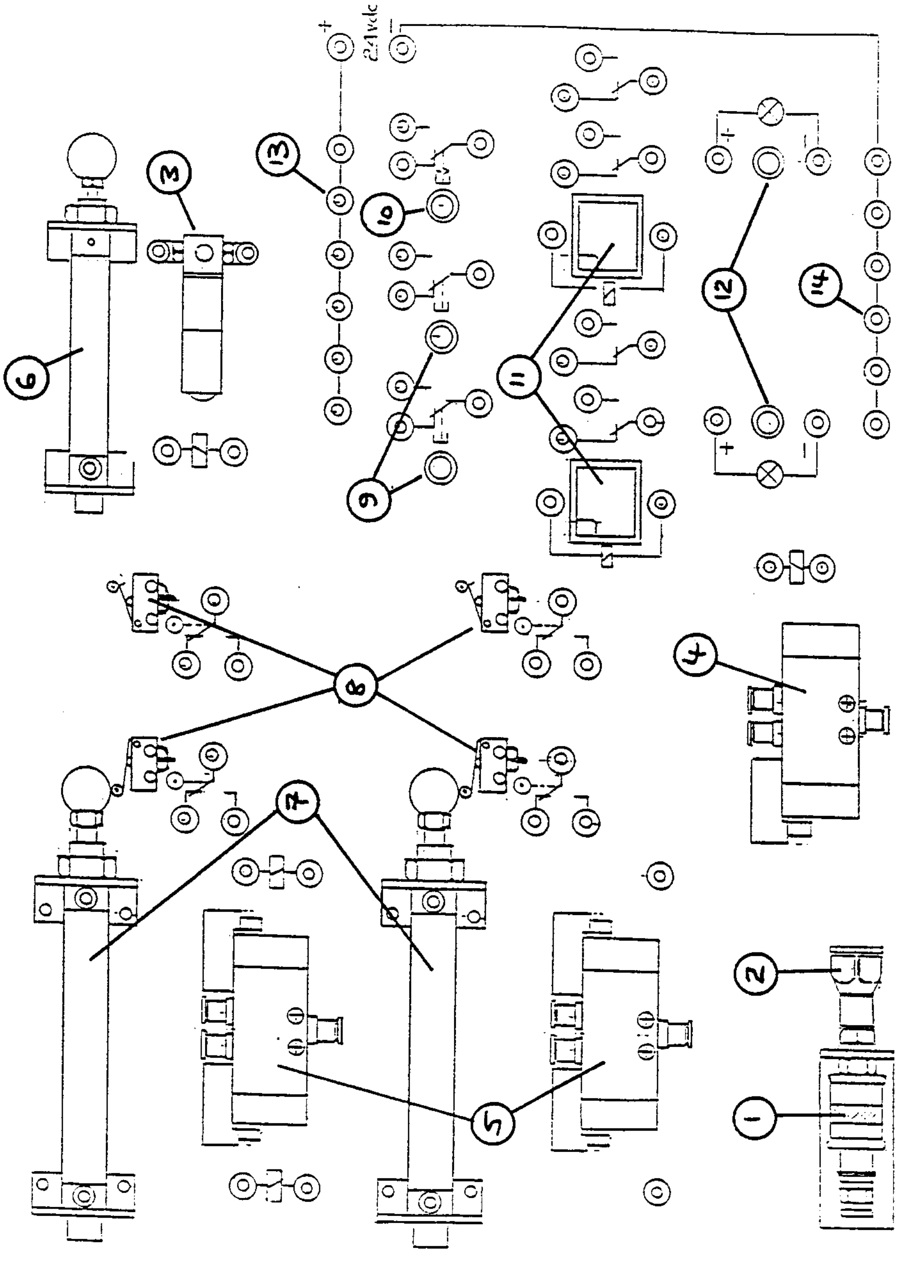
This page has intentionally

been left blank

Tutor Kit



Tutor Layout



Tutor List

Custom made, aluminium framed, lockable transit/storage case (520mm x 390mm x 100mm), complete with component mounting panel, screen printed with all relevant symbols to ISO 1219-1 (pneumatics) and DIN standard (electrical) and fitted with the following components:

Item 1	1 off	3/2 way directional control valve, hand slide (ON/OFF)
Item 2	1 off	4 way manifold
Item 3	1 off	3/2 way directional control valve, solenoid/spring (N/C)
Item 4	1 off	5/2 way directional control valve, solenoid/spring
Item 5	2 off	5/2 way directional control valve, solenoid/solenoid
Item 6	1 off	Single acting cylinder with striker cam
Item 7	2 off	Double acting cylinder with striker cam
Item 8	4 off	Electrical limit switches, each with change over contacts
Item 9	2 off	Electrical push buttons, each with change over contacts
Item 10	1 off	Electrical toggle lever (detent) with change over contacts
Item 11	2 off	Relays, each with 2 sets of change over contacts

Tutor List

Item 12	2 off	Lamps (1 red, 1 green)
Item 13	1 off	6 way manifold (electrical) (+)
Item 14	1 off	6 way manifold (electrical) (-)
Item 15	1 off	Set of electrical cables (red) with 2mm shrouded stackable banana plugs
Item 16	1 off	Set of electrical cables (blue) with 2mm shrouded stackable banana plugs

All components are fitted with 4mm push in fittings for pneumatics, completely wired to 2mm push in shrouded sockets for electrics and mounted ready for use on 24V d.c.

Exercises

1. Lamp (indicator) – direct control
2. Lamp (indicator) - pushbutton controlled
3. Relay control
4. Solenoid actuated valve
5. Relay and lamp function test using open contacts
6. Relay and lamps function test using change over contacts
7. Relay and solenoid control valve function test
8. Assembly fixture
9. Panel removal from a jig
10. Date stamping of a product
11. Bending fixture
12. Product separation (double solenoid valve version)
13. Product separation (single solenoid valve version)
14. Foundry ladle control
15. Product sorting (single solenoid valve version)
16. Product sorting (double solenoid valve version)
17. Conveyor bridge (2 way)
18. Barrier control with indicator lights
19. Component test machine
20. Product cleansing
21. Lift and transfer station
22. Embossing machine

Initial Start Up of Tutor Kit

1) Ensure that the air on/off is in the "off" position by sliding the black knurled sleeve to the left.

2) Connect an air supply, which is clean, dry, and regulated to between 2 to 3 'bar' (29 – 43.5 psi) pressure to the push in fitting on the inlet side of the air on/off valve.

3) Connect a 24 volt d.c. electrical power supply to the red and blue sockets marked 24V d.c. (+/-).

4) Ensure that the electrical power supply is switched "off".

The tutor kit is now ready to use.

This page has intentionally

been left blank

This page has intentionally

been left

Section 6

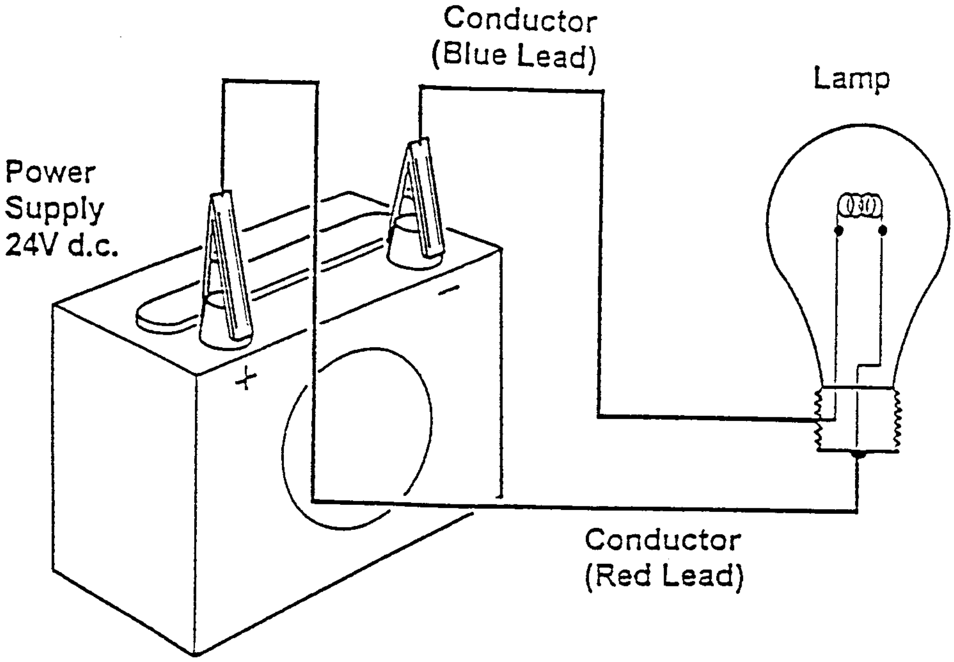
Exercises and Operational procedures

Circuit explanations and Question papers

This page has intentionally

been left blank

Exercise: Lamp (Indicator) – Direct Control



The operating characteristics of a lamp indicator are to be demonstrated by way of observation.

Equipment Required:

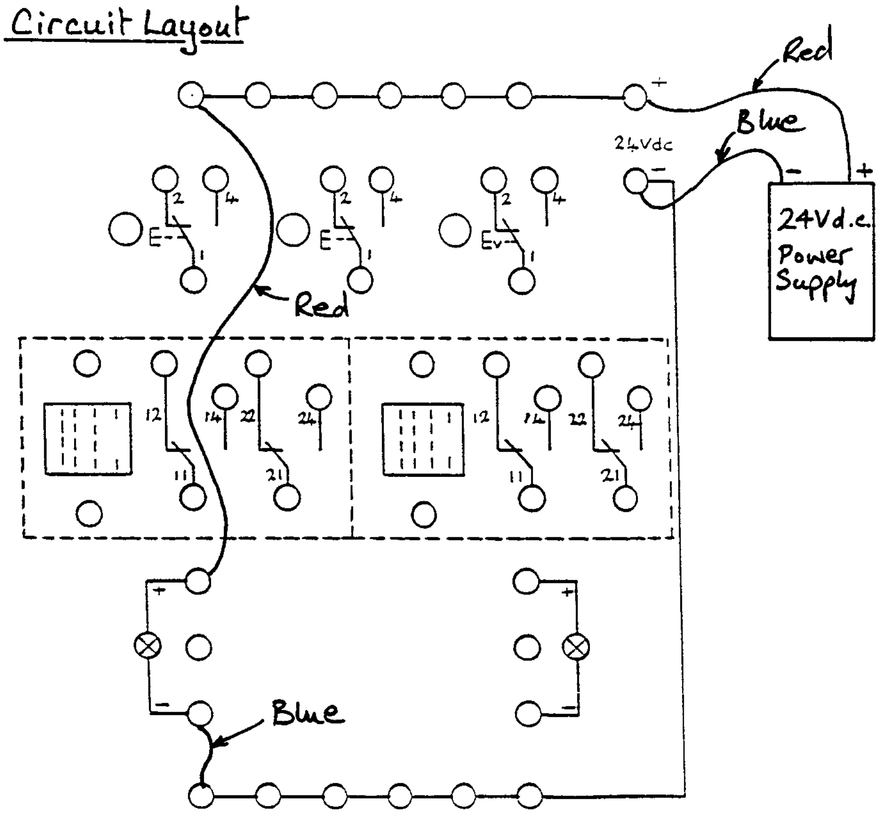
a) 1 off 24V d.c. power supply

b) 1 off Green lamp

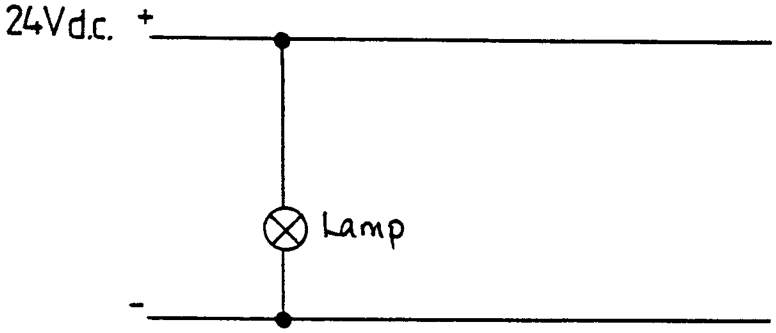
c) Red and blue electrical leads as required

Exercise: Lamp (Indicator) – Direct Control

Circuit Layout



Circuit Diagram



Exercise: Lamp (Indicator) – Direct Control

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.
2. Ensure that the electrical power supply is switched "off".
3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, and the green lamp.
4. Check the assembled circuit against the circuit diagram.
5. Switch 'on' the 24V d.c. power supply and observe what happens.
6. Switch 'off' the 24V d.c. power supply and remove all electrical leads.
7. Compare your observations with the written circuit explanation.
8. Answer the questions for this exercise.

Exercise: Lamp (Indicator) – Direct Control

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position a current is passed from the positive electrical distribution manifold through the green lamp to the negative manifold thereby completing an electrical circuit and illuminating the lamp. Upon actuating the switch to the 'off' position, the electrical circuit is disconnected and the lamp is switched 'off'.

Questions: Lamp (Indicator) – Direct Control

1) For safety reasons should electrical, power source voltages be kept as high or as low as possible in electro pneumatic systems ?

   High .... ☐

   Low .... ☐

2) An electrical power source can be either a.c. or d.c. what do these abbreviations stand for ?

   a.c. = ...

   d.c. = ...

3) This exercise uses a 24V d.c. power supply. List two (2) other electrical supplies in general use:

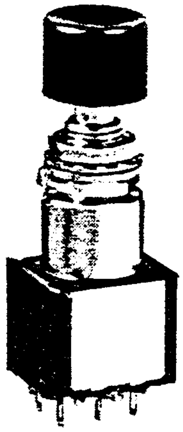
   1. ....

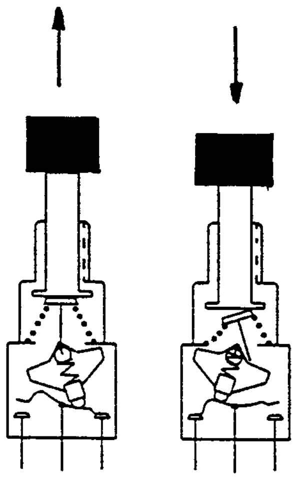
   2. ....

This page has intentionally

been left blank

Exercise: Lamp (Indicator) – Push Button Controlled





The operating characteristics of an electrical push button switch are to be demonstrated by way of observation.

Equipment Required:

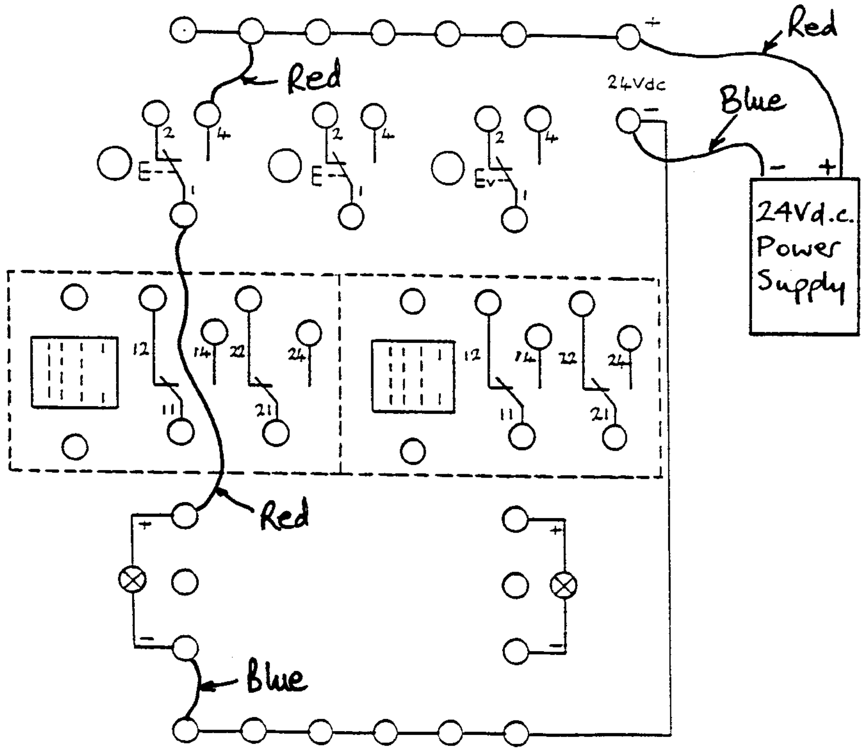
a) 1 off 24V d.c. power supply

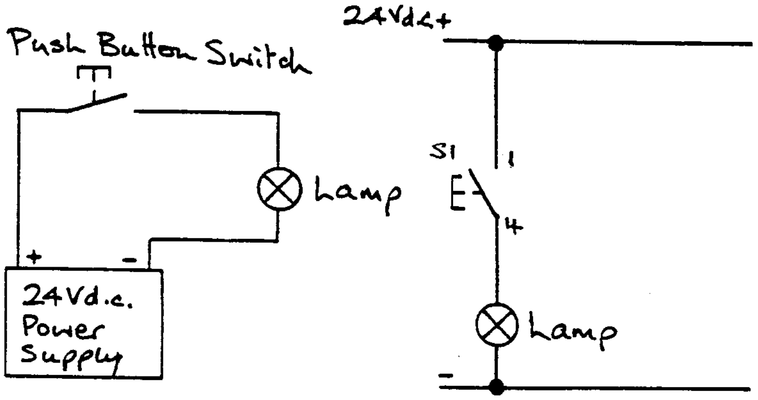
b) 1 off Electrical push button switch (Normally Open) contacts

c) 1 off Green lamp

d) Red and blue electrical leads as required

Exercise: Lamp (Indicator) – Push Button Controlled





Exercise: Lamp (Indicator) – Push Button Controlled

Operational Procedure

1 Connect a 24V d.c. power supply to the electrical distribution manifold.

2 Ensure that the electrical power supply is switched "off".

3 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, and the green lamp.

4 Check the assembled circuit against the circuit diagram.

5 Switch 'on' the 24V d.c. power supply.

6 Depress and hold down the electrical push button (S1) and observe the green lamp.

7 Release the push button (S1) and observe the green lamp.

8 Switch 'off' the 24V d.c. power supply and remove all electrical leads.

9 Compare your observations with the written circuit explanation.

10 Answer the questions for this exercise.

Exercise: Lamp (Indicator) – Push Button Controlled

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position and the push button is depressed a current is passed from the positive electrical distribution manifold through the push button contacts 3 and 4, the green lamp to the negative manifold thereby completing an electrical circuit and illuminating the lamp. The lamp remains illuminated so long as the push button is held operated upon its release the electrical circuit is disconnected and lamp is switched 'off'.

Questions: Lamp (Indicator) – Push Button Controlled

1) List any three (3) of the six (6) methods of generating electricity:

   1) ....

   2) ....

   3) ....

2) Which three (3) values are required to produce an electrical circuit ?

   a) ....

   b) ....

   c) ....

3) Switches may contain a number of contacts, which may be Normally Open (N/O) Normally Closed (N/C) or both. Explain the meaning of the terms Normally Open and Normally Closed (in relation to electrics):

   ....

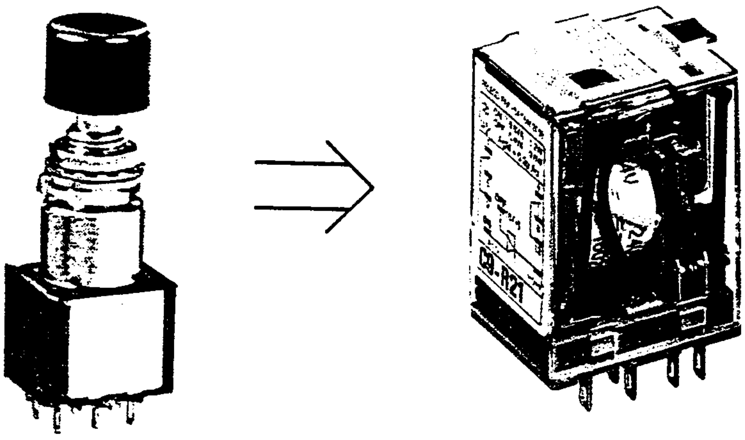
   ....

   ....

This page has intentionally

been left blank

Exercise: Relay Control



The operating characteristics of an electrical relay are to be demonstrated by way of observation.

