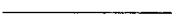

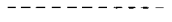


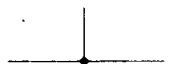
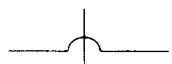
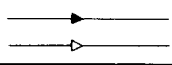
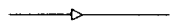


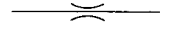






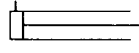
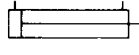
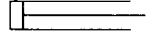
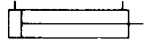
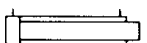


Basic Hydraulic Circuit Design and Analysis













We are going to Discuss Basic Hydraulic Circuits. A Hydraulic Circuit is a Group of Components such as Pumps, Actuators, Control Valves, and Conductors so arranged that they will perform a Useful Task. When analyzing or Designing a Hydraulic Circuit, the following Three Important Considerations must be taken into account: Safety of Operation, Performance of desired Function, and Efficiency of Operation.

It is very important for the fluid power technician or designer to have a working knowledge of components and how they operate in a circuit. Hydraulic circuits are developed through the use of graphical symbols for all components. Before hydraulic circuits can be understood, it is necessary to know these fluid power symbols.

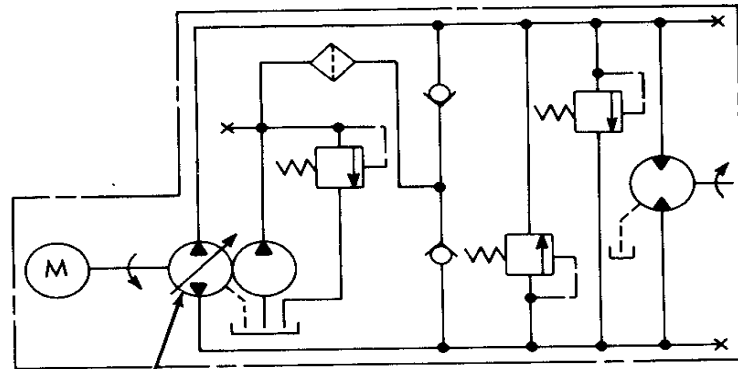
Next table gives of Symbols that conform to the American National Standards Institute (ANSI) Specifications.

THE SYMBOLS SHOWN CONFORM TO THE AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI) SPECIFICATIONS. BASIC SYMBOLS CAN BE COMBINED IN ANY COMBINATION. NO ATTEMPT IS MADE TO SHOW ALL COMBINATIONS.	
LINE FUNCTIONS	
LINE, WORKING	
LINE, PILOT (L > 20W)	
LINE, DRAIN (L < 5W)	
CONNECTOR	
LINE, FLEXIBLE	
LINE, JOINING	
LINE, PASSING	
DIRECTION OF FLOW, HYDRAULIC PNEUMATIC	
LINE TO RESERVOIR ABOVE FLUID LEVEL BELOW FLUID LEVEL	
LINE TO VENTED MANIFOLD	
PLUG OR PLUGGED CONNECTION	
RESTRICTION, FIXED	
RESTRICTION, VARIABLE	
PUMPS	
PUMP, SINGLE FIXED DISPLACEMENT	
PUMP, SINGLE VARIABLE DISPLACEMENT	
MOTORS AND CYLINDERS	
MOTOR, ROTARY, FIXED DISPLACEMENT	
MOTOR, ROTARY VARIABLE DISPLACEMENT	
MOTOR, OSCILLATING	
CYLINDER, SINGLE ACTING	
CYLINDER, DOUBLE ACTING	
CYLINDER, DIFFERENTIAL ROD	
CYLINDER, DOUBLE END ROD	
CYLINDER, CUSHIONS BOTH ENDS	

