Chapter 13 Example Circuits

13.1 Limiting Maximum Pressure

13.1.1 Relief Valve

Maximum pressure is the relief valve setting (ideal)
Operating pressure is dictated by the burden

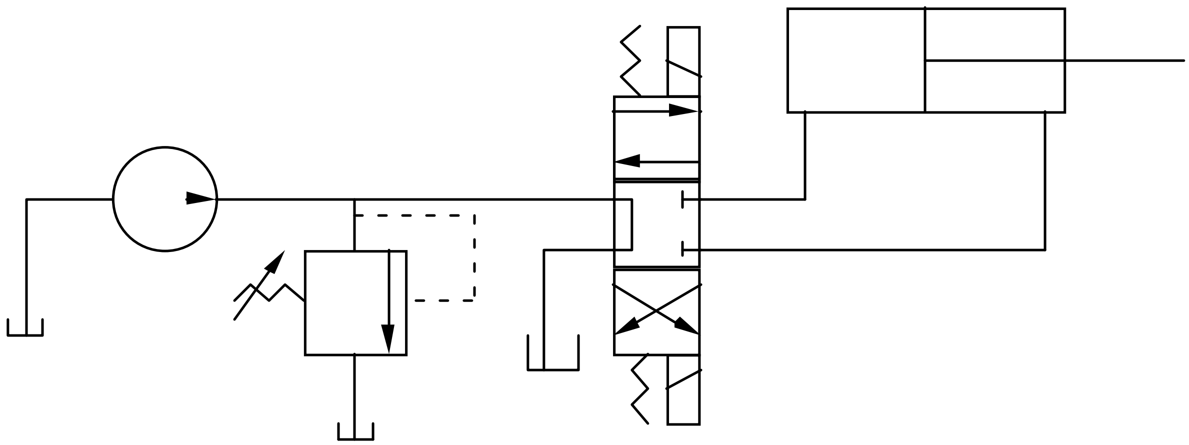


Figure 13.1 Relief Valve to limit pressure

13.1.2 Hydraulic Fuse

One shot affair
Overload protection

13.1.3 Pressure Compensating Pump

Maximum pressure is set by the deadhead value

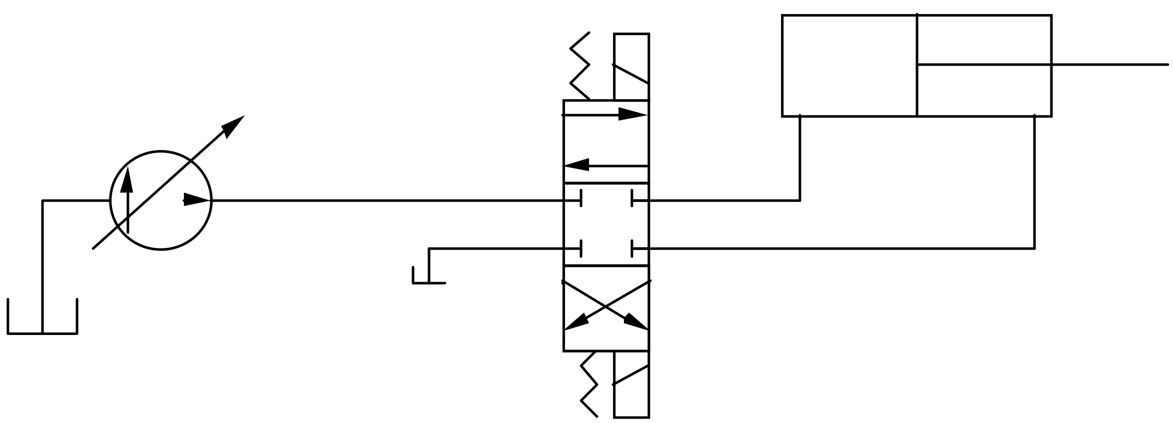
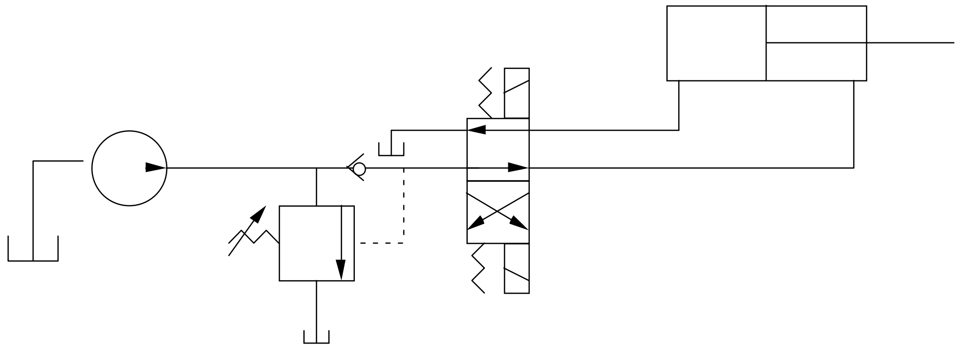


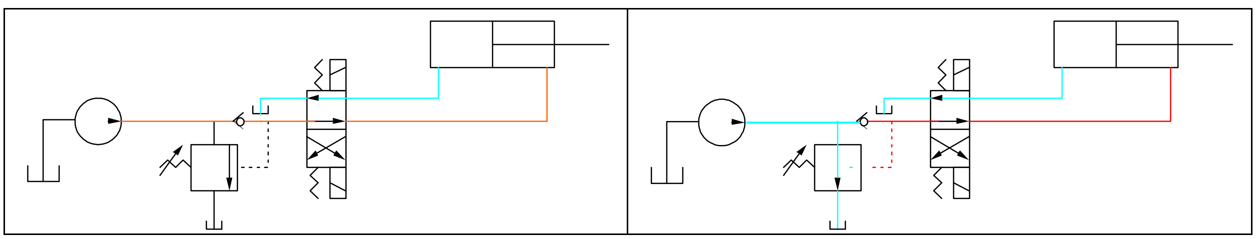
Figure 13.2 Deadhead pressure to limit system pressure

13.2 Unloading Circuits

13.2.1 Bypass system

This circuit unloads the pump when the ram reaches the end of its stroke



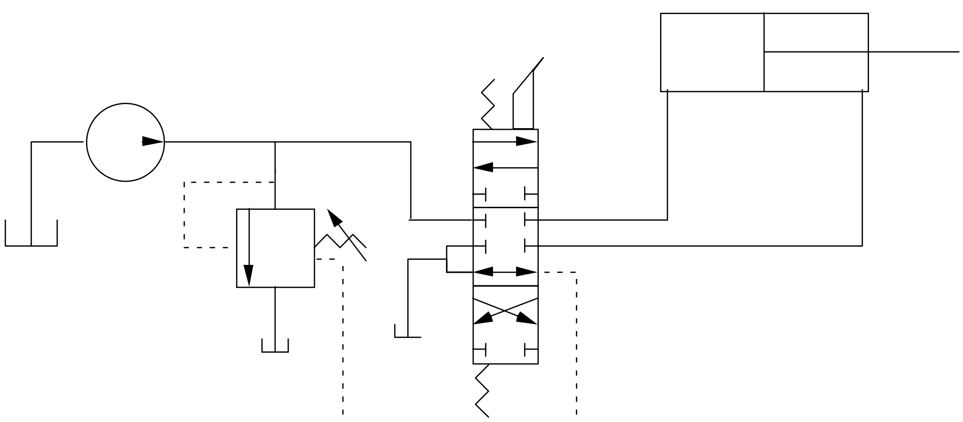


Normal operation   Pump unloaded

Figure 13.3 Unloading valve to limit pressure

13.2.2 Balanced Relief Valve

In the neutral position, the pump is unloaded



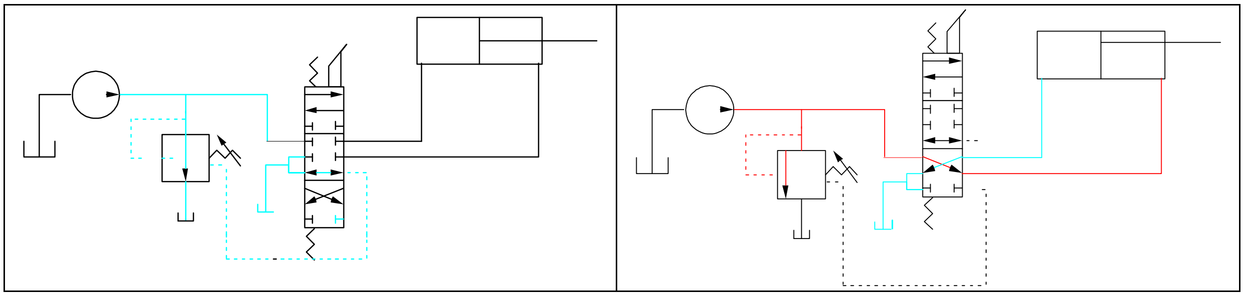
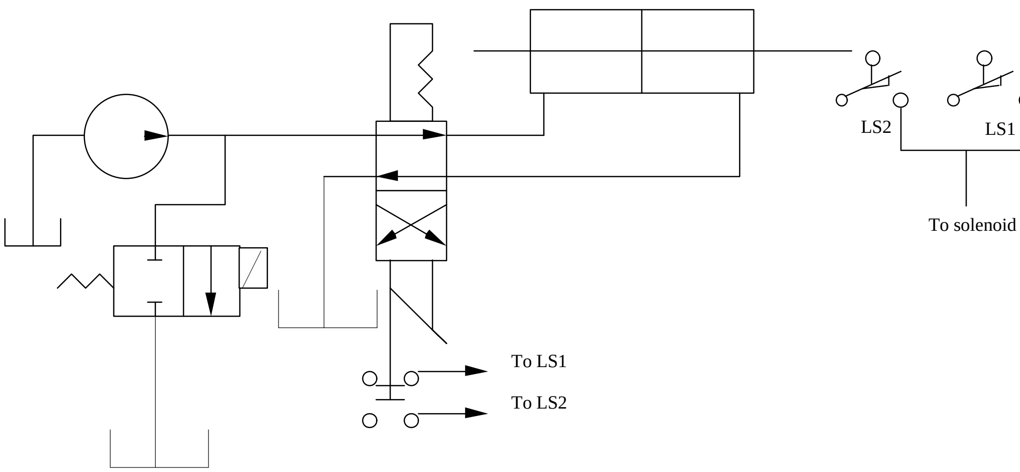
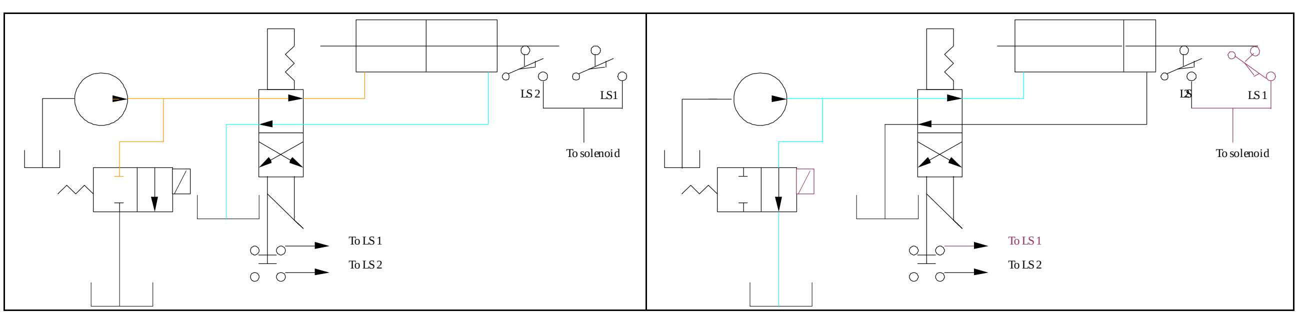


Figure 13.4 Balanced relief valve

13.2.3 Electronic Unloading

Operator manually switches valve to position shown. LS1 is activated. Piston moves to the right until LS1 is engaged which, in turn, actuates the pump valve solenoid. The valve is opened dumping flow to tank at low pressure. To reverse, LS1 is de-activated, closing the solenoid valve.





