HYDRAULICS AND PNEUMATICS

Chapter – 2

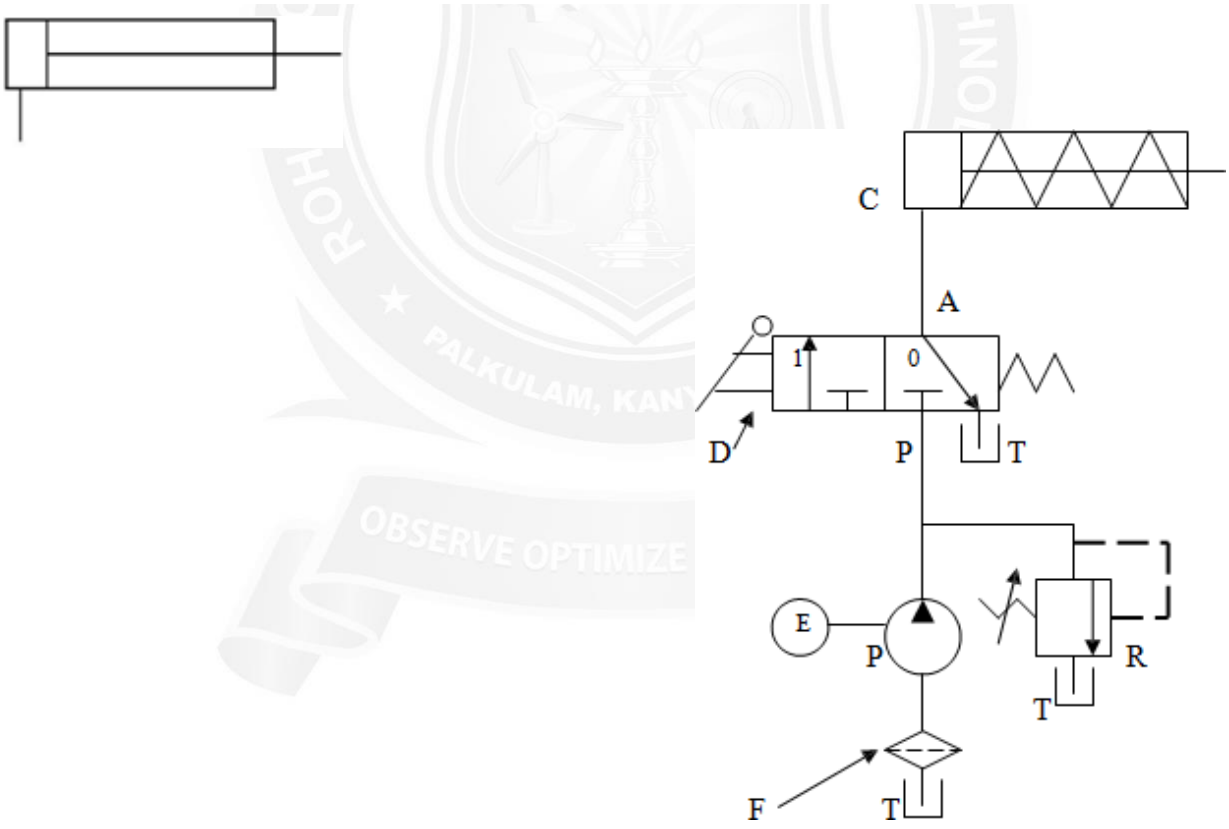
UNIT III HYDRAULIC CIRCUITS AND SYSTEMS

Industrial hydraulic circuits – Regenerative, Pump Unloading, Double- Pump, Pressure Intensifier, Air-over oil circuit.

Control of a Single- Acting Hydraulic Cylinder

In single acting cylinder hydraulic force is exerted on the piston for forward movement (to right in the figure shown). For retraction, no hydraulic force is applied and the rod moves (toleft) due to a spring force or weight of the piston and rod

Figure shows a two-position, three way, manually operated, spring offset directional control valve (DCV) used to control the operation of a single – acting cylinder.



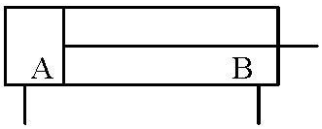
As valve is moved to occupy position 1 (left) flow goes to rod end and rod is pushed to right.