Equipment Required:

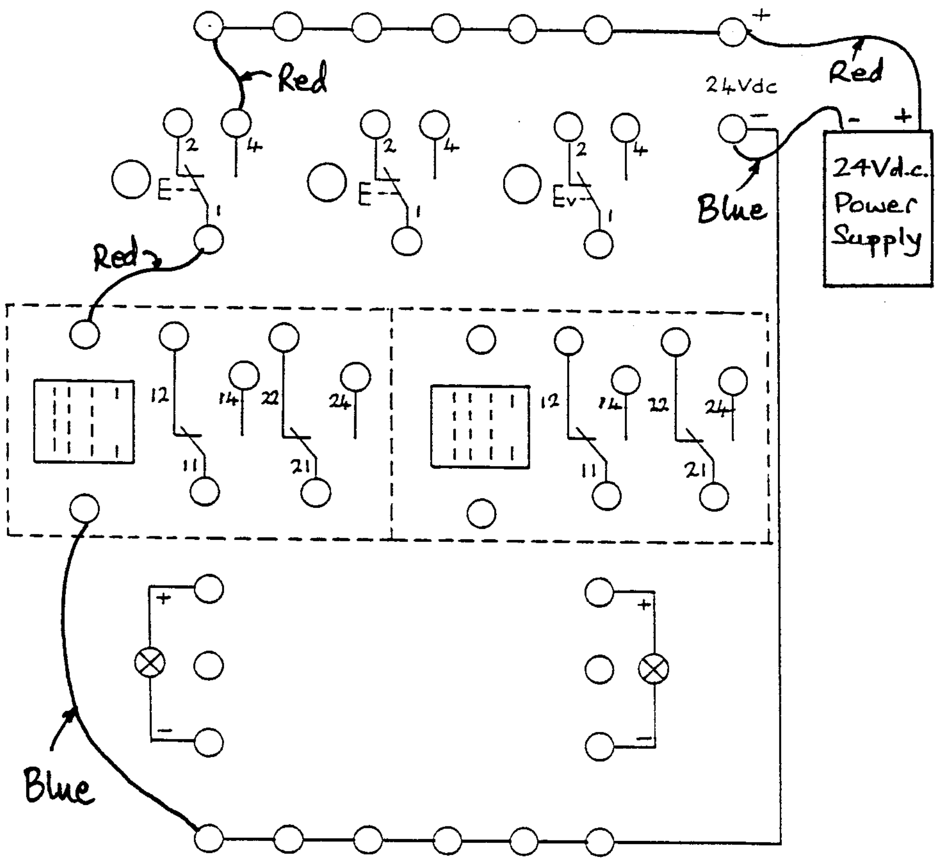
a) 1 off 24V d.c. power supply

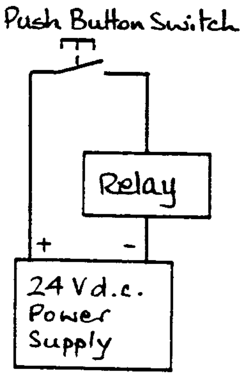
b) 1 off Electrical push button switch (Normally Open) contacts

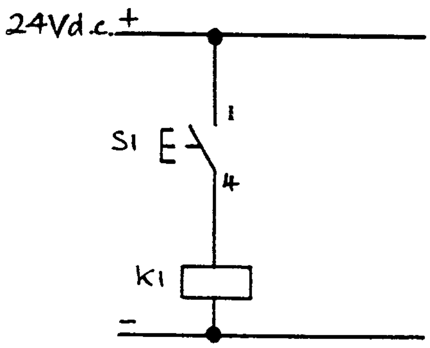
c) 1 off Electrical relay

d) Red and blue electrical leads as required

Exercise: Relay Control







Exercise: Relay Control

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.
2. Ensure that the electrical power supply is switched "off".
3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, and the electrical relay.
4. Check the assembled circuit against the circuit diagram.
5. Switch 'on' the 24V d.c. power supply.
6. Depress and hold down the electrical push button (S1) and observe what happens.
7. Release the push button (S1) and observe what happens.
8. Switch 'off' the 24V d.c. power supply and remove all electrical leads.
9. Compare your observations with the written circuit explanation.
10. Answer the questions for this exercise.

Exercise: Relay Control

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position and the push button is depressed a current is passed from the positive electrical distribution manifold through the push button contacts 3 and 4, the operating coil of the relay to the negative manifold, thereby completing an electrical circuit and operating the relay. The relay remains operated so long as the push button is held depressed upon its release the electrical circuit is disconnected and the relay is de-energised.

Questions: Relay Control

1) The electrical push button switch used in this exercise has contacts labelled 3 and 4, what do these numbers mean ?

....

....

....

2) In this exercise, the connections to the green lamp are marked positive (+) and negative (-) what is the reason for this ?

....

....

....

3) List three (3) advantages of electro pneumatics when compared to pneumatics:

   a) ....

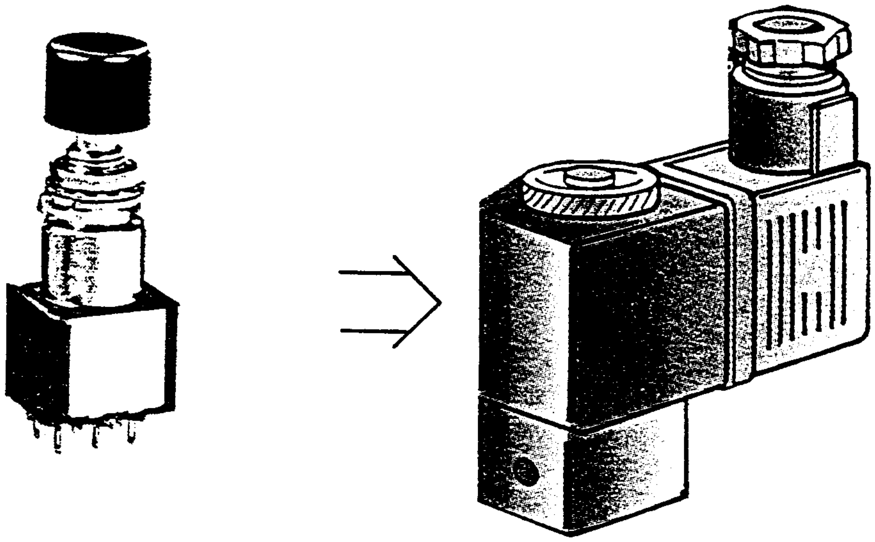
   b) ....

   c) ....

This page has intentionally

been left blank

Exercise: Solenoid Actuated Valve



The operating characteristics of a solenoid actuated valve are to be demonstrated by way of observation.

Equipment Required:

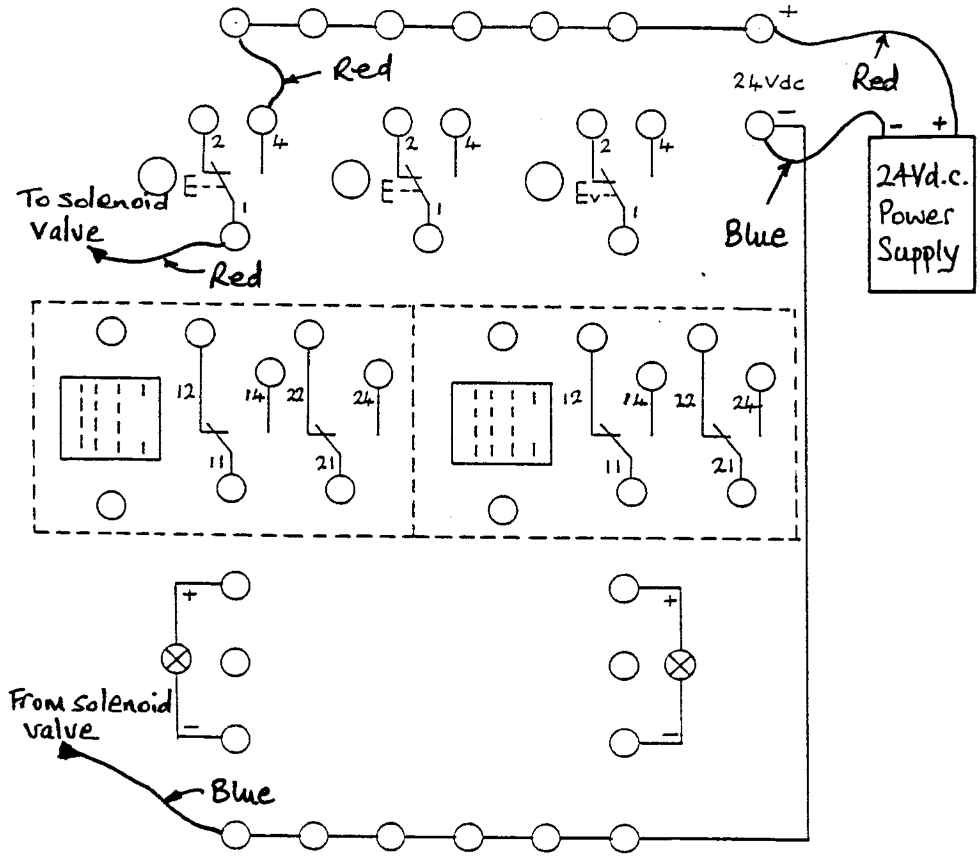
a) 1 off 24V d.c. power supply

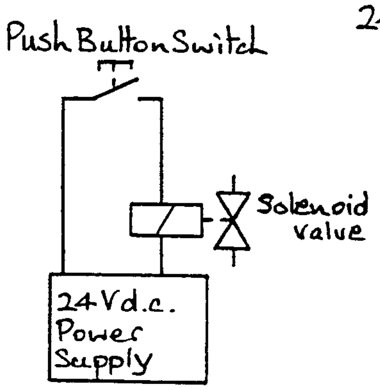
b) 1 off Electrical push button switch (Normally Open) contacts

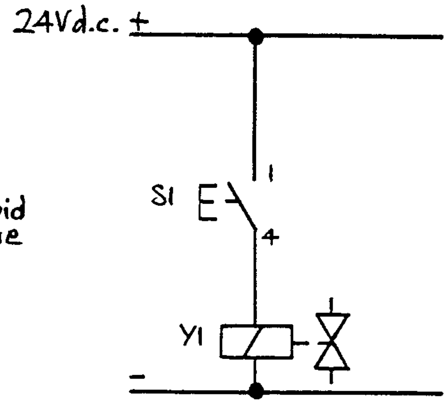
c) 1 off 3/2 Way solenoid actuated directional control valve (24V d.c.)

d) Red and blue electrical leads as required

Exercise: Solenoid Actuated Valve







Exercise: Solenoid Actuated Valve

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.

2. Ensure that the electrical power supply is switched "off".

3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, and the 3/2 way solenoid actuated directional control valve.

4. Check the assembled circuit against the circuit diagram.

5. Switch 'on' the 24V d.c. power supply.

6. Depress and hold down the electrical push button (S1) and observe what happens.

7. Release the push button (S1) and observe what happens.

8. Switch 'off' the 24V d.c. power supply and remove all electrical leads.

9. Compare your observations with the written circuit explanation.

10. Answer the questions for this exercise.

Exercise: Solenoid Actuated Valve

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position and the push button is depressed a current is passed from the positive electrical distribution manifold through the push button contacts 3, 4 and the solenoid coil of the 3/2 way directional control valve to the negative manifold, thereby completing an electrical circuit and energising the solenoid operating the valve. Upon release of the push button switch, the electrical circuit is disconnected de-energising the solenoid.

Questions: Solenoid Actuated Valve

1) Draw the symbol according to ISO 1219 for a direct operated solenoid valve 3/2 way Normally Closed version:

2) Draw the symbol according to DIN/BS3939 (electrical symbols) for a mechanical valve (solenoid operated):

3) List two (2) ways of protecting an electrical circuit:

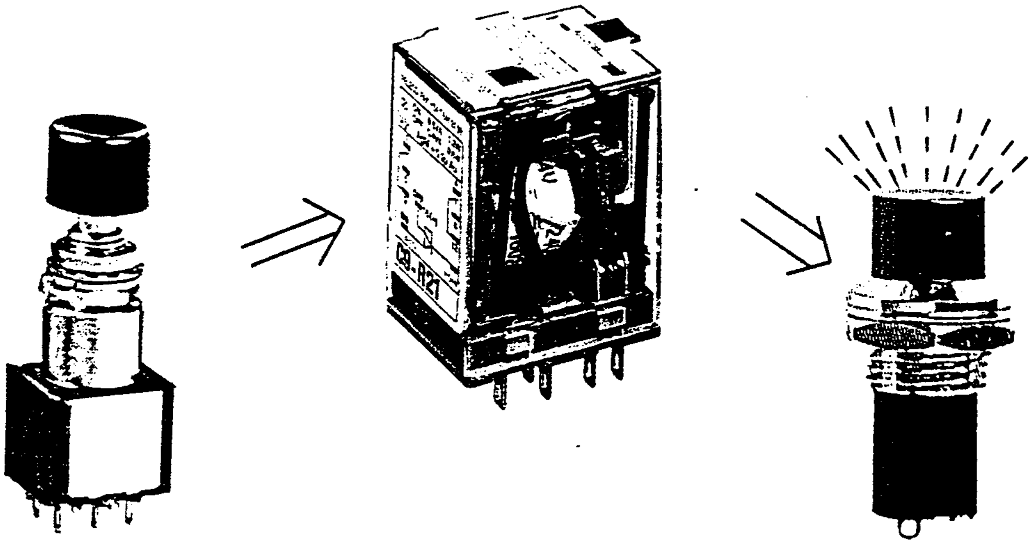
   1) ....

   2) ....

This page has intentionally

been left blank

Exercise: Relay and Lamp Function Test using Open Contacts



The operating characteristics of a relay and lamp using open contacts are to be demonstrated by way of observation.

Equipment Required:

a) 1 off 24V d.c. power supply

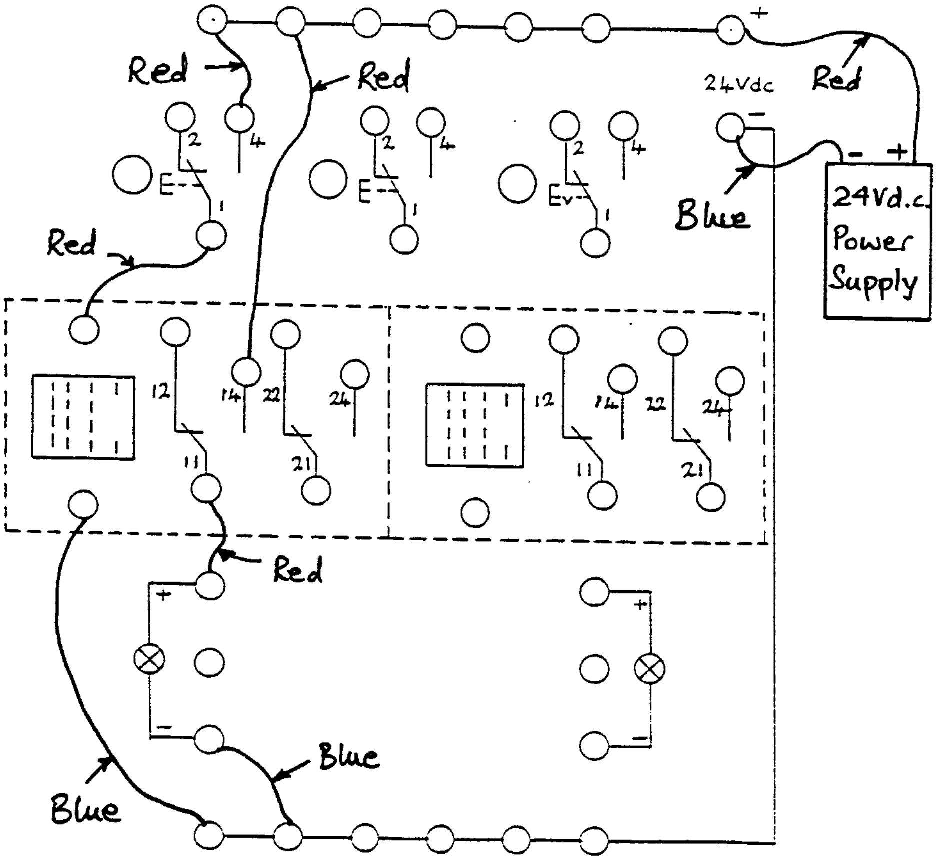
b) 1 off Electrical push button switch (Normally Open) contacts

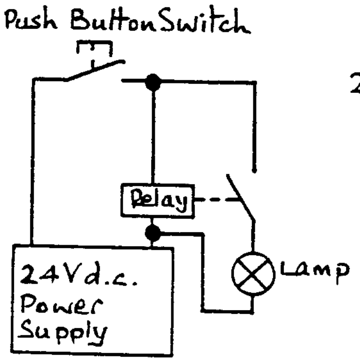
c) 1 off Electrical relay with open contacts

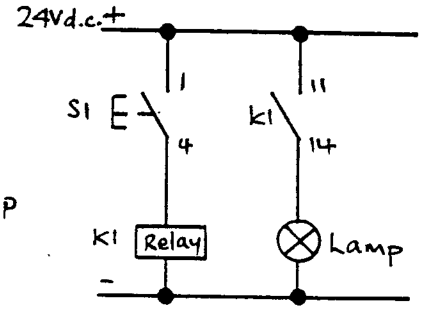
d) 1 off Green lamp

e) Red and blue electrical leads as required

Exercise: Relay and Lamp Function Test using Open Contacts







Exercise: Relay and Lamp Function Test using Open Contacts

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.

2. Ensure that the electrical power supply is switched "off".

3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay, and the green lamp.

4. Check the assembled circuit against the circuit diagram.

5. Switch 'on' the 24V d.c. power supply.

6. Depress and hold down the electrical push button (S1) and observe the green lamp.

7. Release the push button (S1) and observe the green lamp.

8. Switch 'off' the 24V d.c. power supply and remove all electrical leads.

9. Compare your observations with the written circuit explanation.

10. Answer the questions for this exercise.

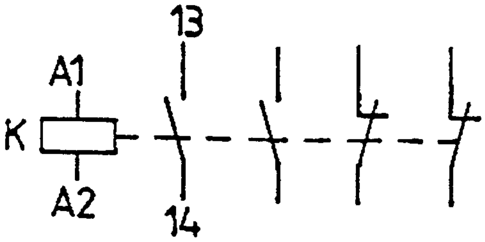
Exercise: Relay and Lamp Function Test using Open Contacts

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position and the push button is depressed a current is passed from the positive manifold through the push button contacts 3 and 4, the coil of the relay to the negative manifold, thereby completing an electrical circuit and operating the relay. The set of normally open contacts 11 and 14 now close passing a current from the positive manifold through the green lamp to the negative manifold causing the lamp to illuminate. The lamp will remain illuminated so long as the push button is held depressed, upon its release, the circuit to the relay is disconnected de-energising its coil and reopening the normally open contacts thereby breaking the circuit to the green lamp switching it 'off'.

Questions: Relay and Lamp Function Test using Open Contacts

1) Complete according to DIN standards the numbering of the contacts on the relay shown below:



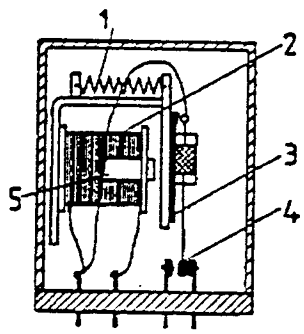
2) Explain the meaning of the numbers relating to the relay contacts:

....

....

....

3) Identify the component parts of the relay shown below:



1 ....

2 ....

3 ....

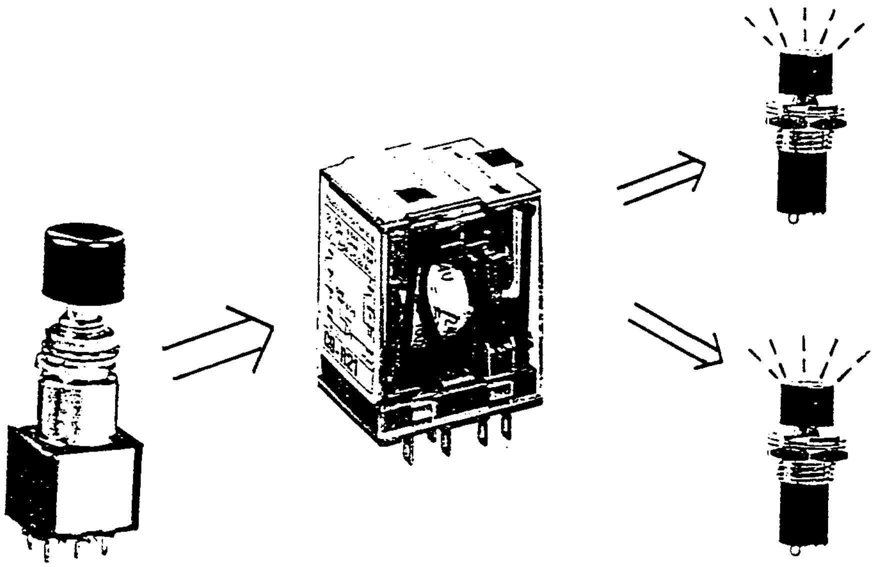
4 ....

5 ....

This page has intentionally

been left blank

Exercise: Relay and Lamps Function Test using Change Over Contacts



The operating characteristics of relay and lamps using change over contacts are to be demonstrated by way of observation.