Normal Operation

PSI activated, Solenoid engages

Figure 13.5 Unloading pressure using electronic limit switches

13.2.4 Pressure Switch

Actuation of pump valve is initiated by a pressure switch

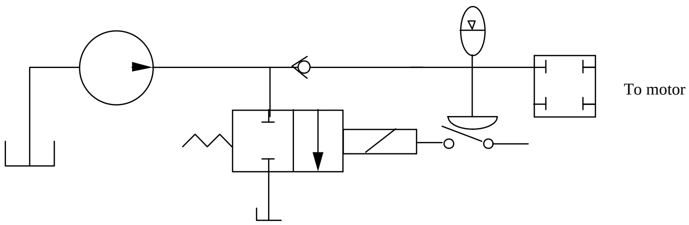


Figure 13.6 Pressure limiting using pressure switches

13.2.5 By-pass ports

When the end of the stroke is reached, the fluid is by-passed to tank via the by-pass port.

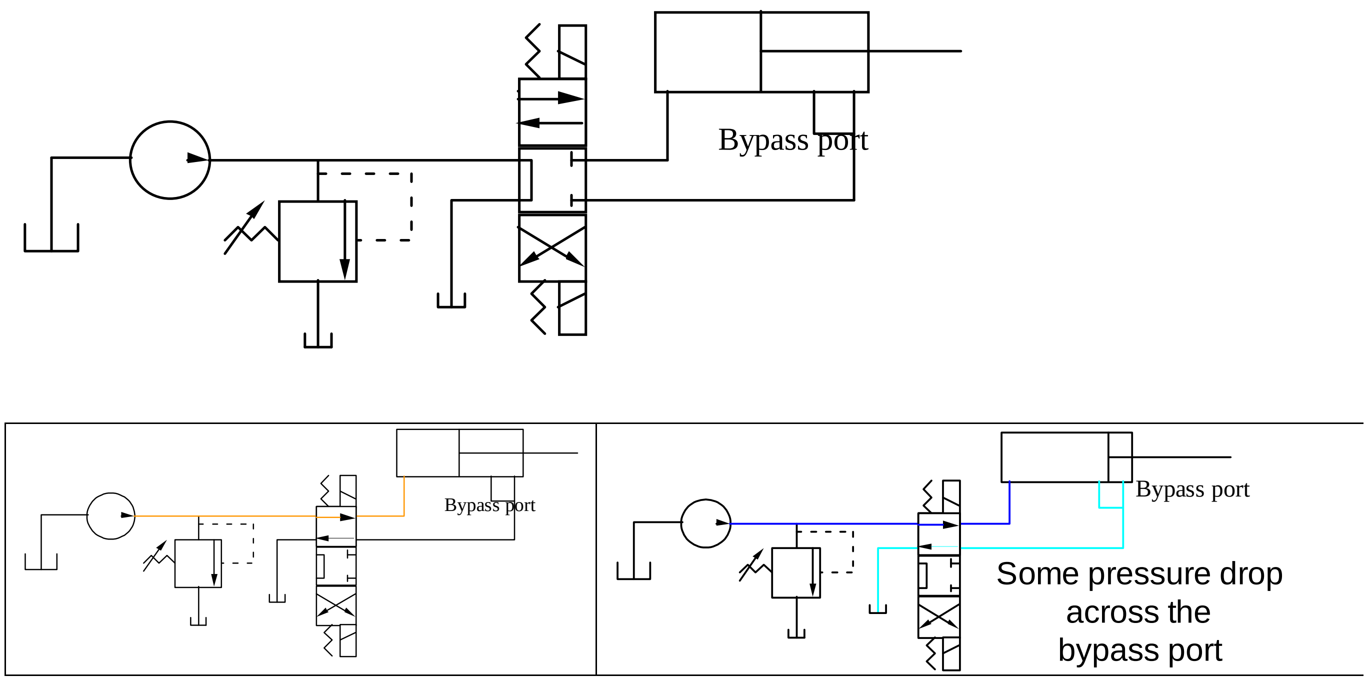


Figure 13.7 Use of Bypass ports to limit pressure

13.2.6 Two by-pass ports

This system will not work if there is an external force on the actuator at the end of the stroke.

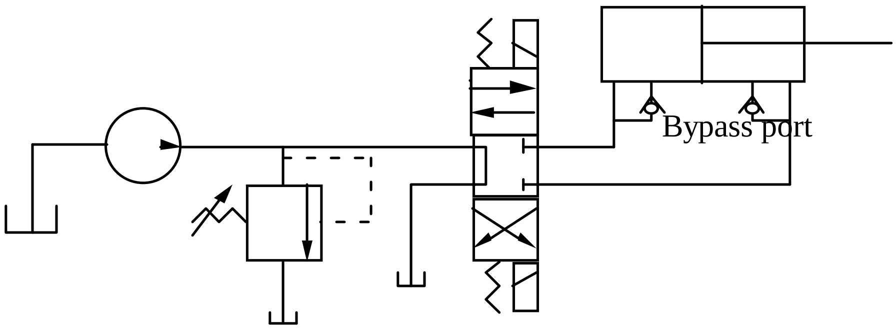


Figure 13.8 Bypass port example

13.3 High-Low Circuits

This circuit is used to provide two output speeds. RV1 is set a low value, RV2 is high. At low system pressure, RV1 and RV2 are not active, The flow to the system is the sum of both pumps. As the system pressure approaches RV1, pump RV1 is unloaded at PRV1 and only flow from pump RV2 is delivered to the actuator. Thus we have high flow rates at low pressure and low flow rates at high pressure.

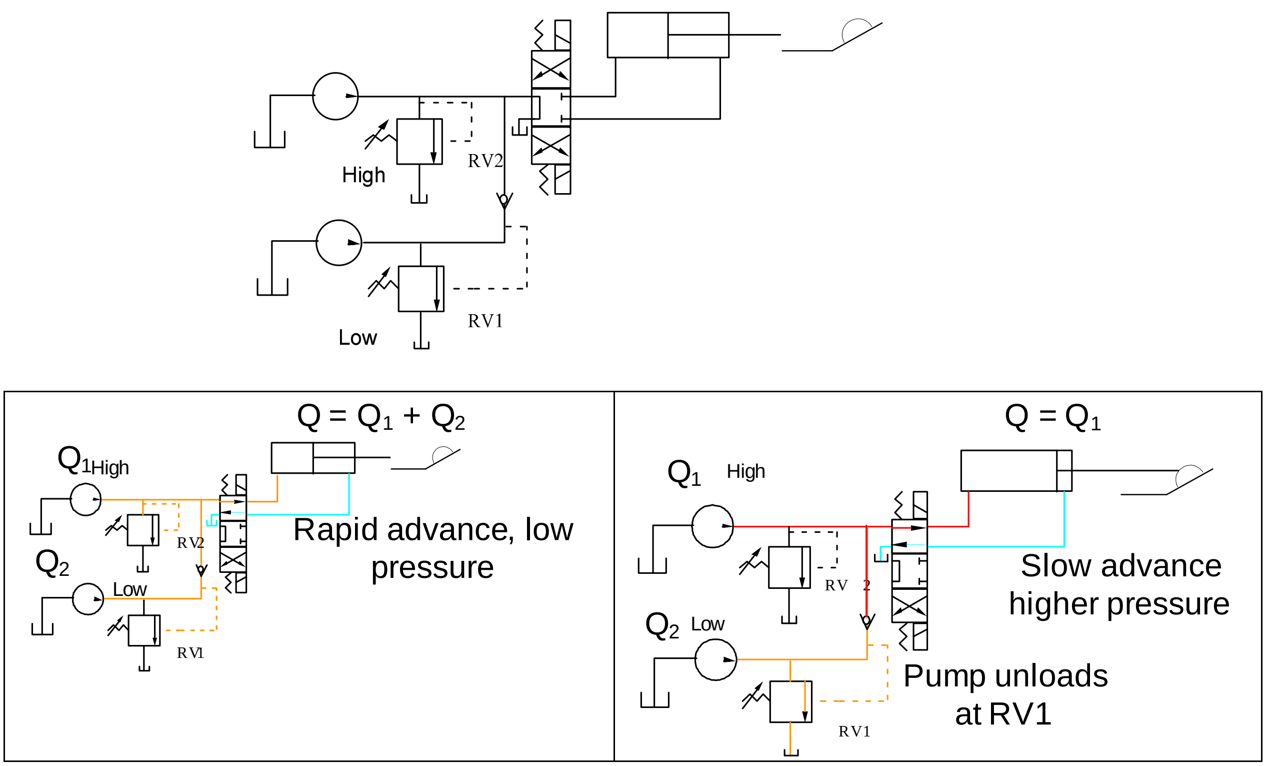
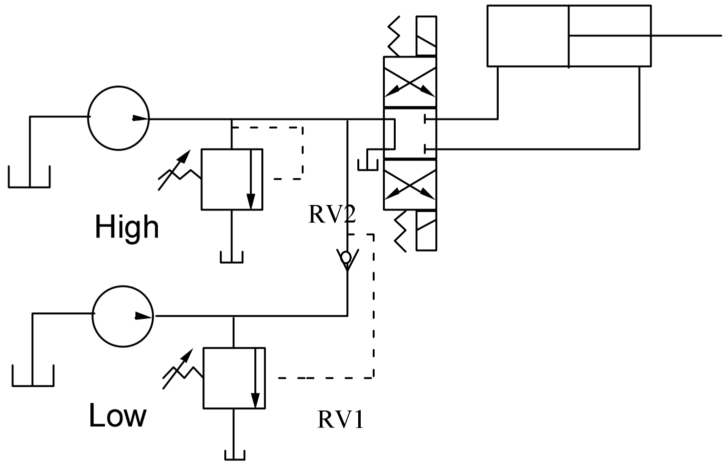


Figure 13.9 High-Low Circuit

In this case, the pump unloads at a low pressure when the pressure at RV1 is reached.



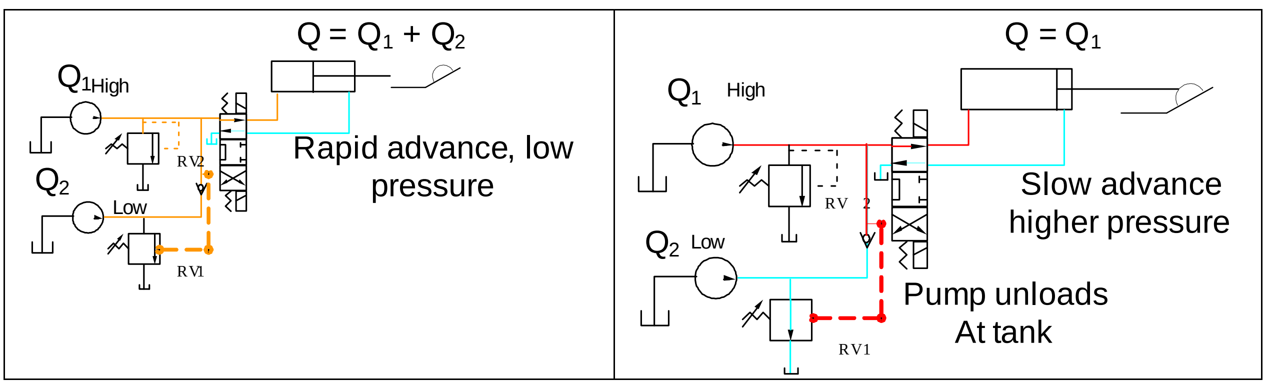


Figure 13.10 Second High – low circuit

13.4 Circuits for controlling cylinder pressure

In this circuit, the pump relief valve is for pump protection. RV1 and RV2 limit pressure in each of the lines.