When valve is moved to position 0, i.e. shifted to right indicated position, flow from pump is blocked in the valve. There is no hydraulic pressure on the

piston side. The flow goesto tank via relief valve at the set pressure. The actuator moves to left due to spring force acting on the rod end of piston.

Control of Double Acting Hydraulic Cylinder:

Double –Acting cylinders can be extended and retracted hydraulically. Thus, an output forcecan be applied in two directions.

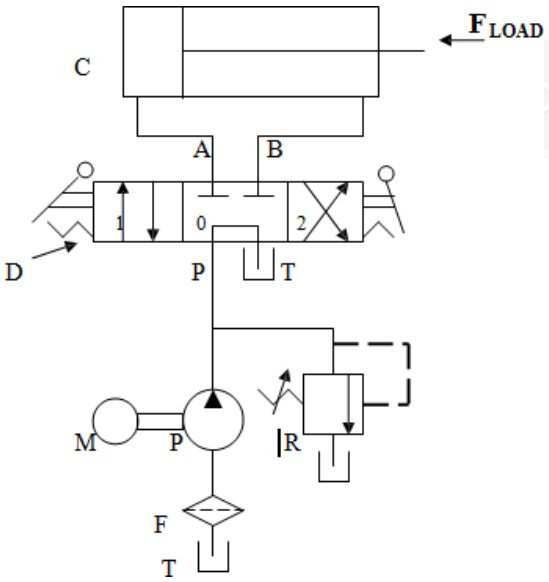


Double acting cylinder

The valve is manual 3postion /4-way valve. In the neutral or valve central (0) position, oil from pump goes to tank, and no action on actuator. Note that the valve does not go through reliefvalve to tank, thereby saving power (Pressure set in relief valve x pump flow rate). There is minor power loss due to drop in valve orifices, and piping.

In position 1 of valve, oil flow is P to A. ie. from pump to piston side and rod moves to rightacting on the load. Oil from rod side chamber of cylinder goes to tank (B to T).

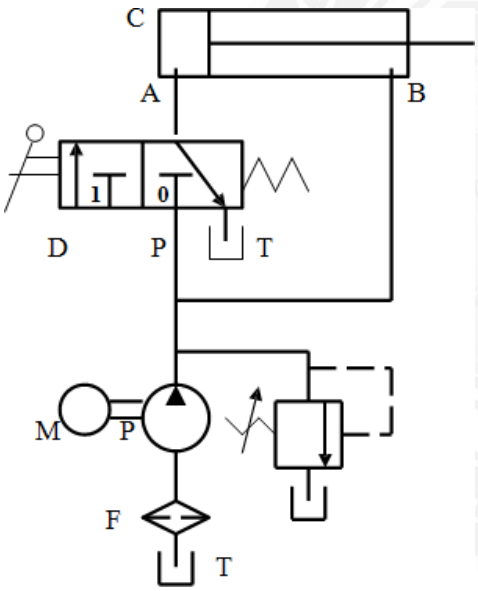
In position 2, Oil from pump goes to rod end (P to B) and Oil from piston end goes to tank. (Ato T) thereby pushing the rod (load) to left.



Regenerative circuit:

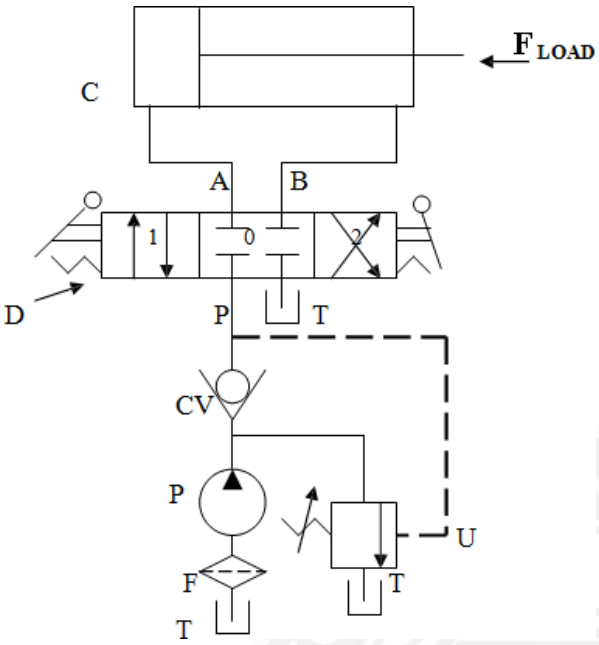
Operation: Figure shows a regenerative circuit that is used to speed up the extending speedof a double-acting hydraulic cylinder.