Equipment Required:

a) 1 off 24V d.c. power supply

b) 1 off Electrical push button switch (Normally Open) contacts

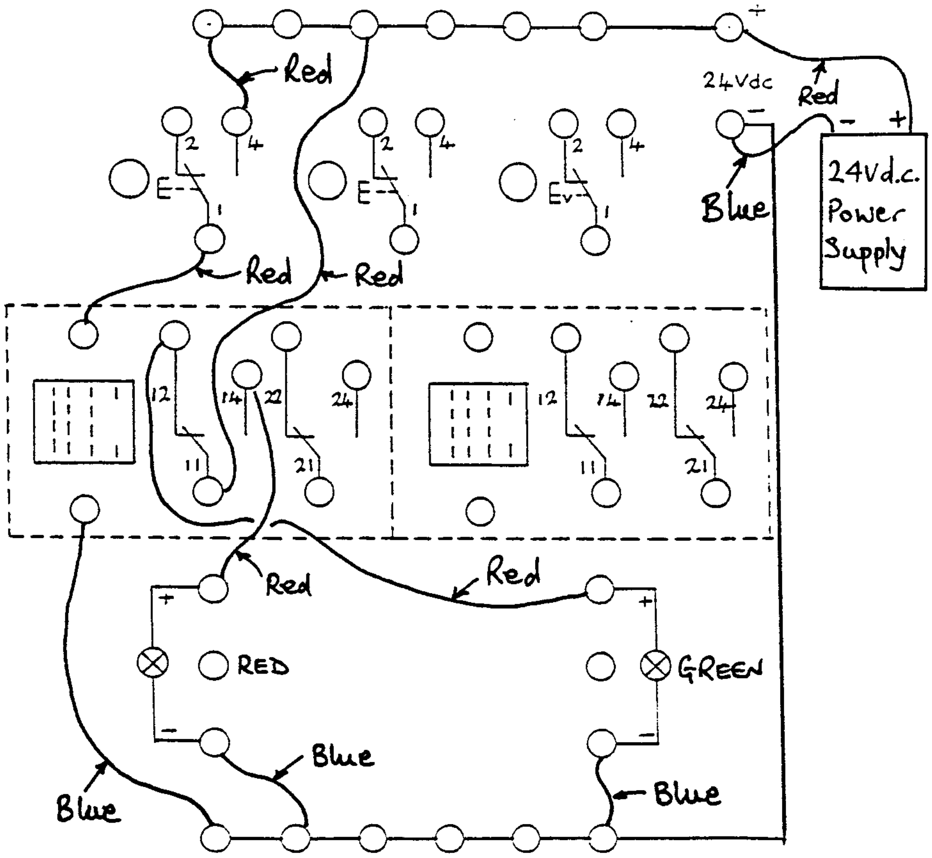
c) 1 off Electrical relay with open contacts

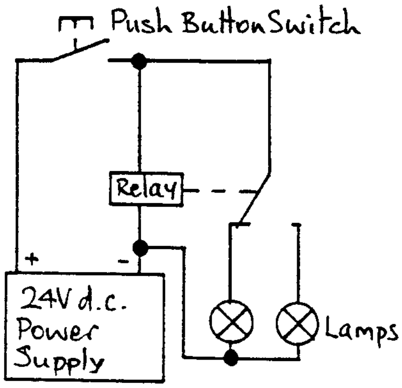
d) 1 off Green lamp

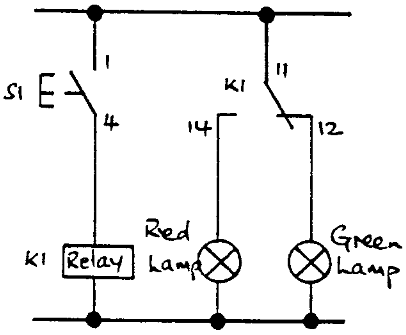
e) 1 off Red lamp

f) Red and blue electrical leads as required

Exercise: Relay and Lamps Function Test using Change Over Contacts







Exercise: Relay and Lamps Function Test using Change Over Contacts

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.
2. Ensure that the electrical power supply is switched "off".
3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay, green lamp and the red lamp.
4. Check the assembled circuit against the circuit diagram.
5. Switch 'on' the 24V d.c. power supply.
6. Depress and hold down the electrical push button (S1) and observe the green lamp.
7. Release the push button (S1) and observe the red lamp.
8. Switch 'off' the 24V d.c. power supply and remove all electrical leads.
9. Compare your observations with the written circuit explanation.
10. Answer the questions for this exercise.

Exercise: Relay and Lamps Function Test using Change Over Contacts

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position a current is passed from the positive electrical manifold through the normally closed set of contacts 11 and 12 of the relay and the green lamp to the negative manifold thereby completing an electrical circuit illuminating the 'green' lamp. Upon depressing the push button a current is passed through the relay coil operating the relay, thereby changing the state of its contacts i.e. the normally closed contacts 11 and 12 'open' and the normally open contacts 11 and 14 'close'. The electrical circuit through the green lamp is disconnected and the lamp is switched 'off' at the same time the now 'closed' contacts 11 and 14 pass a current through the red lamp completing an electrical circuit illuminating the red lamp. Upon release of the push button switch the relay is de-energised and its contacts revert to their original state switching 'off' the red lamp and switching back 'on' the green lamp.

Questions: Relay and Lamps Function Test using Change Over Contacts

1) Draw the symbol according to DIN standards for the operating coil of a relay:

2) Draw the symbol according to DIN standards for the following contacts:

Single pole Single throw

Double pole Single throw

Double pole Double throw

3) In a d.c. electrical circuit do electrons flow (a) from positive to negative, or (b) from negative to positive ?

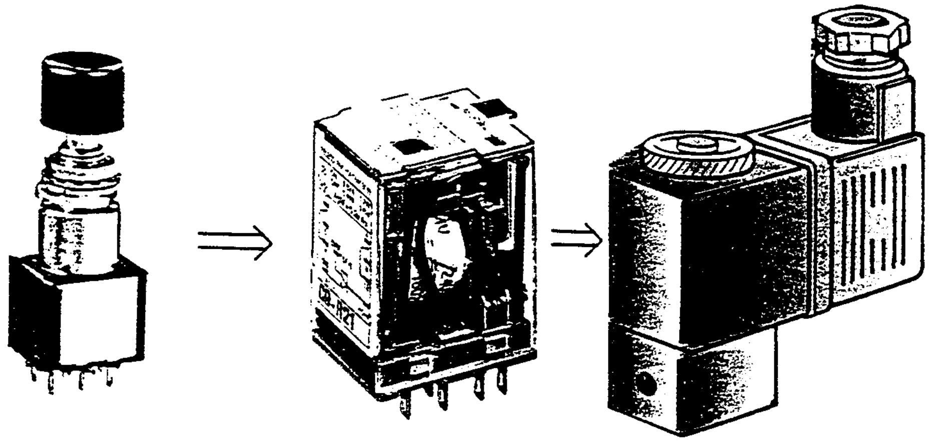
☐ (a) from positive to negative

☐ (b) from negative to positive

This page has intentionally

been left blank

Exercise: Relay and Solenoid Control Valve Function Test



The operating characteristics of relay and a solenoid control valve are to be demonstrated by way of observation.

Equipment Required:

a) 1 off 24V d.c. power supply

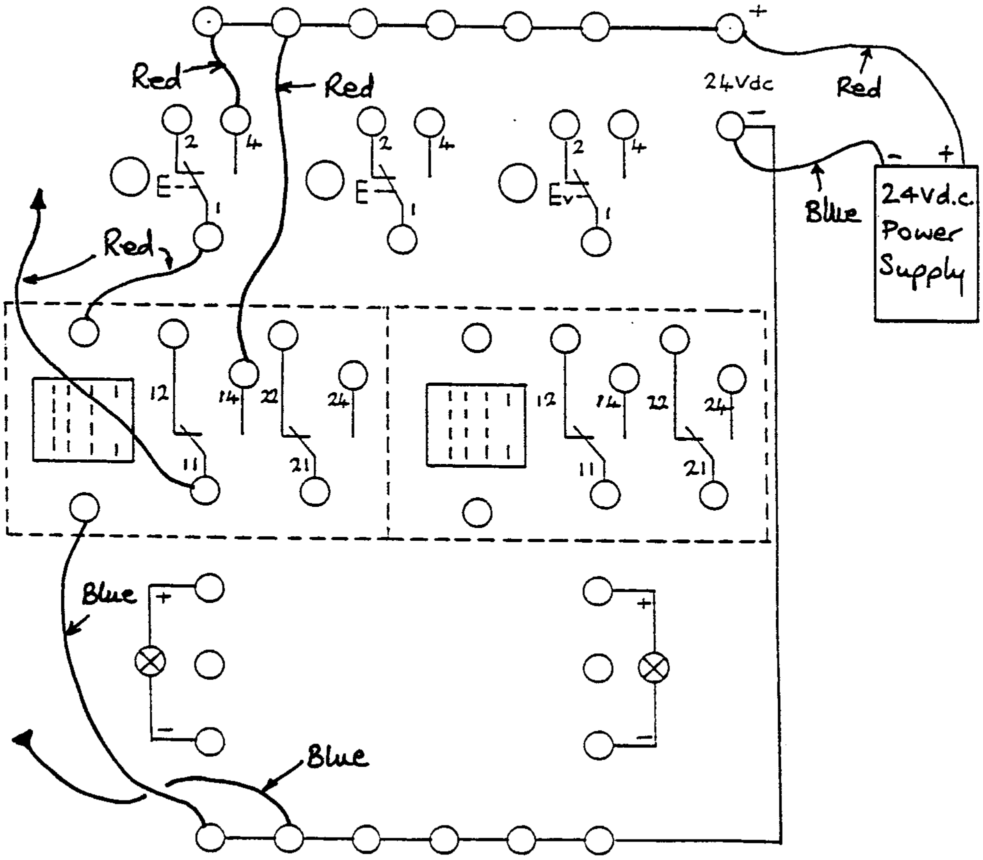
b) 1 off Electrical push button switch (Normally Open) contacts

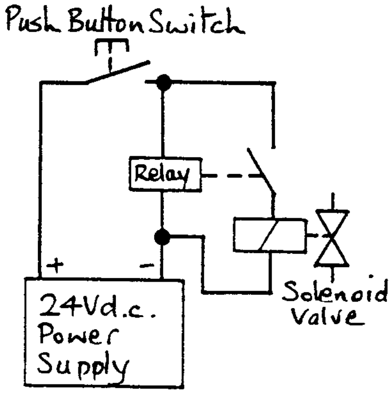
c) 1 off Electrical relay with open contacts

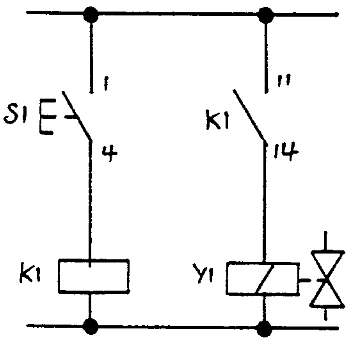
d) 1 off 3/2 Way solenoid actuated directional control valve (24V d.c.)

e) Red and blue electrical leads as required

Exercise: Relay and Solenoid Control Valve Function Test







Exercise: Relay and Solenoid Control Valve Function Test

Operational Procedure

1. Connect a 24V d.c. power supply to the electrical distribution manifold.

2. Ensure that the electrical power supply is switched "off".

3. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay, and the 3/2 way solenoid actuated directional control valve.

4. Check the assembled circuit against the circuit diagram.

5. Switch 'on' the 24V d.c. power supply.

6. Depress and hold down the electrical push button (S1) and observe what happens.

7. Release the push button (S1) and observe what happens.

8. Switch 'off' the 24V d.c. power supply and remove all electrical leads.

9. Compare your observations with the written circuit explanation.

10. Answer the questions for this exercise.

Exercise: Relay and Solenoid Control Valve Function Test

Circuit Explanation

When the switch on the power supply is actuated to the 'on' position and the push button is depressed a current is passed from the electrical positive manifold through the push button contacts 3, 4 and the relay coil to the negative manifold thereby completing an electrical circuit and operating the relay. The normally 'open' contacts 11 and 14 close passing a current through the solenoid coil on the 3/2 way directional control valve and operating the valve. Releasing the push button disconnects the circuit to the relay reopening contacts 11 and 14 thereby de-energising the solenoid valve returning it to its original state.

Questions: Relay and Solenoid Control Valve Function Test

1) The relay used in this exercise has a manual override switch, what function does it perform ?

   ....

   ....

   ....

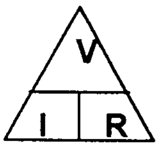
2) A useful option for pneumatic solenoid valves is to have them with solenoid plugs which contain an LED this then shows the status of the solenoid. What do the letters LED stand for ?

   ....

   ....

   ....

3) OHM's law is normally expressed as "the magic triangle" shown below. What do the letters V, I, R mean ?



V = ...

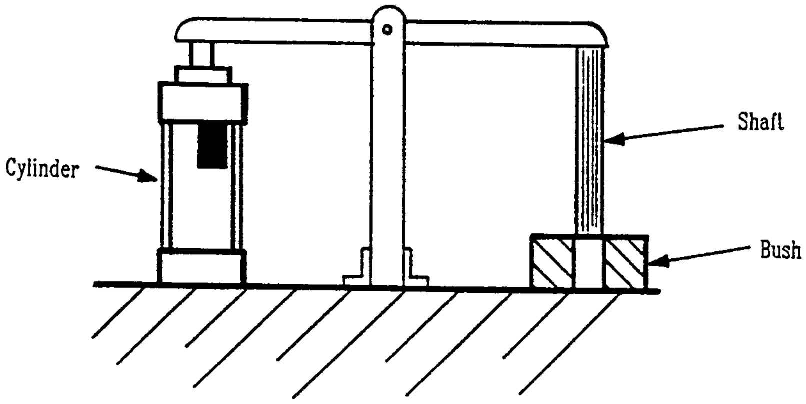
I = ...

R = ...

This page has intentionally

been left blank

Exercise: Assembly Fixture



Splined shafts are to be assembled into bushes, the assembly requires a press fit. The shafts are placed manually into the bush (on a tapered start) a push button is then actuated to extend a single acting cylinder, through a linkage, as the cylinder extends the shaft is pressed home. The cylinder is to retract as soon as the push button is released.

Exercise: Assembly Fixture

Equipment Required:

a) 1 off Single acting spring return cylinder

b) 1 off 3/2 Solenoid actuated spring return directional control valve

c) 1 off Electrical push button with (Normally Open) contacts and momentary operation

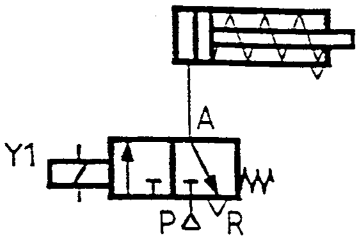
d) 1 off Pneumatic "on/off" slide valve

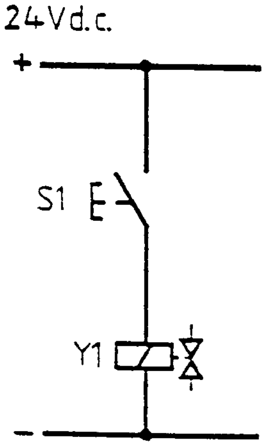
e) 1 off 24V d.c. power supply

f) Pneumatic tubing as required

g) Red and blue electrical leads as required

Exercise: Assembly Fixture





Exercise: Assembly Fixture

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 3/2 solenoid operated spring return valve and the single acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button and the solenoid on the 3/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and hold down the electrical push button and observe the action of the cylinder.

11 Release the push button and observe the action of the cylinder.

Exercise: Assembly Fixture

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Assembly Fixture

Circuit Explanation

In this exercise the switch (S1) is connected 'direct' to the solenoid (Y1), when the switch is operated and the contacts are closed the current will flow to the solenoid, which is then energised and 3/2 way valve is therefore actuated and air passes to the rear of the cylinder. The cylinder extends and remains extended until the solenoid Y1 is de-energised, allowing the 3/2 way valve to reset and exhaust the cylinder, which will then retract by means of an internal spring.

Questions: Assembly Fixture

1) Compressed air is generally measured in P-S-I or BAR. What do these abbreviations mean ?

   P-S-I ....

   BAR ....

2) What is the function of a directional control valve ?

   ....

   ....

   ....

3) Valves are referred to by sizes e.g. M5, 1/8, ¼, what do these sizes refer to ?

   ....

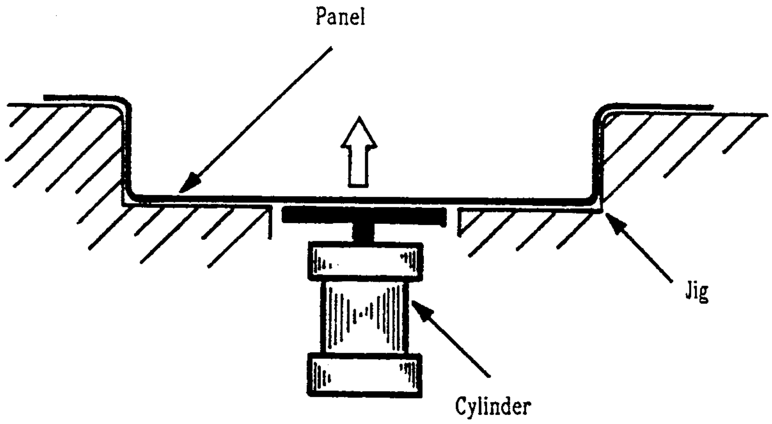
   ....

   ....

This page has intentionally

been left blank

Exercise: Panel Removal from a Jig



A sheet metal panel is placed in a jig while an operation is carried out upon it. Once the operation is complete the panel is to be lifted clear of the jig so that the operator can remove it with ease. The mechanism used to lift the panel is to be a single acting cylinder, which is to be controlled by means of two (2) push button switches (either <u>or</u> both actuated will result in the cylinder extending).

Exercise: Panel Removal from a Jig

Equipment Required:

a) 1 off Single acting spring return cylinder

b) 1 off 3/2 Solenoid actuated spring return directional control valve

c) 2 off Electrical push button with (Normally Open) contacts and momentary operation

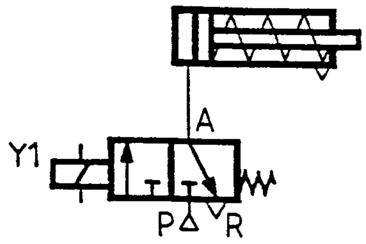
d) 1 off Pneumatic "on/off" slide valve

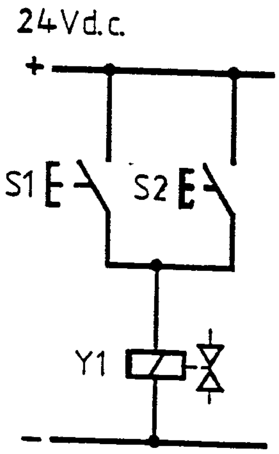
e) 1 off 24V d.c. power supply

f) Pneumatic tubing as required

g) Red and blue electrical leads as required

Exercise: Panel Removal from a Jig





Exercise: Panel Removal from a Jig

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 3/2 solenoid operated spring return valve and the single acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push buttons and the solenoid on the 3/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and hold down the electrical push button (S1) and observe the action of the cylinder.

11 Release the push button (S1) and observe the action of the cylinder.

Exercise: Panel Removal from a Jig

Operational Procedure - continued

12 Depress and hold down the electrical push button (S2) and observe the action of the cylinder.

13 Release the push button (S2) and observe the action of the cylinder.

14 Depress and hold down the electrical push buttons (S1) and (S2) together and observe the action of the cylinder.

15 Release the push buttons (S1) and (S2) and observe the action of the cylinder.

16 Switch 'off' both the electrical power supply and the compressed air supply.

17 Remove all pneumatic tubing and electrical leads.

18 Compare your observations with the written circuit explanation.

19 Answer the questions for this exercise.

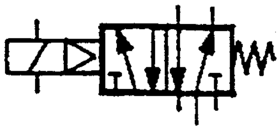
Exercise: Panel Removal from a Jig

Circuit Explanation

When either the push button S1 or the push button S2 are operated current is passed to the solenoid, which is then energised switching the 3/2 way valve and extending the cylinder. When both switches are released, the solenoid is de-energised and the cylinder will retract.