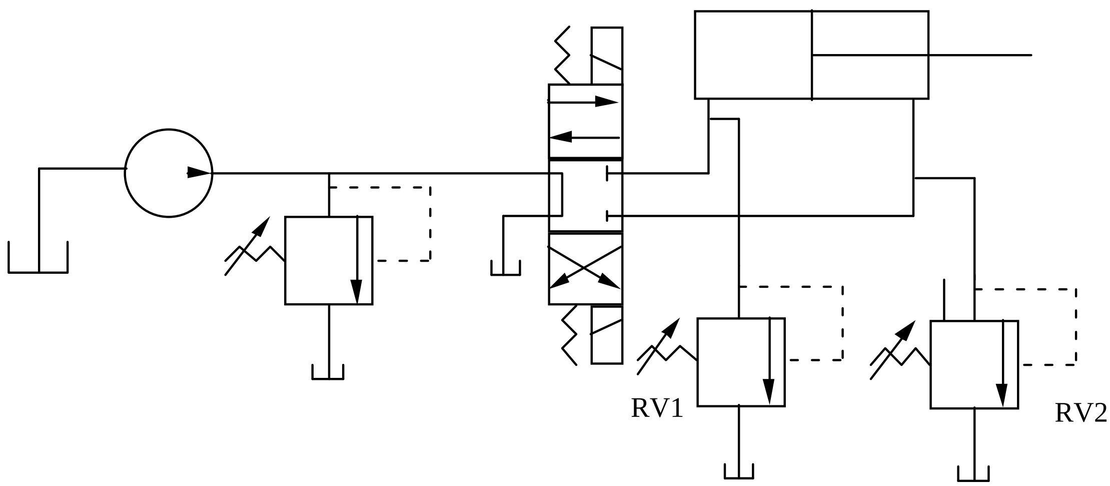
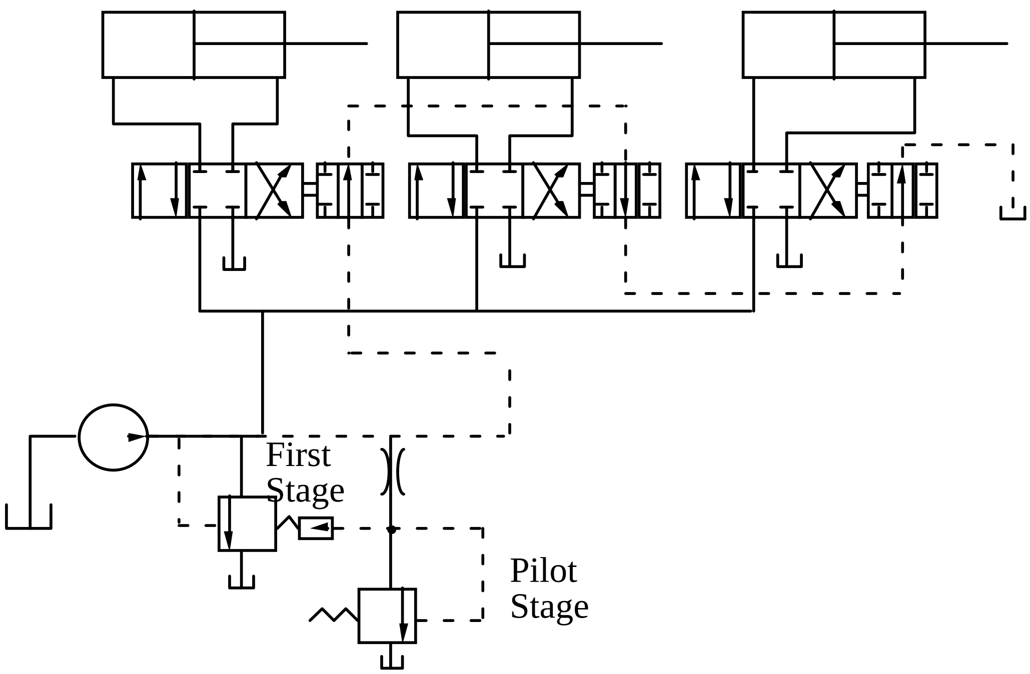


Figure 13.11 Pressure limits in each branch

13.5 Multi-branch Circuits

Here is the case of a single pump providing fluid to several circuits. Only one circuit is activated at a time; if two are activated, the fluid will travel to the system with the lowest burden resistance. In neutral (all valves), the pilot pressure on the first stage is low, unloading the pump. If any valve is actuated, the pilot line is blocked, the first stage relief valve is de-activated and thus the pilot stage becomes the relief valve for the system.



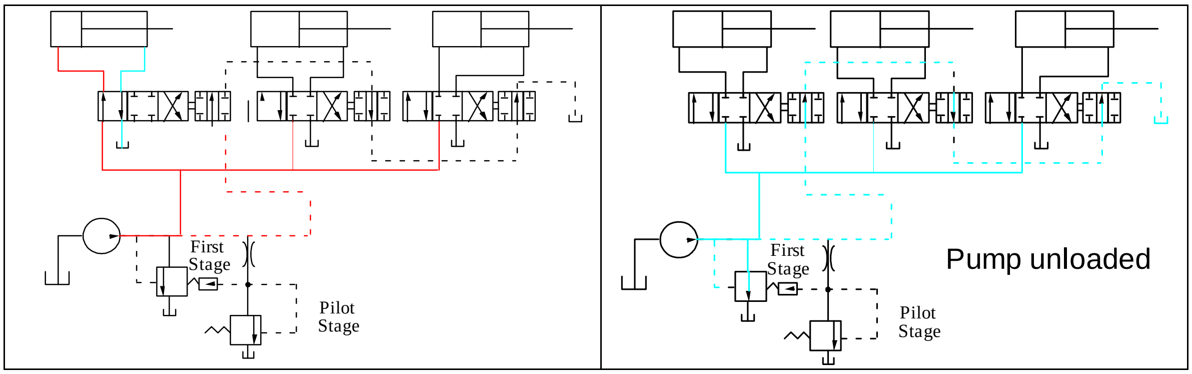


Figure 13.12 Multi-branch pressure limited circuits

A modified version of this circuit enables the system pressure to be dictated at a pressure set on relief valve #1 only if this circuit is activated. The pressure setting must be less than the main system relief valve value.

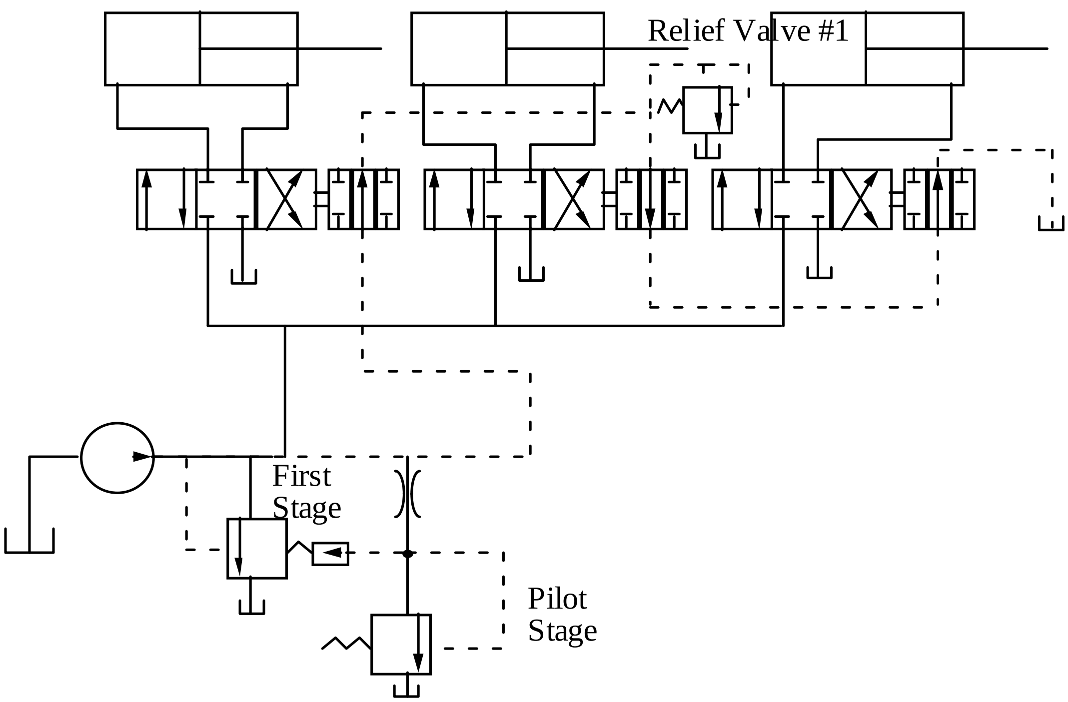
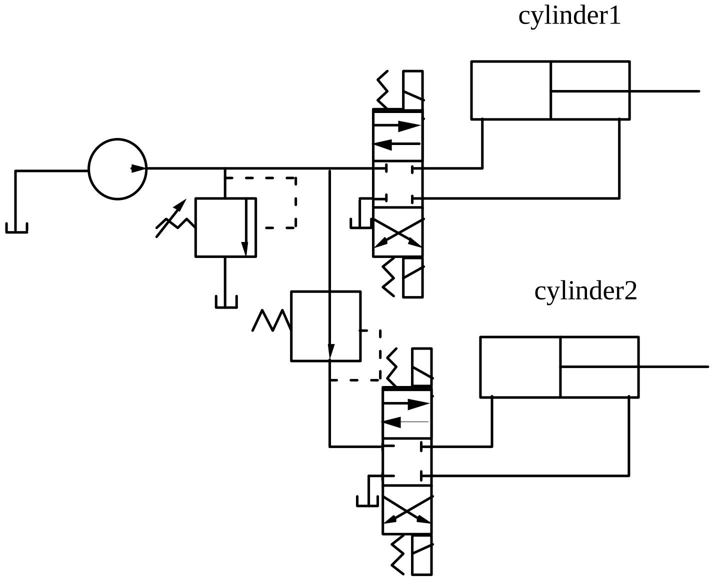


Figure 13.13 Multi pressure, multi branch circuit

13.6 Use of Pressure Reducing Valves

The pressure in cylinder 1 is limited by the main relief valve. Pressure in cylinder #2 is limited by the setting of the pressure reducing valve. Note that the pressure in circuit #2 is controlled as well as limited