It can be seen that in position 1 when pump is connected to piston side chamber ,ie., when mainload is operated, fluid from piston side also flows into it. Thereby the flow rate is more than pump flow. Thus the velocity of actuation on piston side is increased by the ratio (A_p / A_r),where A_p is the piston area and A_r is the rod area. .However, the net force due to the piston rod is reduced to A_r x Pressure. In position 2, when flow is directed to rod side, oil from the piston side flows to tank directly.



PUMP UNLOADING CIRCUIT

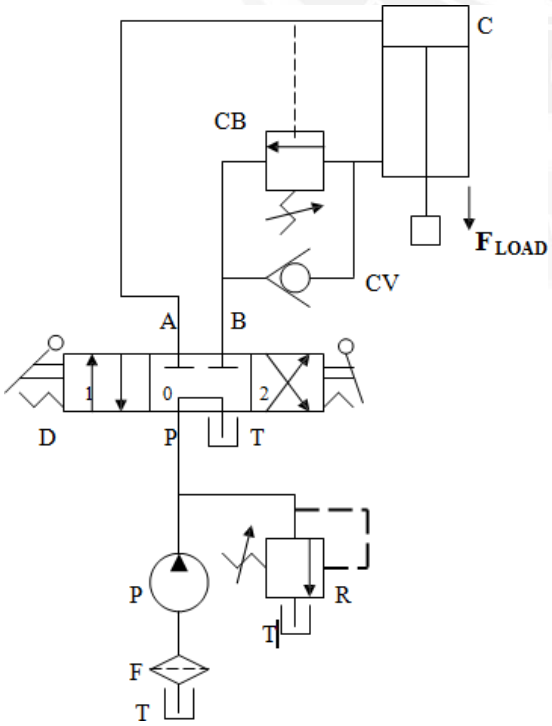
The figure shows a circuit using an unloading valve to unload a pump. The unloading valve opens when thecylinder reaches the end of its extension stroke because the check valve keeps high-pressure oil in the pilot lineof the unloading valve. When the DCV is shifted to retract the cylinder, the motion of the piston reduces the pressure in the pilot line of the unloading valve. This resets the unloading valve until the cylinder is fully retracted, at which point the unloading valve unloads the pump. Thus, the unloading valve unloads the pump at theends of the extending and retraction strokes as well as in the spring-centered position of the DCV.



COUNTER BALANCE VALVE CIRCUIT:

Counter balance valve is used to hold loads in vertical position without descending while idling in neutral position. Rod side fluid cannot flow unless a pilot pressure acts on the valve and permits flow to tank.

The valve spring so set that pressure required ishigher than for upward stroke.



Hydraulic Cylinder Sequencing Circuits:

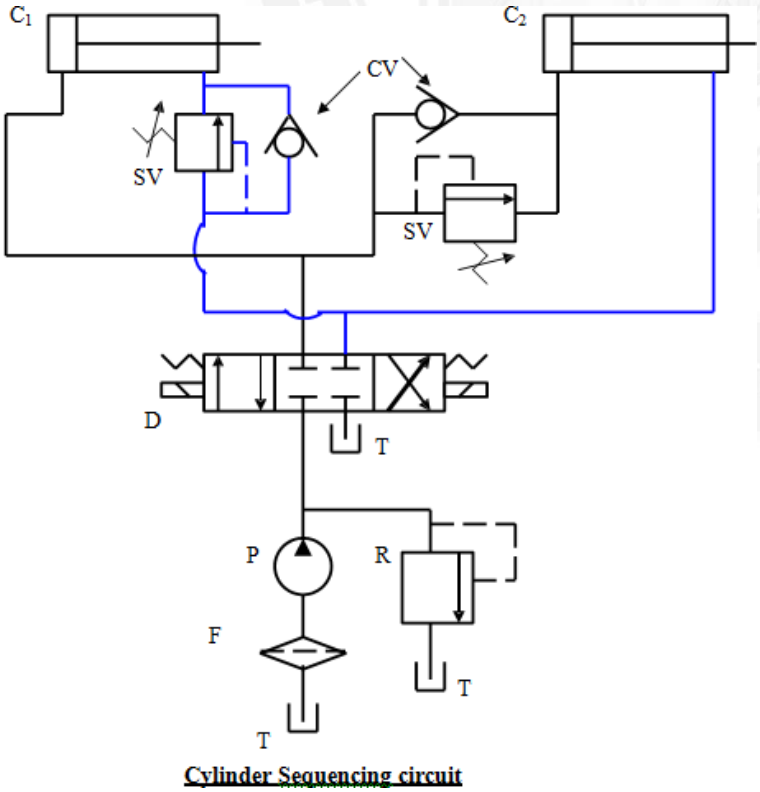
Figure shows an example where two sequence valves are used to control the