Questions: Panel Removal from a Jig

1) Label the ports according to I.S.O. 5599 on the directional control valve shown below:



2) Switches S1 and S2 are connected in such a way as to provide a logic function. Identify the correct function from the following list :

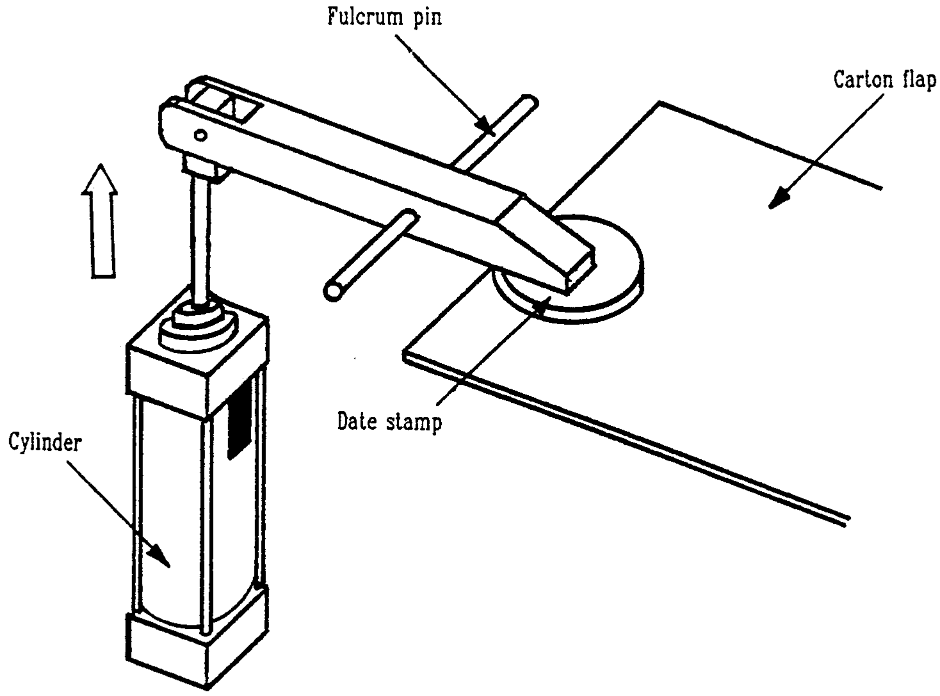
- ☐ .... AND
- ☐ .... OR
- ☐ .... YES
- ☐ .... NOT

3) Draw the symbol according to ISO 1219-1 for a single acting spring return cylinder:

This page has intentionally

been left blank

Exercise: Date Stamping of a Product



Products are to be date stamped (e.g. sell by date on foodstuffs) they are then packed into cartons the cartons themselves are also to be date stamped on the flap. The date stamp is fitted to the end of a linkage via a fulcrum pin this linkage comes into contact with the carton flap when a double acting cylinder extends. The signal to start this operation is generated by means of a push button.

Exercise: Date Stamping of a Product

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Solenoid actuated spring return directional control valve

c) 1 off Electrical push button with (Normally Open) contacts and momentary operation

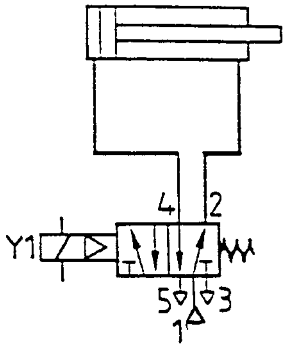
d) 1 off Pneumatic "on/off" slide valve

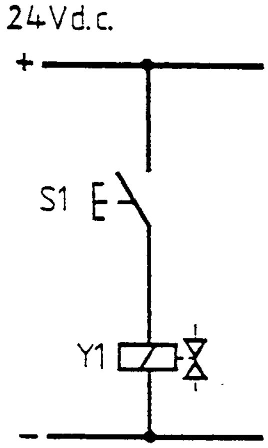
e) 1 off 24V d.c. power supply

f) Pneumatic tubing as required

g) Red and blue electrical leads as required

Exercise: Date Stamping of a Product





Exercise: Date Stamping of Product

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid actuated spring return valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button and the solenoid on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and hold down the electrical push button (S1) and observe the action of the cylinder.

11 Release the push button (S1) and observe the action of the cylinder.

Exercise: Date Stamping of a Product

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Date Stamping of a Product

Circuit Explanation

In the exercise shown the switch (S1) is connected 'direct' to the solenoid (Y1) when the switch is operated and the contacts are closed, the current will flow to the solenoid which is then energised and the 5/2 way valve is therefore actuated, air passes to the rear of the cylinder with the front end of the cylinder open to exhaust (via the 5/2 way valve). The cylinder extends and remains extended until the solenoid Y1 is de-energised allowing the 5/2 way valve to reset (by means of the spring) and exhaust the rear of the cylinder with supply air to the front of the cylinder, which will then retract.

Questions: Date Stamping of a Product

1) Draw the symbol, according to ISO 1219-1 for a pneumatic double acting cylinder:

2) What position would the cylinders assume if there was an electrical power failure ?

....

....

....

3) In an electrical circuit, there is always a danger the circuit may be overloaded. Give an example of a simple protection unit to cater for this event and state where it would be fitted:

....

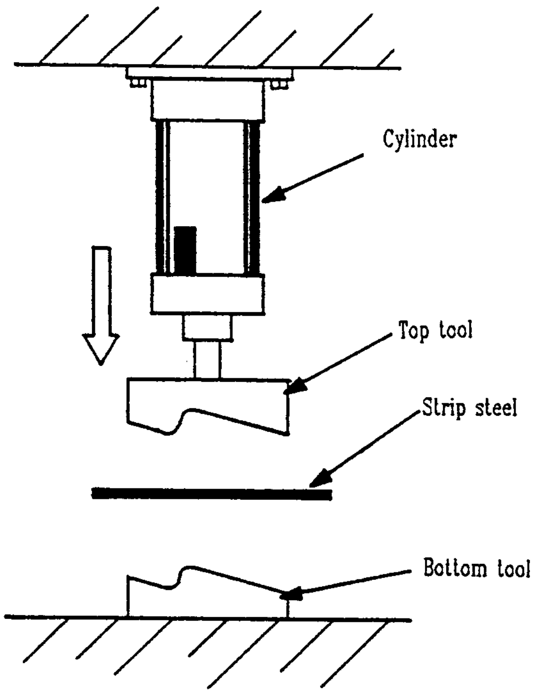
....

....

This page has intentionally

been left blank

Exercise: Bending Fixture



Strip steel is to be bent to form brackets, the strip is placed into a fixture and is bent by a single acting cylinder. For this cylinder to bend the steel a certain momentum is required during its extend stroke, this can only be achieved if the directional control valve controlling the cylinder is of sufficient size to allow the required amount of compressed air to flow to the cylinder. The start signal is generated by means of a push button which is to be situated at least five (5) metres away from the fixture.

The cylinder bore is to be 150 mm and its stroke is to be 100 mm.

Exercise: Bending Fixture

Equipment Required

a) 1 off Single acting spring return cylinder

b) 1 off 3/2 Solenoid actuated spring return directional control valve

c) 1 off Electrical push button with Normally Open contacts and momentary operation

d) 1 off Electrical relay

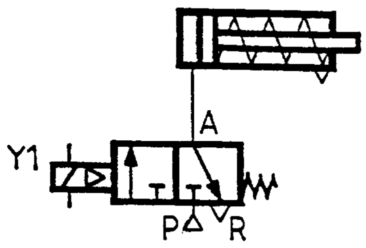
e) 1 off Pneumatic "on/off" slide valve

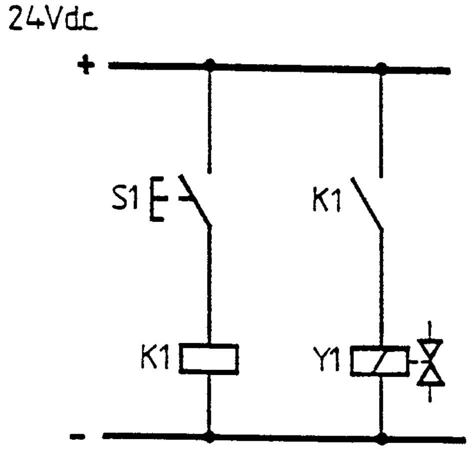
f) 1 off 24V d.c. power supply

g) Pneumatic tubing as required

h) Red and blue electrical leads as required

Exercise: Bending Fixture





Exercise: Bending Fixture

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 3/2 solenoid operated spring return valve and the single acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay, and the solenoid on the 3/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and hold down the electrical push button and observe the action of the cylinder.

11 Release the push button and observe the action of the cylinder.

Exercise: Bending Fixture

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Bending Fixture

Circuit Explanation

With electrical control circuits is generally considered good working practice to install a relay into the system as shown in the circuit. When the switch S1 is operated, it passes current to the relay K1 which is energised, this closes the contacts of K1 thus allowing current to flow to the solenoid Y1. This solenoid is energised for the duration that the relay contacts are held closed, the cylinder is kept extended until the switch S1 is released, and the current is removed from the relay K1 (this will de-energise the solenoid Y1 and allow the cylinder to retract). As the switch is not connected to the solenoid this is known as, 'indirect' control.

Questions: Bending Fixture

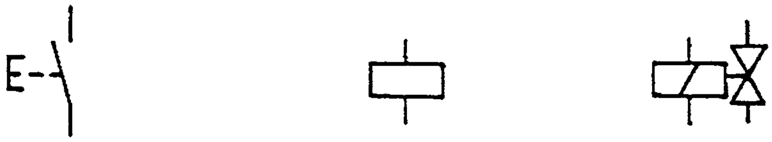
1) The black arrows drawn inside the squares of the pneumatic valve indicate what ?

....

....

....

2) Identify the following symbols according to the DIN/BS 3939 standard:



....

....

....

3) List two (2) disadvantages of a single acting spring return cylinder:

....

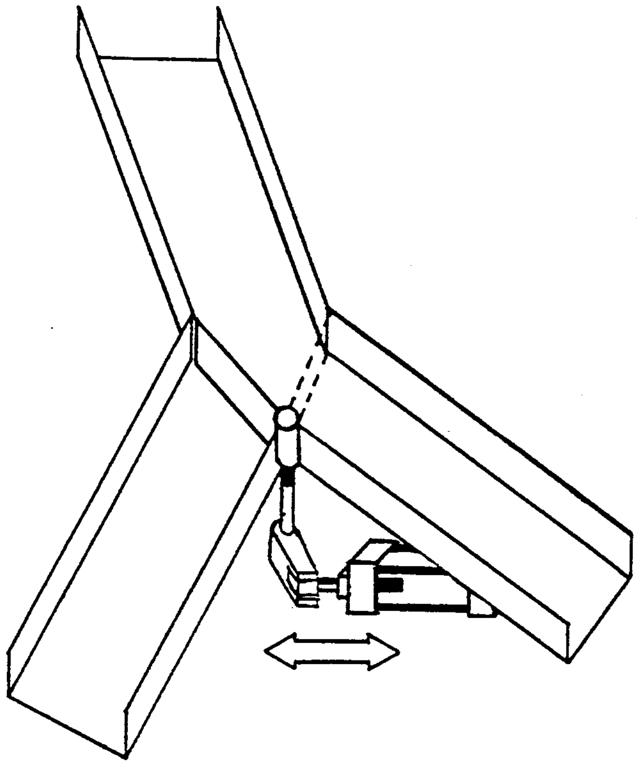
....

....

This page has intentionally

been left blank

Exercise: Product Separation (Double Solenoid Valve version)



Products (e.g. parcels) are to be separated in a distribution warehouse where the incoming products arrive on one conveyor and are to be dispatched to either of two output conveyors. The required output conveyor is selected by a double acting cylinder, which in turn is controlled by an operator. The operator has in front of him two (2) push buttons (separate units) when one push button is actuated, the cylinder will extend and remain extended even when this push button is released. To retract the cylinder the other push button must be actuated, again the cylinder will remain retracted even when the push button is released until such time that the first (extend) push button is actuated again.

Exercise: Product Separation (Double Solenoid Valve version)

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 2 off Electrical push button with normally open contacts and momentary operation

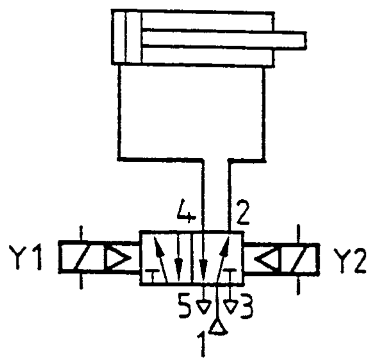
d) 1 off Pneumatic "on/off" slide valve

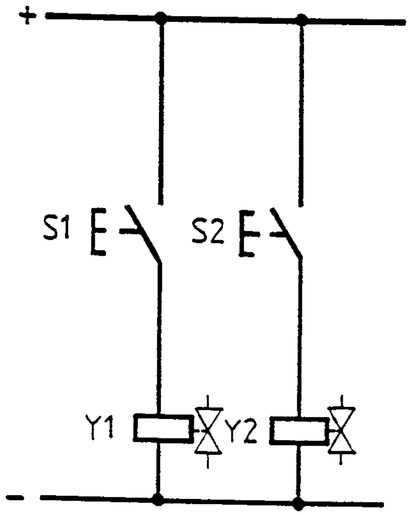
e) 1 off 24V d.c. power supply

f) Pneumatic tubing as required

g) Red and blue electrical leads as required

Exercise: Product Separation (Double Solenoid Valve version)





Exercise: Product Separation (Double Solenoid Valve version)

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram, connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated directional control valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push buttons and the solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button (S1) and observe the action of the cylinder.

11 Depress and release the electrical push button (S2) and observe the action of the cylinder.

Exercise: Product Separation (Double Solenoid Valve version)

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

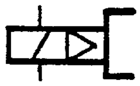
Exercise: Product Separation (Double Solenoid Valve version)

Circuit Explanation

This circuit utilises a double solenoid directional control valve. Operation of push button switch S1 allows current to flow and energise the solenoid Y1. When Y1 is energised the 5/2 way valve switches and air will pass to the rear of the cylinder with the front of the cylinder exhausting, the cylinder therefore extends and remains extended until the second push button switch S2 is operated. When S2 is operated it energises the solenoid Y2 which retracts the cylinder with air passing to the front of the cylinder and the rear of the cylinder exhausting.

Questions: Product Separation (Double Solenoid Valve version)

1) A pneumatic directional control valve (DCV) is to be actuated as per the symbol shown below, what does this symbol represent ?



....

....

....

2) Will a double acting cylinder (normal style) deliver a greater force when:

☐ .... Extending

☐ .... Retracting

☐ .... Be equal in both directions

3) Explain the reason for your answer to question 2:

....

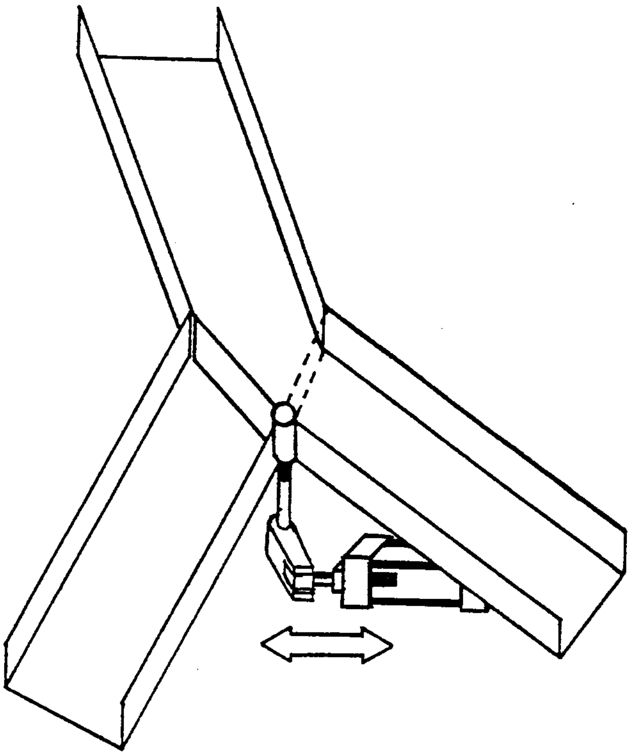
....

....

This page has intentionally

been left blank

Exercise: Product Separation (Single Solenoid Valve version)



Products (e.g. parcels) are to be separated in a distribution warehouse where the incoming products arrive on one conveyor and are to be dispatched to either of two output conveyors. The required output conveyor is selected by a double acting cylinder which in turn is controlled by an operator. The operator has in front of him two (2) push buttons (separate units) when one push button is actuated, the cylinder will extend and remain extended even when this push button is released. To retract the cylinder the other push button must be actuated, again the cylinder will remain retracted even when the push button is released until such time that the first (extend) push button is actuated again.

Exercise: Product Separation (Single Solenoid Valve version)

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Single solenoid actuated spring return directional control valve

c) 1 off Electrical push button with normally open contacts and momentary operation

d) 1 off Electrical push button with normally closed contacts and momentary operation

e) 1 off Electrical relay

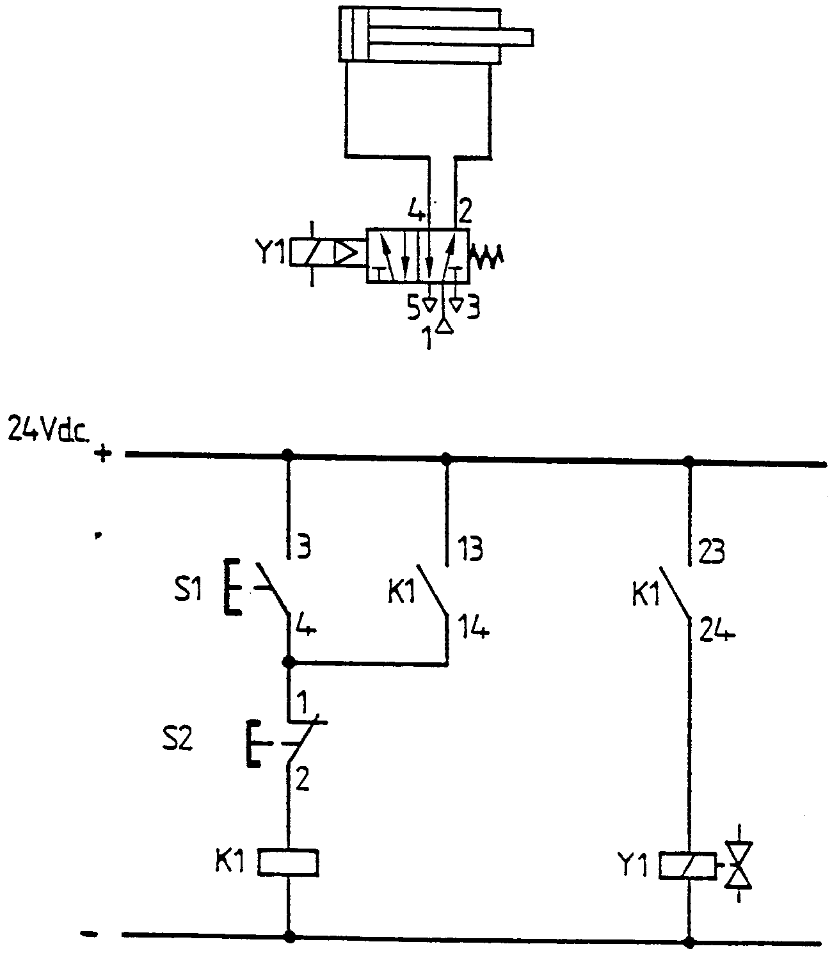
f) 1 off Pneumatic "on/off" slide valve

g) 1 off 24V d.c. power supply

h) Pneumatic tubing as required

i) Red and blue electrical leads as required

Exercise: Product Separation (Single Solenoid Valve version)



Exercise: Product Separation (Single Solenoid Valve version)

Operational Procedure

1. Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.
2. Connect a 24V d.c. power supply to the electrical distribution manifold.
3. Actuate the air "on/off" slide valve to the 'off' position.
4. Ensure that the electrical power supply is switched "off".
5. Following the pneumatic circuit diagram, connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated directional control valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).
6. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay, and the solenoid on the 5/2 directional control valve (DCV).
7. Check the assembled circuits against the circuit diagrams.
8. Switch 'on' the 24V d.c. power supply.
9. Actuate the air "on/off" valve to the 'on' position.
10. Depress and release the electrical push button (S1) and observe the action of the cylinder.
11. Depress and release the electrical push button (S2) and observe the action of the cylinder.

Exercise: Product Separation (Single Solenoid Valve version)

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Product Separation (Single Solenoid Valve version)

Circuit Explanation

This circuit utilises a single solenoid directional control valve. Push button switch S2 has normally closed contacts and when the push button switch S1 is operated, current will flow to relay K1 which is then energised closing the open contacts of this relay. When the contacts 13, 14 close they will allow current to flow and keep the relay energised even when switch S1 is released this is known as a 'latch' (sometimes referred to as a 'self holding circuit'). The contacts 23, 24 are also closed and this allows current to flow to the solenoid Y1 which is then energised switching the 5/2 way valve against the spring, Y1 will remain energised all the time that relay K1 is energised keeping the 5/2 way valve switched. To de-energise the solenoid Y1 and allow the 5/2 way valve to reset the relay K1 must be de-energised this is achieved by operation of the push button S2 this opens the contacts and breaks the feed to the relay (deletes the latch), which then resets allowing the contacts to open.