MISCELLANEOUS UNITS		BASIC VALVE SYMBOLS (CONT.)	
DIRECTION OF ROTATION (ARROW IN FRONT OF SHAFT)		VALVE, SINGLE FLOW PATH, NORMALLY OPEN	
COMPONENT ENCLOSURE		VALVE, MAXIMUM PRESSURE (RELIEF)	
RESERVOIR, VENTED		BASIC VALVE SYMBOL, MULTIPLE FLOW PATHS	
RESERVOIR, PRESSURIZED		FLOW PATHS BLOCKED IN CENTER POSITION	
PRESSURE GAGE		MULTIPLE FLOW PATHS (ARROW SHOWS FLOW DIRECTION)	
TEMPERATURE GAGE		VALVE EXAMPLES	
FLOW METER (FLOW RATE)		UNLOADING VALVE, INTERNAL DRAIN, REMOTELY OPERATED	
ELECTRIC MOTOR		DECELERATION VALVE, NORMALLY OPEN	
ACCUMULATOR, SPRING LOADED		SEQUENCE VALVE, DIRECTLY OPERATED, EXTERNALLY DRAINED	
ACCUMULATOR, GAS CHARGED		PRESSURE REDUCING VALVE	
FILTER OR STRAINER		COUNTER BALANCE VALVE WITH INTEGRAL CHECK	
HEATER		TEMPERATURE AND PRESSURE COMPENSATED FLOW CONTROL WITH INTEGRAL CHECK	
COOLER		DIRECTIONAL VALVE, TWO POSITION, THREE CONNECTION	
TEMPERATURE CONTROLLER		DIRECTIONAL VALVE, THREE POSITION, FOUR CONNECTION	
INTENSIFIER		VALVE, INFINITE POSITIONING (INDICATED BY HORIZONTAL BARS)	
PRESSURE SWITCH			
BASIC VALVE SYMBOLS			
CHECK VALVE			
MANUAL SHUT OFF VALVE			
BASIC VALVE ENVELOPE			
VALVE, SINGLE FLOW PATH, NORMALLY CLOSED			

METHODS OF OPERATION		METHODS OF OPERATION	
PRESSURE COMPENSATOR		LEVER	
DETENT		PILOT PRESSURE	
MANUAL		SOLENOID	
MECHANICAL		SOLENOID CONTROLLED, PILOT PRESSURE OPERATED	
PEDAL OR TREADLE		SPRING	
PUSH BUTTON		SERVO	

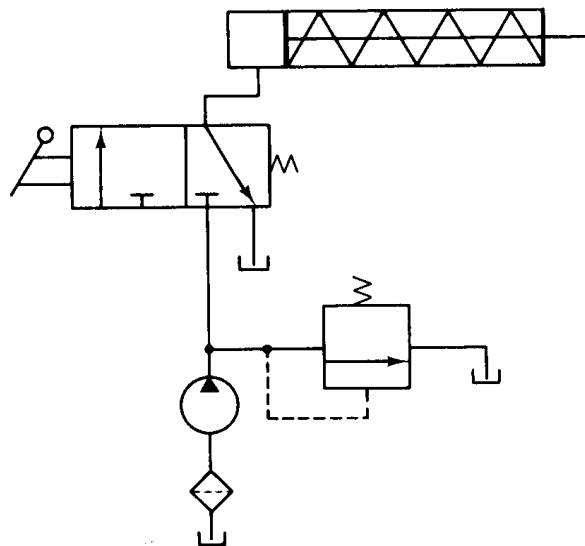
Closed-Circuit Drives are Available as Completely Integrated Units with all the Controls and valving Enclosed in a Single, Compact Housing. Figure 1 shows such a System, which is Driven by an Electric Motor. Notice the Lever Controls for Varying the Pump Displacement. This Unit is not only Rugged and Compact but also is Easy to Install.



OPTIONAL HANDWHEEL-ELECTRIC-LEVER-SERVO CONTROLLED

2. CONTROL OF A SINGLE-ACTING HYDRAULIC CYLINDER

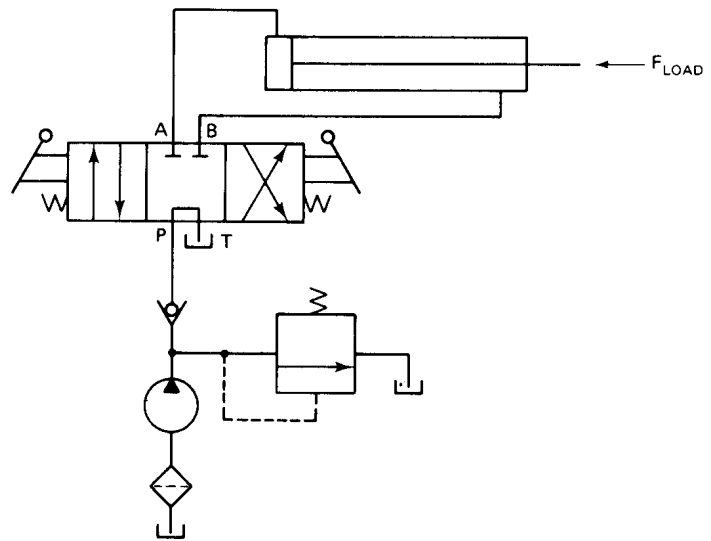
A Two-Position, Three-Way, Manually Actuated, Spring Offset Directional Control Valve (DCV) can be Used to Control the operation of a single-Acting Cylinder. In the spring offset mode, full pump flow goes to the Tank via the Pressure Relief Valve. The spring in the rod end of the cylinder Retracts the Piston as oil from the blank end drains back to the Tank. When the valve is manually actuated into its Left Envelope, flow Path Configuration, Pump Flow Extends the Cylinder. At Full Extension, pump flow goes through the Relief Valve. Deactivation of the DCV allows the Cylinder to Retract as The DCV Shifts into its Spring Offset Mode.