sequence of operations of two double-acting cylinders C1 and C2 . When the DCV is shifted into its left position, the left cylinder extends completely, and pressure builds up and only when the left cylinder pressure reaches the pressure setting of sequence valve, the sequence valve connected to the right cylinder opens and permits flow to rod end of C2, and extends it.

If the DCV is then shifted to right position, flow to rod end of C1 is blocked, but flows freely to rod end of C2. After C2 retracts fully, pressure builds up till the valve connected to C1 opens.

Thus the sequence is C1Ext - C2Ext - C2Retr – C1 Retr.

One can find the application of this circuit in press circuit. For example, the left cylinder the clamping cylinder C1 could extend and clamp a work piece. Then the right cylinder C2, the punching cylinder extends to punch a hole in the work piece. The right cylinder then retracts the punch , and then the left cylinder retracts to declamp the work piece for removal.

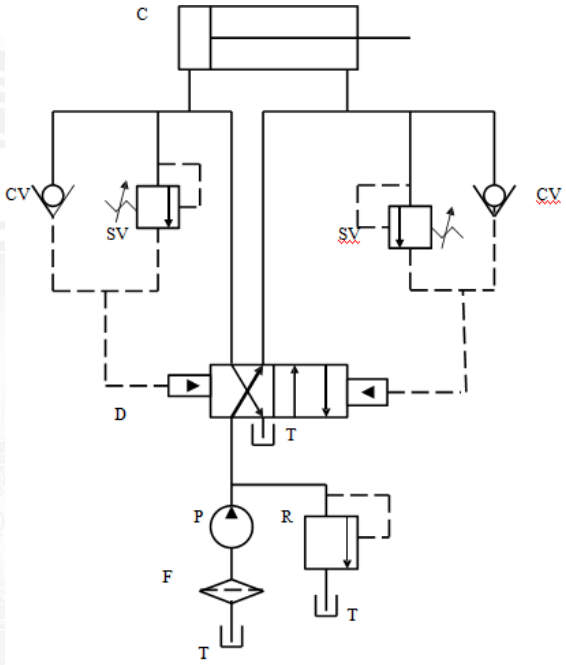


Cylinder Sequencing circuit

Automatic Cylinder Reciprocating System

1. Using Sequence Valve

Operation: In the left position of valve shown, P is connected to rod-side, and the rod retracts. After piston reaches the left end, pressure builds up on rod side whichopens the sequence valve on the right and permits pilot hydraulic line to act on the main DCV to switch to right position. Check valves allow pilot oil to leave either end of the DCV while pilot pressure is applied to the oppositeend.



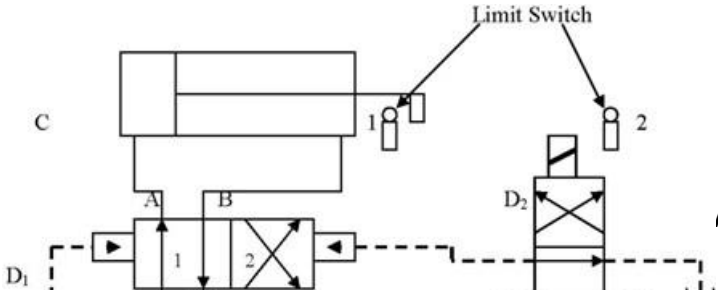
Automatic Cylinder Reciprocating System using Sequence valves

2. Using limit switches and solenoid valve, and a pilotoperated DCV.

Operation: Suppose the left position of the main DCV is on.