Questions: Product Separation (Single Solenoid Valve version)

1) Identify an advantage of the single solenoid (spring return) valve version over the double solenoid valve version:

   ....

   ....

   ....

2) Different voltages are used to operate solenoid valves, list the three (3) most commonly used and state if a.c. or d.c. or both:

   a) ....

   b) ....

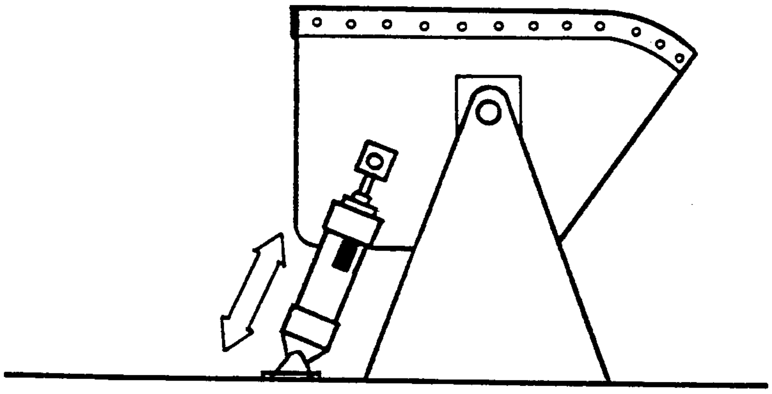
   c) ....

3) In this application it may be useful to use a double acting cylinder with adjustable cushioning (in both directions of travel), draw the ISO 1219-1 symbol for this component:

This page has intentionally

been left blank

Exercise: Foundry Ladle Control



In a foundry, molten metal is to be poured from a ladle, a double acting cylinder is used to lift (tilt) the ladle. To extend the cylinder a push button must be actuated, to retract the cylinder a second push button must be actuated. The cylinder will remain in the last position that it is sent to until the opposite push button is actuated.

Exercise: Foundry Ladle Control

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 2 off Electrical push button with normally open contacts and momentary operation

d) 2 off Electrical relay

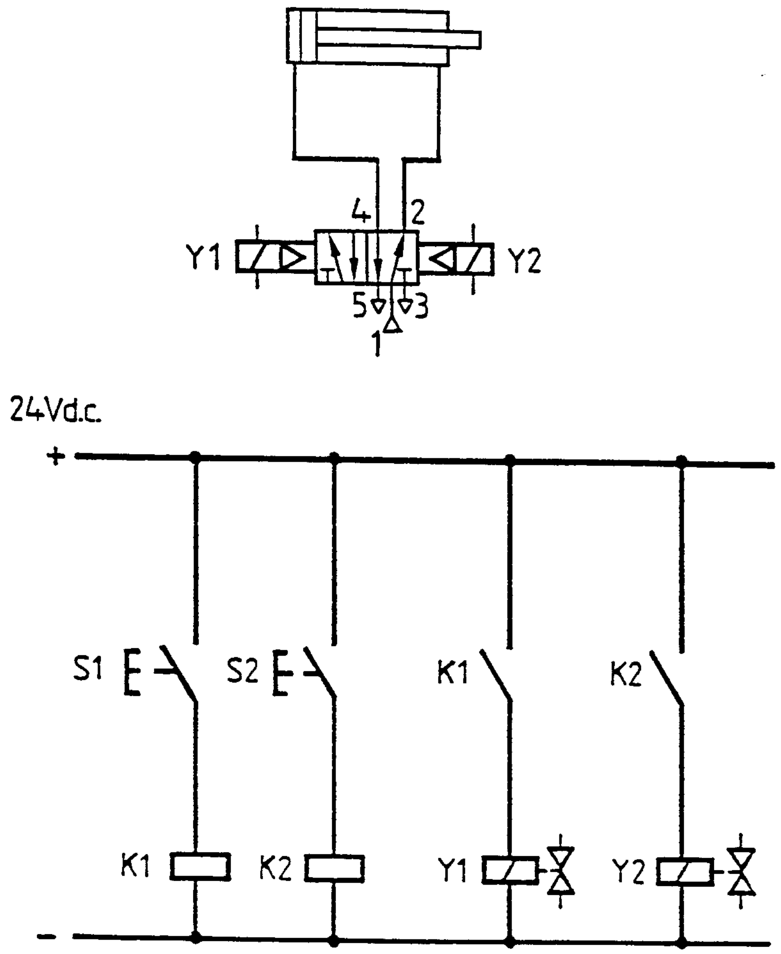
e) 1 off Pneumatic "on/off" slide valve

f) 1 off 24V d.c. power supply

g) Pneumatic tubing as required

h) Red and blue electrical leads as required

Exercise: Foundry Ladle Control



Exercise: Foundry Ladle Control

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram, connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated directional control valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relays, and the solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button (S1) and observe the action of the cylinder.

11 Depress and release the electrical push button (S2) and observe the action of the cylinder.

Exercise: Foundry Ladle Control

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Foundry Ladle Control

Circuit Explanation

Operation of push button switch S1 allows current to flow and energise relay K1 upon being actuated the contacts of this relay will close and this will then allow current to flow and energise the solenoid Y1. When Y1 is energised the 5/2 way valve switches and air will pass to the rear of the cylinder with the front of the cylinder exhausting, the cylinder therefore extends and remains extended until the second push button switch S2 is operated. When S2 is operated it energises relay K2 closing the contacts of this relay, current will then flow via these contacts and energise the solenoid Y2 which resets the 5/2 way valve to the condition as drawn, the cylinder subsequently retracts with air passing to the front of the cylinder and rear of the cylinder exhausting.

Questions: Foundry Ladle Control

1) List four (4) types of electrical switch commonly used in electro pneumatic circuits/systems:

   i) ....

   ii) ....

   iii) ....

   iv) ....

2) For safety reasons switches such as push buttons etc should always be placed where in an electrical circuit and why ?

   ....

   ....

   ....

3) List three (3) disadvantages of electro pneumatics when compared to pneumatics:

   a) ....

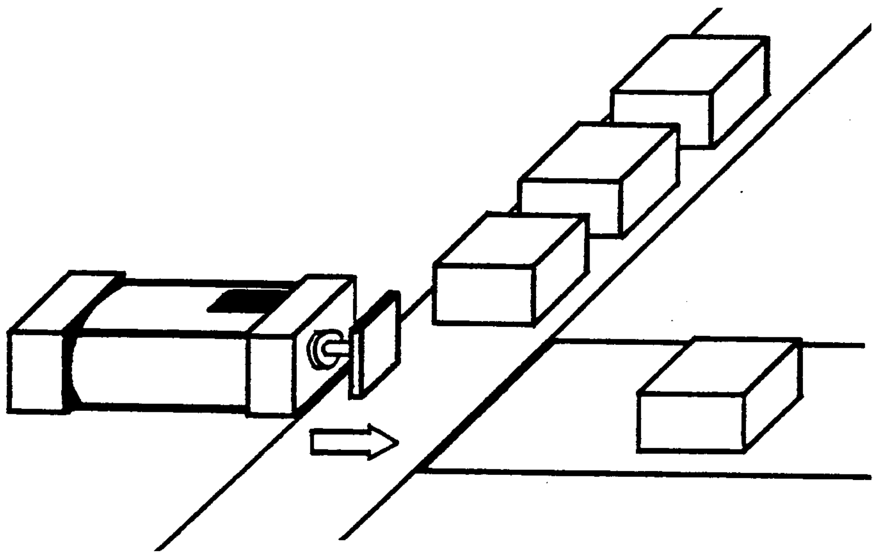
   b) ....

   c) ....

This page has intentionally

been left blank

Exercise: Product Sorting (Single Solenoid Version)



Components arrive on a conveyor and are to be pushed into a power press by means of a double acting cylinder. There are two (2) push buttons and the cylinder is only to extend when both push buttons are actuated (if only one (1) push button is actuated the cylinder is to remain retracted). Once the cylinder starts to extend if either or both push buttons are released the cylinder is to immediately retract to its start condition.

Exercise: Product Sorting (Single Solenoid Version)

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Single solenoid actuated spring return directional control valve

c) 2 off Electrical push button with normally open contacts and momentary operation

d) 1 off Electrical relay

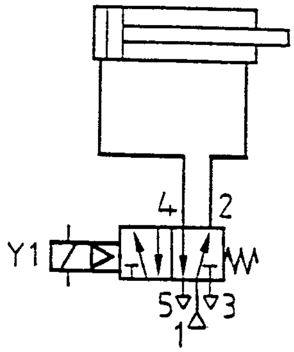
e) 1 off Pneumatic "on/off" slide valve

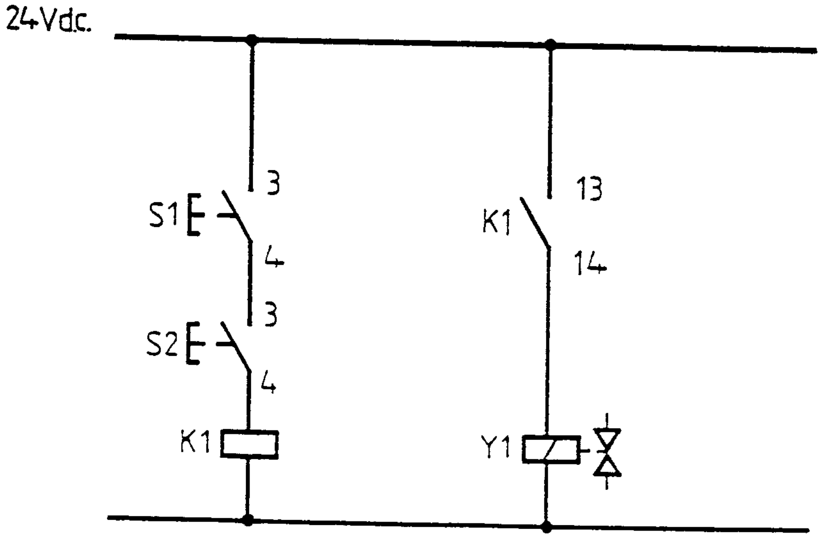
f) 1 off 24V d.c. power supply

g) Pneumatic tubing as required

h) Red and blue electrical leads as required

Exercise: Product Sorting (Single Solenoid Version)





Exercise: Product Sorting (Single Solenoid Version)

Operational Procedure

1. Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.
2. Connect a 24V d.c. power supply to the electrical distribution manifold.
3. Actuate the air "on/off" slide valve to the 'off' position.
4. Ensure that the electrical power supply is switched "off".
5. Following the pneumatic circuit diagram, connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated spring return valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).
6. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay and the solenoid on the 5/2 directional control valve (DCV).
7. Check the assembled circuits against the circuit diagrams.
8. Switch 'on' the 24V d.c. power supply.
9. Actuate the air "on/off" valve to the 'on' position.
10. Depress and release the electrical push button (S1) and observe the action of the cylinder.
11. Depress and release the electrical push button (S2) and observe the action of the cylinder.

Exercise: Product Sorting (Single Solenoid Version)

Operational Procedure - continued

12 Depress and release both the electrical push buttons (S1) and (S2) together and observe the action of the cylinder.

13 Switch 'off' both the electrical power supply and the compressed air supply.

14 Remove all pneumatic tubing and electrical leads.

15 Compare your observations with the written circuit explanation.

16 Answer the questions for this exercise.

Exercise: Product Sorting (Single Solenoid Version)

Circuit Explanation

Upon actuation of 'both' push button switches S1 and S2 the relay K1 is energised closing the contacts 13, 14 and allowing current flow to the solenoid Y1. Once Y1 is energised the 5/2 way valve switches extending the cylinder until either S1 or S2 are released when the relay K1 will be de-energised which in turn will de-energise the solenoid Y1 allowing the 5/2 way valve to reset to the condition shown and the cylinder retracts.

Questions: Product Sorting (Single Solenoid Version)

1) What is the difference between a 'limit switch' and a 'proximity switch' ?

....

....

....

2) Coils and solenoids which operate on direct current (d.c.) are polarity conscious what is meant by this ?

....

....

....

3) Identify the correct statement from the list below:

Solenoid actuated pneumatic valves are:-

a) Control valves ☐

b) Signal valves ☐

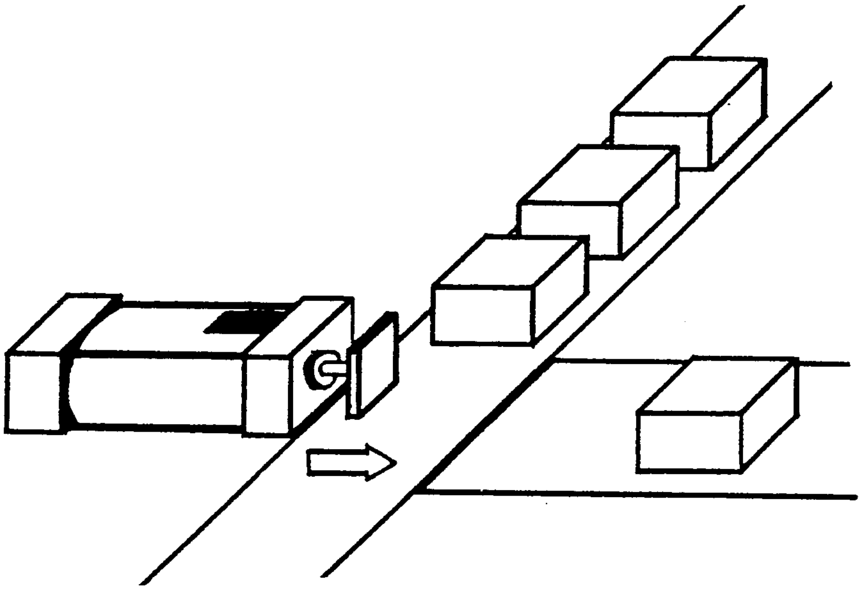
c) Either a) or b) according to application ☐

d) Neither a) or b) ☐

This page has intentionally

been left blank

Exercise: Product Sorting (Double Solenoid Version)



Components arrive on a conveyor and are to be pushed into a power press by means of a double acting cylinder. There are two (2) push buttons and the cylinder is only to extend when both push buttons are operated (if only one (1) push button is operated the cylinder is to remain retracted). Once the cylinder starts to extend if either or both push buttons are released the cylinder is to immediately retract to its start condition.

Exercise: Product Sorting (Double Solenoid Version)

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 2 off Electrical push button with normally open contacts and momentary operation

d) 1 off Electrical relay

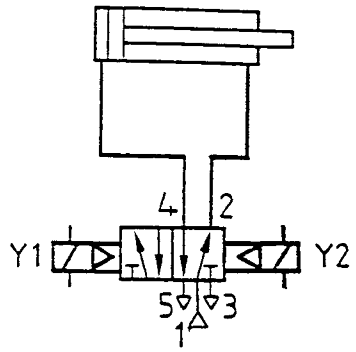
e) 1 off Pneumatic "on/off" slide valve

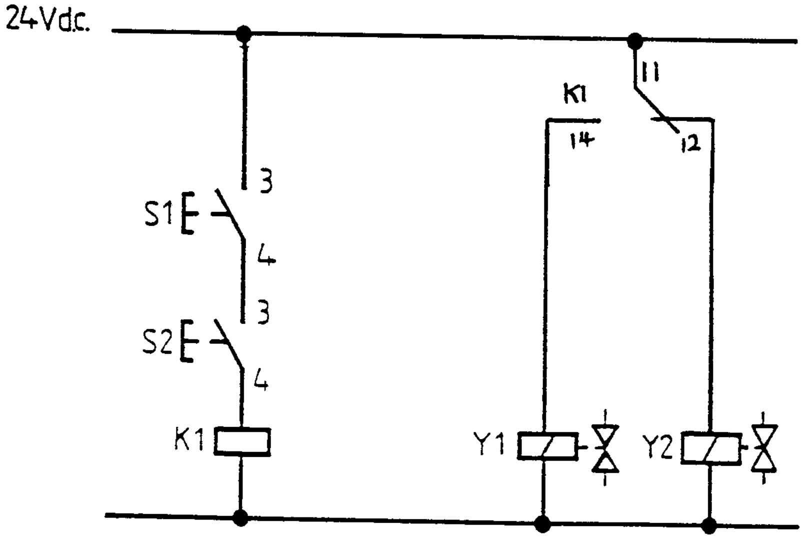
f) 1 off 24V d.c. power supply

g) Pneumatic tubing as required

h) Red and blue electrical leads as required

Exercise: Product Sorting (Double Solenoid Version)





Exercise: Product Sorting (Double Solenoid Version)

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram, connect tubing between the "on/off" valve, air distribution manifold, 5/2 double solenoid valve, and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relay and the solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button (S1) and observe the action of the cylinder.

11 Depress and release the electrical push button (S2) and observe the action of the cylinder.

Exercise: Product Sorting (Double Solenoid Version)

Operational Procedure - continued

12 Depress and release both the electrical push buttons (S1) and (S2) together and observe the action of the cylinder.

13 Switch 'off' both the electrical power supply and the compressed air supply.

14 Remove all pneumatic tubing and electrical leads.

15 Compare your observations with the written circuit explanation.

16 Answer the questions for this exercise.

Exercise: Product Sorting (Double Solenoid Version)

Circuit Explanation

When push button switch S1 or S2 are actuated nothing will happen due to the fact that the switches are wired in 'series' they must both be operated before current will be allowed to flow to the relay K1. Once 'both' push button switches S1 and S2 are actuated together, current passes to the relay K1 energising it closing the open contacts 11, 14, and opening the contacts 11, 12 of this relay. With the relay K1 energised the solenoid Y1 will be energised switching the 5/2 way valve and extending the cylinder immediately 'either' S1 or S2 are released the relay K1 is de-energised the solenoid Y1 will be de-energised and the solenoid Y2 will now be energised (due to the closed contacts 21, 22 allowing current flow to it), this resets the 5/2 way valve to the condition shown and the cylinder will be retracted.

Questions: Product Sorting (Double Solenoid Version)

1) Is the valve in the solution:-

   a) Normally Closed ☐

   b) Normally Open ☐

   c) Neither ☐

   Explain your answer:

   ....

   ....

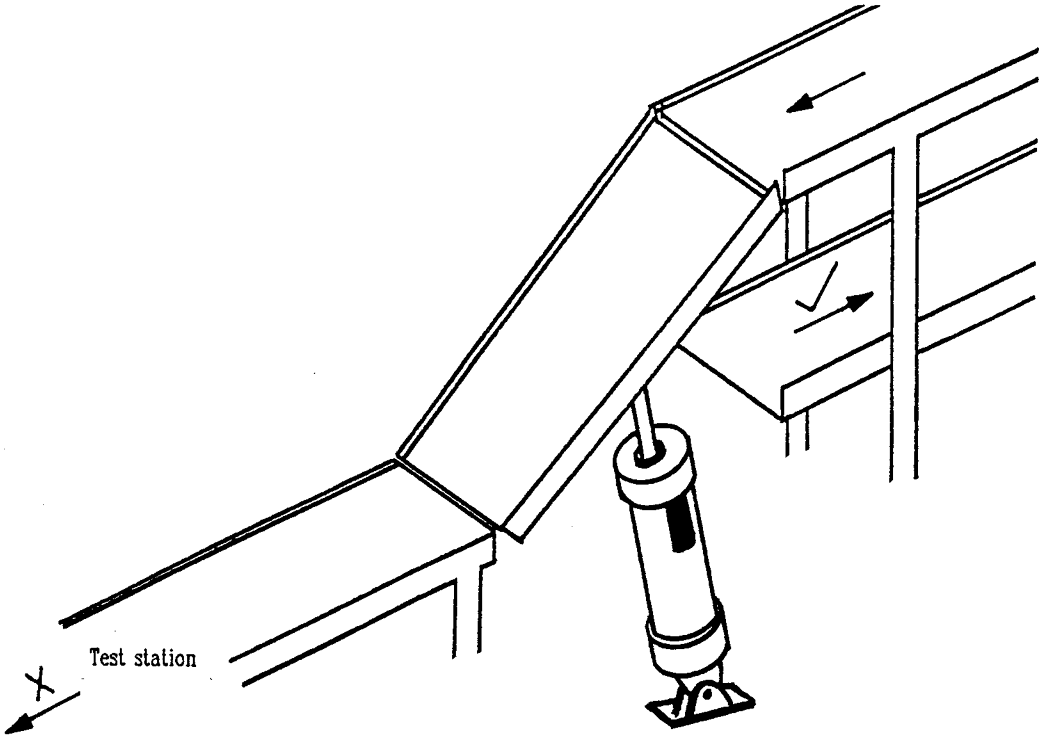
2) Switches S1 and S2 are connected in such a way as to provide an 'AND' function. Draw the symbol according to ISO 1219-1 for a AND valve to give a pneumatic version of an AND function:

3) Draw the symbol for a relay with three (3) sets of Normally Open contacts:

This page has intentionally

been left blank

Exercise: Conveyor Bridge (2 way)



Components arrive on an upper conveyor and are transferred via a bridging section, which swivels to a test station at the lower level. Components that pass the tests are then transferred out on the lower conveyor once again via the bridging section. Failed components pass through the test station and are sent for rework or scrapped according to their reason for failure.