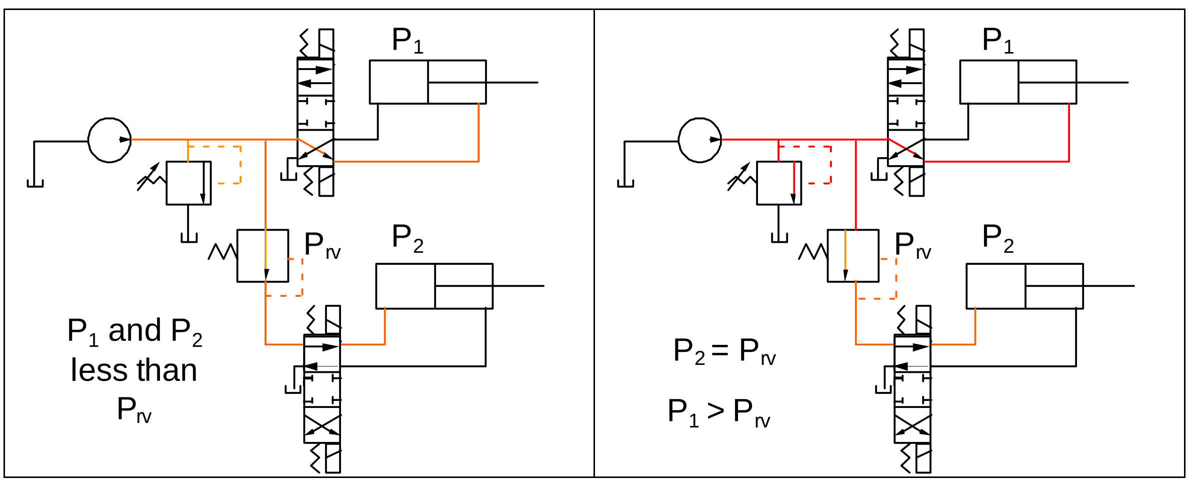


Figure 13.14 Pressure reducing circuit

13.7 Complex Multi-Pressure System

In the neutral position, RV1 sets the maximum pressure. Switching the Relief Valve Directional Control Valve, will enable RV2 or RV3 and thus, maximum system pressure is changed

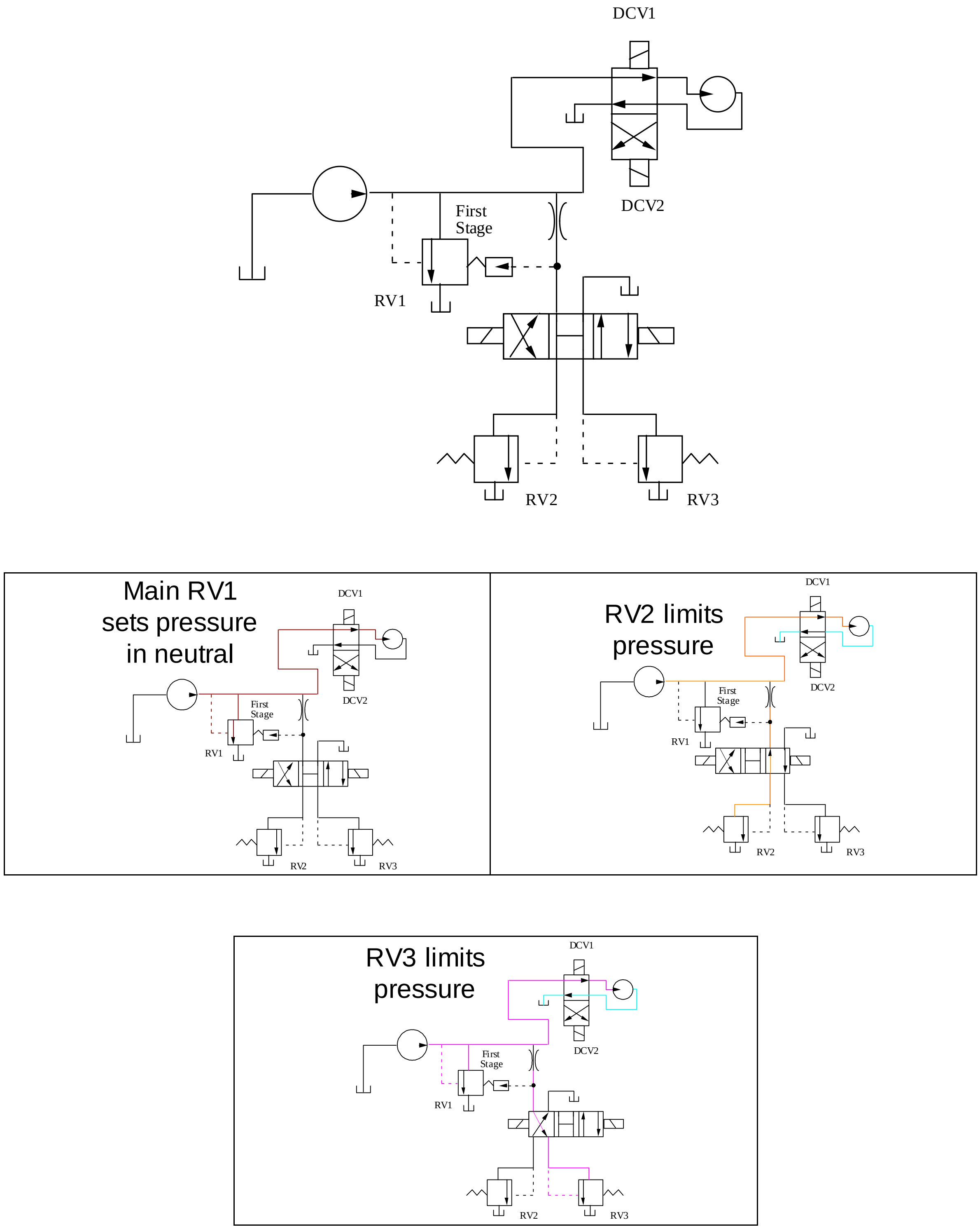


Figure 13.15 Multi-Pressure circuit

13.8 Accumulator Circuits

The purpose of accumulator circuits is to provide a means to store energy or provide pressurized fluid on demand. Accumulator circuits can also be used to absorb pressure shocks.

The first circuit is a standard accumulator circuit when the accumulator is the primary source of fluid. The pump unloads when the relief valve setting is encountered. The pump becomes active (as far as the rest of the circuit is concerned) when the reseating pressure on the relief valve is reached.

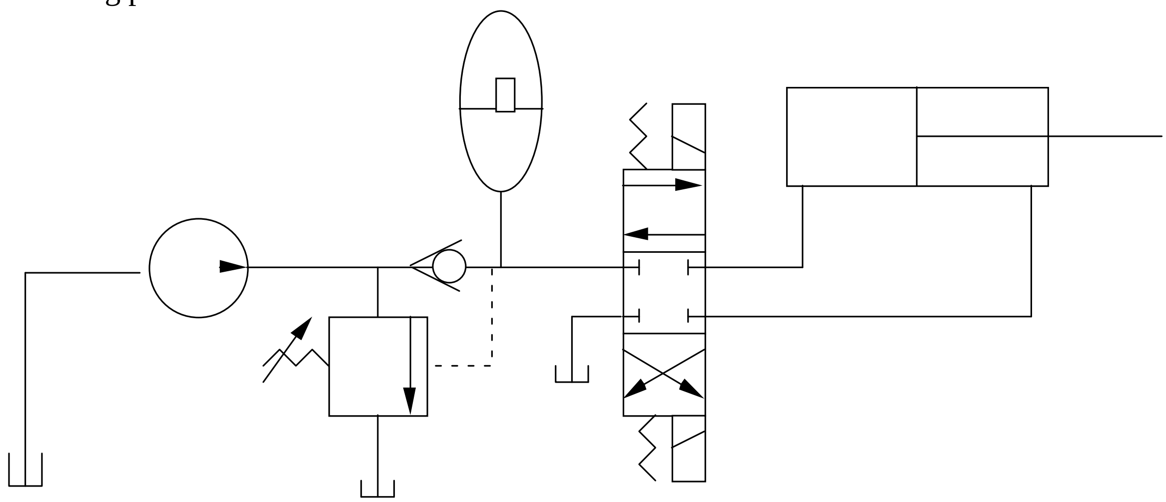


Figure 13.16 Accumulator circuit #1

In this case, the pump is always active. The accumulator is used to provide constant pressure to the circuit when desired.

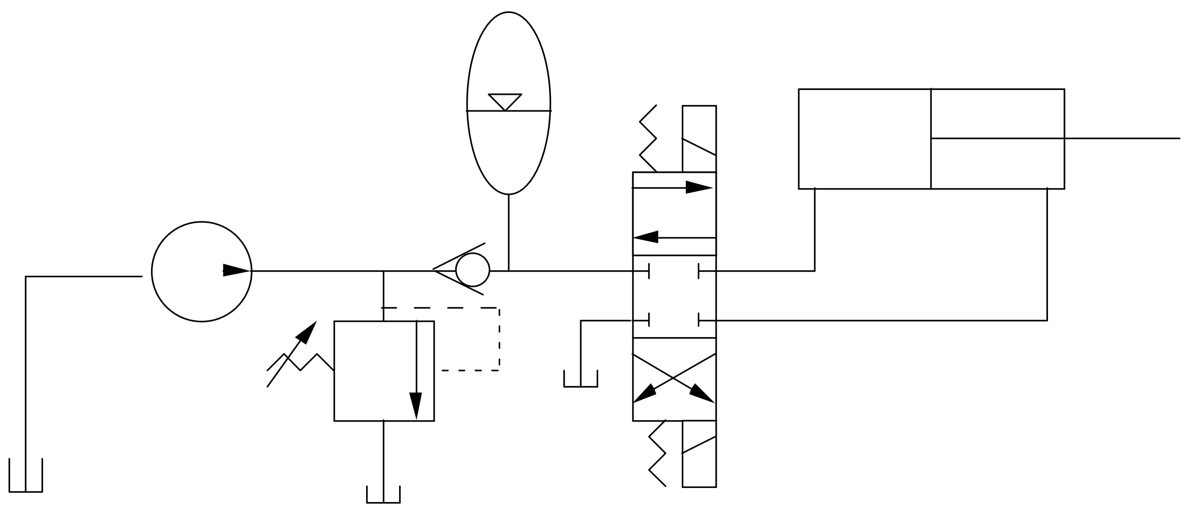


Figure 13.17 Accumulator circuit #2

The accumulator exercises pressure control only in the line it acts.

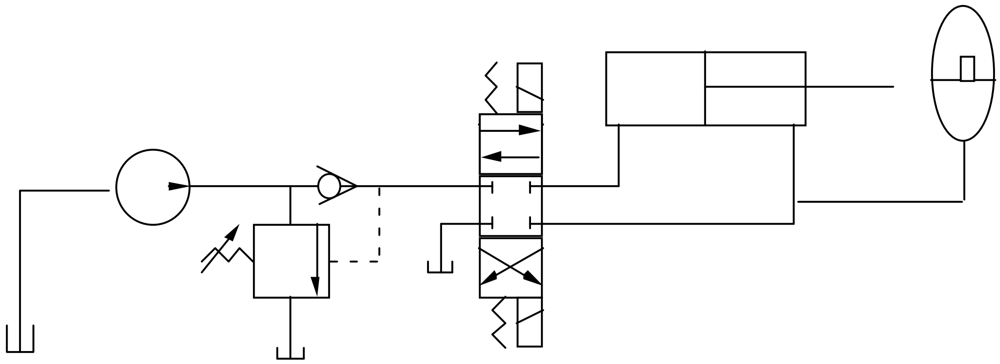


Figure 13.18 Accumulator downstream

The accumulator is used to absorb pressure shocks in the system.

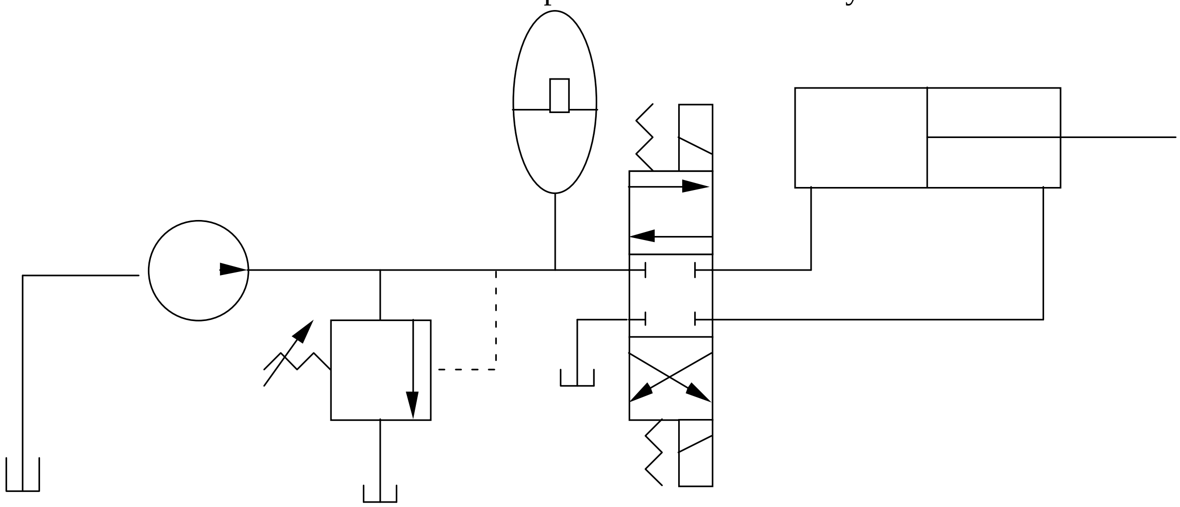


Figure 13.19 Shock absorption accumulator

This accumulator absorbs shocks near the motor only.

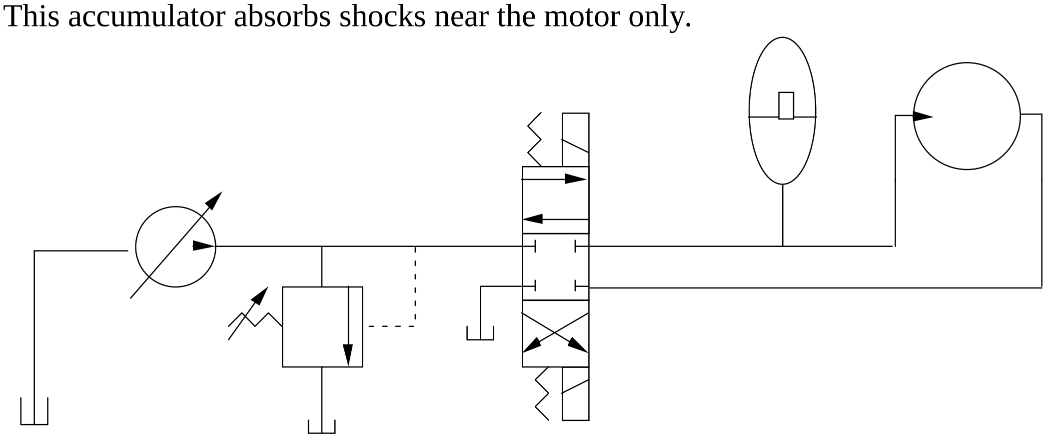


Figure 13.20 Accumulator near motor upstream

13.9 Circuits for Flow Control

13.9.1 Regenerative Circuits

When the regenerative flow position of the DCV is activated, both sides if the actuator are at the same pressure. Flow from the rod end of the actuator is forced back to the blank end effectively increasing the flow to (and the velocity of) the ram. This is at the expense of the system pressure which must increase to meet the burden force requirements.

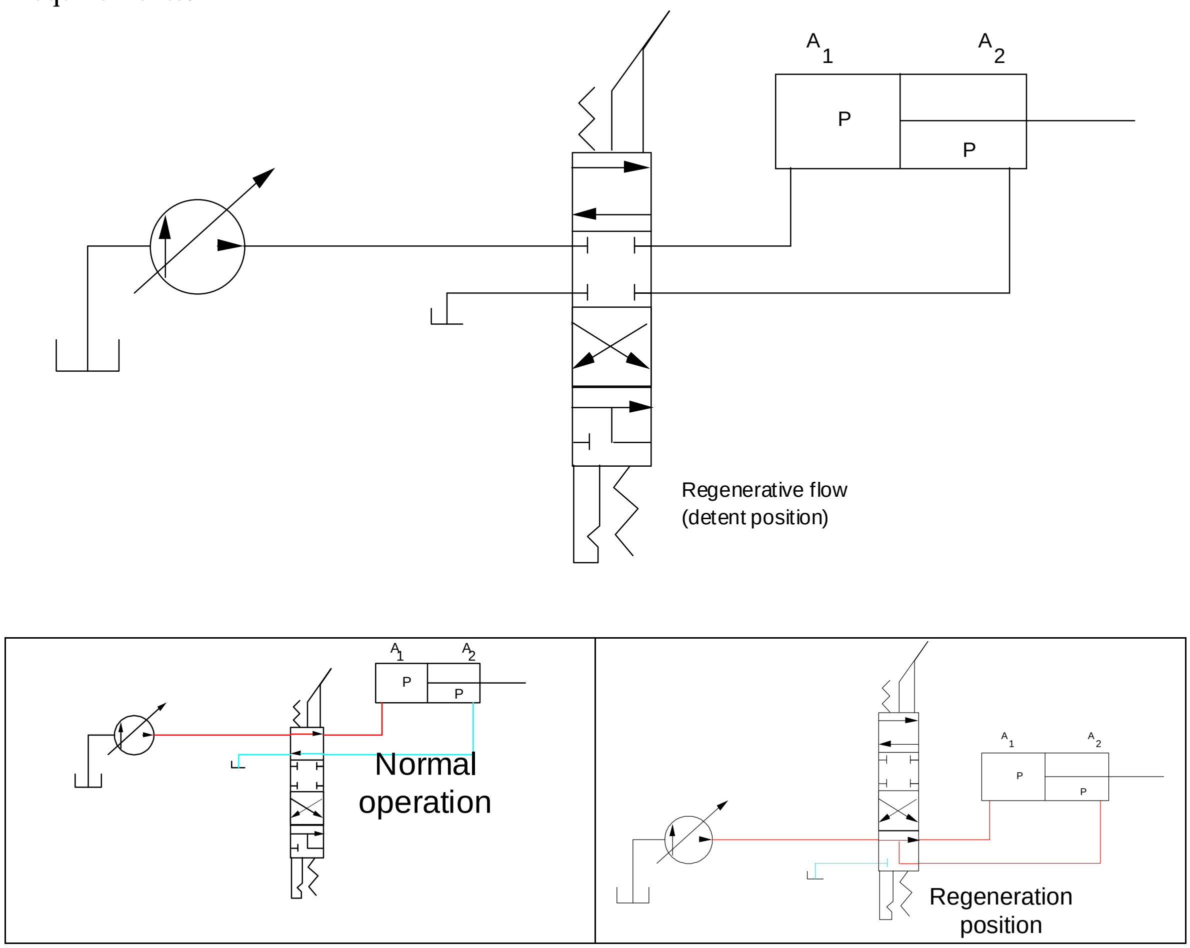


Figure 13.21 Regenerative circuit

Now let P be the system pressure. Let

$F_1 = P A_1$

$F_2 = P A_2$

and F_L = Burden force

Then $F_1 + F_2 \pm F_L$ or $P A_1 - P A_2 = F_L$

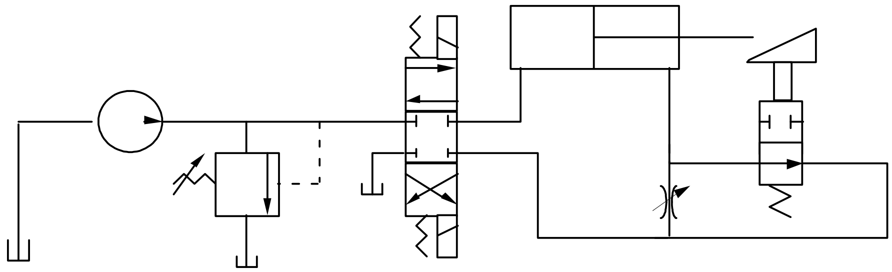
or $P (A_1 - A_2) = F_L$

Thus $P = \dfrac{F_L}{A_1 - A_2}$

The total flow to the actuator is $Q_{pump} + Q_{actuator}$ (ram side)

13.9.2 Intermittent Feed Control

There is unrestricted flow until the valve is activated. At this point meter out occurs



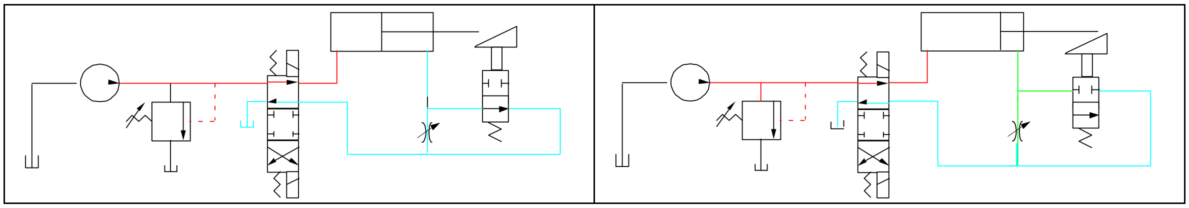


Figure 13.22 Intermittent feed control

13.9.3 Deceleration Control

Special deceleration valves create slowly closing variable orifices to decelerate the system at the end of the stroke. A special mechanical cam is used to set the deceleration rate.

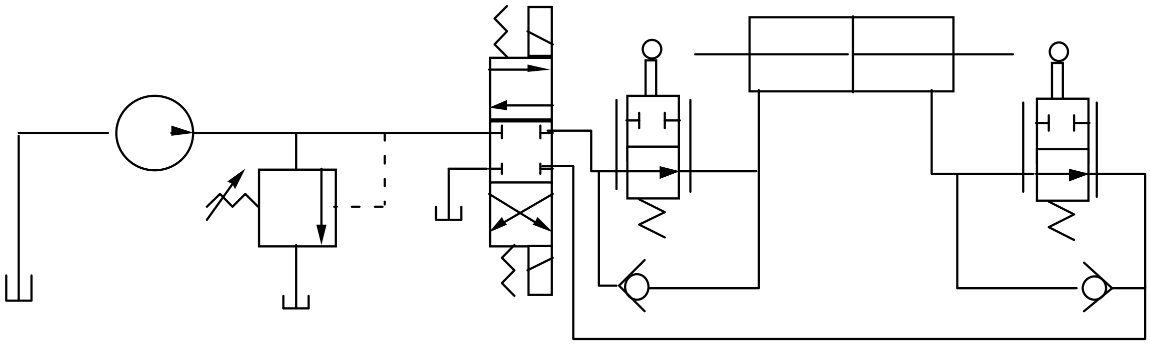


Figure 13.23 Deceleration control

13.9.4 Multiple Area Control and Compound Cylinders

In this circuit we have a fast forward situation (small area, low force) and a slow reverse (large areas due to two exposed area) but a large force possibility.

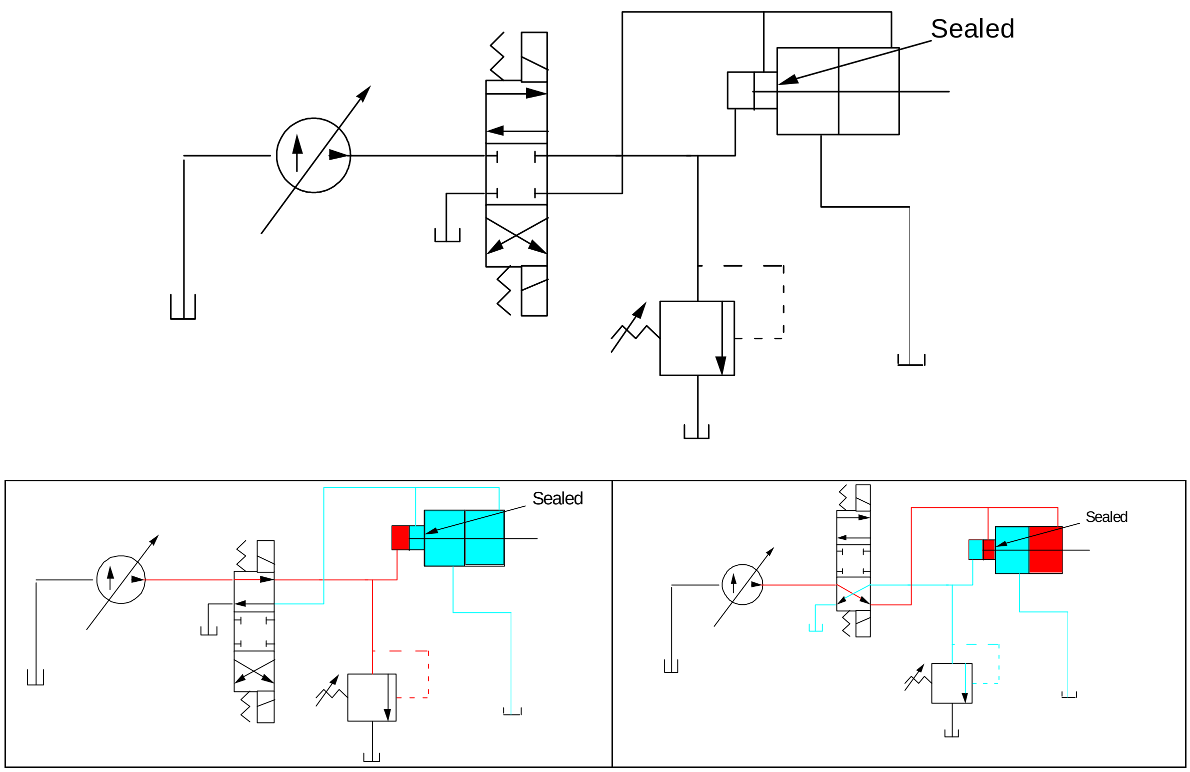


Figure 13.24 Transformer circuit

13.9.5 Prefill System (Press)

In this circuit, the prefill valve is activated when the ram is lowered. The pilot operated valve is also used to allow the fluid to return to tank when the ram is raised. The operation of this circuit will be discussed in class.

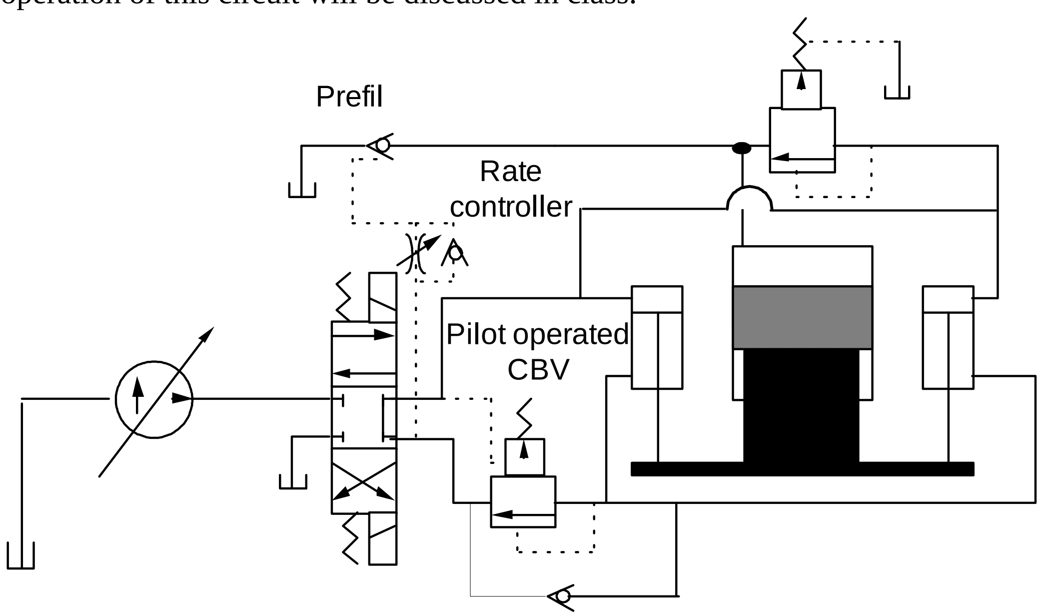


Figure 13.25 Hydraulic press

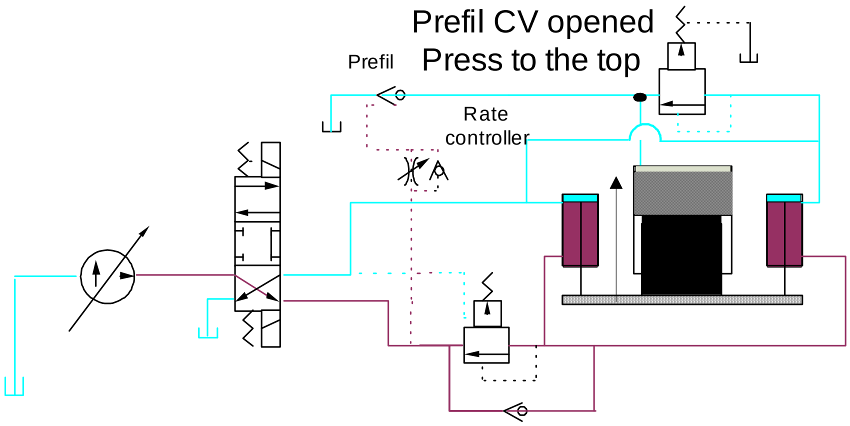


Figure 13.25 (a)Lifting press

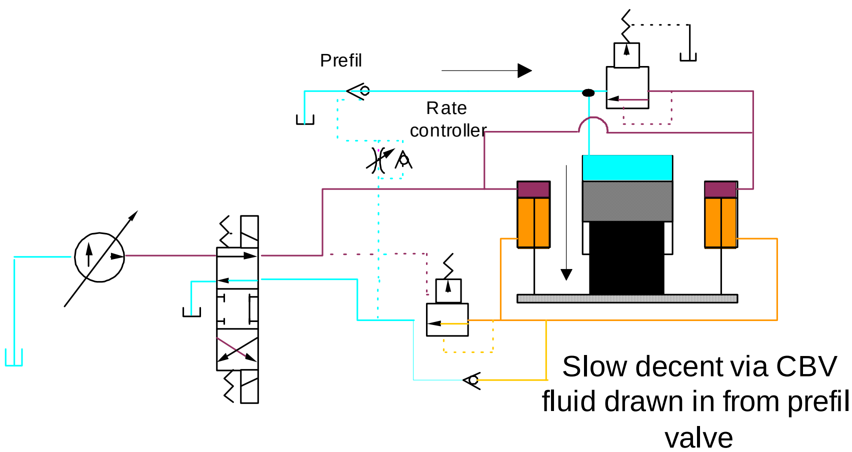


Figure 13.25 (b) Lowering press

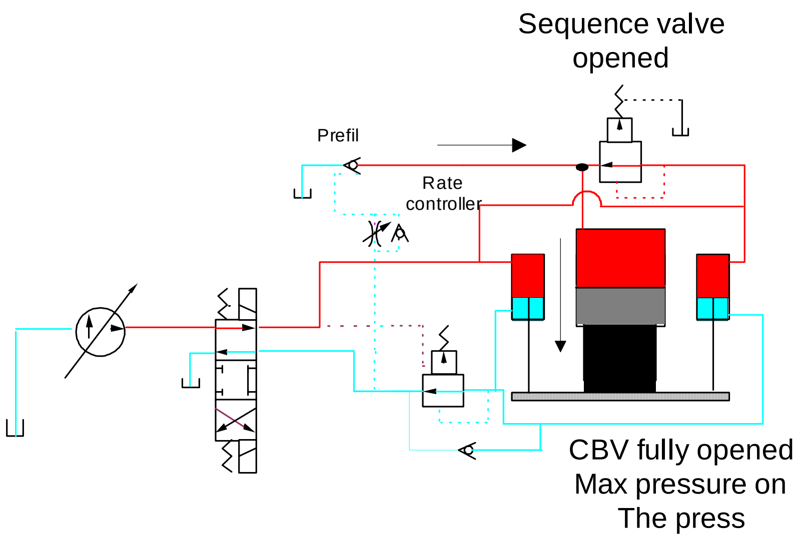


Figure 13.25 (c) Full pressure

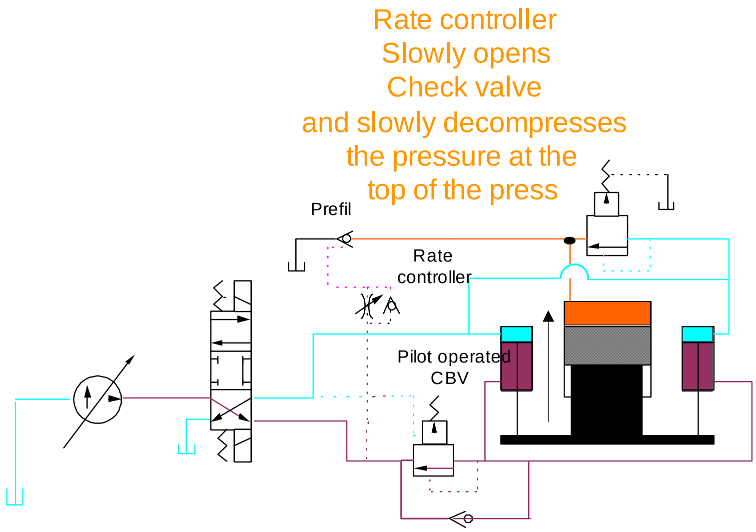


Figure 13.25 (d) Decompression

13.9.6 Flow Divider Circuits**.**

Flow divider circuits split the pump flow into two paths, hopefully independent of the loading conditions. The first circuit is meter in. The second, a meter out configuration.

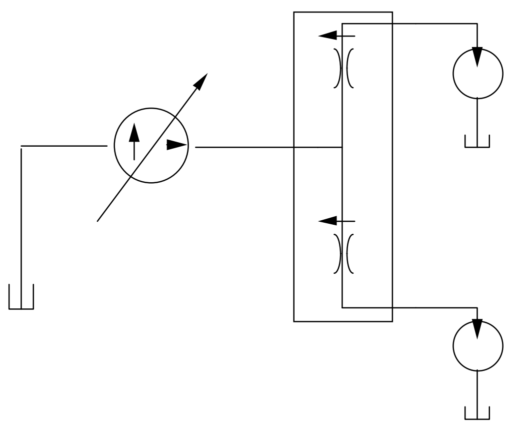


Figure 13.26 Flow divider circuit

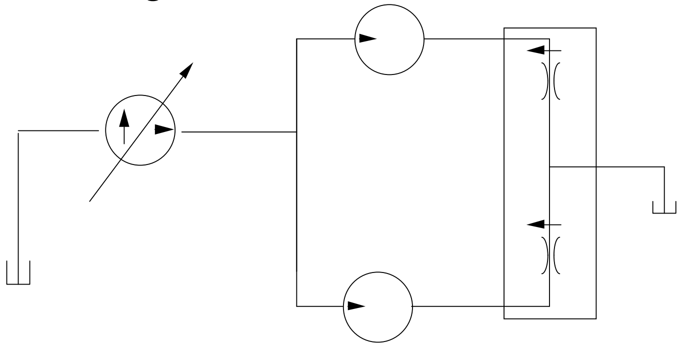
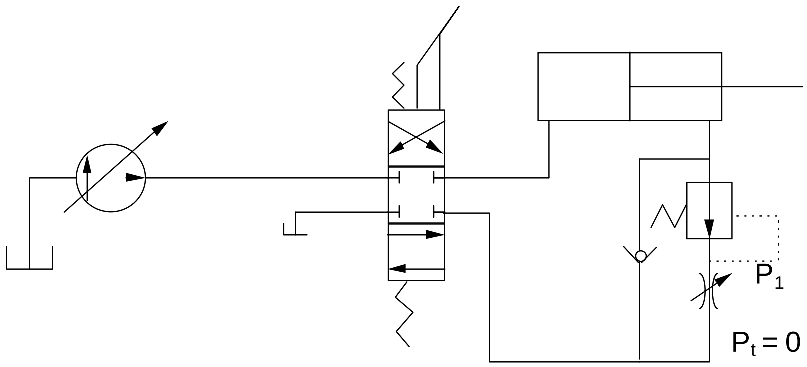


Figure 13.27 Flow divider circuit using motors

13.9.7 Basic Meter out (Control)

This is a simple way of making a pressure compensated flow control valve in a meter out configuration. The pressure reducing valve maintains a constant pressure drop across the orifice



$$Q = C_d \, A \sqrt{\frac{2}{\rho} P_1}$$

$$\textit{but } P_1 \textit{ is a constant}$$

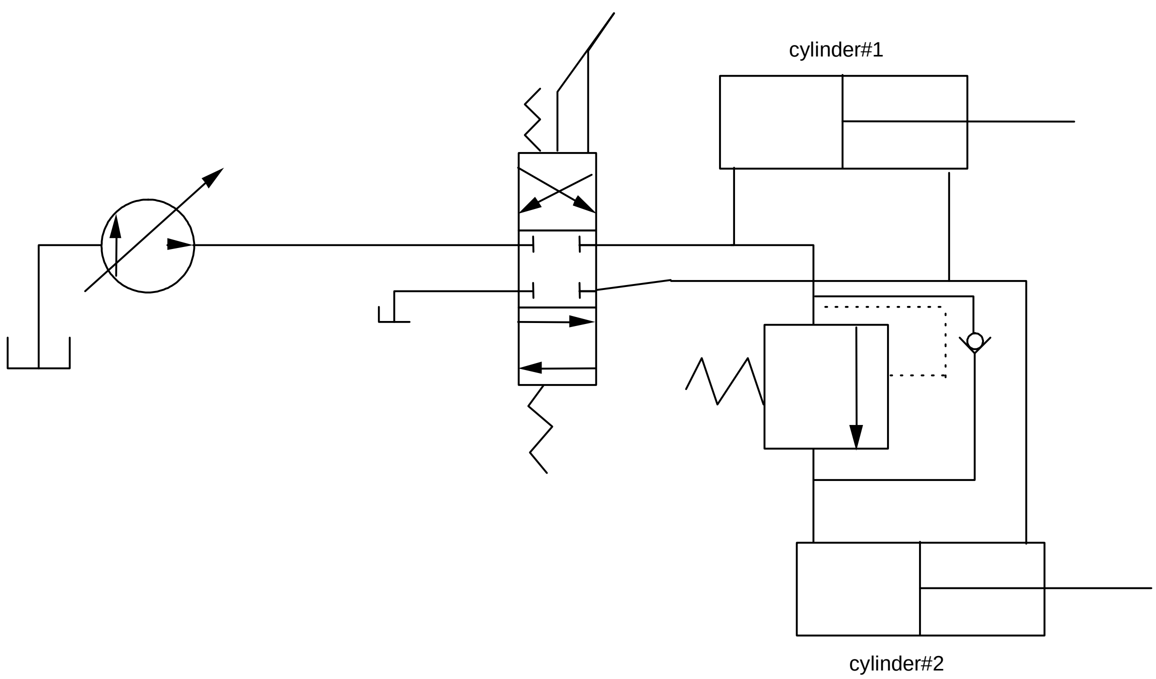
$$\textit{Therefore } Q = \textit{constant}$$

Figure 13.28 Meter-out circuit

13.10 Other Circuits

13.10.1 Sequence circuits

When cylinder #1 is fully retracted, the pressure increases until the sequence valve is activated. Cylinder #2 then moves.



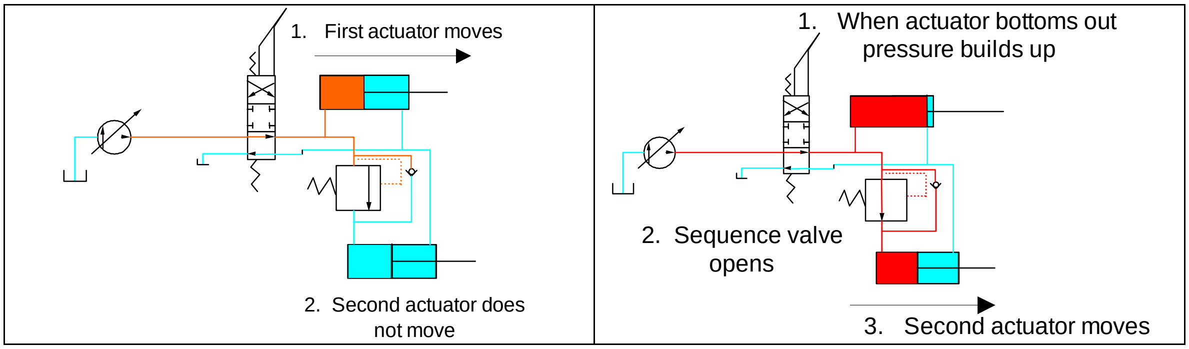
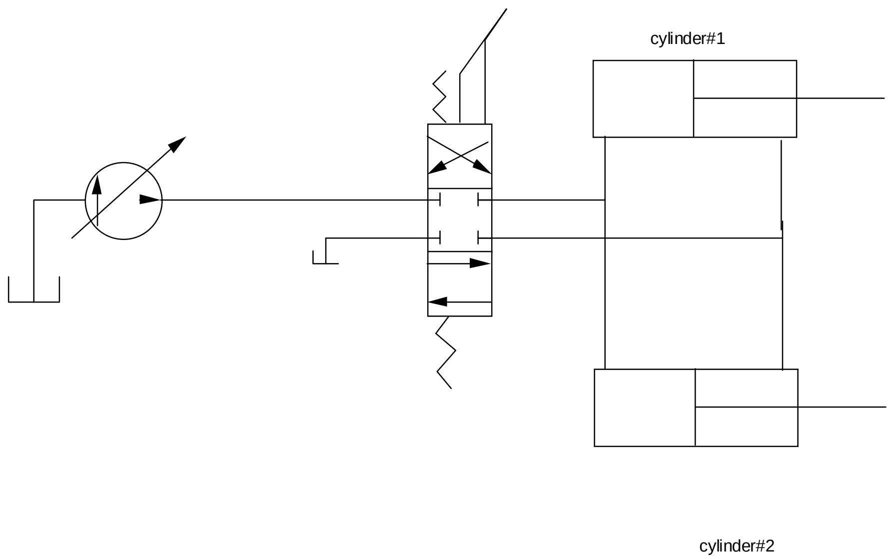


Figure 13.29 Sequence circuit

13.10.2 Synchronization Circuits

Is this circuit adequate for flow synchronization of two cylinders?



Answer. No See below.

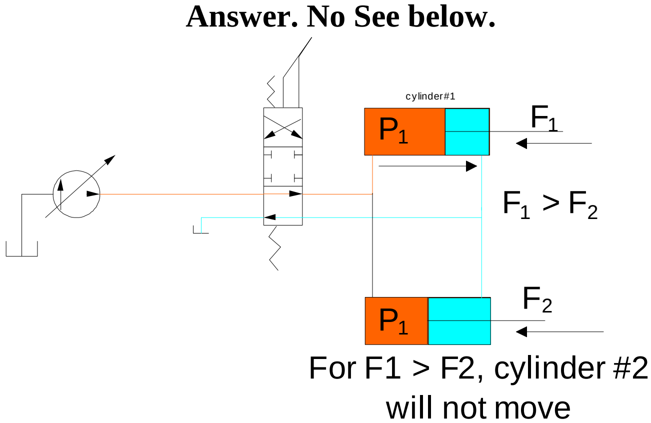


Figure 13.30 Synchronization with no flow control

NOTE Synchronization can only be absolutely ensured by using servo-systems (closed loop control)

This is a master slave circuit where the area of the rod end of the first cylinder must exactly match the area of the blank end of the second cylinder. A problem occurs if leakage is present.

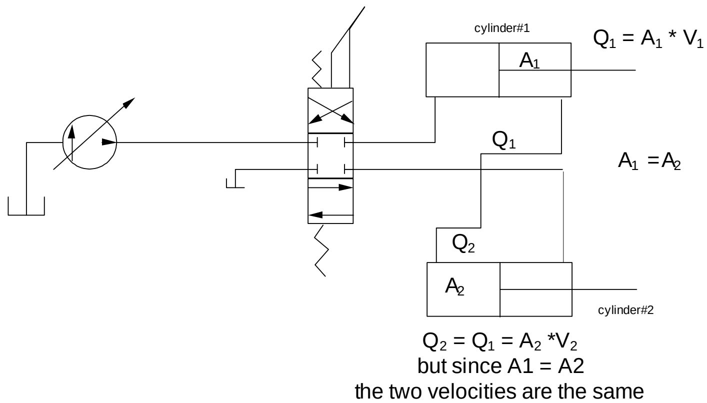


Figure 13.31 Master – slave circuit

Other methods of synchronization include the use of meter in and meter out circuits (flow dividers.) The accuracy strongly depends on the flow divider/combiner accuracy.

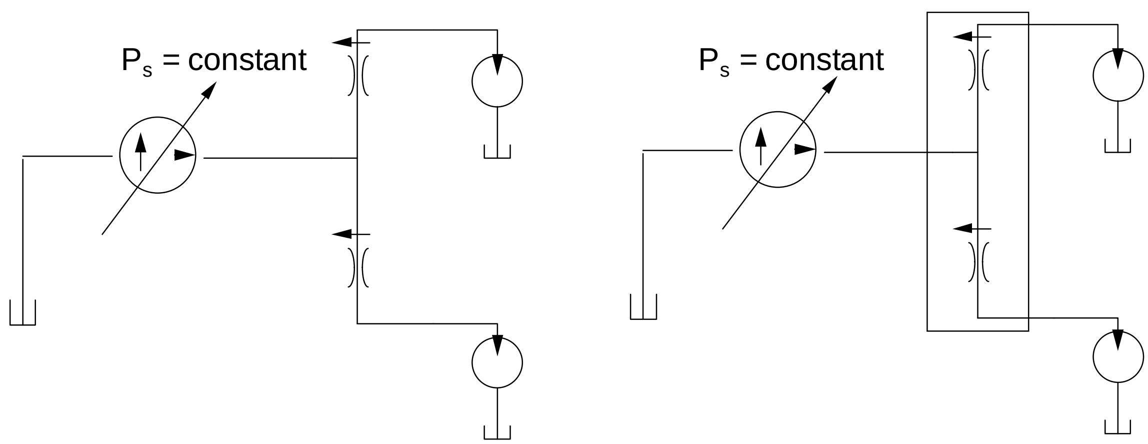


Figure 13.32 Meter in and flow divider circuits to synchronize flow
Note this circuit also isolates the two loads so that changes in the pressures at the motors will not affect the other circuit

13.10.3 Multi-load circuits

To isolate multi-load circuits, we must unsure that the pressure at the pump is always constant. Thus changes in the flow or load pressure in one circuit will not affect the others. THIS IS VERY IMPORTANT. Figure 13.22 demonstrates one way of accomplishing this.

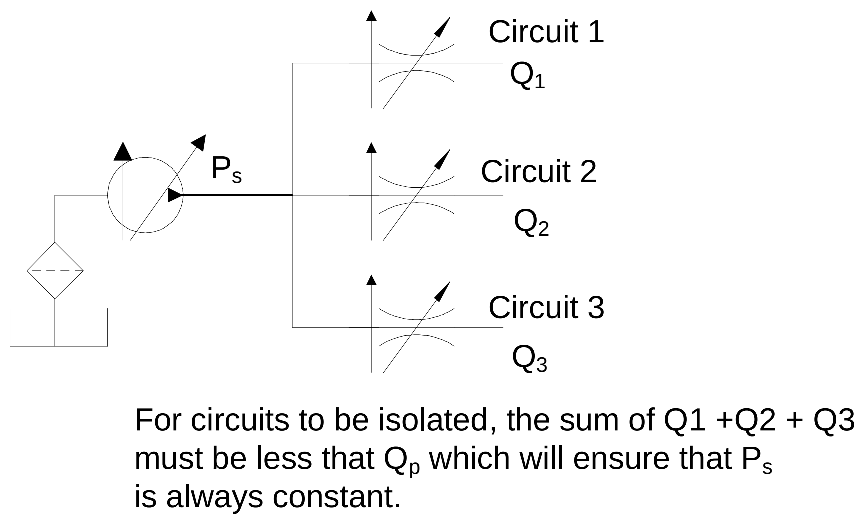


Figure 13.33 Isolation of circuits.

13.10.4 Load Locking Circuits

Cross over check valves keep the load locked into place when system pressure is removed. This is a very important safety feature for gravity (over-running) loaded actuators.

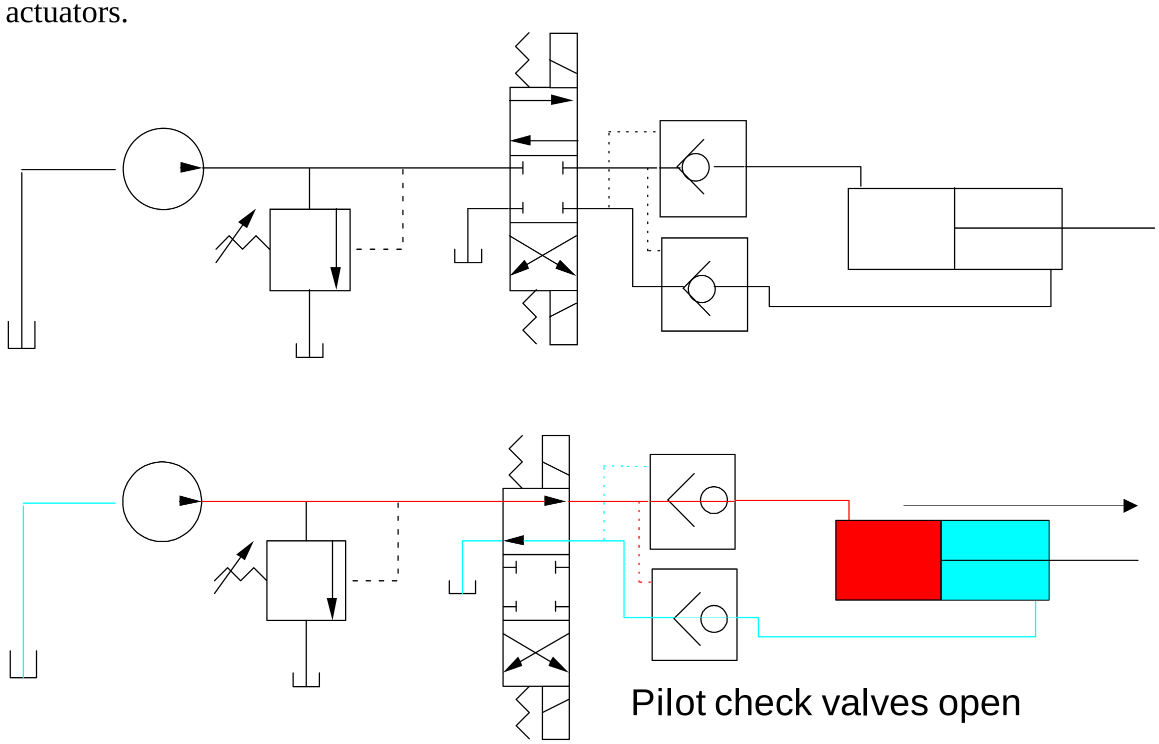


Figure 13.34 Load locking circuit

13.10.5_Counter-Balance circuit

Maintains a constant controlled back pressure on the actuator.

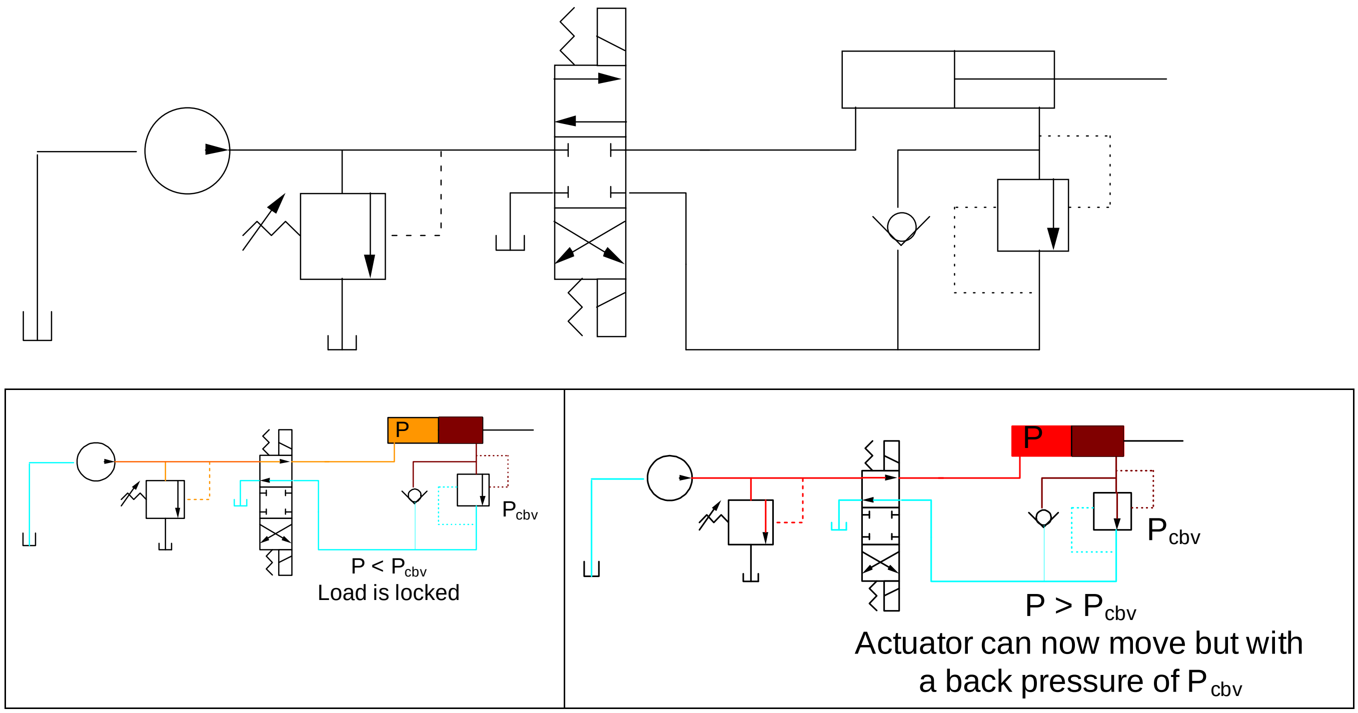
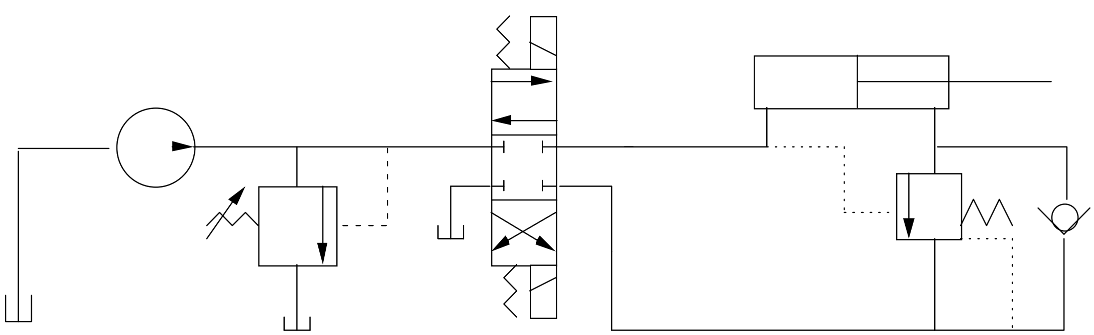


Figure 13.35 Counterbalance circuits

This circuit uses a balanced counterbalance valve which slowly opens only if the upstream pressure is high. At low upstream pressures, a constant back pressure exists (regular counter-balance valve).



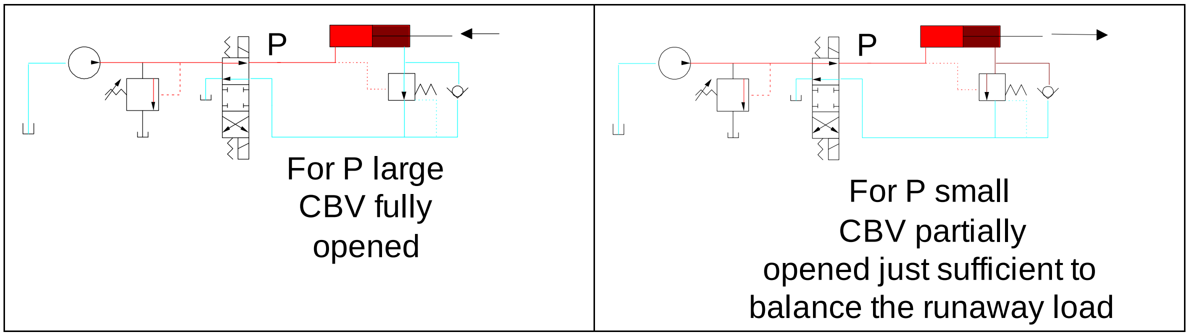


Figure 13.36 Pilot operated counterbalance circuits