Then the piston rod moves to right > It hits the limit switch 2 > which energises solenoid valve D2 > which shifts the solenoid operated DCV (D2) to position (top as shown) > which now permits pilot oil from D2 to right end of DCV D1 > changes D1 position 2 > flow is now to rod end > rod moves to left till it hits limit switch 1.

Now the reverse of the above sequence is repeated so that Position 1 of the main DCV becomes operative. Thus it leads to automatic reciprocation of the actuator between the limit switch positions.



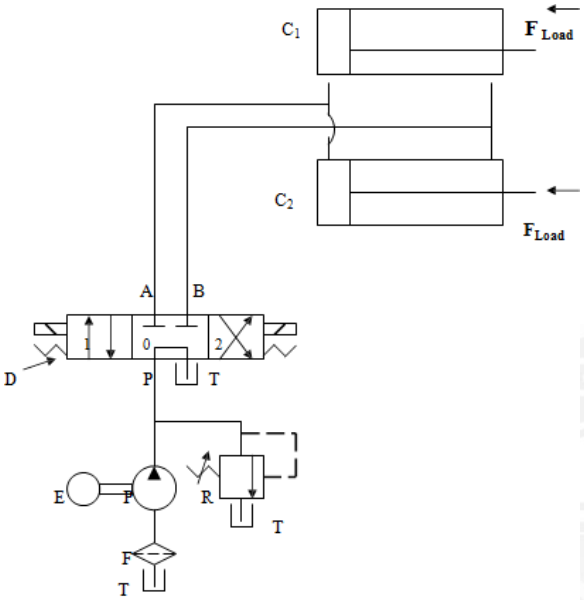
Cylinder Synchronizing Circuits:

Circuits are shown for synchronising the operation of two cylinders (ie simultaneous equalmovement).

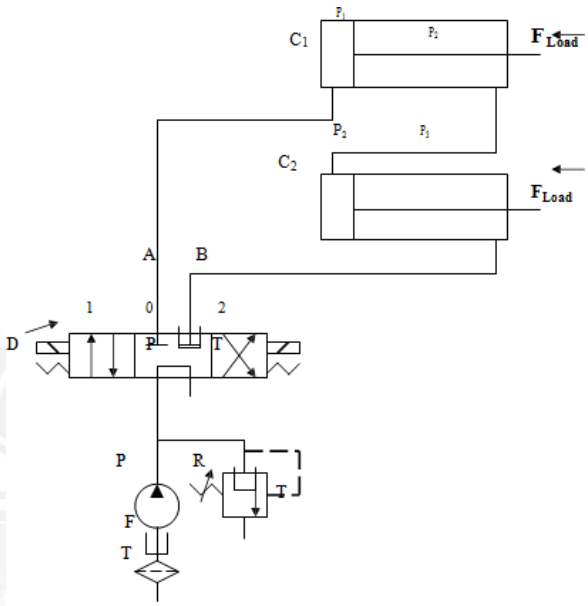
a. **Cylinder connected in Parallel**

   In the circuit shown, piston or rod ends of both cylinders are connected to one line. Thusoil flows simultaneously. However, if load on one cylinder is more, the other cylinder needing less pressure operates first, and after completion of stroke, pressure builds up tooperate the second cylinder. This operation is not synchronised. The problem may arise with slight differences in the size of cylinders as well.

b. **Cylinders connected in Series**: The rod end of C1 is connected to piston end of C2. Thus C1 and C2 have to move together. However, for to have equal stroke, rod end area of C1 should be equal to piston area of C1. Also, rod end of C2 has to have high pressureto do work by C2. Hence piston side pressure would be that much higher.



Cylinder hooked in parallel for synchronizing
(will not operate)



Cylinder hooked in Series for synchronizing
(Will Operate)

SPEED CONTROL

Speed control of Hydraulic Cylinder: Speed control of a hydraulic cylinder is accomplishedusing a flow control valve. A flow control valve regulates the speed of the cylinder by controlling the flow rate to and of the actuator.

There are 3 types of speed control:

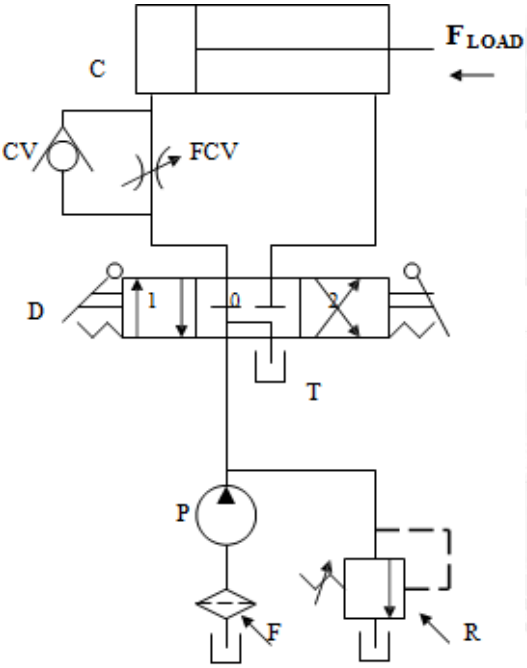
- Meter-in circuit (Primary control)
- Meter-out circuit (Secondary control)
- Bleed -off circuit (By pass control)

1. **Meter – in Circuit** : In this type of speed control, the flow control valve is placed betweenthe pump and the actuator. Thereby, it controls the amount of fluid going into the actuator. Figure below shows meter-in circuit. When the direction is reversed, oil from piston side flows to tank via check valve as well as FC valve freely. The excess flow is dumped to tank via relief valve.

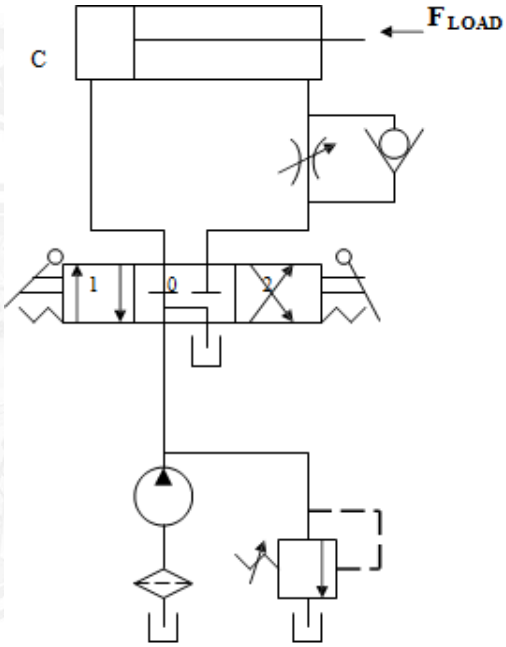
2. Meter – out Circuit : In this type of speed control, the flow control valve is placed between the actuator and the tank . Thereby, it controls the amount of

fluid going out of the actuator and thereby the speed of retraction.

Meter out circuits are useful to control free fall of loads due to gravity etc. connected to the load. Oil is dumped at load pressure but not at relief valve set pressure. However, meter –out can lead to high pressure intensification sometimes twice supply pressure, leading to damage of seals etc. Still it is favoured in drilling, reaming and milling when it is required to control the tool feed rate.

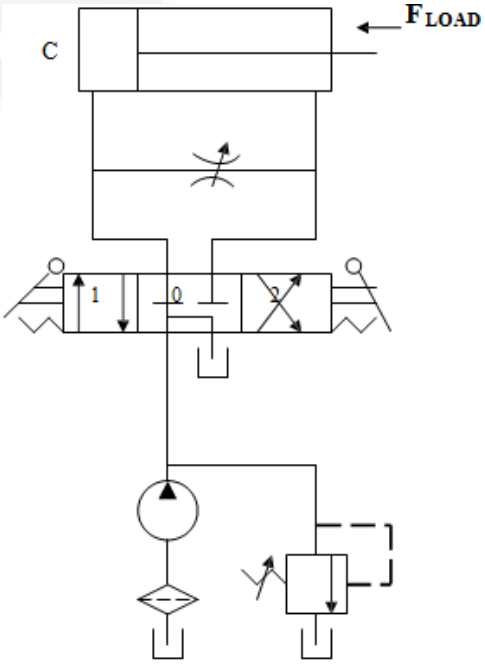


Meter – in circuit.