The cylinder will normally be in an extended condition (bridge "up") when a component is transferred to the lower (output) conveyor the cylinder is to be retracted by the actuation of a push button once the component has transferred to the lower conveyor the cylinder is to automatically extend again ready for the next component.

Exercise: Conveyor Bridge (2 way)

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 1 off Electrical push button with normally open contacts and momentary operation

d) 1 off Limit switch normally open contacts

e) 2 off Electrical relays

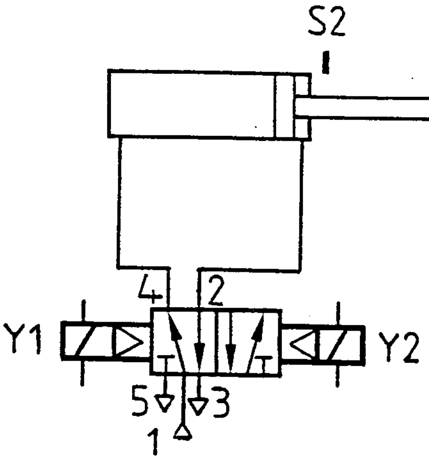
f) 1 off Pneumatic "on/off" slide valve

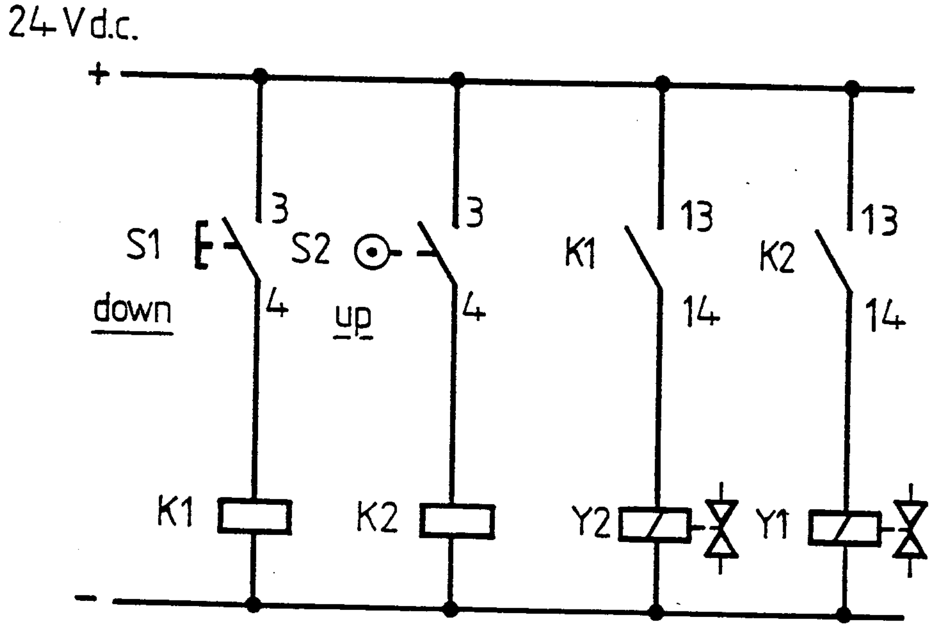
g) 1 off 24V d.c. power supply

h) Pneumatic tubing as required

i) Red and blue electrical leads as required

Exercise: Conveyor Bridge (2 way)





Exercise: Conveyor Bridge (2 way)

Operational Procedure

1. Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2. Connect a 24V d.c. power supply to the electrical distribution manifold.

3. Actuate the air "on/off" slide valve to the 'off' position.

4. Ensure that the electrical power supply is switched "off".

5. Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relays and the solenoids on the 5/2 directional control valve (DCV).

7. Check the assembled circuits against the circuit diagrams.

8. Switch 'on' the 24V d.c. power supply.

9. Actuate the air "on/off" valve to the 'on' position.

10. Depress and release the electrical push button (S1) and observe the action of the cylinder.

Exercise: Conveyor Bridge (2 way)

Operational Procedure - continued

11 Switch 'off' both the electrical power supply and the compressed air supply.

12 Remove all pneumatic tubing and electrical leads.

13 Compare your observations with the written circuit Explanation.

14 Answer the questions for this exercise.

Exercise: Conveyor Bridge (2 way)

Circuit Explanation

Operation of push button switch S1 (down) allows current to flow and energise relay K1 upon being energised the contacts of this relay will close and this will then allow current to flow and energise the solenoid Y2. When Y2 is energised the 5/2 way valve switches and air will pass to the front of the cylinder with the rear of the cylinder exhausting, the cylinder therefore retracts lowering the bridge until the limit switch S2 (up) is operated. When S2 is operated it energises relay K2 closing the contacts of this relay current will then flow via these contacts and energise the solenoid Y1 which resets the 5/2 way valve to the condition as drawn, the cylinder subsequently extends with air passing to the rear of the cylinder and the front of the cylinder exhausting this lifts the bridge to its upper position ready for the next component.

Questions: Conveyor Bridge (2 way)

1) How does the 5/2 way valve in this solution differ from the valve used in the other circuits/solutions ?

....

....

....

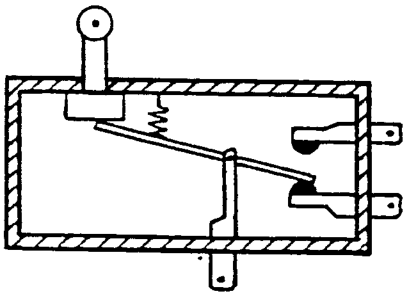
2) In the solution what is the function of limit switch S2 ?

....

....

....

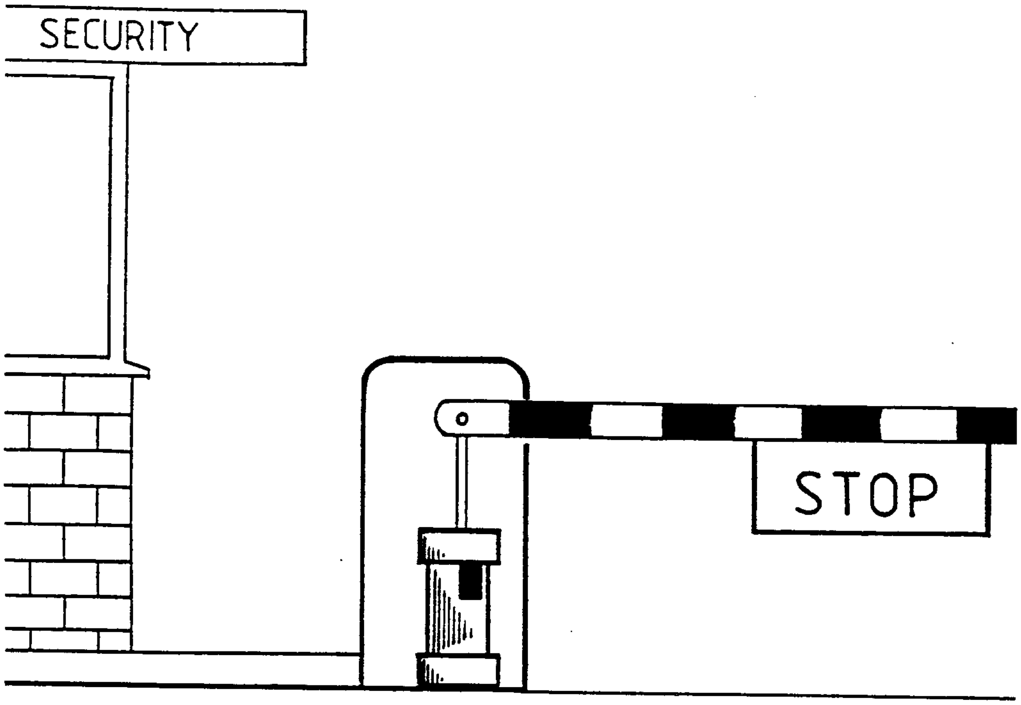
3) The diagram below is of a typical mechanical limit switch (contact type) draw the DIN symbol which represents it and label the contacts:



This page has intentionally

been left blank

Exercise: Barrier Control with Indicator Lights



An entry/exit barrier at a factory gate is to be controlled by means of a double acting cylinder. The barrier is raised and lowered by security personnel situated in the adjacent gatehouse. To raise the barrier a push button must be actuated, immediately the barrier starts to move this push button can be released and the barrier will continue to rise until it is at its maximum height where it will stay until a second (totally separate) push button is actuated. Once the second push button is actuated the barrier will lower, again as soon as the barrier starts to move the push button can be released and the barrier will continue to lower until it reaches its lowest position where it will remain until the first (raise) push button is actuated once again.

It should be noted that the cylinder is in the extended position when the circuit is at rest (barrier closed). When the barrier is in the down position, a red light will illuminate. With the barrier in the up position, a green light will illuminate.

Exercise: Barrier Control with Indicator Lights

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 2 off Electrical push button with normally open contacts and momentary operation

d) 2 off Electrical relays

e) 1 off Green lamp

f) 1 off Red lamp

g) 2 off Limit switches normally open

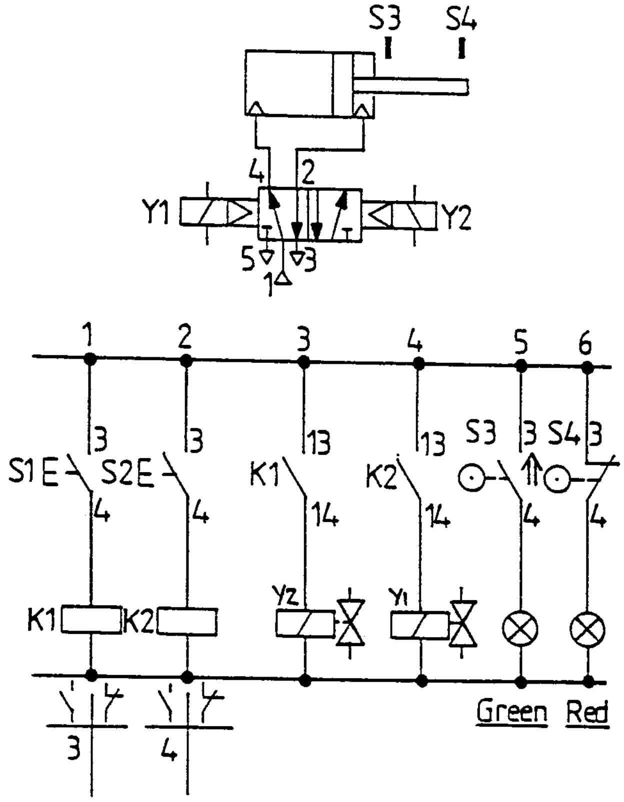
h) 1 off Pneumatic "on/off" slide valve

i) 1 off 24V d.c. power supply

j) Pneumatic tubing as required

k) Red and blue electrical leads as required

Exercise: Barrier Control with Indicator Lights



Exercise: Barrier Control with Indicator Lights

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 double solenoid operated directional control valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relays, and the solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button (S1) and observe the action of the cylinder and indicator lamps.

Exercise: Barrier Control with Indicator Lights

Operational Procedure – continued

11 Depress and release the electrical push button (S2) and observe the action of the cylinder and indicator lamps.

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Barrier Control with Indicator Lights

Circuit Explanation

In the 'at rest' condition the cylinder is extended, S4 switch is held operated therefore the red lamp is illuminated, indicating the barrier is in the down position. Operation of push button switch S1 ('up') allows current to flow and energise relay K1, upon being energised the contacts of this relay will close and this will then allow current to flow and energise the solenoid Y2. When Y2 is energised the 5/2 way valve switches and air will pass to the front of the cylinder with the rear of the cylinder exhausting, the cylinder therefore retracts lifting the barrier, as the barrier lifts limit switch S4 is released disconnecting the circuit to the red lamp switching it off. The cylinder remains retracted (barrier 'up') until the second push button switch S2 ('down') is operated. When S2 is operated it energises relay K2 closing the contacts of this relay, current will then flow via these contacts and energise the solenoid Y1 which resets the 5/2 way valve to the condition as drawn, the cylinder subsequently extends with air passing to the rear of the cylinder this lowers the barrier to its closed position. When the cylinder is in its fully retracted position limit switch S3 is actuated passing a current through to the green lamp thereby illuminating it and showing that the barrier is 'up'.

Questions: Barrier Control with Indicator Lights

1) List three (3) advantages of a relay:

   i) ....

   ii) ....

   iii) ....

2) List three (3) disadvantages of a relay:

   i) ....

   ii) ....

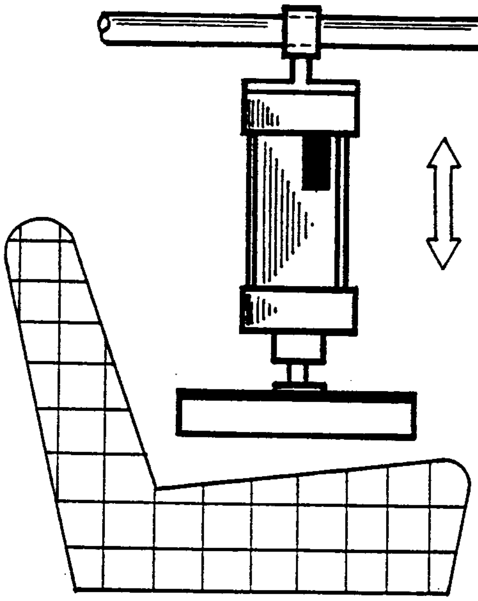
   iii) ....

3) Draw the symbol according to DIN standards for a relay with four (4) sets of change over contacts and label the contacts:

This page has intentionally

been left blank

Exercise: Component Test Machine



Chairs are to be tested for strength and durability this test is to be carried out by using a double acting cylinder, which once the system is switched "on", is to continuously cycle (extend and then immediately retract repeatedly) until it is switched 'off'. When the system is switched 'off' the cylinder must stop in the retracted position irrelevant to its position at that time.

Exercise: Component Test Machine

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 1 off Electrical toggle lever with normally open contacts and detent operation

d) 2 off Electrical relay

e) 2 off Electrical limit switch

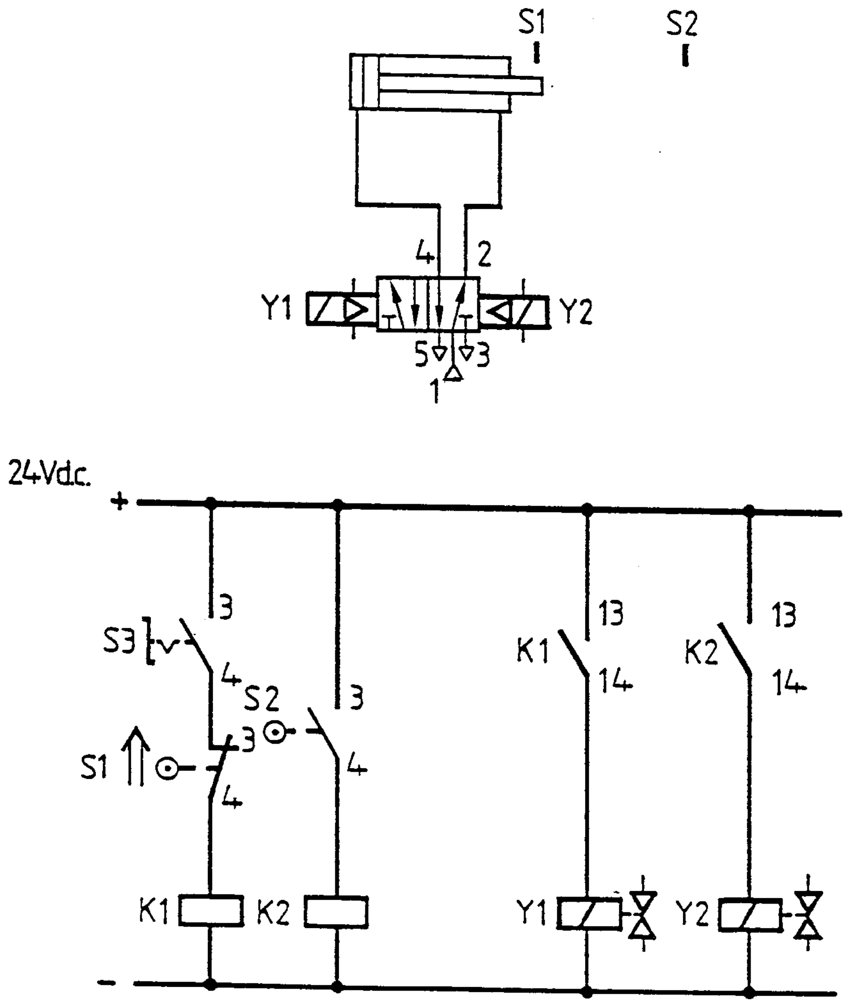
f) 1 off Pneumatic "on/off" slide valve

g) 1 off 24V d.c. power supply

h) Pneumatic tubing as required

i) Red and blue electrical leads as required

Exercise: Component Test Machine



Exercise: Component Test Machine

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 double solenoid operated valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, electrical relays and the two solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Actuate the (S3) switch to the 'on' position and observe the action of the cylinder.

11 Actuate the (S3) switch to the 'off' position and observe the action of the cylinder.

Exercise: Component Test Machine

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

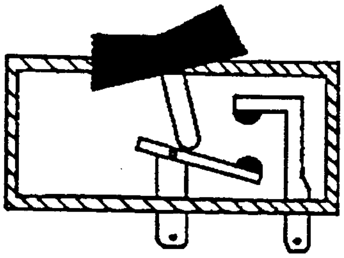
Exercise: Component Test Machine

Circuit Explanation

The limit switch S1 is located at the cylinder instroke position and is therefore actuated when the circuit is at rest. When the switch S3 is turned to the "on" position current is allowed to travel through both switches to the relay K1 which is then energised closing the contacts 13, 14 and in turn energising solenoid Y1 and extending the cylinder. As the cylinder extends it releases limit switch S1 which reverts to its 'normally open' condition breaking the feed to and de-energising relay K1 subsequently solenoid Y1 is also de-energised, the cylinder however continues to extend as the directional control valve is of the memory type. At the fully extended position, the cylinder actuates the limit switch S2 closing the contacts and energising relay K2. When relay K2 is energised, the contacts are closed, and the solenoid Y2 is energised, this resets the 5/2 way valve to the condition as drawn retracting the cylinder. As the cylinder retracts the limit switch S2 is released breaking the feed to relay K2 which is de-energised this results in the de-energising of solenoid Y2, at the fully instroked position limit switch S1 is again actuated and the cycle will be repeated and keep repeating until such time that the switch S3 is reselected to the 'off' position, when this happens the cycle will be completed and stop with the cylinder retracted due to the 'on/off' switch being in the extend line.

Questions: Component Test Machine

1) Draw the symbol according to DIN standards for the manually operated switch latching type shown below:



2) In the solution what is the function of the limit switches S1 and S2 ?

....

....

....

3) What is indicated by the arrow that is drawn next to the limit switch S1 in the solution ?

....

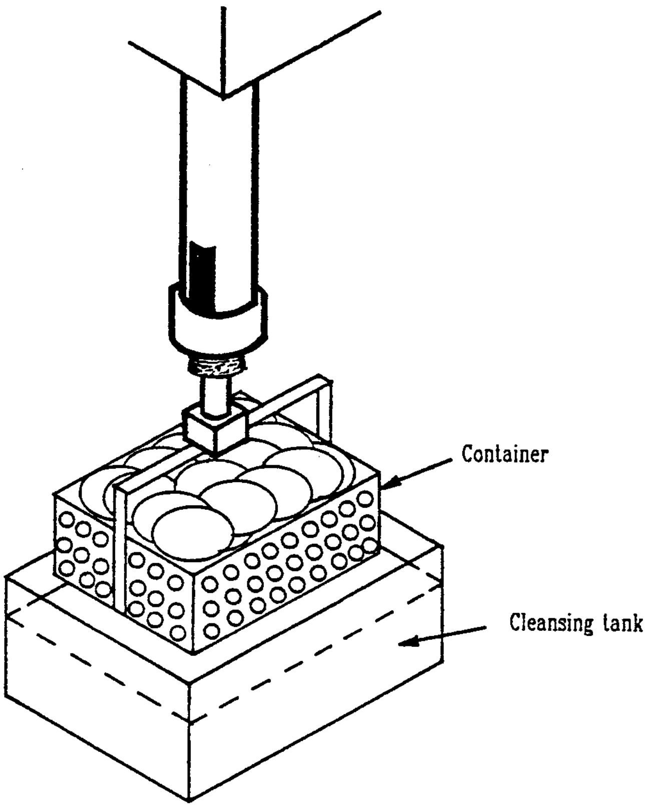
....

