Feedback

Hydraulics Trainer
36-500

- Computer Assisted Learning
- Electricity & Electronics
- Control & Instrumentation
- Process Control
- Mechatronics
- Robotics
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- Electrical Power & Machines
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Technology Training for tomorrow's world

Hydraulics Trainer

36-500

Feedback

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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

Refer to accompanying documents

CAUTION - RISK OF ELECTRIC SHOCK

CAUTION - ELECTROSTATIC SENSITIVE DEVICE

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.

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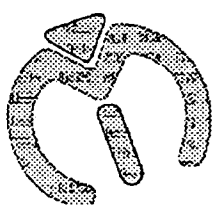

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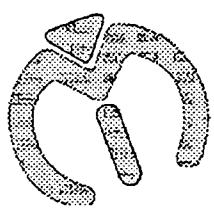

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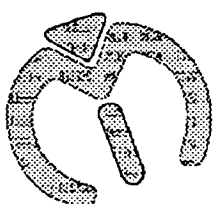
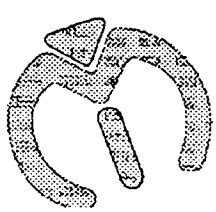




Section 1

Safety requirements when using hydraulics

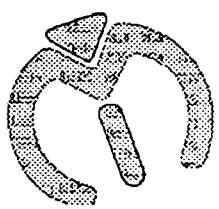
Introduction to hydraulics

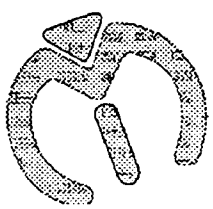
Basic principles of hydraulic power

What is hydraulics?

Characteristics of hydraulics

Applications of hydraulics





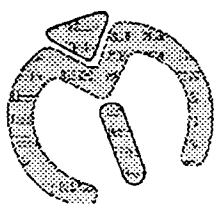
Safety Requirements when using Hydraulics

General

With any type of engineering there is always potential hazards regarding health and safety requirements whilst working with hydraulics. Most of them can be avoided by using a little logic and simple common sense. The following advice will help with the safety requirements.

Fluids

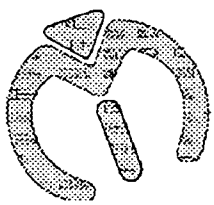
- ✓ Due to the fluids used with hydraulics, it is recommend that a barrier cream is applied to hands before commencing any work. They should be washed thoroughly before and after using the toilet, also prior to eating any food and after completing any work.
- ✓ Safety goggles should be worn at all times to prevent any of the fluids being used from coming into contact with the eyes.
- ✓ Always check you have the correct fluids you require before commencing any work. If you are in doubt as to the nature of any fluid, then check to see if there are specific precautions, which need to be taken before commencing.
- ✓ Care needs to be taken with regard to oily clothing and contact with the skin. Do not leave oily clothing in contact with the skin longer than necessary. Also be careful with oily rags, they should not be put pockets as the oil soaks through clothing very quickly.
- ✓ If any oil is exposed to your skin, in the form of a 'soaking', then you should take a bath and completely change your clothing at your earliest convenience.



Safety Requirements when using Hydraulics

- ✓ Some people may find that they have a skin irritation or a rash, when using or coming into contact with hydraulic fluids, if this is the case then seek medical advice as soon as possible.

- ✓ When using hydraulic equipment and fluids you need to be aware that both can become very hot whilst operating. Contact should be avoided with hot pipes, connectors, and units. Hot pipes should not be disconnected, as the oil in them will be very hot.



Introduction to Hydraulics

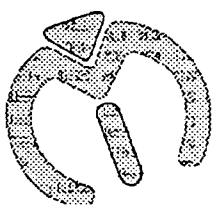
Hydraulic power is being used more and more in all types of industries to replace expensive and intricate mechanisms such as gear trains, cams and levers, which become more complex as additional operations are demanded.

To remain competitive in periods of recession and cost cutting, machines and plant are required to operate with a minimum of manual control and attendance and to produce products at ever lower costs.

Hydraulic systems coupled with Electric/Electronic or Pneumatic control gives an ideal solution at the minimum cost.

Hydraulic actuation offers many advantages over other mediums and the following list gives some of the factors, which make it suitable for many applications: -

- Complex controls with mechanical simplicity.
- Infinite variety of speeds, which are accurately controlled and changeable during operation.
- Smooth, vibration free action, unaffected by variations in load.
- End of stroke cushioning, removing hard impacts.
- High pressure available, where required, with or without motion.
- Motion available as linear, rotary or part rotary in any plane.
- Self-lubricating.
- Safety features and interlocks easily incorporated.
- High efficiencies possible.
- Power can be stalled, interrupted, reversed, varied almost instantaneously.
- Possible to transmit force to positions inaccessible by mechanical means.
- Elimination of high wearing mechanical parts, such as clutches, gearboxes, etc...



Basic Principles of Hydraulic Power

Hydraulics is the science based on the physical characteristics at rest and in motion. Power hydraulics is concerned with these characteristics to transfer power from one location to another.

Joseph Bramah was the main instigator of hydraulic power when he built the first hydraulic press in 1795, but electrical power in later years took over some of the main hydraulic operations in industry.

The accumulator system which was used in the early days of hydraulics (powered by water) was very cumbersome and inefficient and it wasn't until the 'Self Contained System' was introduced, using a separate pump for each machine, that hydraulic power once again came into prominence.

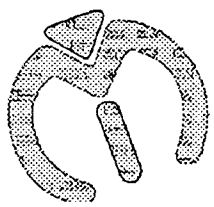
Another reason was that oil was the power medium instead of water, which gave chemical reliability, corrosion resistance, lubrication properties, and practical incompressibility.

Liquids conform to the following rules: -

'AT REST' - Equal pressure throughout the system

'IN MOTION' - Flow from high pressure to low pressure

Pressure can only be created when the flow of liquid is working against a resistance, therefore if there is no resistance there will be no pressure.

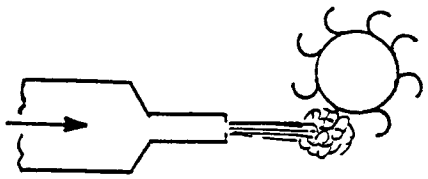


What is Hydraulics?

Hydraulics falls into the category of Hydromechanics. This can be subdivided into Hydrodynamics and Hydrostatics.

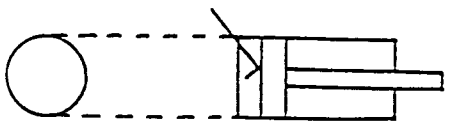
Hydrodynamics

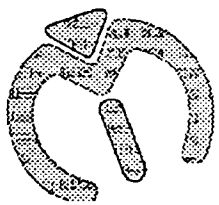
Force = mass x acceleration



Hydrostatics

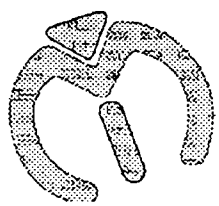
Force = pressure x area





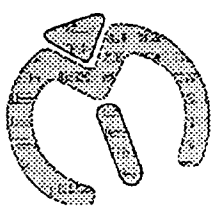
Characteristics of Hydraulics

- Large forces despite small size
- Self-lubricating
- Exact positioning available
- Smooth motions due to relative incompressibility of fluid
- Possible to start under maximum load/s
- Transmission of force
- Can be messy
- Can be sensitive to temperature change/s
- Sensitive to contamination
- Maximum working speed 0,5 m/s



Characteristics of Hydraulics

- Possible danger due to high pressure
- Limited energy storage
- Circulation of fluid – return lines required
- Transmission of shock waves (valves switching) – noise
- Breakdown of fluid (due to ageing)
- Possible toxicity of fluid



Applications of Hydraulics

Agricultural Machinery

Harvesters
Tractor Accessories

Civil Engineering Plant

Excavators
Bulldozers
Graders
Cranes

Injection Moulding Machines, Smelting Plants, Foundries and Forges, Machine Tools.

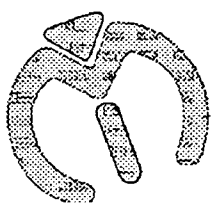
Presses
Planing, shaping, milling, drilling and sanding machines
Woodworking machines

Aerospace

Under-carriage
Bay doors
Radar dish
Flaps & ailerons
Docking equipment

Ship Building

Stabilisers
Container handling
Rudder



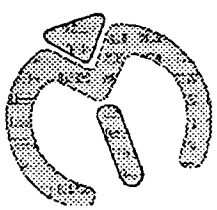
Applications of Hydraulics

Military Vehicles & Equipment

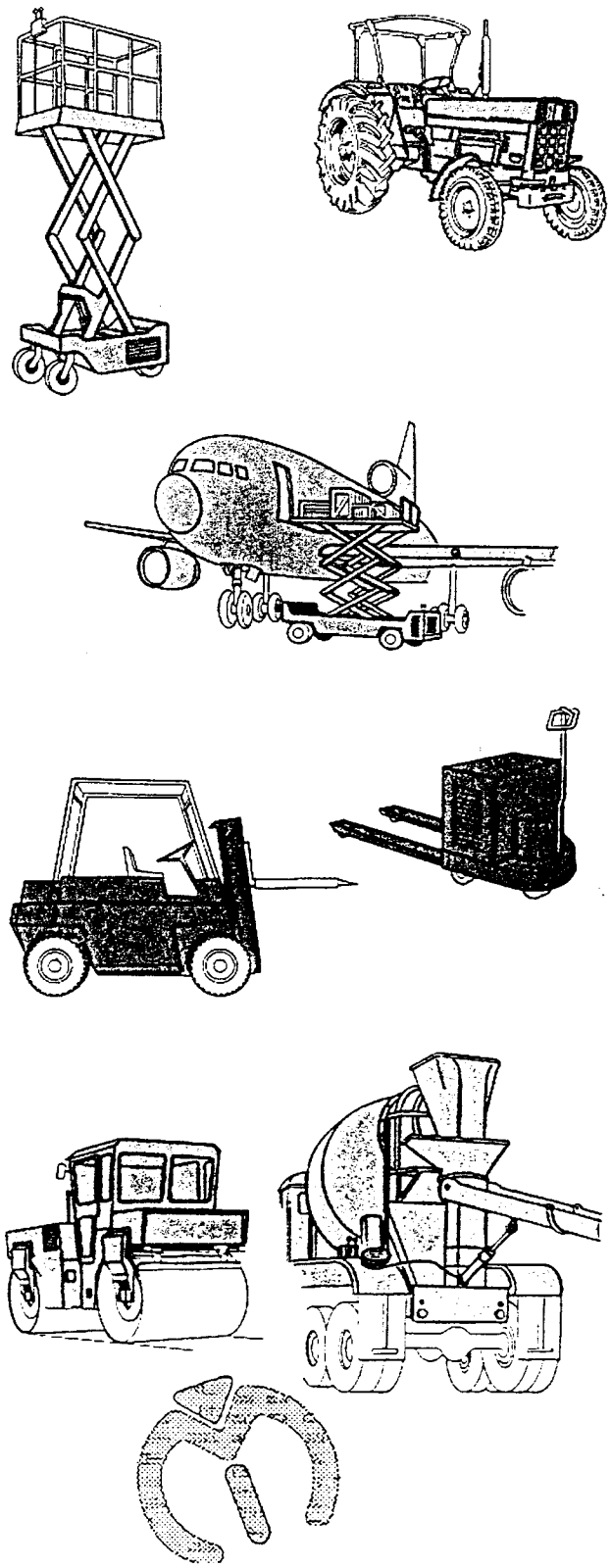
Barrel elevation
Recovery vehicles

Lifts, Inspection Ramps & Commercial Vehicles

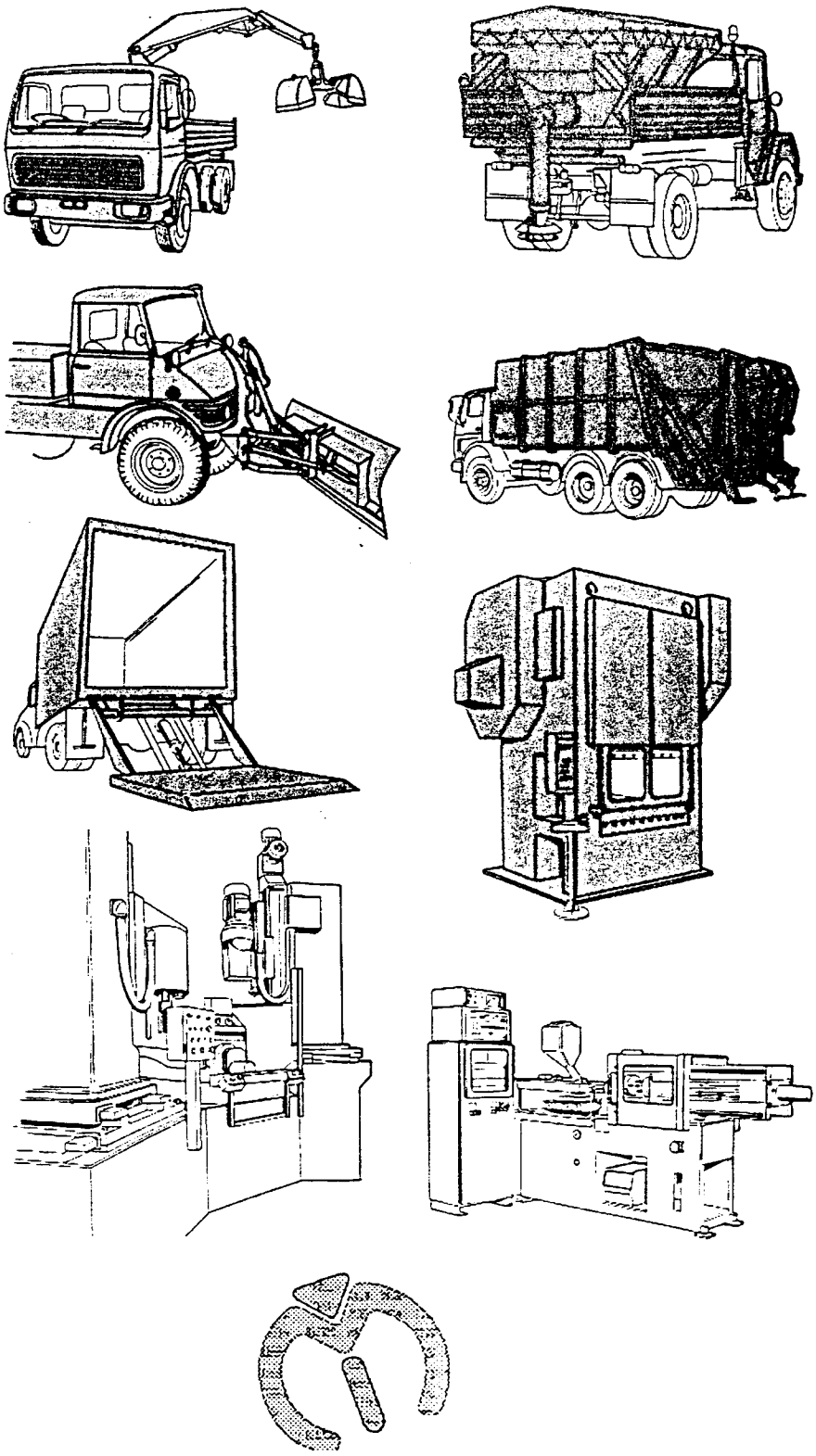
Hydraulic handling boom
Hydraulic tail lift

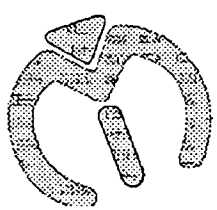


Applications of Hydraulics



Applications of Hydraulics





Section 2

The concept of power transmission

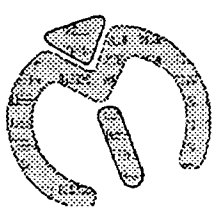
Pascal's Law

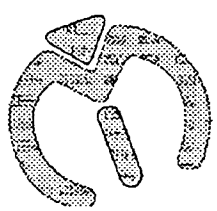
Pressure

Basic of hydraulics

How hydraulic systems work

Hydraulic formulae





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.

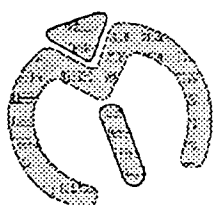
The concept of pressure must also be explained. Pressure is force per unit area and is expressed in Pascals (**Pa**). Both force and pressure are primarily measures of effort. A force may be acting upon a motionless object without moving the object, if the force is insufficient to overcome the inertia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

Pressure

The force exerted on one square centimetre by a column of air that reached 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 meter (**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 an hydraulic actuator exerts a force on an object over a given distance. Thus, work has been accomplished.

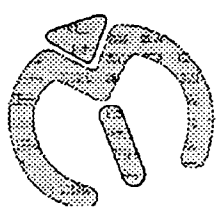
The concept of work, however, makes no allowance for time. The SI – unit of work is the Joule. 1 Joule (**J**) = 1 Newton metre (**Nm**).



The Concept of Power Transmission

Power is work performed per unit of time. Thus, it can be said that power is the rate at which energy is transferred or converted into work, like heat.

The SI – unit of power is the Watt. 1 Watt (**W**) = 1 Joule per second (**J/S**).

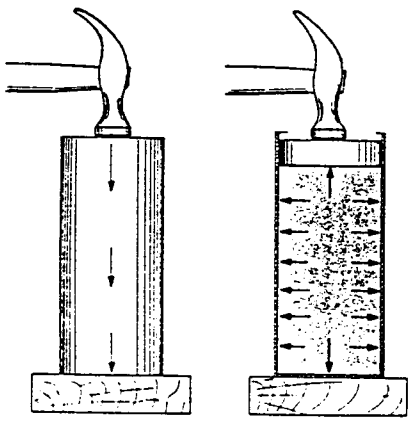


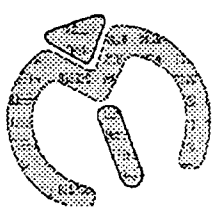
Pascal's Law

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.

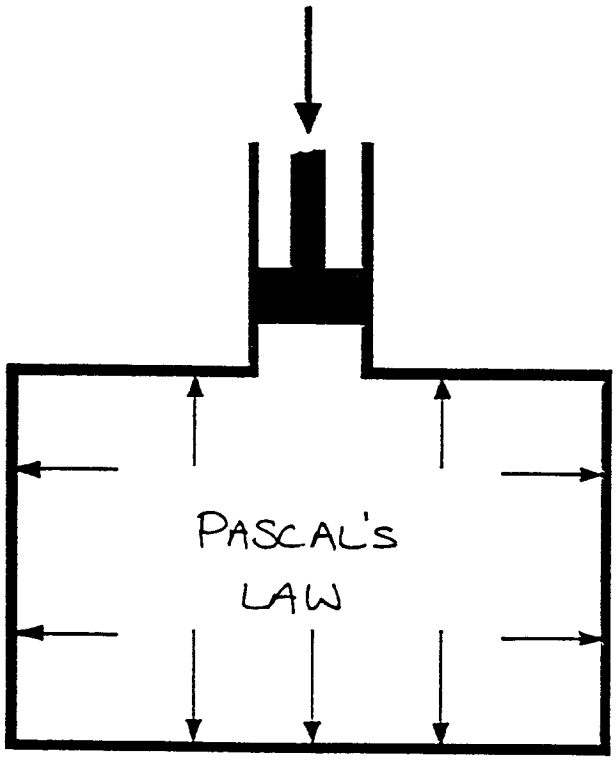
When a force is applied to the end of a column of a confined fluid, that force is transmitted straight through the column to its opposite end, but also equally undiminished in every other direction, sideways, downwards and upwards. Pascal's law defines this physical behavior. Pascal's discovery has opened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

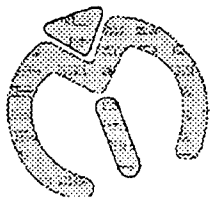




Pascal's Law

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.





Pressure

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

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

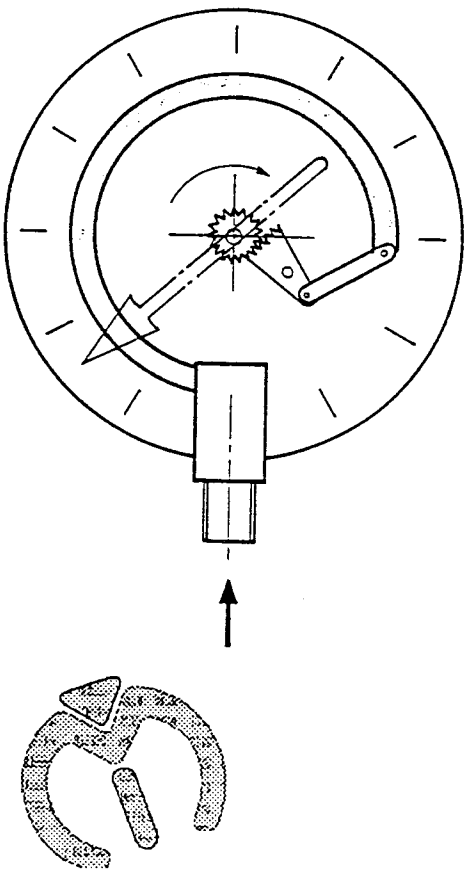
2) Bar (atmospheres) – (metric system)

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)

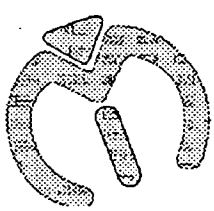
The component used to measure pressure is a gauge, a sample of which is shown below.



Pressure

When fluid is fed into the pressure gauge, it will try to straighten the bourdon tube, due to the pressure of the fluid. The higher the pressure the more it will try to straighten the tube, as the tube deflects it will register on the scale, as the indicator is connected via a gear mechanism to the tube.

Hydraulic pressure gauges are generally filled with Glycerin, this is to avoid damage to the gauge when pressure surges occur, the glycerin in the gauge is a dense fluid and therefore acts as a very successful damper, without it the indicator would travel too fast and possibly come off the end of the gear mechanism.



Basics of Hydraulics

Illustration (1) below shows that if two weights of equal size e.g. 10kg are placed on the top of each piston the down force would be equal and there would be no piston movement taking place. If however two different size weights were used e.g. 10kg and 15kg, see illustration (2) then the piston supporting the larger weight would be forced downwards, raising the piston with the lighter weight.

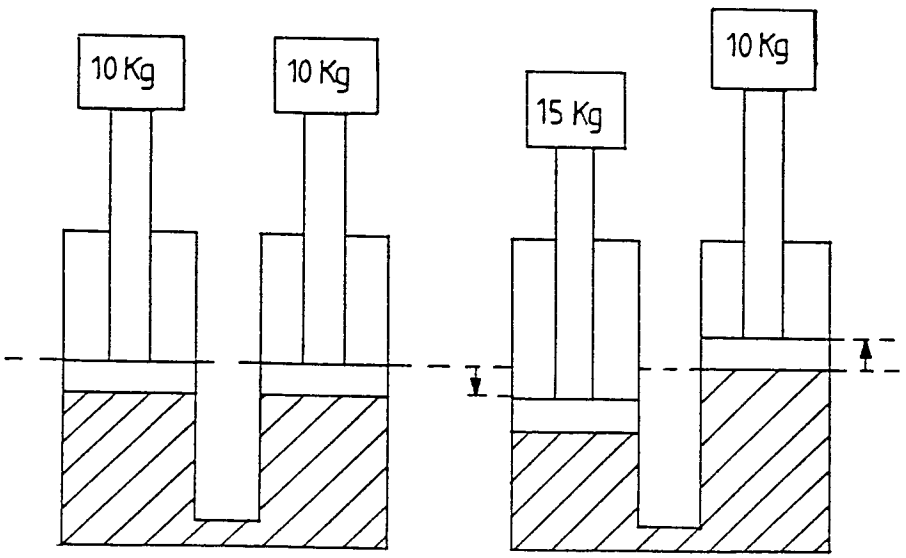


Illustration 1

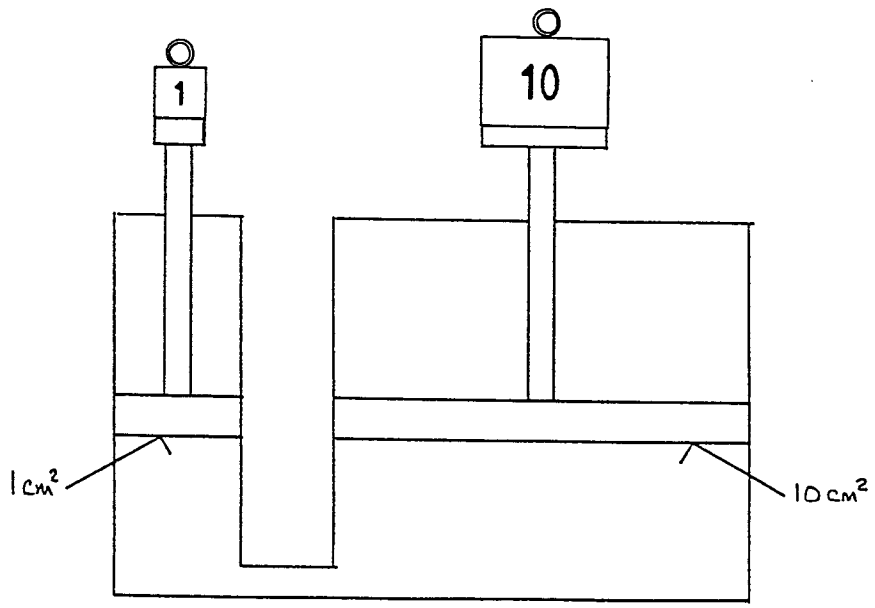
Illustration 2

Basics of Hydraulics

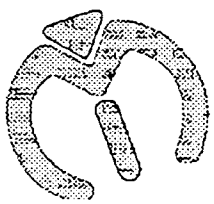
Transmission of Energy

Fluid can be regarded as incompressible for practical purposes. A push on one end of a pipe full of fluid is immediately transmitted to the other end. The fluid not only acts as a solid rod in a straight pipe but the effect is the same when the pipe is bent.

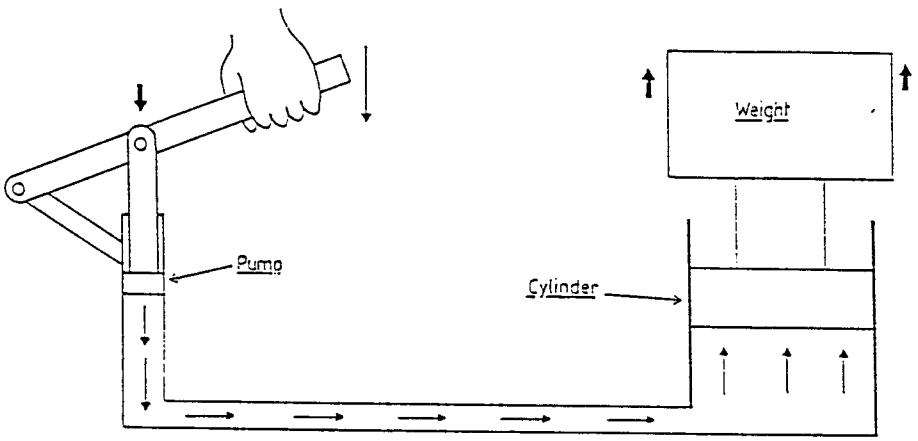
This ability to transmit energy other than in a straight line is one of the main advantages of using hydraulics for transmitting power.



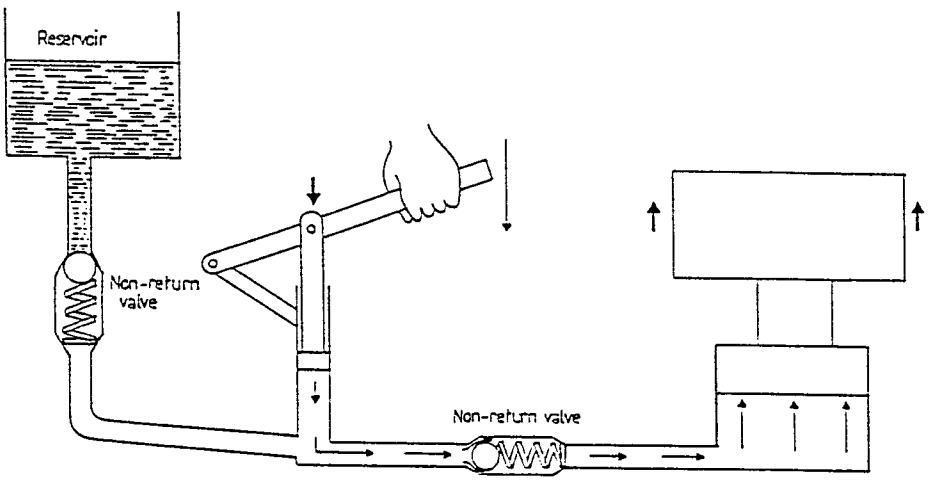
Liquids provide great increase in work force.

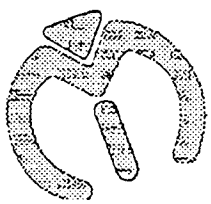


How Hydraulic Systems Work

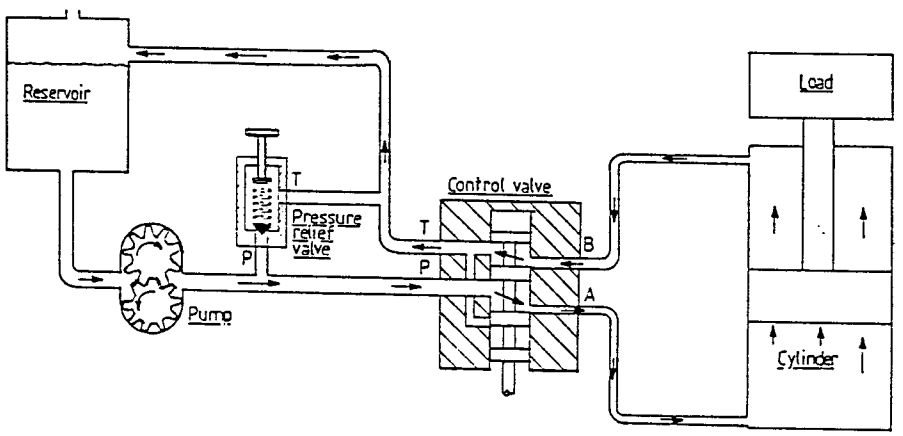


How Hydraulic Systems Work

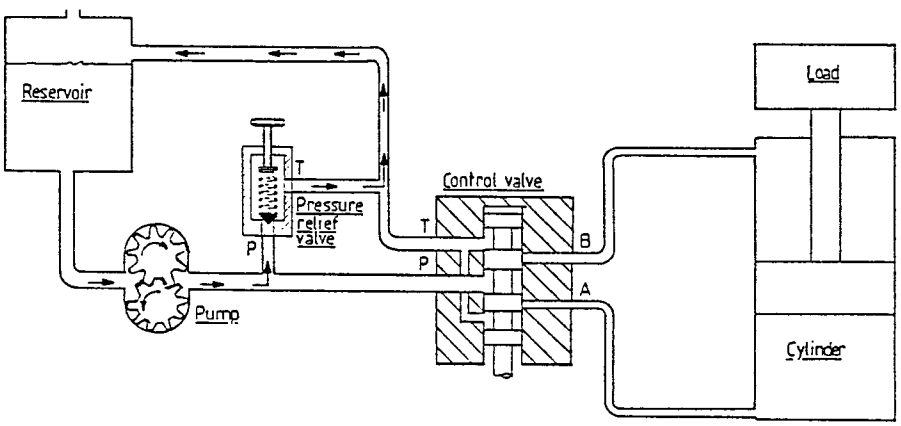


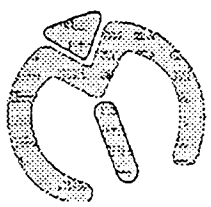


How Hydraulic Systems Work



How Hydraulic Systems Work





Hydraulic Formulae

Force (F)	=	Area (A)	x	Pressure (P)
Newtons (N)	=	Square Centimetres (sq. cm.)	x	Pascals (Pa)
Pounds (lbf)		Square Inches (sq. in.)		Pounds/sq. in. (P.S.I.)

Note:
The Pascal is a very small unit of pressure and therefore KiloPascal (kPa), MegaPascal (Mpa) or Bar are more commonly used.

100 kPa = $\frac{10N}{Cm^2}$ = 14,5 p.s.i. = 1 bar

e.g. 5000 kPa = 725 p.s.i. = 50 bar

F = A x P $P = \frac{F}{A}$ $A = \frac{F}{P}$

Work Done (W.D.)	=	Force (F)	x	Distance (D)
Newton Metres (Nm)		Newton (N)		Metres (m)
Pounds feet (lbf. Ft.)		Pounds (lbf.)		Feet (ft.)

W.D. = F x D

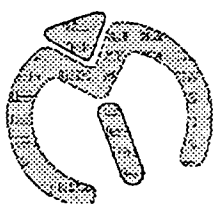
Quantity (Q)	=	Area (A)	x	Distance (D)
Cubic Centimetres (c.c.)		Square Centimetres (cm^2)		Centimetres (cm)
Cubic Inches (cu. In.)		Square Inches (in^2)		Inches (in.)

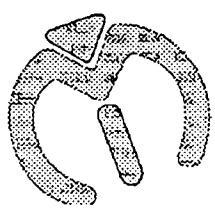
Q = A x D

Note:

277 cu. In. = 1 gallon

1 gallon/minute @ 1500 p.s.i. is equivalent to 1 horsepower (h.p.)
4,54 litres/minute @ 100 bar is equivalent to 1 h.p. (0,75 kw)





Section 3

Basic hydraulic systems

Hydraulic reservoir

Pump types

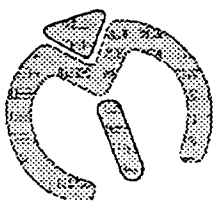
Valve types: Pressure control, Directional control, Flow control and Non-return

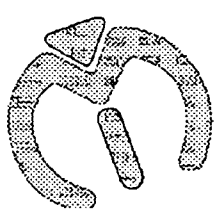
Cylinders

Operation of a single acting cylinder

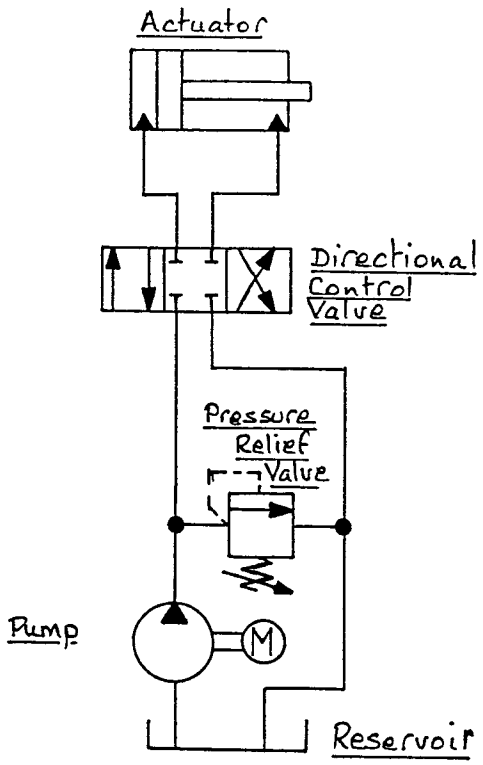
Operation of a double acting cylinder

Motors





Basic Hydraulic Systems



A basic practical hydraulic system requires five units as shown in the illustration. They are as follows:

- Reservoir
- Pump
- Control Valve
- Actuator
- Relief Valve

The reservoir caters for varying fluid volumes in the system as the cylinder extends and retracts. Reservoirs also allow for changes in volume due to temperature. They also act as a cooler and will hold a reservoir of fluid in case of minor leakages.

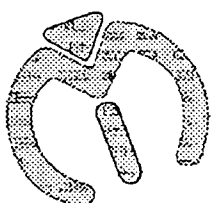
Basic Hydraulic Systems

The pump creates a flow of fluid around the system, it may deliver its flow at near zero pressure or between there and the maximum system pressure depending on the load on the system. It is the load, which creates the pressure and not the pump.

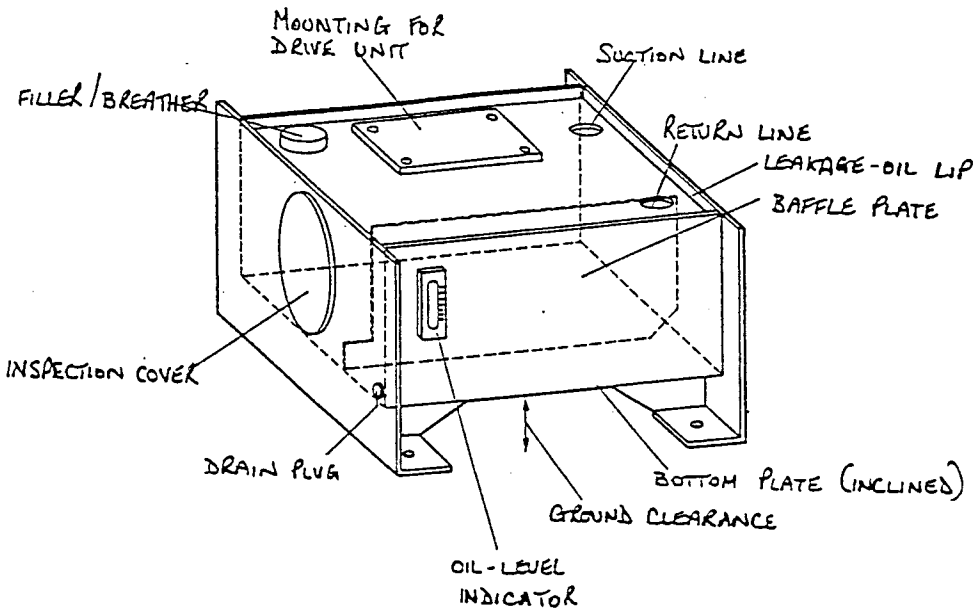
The control valve directs the flow of fluid to operate the actuator in the direction required and connects opposite service line from the actuator back to reservoir. It also may have a third function e.g. to divert the pump flow direct back to reservoir when the value is in neutral.

The actuator moves the load. For linear movement a cylinder is usually used, for rotary movement a hydraulic motor is usually used. When a cylinder comes to the end of its stroke the flow from the pump is completely restricted e.g. the delivery line is blanked off. Pressure will immediately rise and will cause damage e.g. burst cylinder, pump, or a pipe unless a safety (relief) valve is fitted.

The relief valve limits the maximum pressure, which can occur in the system and so prevents overloading units, and also determines the maximum effort, which can be applied by the actuator. NB: the main relief valve is always the next unit (component) after (down stream of) the pump.



Hydraulic Reservoir



This is the storage vessel for the fluid which is used in the hydraulic system and comprises: tank with sloping base (for silt and other contaminants) to run to the lowest point, where there is a drain plug, sight glass with minimum and maximum levels marked, baffle plate to reduce turbulence between suction (delivery) and return sections of the reservoir, suction (feed to pump), return line (from system), filler with strainer and breather.

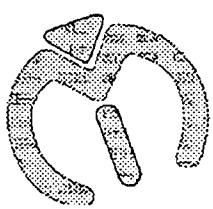
The tank should ideally be on legs, so as to lift it above floor level, to allow air circulation (to aid cooling) and the top should be removable for periodic cleaning.

Hydraulic Reservoir

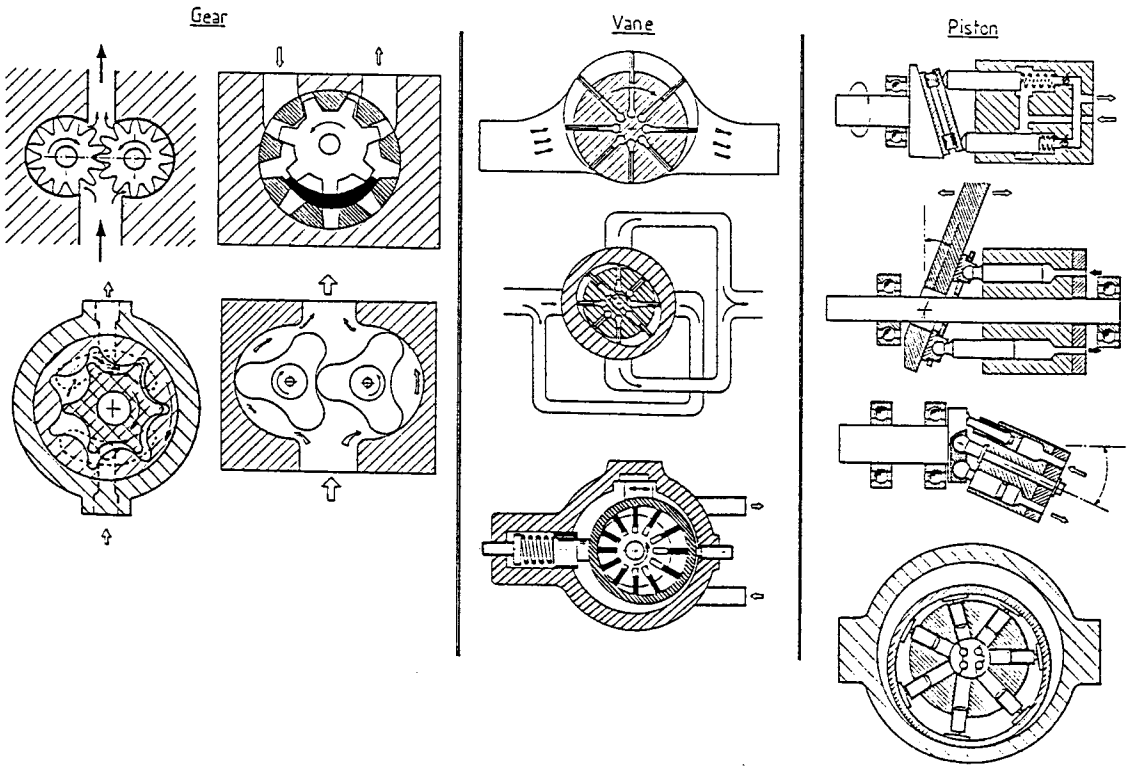
The reservoir capacity should be adequate to cater for changes in fluid volume within the system, and with sufficient surface area to provide system cooling. An oversize reservoir can present some disadvantages such as increased cost and size.

- The minimum reservoir capacity should be at least twice the pump delivery per minute. This must be regarded as an absolute minimum and may not be sufficient to allow for volume changes in the system.

- Ideally, the reservoir capacity should be 3-4 times the pump delivery per minute. This may well be too high a volume for mobile applications.



Pump Types



There are generally three types of pumps, which are most commonly used in hydraulics; these are gear, vane, and piston.

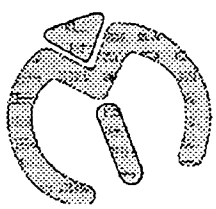
The pump is probably the most important and least understood component in the hydraulic system. Its function is to convert mechanical energy to hydraulic energy by pushing the hydraulic fluid into the system. Pumps are made in many different shapes and sizes; they can also be manual or mechanical with various pumping mechanisms for many different purposes. All pumps though fall into two categories, which are hydrodynamic or hydrostatic.

Pump Types

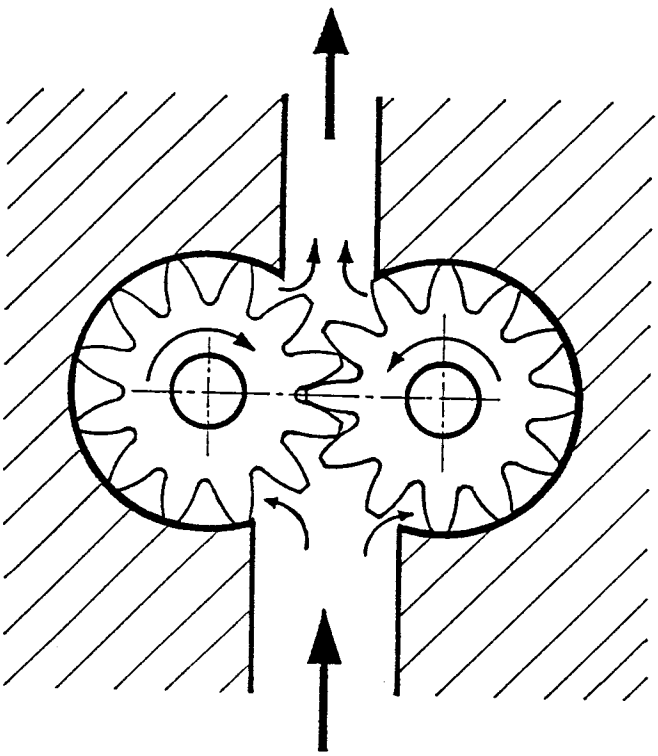
Hydrostatic

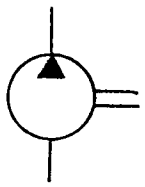
Hydrostatic or positive displacement pumps as their name implies provide a given amount of fluid for every cycle, stroke, or revolution. Their output is independent of outlet pressure, (except for leakage losses) making them well suited for use in the transmission of power.

Note: Pumps deliver **FLOW**, not pressure; pressure is created by causing resistance to the flow.



Gear Pump (External Gear)

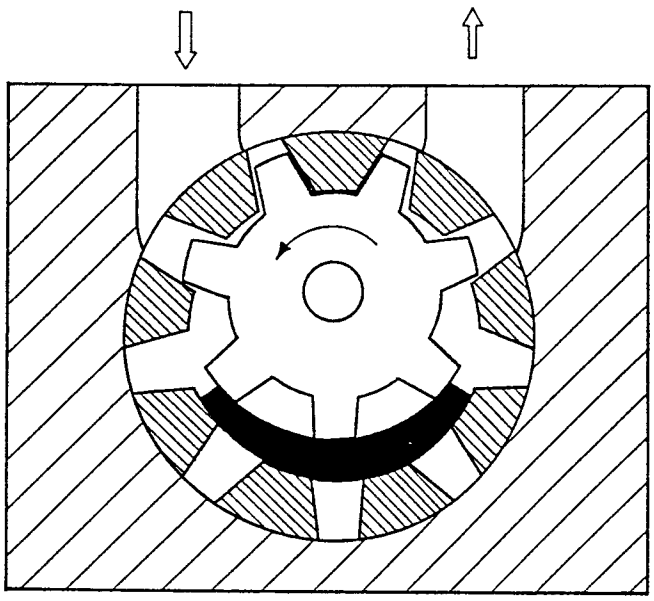




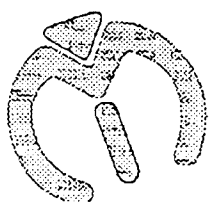
The external gear pump is one of the most common types of hydraulic pump used, especially in applications where cost is a primary consideration.

One of the gears within the pump is driven by an electric motor (static applications) or internal combustion engine (mobile applications), as this gear rotates it drives the second gear. As the gears rotate hydraulic fluid is drawn from, the pump input (suction) port and passed around the outside of the gears to the output (delivery) port. The volume displaced per revolution is the amount of fluid in the gear cavity (space between gear and pump housing) multiplied by the number of cavities. Hydraulic pumps are quoted in terms of displacement per revolution (cc/rev). The speed at which the pump is run will determine the actual volume of fluid delivered.

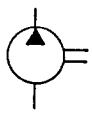
Gear Pump (Internal Gear)

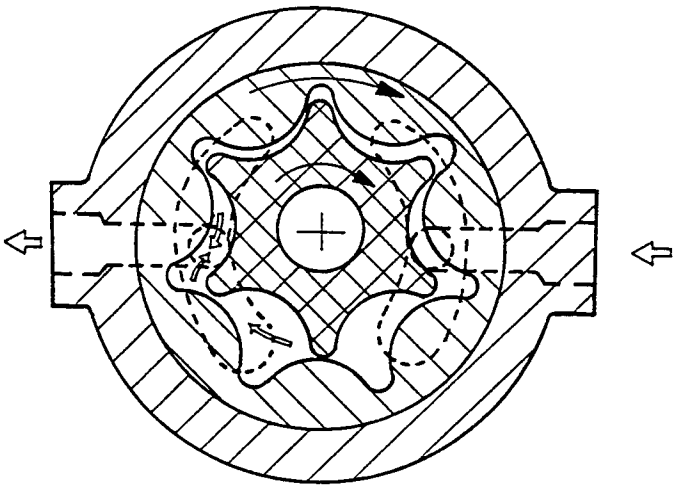


The inner gear is driven and this in turn (through the meshing of the gears), drives the outer gear. The gears are eccentric and in the gap created there is located a fixed crescent seal (shown at the bottom in the diagram). As the gears rotate the fluid is drawn in through the inlet, port (left in diagram) to fill the voids between the gears, the fluid is then transferred through the pump until it is forced out to the delivery port (top right in diagram).



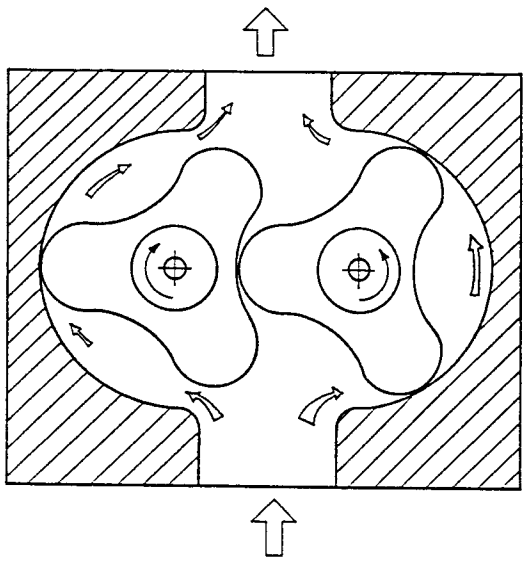
Gear Pump (Gerotor)



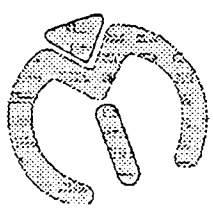


The gerotor type hydraulic pump operates much like an internal gear pump. The inner rotor is driven and carries the outer rotor around in mesh. Pumping chambers are formed between the rotor lobes; the crescent seal is not used, instead the tips of the inner rotor contact the outer rotor to seal the chambers from each other.

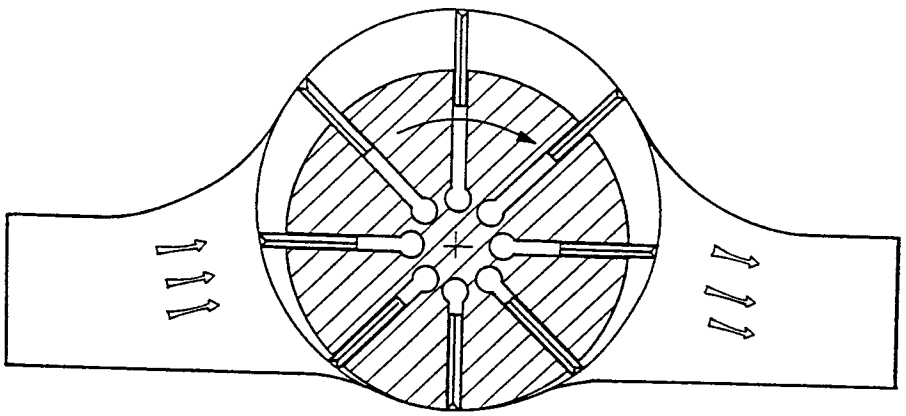
Gear Pump (Lobe)



The lobe (sometimes called a rotor) type of hydraulic pump operates on the same principles as an external gear pump. This type of pump generally has a higher displacement than the standard external gear pump.



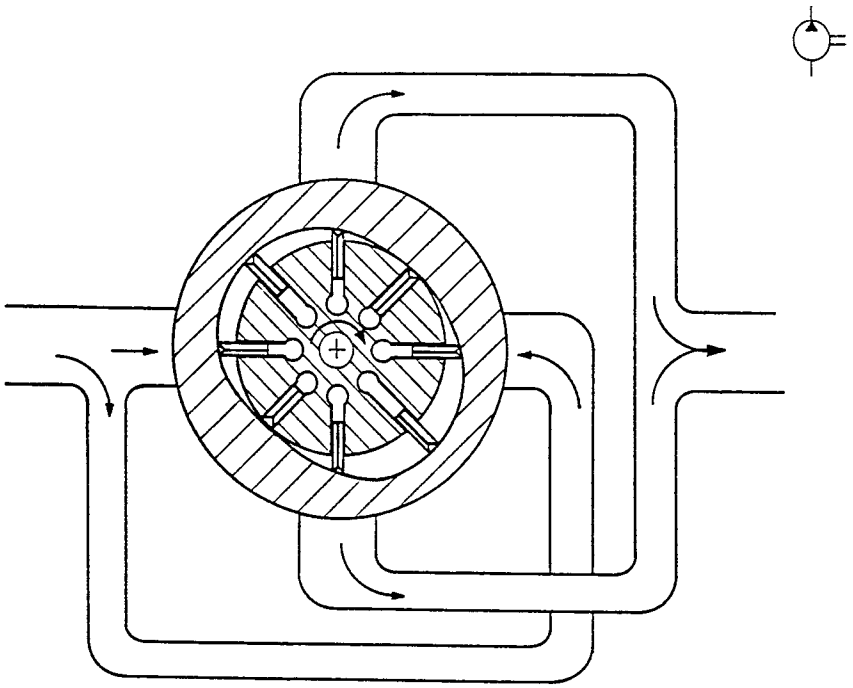
Vane Pump (Unbalanced)



With the vane pump a slotted rotor is fitted to the drive shaft and turns inside a cam rig. Vanes are located within the rotor slots and as the rotor is turned, these vanes are thrown out to the cam ring through centrifugal force. Pumping chambers are formed between the vanes and fluid is taken in through the inlet port (left) and transferred across the pump to the delivery port (right). At the pump inlet a partial vacuum is created by the volume of the pumping chamber increasing and the fluid is forced out through the delivery port as the space decreases. The pump displacement depends upon the width of the pumping chamber and the throw of the vanes.

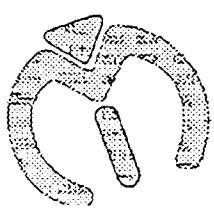
The pump construction shown is unbalanced and the shaft is side loaded from pressure on the rotor.

Balanced Vane Pump

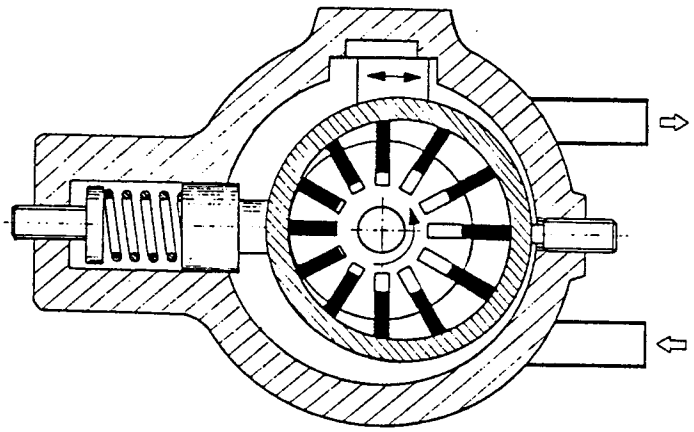


With the balanced vane pump the cam ring is elliptical rather than circular and the inlet is split between two ports (there is only one connection port, the split is designed into the pump housing), the outlet (delivery) is also two ports connected within the pump housing. Due to the two outlet ports, the pressure forces acting upon the rotor are at 180^0 to each other and therefore cancel each other out, this prevents side loading of the drive shaft and bearings.

One disadvantage of the balanced design vane pump is that the displacement cannot be varied and this type of pump is therefore a 'fixed displacement'.

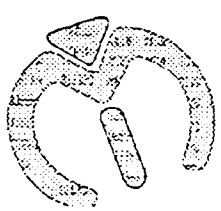


Variable Vane Pump

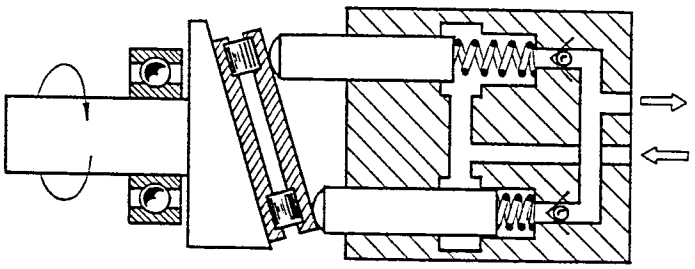


The variable displacement vane pump, pumps the fluid on the same principle as a fixed displacement vane pump. A heavy spring (shown to the left in the diagram) operating on a piston keeps the stroke ring in position, when the pump starts and there is no pressure in the system the stroke ring is to the extreme right and the vanes will give maximum throw and therefore maximum displacement. As the system pressure increases the force acting against the piston and spring also increases, if this force becomes greater than that of the spring the stroke ring will move across to the left. As the stroke ring moves so the throw of the vanes is reduced and this reduces the displacement of the pump, when the maximum pressure is reached the stroke ring will be in a concentric position to the shaft and rotor and there will be no flow from the pump. Therefore with minimum pressure the pump gives maximum flow and with maximum pressure zero flow, when the pressure drops again the stroke ring will move to an eccentric position and resume flow.

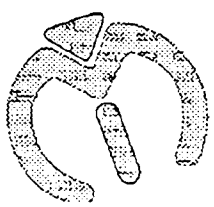
Variable displacement vane pumps are pressure unbalanced and are therefore limited to low pressure hydraulic systems.



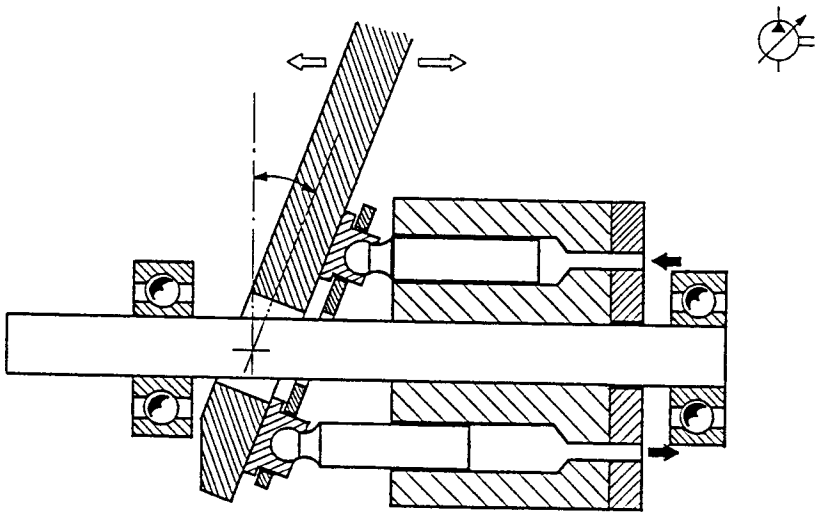
Axial Piston Pump (Wobble Plate)



With this type of piston pump the drive shaft is connected to an inclined plate, the angle of this inclined plate is fixed and non-adjustable and therefore the displacement from the pump is fixed and non-variable, this design is known as a 'wobble plate'. This plate is rotated and runs against a number of pistons, which are mounted within the pump body. When the wobble plate rotates so the pistons will move in and out (due to the springs behind them). As the pistons move out they will draw fluid into the chamber behind them, then as the piston is pushed back in by the wobble plate this fluid will be forced out of the chamber and into the delivery line. To avoid drawing fluid back into the chamber, which has been previously delivered there is a check (non-return) valve fitted behind each piston.



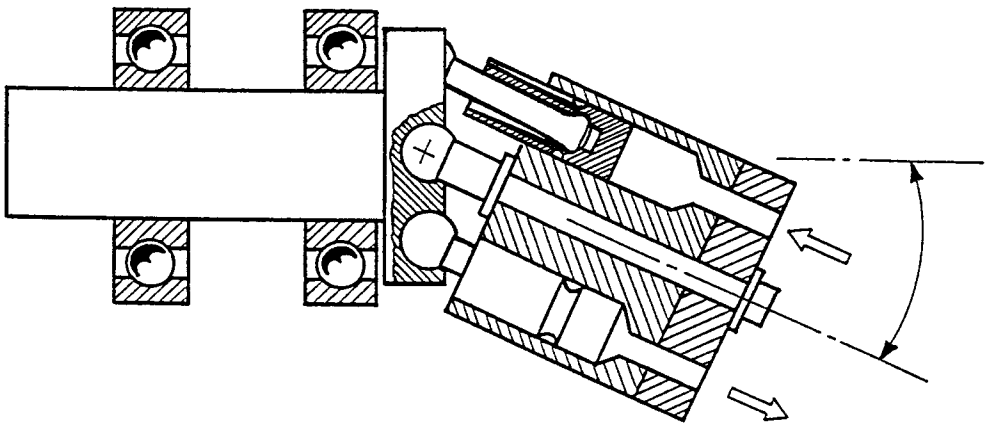
Axial Piston Pump (Swash Plate)



"Swash plate" piston pumps are available as either fixed or variable displacement versions. They are similar in operation to the wobble plate pump shown previously however the main difference is that with the swash plate design, the plate does not rotate but remains stationary and the wobble plate rotates.

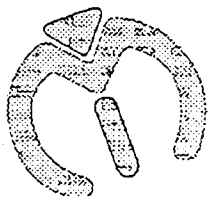
With the fixed displacement swash plate pump the angle of the swash plate does not change and therefore the throw of the pistons (and the displacement) remains constant. With the variable displacement swash plate pump as shown above the 'angle of swash' is adjustable and as this angle is adjusted, so the distance that the pistons travel is also varied, this will then give the variable displacement required of the pump.

Axial Piston Pump (Bent Axis)

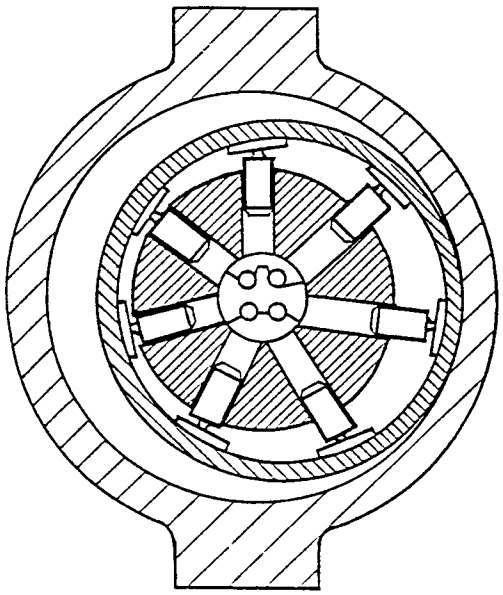


With this type of pump, the cylinder barrel is driven by the pistons, which in turn are themselves driven by the drive flange. The cylinder barrel is located and guided at its periphery by either a centre pin or a needle bearing and is pivoted about the horizontal axis of the shaft. The displaced volume of fluid is varied in accordance with this pivot angle and reversible pumps can also be obtained using this principle.

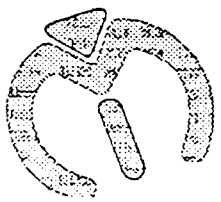
The pistons and drive flange are connected by means of a ball-joint; this pulls out the pistons during the suction phase and forces them back in during delivery phase.



Radial Piston Pump



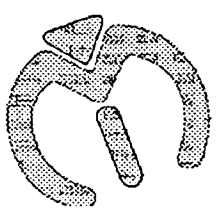
The radial piston pump consists of a number of pistons running radially within a stroke ring, which is in itself located within the pump housing; the position of this stroke ring is variable (according to pressure). At the end of the pistons, where they come into contact with the stroke ring there are 'slipper pads' which swivel to take up correct alignment with the stroke ring (this is necessary due to the movement of the stroke ring the angle of contact will vary). When the pump first starts and there is no system pressure, the stroke ring will be to the extreme right, giving maximum throw to the pistons and therefore maximum displacement from the pump. As the system pressure increases so the stroke ring will move across to the left and reduce the throw of the pistons, this will then reduce the displacement, eventually when the maximum system pressure has been achieved the stroke ring will be in concentric position and there will be zero displacement from the pump. As the pistons move out they will draw fluid form the inlet and then as they rotate they will be forced back in and transfer this fluid to the delivery port.



Pump Selection

The main criteria when selecting a pump are as follows:

- Working pressure required
- Delivery (flow rate) required
- Type of fluid to be pumped (FR)
- Size and weight
- Life required
- Noise
- Effect/tolerance of dirt
- Efficiency
- Ease of maintenance
- Availability of spare parts
- Cost



Valve Types

Hydraulic valves can vary considerably in shape, size, and design from manufacturer to manufacturer. They are divided into sections dependant upon their function, as follows:

⇒ Pressure control valves

⇒ Directional control valves

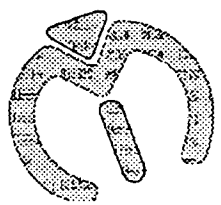
⇒ Flow control valves

⇒ Non-return valves

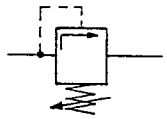
Pressure Control Valves

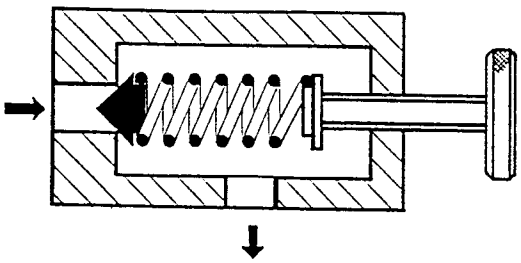
Relief Valves

The relief valve is found in virtually every hydraulic system. It is normally a closed valve connected between the pressure line (pump outlet) and the reservoir. Its purpose is to limit pressure in the system to a preset maximum by diverting some or all of the pump's output to the tank when the pressure setting is reached.



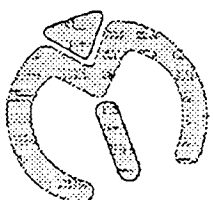
Simple Relief Valve (Direct Operating)



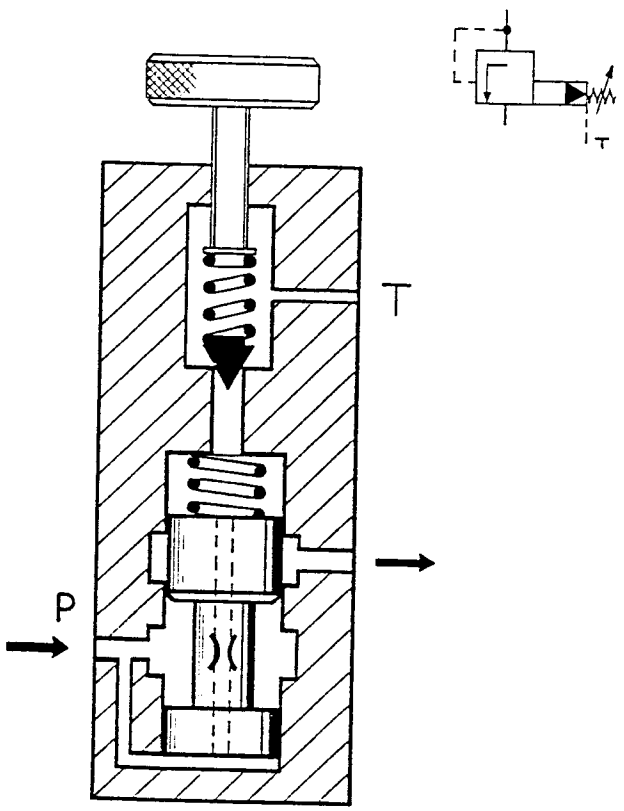


A simple or direct acting relief valve may consist of nothing but a ball or poppet held seated in the valve body by a heavy spring. When pressure inlet is insufficient to overcome the force of the spring, the valve remains closed. When the preset pressure is reached, the ball or poppet is forced off its seat and allows flow through the outlet to tank for as long as excess pressure is maintained.

In most of these valves, an adjusting screw is provided to vary the spring force. Thus, the valve can be set to open at any pressure within its specified range.



Relief Valve (Indirect Operating)



Fluid enters valve at port **P** and acts upon the internal faces of the spool, creating an hydraulic balance, the incoming fluid is also directed (internally) to the base of the spool, where it passes through the centre of the spool and the pressure is then applied to the pilot valve at the top of the unit. Once the pressure rises to a level sufficient to overcome the spring in the pilot unit the poppet opens and allows fluid to return to tank, this causes the pressure at the top of the spool to drop and the spool will therefore be lifted, this then opens the passage from **P** to **T** and the main flow is thereby returned to tank.

Directional Control Valves

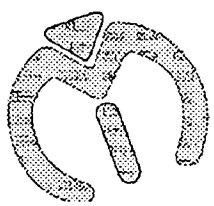
Directional control valves, control start, stop, and the direction of the fluid flow. They are characterised by their number of ports and the number of position that they can switch to. For example, the designation 3/2 way valve means a directional control valve, which has 3 ports and 2 switched positions, 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 (**P**), output(s) (**A, B**, etc) and (**T**) tank.

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 hydraulic (pilot) and electrical (solenoid) or indeed combinations of these operating mechanisms are also possible.

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

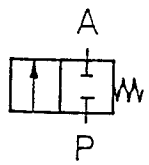
DIRECTIONAL CONTROL VALVES

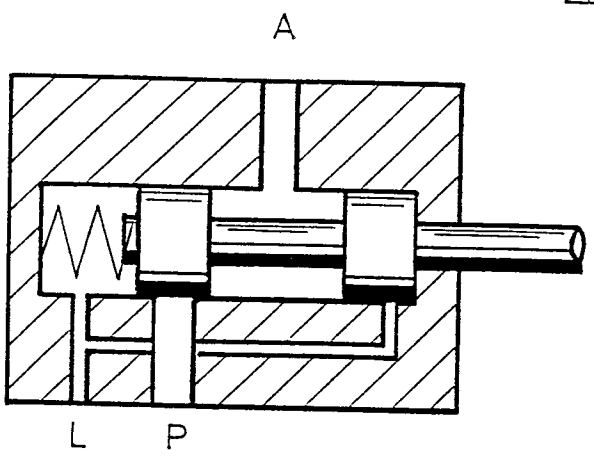
MANUALLY OPERATED	MECHANICALLY ACTUATED	PILOT ACTUATED	ELECTRICALLY ACTUATED
Push Button	Roller	Hydraulic	Solenoid, direct
Key Switch	One-way Roller	Pneumatic	Solenoid, internal pilot
Lever	Plunger		Solenoid, ext. pilot
Rotary Lever			Solenoid, manual override
Lever with Detent			
Foot Pedal			

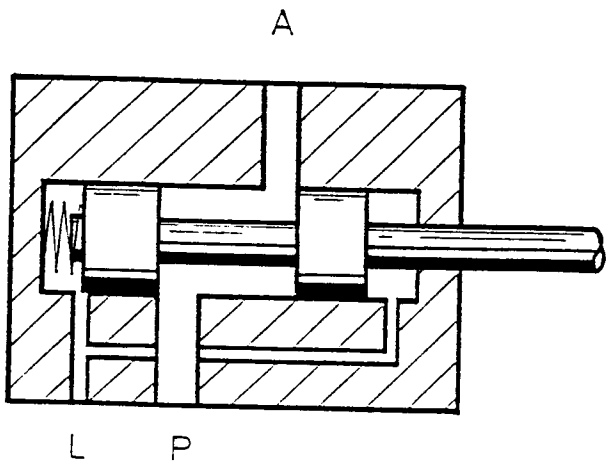


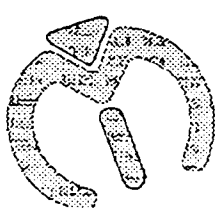
Directional Control Valve

2/2 Way Directional Control Valve (DCV)









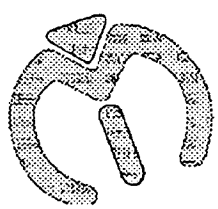
Directional Control Valve

2/2 Way Directional Control Valve (DCV)

This is the basic directional control valve (**DCV**) used in hydraulics; the version shown is of the normally closed (**N/C**) type. When it is unoperated the spring is in control and holds the spool in the position illustrated in the top diagram, here the supply **P** and the output **A**, are both blocked internally within the valve.

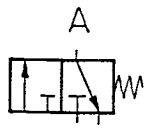
When the spool is moved across (as shown in the bottom diagram) the supply **P** and output **A** are connected, the valve will remain in this condition until such time that the spool is reset (valve unoperated and spring in control), this will again block both ports **P** and **A**.

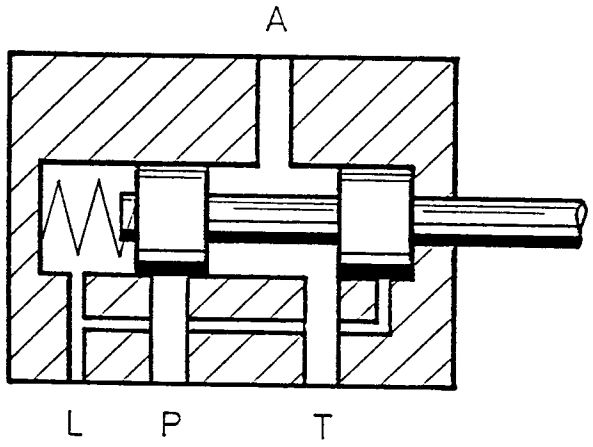
The chambers at each end of the spool are linked internally to a leakage port, marked **L**, to avoid the possibility of pressure build up within the valve (due to fluid passing the lands of the spool).

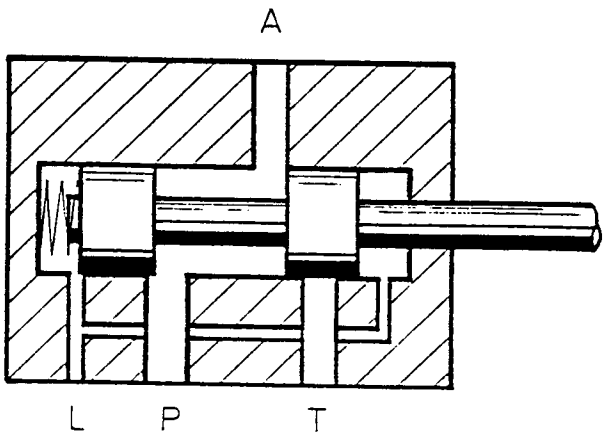


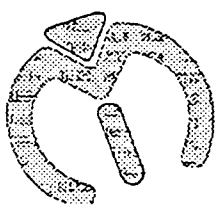
Directional Control Valve

3/2 Way Directional Control Valve (DCV)









Directional Control Valve

3/2 Way Directional Control Valve (DCV)

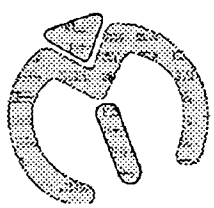
This valve has **3** ports and **2** positions, hence it is called a 3 port 2 position valve, this is then abbreviated to **3/2** way.

In its unopened condition, shown in the top diagram, the spring is in control and the spool is in its right hand position, connecting the output port **A** with the return to tank port **T**, the supply port **P** is internally blocked in this condition.

When the valve is operated, the spool is moved across against the spring (bottom diagram) and the supply port **P** and output **A** are now connected, with the tank port **T** internally blocked.

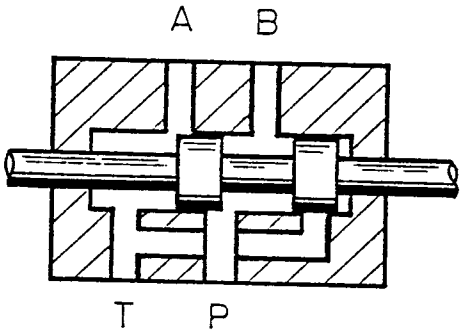
To avoid pressure building up in the chambers at each end of the spool a leakage line is incorporated within the valve, any fluid that passes the lands of the spool into either end chamber must be allowed to leak (to tank) unhindered.

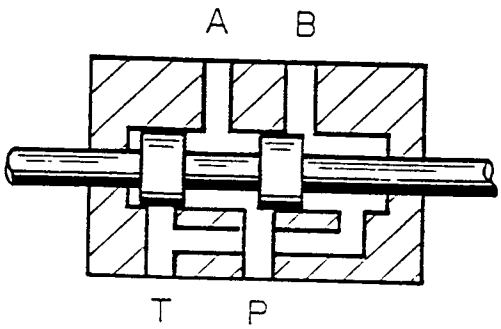
The valve featured is of the normally closed (N/C) type, (supply blocked when the valve is unoperated).



Directional Control Valve

4/2 Way Directional Control Valve (DCV)





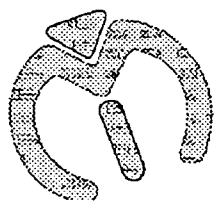
Directional Control Valve

4/2 Way Directional Control Valve (DCV)

This valve has **4** ports and **2** positions, hence it is called a 4 port 2 position valve, this is then abbreviated to **4/2** way. The 4 ports are **P** – supply, **A** and **B** – outputs and **T** – return to tank. There are no springs within the valve shown above to send the spool to any predetermined position.

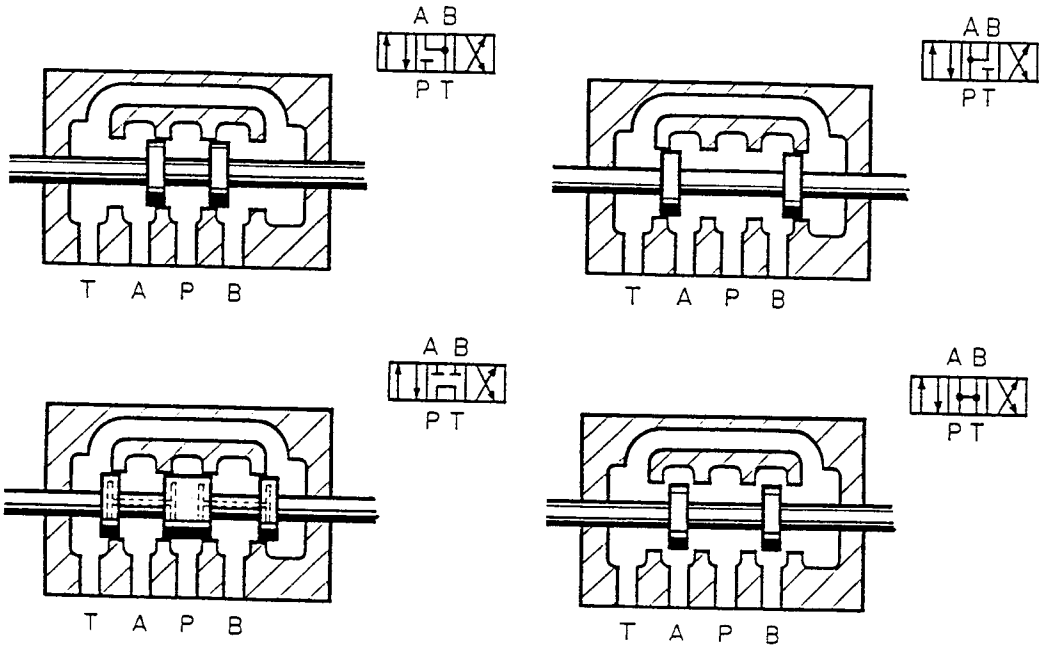
With the spool to the right (top diagram) the fluid flows from supply **P** to output **B**, while the fluid in the output line **A** is returned to tank line **T**. When the spool is moved across, (bottom diagram) the connections are reversed and fluid from **P** is now flowing to output port **A** with fluid from output **B** travelling through the valve to tank line **T**.

Note: There is only one T port on the valve, both A and B lines are connected to it internally within the valve body (at their respective times).



Directional Control Valve

4/3 Way Centre Position Variants



Numerous different centre conditions are available for 4/3 way valves; four of the most popular formats are shown above.

Directional Control Valve

4/3 Way Centre Position Variants

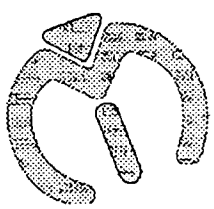
Top left: Supply blocked, both outputs open to tank – P/A, B, T.

Top right: Supply open to both outputs, tank port blocked – P, A, B/T.

Bottom left: Supply connected to tank, both outputs blocked - P, T/A/B, (sometimes called TANDEM or RECIRCULATING centre).

Bottom right: All points internally connected – P, A, B, T.

Note: The valve body is identical in all variants, it is the spool that differs, in the positions and widths of the lands, in some instances there is also a centre or cross drilling through the spool.



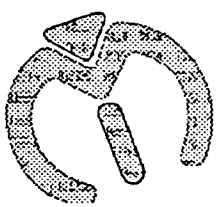
Flow Control Valves

Functions and Symbols

Flow control valves have the task of controlling the speed of hydraulic actuators (cylinders and motors). This is achieved by varying the open cross section of a restrictor, therefore changing the volumetric flow Q through the actuator.

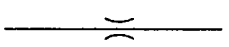
Depending upon the accuracy, which can be achieved, one differentiates between throttle valves and flow control valves. The graphical symbol signifies a restriction of the passage diameter.

Often, it is the case that throttle valves and flow control vales are only required for one direction of flow. To this end, they are combined with a non-return valve (check valve) to form a throttle with reverse free flow.



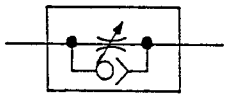
Flow Control Valves

Functions and Symbols

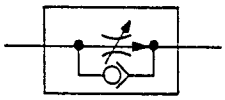


Restrictor

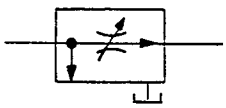
Throttle



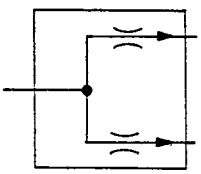
Throttle/check value
(one-way flow control)



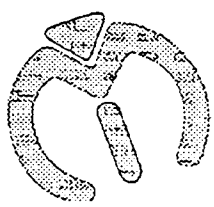
2-way flow control valve,
Pressure compensated



3-way flow control valve,
Pressure & temperature compensated

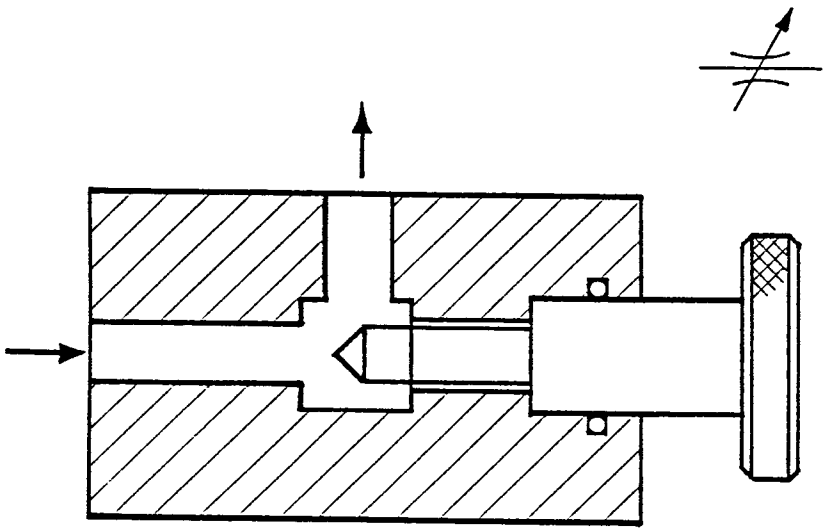


Flow divider



Flow Control Valves

Throttle Valve

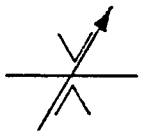


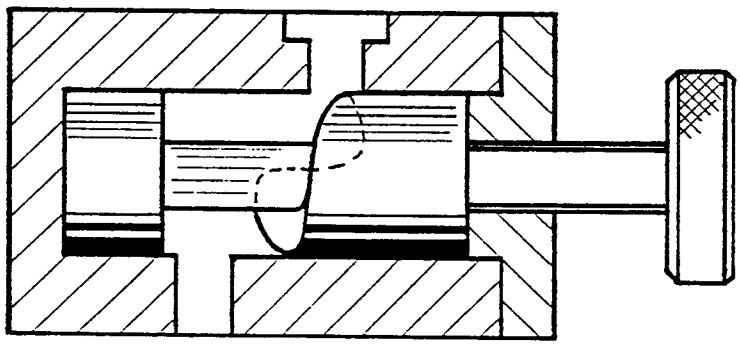
This valve has a built in adjustable orifice, by adjusting the knurled control knob of the valve the orifice size can be varied, by varying the size of the orifice the fluid flow across this orifice is also varied. The fluid flow will be the same in both directions through this type of flow control valve.

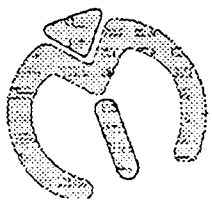
Flow Control Valves

Blend Valve (Fine Throttle)

This is another type of throttle valve, however the contact area of the throttling element is a lot finer than the version shown on the previous page.

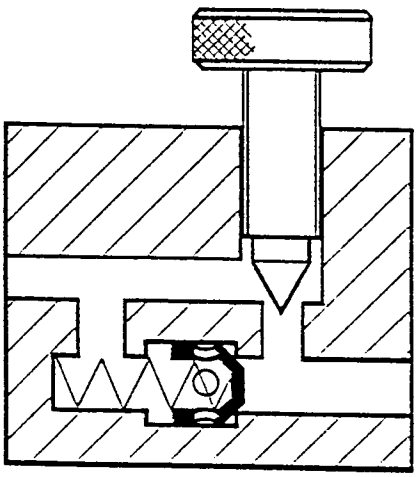






Flow Control Valves

Throttle Check Valve - (One-Way Flow Control Valve)



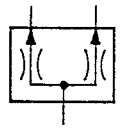
This valve is actually a combination of a throttle valve and a check valve into one unit.

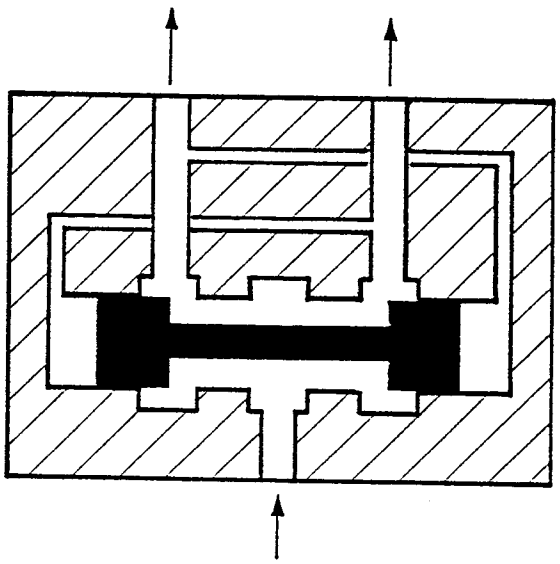
When fluid flow is from left to right the check valve is closed and the flow can only be through the adjustable orifice (throttle) of the valve. When the flow is reversed, the fluid can pass both through the throttle and also through the check valve, therefore in this direction full flow is achieved, hence one-way flow control.

Note: This type of valve (as shown) is not temperature (viscosity) or pressure compensated.

Flow Control Valves

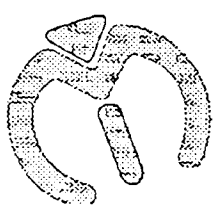
Flow Divider (50:50)





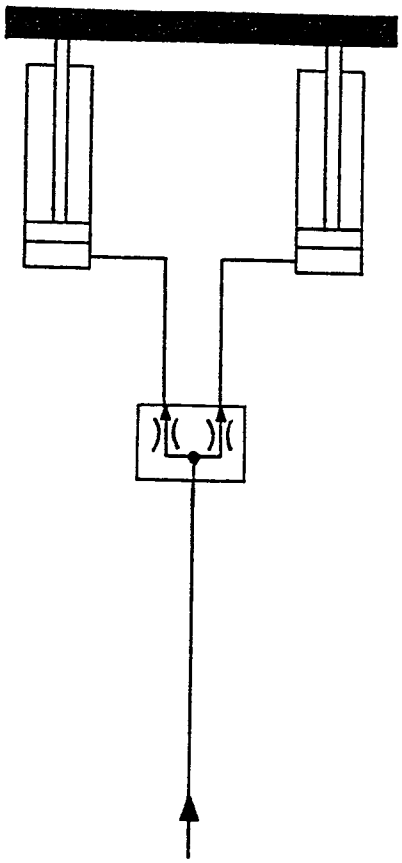
The flow divider is used to split the incoming flow to two outputs ports. The incoming flow (bottom port) passes the spool and feeds to the output ports (top), internally in the valve the outgoing flow is also passed to the opposite end of the dividing spool, this spool then compensates for any fluctuations at the output ports and adjusts its position accordingly, thus maintaining a 50:50 split of flow. This type of flow divider is therefore pressure compensated.

Flow dividers can be obtained where they have an unequal split of the flow and also they are available in 'priority' versions. Some flow dividers can also be used as flow combiners (collectors).

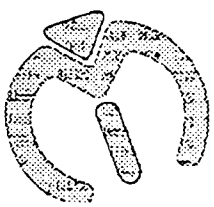


Flow Control Valves

Example Circuit

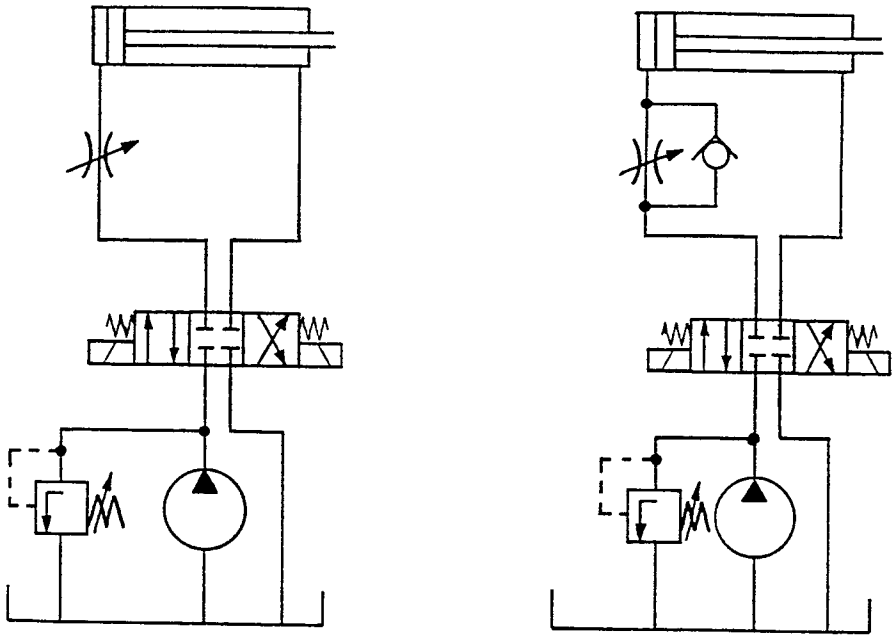


Control of two single acting cylinders lifting a weight, via a flow divider. The cylinders will retract under external load once the fluid is allowed to flow from the rear chambers of the cylinders. If the flow divider is a 50:50 ratio the cylinders will extend together, where the flow divider is pressure compensated if one cylinder has a higher load (the weight for example may not be evenly distributed) then this addition load will be sensed by the flow divider and compensated for by moving the spool and increasing the flow to the cylinder with the greater load.

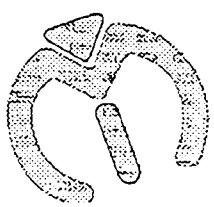


Flow Control Valves

Example Circuits

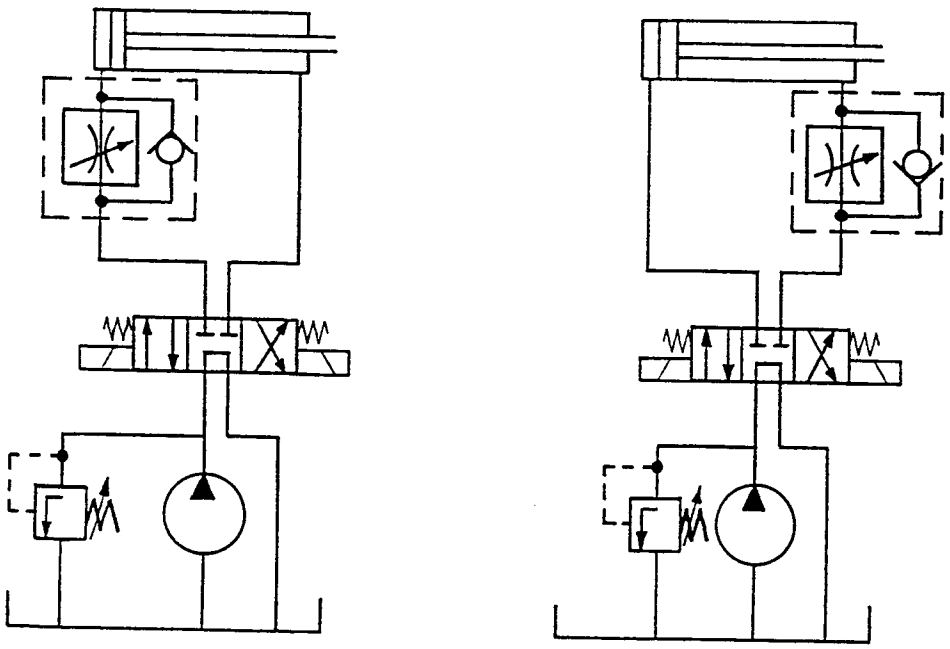


The two circuits shown are examples of flow control, the left hand circuit shows a throttle valve fitted into the line feeding the rear of the cylinder, this will control both the forward and retract speeds of the piston. If it is required to control the piston speed in one direction only, then the throttle valve alone is not suitable, a solution could be to incorporate a check valve, fitted into a by-pass, as shown in the right hand circuit, the piston will now extend in a controlled manner due to the fluid flowing into the cylinder through the throttle (by-pass blocked) and return at normal speed due to the fluid flowing through the by-pass in an unrestricted fashion. The configuration in the right hand circuit constitutes a 'one way flow control' and can be built from separate components or obtained as a one-piece unit. The type of control shown in the right hand circuit is often called 'Meter In' control, due to it controlling the fluid flow into the cylinder, this type of flow control is not suitable in all applications.



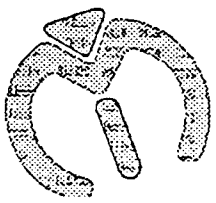
Flow Control Valves

Example Circuits



The circuits shown above are examples of how and where flow control valves may be used. The left hand circuit shows 'Metering In' while the right hand circuit shows 'Metering Out' control. In both cases, it is the forward (extend) speed of the piston that is being controlled.

Note: Which method is used ('Meter In' or 'Meter Out') will be dependant upon the actual application, load factors, etc there is no one method suitable for all applications.

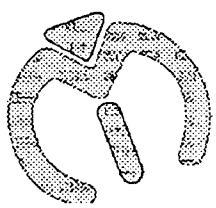


Check Valves (Non-Return Valves)

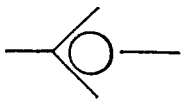
The simplest form of directional control valve is the non-return or check valve, which only allows flow in one direction, thus preventing flow in the reverse direction.

This valve and its symbol are shown over the page. Check valves are available with different spring rates to give particular cracking pressure. The cracking pressure is that at which the check valve just opens. If a specific cracking pressure is essential to the functioning of a circuit, it is usual to show a spring on the check valve symbol. The pressure drop over the check valve depends upon the flow rate; the higher the flow rate, the further the ball or poppet has to move off its seat and so the higher the spring force.

Ball type check valves have the least expensive form of construction, but as the ball is not guided, there is a tendency for leakage to occur. Although the manufacturers claim their check valves are leak free in one direction of flow and allow free flow in the reverse direction, a tiny scratch, wear mark, or imperfection on the poppet or seat will permit some leakage. Soft seated check valves use Delrin or similar polymer material for the seating and 100% sealing is possible but at the expensive of valve life. However they are not generally suitable for pressures above 200 bar or temperatures above 35^{0}C. Valves, which seal satisfactorily at high pressure, may leak at lower pressures. At high pressure, the poppet is forced onto the seat hydraulically giving a good seal; at low pressures, the sealing force is less and the valve may leak.

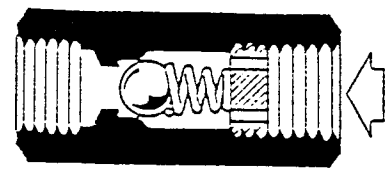


Check Valves (Non-Return Valves)

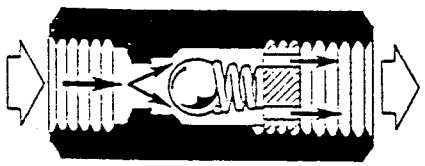


Ball Type

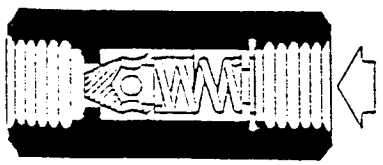
No Flow



Free Flow

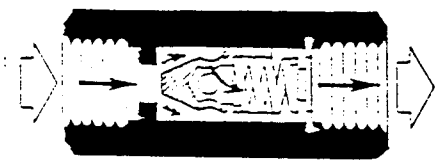


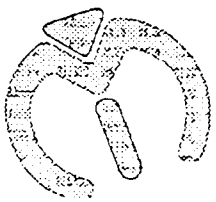
Poppet Type



No Flow

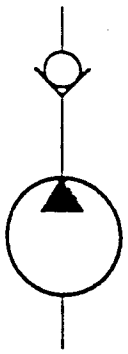
Free Flow



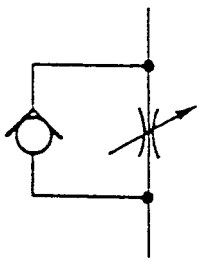


Applications for Check Valves

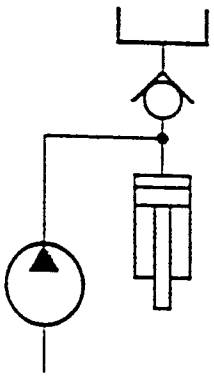
Check valves can be used in a multitude of different applications, a few different examples are detailed below.



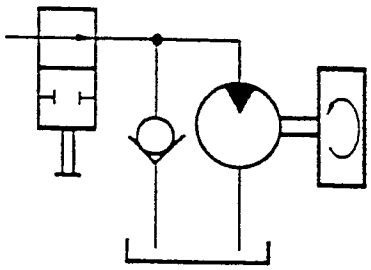
Check valve prevents the load from causing reversal pump drive when it is being lowered



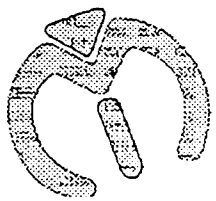
Flow-control valve with reverse free flow (non-return valve with restriction)



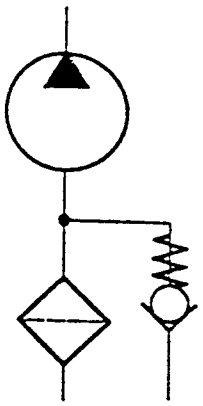
Prefill valve in presses

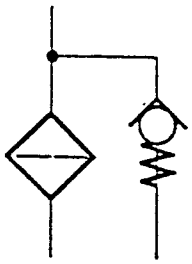


Anti-cavitation valve with rotating masses

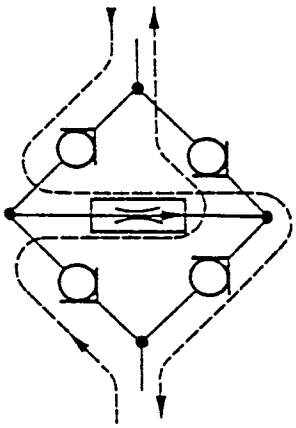


Applications for Check Valves

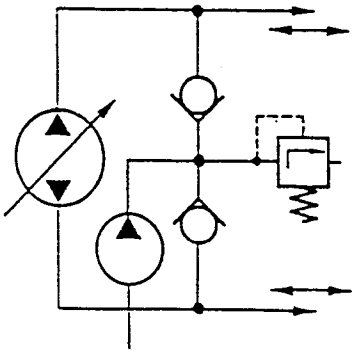




Bypass for clogged filter
(cracking pressure 0.5 – 3 bar)



Graetz rectifier circuit for pressure-compensated flow-control valve

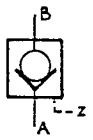


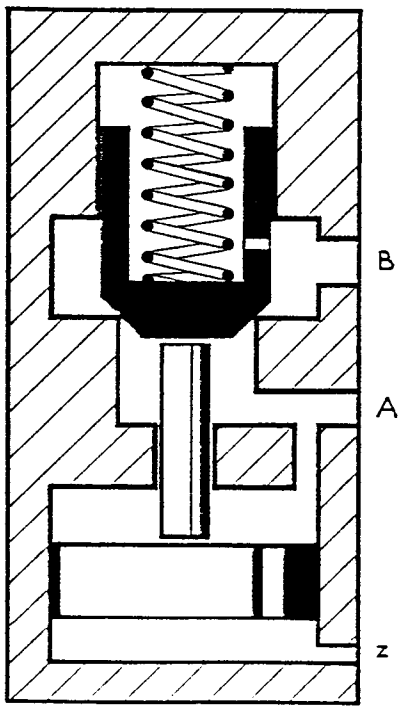
Supercharge in closed circuits

Pilot Operated Check Valve

Pilot Operated (P.O.) Check Valve

These are normally closed check valves, which may be opened by a pilot signal, or less commonly held closed by a pilot signal. The pilot pressure needed to open the check valve against a load pressure depends upon the ratio of the areas of the pilot piston and check valve. A pilot operated check valve is shown below. Most manufacturers offer a range of pilot ratios i.e. if the pilot ratio is 4:1, the pilot pressure required to open the valve is 25% of the load pressure.



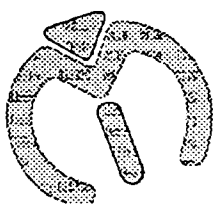


Pilot Operated Check Valve

Pilot Operated (P.O.) Check Valve

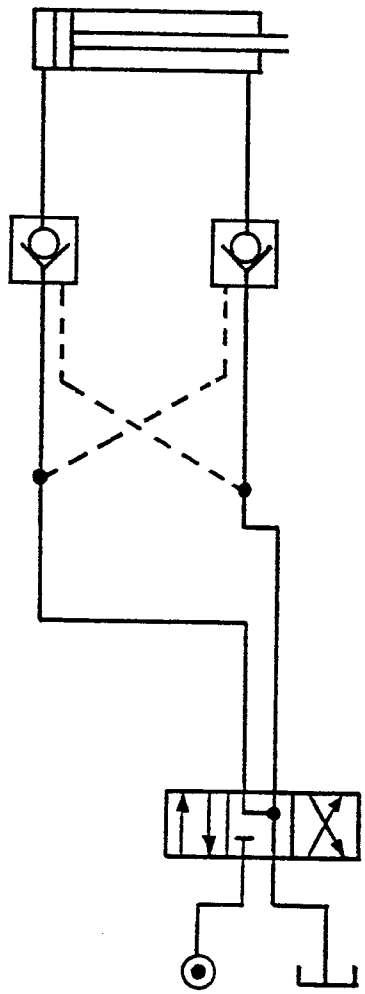
When fluid flows from port **A** to **B**, it will do so unhindered (as with a normal check valve). When the fluid flow is reversed from port **B** to **A**, the check valve closes and the flow is blocked (checked).

To allow the fluid to flow from **B** to **A**, a pilot must be applied to port **Z**, this pilot will operate against the piston of the valve and move it against the spring, opening the check valve and allowing flow from port **B** to port **A**, immediately the pilot is removed the check valve closes again and stops the flow from **B** to **A**.

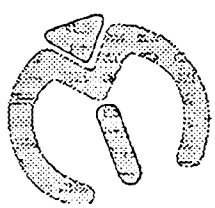


Pilot Operated Check Valve

Example Circuit



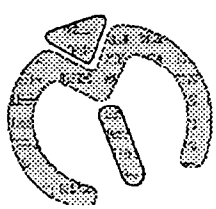
With this example, the double acting cylinder is being controlled by two pilot operated check valves, as well as the 4/3 way valve. One P.O. check valve is in each cylinder feed line.



Pilot Operated Check Valve

Example Circuit

This will give the following control: when the fluid is fed to the rear of the cylinder (4/3 moved to left square of the symbol), the right hand P.O. check valve will be opened to allow the cylinder to extend. When the 4/3 way valve is moved to the right hand square of the symbol the operation is reversed. However, when the 4/3 way valve is centralised during the cylinder stroke, the cylinder will stop and be held in position by the fluid, which in turn is trapped by the P.O. check valves. This is more positive than relying solely on a closed centre DCV (fluid will leak across the spool of a closed centre valve and therefore the pressure will be lost over a period of time and the cylinder could move, the P.O. check valve is of the poppet design principle and therefore should be leakage free).

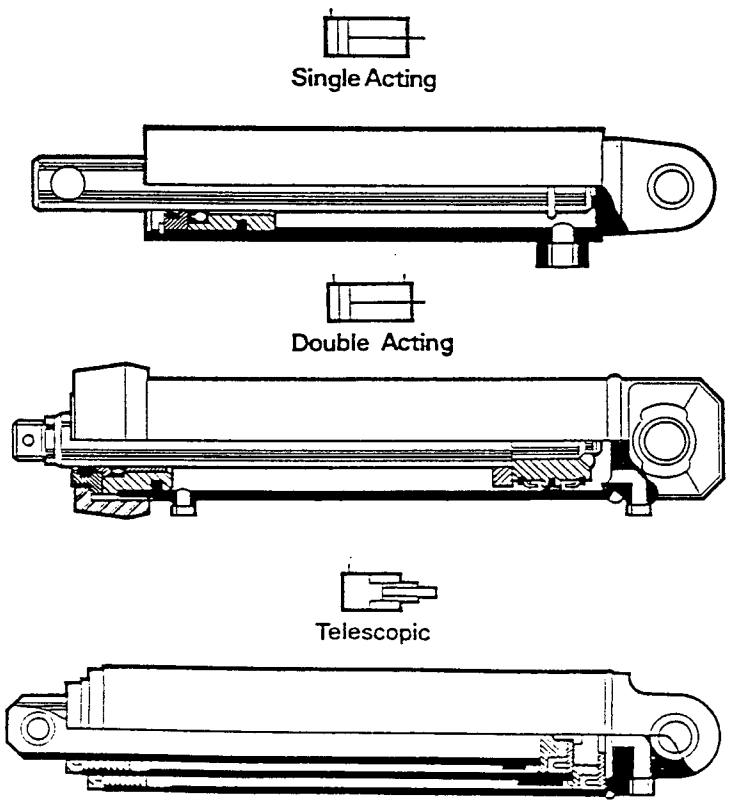


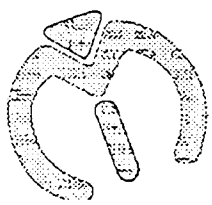
Cylinders

Cylinders can be single acting, double acting, or telescopic. Their design is affected by factors of mechanical strength as well as by considerations of pressure, area, and load.

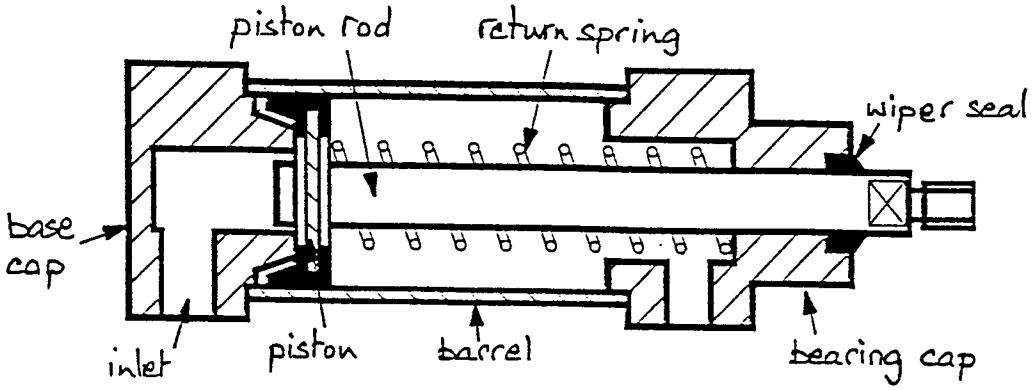
Single acting cylinders rely on a mechanical load or spring to move them in one direction.

In telescopic cylinders, the larger diameter sections extend first because the pressure required in moving the load will be lower than on the smaller diameter sections.





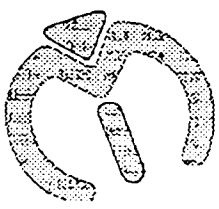
Operation of a Single Acting Cylinder



The diagram shows a single acting cylinder with spring return.

When fluid 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 or raise a weight and extend the piston rod.

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

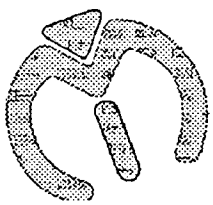


Operation of a Single Acting Cylinder

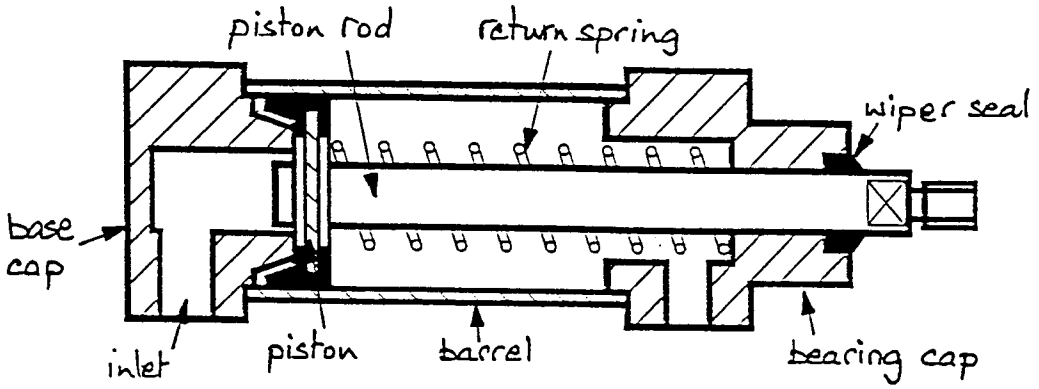
The force, which acts upon the piston, will be determined by the pressure applied and the surface area to which the pressure is applied.

Force = Pressure x Area

The piston diameter will be equal to the internal diameter of the cylinder, known as the BORE.



Operation 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 hydraulic power during extend and retract movements and therefore does not rely on springs or external mechanical force. Theoretically, the stroke length is limited only by the length of tubing available (for cylinder barrel), and the length of round bar available (for piston rod). In practice, limits are placed on the stroke length due to factors such as buckling load, which effects 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, the greater the stroke length the lower the load required to buckle the piston rod

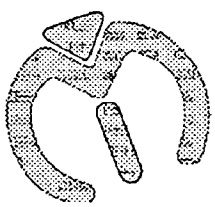
Operation of a Double Acting Cylinder

With double acting cylinders, it is also very easy to achieve speed control, which can be another reason for selecting them.

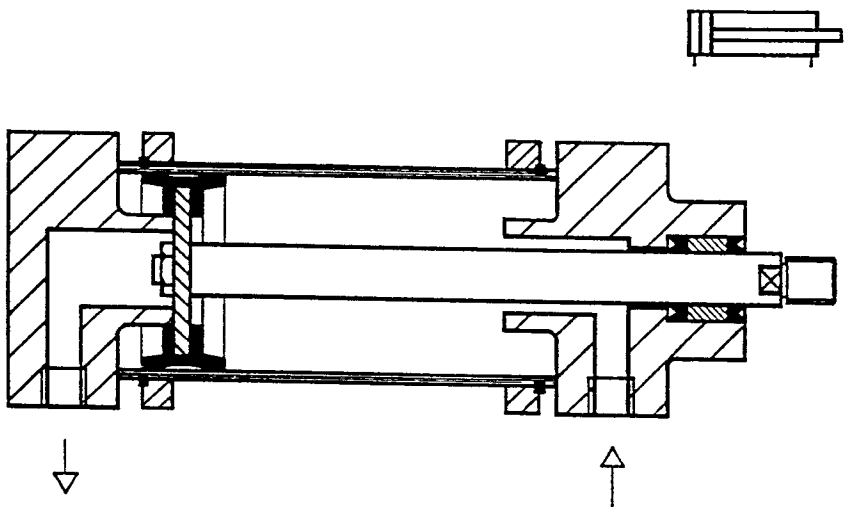
The diagram above shows the main component parts of a double acting cylinder.

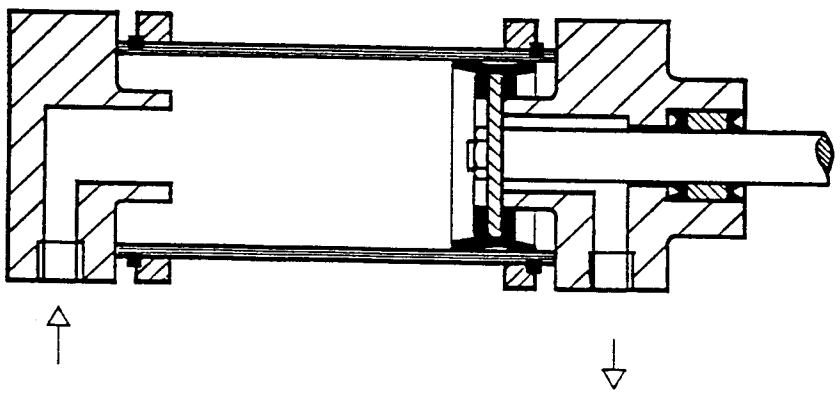
When fluid is passed into the rear chamber of the double acting cylinder and the front chamber is connected back to tank (via the DCV), the piston, and piston rod will extend. If the flow remains to the rear chamber, the cylinder will stop at the end of its stroke and remain extended, until the fluid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

Remember that: **Force = Pressure x Area.**



Operation of a Double Acting Cylinder





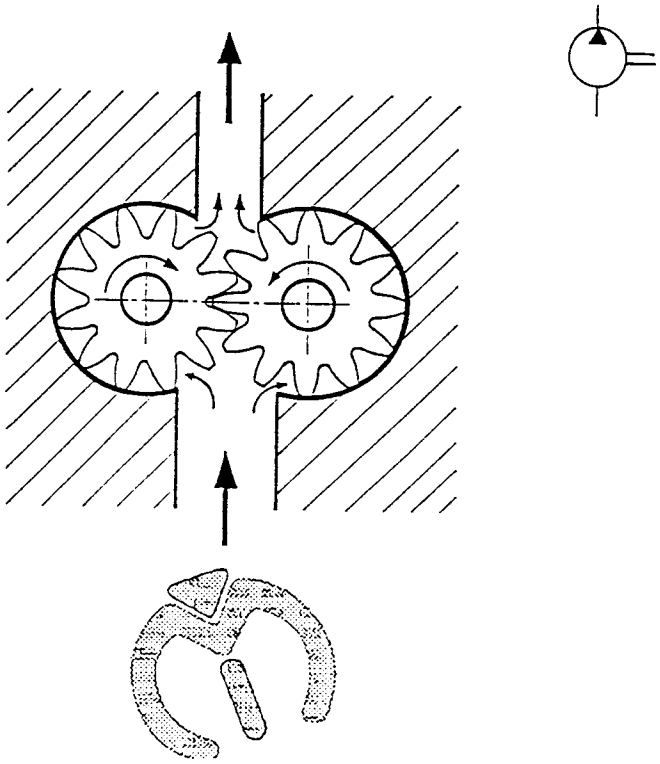
Hydraulic Motors

Motor is the name usually given to a rotary (360^0 +) hydraulic actuator. Motors very closely resemble pumps in construction. Instead of pushing on the fluid as the pump does, as output members in the hydraulic system, they are pushed by the fluid and develop torque and continuous rotating motion. Since both inlet and outlet ports may at times be pressurised, most hydraulic motors are externally drained.

Gear Motors

A gear motor develops torque through pressure on the surface of gear teeth. The two gears mesh and rotate together, with only one gear coupled to the drive shaft. The motor is reversible by reversing flow. The displacement of a gear motor is fixed and is roughly equal to the volume between two teeth multiplied by the number of teeth.

Gear motors of this type are frequently limited to about 140 bar (2000 psi) operating pressure and the 2400 rpm range. Principal advantages have been their simplicity and a rather high dirt tolerance.

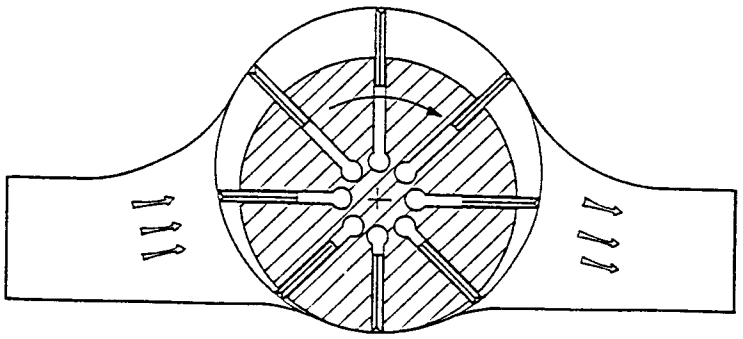


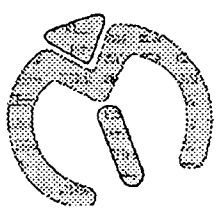
Gear Motors

These are offset, however, by somewhat lower efficiency. With current emphasis on higher performance and more sophisticated filtering equipment, the trend is toward piston type motors in many machinery and mobile equipment applications.

Vane Motors

In a vane motor, torque is developed by pressure on exposed surfaces of rectangular vanes, which slide in and out of slots in a rotor splined to the drive shaft. As the rotor turns, the vanes follow the surface of a cam ring, forming sealed chambers, which carry the fluid from the inlet to the outlet.





Section 4

Hydraulic tutor

Tutor layout

Tutor list – Introductory tutor

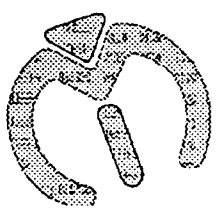
Exercises – Introductory tutor

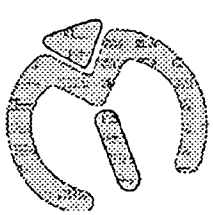
Tutor list – Advanced tutor

Exercises – Advanced tutor

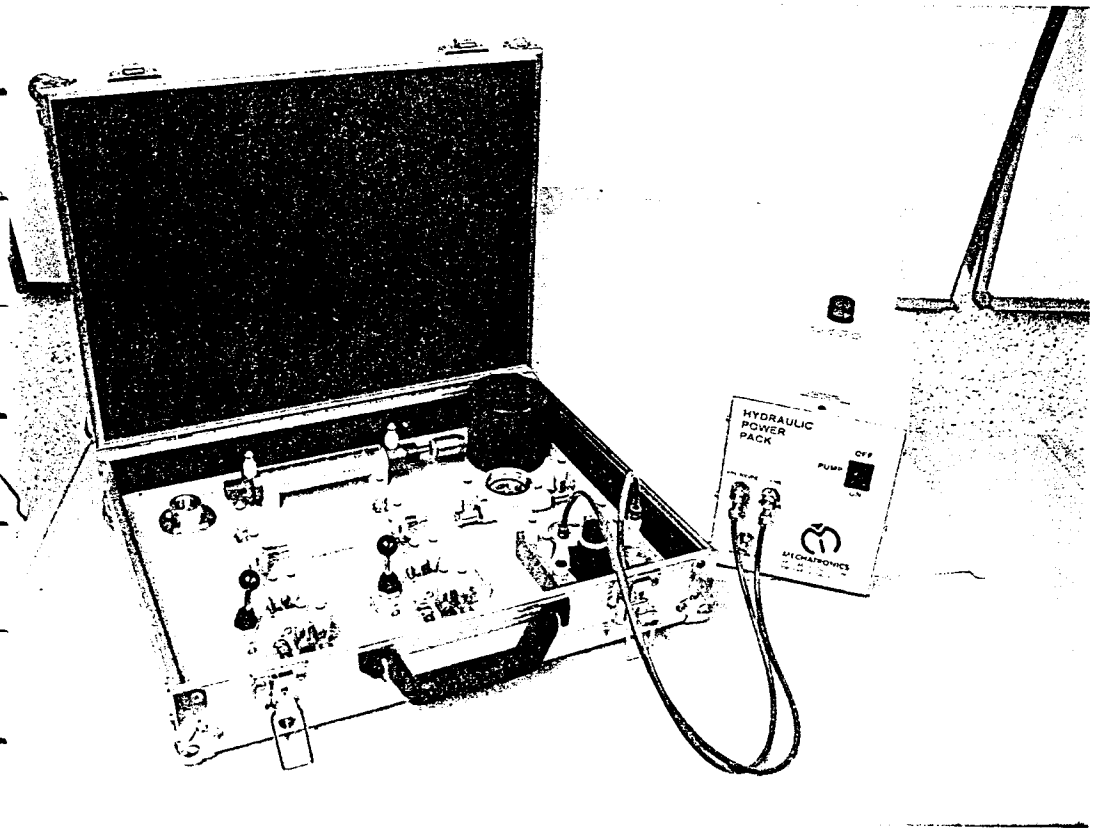
Initial start up of hydraulic power pack

Operating instructions

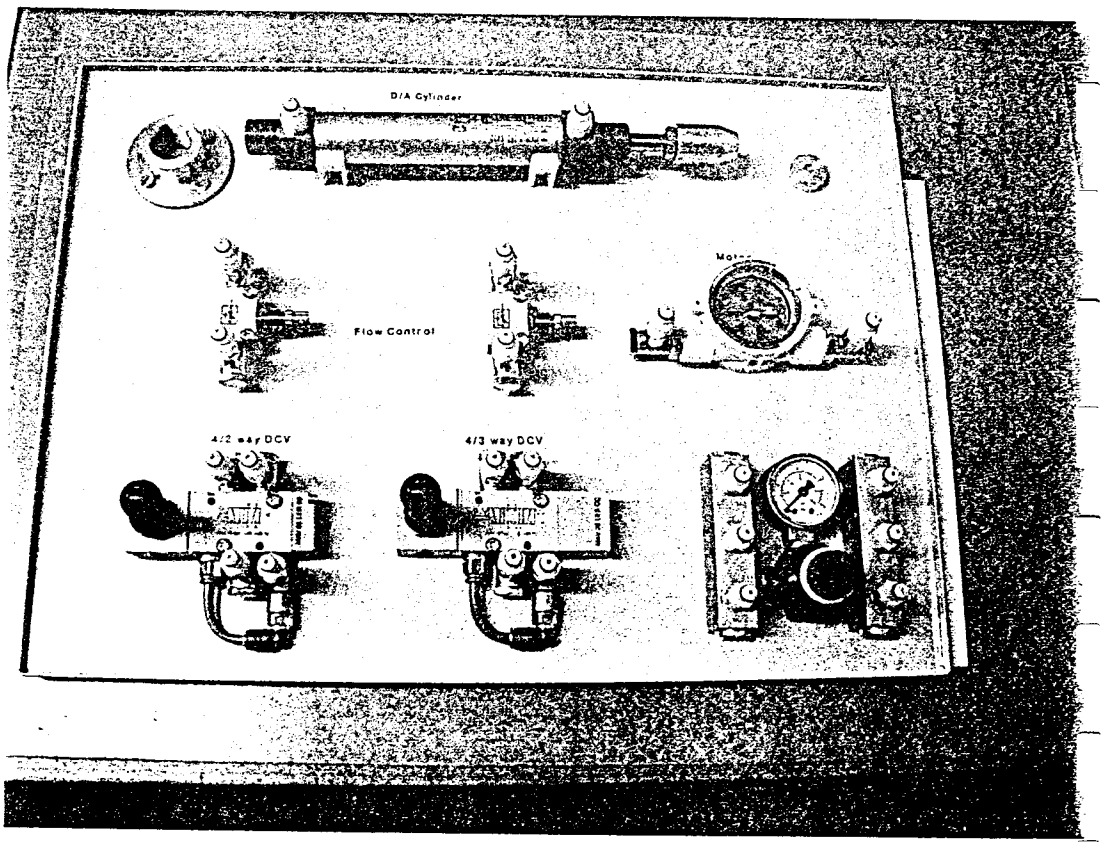




Hydraulic Tutor
Introductory Level

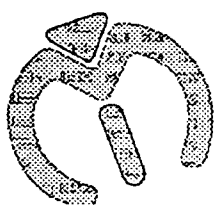


Tutor Layout
Introductory Level



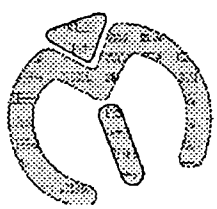
Tutor List – Introductory Tutor

Item 1	1 off	pressure relief valve
Item 2	1 off	pressure manifold
Item 3	1 off	tank manifold
Item 4	1 off	4/3 directional control valve lever operated detent
Item 5	1 off	4/2 directional control valve lever operated detent
Item 6	1 off	bi-directional motor/flow meter
Item 7 & 8	2 off	one way flow control valve
Item 9	1 off	double acting cylinder
Item 10	1 off	4kg load weight

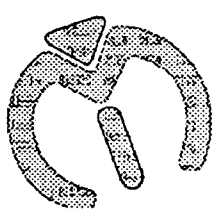


Exercises – Introductory Tutor

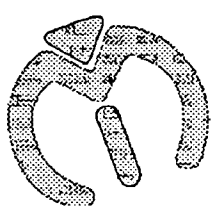
1. Pressure relief valve
2. Directional control valve
3. Flow control valve function
4. Door operation
5. Table lift
6. Door hopper control
7. Machine feed (Metering 'Out')
8. Machine feed (Metering 'In')
9. Hydraulic crane
10. Surface grinder traverse
11. Rolling mill conveyor
12. Power winch



Hydraulic Tutor
Advanced Level



Tutor Layout
Advanced Level



Tutor List – Advanced Tutor

Item 1	1 off	pressure relief valve
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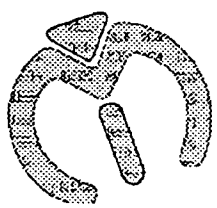
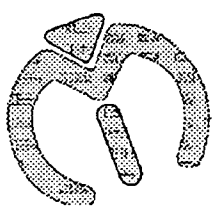
Item 3	1 off	tank manifold
Item 4	1 off	4/3 directional control valve lever operated detent
Item 5	1 off	4/2 directional control valve lever operated detent
Item 6	1 off	bi-directional motor/flow meter
Item 7 & 8	2 off	one way flow control valve
Item 9	2 off	double acting cylinder
Item 10	1 off	4kg load weight
Item 11	1 off	check vale
Item 12	1 off	pilot operated check valve
Item 13	1 off	counter balance/sequence valve



Exercises – Advanced Tutor

1. Pressure relief valve
2. Directional control valve
3. Flow control valve function
4. Check valve function
5. Pilot operated check valve function
6. Door operation
7. Table lift
8. Door hopper control
9. Machine feed (Metering 'Out')
10. Machine feed (Metering 'In')
11. Hydraulic crane
12. Door with inching facility
13. Surface grinder traverse
14. Press with counterbalance
15. Rolling mill conveyor
16. Power winch
17. Press and clamp



Initial Start Up of Hydraulic Power Pack

1. Fill water tank to a level somewhere in between the minimum and maximum mark on the dipstick.

2. Ensure the on/off switch is in the "off" position.

3. Open the bleed valve by turning anti-clockwise until fully open.

4. Connect the two feed hoses to the hydraulic tutor at pressure and tank manifolds respectively.

5. Plug in the electric supply.

6. Switch 'on' the pump.

7. Allow to run for 10 – 15 seconds with the bleed valve fully opened.

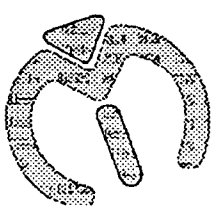
8. With the pump still running close the bleed valve to the fully closed position, by turning clockwise.

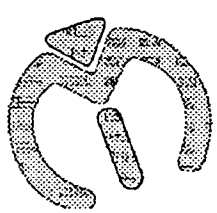
9. Check if there is a pressure reading on the gauge located on the pressure manifold on the training unit.

   If there is no pressure reading indicated, then repeat steps 2 – 9.

10. When a pressure reading appears on the gauge adjust the pressure relief valve clockwise until a reading of between 2 - 2½ bar is achieved.

11. The tutor kit is now ready to be used.

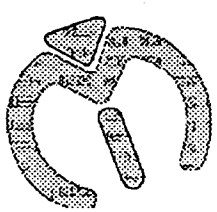


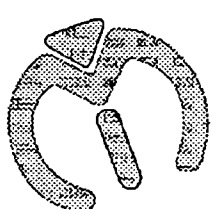


Section 5

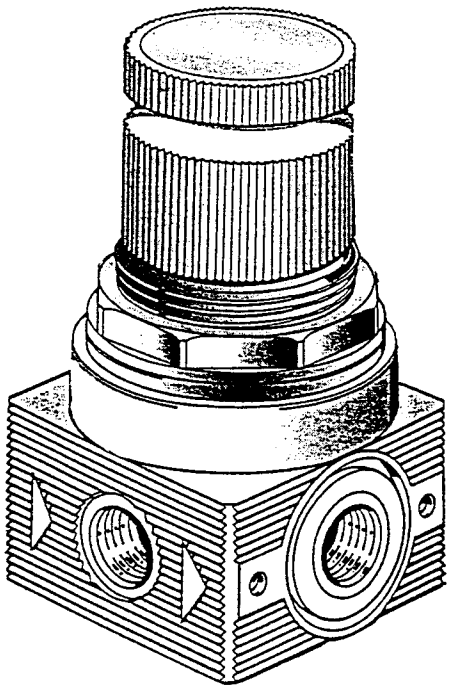
Exercises and Operational procedures

Circuit explanations and Question Papers





Exercise: Function Test on a Pressure Relief Valve



The characteristics of a pressure relief valve are to be demonstrated by way of measurements, as indicated.

Equipment Required:

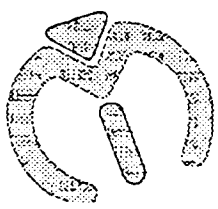
a) 1 off Flow control valve

b) 1 off Pressure relief valve

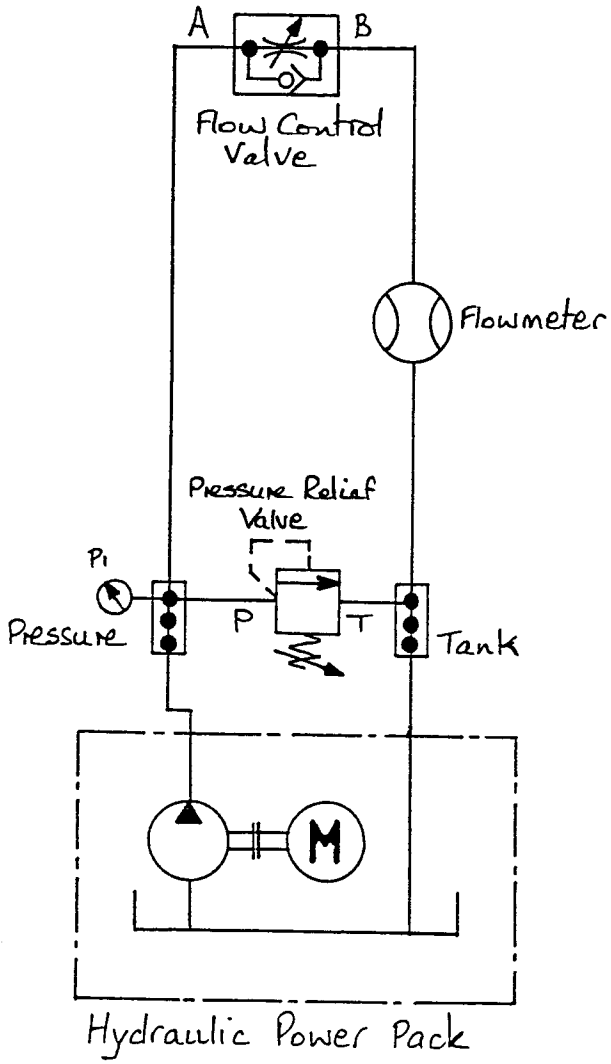
c) 1 off Flow meter

d) 1 off Distribution manifold pressure/tank

e) Connection hoses as required



Exercise: Function Test on a Pressure Relief Valve



Exercise: Function Test on a Pressure Relief Valve

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, flow control valve, flow meter and tank manifold as required.

4 Check the assembled circuit with the circuit diagram.

5 Fully close the flow control valve by turning the adjuster clockwise.

6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

7 Open the flow control fully by turning the adjuster anti-clockwise.

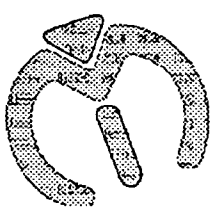
8 Observe if the flow meter is:

Rotating	
Not Rotating	

9 Now fully close the flow control valve and observe if the flow meter is:

Rotating	
Not Rotating	

10 Switch "off" the power pack and remove all hoses.

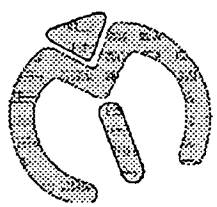


Exercise: Function Test on a Pressure Relief Valve

Operational Procedure - continued

11 Compare your observations with the circuit explanation.

12 Answer the questions for this exercise.

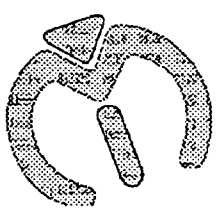


Exercise: Function Test on a Pressure Relief Valve

Circuit Explanation

In this exercise the "motor/flow meter" is used to monitor flow within the system, and the "flow control valve" is used as an on/off valve.

With the flow control valve fully closed and the pump running it can be observed that the flow meter is 'not rotating' indicating there is no fluid passing through the flow control valve. Because the fluid is not passing through the flow control valve the pump will build up pressure at the port '**P**'. Upon reaching a pressure of 2.5 bar (36 psi) the relief valve will open returning the fluid to tank, whilst maintaining the system pressure. When the flow control valve is open the flow meter rotates and the pressure reading falls to approximately 2 bar (29 psi) indicating the fluid is now flowing through this part of circuit, and not through the relief valve.



Questions: Function Test on a Pressure Relief Valve

1) Pressure relief valves are used for what purpose/s?

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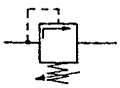
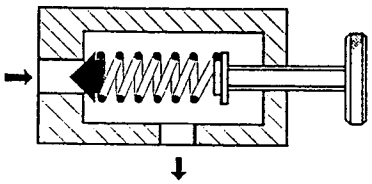
.....

2) Describe the function of the direct operated pressure relief valve, illustrated below:





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3) Where in the hydraulic circuit should the pressure relief valve/s be fitted?

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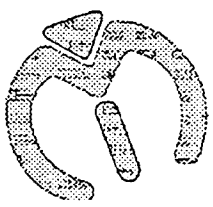
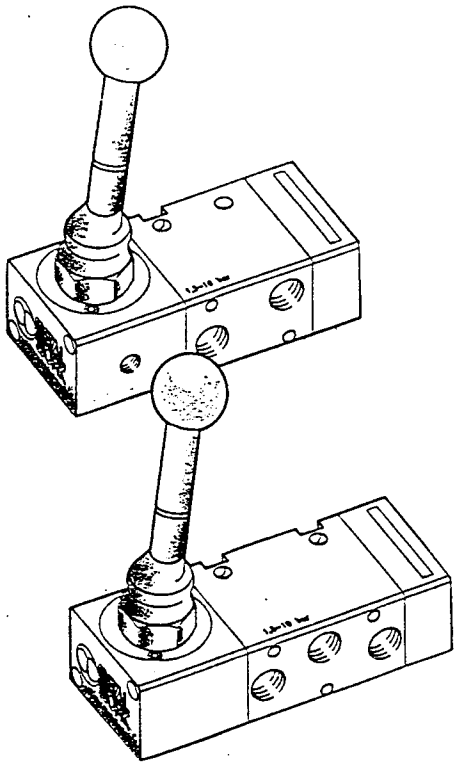
.....



Exercise: Directional Control Valves

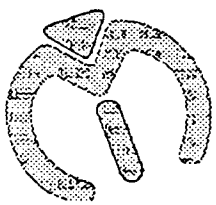


The operational functions of directional control valves (DCV's) are to be demonstrated by the reading of a circuit diagram and data recording.

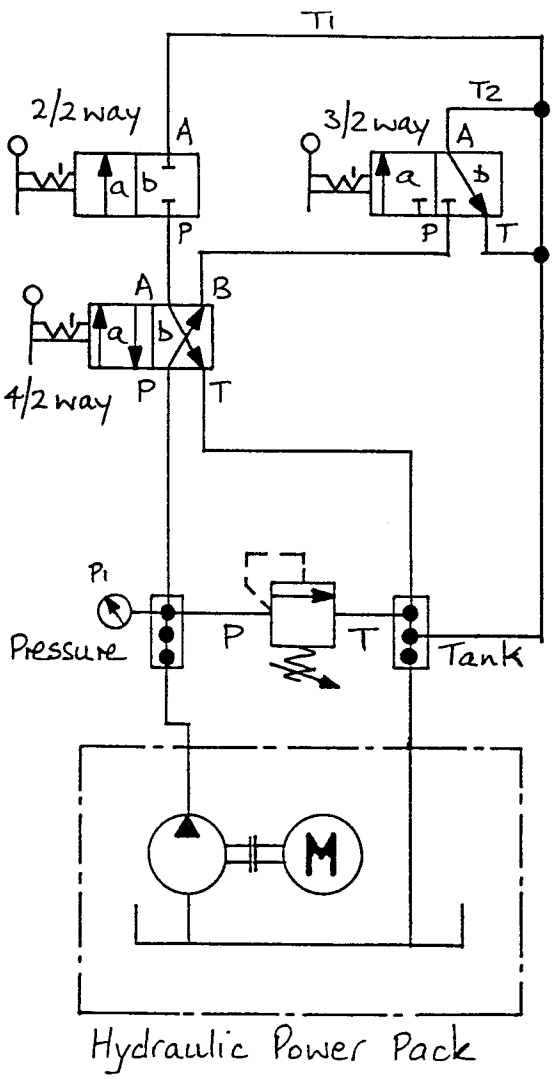
Equipment required

a) Circuit diagram

b) Data table



Exercise: Directional Control Valves



Exercise: Directional Control Valves

Operational Procedure

1 Reading the circuit diagram only (assembly of equipment is not required) enter into the table below the following:

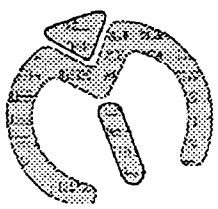
a) The flow path through the directional control valves (e.g. P→B, A→T).

b) Whether there should be flow in lines T1 and/or T2.

Column 1 has been completed as an example.

	1	2	3	4	5	6	7	8
4/2 way directional control valve (condition)	**b**	b	b	b	a	a	a	a
4/2 way flow direction	**P → B A → T**							
2/2 way directional control valve (condition)	**b**	a	b	a	b	a	b	a
2/2 way flow direction	**P → A Closed**							
3/2 way directional control valve (condition)	**b**	b	a	a	b	b	a	a
3/2 way flow direction	**P → A Closed A → T Open**							
Flow from	**T1 T2**							
Yes/No	**No No**							

↑
example



Exercise: Directional Control Valves

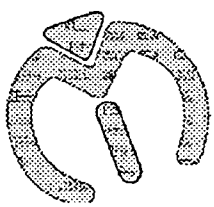
Circuit Explanation

With the circuit in the "at rest" condition, as drawn the 4/2 way directional control valve (DCV) is in position '**b**'. This allows fluid to flow from **P** to **B** and on through the circuit to the 3/2 way DCV where it is blocked. To get fluid flow in line T2 the 3/2 way DCV must be operated.

When the 4/2 way DCV is switched to position '**a**' the fluid flows from **P** to **A** and then to the 2/2 way DCV. The 2/2 way DCV is normally closed and therefore the fluid flow is blocked. To get fluid flow is line T1 the 2/2 way DCV must be operated.

If the 4/2 way DCV is in position '**b**' there cannot be any fluid flow in line T1 no matter what position the 2/2 way DCV is in.

Like wise if the 4/2 way DCV is in position '**a**' it is impossible to get fluid flow in line T2 no matter what position the 3/2 way DCV is in.



Questions: Directional Control Valves

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

.....

.....

.....

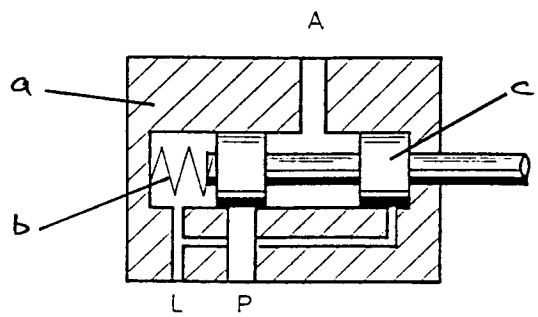
2) Draw the symbol (to I.S.O. 1219-1) for a 4/2 way directional control valve:

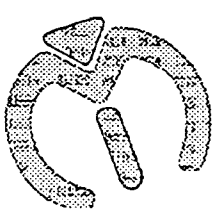
3) Name the three functional parts (a-c) of the directional control valve illustrated below:

a) .....

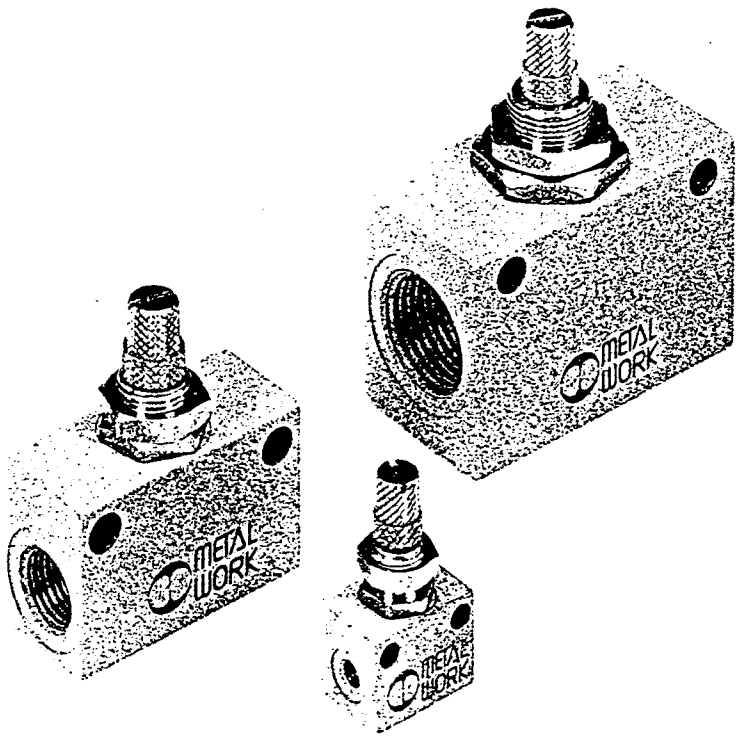
b) .....

c) .....





Exercise: Function Test on a One-Way Flow Control Valve



The operating characteristics of a one way flow control valve are to be demonstrated by way of measurement and observation.

Equipment required

a) 1 off One way flow control valve

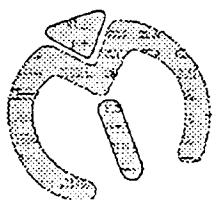
b) 1 off 4/3 directional control valve

c) 1 off Flow meter

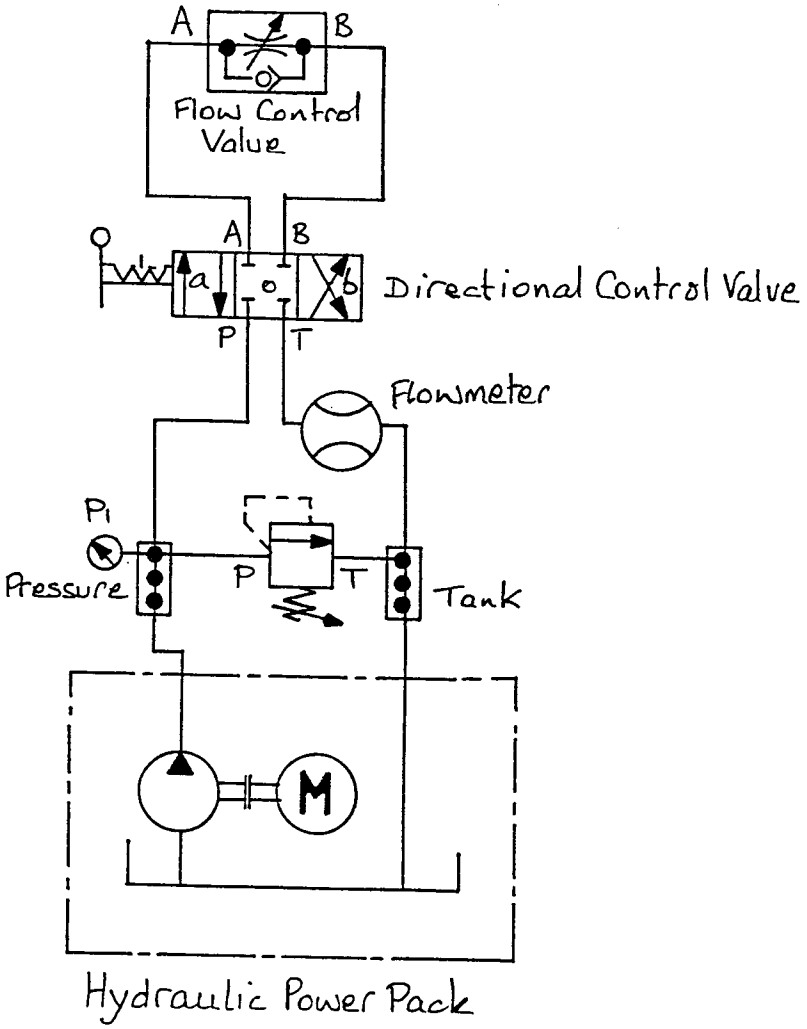
d) 1 off Pressure relief valve

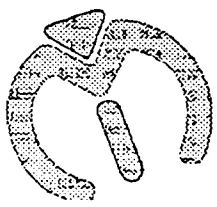
e) 1 off Distribution manifold pressure/tank

f) Connection hoses as required



Exercise: Function Test on a One Way Flow Control Valve





Exercise: Function Test on a One Way Flow Control Valve

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, one way flow control valve, flow meter, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the 4/3 directional control valve (DCV) to the centre position '**o**'.

6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

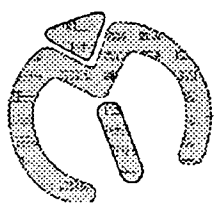
7 Operate the 4/3 DCV to position '**a**' and adjust the one way flow control valve clockwise or anti clockwise until the flow meter rotates at approximately two (2) revolutions per second.

8 Now operate 4/3 DCV to position '**b**' and observe the rotational speed of the flow meter. If the speed is different from the two (2) revolutions set by the flow control valve, then try readjusting as required.

9 Switch 'off' the hydraulic power pack and remove all the hoses.

10 Compare your observations with the circuit explanation.

11 Answer the questions for this exercise.



Exercise: Function Test on a One Way Flow Control Valve

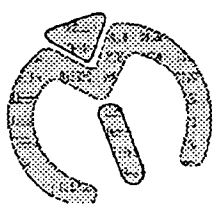
Circuit Explanation

When the 4/3 way directional control valve (DCV) is switched to the '**a**' position fluid will flow from port **P** to port **A** through the flow control valve and back to tank via ports **B** and **T**. Due to the flow travelling from **A** to **B** of the flow control valve it can be adjusted, this can be monitored at the flow meter.

If the 4/3 way DCV is switched to the '**b**' position the fluid flows in the reverse direction through the circuit and hence the flow control valve. With the fluid flowing through the flow control valve from **B** to **A** there is no adjustment available (due to the by-pass with check).

By switching from position '**a**' to '**b**' of the 4/3 way DCV and back repeatedly the difference in fluid flow can be observed at the flow meter.

With the 4/3 way DCV selected to the '**o**' position the output ports **A** and **B** are blocked and no flow takes place in the circuit.



Questions: Function Test on a One Way Flow Control Valve

1) The one way flow control valve is a combination of two (2) components, name them:

a) .....

b) .....

2) Which direction of fluid flow is "free flow" on the flow control valve?

.....

.....

.....

3) Which direction of fluid flow is "controlled (throttled)" on the flow control valve?

.....

.....

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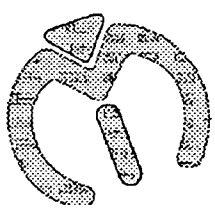
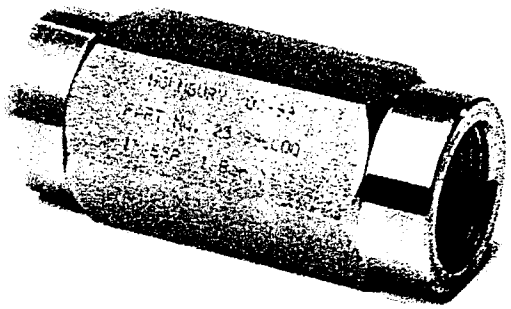


Exercise: Function Test on a Check Valve



The operating characteristics of a check valve are to be demonstrated by way of measurement and observation.

Equipment required

a) 1 off Check valve

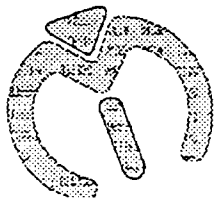
b) 1 off 4/3 directional control valve

c) 1 off Flow meter

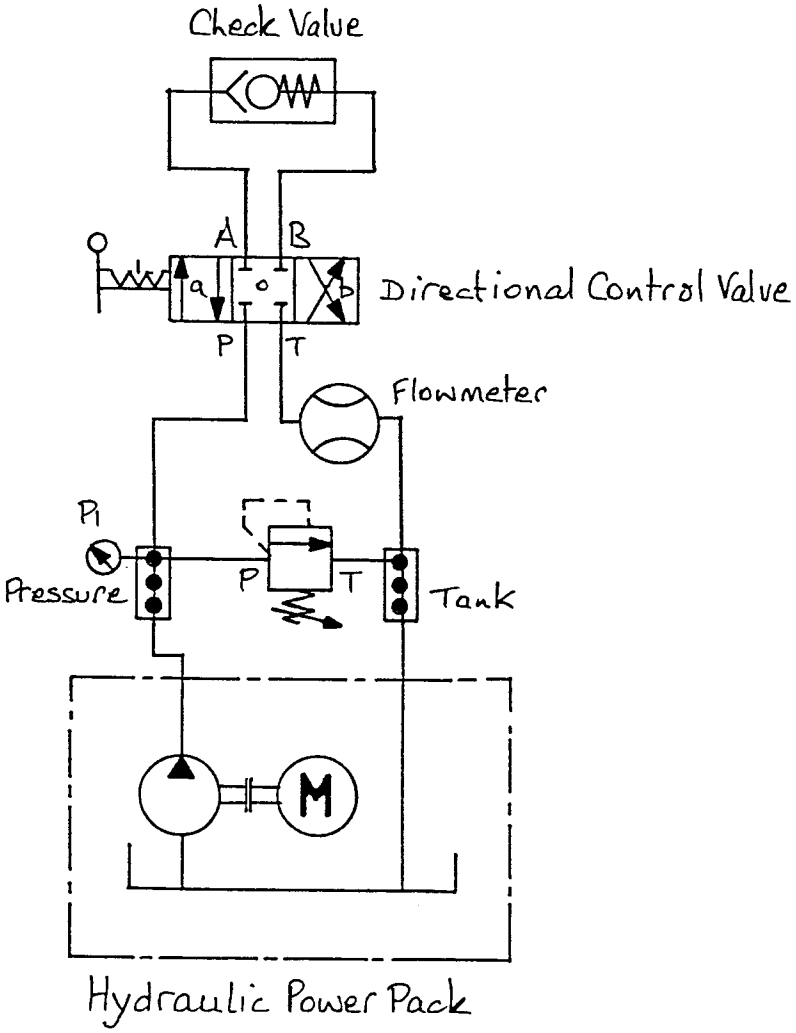
d) 1 off Pressure relief valve

e) 1 off Distribution manifold pressure/tank

f) Connections hoses as required



Exercise: Function Test on a Check Valve



Exercise: Function Test on a Check Valve

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, check valve, flow meter, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the 4/3 directional control valve (DCV) to the centre position '**o**'.

6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2 bar (29 psi).

7 Operate the 4/3 DCV to position '**a**' and observe if the flow meter indicates fluid flow?

Yes		**No**	

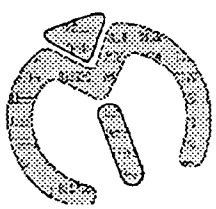
Now operate the 4/3 DCV to position '**b**' and again observe if the flow meter indicates fluid flow?

Yes		**No**	

8 Switch 'off' the hydraulic power pack and remove all hoses.

9 Compare your observations with the circuit explanation.

10 Answer the questions for this exercise.



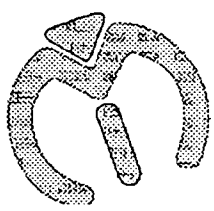
Exercise: Function Test on a Check Valve

Circuit Explanation

With the 4/3 way directional control valve (DCV) in its mid position '**o**' there is no flow through the circuit in any direction.

When the 4/3 way DCV is switched to its '**a**' position the fluid flows from port **P** to port **A** and then through the check valve to port **B** and then to tank via port **T**. This can be seen by observing the flow meter.

By selecting the 4/3 way DCV to its '**b**' position the check valve closes and there is no flow (path **B** to **A** of the DCV is blocked). Due to the no flow situation the flow meter will not be rotating.



Questions: Function Test on a Check Valve

1) Give another names for a check valve:

.....

.....

.....

2) What is the term given to the 'pressure' required to start to open a check valve?

.....

.....

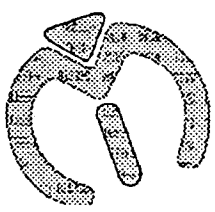
.....

3) What is the function of a check valve?

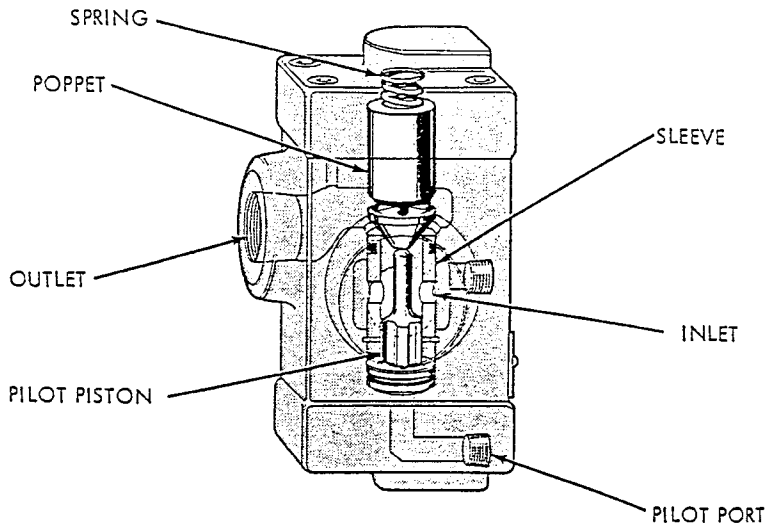
.....

.....

.....



Exercise: Function Test on a Pilot Operated Check Valve



The operating characteristics of a pilot operated check valve are to be demonstrated by way of measurement and observation.

Equipment required

a) 1 off Pilot operated check valve

b) 1 off 4/3 directional control valve

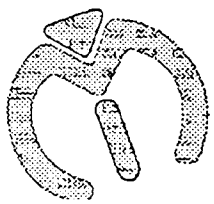
c) 1 off 4/2 directional control valve

d) 1 off Flow meter

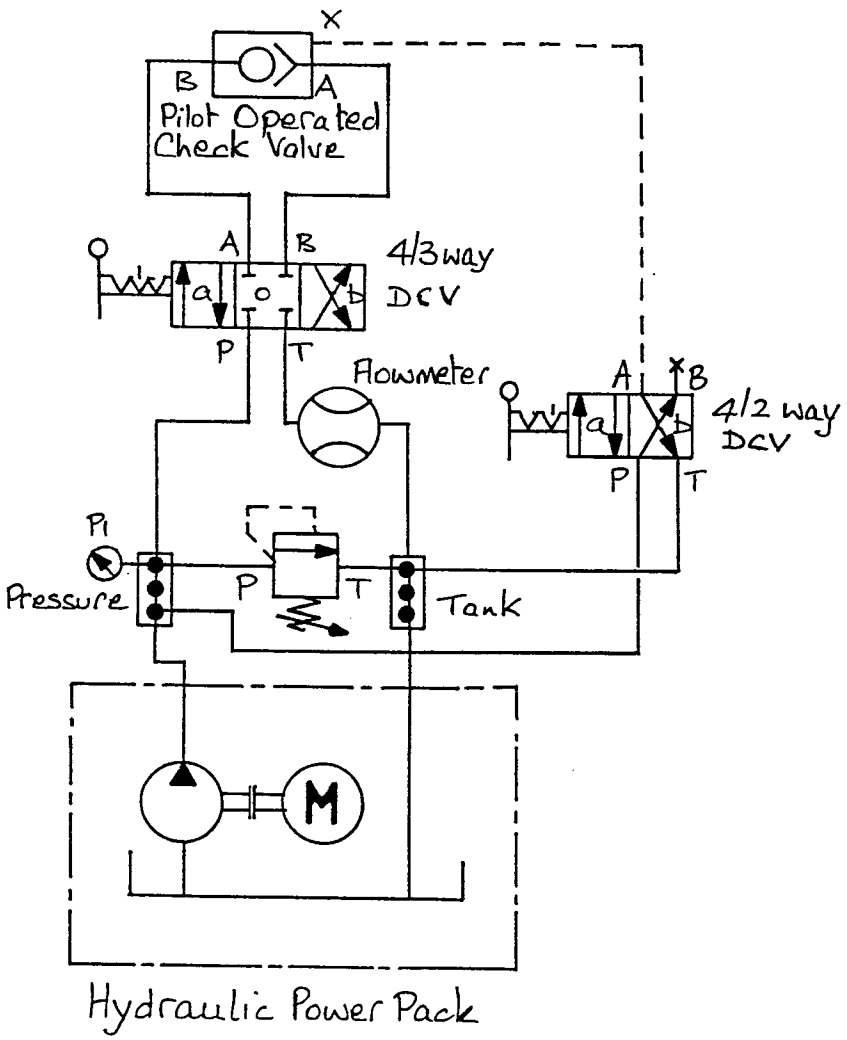
e) 1 off Pressure relief vale

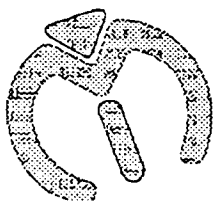
f) 1 off Distribution manifold pressure/tank

g) Connection hoses as required



Exercise: Function Test on a Pilot Operated Check Valve





Exercise: Function Test on a Pilot Operated Check Valve

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, 4/2 directional control valve (in this exercise used as a 3/2 directional control valve), pilot operated check valve, flow meter, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the 4/3 directional control valve (DCV) to the centre position '**o**' and the 3/2 directional control valve (DCV) to the position '**b**'.

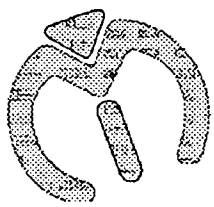
6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2 bar (29 psi).

7 Operate the 4/3 DCV to position '**b**' and observe if the flow meter indicates fluid flow?

Yes		**No**	

8 Now operate the 4/3 DCV to position '**a**' and again observe if the flow meter indicates fluid flow?

Yes		**No**	



Exercise: Function Test on a Pilot Operated Check Valve

Operational Procedure - continued

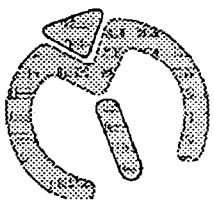
9 With the 4/3 DCV still in the '**a**' position, operate the 3/2 DCV to position '**a**' and record if the flow meter indicates flow:

Yes		**No**	

10 Switch 'off' the hydraulic power pack and remove all hoses.

11 Compare your observations with the circuit explanation.

12 Answer the questions for this exercise.



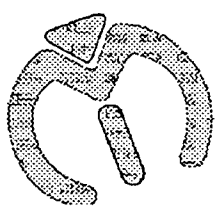
Exercise: Function Test on a Pilot Operated Check Valve

Circuit Explanation

With the circuit in the 'at rest' condition (as drawn) there is no flow taking place, due to the 4/3 way directional control valve (DCV) being in position '**o**' (all ports blocked) and the 4/2 way DCV being in position '**b**' (pilot line open to tank).

If the 4/3 way DCV is selected to its '**b**' position the fluid will flow from port **P** to **B** through the pilot operated (P.O.) check valve (free flow direction) and back to port **A** of the 4/3 way DCV, then to tank via port **T**.

When the 4/3 way DCV is selected to its '**a**' position the check valve will close and no flow will take place. However the check valve may be opened by applying a signal (pressure) to the 'pilot' port. The pressure to do this comes from the 4/2 way DCV once it is selected to its '**a**' position, allowing flow from port **P** to output port **A** and onto the pilot port of the P.O. check valve.



Questions: Function Test on a Pilot Operated Check Valve

1) On the P.O. check valve in the tutor case, does the pilot open or close the check valve?

.....

.....

.....

2) The line from port **A** of the 4/2 way DCV to the P.O. check valve is a dashed line, why?

.....

.....

.....

3) Whenever using a check valve in a circuit, what must we be aware of?

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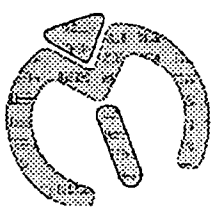
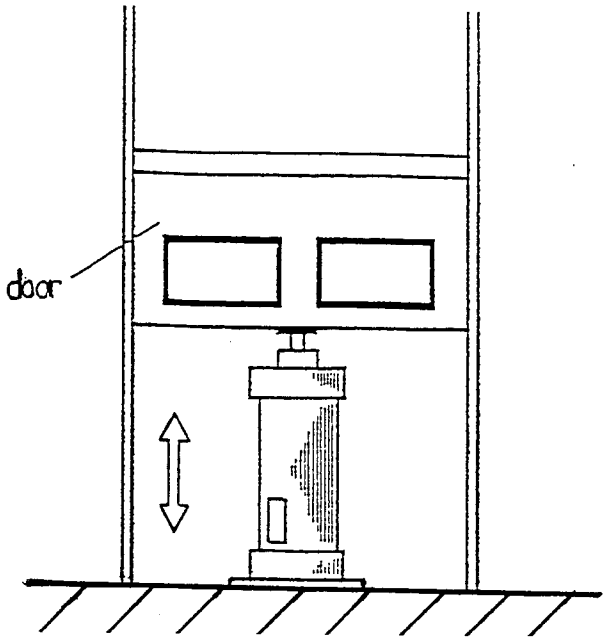
.....



Exercise: Door Operation



A single acting hydraulic cylinder is to be used to raise a door, the cylinder lifts the door by extending, and this is achieved by input of hydraulic force. The door is lowered by allowing its own weight to retract the cylinder, thereby utilising gravitational force.

Equipment Required:

a) 1 off Single acting cylinder

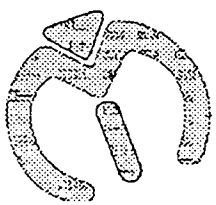
b) 1 off 3/2 way lever actuated, directional control valve

c) 1 off Pressure relief valve

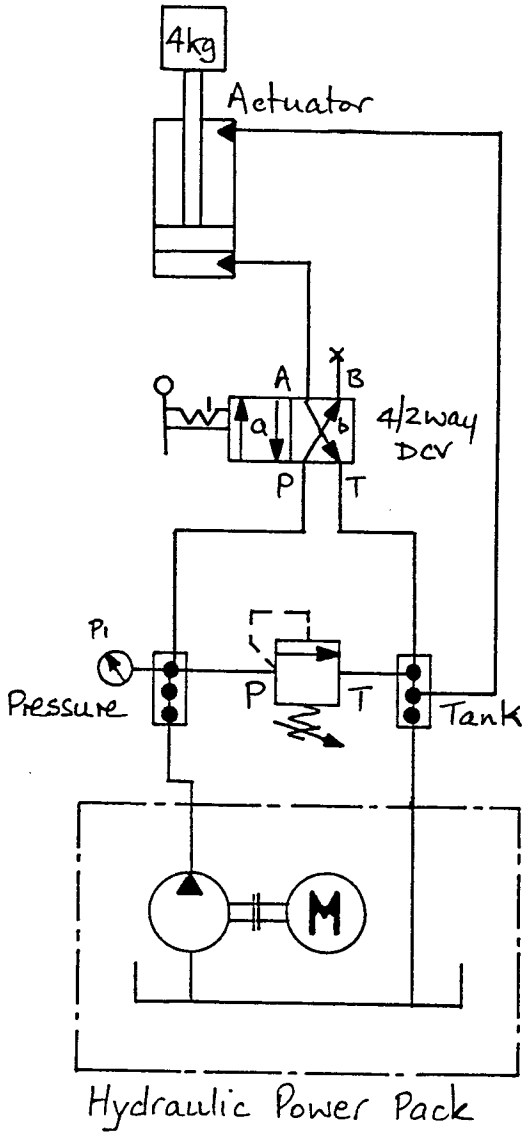
d) 1 off Distribution manifold pressure/tank

e) Connection hoses as required

Option) 4kg weight



Exercise: Door Operation



Exercise: Door Operation

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Unclip the cylinder from its horizontal position and fully screw it into the vertical mounting flange.

4 Fit the 4kg weight to the top of the now vertical cylinder.

5 Following the circuit diagram, connect the hoses between the pressure manifold, directional control valve, flow meter and the tank manifold as required.

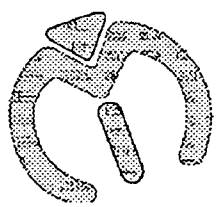
6 Check your assembled circuit against the circuit diagram.

7 Switch 'on' the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

8 Operate the cylinder using the 4/2 way directional control valve (DCV) and enter into the table below the following information:

a) Spool position (square '**a**' or '**b**') of the DCV.
b) Flow direction through the DCV.
c) Pressure readings on P1.

Weight Condition	Spool Position	Flow Directions	P1
Raising			
Lowering			
Piston fully retracted			
Piston fully extended			



Exercise: Door Operation

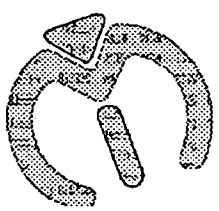
Operational Procedure - continued

9 Ensure that the cylinder is fully retracted, (weight fully lowered) and switch 'off' the hydraulic power pack, then remove all hoses.

10 Remove the weight and return the cylinder to the horizontal mounting clips.

11 Compare your observations with the written circuit explanation.

12 Answer the questions for this exercise.

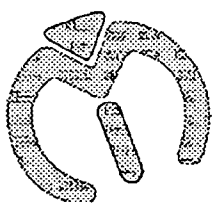


Exercise: Door Operation

Circuit Explanation

The lever valve controlling the single acting cylinder is of the 3/2 way, normally closed (**N/C**) type. In the 'at rest' condition the fluid supply to the valve is closed at port **P**, the output port **A**, which is connected to the cylinder, is open to tank port **T**, thereby allowing the cylinder to be retracted, due to the external load.

Upon actuation of the lever valve the supply **P** is connected to the output **A** and the tank port is closed (**T**), this allows fluid to travel into the cylinder, the piston and piston rod will now extend. When the lever valve is actuated to position **'b'** the fluid supply is closed at **P** and the fluid in the cylinder is allowed to flow to the tank via **A** to **T**, the cylinder is now free to retract.



Questions: Door Operation

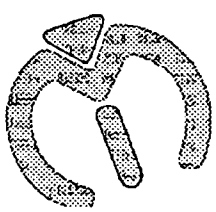
1) Draw the symbol, for a Single Acting Cylinder, with spring return, according to the I.S.O. 1219-1 standard: -

2) List two (2) disadvantages of a Single Acting Cylinder, with spring return: -

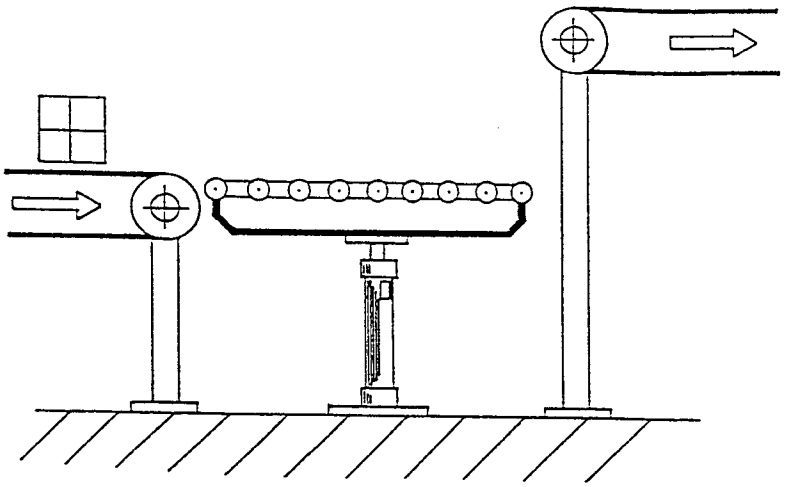
i) .....

ii) .....

3) Draw the symbol for a 3/2 way N/C push button operated, spring return valve, according to the I.S.O. 1219-1 standard:



Exercise: Lift Table



Boxes, which are fed along a conveyor belt, are to be lifted to a second belt by means of a lift table. The table is to be controlled by means of a double acting cylinder, this cylinder will extend when a lever operated directional control valve is switched and remain extended until such time that the valve is reselected to its initial position.

Equipment Required:

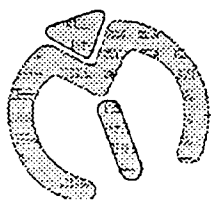
a) 1 off Double acting cylinder

b) 1 off 4/2 way lever actuated, directional control valve

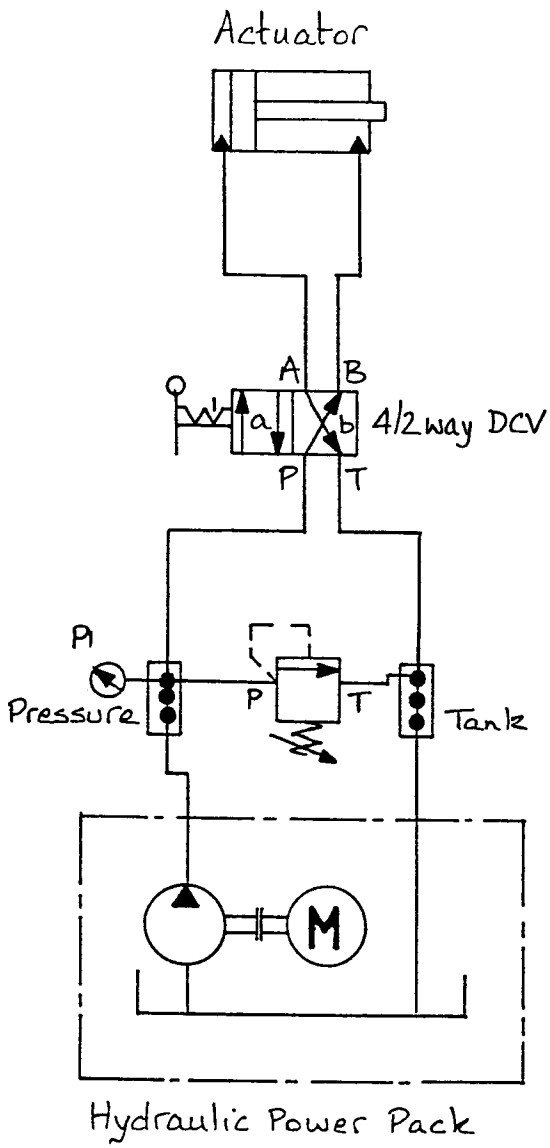
c) 1 off Pressure relief valve

d) 1 off Distribution manifold pressure/tank

e) Connection hoses as required



Exercise: Lift Table



Exercise: Lift Table

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram connect hoses between the pressure manifold, directional control valve, cylinder and the tank manifold.

4 Switch 'on' the hydraulic power pack and adjust the pressure relief valve setting to 2 bar (29 psi).

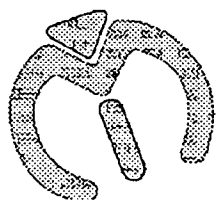
5 Operate the cylinder using the 4/2 way directional control valve and enter into the table below the following information:

Spool position (square '**a**' or '**b**') of the DCV.

Flow direction through the DCV.

Pressure reading on P1.

Movement of Piston Rod	Spool Position	Flow Directions	P1
Forward			
Return			



Exercise: Lift Table

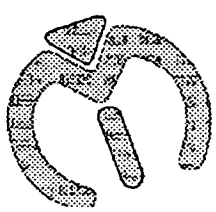
Operational Procedure - continued

6 Ensure that the cylinder is fully retracted, then switch 'off' the hydraulic power pack.

7 Remove all hoses.

8 Compare your observations with the written circuit explanation.

9 Answer the questions for this exercise.

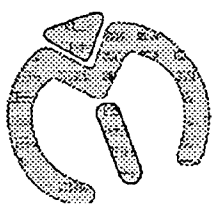


Exercise: Lift Table

Circuit Explanation

The lever valve controlling the double acting cylinder is of the 4/2 way directional control valve (DCV) type. In the 'at rest' condition the fluid supply to the valve at port **P** is transferred to port **B**, which is connected to the front end of the cylinder. The connection from the rear of the cylinder is connecting to port **A** that in turn is connected to port **T** thereby connecting the rear end of the cylinder to tank.

Upon actuation of the lever valve the supply **P** is connected to the output **A** and the tank port **T** is connected to port **B**. This allows fluid to enter the rear end of the cylinder and allows the fluid in the front end of the cylinder to return to tank **T**. The piston and piston rod will now extend. When the lever valve is actuated to position **'b'** the fluid supply at port **P** is now connecting to port **B** directing the fluid to the front end of the cylinder, the rear end is now connected to the tank port **T** via port **A**, the cylinder is now free to retract to its original position.



Questions: Lift Table

1) What do the letters P, T, A, and B marked upon ports of the hydraulic valves represent?

P = ...

T = ...

A & B = ...

2) List five (5) methods of operating a spool valve:

i) .....

ii) .....

iii) .....

iv) .....

v) .....

3) With a standard double acting cylinder more force is created as the piston extends than when it retracts (in application without pressure control), why is this?

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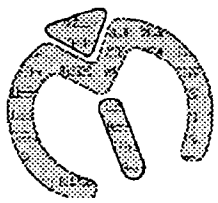
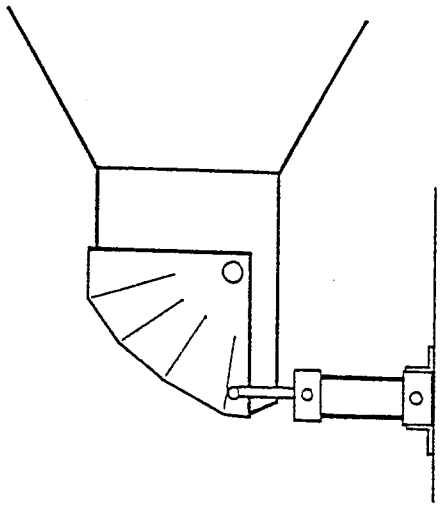
.....

.....



Exercise: Door Hopper Control



Bulk Material is to be emptied from a hopper at varying rates by means of a double acting cylinder controlled by a 4/3 way directional control valve (DCV).

Equipment Required:

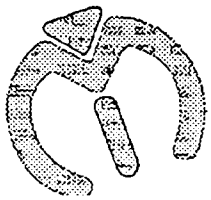
a) 1 off Double acting cylinder

b) 1 off 4/3 Way directional control valve

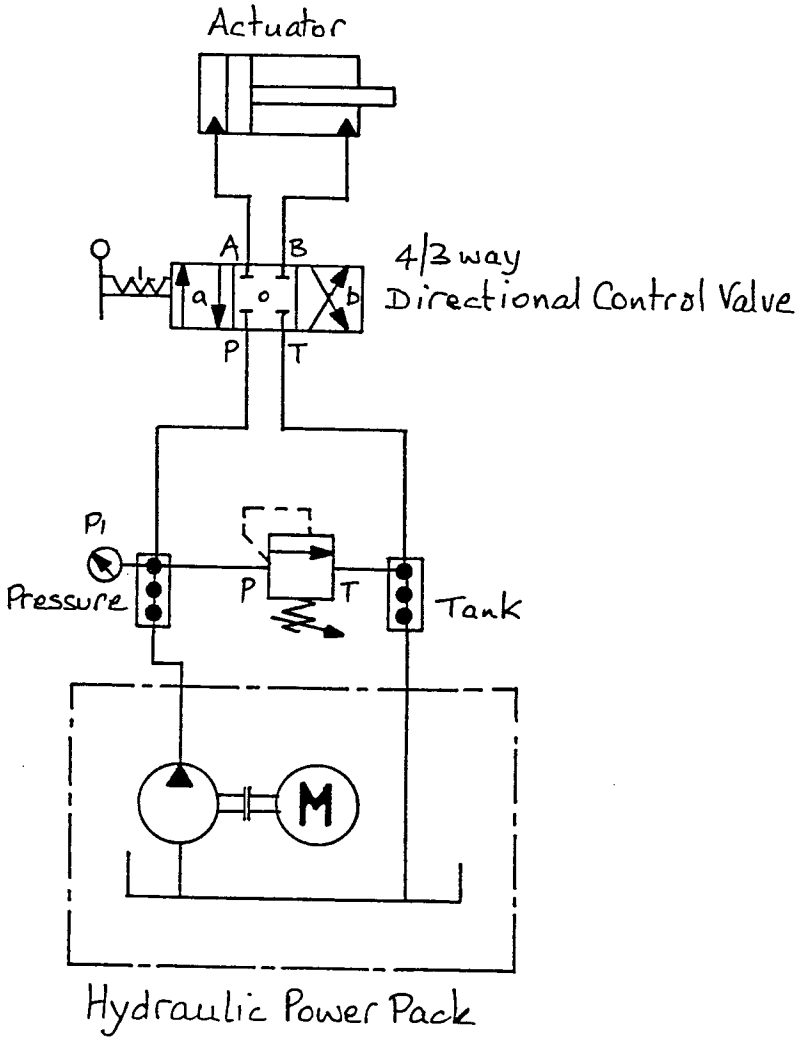
c) 1 off Pressure relief valve

d) 1 off Distribution manifold pressure/tank

e) Connection hoses as required



Exercise: Door Hopper Control



Exercise: Door Hopper Control

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, cylinder, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

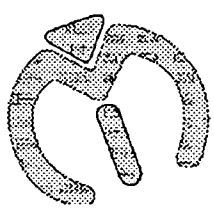
5 Operate the 4/3 directional control valve (DCV) to the centre position '**o**'.

6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

7 Operate the 4/3 DCV in order to extend, retract and stop the cylinder in a mid stroke position and enter into the table below the following information:

Spool position (square '**a**', '**o**' or '**b**') of the DCV.
Flow direction through the DCV.
Pressure reading on P1.

Cylinder	P1	4/3 way DCV flow directions	4/3 way DCV position
Extending			
Stopped Mid position			
Retracting			



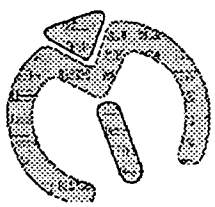
Exercise: Door Hopper Control

Operational Procedure - continued

8 Ensure that the cylinder is fully retracted, then switch off the hydraulic power pack and remove all hoses.

9 Compare your observations with the written circuit explanation.

10 Answer the questions for this exercise.



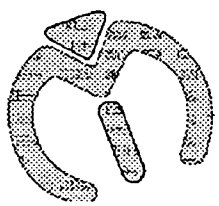
Exercise: Door Hopper Control

Circuit Explanation

The lever valve controlling the double acting cylinder is of the 4/3 way closed centre directional control valve (DCV). In the 'at rest' condition with the valve in the centre position **'o'** all ports are blocked therefore the cylinder is held in the rear position.

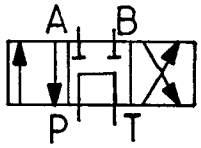
Upon actuation of the lever valve to the **'a'** position the supply **P** is connected to the output **A** and the tank port **T** is connected to port **B**. This allows fluid to enter the rear end of the cylinder and allows the fluid in the front end of the cylinder return to tank **T**. The piston and piston rod will now extend. When the lever valve is actuated to position **'b'** the fluid supply at port **P** is now connecting to port **B** directing the fluid to the front end of the cylinder, the rear end is now connected to the tank **T** via port **A**, the cylinder is now free to retract to its original position.

If while the cylinder is extending or retracting the lever valve is actuated to its centre position **'o'** the cylinder will stop at this point and will be hydraulically locked due to ports **A** and **B** being blocked. This type of valve will allow not only forward and reverse operation but also stop and inching facility.



Questions: Door Hopper Control

1) What advantage does the 4/3 way directional control valve (shown below) provide when the centre position **'o'** is selected?



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2) With a standard double acting cylinder the piston retracts at a greater speed than it extends (in an application without speed control), what is it that causes this?

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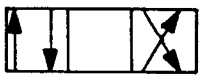
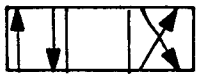
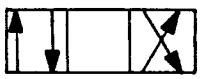
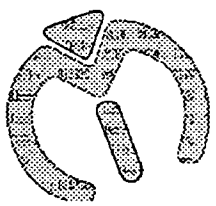
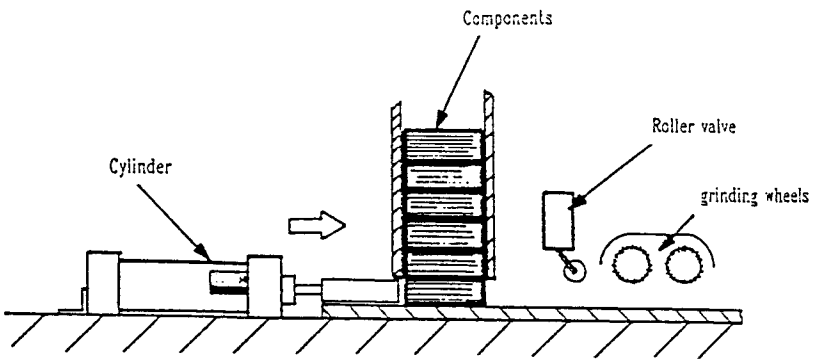
3) The 4/3 way DCV's used in this exercise have different centre conditions, complete the three symbols shown below, showing three other versions of centre conditions:-



Exercise: Machine Feed



On a machine tool e.g. surface grinder, components are to be fed by means of an hydraulic cylinder, controlled by a lever operated directional control valve (DCV). Upon operation of this DCV the cylinder is to extend slowly (and adjustable), while the machining operation takes place.

The cylinder continues to extend and will stop at the end of its stroke, until the DCV is reset, the cylinder will then retract at its normal speed until the cylinder reaches the end of its stroke.

Equipment Required:

a) 1 off Double acting cylinder

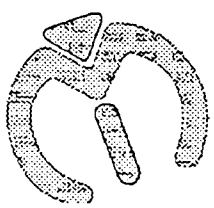
b) 1 off 4/2 Way directional control valve

c) 1 off Pressure relief valve

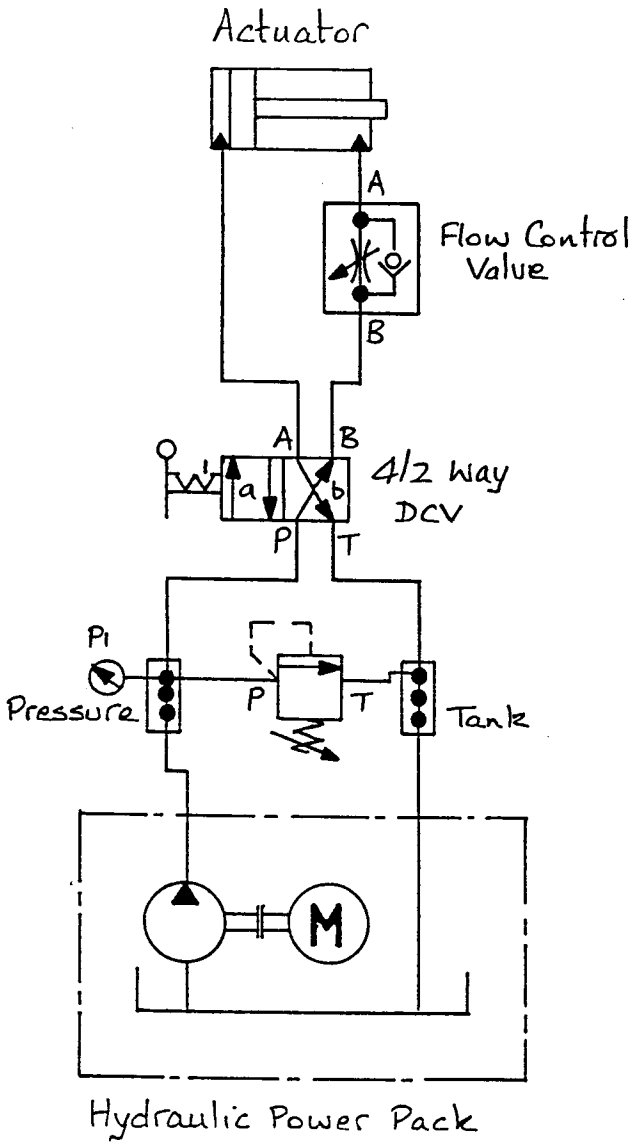
d) 1 off Flow control valve

e) 1 off Distribution manifold pressure/tank

f) Connection hoses as required



Exercise: Machine Feed (Metering 'Out')



Exercise: Machine Feed (Metering 'Out')

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, one way flow control valve, cylinder, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

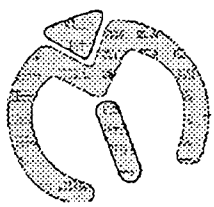
5 Operate the 4/2 directional control valve (DCV) to the position '**b**'.

6 Open the one way flow control valve by turning the adjuster anti-clockwise until it stops.

7 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

8 Using the 4/2 DCV to extend and retract the cylinder adjust the one way flow control valve clockwise in increments until the cylinder extending stroke takes fourteen (14) seconds to complete. Enter into the table below the information required.

Movement of piston	Flow directions	Pressure	Movement of the piston rod (time taken in seconds)
Extending			
Retracting			



Exercise: Machine Feed (Metering 'Out')

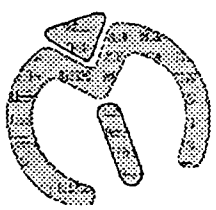
Operational Procedure - continued

9 Retract the cylinder and switch 'off' the hydraulic power pack.

10 Remove all hoses.

11 Compare your observations with the written circuit explanation.

12 Answer the questions for this exercise.

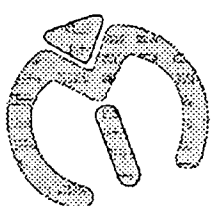


Exercise: Machine Feed (Metering 'Out')

Circuit Explanation

The lever valve controlling the double acting cylinder is a 4/2 way directional control valve (DCV). In the 'at rest' condition the fluid supply to the valve at port **P** is transferred to port **B**, which is connected to the port **B** of the flow control valve. Port **A** of the flow control flow is then connected to the front end of the cylinder. The connection from the rear of the cylinder is connecting to port **A** of the DCV, which in turn is connected to port **T** thereby connecting the rear end of the cylinder to tank.

Upon actuation of the lever valve to the **'a'** position the supply **P** is connected to the output **A** and the tank port **T** is connected to port **B**. This allows fluid to enter the rear end of the cylinder and also allows the fluid in the front end of the cylinder to enter port **A** of the flow control valve, closing the check valve. Fluid then flows through the restrictor and out of port **B** of the flow control valve to tank **T** (via port **B – T** of the DCV). The piston and piston rod will now extend at the speed set by the flow control valve adjuster. When the lever valve is actuated to position **'b'** the fluid supply at port **P** is now connected to port **B** directing the fluid to the front end of the cylinder via the check valve in the flow control valve. The rear end is now connected to the tank **T** via port **A**, the cylinder is now free to retract to its original position, at normal speed.



Questions: Machine Feed (Metering 'Out')

1) What is the function of a flow control valve?

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.....

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2) What does the term "Meter Out" mean?

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3) List one disadvantage of "Metering Out" when controlling the speed of a cylinder: -

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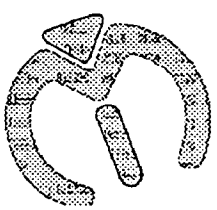
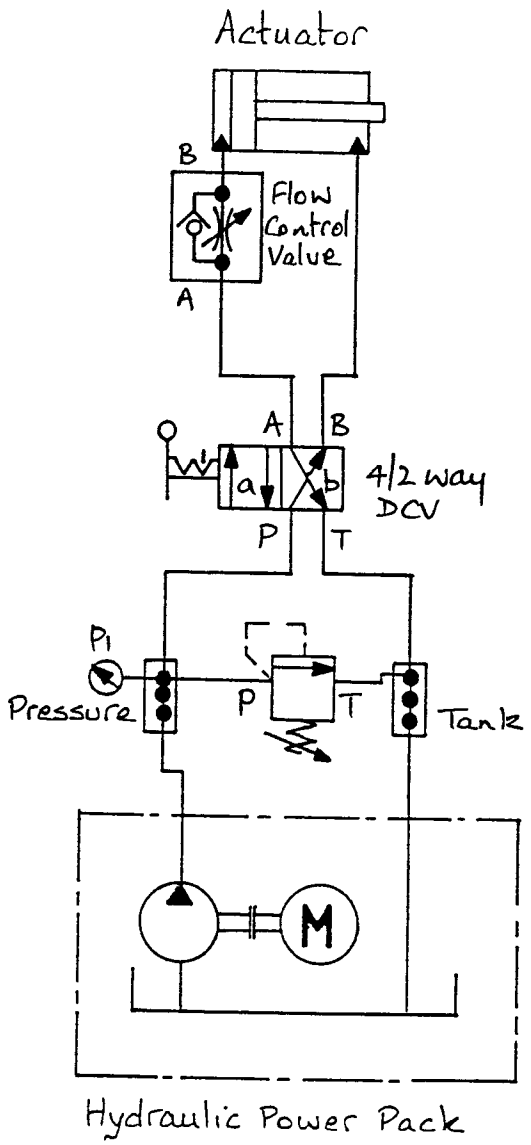
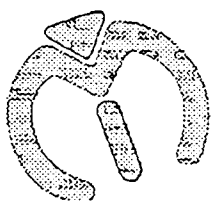


Exercise: Machine Feed (Metering 'In')





Exercise: Machine Feed (Metering 'In')

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, one way flow control valve, cylinder and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

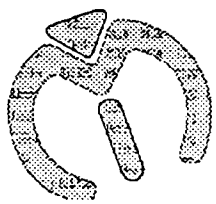
5 Operate the 4/2 directional control valve (DCV) to the position '**b**'.

6 Open the one way flow control valve by turning the adjuster anti-clockwise until it stops.

7 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

8 Using the 4/2 DCV to extend and retract the cylinder adjust the one way flow control valve clockwise in increments until the cylinder extending stroke takes fourteen (14) seconds to complete. Enter into the table below the information required.

Movement of piston	Flow directions	Pressure	Movement of the piston rod (time taken in seconds)
Extending			
Retracting			



Exercise: Machine Feed (Metering 'In')

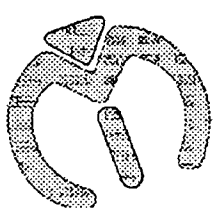
Operational Procedure - continued

9 Retract the cylinder and switch 'off' the hydraulic power pack.

10 Remove all hoses.

11 Compare your observations with the written circuit explanation.

12 Answer the questions for this exercise.

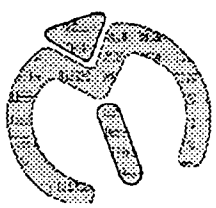


Exercise: Machine Feed (Metering 'In')

Circuit Explanation

The lever valve controlling the double acting cylinder is a 4/2 way directional control valve (DCV). In the 'at rest' condition the fluid supply to the valve at port **P** is transferred to port **B**, which in turn is connected to the front end of the cylinder. The connection from the rear of the cylinder is connected to port **B** of the flow control valve which in turn is connected to port **A** and **T** of the (DCV) and back to tank.

Upon operation of the 4/2 way lever valve, fluid flows from **P** to **A**, this allows fluid to enter the flow control valve at port **A** closing the check valve and therefore passing through the restrictor to port **B** and into the rear end of the cylinder. The piston and piston rod will now extend at the speed set by the flow control valve adjuster. When the lever valve is actuated to the **'b'** position the fluid supply at port **P** is now connecting port **B** directing the fluid to the front end of cylinder. The rear end of the cylinder is now connected to the **B** port of the flow control valve and to tank via port **A** and **T**, the cylinder is now free to retract to its retracted position, at normal speed.



Questions: Machine Feed (Metering 'In')

1) What does the term "Meter In" mean?

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2) List one disadvantage of "Metering In" when controlling the speed of an actuator?

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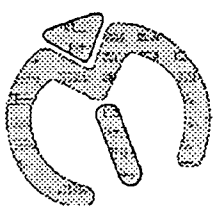
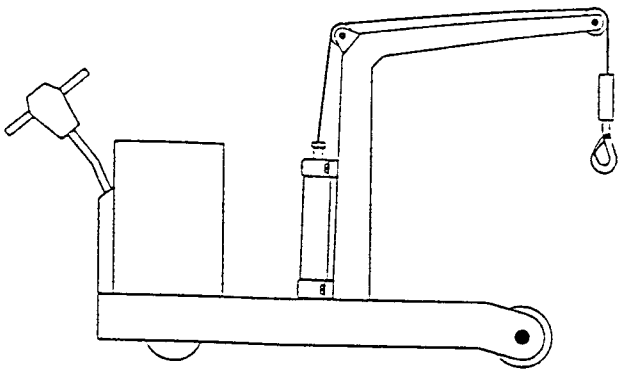
3) Draw the symbol according to ISO 1219-1 for a throttle check valve (one-way flow control valve):-



Exercise: Hydraulic Crane



Press tools are to be lifted for positioning into a power press by means of a small hydraulic crane. A double acting cylinder is used to perform the lifting and lowering tasks, with flow control valves being used to control the speed of the cylinder movement on both extend and retract strokes.

Equipment required

a) 1 off Double acting cylinder

b) 1 off 4/3 Way directional control valve

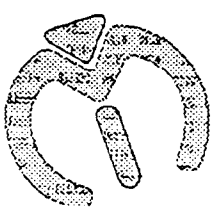
c) 2 off Flow control valve

d) 1 off Pressure relief valve

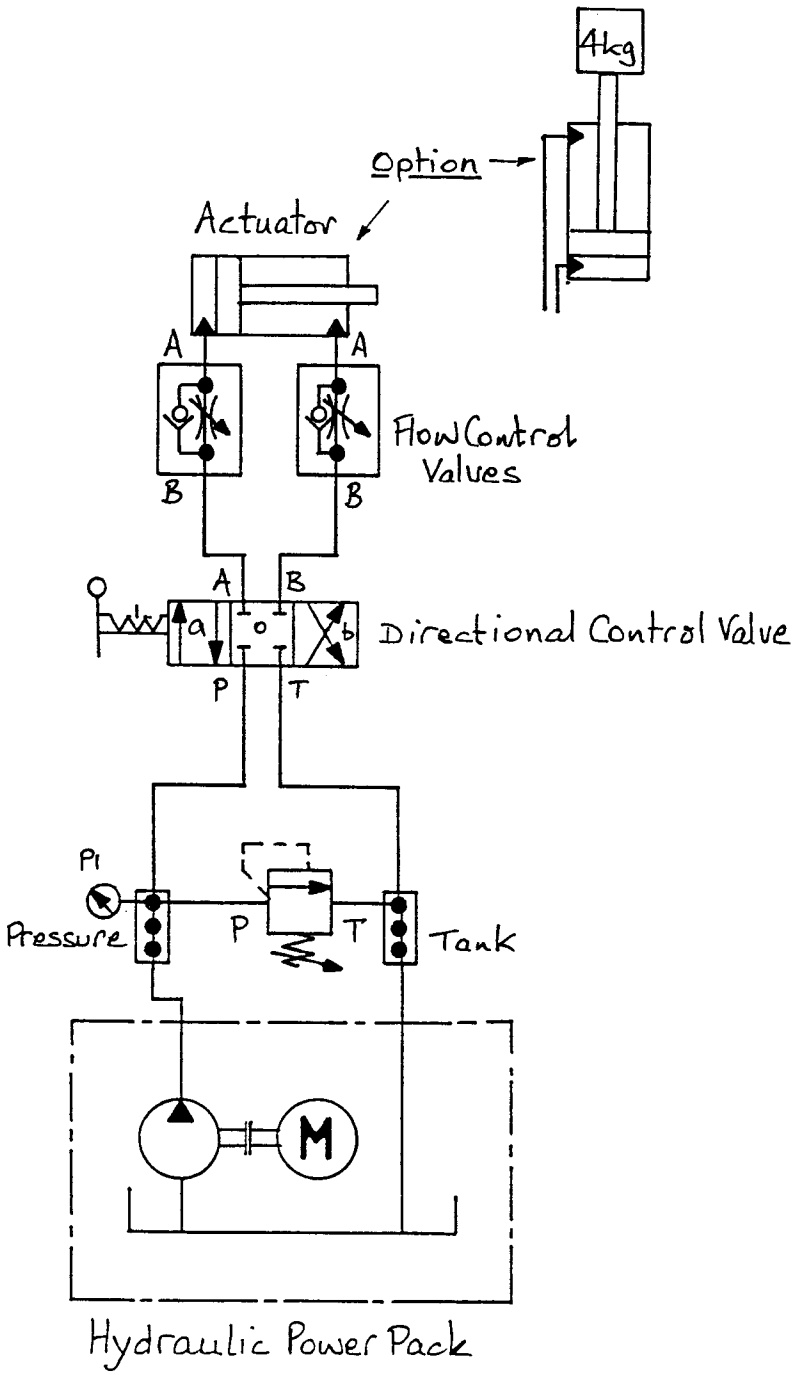
e) 1 off Distribution manifold pressure/tank

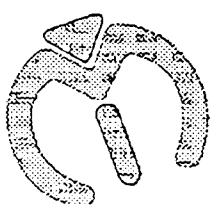
f) Connection hoses as required

Option) 4kg weight



Exercise: Hydraulic Crane





Exercise: Hydraulic Crane

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram connect hoses between the pressure manifold, 4/3 directional control valve, flow control valves, cylinder and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the 4/3 directional control valve (DCV) to the centre position '**o**'.

6 Open the one way flow control valves by turning the adjuster anti-clockwise until they stop.

7 Start the hydraulic power pack and adjust the pressure relief valve to a setting of 2.5 bar (36 psi).

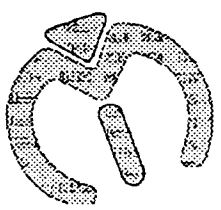
8 Use the 4/3 DCV to extend and retract the cylinder and adjust the two one way flow control valves clockwise in increments to achieve a cylinder extend and retract time of twelve (12) seconds.

9 Retract the cylinder and switch 'off' the hydraulic power pack.

10 Remove all hoses.

11 Compare your observations with the written circuit explanation.

12 Answer the questions for this exercise.



Exercise: Hydraulic Crane

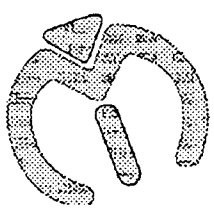
Circuit Explanation

The lever valve controlling the double acting cylinder is a 4/3 way closed centre directional control valve (DCV). In the 'at rest' condition with the valve in the centre position **'o'** all ports are blocked therefore the cylinder is held in the rear position.

Upon actuation of the lever valve to the **'a'** position the supply **P** is connected to the output **A** and the tank port **T** is connected to port **B**. This allows fluid to enter the rear end of the cylinder via port **B** across the check valve to port **A** of the flow control valve, the front end of the cylinder is now connected to tank **T** via port **A** of the flow control valve across the restrictor to port **B** then to port **B** of the directional control valve (DCV) and then to tank (**T**).

The piston and piston rod will now extend at a speed generated by the adjuster on the flow control valve connected to the front end of the cylinder. When the lever valve is actuated to position **'b'** the fluid supply at port **P** is now connecting to port **B** directing the fluid to the front end of the cylinder via the flow control valve, the rear end is now connected to the tank (**T**) via port **A**, the cylinder is now free to retract to its original position at a speed controlled by the flow control valve connected to the rear of the cylinder.

If while the cylinder is extending or retracting the lever valve is actuated to its centre position **'o'** the cylinder will stop at this point and will be hydraulically locked due to ports **A** and **B** being blocked. This type of valve will allow not only forward and reverse operation but also stop and inching facility.



Questions: Hydraulic Crane

1) What are the disadvantages of flow control valves?

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2) Identify the designated parts of the flow control valve shown below:-

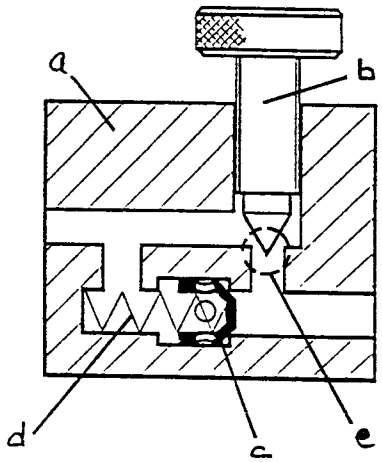
a) .....

b) .....

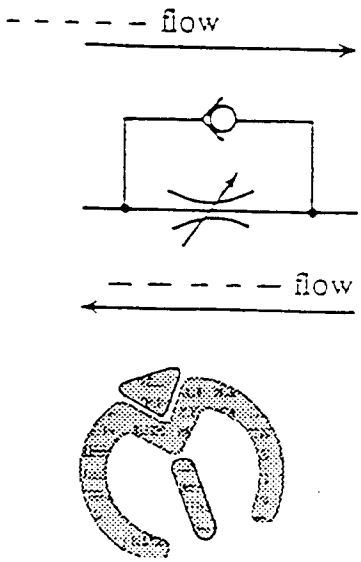
c) .....

d) .....

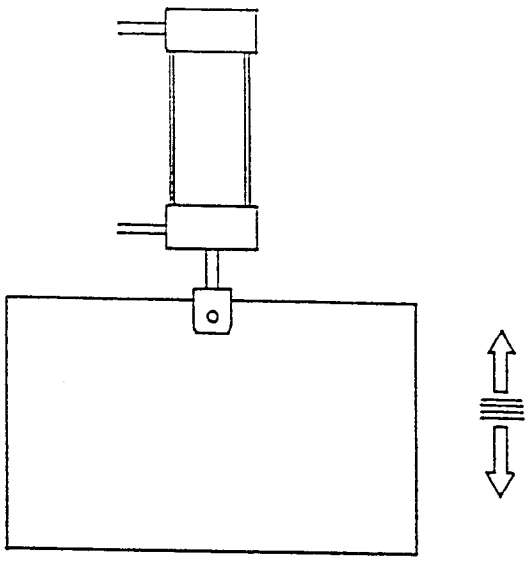
e) .....



3) Complete the wording on the graphical symbol below to show "free flow" and "controlled flow" through the valve:



Exercise: Door with Inching Facility



A double acting cylinder is used to open and close a door. It must be possible to move the door to any immediate position by means of an inching operation. The cylinder must be clamped hydraulically at all times that it is in an intermediate position.

Equipment Required

a) 1 off Double acting cylinder

b) 1 off 4/3 Way directional control valve

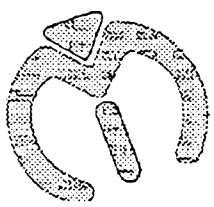
c) 1 off Pilot operated (P.O.) check valve

d) 1 off Pressure relief valve

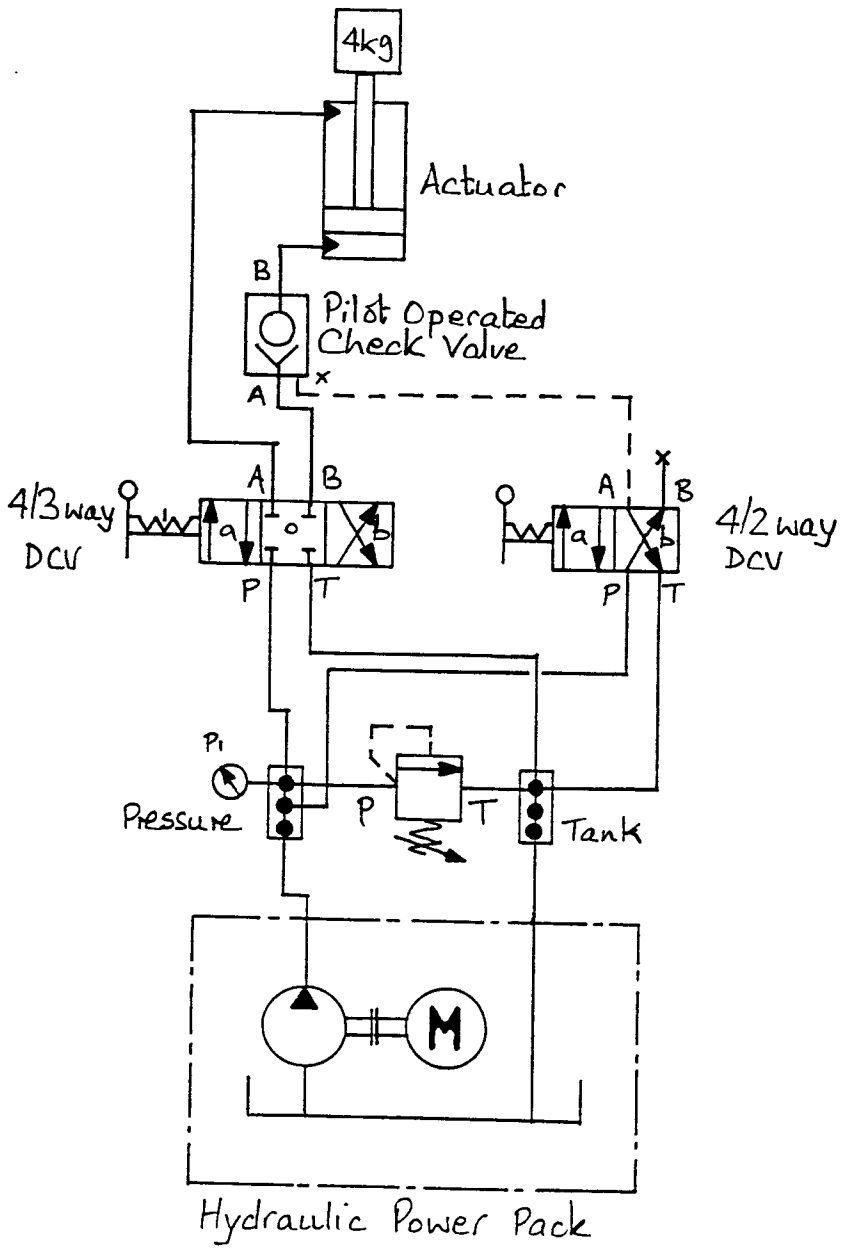
e) 1 off Distribution manifold pressure/tank

f) 1 off 4kg weight

g) Connection hoses as required.



Exercise: Door with Inching Facility



Exercise: Door with Inching Facility

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Remove the cylinder from its horizontal mounting clips and fully screw it into the vertical mounting flange.

4 Fit the 4kg weight to the top of the now vertical cylinder.

5 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, 4/2 directional control valve, pilot operated check valve, cylinder and the tank manifold.

6 Check the assembled circuit against the circuit diagram.

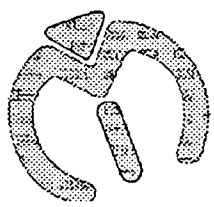
7 Start the hydraulic power pack and adjust the pressure relief valve to a setting of 2.5 bar (36 psi).

8 Operate the 4/3 directional control valve (DCV) to the position '**b**' in order to raise the weight (door). Now by changing the valve to the '**o**' position the cylinder is hydraulically locked.

9 With the 4/3 DCV in the '**a**' position the 4/2 DCV may be used to inch the door down by applying pressure to the '**x**' (signal) port of the pilot operated check valve.

10 Ensure that the cylinder is fully retracted, (weight fully lowered) and switch 'off' the hydraulic power pack, then remove all hoses.

11 Remove the weight and return the cylinder to the horizontal mounting clips.



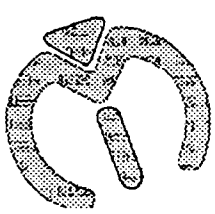
Exercise: Door with Inching Facility

Operational Procedure - continued

12 Compare your observations with the written circuit explanation.

13 Answer the questions for this exercise.

It should be noted that the 4/2 way DCV has one of its output ports blocked and it is therefore giving the function of a 3/2 way DCV, in this particular operation.



Exercise: Door with Inching Facility

Circuit Explanation

The lever valve controlling the double acting cylinder is a 4/3 closed centre directional control valve (DCV) valve, the second is a 4/2 directional control valve (DCV) which in this exercise is being used as a 3/2 valve. In the 'at rest' condition with the 4/3 (DCV) in the centre position **'o'** all ports are blocked therefore the cylinder is held in the retracted position. The 4/2 valve is in its position '**b**' with the port **P** blocked and port **A** connected to tank.

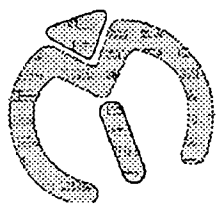
Upon actuation of the 4/3 lever valve to the '**b**' position the supply **P** is connected to the output **B** and the tank port **T** is connected to port **A**. This allows fluid to enter the rear end of the cylinder through the **P.O.** check valve and also allows the fluid in the front of the cylinder to return to tank **T**. The piston and piston rod will now extend raising the weight.

When the 4/3 (DCV) lever valve is actuated to the '**a**' position port **P** is now connected to port **A** and port **B** to tank (**T**). The cylinder will now try to retract but will be unable to because the fluid leaving the rear of the cylinder is blocked by the **P.O.** check valve therefore the cylinder is now hydraulically locked.

By actuating the 4/2 (DCV) to its '**a**' position port **P** is now connected to port **A** and port **B** is connected to **T**.

Pressure is now applied to the port '**X**' on the **P.O.** check valve thereby forcing the check valve open, fluid is now free to flow back to tank via ports **B** and '**T**' of the (DCV).

The cylinder is now free to retract to its original position. If while the cylinder is retracting the 4/2 (DCV) is operated to its '**b**' position the signal will be removed from the **P.O.** check valve and the cylinder will again become hydraulically locked. This operation provides the inching facility.



Questions: Door with Inching Facility

1) When does a pilot operated check valve allow fluid from **A** to **B**?

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.....

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2) When does a pilot operated check valve allow fluid from **B** to **A**?

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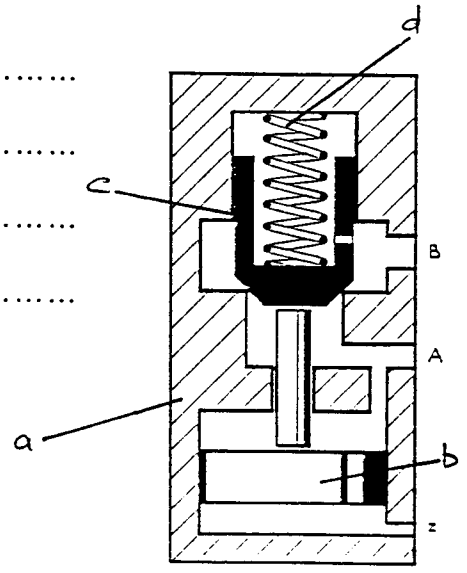
3) Name the main parts of the pilot operated check valve identified in the diagram below:

a) .....

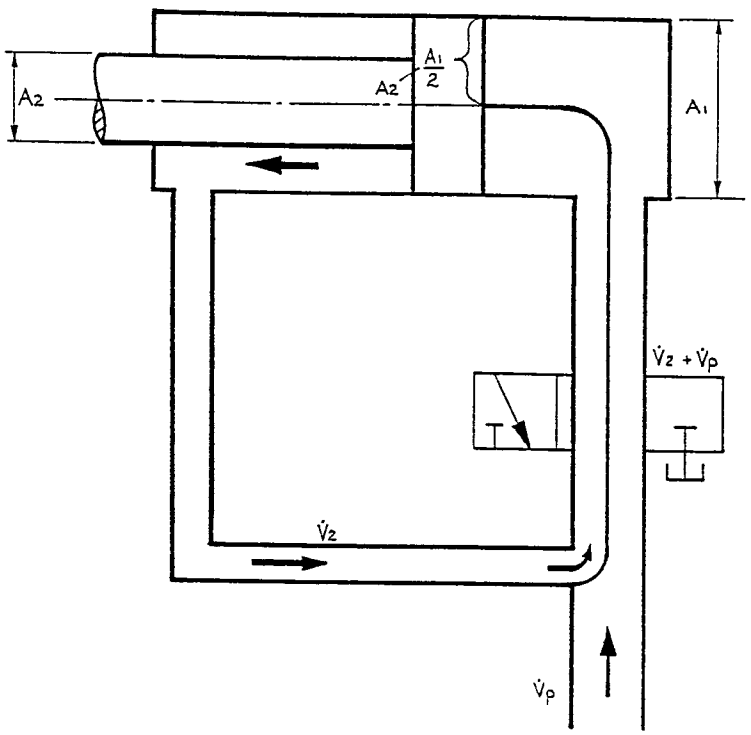
b) .....

c) .....

d) .....

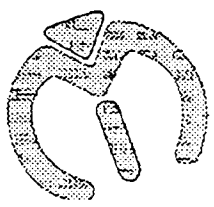


Regenerative Circuit

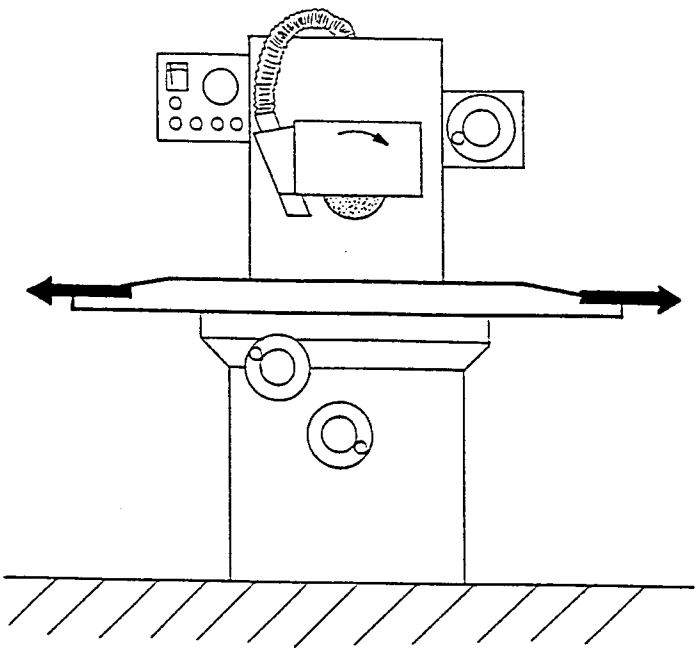


This type of circuit is used where the cylinder is of a 2:1 ratio (piston area twice that of the annulus area). When the cylinder is switched to the extend mode the volume of fluid from the front chamber of the cylinder will flow to the rear chamber of the cylinder and thereby supply 50% of the required volume, (if piston to annulus area is 2:1 then the front chamber is half the volume of the rear chamber). The remaining fluid required is fed from the pump.

With regenerative control of a 2:1 cylinder the extend and retract speeds are the same the extend and retract forces are the same.



Exercise: Surface Grinder Traverse



The longitudinal table of a surface grinder is to driven by means of a double acting cylinder. In order to produce the correct surface finish it is important that the speeds in both directions of table travel are the same.

Equipment Required

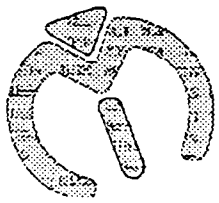
a) 1 off Double acting cylinder

b) 1 off 4/2 Way directional control valve

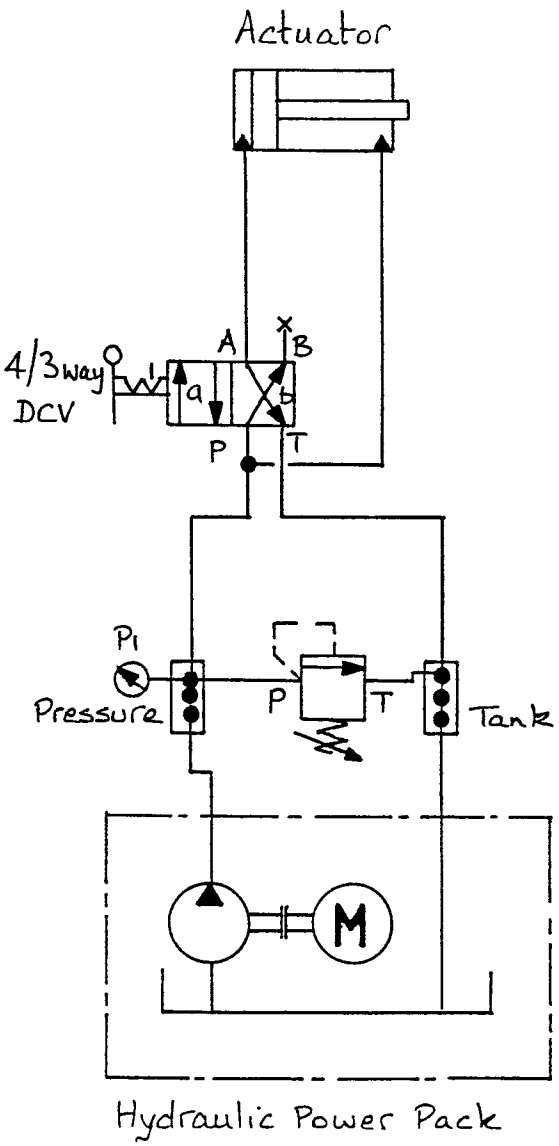
c) 1 off Pressure relief valve

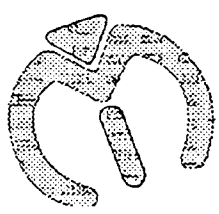
d) 1 off Distribution manifold pressure/tank

e) Connection hoses as required



Exercise: Surface Grinder Traverse





Exercise: Surface Grinder Traverse

Operational Procedure

1 Ensure that the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, cylinder, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

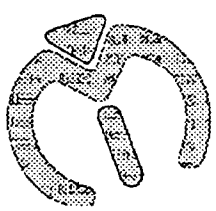
5 Start the hydraulic power pack and adjust the pressure relief valve to a setting of 2.5 bar (36 psi).

6 Operate the cylinder using the 4/2 directional control valve (DCV) and enter into the table below the information required.

Movement of Piston	Flow Directions	Pressure	Movement of the Piston Rod (time taken in seconds)
Extend			
Retract			

7 Retract the cylinder and switch 'off' the hydraulic power pack.

8 Remove all hoses.

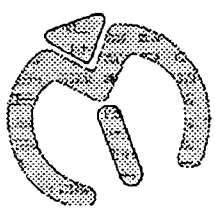


Exercise: Surface Grinder Traverse

Operational Procedure - continued

9 Compare your observations with the circuit explanation.

10 Answer the questions for this exercise.



Exercise: Surface Grinder Traverse

Circuit Explanation

In the 'at rest' condition the 4/2 way directional control valve (DCV) is in the '**b**' position, this allows any fluid in the rear chamber of the cylinder to flow back to tank, via ports **A** and **T** of the DCV. The pump flow is delivered to the front chamber of the cylinder, keeping it retracted.

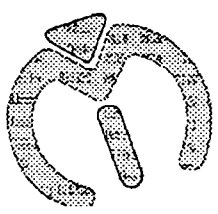
Upon switching the 4/2 way DCV to the '**a**' position the pump flow is directed into the rear of the cylinder, along with the fluid from the front chamber of the cylinder. The cylinder extends. When the valve is reselected to position '**b**' the pump flow goes to the front chamber of the cylinder, with the rear chamber of the cylinder connected to tank.

Note:

a) If the cylinder used in this application is a true 2:1 ratio (full piston area twice that of the piston less piston rod) then the extend and retract speeds would be the same.

b) The cylinder in the tutor case is not a 2:1 ratio and therefore it will not be possible to get the same speed in both directions.

c) In this circuit the DCV required is a 3/2 way, by using a 4/2 way with the port **B** blocked, this is equal to a 3/2 way normally closed (N/C).



Questions: Surface Grinder Traverse

1) What is the purpose of a 'regenerative' circuit, which utilises a 2:1 ratio double acting cylinder?

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.....

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2) What disadvantage is there when using regeneration?

.....

.....

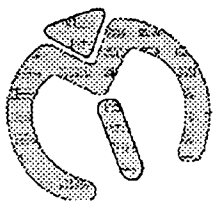
.....

3) In a regenerative circuit what is the relationship between the extend and retract speeds of the cylinder?

a) extend is greater ..... ☐

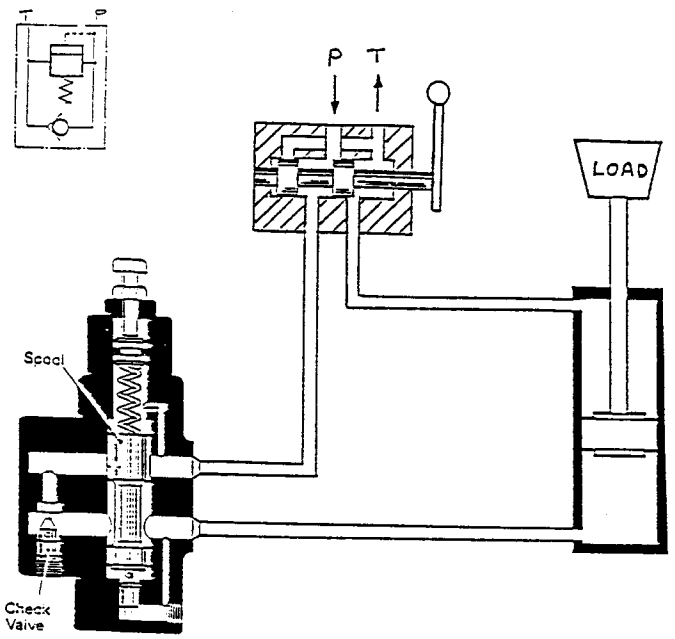
b) retract is greater ..... ☐

c) they are both the same ..... ☐



Counterbalance Valves

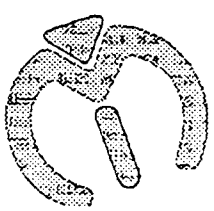
These are basically relief valves but used in a particular application to set up a back pressure in a circuit. They are frequently employed to 'counterbalance' a load as shown in the circuit below. Here the valve creates a back pressure to prevent the load running away when the cylinder is retracting. The usual pressure setting is 1.3 times the load induced pressure.



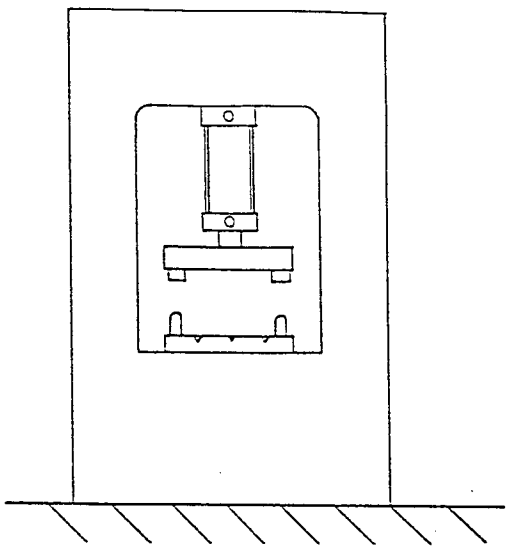
When raising the load fluid flow is to the cylinder through a check valve in the counterbalance valve. The hydraulic loads on the spool are balanced and it is held down by the spring.

When flow ceases the check valve closes and fluid is trapped on the rod side of the cylinder.

When fluid is fed to the head side of the piston to extend the cylinder it will intensify the pressure on the rod side of the cylinder piston. This is felt under the small piston, (of the counterbalance valve) below the main spool, which lifts the spool against the spring and allows fluid from the rod end of the cylinder to pass to the control valve and the return line.



Exercise: Press with Counterbalance



A large power press is to be raised and lowered by means of a double acting hydraulic cylinder. Due to the heavy weight of the tool the cylinder will break away on the down stroke. To overcome this problem a counterbalance valve is to be used, this will allow the tool to be lowered in a controlled mode.

Equipment Required

a) 1 off Double acting cylinder

b) 1 off 4/2 Way directional control valve

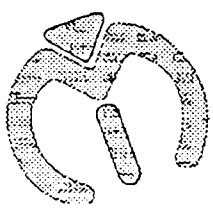
c) 1 off Counterbalance valve

d) 1 off Pressure relief valve

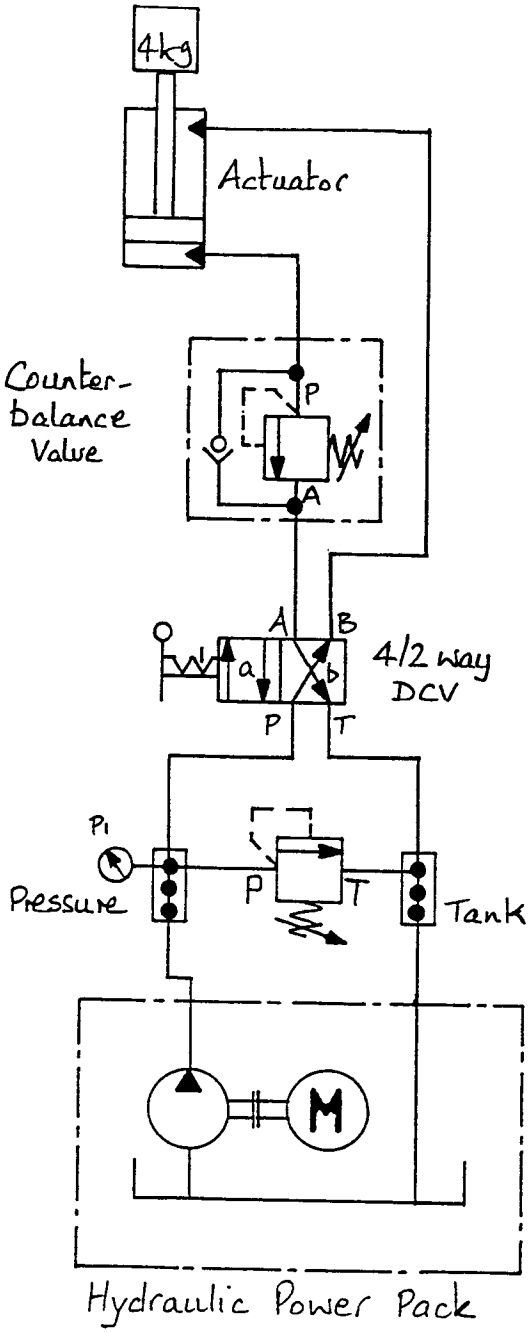
e) 1 off Distribution manifold pressure/tank

f) 1 off 4kg weight

g) Connection hoses as required



Exercise: Press with Counterbalance



Exercise: Press with Counterbalance

Operational Procedure

3 Ensure the hydraulic power pack is switched "off".

4 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

5 Remove the cylinder from its horizontal mounting clips and fully screw it into the vertical mounting flange.

6 Fit the 4kg weight to the top of the now vertical cylinder.

7 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, counterbalance valve, cylinder, and the tank manifold.

8 Adjust the counterbalance valve to its minimum pressure setting by turning the adjuster anti-clockwise until it stops (**note:** lift the white ring to unlock the adjuster).

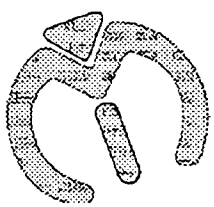
9 Check the assembled circuit against the circuit diagram.

10 Operate the cylinder using the 4/2 directional control valve (DCV) to the position '**b**'.

11 Start the hydraulic power pack and adjust the pressure relief valve to a setting of 2.5 bar (36 psi).

12 Operate the cylinder up and down several times, then whilst the weight is lowering switch 'off' the hydraulic power pack and observe what happens.

13 Now set the counterbalance valve to a high setting by turning the adjuster clockwise until it 'clicks'.



Exercise: Press with Counterbalance

Operational Procedure - continued

14 Restart the hydraulic power pack and using the 4/2 DCV, extend the cylinder.

15 Operate the 4/2 DCV to position '**b**' and adjust the counterbalance valve anti-clockwise in increments until the weight begins to lower.

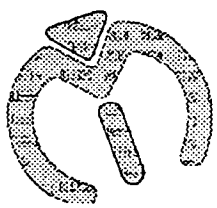
16 Operate the cylinder up and down several times, then whilst the weight is lowering switch 'off' the hydraulic power pack and again observe what happens.

17 Ensure that the cylinder is fully retracted, (weight fully lowered) and switch 'off' the hydraulic power pack, then remove all hoses.

18 Remove the weight and return the cylinder to the horizontal mounting clips.

19 Compare your observations with the written circuit explanation.

20 Answer the questions for this exercise.

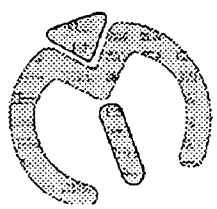


Exercise: Press with Counterbalance

Circuit Explanation

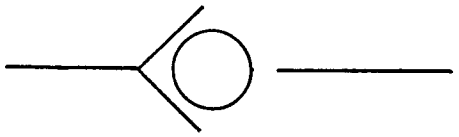
The lever valve controlling the double acting cylinder is a 4/2 way directional control valve (DCV). In the "at rest" condition the fluid supply to the valve is connected to the front end of the cylinder. The connection from the rear end of the cylinder is connected to port **P** of the counterbalance, which is transferred to port **A**, this is then connected to tank via port **A** and **T** of the 4/2 way DCV.

Upon actuation of the lever valve to the '**a**' position fluid is supplied to the rear of the cylinder via the check valve in the counterbalance valve. The piston and piston rod will now extend raising the weight. When the lever valve is actuated to position '**b**' fluid supply at port **P** is now connecting to port **B** directing fluid to the front end of the cylinder the rear end of the cylinder is now connected to the tank port via the counterbalance valve and the 4/2 way DCV, the cylinder will now retract applying pressure to port **P** of the counterbalance valve. When this pressure reaches the valves set valve it will open allowing the cylinder to retract lowering the weight.



Questions: Press with Counterbalance

1) Identify the valve shown and state its purpose in this exercise:



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2) What is the function of a counterbalance valve?

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3) Should the pressure setting on the counterbalance valve be slightly higher or lower than that required to hold the load and why?

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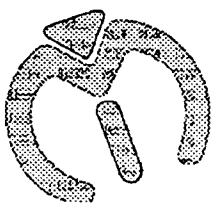
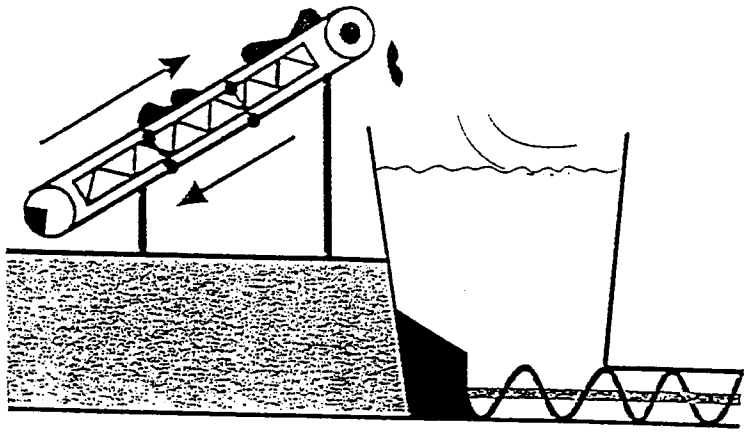


Exercise: Rolling Mill Conveyor



In a rolling mill, a roller conveyor is to be used to transfer raw material into a storage vessel. An hydraulic motor powers the conveyor. The conveyor speed must be adjustable.

Equipment Required

a) 1 off Hydraulic motor

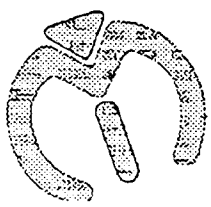
b) 1 off 4/2 Way directional control valve

c) 1 off Flow control valve

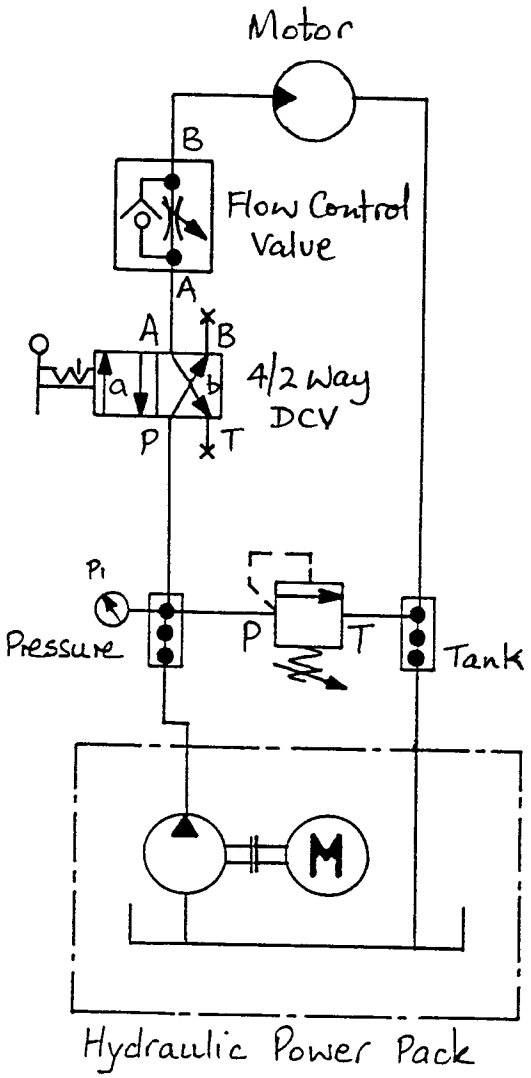
d) 1 off Pressure relief valve

e) 1 off Distribution manifold pressure/tank

f) Connection hoses as required



Exercise: Rolling Mill Conveyor



Exercise: Rolling Mill Conveyor

Operational Procedure

1 Ensure that the hydraulic power pack is switch "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, one way flow control valve, hydraulic motor, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the motor using the 4/2 directional control valve (DCV), (which in this exercise is used as a 2/2 DCV) to position '**b**'.

6 Open the one way flow control valve by turning the adjuster anti-clockwise until it stops.

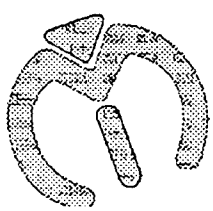
7 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

8 Operate the 2/2 DCV to position '**a**' to start the motor rotating and adjust the one way flow control valve clockwise in increments to produce a rotational speed of the motor of 60 revolutions per minute (rpm).

9 Switch 'off' the hydraulic power pack and remove all hoses.

10 Compare your observations with the written circuit explanation.

11 Answer the questions for this exercise.



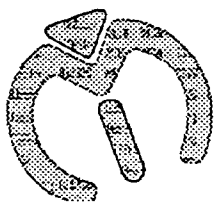
Exercise: Rolling Mill Conveyor

Circuit Explanation

The lever valve controlling the motor is a 4/2 way directional control valve (DCV), which in this exercise is being used as a 2/2 way DCV. In the "at rest" condition with the 2/2 DCV in position '**b**' port **P** is blocked and therefore the motor is stationary.

Upon actuation of the lever valve to the '**a**' position the supply **P** is connected to port **A** directing fluid to the flow control valve (port **A**), fluid entering the flow control valve closes the check valve and is directed through the valve to the input of the motor. The motor will rotate passing fluid across it, which is then returned to tank. When the flow through the flow control valve is adjusted, the speed of the motor rotation will be varied.

Actuation of the 2/2 lever valve to the '**b**' position will stop the motor rotating. The flow control valve is set to "meter in" with this circuit diagram.



Questions: Rolling Mill Conveyor

1) List three (3) types of hydraulic motor (by design, not brand):

   a) .....

   b) .....

   c) .....

2) What is the difference between an hydraulic motor and an hydraulic pump?

   .....

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   .....

3) Why do hydraulic motors have leakage ports?

   .....

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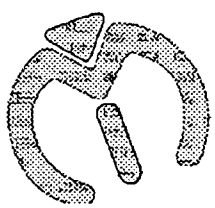
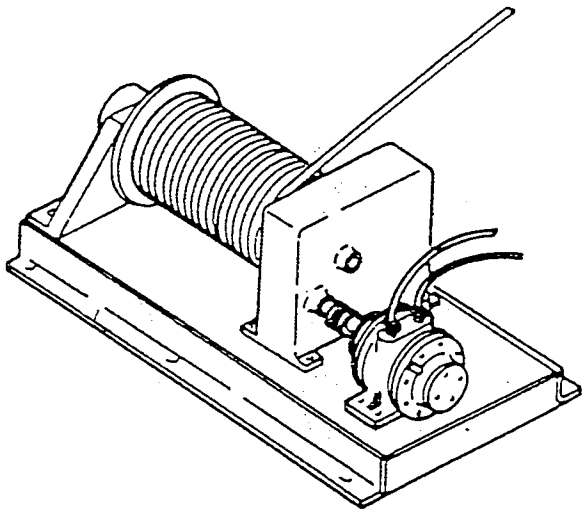


Exercise: Power Winch



A power winch is to be driven by means of a bi-directional hydraulic motor, the rotation speed of the motor is to be controllable (adjustable) in both directions of travel.

Equipment Required

a) 1 off Motor

b) 1 off 4/3 Way directional control valve

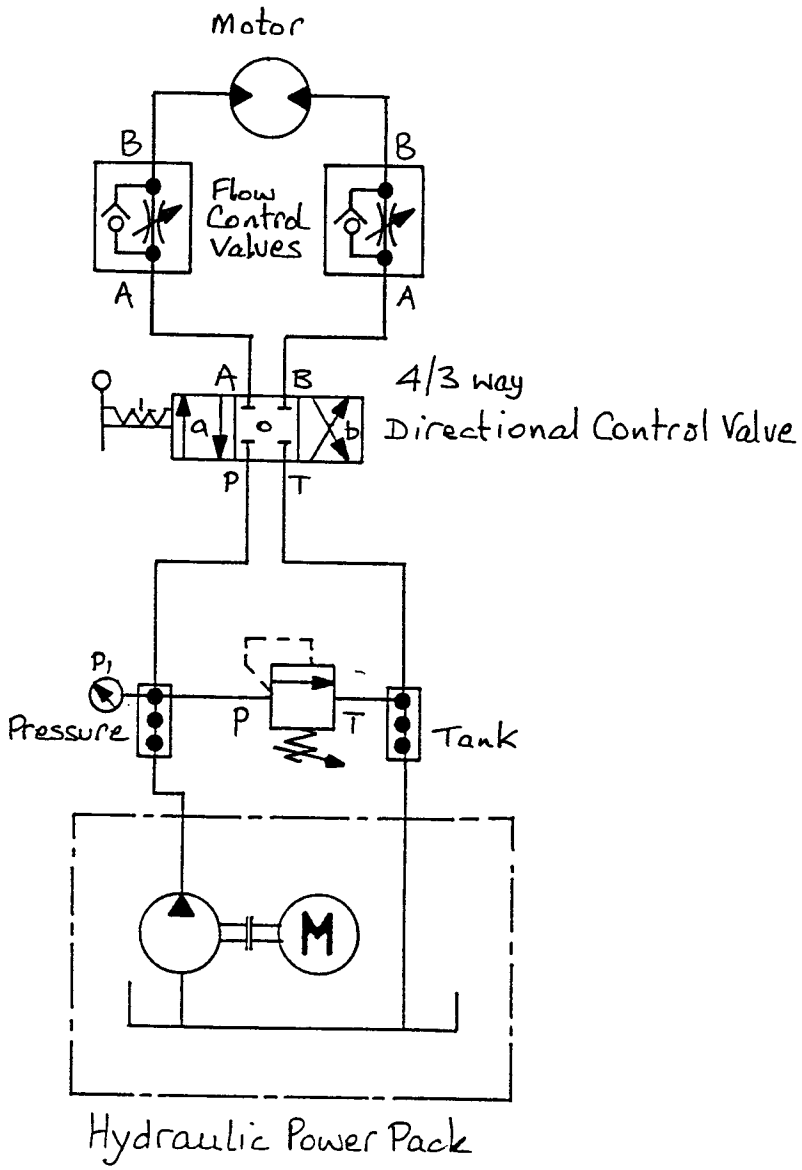
c) 2 off Flow control valve

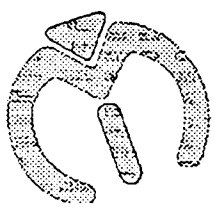
d) 1 off Pressure relief valve

e) 1 off Distribution manifold pressure/tank

f) Connection hoses as required

Exercise: Power Winch





Exercise: Power Winch

Operational Procedure

1 Ensure the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/3 directional control valve, one way flow control valves, bi-directional motor, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Operate the motor using the 4/3 directional control valve (DCV) to the centre position **'o'**. Start the hydraulic power pack and adjust the pressure relief valve to a setting of 2.5 bar (36 psi).

6 Open the one way flow control valves by turning the adjuster anti-clockwise until it stops.

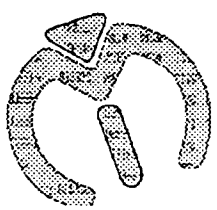
7 Use the 4/3 DCV to rotate the motor clockwise and anti clockwise and adjust the two one way flow control valves clockwise in increments to achieve a rotational speed clockwise of sixty (60) revs per minute (rpm) and anti - clockwise 100 rpm.

8 Stop the motor and switch of the hydraulic power pack.

9 Remove all hoses.

10 Compare your observations with the written circuit explanation.

11 Answer the questions for this exercise.



Exercise: Power Winch

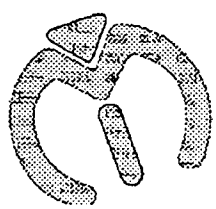
Circuit Explanation

When the circuit is in the 'at rest' position the 4/3 directional control valve (DCV) is in its mid-position, with all ports closed. There is no fluid flowing through the circuit and the motor will not rotate.

If the 4/3 way DCV is selected to its '**a**' position fluid flows from **P** to **A** through the left hand flow control valve into the motor. This left hand flow control valve will dictate the rotational speed of the motor (Metering 'In'). The motor rotates anti-clockwise, the fluid passing across it goes back to tank, via the right hand flow control valve (through the by-pass), and ports **B** to **T** of the 4/3 way DCV .

By reversing the 4/3 way DCV to position '**b**' the motor reverses (clockwise) and the rotational speed is now controlled by the right hand flow control valve.

Both flow control valves are set to Meter 'In' according to the circuit diagram.



Questions: Power Winch

1) Which of the following statements is correct?

☐ The speed of an hydraulic motor is determined by the pressure of the fluid.

☐ The speed of an hydraulic motor is determined by the flow rate of the fluid flowing through it.

2) How is the direction of rotation for an hydraulic motor reversed?

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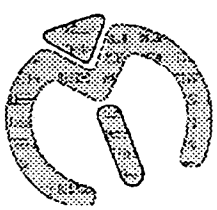
3) List three (3) advantages of an hydraulic motor over a conventional electric motor:

i) .....

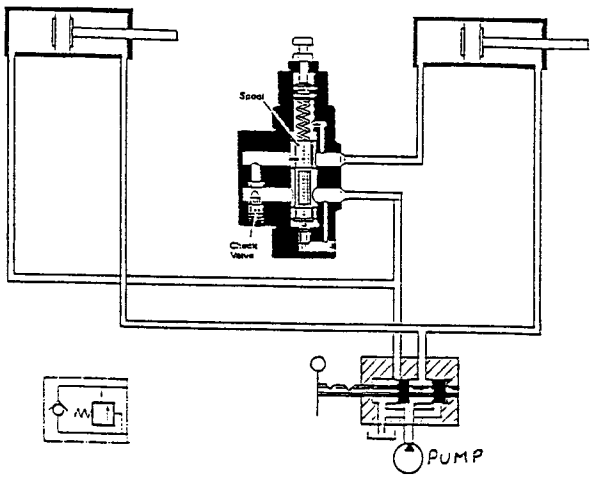
ii) .....

iii) .....



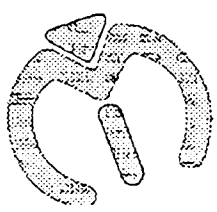
Pressure Sequence Valves

Sequence valves sense a change in pressure in a system and transmit a hydraulic signal when the set pressure has been reached. The valve may be normally open or normally closed, changing state when the system reaches the set pressure. They may also be used to assure priority hydraulic pressure in one system before another can operate.

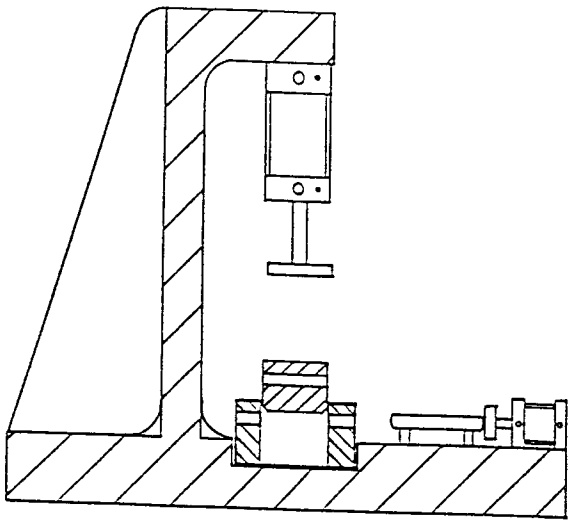


An important feature of all sequence valves is a separate drain connection from the spring chamber. This because unlike a conventional relief valve a high pressure can occur in the output port during the normal course of operation. Should it be internally drained any pressure in the output port will be reflected back into the spring chamber causing malfunction. In fact a sequence valve may be used as a relief valve in any circuit where excessive back pressures are encountered in the return line. The independently drained pilot makes sequence valves insensitive to downstream back pressure.

A normally closed sequence valve with integral reverse flow check valve is shown above together with an established application which is to sense that a component has been clamped before initiating the next stage in a 'sequence' of operations. When the component is unclamped the pressure falls and the sequence valve closes. The check valve prevents the signal being trapped and allows it to decay back past the sequence valve poppet.



Exercise: Press and Clamp



Components are to be assembled on a clamp and press fixture, a bush is to be pressed into a collar and then held while a dowel is inserted. The first cylinder will extend and push the bush into the collar and only when sufficient pressure has built up in the system (to signify that the bush has been pushed fully home) will the second cylinder extend and push the dowel into the assembly to retain the bush within the collar. Both cylinders may retract together.

Equipment Required

a) 2 off Double acting cylinder

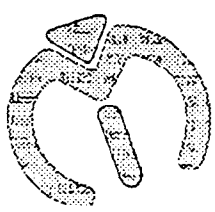
b) 1 off Pressure sequence valve

c) 1 off 4/2 Way directional control valve

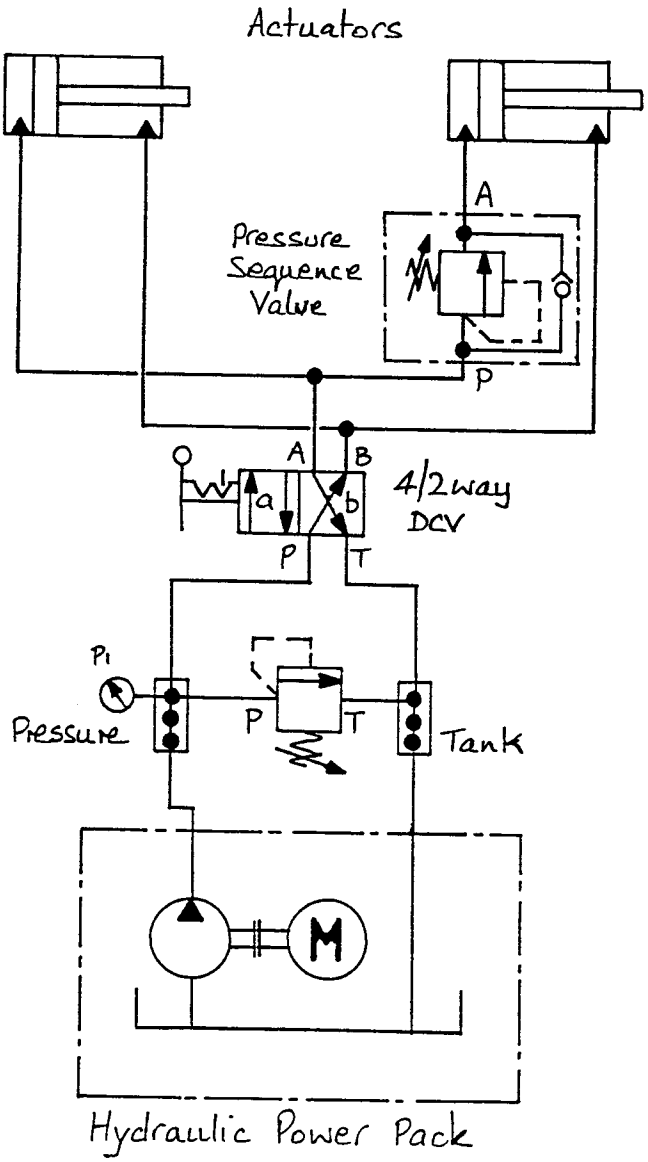
d) 1 off Pressure relief valve

e) 1 off Distribution manifold pressure/tank

f) Connection hoses as required



Exercise: Press and Clamp



Exercise: Press and Clamp

Operational Procedure

1 Ensure the hydraulic power pack is switched "off".

2 Connect the "pressure feed" and "tank return" hoses on the hydraulic power pack to the 'pressure' and 'tank' manifolds in the tutor case.

3 Following the circuit diagram, connect hoses between the pressure manifold, 4/2 directional control valve, sequence valve, cylinders, and the tank manifold.

4 Check the assembled circuit against the circuit diagram.

5 Adjust the sequence valve to a high setting by turning the adjuster clockwise (**note**: lift the white ring to unlock the adjuster). Operate the 4/2 directional control valve to position '**b**'.

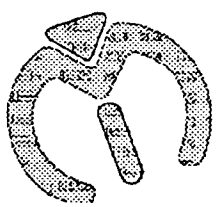
6 Start the hydraulic power pack and adjust the pressure relief valve setting to 2.5 bar (36 psi).

7 Operate the 4/2 directional control valve (DCV) to '**a**' to extend the first cylinder, now adjust the sequence valve anti-clockwise until the second cylinder extends. The operating sequence is now set.

8 Use the 4/2 DCV to extend and retract the cylinders and observe their operation.

9 Retract both cylinders and switch 'off' the hydraulic power pack.

10 Remove all the hoses.

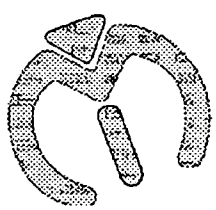


Exercise: Press and Clamp

Operational Procedure - continued

11 Compare your observations with the written circuit explanation.

12 Answer the questions for this exercise.



Exercise: Press and Clamp

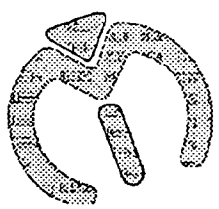
Circuit Explanation

In the 'at rest' condition of the circuit the 4/2 way directional control valve (DCV) is in its '**b**' position with port **P** connected to **B** and port **A** connected to **T**. The pump flow is therefore fed to the front chambers of both cylinders with the rear chambers of both cylinders connected back to tank. Both cylinders are retracted.

Once the 4/2 way DCV is selected to position '**a**' the pump flow is diverted to output **A**, which feeds the rear chambers of both cylinders, the front chambers are connected, via port **B**, back to tank.

The right hand cylinder will not extend straight away, due to the pressure relief (sequence) valve. Firstly the left hand cylinder will extend and only when the pressure in this part of the system is sufficient, will the pressure relief valve open and allow flow to the rear chamber of the right hand cylinder, which now extends. The operation is therefore 'sequential'.

When the 4/2 way DCV is re-selected to its '**b**' position, it is required that both cylinders retract together (not sequentially) and this is achieved by means of the by-pass check valve, fitted in parallel with the pressure relief valve. Fluid flows from port **B** of the DCV to the front chambers of both cylinders, the rear chambers of both cylinders are open to tank via port **A** of the DCV (and in the case of the right hand cylinder, also the by-pass check valve).



Questions: Press and Clamp

1) To what family of valves to 'sequence' valves belong?

.....

.....

.....

2) What does a 'sequence' valve consist of?

.....

.....

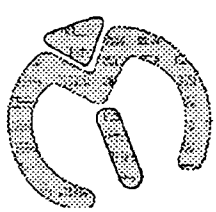
.....

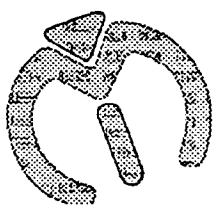
3) Is a sequence valve normally open (N/O) or normally closed (N/C)?

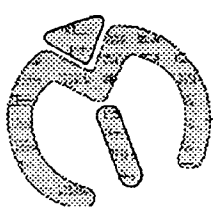
.....

.....

.....

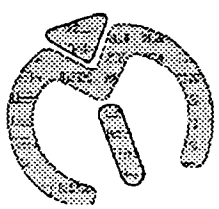






Section 6

Answers to Question Papers

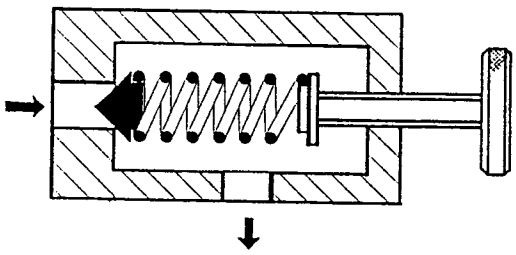


Answers: Function Test on a Pressure Relief Valve

1) Pressure relief valves are used for what purpose/s?

To determine and control the maximum safe working pressure in the circuit/ system, thereby protecting the pump from overpressure.

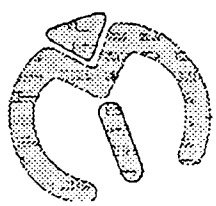
2) Describe the function of the direct operated pressure relief valve, illustrated below:



As the pressure develops in the circuit/system, the rising pressure at port 'P' causes the poppet to be forced off its seat against the spring, this allows the excess pressure to be relieved through port 'T' of the valve and back to tank.

3) Where in the hydraulic circuit should the pressure relief valve/s be fitted?

It should be the first component after the pump; <u>additional</u> pressure relief valves may be fitted elsewhere in the circuit to protect other components.

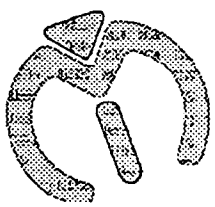


Answers: Directional Control Valve

Operational Procedure

	1	2	3	4	5	6	7	8
4/2 way directional control valve (condition)	**b**	b	b	b	a	a	a	a
4/2 way flow direction	**P→B A→T**	P→B A→T	P→B A→T	P→B A→T	P→A B→T	P→A B→T	P→A B→T	P→A B→T
2/2 way directional control valve (condition)	**b**	a	b	a	b	a	b	a
2/2 way flow direction	**P→ A Closed**	P→ A Open	P→ A Closed	P→ A Open	P→A Closed	P → A Open	P → A Closed	P → A Open
3/2 way directional control valve (condition)	**b**	b	a	a	b	b	a	a
3/2 way flow direction	**P→A Closed A → T Open**	P→ A Closed A → T Open	P→A Open A → T Closed	P→ A Open A → T Closed	P→ A Closed A → T Open	P→ A Closed A → T Open	P→ A Open A → T Closed	P→ A Open A → T Closed
Flow from	**T1 T2**	T1 T2	T1 T2	T1 T2	T1 T2	T1 T2	T1 T2	T1 T2
Yes/No	No No	No No	No Yes	No Yes	No No	Yes No	No No	Yes No

↑
example

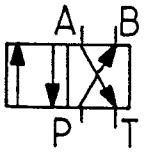


Answers: Directional Control Valves

1) 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.

2) Draw the symbol (to I.S.O. 1219-1) for a 4/2 way directional control valve:

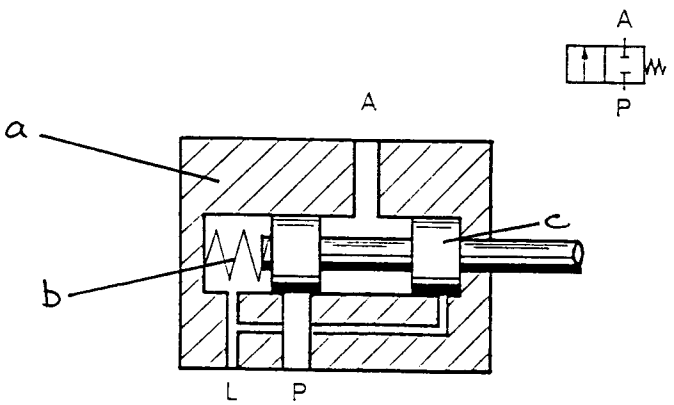


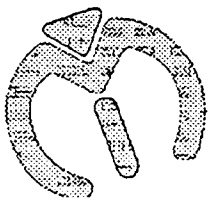
3) Name the three functional parts (a-c) of the directional control valve illustrated below:

a) **Valve body**

b) **Control spring**

c) **Spool**





Answers: Function Test on a One Way Flow Control Valve

1) The one way flow control valve is a combination of two (2) components, name them:

c) Throttle valve

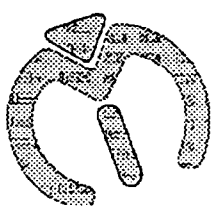
d) Check valve (in by-pass)

2) Which direction of fluid flow is "free flow" on the flow control valve?

B → A

3) Which direction of fluid flow is "controlled (throttled)" on the flow control valve?

A → B



Answers: Function Test on a Check Valve

1) Give another names for a check valve:

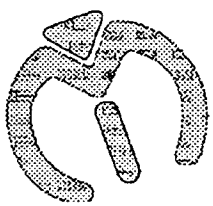
Non- return valve

2) What is the term given to the 'pressure' required to start to open a check valve?

Cracking pressure

3) What is the function of a check valve?

To allow flow to take place in one (1) direction only



Answers: Function Test on a Pilot Operated Check Valve

1) On the P.O. check valve in the tutor case, does the pilot open or close the check valve?

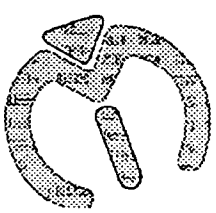
Open

2) The line from port **A** of the 4/2 way DCV to the P.O. check valve is a dashed line, why?

Because it is a 'pilot' line

3) Whenever using a check valve in a circuit, what must we be aware of?

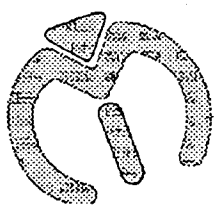
The potential to trap fluid in a certain part of a circuit and possibly create "pressure intensification"



Answers: Door Operation

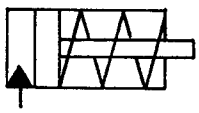
Operational Procedure

Weight condition	Spool position	Flow directions	P1
Raising	a	P → A B → T	2.2
Lowering	b	P → B A → T	2.2
Piston fully retracted	b	P → B A → T	2.5
Piston fully Extended	a	P → A B → T	2.5



Answers: Door Operation

1) Draw the symbol, for a single acting cylinder, with spring return, according to the I.S.O. 1219-1 standard:

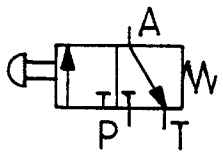


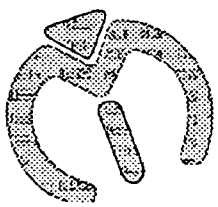
2) List two (2) disadvantages of a single acting cylinder, with spring return:

i) Extra force is required to overcome the spring.

ii) The cylinder is physically longer to accommodate the return spring when it is compressed.

3) Draw the symbol for a 3/2 way N/C push button operated, spring return valve, according to the I.S.O. 1219-1 standard:

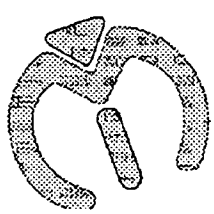




Answers: Lift Table

Operational Procedure

Movement of Piston Rod	Spool Position	Flow Directions	P1
Forward	a	P → A B → T	
Return	b	P → B A → T	



Answers: Lift Table

1) What do the letters P, T, A, and B marked upon ports of the hydraulic valves represent?

P = **Pressure (supply) port**

T = **Tank (return) port**

A & B = **Output (service) ports**

2) List five (5) methods of operating a spool valve:

i) **Manual lever**

ii) **Electrical (solenoid)**

iii) **Mechanical (cam/roller)**

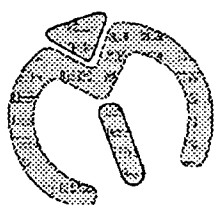
iv) **Hydraulic pilot**

v) **Pneumatic pilot**

3) With a standard double acting cylinder more force is created as the piston extends than when it retracts (in application without pressure control), why is this?

Force is a product of pressure x area.

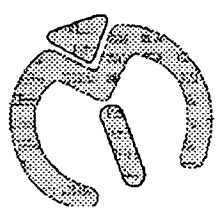
When the cylinder extends the pressure is applied to the full face of the piston but on retracting it is only applied to the area of the piston less the area of the piston rod, this being a smaller area will result in a lower force, therefore the extend force is higher than the retract force.



Answers: Door Hopper Control

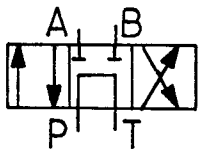
Operational Procedure

Cylinder	P1	4/3 way DCV flow directions	4/3 way DCV position
Extending	2.2	P → A B → T	a
Stopped Mid position	2.5	P → A → B → T Blocked	o
Retracting	2.2	P → B A → T	b



Answers: Door Hopper Control

1) What advantage does the 4/3 way directional control valve (shown below) provide when the centre position **'o'** is selected?



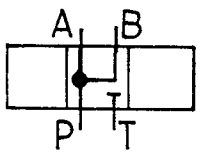
The pump flow is directed back to tank, at low pressure, this results in less heat build-up and therefore is energy saving method.

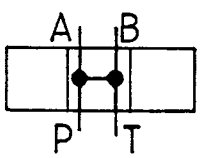
However it should be noted that this type of 4/3 way valve cannot be used in all applications.

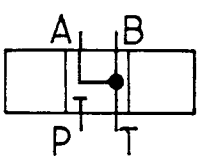
2) With a standard double acting cylinder the piston retracts at a greater speed than it extends (in an application without speed control), what is it that causes this?

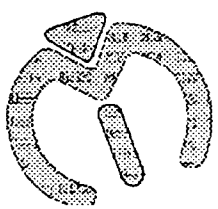
When retracting, the volume of the front chamber of the cylinder is smaller due to the volume taken up by the piston rod and this smaller volume can be filled quicker, therefore retract speed is faster than extend.

3) The 4/3 way DCV's used in this exercise have different centre conditions, complete the three symbols shown below, showing three other versions of centre conditions:-





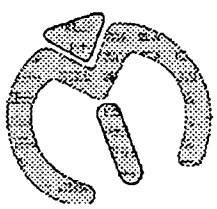




Answers: Machine Feed (Metering 'Out')

Operational Procedure

Movement of piston	Flow directions	Pressure	Movement of the piston rod (time taken in seconds)
Extending	P → A B → T	2.5	14
Retracting	P → B A → T	2.4	5



Answers: Machine Feed (Metering 'Out')

1) What is the function of a flow control valve?

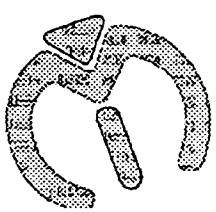
To throttle flow and slow down the operation of a cylinder.

2) What does the term "Meter Out" mean?

Regulating the speed of an actuator by controlling the amount of fluid leaving the actuator.

3) List one (1) disadvantage of "Metering Out" when controlling the speed of a cylinder: -

Metering out can create a back pressure on the piston front end, which requires additional pressure at piston rear end.



Answers: Machine Feed (Metering 'In')

Operational Procedure

Movement of piston	Flow directions	Pressure	Movement of the piston rod (time taken in seconds)
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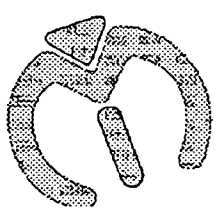


Answers: Machine Feed (Metering 'In')

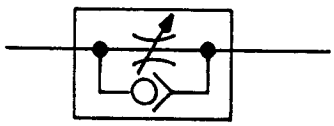
1) What does the term "Meter In" mean?

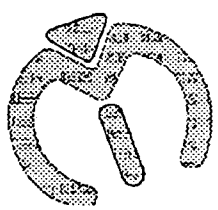
Regulating the speed of an actuator by controlling the amount of fluid entering the actuator.

2) List one disadvantage of "Metering In" when controlling the speed of an actuator?

If "Meter In" was used to try to control the speed to a cylinder that had a heavy load attached, the load would descend uncontrolled.

3) Draw the symbol according to ISO 1219-1 for a throttle check valve (one-way flow control valve):-





Answers: Hydraulic Crane

1) What are the disadvantages of flow control valves?

When the cylinder/s operate at reduced speed/s a lower flow rate (volume) of fluid is required and therefore the excess pump displacement is passed across the pressure relief valve, creating heat and wasting energy.

2) Identify the designated parts of the flow control valve shown below:-

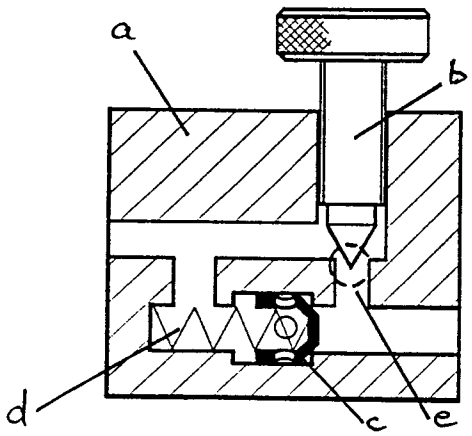
a) Valve body

b) Needle valve

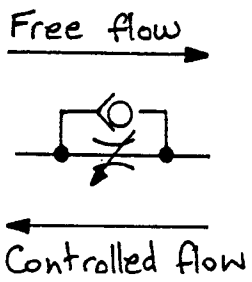
c) Check valve poppet

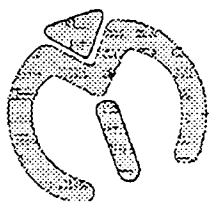
d) Check valve spring

e) Throttle orifice



3) Complete the wording on the graphical symbol below to show "free flow" and "controlled flow" through the valve:





Answers: Door with Inching Facility

1) When does a pilot operated check valve allow fluid from **A** to **B**?

When a pressure is applied to port 'A'.

2) When does a pilot operated check valve allow fluid from **B** to **A**?

When a pressure (signal) is applied to port 'X'.

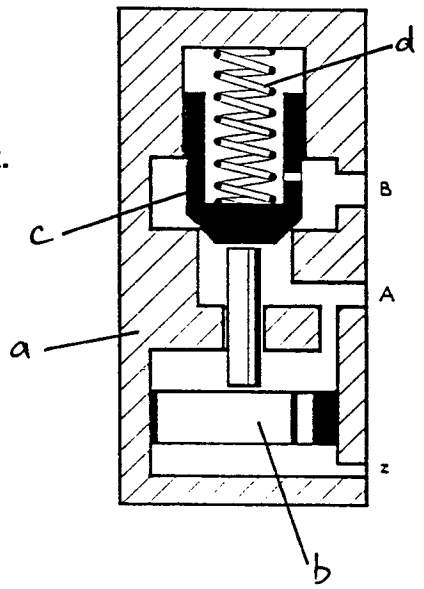
3) Name the main parts of the pilot operated check valve identified in the diagram below:

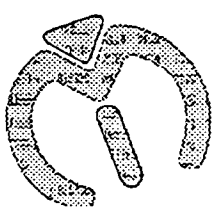
a) **Valve Body.**

b) **Pilot Piston.**

c) **Main Check Valve Poppet.**

d) **Poppet Spring.**





Answers: Surface Grinder Traverse

1) What is the purpose of a 'regenerative' circuit, which utilises a 2:1 ratio double acting cylinder?

To achieve the same speed on both extend and retract strokes of the cylinder.

2) What disadvantage is there when using regeneration?

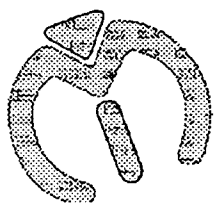
The pushing force on the extend stroke is diminished by the back pressure acting upon the annulus side of the piston.

3) In a regenerative circuit what is the relationship between the extend and retract speeds of the cylinder?

a) extend is greater ..... ☐

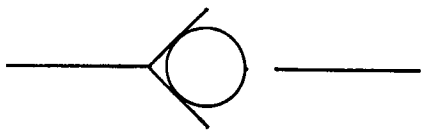
b) retract is greater ..... ☐

c) they are both the same ..... ☑



Answers: Press with Counterbalance

1) Identify the valve shown and state its purpose in this exercise:



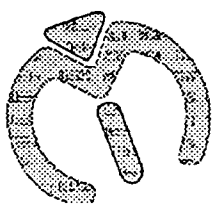
A non-return valve (or check valve). Its purpose in this exercise is to open and by-pass the counterbalance valve when requiring to raise the piston and load and to close when the load is being lowered so that the fluid flow is only across the counterbalance valve.

2) What is the function of a counterbalance valve?

A counterbalance valve is used to create a back pressure in a circuit to prevent a load running away whilst being raised or lowered.

3) Should the pressure setting on the counterbalance valve be slightly higher or lower than that required to hold the load and why?

Higher – the usual pressure setting is 3o% higher than the load induced pressure.



Answers: Rolling Mill Conveyor

1) List three (3) types of hydraulic motor (by design, not brand):

   a) Gear.

   b) Vane.

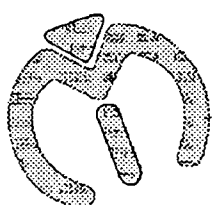
   c) Piston.

2) What is the difference between an hydraulic motor and an hydraulic pump?

   An hydraulic motor takes in fluid from the system and converts hydraulic energy into mechanical energy, whereas a pump displaces fluid into the system and converts electrical energy into hydraulic energy.

3) Why do hydraulic motors have leakage ports?

   To prevent an internal build up of pressure that would cause damage to the motor if it was not allowed to drain back to tank.



Answers: Power Winch

1) Which of the following statements is correct?

☐ The speed of an hydraulic motor is determined by the pressure of the fluid.

☑ The speed of an hydraulic motor is determined by the flow rate of the fluid flowing through it.

2) How is the direction of rotation for an hydraulic motor reversed?

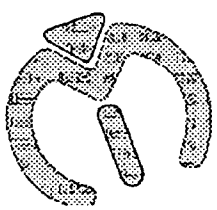
By reversing the direction of fluid flow through the motor (this is achieved by switching the directional control valve controlling the motor).

3) List three (3) advantages of an hydraulic motor over a conventional electric motor:

i) Instantly reversible.

ii) High power to weight ratio.

iii) Simple to control.



Answers: Press and Clamp

1) To what family of valves to 'sequence' valves belong?

Pressure control.

2) What does a 'sequence' valve consist of?

Pressure relief valve.

By-pass with check valve.

3) Is a sequence valve normally open (N/O) or normally closed (N/C)?

Normally closed (N/C).