Meter – out Circuit.

Bleed off circuit: This circuit is used to overcome the disadvantages of meter-in and meter- out circuits. Here, a flow control valve is kept between either ends. Flow is controlled in each direction, and excess flow to tank is not through relief valve.



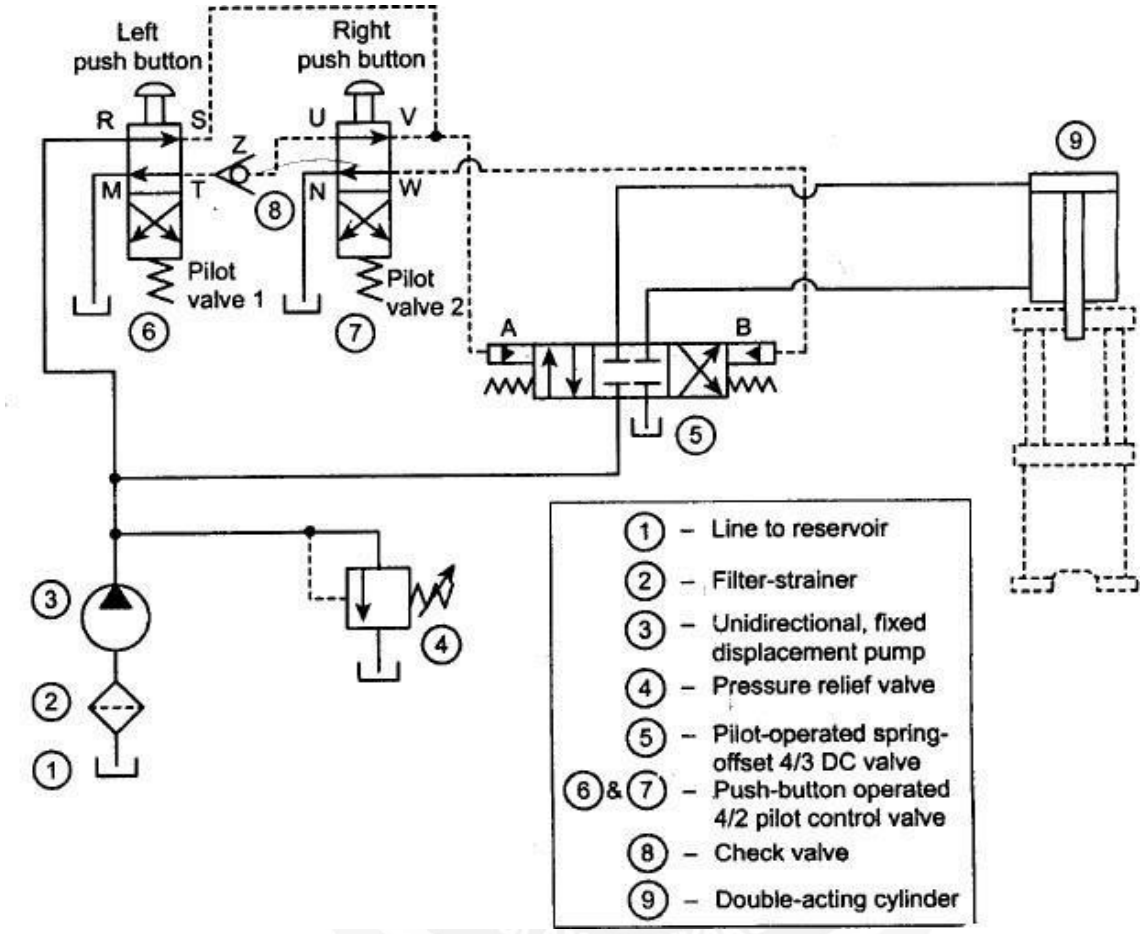
Bleed – 0ff Circuit.

FAIL-SAFE CIRCUIT

Fail-safe circuit is designed to safeguard the operator, the machine and work piece. These circuits prevent any possible injury to the operator or damage to the machine and the work piece. One such fail safe circuit is explained below. It is also called as two handed safety circuit. Figure shows the two handed safety control circuit. This circuit uses a pilot-operated spring-offset 4/3 DCV and two push buttons. When the 4/3 DCV valve is in its centre position, the oil flows is diverted back to tank through the pressure relief valve. Therefore the cylinder is hydraulically locked. When operator pushes down both left and right push buttons, the oil flows in through port R of pilot valve1 and out through ports, then through port V of pilot valve 2 and out port U. but check valve Z stops flow. At the same time, the oil also flows to pilot connection A of 4/3 DCV causing the DCV to shift to its left mode.

When the cylinder and thus the cylinder extends. Thus extension of cylinder takes place only when the operator depresses both the push buttons. When the operator pushes the right button only, oil flows in through port R to port S of pilot valve1, then through port V to port N of pilot valve2. Thus the oil is drained to the tank through the pilot valve2. This allow the 4/3 DCV to return to neutral position, thus the cylinder is hydraulically locked. When the operator pushes the left push button only, oil flows in port R of pilot valve1 and out port T, then unseats ball in check valve Z, then on to port U of pilot valve2, and out port V. Oil follows the path of least resistance so it passes in port S of pilot valve1, out port M and into sump. It does not build up enough pressure to keep pilot pressure on pilot connection A so 4/3 DCV shifts back to neutral position, thus the cylinder is hydraulically locked. When the operator releases both left and right push buttons, oil flows in port R of pilot valve1 and out port T, then through check valve Z and into port U of pilot valve2. Now the oil flows out port W into pilot connection B of 4/3 DCV shifting its position to right mode. When the 4/3 DCV is shifted to its right

mode, the oil from the pump flows into the rod end of the cylinder and hence the cylinder retracts. Thus the retraction of cylinder takes place only when the operator releases both the push buttons.



Double-Pump Hydraulic System

Figure shows an application for an unloading valve. It is a circuit that uses a high-pressure, low-flow pump in conjunction with a low-pressure, high-flow pump. A typical application is a sheet metal punch press in which the hydraulic cylinder must extend rapidly over a great distance with low-pressure but high-flow requirements. This occurs under no load. However during the punching operation for short motion, the pressure requirements are high, but the cylinder travel is small and thus the flowrequirementsare low. The circuit in Fig. eliminates the necessity of having a very expensive high-pressure, high-flow pump.

When the punching operation begins, the increased pressure opens the unloading valve to unload the low-pressure pump. The purpose of relief valve is to protect the high-pressure pump from over pressure at the end of cylinder stroke and when the DCV is in its spring-centered mode. The check valve protects the low-pressure pump from high pressure, which occurs during punching operation, at the ends of the cylinder stroke and when the DCV is in its spring-centered mode.

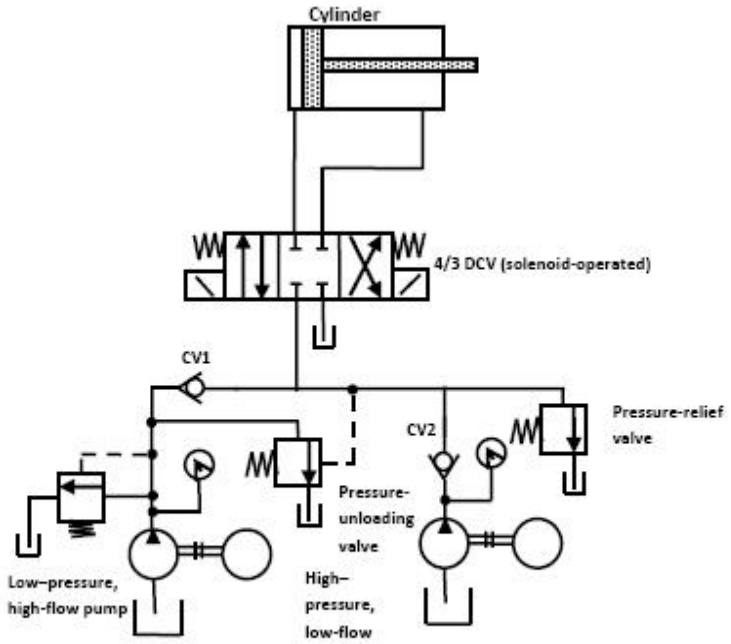


Figure 1.5 Double-pump circuit.