....

This page has intentionally

been left blank

Exercise: Product Cleansing



Components are to be washed before assembly they are placed into a container, which is to be dipped in and out of the cleansing fluid. Once the "start" push button has been actuated, the cylinder is to continuously cycle until such time that the 'stop' push button is actuated (two (2) separate push buttons are required).

When the stop push button is actuated, the cylinder must stop in the retracted (container 'up') position.

Exercise: Product Cleansing

Equipment Required:

a) 1 off Double acting cylinder

b) 1 off 5/2 Double solenoid actuated directional control valve

c) 1 off Electrical push button with normally open contacts and momentary operation

d) 1 off Electrical push button with normally closed contacts and momentary operation

e) 2 off Electrical relay

f) 2 off Electrical limit switch with normally open contacts

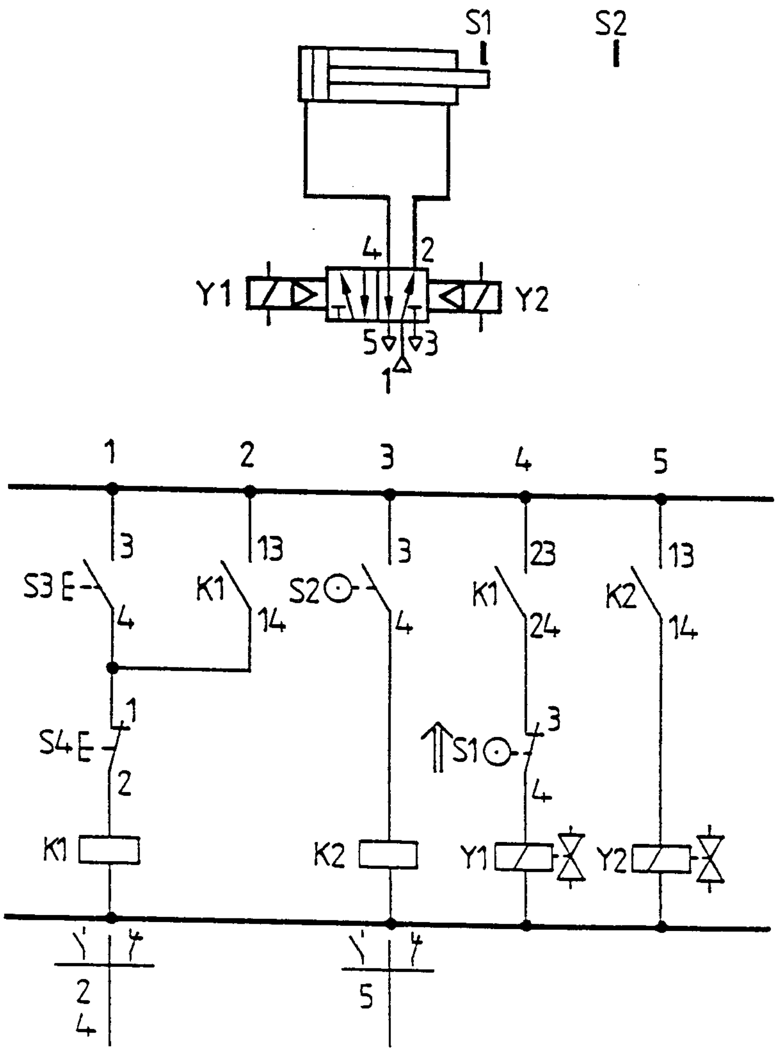
g) 1 off Pneumatic "on/off" slide valve

h) 1 off 24V d.c. power supply

i) Pneumatic tubing as required

j) Red and blue electrical leads as required

Exercise: Product Cleansing



Exercise: Product Cleansing

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 double solenoid operated valve and the double acting cylinder. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push buttons, electrical relays, limit switches, and the two solenoids on the 5/2 directional control valve (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button (S3) and observe the action of the cylinder.

11 Depress and release the electrical push button (S4) and observe the action of the cylinder.

Exercise: Product Cleansing

Operational Procedure - continued

12 Switch 'off' both the electrical power supply and the compressed air supply.

13 Remove all pneumatic tubing and electrical leads.

14 Compare your observations with the written circuit explanation.

15 Answer the questions for this exercise.

Exercise: Product Cleansing

Circuit Explanation

Operation of the 'start' push button switch S3 will close the contacts and allow current to pass through the normally closed contacts of the 'stop' push button switch S4 to energise the relay K1. Once K1 has been energised the contacts in lines 2 and 4 are closed those in lines 2 will create the latch keeping K1 energised when the start push button is released while the contacts in line 4 will allow current to pass through limit switch S1 (which is of the 'normally open' type but is actuated therefore the contacts are closed as shown). Current passing through the switch will then cause the energising of solenoid Y1 and the subsequent switching of the 5/2 way valve extending the cylinder. As the cylinder extends it will release limit switch S1, the contacts of this switch open and the solenoid Y1 is then de-energised (this does not cause a problem as the 5/2 way valve is of the memory type) once the cylinder has fully extended it actuates the limit switch S2 this closes the contacts of this switch and energises the relay K2, closing its contacts in line 5 energising the solenoid Y2, this reverses the 5/2 way valve retracting the cylinder. As the cylinder retracts it releases the limit switch S2 de-energising Y2 and at its fully retracted position actuates the limit switch S1 once again, the cycle is then repeated. The circuit will continue to repeat until the normally closed 'stop' push button switch S4 is operated opening its contacts and de-energising the relay K1 this opens the contacts in line 4 ensuring that solenoid Y1 cannot be energised and therefore the cylinder stops in the retracted position (the extend signal is eliminated).

Questions: Product Cleansing

1) What is the function of the K1 contact shown in line 2 of the circuit diagram ?

....

....

....

2) What is the name generally given to the circuit shown in line 1 and 2 of the electrical diagram ?

....

....

....

3) What do the small box diagrams below lines 1 and 3 of the electrical circuit diagram signify ?

....

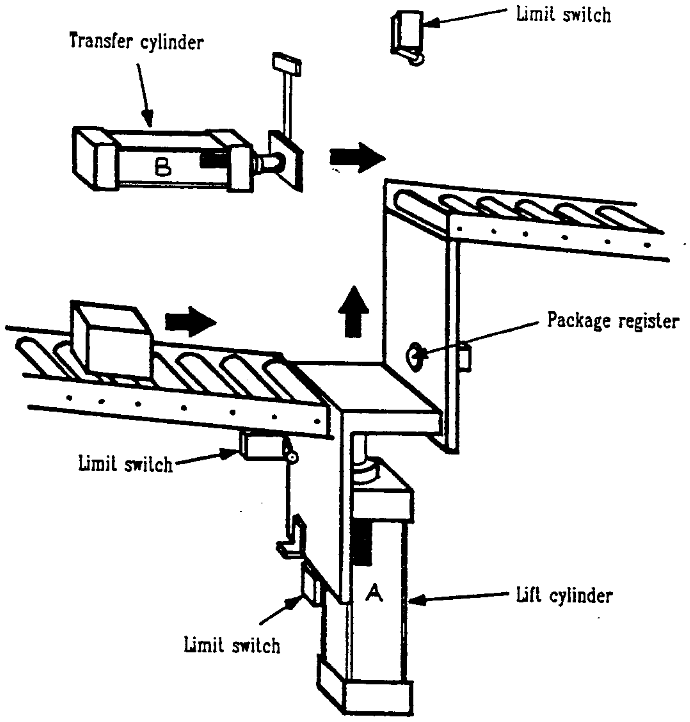
....

....

This page has intentionally

been left blank

Exercise: Lift and Transfer Station



Packages arrive at a transfer station, upon actuating a package register they are lifted by cylinder 'A' (lift cylinder) to a second level when this level is reached the package is pushed onto the roller track by cylinder 'B' (transfer cylinder). Once cylinder 'B' has fully extended cylinder 'A' will retract (lower), only after cylinder 'A' has reached its initial (fully retracted) position will cylinder 'B' retract.

Cylinder 'A' remains retracted until the next package arrives when it does the cycle will be repeated.

Exercise: Lift and Transfer Station

Equipment Required:

a) 2 off Double acting cylinder

b) 2 off 5/2 Double solenoid actuated directional control valve

c) 1 off Electrical push button with normally open contacts and momentary operation

d) 4 off Electrical limit switch with normally open contacts

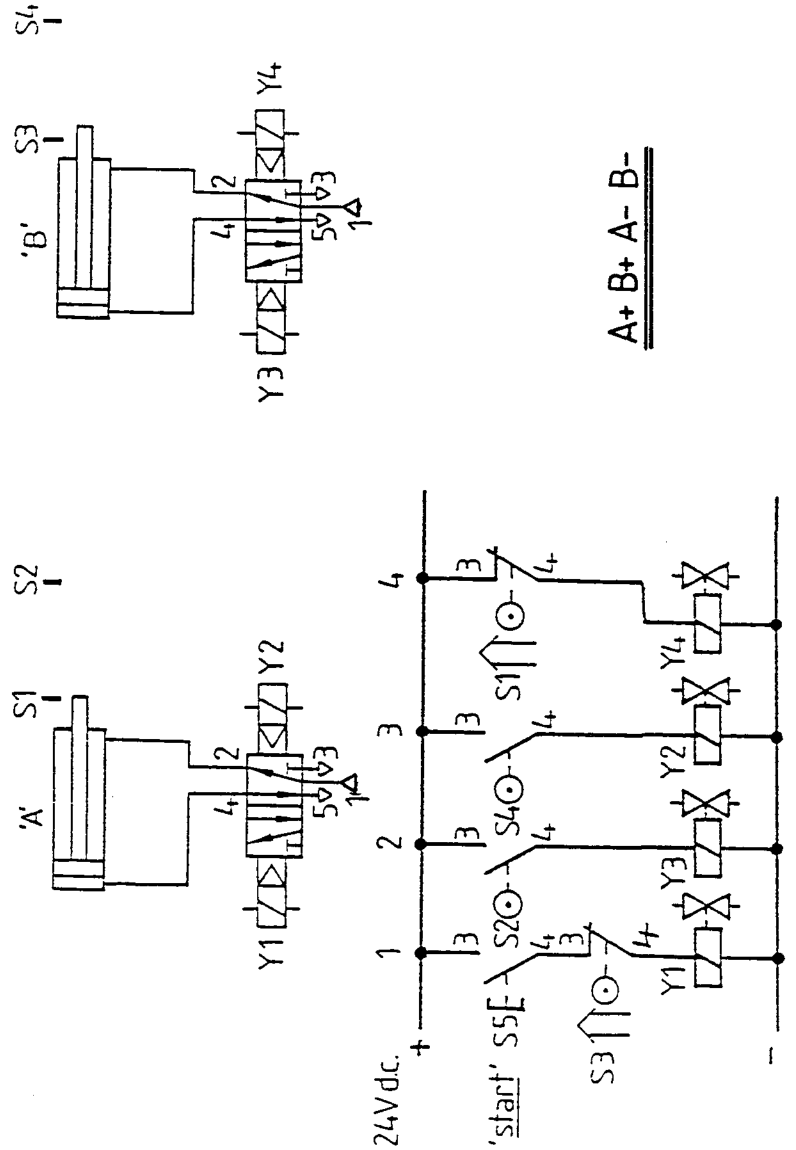
e) 1 off Pneumatic "on/off" slide valve

f) 1 off 24V d.c. power supply

g) Pneumatic tubing as required

h) Red and blue electrical leads as required

Exercise: Lift and Transfer Station



Exercise: Lift and Transfer Station

Operational Procedure

1. Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2. Connect a 24V d.c. power supply to the electrical distribution manifold.

3. Actuate the air "on/off" slide valve to the 'off' position.

4. Ensure that the electrical power supply is switched "off".

5. Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated valves and the double acting cylinders. (Note: fit blanking plugs to any unused manifold connections).

6. Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, limit switches and the solenoids on the 5/2 directional control valves (DCV).

7. Check the assembled circuits against the circuit diagrams.

8. Switch 'on' the 24V d.c. power supply.

9. Actuate the air "on/off" valve to the 'on' position.

10. Depress and release the electrical push button (S5) and observe the action of the cylinders.

Exercise: Lift and Transfer Station

Operational Procedure - continued

11 Switch 'off' both the electrical power supply and the compressed air supply.

12 Remove all pneumatic tubing and electrical leads.

13 Compare your observations with the written circuit explanation.

14 Answer the questions for this exercise.

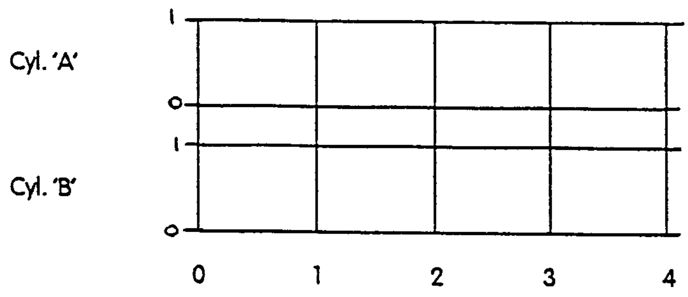
Exercise: Lift and Transfer Station

Circuit Explanation

Upon operation of the 'start' push button switch S5 (which simulates the package register) current will pass through the limit switch S3 (which is a 'normally open' switch actuated by cylinder 'B' and therefore in the closed state) and energise the solenoid Y1, extending the cylinder 'A' (and during this movement releasing limit switch S1 the contacts of which will now revert to their normal condition 'open'). When cylinder 'A' reaches its forward end position the limit switch S2 is actuated closing its contacts and passing current to solenoid Y3 thereby extending cylinder 'B' (again as the cylinder extends the limit switch S3 is released). At its forward end position cylinder 'B' will actuate limit switch S4 closing its contacts and energising solenoid Y2 retracting cylinder 'A' to its original (fully instroked) position. Cylinder 'A' releases the limit switch S2 as it retracts and upon full retraction actuates limit switch S1 closing its contacts (as drawn), energising solenoid Y4 and retracting cylinder 'B' (releasing S4 and at the fully instroked position actuating S3). The circuit is now back to its start condition ready for another operation however if the 'start' switch has been held down the cycle will repeat once cylinder 'B' has fully retracted.

Questions: Lift and Transfer Station

1) In this exercise a 'motion step diagram' is shown illustrating the cylinder sequence A+, B+, A-, B-. Complete the diagram below to illustrate the sequence B-, A+, B+, A-:



2) In the solution what position would the cylinders assume if there was an electrical power failure as cylinder 'A' was retracting and why ?

....

....

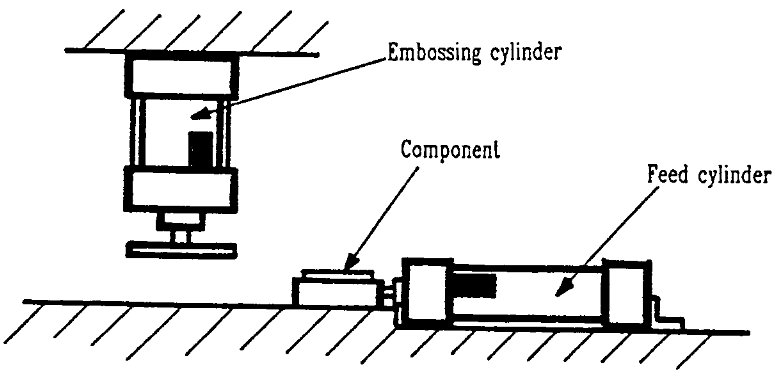
....

3) The solution does not utilise any relays (direct operation), show by means of a diagram a solution utilising relays:

This page has intentionally

been left blank

Exercise: Embossing Machine



Plastic components are to be embossed with a serial number, they are manually placed into a holder. This holder is then fed by means of a double acting cylinder 'A' to a position below the embossing cylinder 'B' once this location is reached the embossing cylinder 'B' will extend and emboss the component. Once the component is embossed cylinder 'B' must fully retract first, then cylinder 'A' may retract to its initial position. At this point the cycle stops, the component is removed from the holder and a new component is loaded. Each cycle is started by means of a push button.

Exercise: Embossing Machine

Equipment Required:

a) 2 off Double acting cylinder

b) 2 off 5/2 Double solenoid actuated directional control valve

c) 1 off Electrical push button with normally open contacts and momentary operation

d) 3 off Electrical limit switch with normally open contacts

e) 1 off Electrical limit with normally closed contacts

f) 1 off Electrical relay

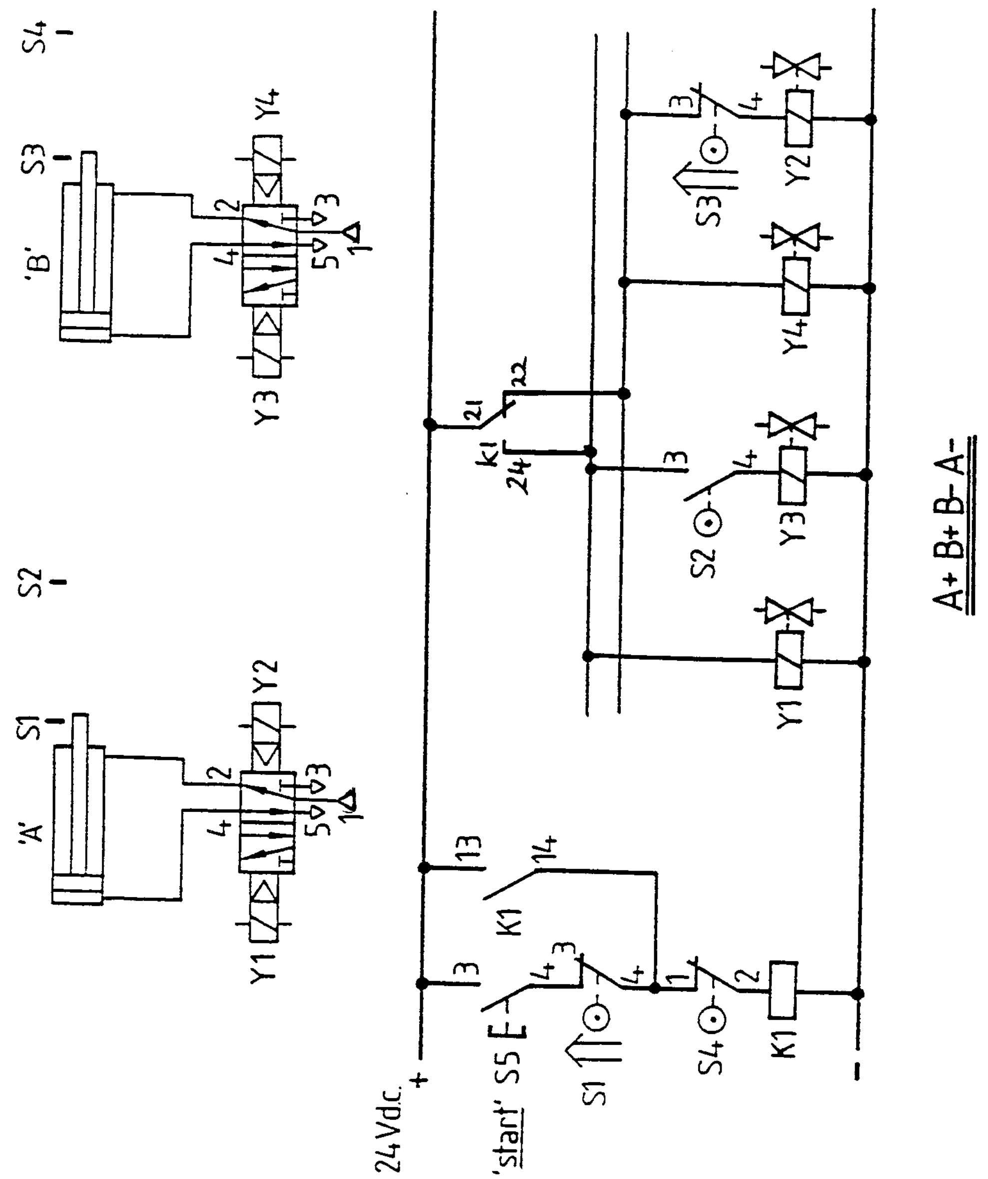
g) 1 off Pneumatic "on/off" slide valve

h) 1 off 24V d.c. power supply

i) Pneumatic tubing as required

j) Red and blue electrical leads as required

Exercise: Embossing Machine



Exercise: Embossing Machine

Operational Procedure

1 Connect a compressed air supply regulated to between two (2) and three (3) bar pressure (29 – 43.5 psi) to the inlet port of the "on/off" slide valve.

