

Section

8000

How to Read Symbols in a Hydraulic Schematic

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HOW TO READ SYMBOLS IN A HYDRAULIC SCHEMATIC

Introduction

Accurate diagrams of hydraulic circuits are essential to the man who must repair them. The diagram shows how the components will interact. It shows the field technician how it works, what each component should be doing and where the oil should be going so that he can diagnose and repair the system.

The purpose of this section is to show you how to find your way around schematic circuit diagrams.

Circuit Diagrams

There are two types of circuit diagrams.

- 1 Cutaway Circuit Diagrams show the internal construction of the components as well as the flow paths. By using colors, shades or various patterns in the lines and passages, they are able to show many different conditions of flow and pressure. Cutaway diagrams take considerably longer to produce because of their complexity.
- 2 Schematic Circuit Diagrams the "shorthand" system of the industry, are usually preferred for troubleshooting. A schematic diagram is made up of simple geometric symbols for the components and their controls and connections.

Symbol Systems

There are several systems of symbols used when making schematic diagrams. They are as follows:

I S O = International Standards Organization

A N S I = American National Standards Institute

A S A = American Standards Association

J I C = Joint Industry Conference

A combination of these symbols are shown in this section. There are differences between the symbols but there is enough similarity so that if you understand the symbols in this section you will be able to interpret other symbols as well.

Using Schematic Symbols

Reservoirs



VENTED RESERVOIR

710L8B



PRESSURIZED RESERVOIR

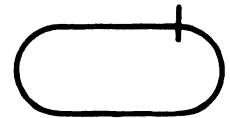
710L8D

A rectangle with the top removed represents a vented reservoir. A rectangle with the top in place represents a pressurized reservoir.



PRESSURIZED RESERVOIR

710L8C



PRESSURIZED RESERVOIR

710L8A

There are other schematic diagrams that show a slightly different version of a pressurized reservoir, but the symbols are similar and easily recognized. An oval with a short line on top or a rectangle with curved sides represents a reservoir that is pressurized.



RETURN LINE ABOVE
THE OIL LEVEL

710L8E

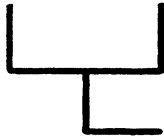
Lines connected to the reservoir usually are drawn from the top, regardless of where the actual connection is.



SUCTION LINE OR RETURN LINE
BELOW THE OIL LEVEL

710L8F

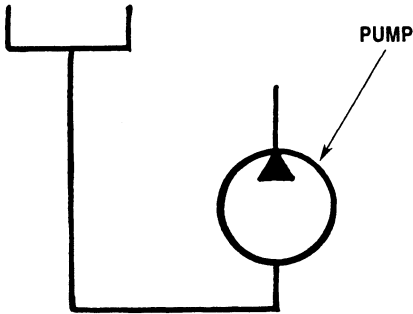
If the hydraulic line terminates below the fluid level, it is drawn all the way to the bottom of the symbol.



RESERVOIR WITH SUCTION LINE ATTACHED AT THE BOTTOM

7108G

A hydraulic line connected to the bottom of the reservoir may be drawn from the bottom of the symbol if the bottom connection is essential to the systems operation



749L8B

If the pump inlet must be charged or flooded with a positive head of oil above the inlet port, we would position the reservoir symbol above the pump symbol, and draw the suction line out of the bottom of the reservoir symbol

Every vehicle or system reservoir has at least two hydraulic lines connected to it, and some may have many more. Often the components that are connected to the reservoir are spread all over the schematic. Rather than having a lot of confusing lines all over the schematic, it is customary to draw individual reservoir symbols close to the components. The reservoir is usually the only component symbol pictured more than once.

Lines, Tubes and Hoses

A hydraulic line, tube, hose or any conductor that carries the fluid between components is shown as a line



710L8H

A working line, such as an inlet pressure or return, is shown as a solid line



OIL FLOWS ONE WAY ONLY

710L8J



OIL CAN FLOW EITHER WAY

710L8K

Working lines with arrows show direction of flow



710L8K

Pilot or control lines are broken into long dashes



710L8B

Drain lines for leakage oil are broken into short dashes



710L8C

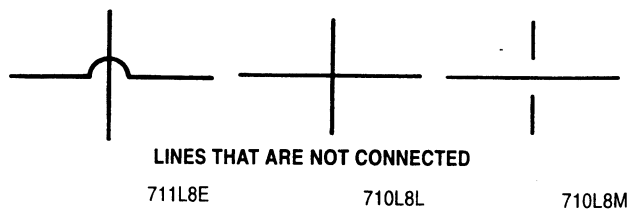
A flexible line is shown as an arc between two dots and is always represented by a solid line



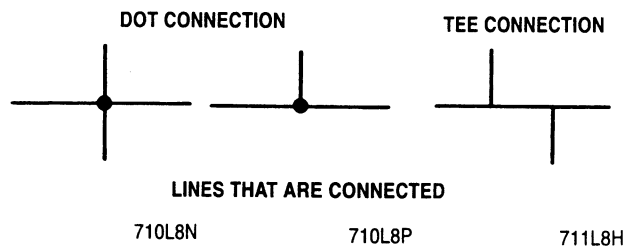
710L8D

Quite often you will see an enclosure outline that indicates that there are several symbols that make up a component assembly such as a valve or a valve stack. The enclosure outline appears like a box and is broken with dashes on all sides.

Crossing or Joining Lines

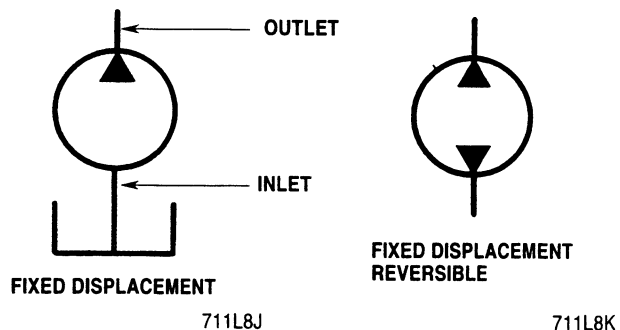


The shortest distance between two components that are connect is a straight line. There are lines that cross other lines but are not connected. There are several ways to show crossing lines.

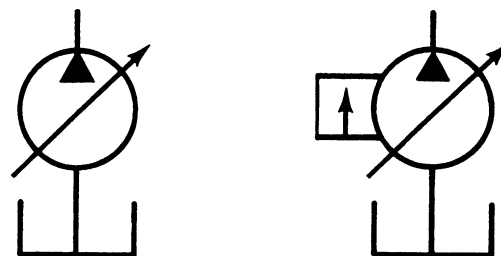


Lines that are connected are shown with a dot that represents the connection or shown as a tee connection. The dot connection is the most commonly used when drawing schematic diagrams.

Pump Symbols

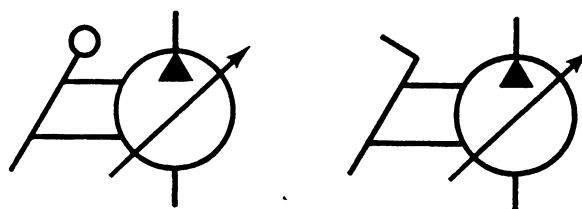


There are many basic pump designs. A simple fixed displacement pump is shown as a circle with a black triangle that is pointing outwards. The black triangle is like an arrow head and points in the direction that the oil will flow. If the pump is reversible or designed to pump in either direction, it will have two black triangles in it and they will be opposite each other.



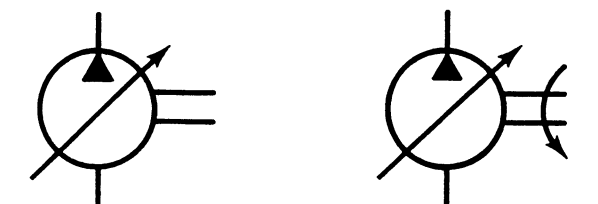
VARIABLE DISPLACEMENT
710L8s **VARIABLE DISPLACEMENT PRESSURE COMPENSATED**
710L8T

A variable displacement pump is designated by drawing an arrow through the pump symbol at 45 degrees. To indicate a variable displacement pressure compensated pump, a small box with an arrow in it will be added to the side of the pump symbol.



LEVER CONTROLLED
710L8V **PEDAL OR TREADLE CONTROLLED**
710L8U

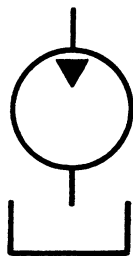
If the pump is controlled by a lever or a pedal, it will be shown on the side of the pump.



PUMP WITH DRIVE SHAFT
710L8W **PUMP WITH DRIVE SHAFT AND DIRECTIONAL ARROW**
711L8L

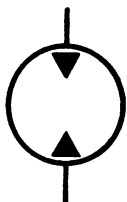
A drive shaft is shown as two short parallel lines extending from the side of the pump. If a curved arrow is shown on the drive shaft, it will indicate the direction of rotation.

Hydraulic Motor Symbols



NONREVERSIBLE MOTOR

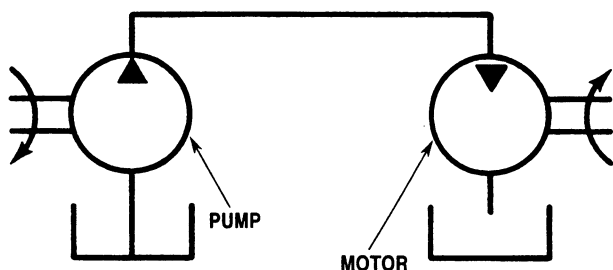
711L8M



REVERSIBLE MOTOR

711L8N

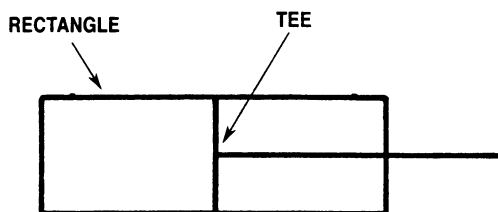
Hydraulic motor symbols are circles with black triangles, but opposite a pump the triangles point inward to show the motor is a receiver of oil. One triangle is used in a nonreversible motor and two triangles are used for a reversible motor.



711L8F

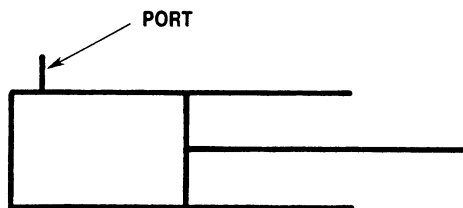
A simple schematic diagram is shown with a hydraulic motor connected to a hydraulic pump.

Cylinder Symbols



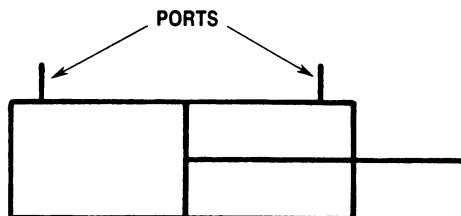
711L8Q

A cylinder symbol is a simple rectangle representing the barrel. The piston and rod are represented by a tee that is inserted into the rectangle. The symbol can be drawn in any position.



SINGLE ACTING CYLINDER

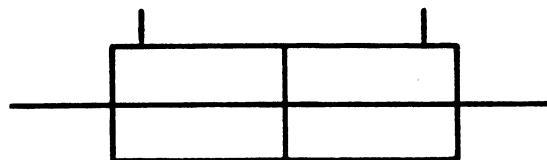
711L8P



DOUBLE ACTING CYLINDER

711L8Q

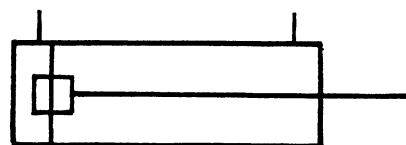
If the cylinder is single acting there is only one port shown on the symbol. The port is shown on the end of the cylinder that receives pressurized fluid and the opposite end of the cylinder is left open. A double acting cylinder symbol has both ends closed and has two ports on the symbol.



DOUBLE ROD END CYLINDER

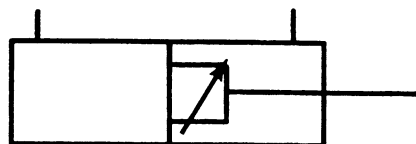
712L8A

A double rod end cylinder has a rod extending from each end of the rectangle.



SINGLE ROD END
FIXED CUSHION BOTH ENDS

749L8E



SINGLE ROD END ADJUSTABLE
CUSHION ROD END ONLY

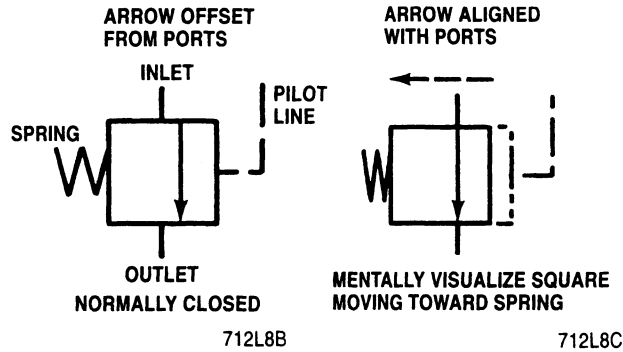
730L8E

Some cylinders have cushions built into them. The cushion slows down the movement of the piston as it nears the end of its stroke. Cylinder cushions are shown as a smaller rectangle on the piston. If the cushion has an adjustable orifice, a slanted arrow is drawn at 45 degrees across the symbol.

Pressure Control Symbols

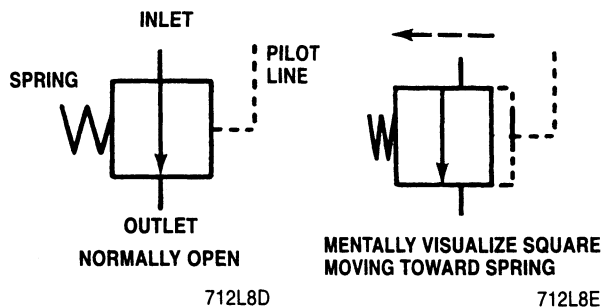
The basic symbol is a square (which is called an envelope) with external port connections and an arrow inside to show the oil passage and direction of flow. Usually this type of valve operates by balancing the oil pressure against a spring, so a spring is shown on one side of the symbol and a pilot pressure line on the other side.

Normally Closed



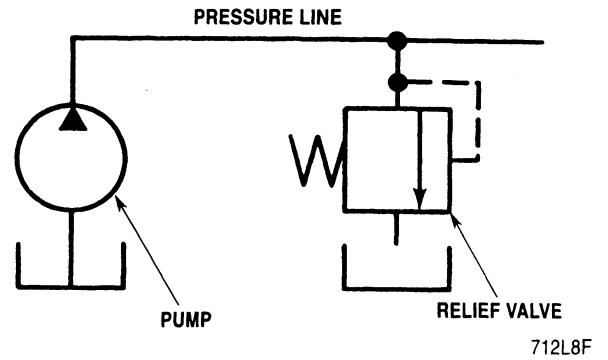
A normally closed valve, such as a relief or sequence valve, is shown with the arrow offset from the ports and toward the pilot pressure line side of the square. The spring holds the valve closed until the pilot line oil pressure is greater than the spring pressure. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil can now flow through the valve.

Normally Open



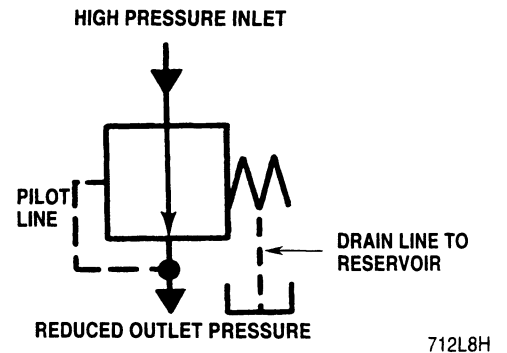
A normally open valve is shown with the arrow connecting the two ports. It closes when pressure overcomes spring force. Mentally visualize a build up of pressure in the pilot line and the square moving over, compressing the spring. The oil flow through the valve is now blocked.

Relief Valve



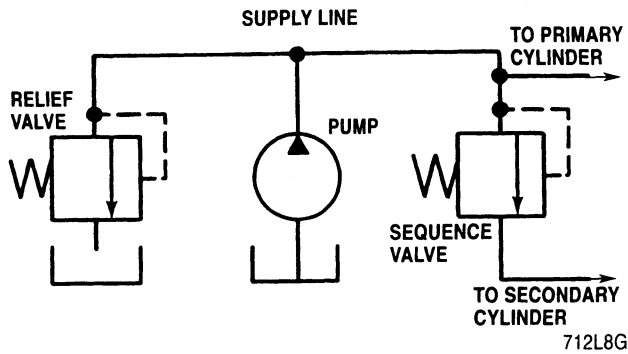
A relief valve is shown as a normally closed symbol connected between the pressure line and the reservoir. The flow direction arrow points away from the pressure line port and toward the reservoir. This shows very graphically how a relief valve operates. When pressure in the system overcomes the valve spring, flow is from the pressure line through the relief valve to the reservoir.

Pressure Reducing Valve



A pressure reducing valve is shown as a normally open symbol in a pressure line. This valve works opposite of a relief valve, since it senses outlet pressure versus inlet pressure. As the outlet pressure builds, it works against a predetermined spring force. As the spring force is overcome, flow through the valve is modulated or shut off.

Sequence Valve

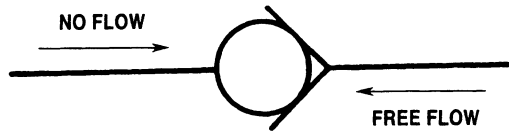


The normally closed symbol is also used for a sequence valve. The inlet port is connected to a primary cylinder and the outlet port to the secondary cylinder line. When the piston in the primary cylinder reaches the end of its stroke, the pressure in the supply line increases. The sequence valve is also connected to the supply line and also feels the increase in pressure. As pressure increases, the square and directional flow arrow moves over, connecting the inlet and outlet ports allowing fluid to flow to the secondary cylinder.

Directional Control Symbols

Simplified Symbols

One Way Valve



A simple ball check valve is shown. When oil pressure is exerted on the left side of the ball, the ball is forced into the V and no oil can flow past it. When oil pressure is applied to the right side of the ball, the ball moves away from the V and oil can flow past it.

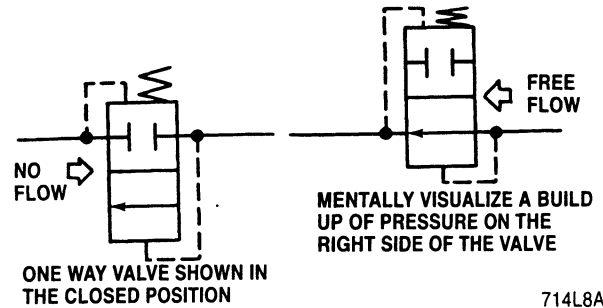
By Pass Valve



A by pass valve is shown as a one way valve with a spring on the ball end of the symbol. This shows that a pressurized flow will be necessary to overcome the spring force and allow flow around the ball.

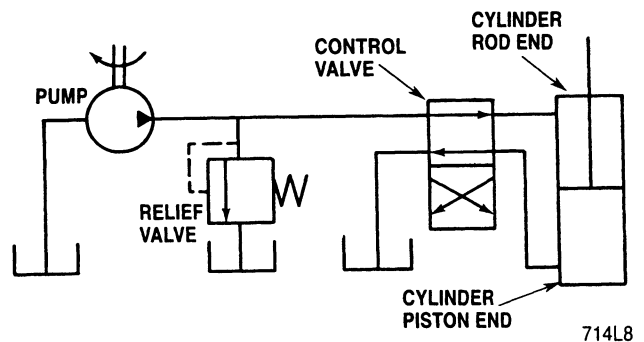
Composite Symbols

One Way Valves

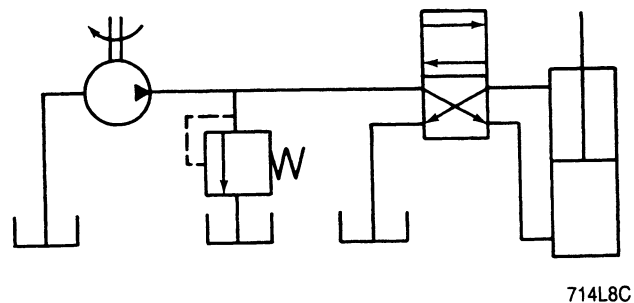


A more complex one way valve is now shown. This directional control symbol uses a multiple envelope (square) system that has a separate square for each position. Remember all of the port connections are made to the envelope that shows the neutral condition of the valve. Within each envelope are arrows showing the flow paths when the valve is shifted to that position.

Two Position Valves

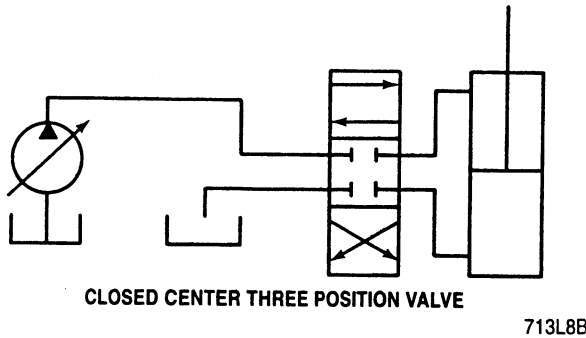
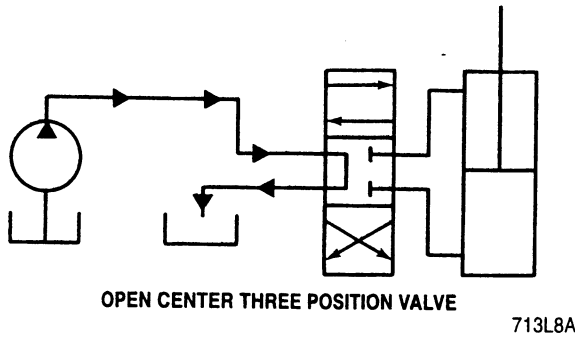


A simple control valve has two envelopes (representing the spool) if it is a two position valve. The envelopes show the flow conditions when they are in one position. The above schematic is showing that oil is being supplied to the rod end of the cylinder. If we mentally visualize the directional control valve moved to the other position, it would be as shown below.



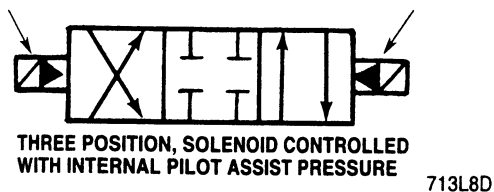
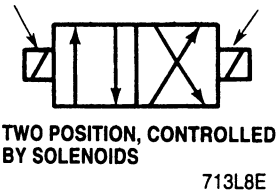
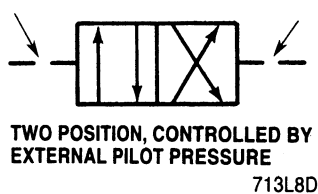
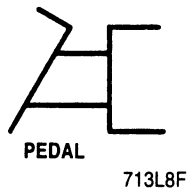
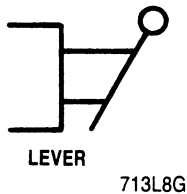
Here, pressurized oil is being supplied to the piston end of the cylinder and oil from the rod end of the cylinder is allowed to flow to the reservoir.

Three Position Valves

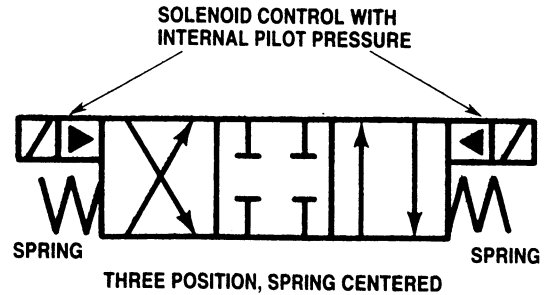


Three position valves will have a centered (neutral) position. The centered position can be either open or closed to flow. The open center is usually used with a fixed displacement pump and the closed center is usually used with a variable displacement pump.

Actuating Controls



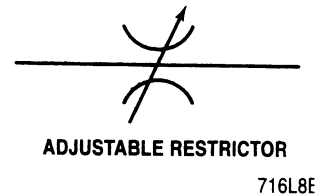
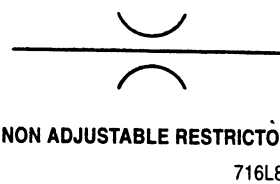
Valve spools are controlled by levers, pedals, pilot oil, electric solenoids, etc., which are called actuating controls. These actuating controls are shown by symbols placed on the ends of the envelopes.



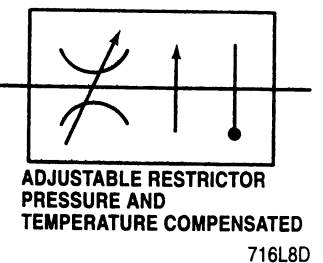
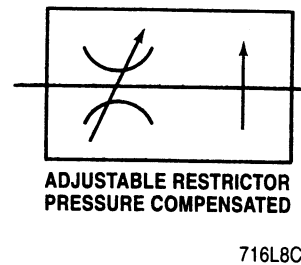
To show that a valve is spring centered, a spring symbol is placed at each end of the envelope. The above schematic shows that an electrical solenoid and pilot pressure assist are required to overcome spring force to move the valve spool.

Flow Control Symbols

Restrictors



The basic flow control symbol is a representation of a restrictor. If the restrictor is adjustable, a slanted arrow is drawn across the symbol. The restrictor could be a special fitting with a small hole in it or a small drilled passageway within a valve. If it is an adjustable restriction, it could be thought of as a water faucet that can be controlled by turning the handle to regulate the flow. Restrictors can be applied to meter out, meter in and bleed off circuits.

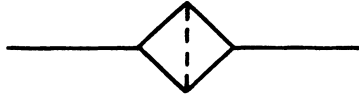


There are adjustable restrictors that are pressure compensated. That means that the size of the opening in the restrictor will change with increases and decreases in pressure. A perpendicular arrow indicates pressure compensation. If the restrictor has both pressure and temperature compensation, the symbol for a thermometer will also be shown.

Accessories

Filters, strainers and heat exchangers are represented as squares that are turned 45 degrees and have the port connection at the corners

A dotted line perpendicular to the flow line indicates a filter or strainer



FILTER OR STRAINER

716L8E

A solid line perpendicular to the flow with black triangles pointing out indicates a cooler



COOLER

716L8F

The symbol for a heater is like the symbol for a cooler, except the black triangles point in



HEATER

731L8G

Two sets of triangles pointing in and out indicates a temperature control unit



TEMPERATURE CONTROL UNIT

731L8H

As you can see, the black triangles point in the direction that the heat is dissipated. Or in the case of the control unit, they show that the heat can be regulated

An oval with details inside indicate an accumulator. The details inside will tell you what type of accumulator it is, spring loaded, gas charged, or other features



GAS CHARGED

716L8G

The divider line indicates there is a separator between the charge and the oil. A hollow triangle indicates gas.



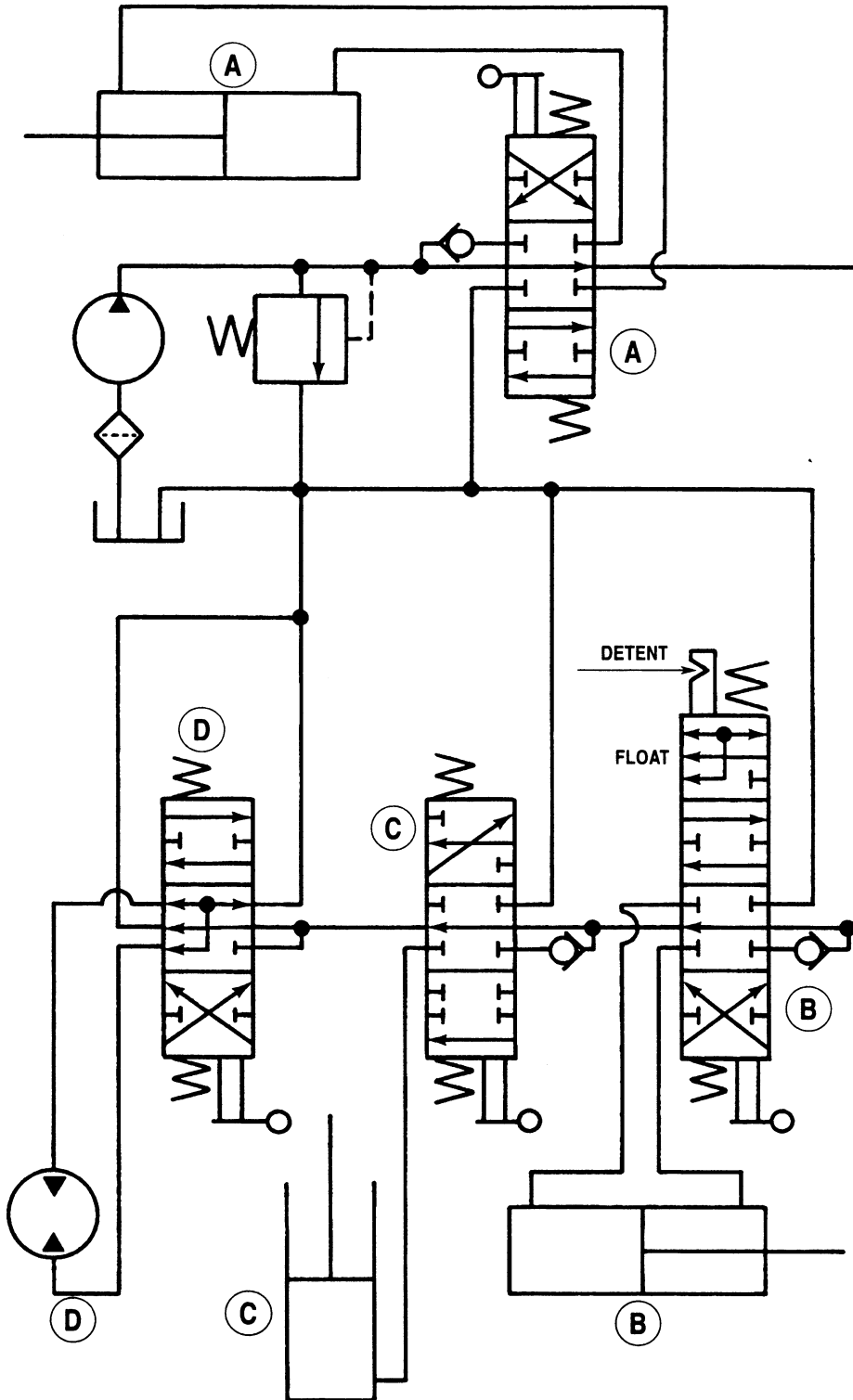
SPRING LOADED

716L8H

A spring shows that the accumulator is spring loaded.

SIMPLE SCHEMATIC

Now that you have completed hydraulic symbols, we have put some of the symbols together to form a simple hydraulic schematic. See if you can find your way around the schematic without reading the text for each valve. The text explains the function of each valve in the hydraulic system.



Valve A

This valve is a three position valve. The spool is lever operated and spring centered. It is an open center valve. Visually place the envelopes into the center position and you will see that the valve will direct oil into one end or the other of cylinder A. When the spool in valve A is moved out of the centered position, the valves downstream will receive no oil.

Valve B

Valve B is similar to valve A but it is a four position valve. The fourth position is a float position and is held into that position with a detent. With this valve the cylinder B can be extended, retracted, or placed in the float position. Visualizes the envelope for the float position in the inlet passageway.

You will see that oil can continue to flow to the next valve downstream and that the rod in cylinder B could be pushed back and forth. The oil could move from one end of the cylinder to the other via the valve. Both ends of the cylinder are also connected to the return line to the reservoir.

Valve C

This valve is also similar to valve A but is designed to control a single acting cylinder. When you visualize placing the upper envelope in the center position you will see that oil can drain back to the reservoir from cylinder C.

At the same time, oil from the pump can flow through valve C to the next valve.

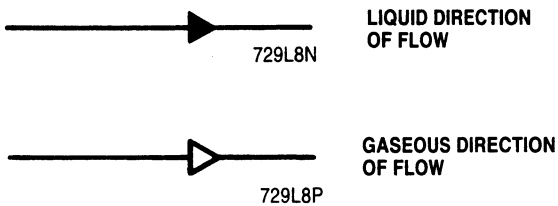
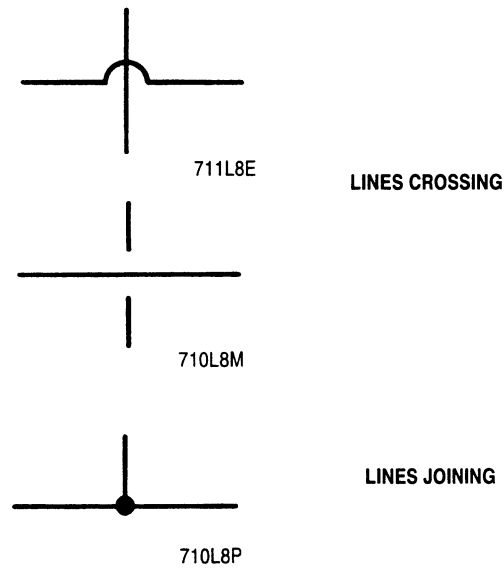
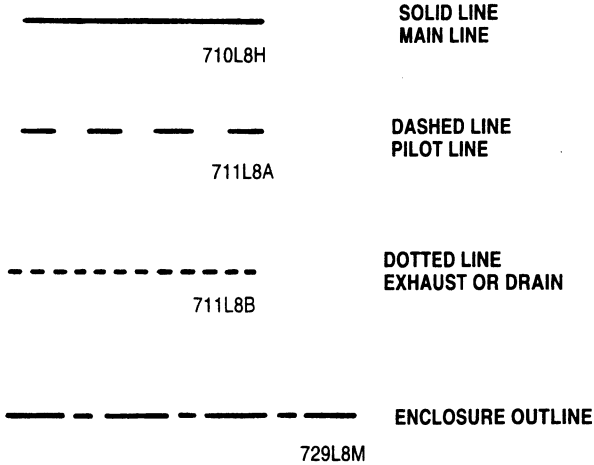
Valve D

Valve D is a lever operated, spring centered valve and is designed to control a hydraulic motor. If a hydraulic motor was turning a flywheel and the oil supply and return were shut off abruptly, this would cause damage to the hydraulic lines, the motor, or whatever it was powering. Therefore when the valve supplying the motor is shut off, the motor should be able to slow down gradually. The center (neutral) position of valve D will allow that to happen by letting oil from the outlet of the motor return to the inlet side.

As you have seen, this brief information is all you need to read hydraulic schematics. The more you use it, the more you will be comfortable using hydraulic schematics as a troubleshooting guide.

COMMON SYMBOLS

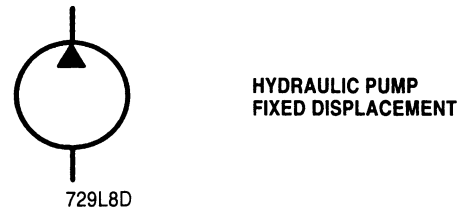
Lines and Line Functions



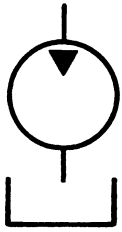
Mechanical Devices



Pumps and Motors

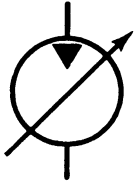


Cylinders



HYDRAULIC MOTOR
FIXED DISPLACEMENT

711L8M



HYDRAULIC MOTOR
VARIABLE DISPLACEMENT

730L8B



HYDRAULIC OSCILLATOR

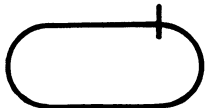
730L8C

Reservoirs



RESERVOIR
OPEN TO ATMOSPHERE

710L8B



PRESSURIZED RESERVOIR

710L8A



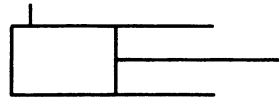
LINE TO RESERVOIR
BELOW FLUID LEVEL

710L8F



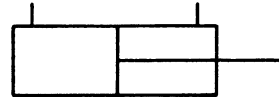
LINE TO RESERVOIR
ABOVE FLUID LEVEL

710L8E



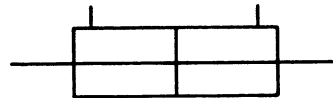
SINGLE ACTING

711L8P



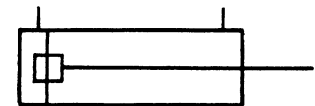
DOUBLE ACTING
SINGLE ROD END

711L8P



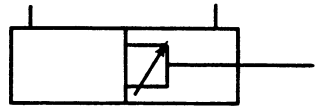
DOUBLE ACTING
DOUBLE ROD END

712L8A



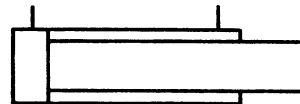
SINGLE ROD END
FIXED CUSHION BOTH ENDS

749L8EP



SINGLE ROD END
ADJUSTABLE CUSHION
ROD END ONLY

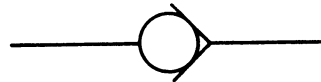
730L8E



DIFFERENTIAL CYLINDER

730L8F

Valves



CHECK VALVE

712L8J



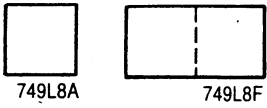
PILOT OPERATED CHECK

731L8A

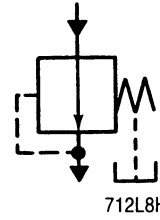


ON - OFF
MANUAL SHUT OFF

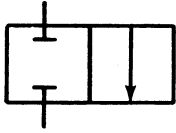
731L8B



REGULATING OR SELECTOR VALVES

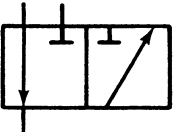


PRESSURE REDUCING VALVE



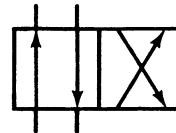
2 POSITION - 2 WAY VALVE

731L8C



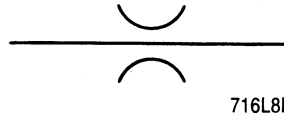
2 POSITION - 3 WAY VALVE

731L8D



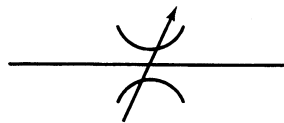
2 POSITION - 4 WAY VALVE

731L8E



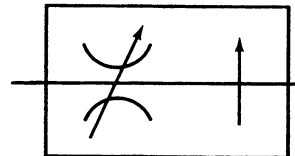
NON - ADJUSTABLE RESTRICTOR

716L8H



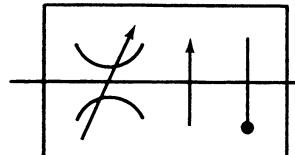
ADJUSTABLE RESTRICTOR

716L8B



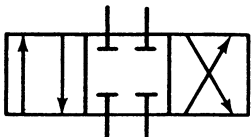
ADJUSTABLE RESTRICTOR PRESSURE COMPENSATED

716L8C



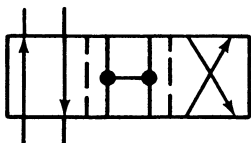
ADJUSTABLE RESTRICTOR (TEMPERATURE AND PRESSURE COMPENSATED)

716L8D



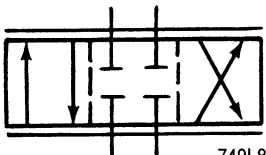
3 POSITION - 4 WAY VALVE

729L8K



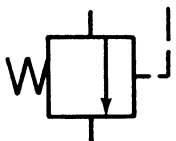
2 POSITION - 4 WAY OPEN CENTER CROSS OVER

729L8L



VALVE CAPABLE OF INFINITE POSITIONING (INDICATED BY HORIZONTAL LINES DRAWN PARALLEL TO THE ENVELOPE)

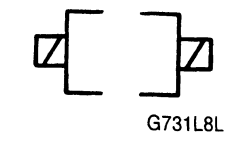
749L8C



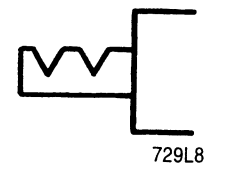
PRESSURE RELIEF VALVE

712L8B

Valve Actuators



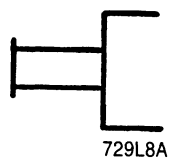
SOLENOID



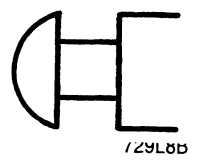
DETENT



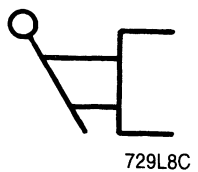
SPRING



MANUAL



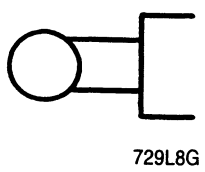
PUSH BUTTON



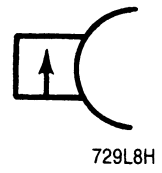
PUSH PULL LEVER



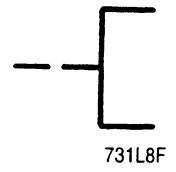
PEDAL



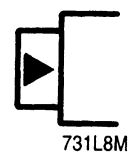
MECHANICAL



PRESSURE COMPENSATED

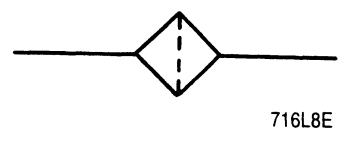


PILOT PRESSURE
REMOTE SUPPLY

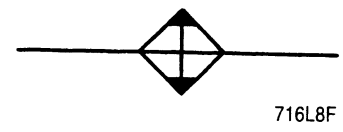


LIQUID SUPPLY

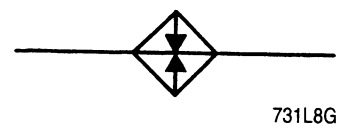
Accessories



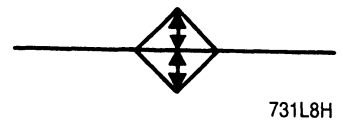
FILTER



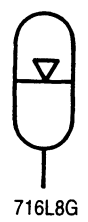
COOLER



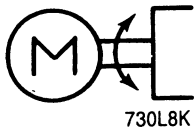
HEATER



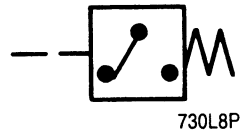
TEMPERATURE
CONTROLLER



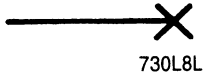
ACCUMULATOR
HYDRO - PNEUMATIC



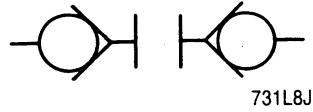
REVERSING MOTOR



PRESSURE SWITCH



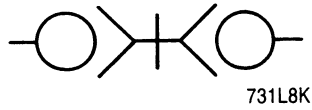
STATION OR TEST POINT



QUICK DISCONNECTS
(DISCONNECTED)



PRESSURE INDICATOR



QUICK DISCONNECTS
(CONNECTED)



TEMPERATURE INDICATOR