3. CONTROL OF A DOUBLE-ACTING HYDRAULIC CYLINDER

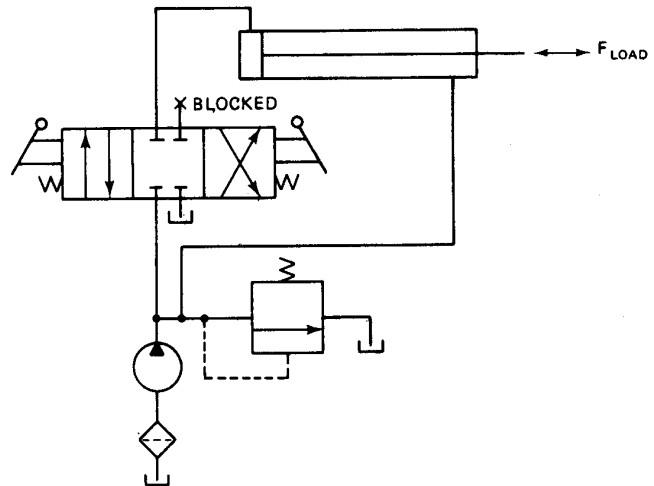
The operation is described as follows:

1. When the four-way valve is in its spring-centered position (tandem design), the cylinder is hydraulically locked. Also the pump is unloaded back to the tank at essentially atmospheric pressure.
2. When the four-way valve is actuated into the flow path configuration of the left envelope, the cylinder is extended against its load force, F_{load} , as oil flows from port P through port A. Also, oil in the rod end of the cylinder is free to flow back to the tank via the four-way valve from port B through port T. Note that the cylinder could not extend if this oil were not allowed to leave the rod end of the cylinder.
3. When the four-way valve is deactivated, the spring-centered envelope prevails, and the cylinder is once again hydraulically locked.
4. When the four-way valve is actuated into the right envelope configuration, the cylinder retracts as oil flows from port P through port B. Oil in the blank end is returned to the tank via the flow path from port A to port T.
5. At the ends of the stroke, there is no system demand for oil. Thus, the pump flow goes through the relief valve at its pressure-level setting unless the four-way valve is deactivated. In any event, the system is protected from any cylinder overloads.
6. The check valve prevents the load (if it becomes excessive) from retracting the cylinder while it is being extended using the left envelope flow path configuration.



4. Regenerative Cylinder Circuit

It is used to speed up the extending speed of a double-acting hydraulic cylinder. Notice that the pipelines to both ends of the hydraulic cylinder are connected in parallel and that one of the ports of the four-way valve is blocked. The operation of the cylinder during the retraction stroke is the same as that of a regular double-acting cylinder. Fluid flows through the DCV via the right envelope during retraction. In this mode, fluid from the pump bypasses the DCV and enters the rod end of the cylinder. Fluid in the blank end drains back to the tank through the DCV as the cylinder retracts. When the DCV is shifted into its left envelope configuration, the cylinder extends. The speed of extension is greater than that for a regular double-acting cylinder because flow from the rod end (Q_R) regenerates with the pump flow (Q_p) to provide a total flow rate (Q_T), which is greater than the pump flow rate to the blank end of the cylinder.



Cylinder Extending Speed

The equation for the extending speed can be obtained as follows: The total flow rate entering the blank end of the cylinder equals the pump flow rate plus the regenerative flow rate coming from the rod end of the cylinder: $Q_T = Q_P + Q_R$ $Q_P = Q_T - Q_R$

We know that the total flow rate equals the piston area multiplied by the extending speed of the piston ($V_{p_{ext}}$). Similarly, the regenerative flow rate equals the difference of the piston and rod areas ($A_p - A_r$) multiplied by the extending speed of the piston. Substituting these two relationships into the preceding equation yields $Q_p = A_p V_{p_{ext}} - (A_p - A_r) V_{p_{ext}}$
Solving for the extending speed of the piston, we have: $V_{p_{ext}} = Q_p / A_r$

From the previous equation, we see that the extending speed equals the pump flow divided by the area of the rod. Thus, a small rod area (which produces a large regenerative flow) provides a large extending speed. In fact the extending speed can be greater than the retracting speed if the rod area is made small enough.

Ratio of Extending and Retracting Speeds

Let's find the ratio of extending and retracting speeds to determine under what conditions the extending and retracting speeds are equal. We know that the retracting speed ($V_{p_{ret}}$) equals the pump flow divided by the difference of the piston and rod areas: $V_{p_{ret}} = Q_p / (A_p - A_r)$

Dividing two equations, we have

$$\frac{V_{p_{ext}}}{V_{p_{ret}}} = \frac{Q_p / A_r}{Q_p / (A_p - A_r)} = \frac{A_p - A_r}{A_r}$$

$$\frac{V_{p_{ext}}}{V_{p_{ret}}} = \frac{A_p}{A_r} - 1$$

From the previous equation, we see that when the piston area equals two times the rod area, the extension and retraction speeds are equal. In general, the greater the ratio of piston area to rod area, the greater the ratio of extending speed to retracting speed.

Load-Carrying Capacity During Extension

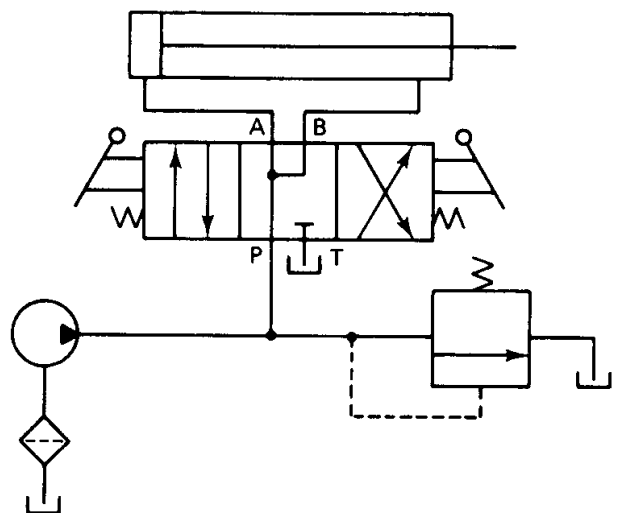
It should be kept in mind that the load-carrying capacity of a regenerative cylinder during extension is less than that obtained from a regular double-acting cylinder. The load-carrying capacity (F_{load}) for a regenerative cylinder equals the pressure times the piston rod area rather than the pressure times piston area. This is due to the same system pressure acting on both sides of the piston during the extending stroke of the regenerative cylinder. This is in accordance with Pascal's law. $F_{load} = P A_r$

Thus, we are not obtaining more power from the regenerative cylinder because the extending speed is increased at the expense of load-carrying capacity.

Drilling Machine Application

A four-way valve has a spring-centered design with a closed tank port and a pressure port opens to outlet ports A and B. The application is for a drilling machine, where the following operations take place:

1. The spring-centered position gives rapid spindle advance (extension).



2. The left envelope mode gives slow feed (extension) when the drill starts to cut into the workpiece.
3. The right envelope mode retracts the piston.

Why does the spring-centered position give rapid extension of the cylinder (drill spindle)? The reason is simple. Oil, from the rod end, regenerates with the pump flow going to the blank end. This effectively increases pump flow to the blank end of the cylinder during the spring-centered mode of operation. Once again we have a regenerative cylinder. It should be noted that the cylinder used in a regenerative circuit is actually a regular double-acting cylinder. What makes it a regenerative cylinder is the way it is hooked up in the circuit. The blank and rod ends are connected in parallel during the extending stroke of a regenerative cylinder. The retraction mode is the same as a regular double-acting cylinder.