2 Connect a 24V d.c. power supply to the electrical distribution manifold.

3 Actuate the air "on/off" slide valve to the 'off' position.

4 Ensure that the electrical power supply is switched "off".

5 Following the pneumatic circuit diagram connect tubing between the "on/off" valve, air distribution manifold, 5/2 solenoid operated valves and the double acting cylinders. (Note: fit blanking plugs to any unused manifold connections).

6 Now following the electrical circuit diagram connect electrical leads between the red/blue electrical manifolds, electrical push button, limit switches, relay and the solenoids on the 5/2 directional control valves (DCV).

7 Check the assembled circuits against the circuit diagrams.

8 Switch 'on' the 24V d.c. power supply.

9 Actuate the air "on/off" valve to the 'on' position.

10 Depress and release the electrical push button S5 and observe the action of the cylinders.

Exercise: Embossing Machine

Operational Procedure - continued

11 Switch 'off' both the electrical power supply and the compressed air supply.

12 Remove all pneumatic tubing and electrical leads.

13 Compare your observations with the written circuit explanation.

14 Answer the questions for this exercise.

Exercise: Embossing Machine

Circuit Explanation

Operation of the 'start' push button switch S5 will allow current to pass through the closed contacts of limit switch S1 (normally open but actuated) and the normally closed contacts of limit switch S4 to energise the relay K1. Two (2) sets of contacts are required to be switched these are open contacts 13, 14 and change over contacts 21, 22 and 24. The contacts 13, 14 are closed to create a latch to keep K1 energised once S5 is released, contacts 21, 22 and 24 are closed and opened respectively to energise and de-energise the solenoids. Therefore upon energising relay K1 current will pass through to solenoid Y1 switching the valve and extending cylinder 'A' this releases limit switch S1 and at the forward end position actuates limit switch S2 closing its contacts and in turn energising solenoid Y3, switching the valve and extending cylinder 'B' this releases limit switch S3 and at the forward end position actuates limit switch S4. When the limit switch S4 is actuated its contacts are opened de-energising relay K1, this breaks the latch and opens contacts 21 and 24 at the same time contacts 21 and 22 are reverted to their closed condition this passes current to solenoid Y4 reversing its valve and retracting cylinder 'B' as the cylinder retracts it releases the limit switch S4 and at the instroke position actuates limit switch S3 closing the contacts of this switch (to the condition as drawn) allowing current to pass and energise solenoid Y2 reversing its valve and retracting cylinder 'A'. The circuit is now back to its start condition where the component can be removed from the fixture and a new component loaded ready for the next operation.

Questions: Embossing Machine

1) For what purpose are the change over contacts of K1 (21, 22 and 24) used ?

....

....

....

2) If an electrical fault were to occur that resulted in both solenoids Y1 and Y2 being energised at the same time what effect may this have on the solenoid coils ?

....

....

....

3) Using the electrical circuit shown in the exercise as a guide design a circuit to produce a two (2) cylinder sequence B-, A+, A-, B+:

This page has intentionally

been left blank

Section 7

Answers to Question papers

This page has intentionally

been left blank

Answers: Lamp (Indicator) - Direct Control

1) For safety reasons should electrical, power source voltages be kept as high or as low as possible in electro pneumatic systems ?

   High .... ☐

   Low .... ☑

2) An electrical power source can be either a.c. or d.c. what do these abbreviations stand for ?

   a.c. = **Alternating Current**

   d.c. = **Direct Current**

3) This exercise uses a 24V d.c. power supply. List two (2) other electrical supplies in general use:

   1. **230V a.c. (home lighting)**
   2. **1.5V d.c. (torches)**

Answers: Lamp (Indicator) - Push Button Controlled

1) List any three (3) of the six (6) methods of generating electricity:

   1) **Heat**
   2) **Friction**
   3) **Chemical action**
   4) **Light**
   5) **Pressure**
   6) **Magnetism**

2) Which three (3) values are required to produce an electrical circuit ?

   a) **Current (amp)**

   b) **Voltage**

   c) **Resistance**

3) Switches may contain a number of contacts, which may be Normally Open (N/O) Normally Closed (N/C) or both. Explain the meaning of the terms Normally Open and Normally Closed (in relation to electrics):

   With Normally Open contacts, the current is not allowed to pass when the relay is de-energised due to the contacts being 'open' (circuit is broken) and with Normally Closed contacts, the current is allowed to pass due to the contacts being 'closed' (circuit is made).

Answers: Relay Control

1) The electrical push button switch used in this exercise has contacts labelled 3 and 4, what do these numbers mean ?

   The contacts are of a Normally 'Open' type.

2) In this exercise, the connections to the green lamp are marked positive (+) and negative (-) what is the reasoning for this ?

   This indicates that a direct current (d.c.) electrical supply is required to illuminate the lamp.

3) List three (3) advantages of electro pneumatics when compared to pneumatics:

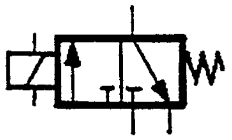
   a) **Electrical signaling is less expensive.**

   b) **Electrical signals travel quicker.**

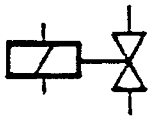
   c) **Electrical components are generally more compact than their pneumatic counterparts.**

Answers: Solenoid Actuated Valve

1) Draw the symbol according to ISO 1219 for a direct operated solenoid valve 3/2 way Normally Closed version:



2) Draw the symbol according to BS3939 (electrical symbols) for a mechanical valve (solenoid operated):



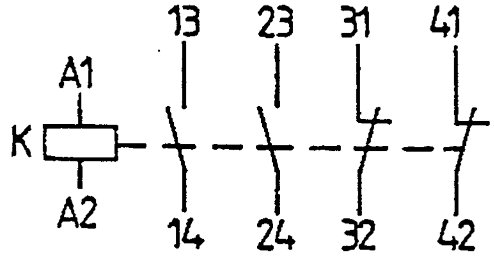
3) List two (2) ways of protecting an electrical circuit:

   1) **Fuse.**

   2) **Thermal Overload.**

Answers: Relay and Lamp Function Test using Open Contacts

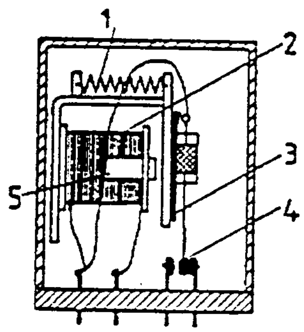
1) Complete according to the DIN standards the numbering of the contacts on the relay shown below:



2) Explain the meaning of the numbers relating to the relay contacts:

Each contact set on the relay has a 2 digit number. The 1st digit in each case denotes the contact set number in relation to the relay coil (i.e. 1, 2, 3, 4). The 2nd pair of digits for each contact set will then determine the condition of that particular contact. For Normally Open (N/O) contacts the 2nd set of digits will be 3 and 4 and for the Normally Closed (N/C) contacts, these digits will be 1 and 2. e.g. 13, 14 would be the 1st set of contacts and are Normally Open (N/O).

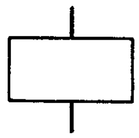
3) Identify the component parts of the relay shown below:



1. **Return spring**
2. **Coil**
3. **Insulation**
4. **Contacts**
5. **Core**

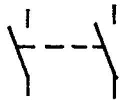
Answers: Relay and Lamps Function Test using Change Over Contacts

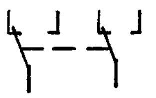
1) Draw the symbol according to DIN standards for the operating coil of a relay:



2) Draw the symbol according to DIN standards for the following contacts:

Single pole Single throw 

Double pole Single throw 

Double pole Double throw 

3) In a d.c. electrical circuit do electrons flow (a) from positive to negative, or (b) from negative to positive ?

☐ (a) from positive to negative

☑ (b) from negative to positive

Answers: Relay and Solenoid Control Valve Function Test

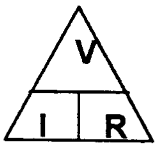
1) The relay used in this exercise has a manual override switch, what function does it perform ?

   Manual override permits manual actuation of the relay without application of an electrical circuit, allowing a function test to be carried out on the relay.

2) A useful option for pneumatic solenoid valves is to have them with solenoid plugs which contain an LED this then shows the status of the solenoid what do the letters LED stand for ?

   Light Emitting Diode

3) OHM's law is normally expressed as "the magic triangle" shown below. What do the letters V, I, R mean ?



V = **Voltage.**

I = **Amperes.**

R = **Resistance.**

Answers: Assembly Fixture

1) Compressed air is generally measured in P-S-I or BAR. What do these abbreviations mean ?

   P-S-I **Pounds per Square Inch.**

   BAR **Barometric.**

2) What is the function of a directional control valve ?

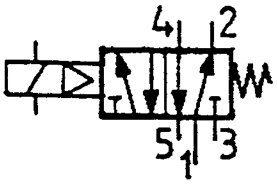
   To control start, stop and direction of fluid flow through the valve and subsequently the circuit/system.

3) Valves are referred to by sizes e.g. M5, 1/8, ¼, what do these sizes refer to ?

   Port size.

Answers: Panel Removal from a Jig

1) Label the ports according to ISO 1219-1 on the directional control valve shown below:



2) Switches S1 and S2 are connected in such a way as to provide a logic function. Identify the correct function from the following list :

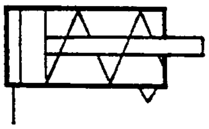
☐ .... AND

☑ .... OR

☐ .... YES

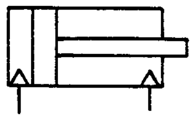
☐ .... NOT

3) Draw the symbol according to ISO 1219-1 for a single acting spring return cylinder:



Answers: Date Stamping of a Product

1) Draw the symbol, according to ISO 1219-1 for a pneumatic double acting cylinder:



2) What position would the cylinders assume if there was an electrical power failure ?

   Retracted.

3) In an electrical circuit, there is always a danger the circuit may be overloaded. Give an example of a simple protection unit to cater for this event and state where it would be fitted:

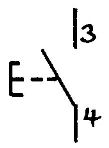
   A fuse which should always be fitted to the live conductor.

Answers: Bending Fixture

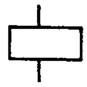
1) The black arrows drawn inside the squares of the pneumatic valve indicate what ?

The direction that air is allowed to flow through the valve.

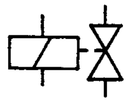
2) Identify the following symbols according to the BS 3939/DIN standard:



Push button switch with Normally Open contacts.



Relay coil



Solenoid actuated mechanical valve

3) List two (2) disadvantages of a single acting spring return cylinder:

Can only be used to do work in one direction of travel (that controlled by compressed air).

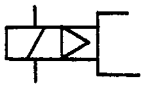
Increased overall length due to the space required for the compressed spring when the piston is extended.

Limited sizes available (stroke and bore) on standard units often the maximum bore available is 100 mm and maximum stroke is also 100 mm (although specials are available from some companies but at considerable premiums on price).

Unit cost is usually higher than double acting cylinder of same bore and stroke due to extra materials used (spring etc...) extra assembly operations required, lower volume manufacture etc.

Answers: Product Separation (Double Solenoid Valve version)

1) A pneumatic directional control valve (DCV) is to be actuated as per the symbol shown below, what does this symbol represent ?



Indirect solenoid actuation (electrically controlled, pneumatic operated).

2) Will a double acting cylinder (normal style) deliver a greater force when:

☑ .... Extending

☐ .... Retracting

☐ .... Be equal in both directions

3) Explain the reason for your answer to question 2:

The force delivered by a cylinder is determined by the air pressure which is applied to it and the surface area to which this pressure is applied (force = pressure x area). On the extend stroke the pressure is applied to the full surface area of the piston which is greater than the area of the piston less piston rod (the situation during retraction) and therefore a greater force is delivered on extension.

Answers: Product Separation (Single Solenoid Valve version)

1) Identify an advantage of the single solenoid (spring return) valve version over the double solenoid valve version:

   The initial advantage is that the single solenoid valve is a lower cost option than the double solenoid valve, although all the other equipment used is identical in both solutions, so it is only the saving on the valve that can be made.

   In the event of electrical power failure the version utilising the single solenoid valve will have the cylinder retract to its normal position (depending upon application this may be an advantage or a disadvantage).

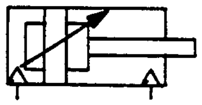
2) Different voltages are used to operate solenoid valves, list the three (3) most commonly used and state if a.c. or d.c. or both:

   a) **24V a.c. and d.c. (d.c. more common)**

   b) **110V a.c.**

   c) **220V a.c.**

3) In this application it may be useful to use a double acting cylinder with adjustable cushioning (in both directions of travel), draw the ISO 1219-1 symbol for this component:



Answers: Foundry Ladle Control

1) List four (4) types of electrical switch commonly used in electro pneumatic circuits/systems:

   i) **Manually operated switch.**

   ii) **Limit switch.**

   iii) **Pressure switch.**

   iv) **Proximity switch.**

2) For safety reasons switches such as push buttons etc should always be placed where in an electrical circuit and why ?

   In the 'live' feed to the circuit, this is so that they can be used to isolate the system on their downstream side and therefore the circuit/system is safer to work on.

3) List three (3) disadvantages of electro pneumatics when compared to pneumatics:

   a) **May prove hazardous (and therefore unsuitable) if used in areas where there is a risk of fire or explosion.**

   b) **Requires two power sources (electricity and compressed air).**

   c) **Two maintenance skills are required to locate and rectify faults.**

Answers: Product Sorting (Single Solenoid Version)

1) What is the difference between a 'limit switch' and a 'proximity switch' ?

   Both check the position of a component (e.g. the piston rod of a cylinder) the limit switch is actuated by physical mechanical contact, whereas the proximity switch does not need to have physical contact to switch (e.g. magnetic, inductive, capacitive, optical proximity switches).

2) Coils and solenoids which operate on direct current (d.c.) are polarity conscious what is meant by this ?

   The connections to the relays and solenoids will be marked + and – and the electrical circuit must be wired accordingly for the equipment to operate correctly. E.g. most units nowadays incorporate an LED (or have them as an option) to indicate the status of the switch, for the LED to function the + and – must be observed, it is sometimes possible to damage the LED if the polarity is reversed.

3) Identify the correct statement from the list below:

   Solenoid actuated pneumatic valves are:-

   a) Control valves ☐

   b) Signal valves ☐

   c) Either a) or b) according to application ☑

   d) Neither a) or b) ☐

Answers: Product Sorting (Double Solenoid Version)

1) Is the valve in the solution:-

   a) Normally Closed ☐

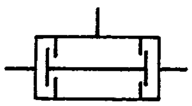
   b) Normally Open ☐

   c) Neither ☑

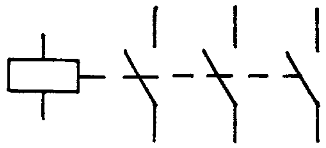
   Explain your answer:

   The terms Normally Closed and Normally Open are not used in relation to valves with two (2) outputs.

2) Switches S1 and S2 are connected in such a way as to provide an 'AND' function. Draw the symbol according to ISO 1219-1 for a AND valve to give a pneumatic version of an AND function:



3) Draw the symbol for a relay with three (3) sets of Normally Open contacts:



Answers: Conveyor Bridge (2 way)

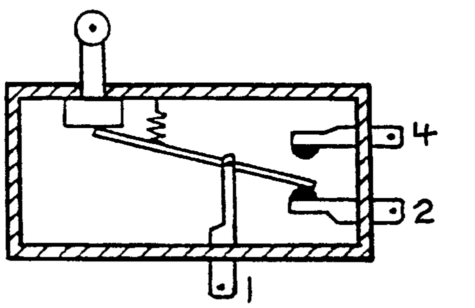
1) How does the 5/2 way valve in this solution differ from the valve used in the other circuits/solutions ?

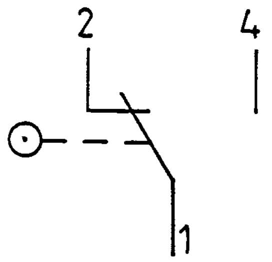
   The valve is exactly the same as in the other circuits, it is just switched to give an output at port 4 when the circuit is 'at rest'.

2) In the solution what is the function of limit switch S2 ?

   Once the cylinder has retracted, it will actuate the limit switch S2 and a signal will be generated to automatically extend the cylinder.

3) The diagram below is of a typical mechanical limit switch (contact type) draw the DIN symbol which represents it and label the contacts:





Answers: Barrier Control with Indicator Lights

1) List three (3) advantages of a relay:

   i) Adaptable for use with various voltages.

   ii) Several independent circuits can be switched at the same time.

   iii) Robust and reliable.

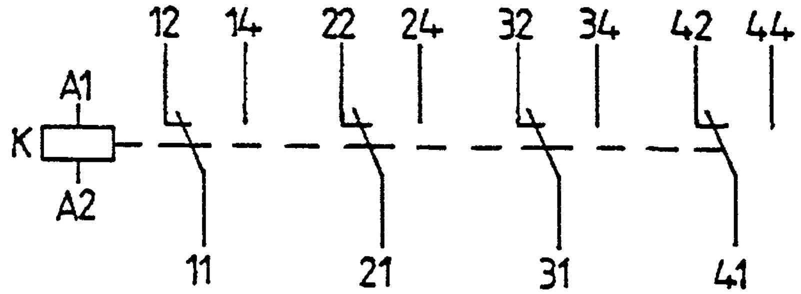
2) List three (3) disadvantages of a relay:

   i) Contacts subject to wear by arcing.

   ii) Large (bulky) when compared to transistors etc.

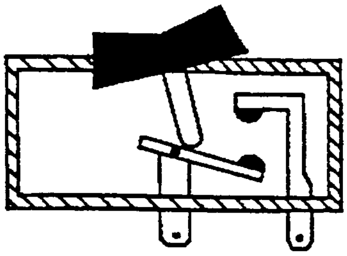
   iii) Limited switching speed (3 – 17 ms).

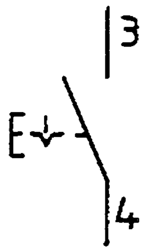
3) Draw the symbol according to DIN standards for a relay with four (4) sets of change over contacts and label the contacts:



Answers: Component Test Machine

1) Draw the symbol according to DIN standards for the manually operated switch latching type shown below:





2) In the solution what is the function of the limit switches S1 and S2 ?

   The limit switches S1 and S2 will be actuated by the piston rod at each end of stroke to achieve and maintain the automatic cycle.

3) What is indicated by the arrow that is drawn next to the limit switch S1 in the solution ?

   This is the symbol used to indicate that the limit switch is actuated when the circuit is 'at rest'.

Answers: Product Cleansing

1) What is the function of the K1 contact shown is line 2 of the circuit diagram ?

When relay K1 is energised the contacts in line 2 will be closed this will allow power to be applied from the + line via line 2 to the coil keeping the relay energised (this applies even after the start push button S3 has been released).

2) What is the name generally given to the circuit shown in line 1 and 2 of the electrical diagram ?

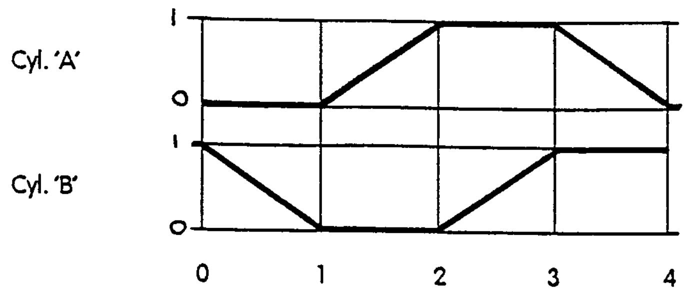
A 'latching circuit' (sometimes called a 'self holding circuit').

3) What do the small box diagrams below lines 1 and 3 of the electrical circuit diagram signify ?

These diagrams show which contacts (N/O or N/C) of the relay are being utilized and where in the circuit those contacts are in use.

Answers: Lift and Transfer Station

1) In this exercise a 'motion step diagram' is shown illustrating the cylinder sequence A+, B+, A-, B-. Complete the diagram below to illustrate the sequence B-, A+, B+, A-:



2) In the solution what position would the cylinders assume if there was an electrical power failure as cylinder 'A' was retracting and why ?

   Cylinder 'A' would continue to retract and cylinder 'B' would remain extended this is due to the double solenoid valves being memory (bi-stable) valves this means that they will remain in the last switched position even when the power is removed (there are no springs to reset them).

3) The solution does not utilise any relays (direct operation), show by means of a diagram a solution utilising relays:

Answers: Embossing Machine

1) For what purpose are the change over contacts of K1 (21, 22 and 24) used ?

   They provide an electrical interlock, which avoids solenoids (Y1 and Y2) or (Y3 and Y4) being energised together and therefore eliminating fighting signals at the valves.

2) If an electrical fault were to occur that resulted in both solenoids Y1 and Y2 being energised at the same time what effect may this have on the solenoid coils ?

   The solenoid coil would overheat and may burn out if left in an energised state for too long.

3) Using the electrical circuit shown in the exercise as a guide design a circuit to produce a two (2) cylinder sequence B-, A+, A-, B+: