The design of a control using logic elements

Now that the most important functions and variations of the control of logic elements have been dealt with, a press control will be examined step-by step as a design exercise.

This sample circuit will act both as a revision exercise and as an aid to understanding how the individual functions so far introduced they may be combined.

Safety controls which are normally found in press circuits are not included in this exercise.

Step One *(Fig.162)*

The motor-pump group and pressure relief function

Logic element (1) is used to limit the pressure within the system. Low pressure by-pass (unloading) is achieved by means of directional valve (1.1) with solenoid Y5 (in the spool position shown).

The spring chamber of valve (1) is at zero pressure via the control line *(yellow)*. Pilot pressure valve (1.2) is inoperative. *(Compare this to Fig. 97 in the chapter on "Pressure Functions")*

When solenoid Y5 is energised to move the valve into position a, the pilot drain line is blocked and the pressure relief function is enabled.

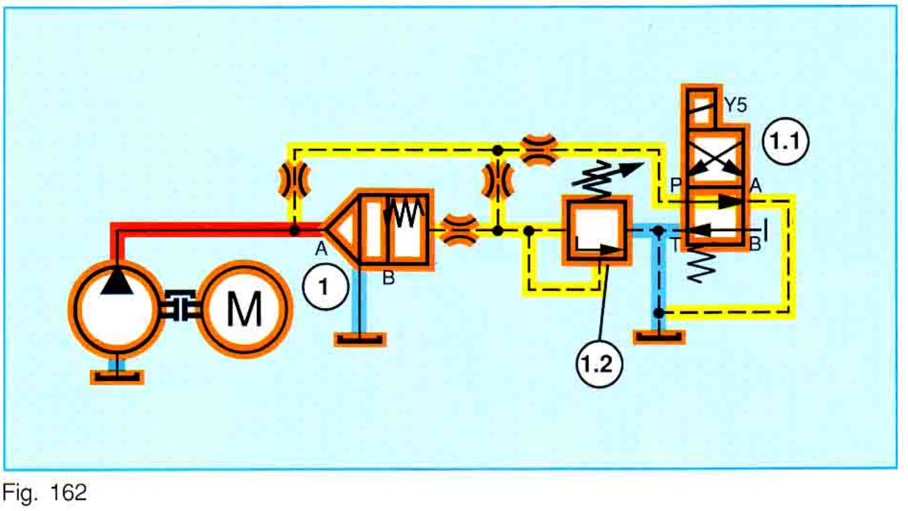

Fig. 162

Step Two

Retracting the cylinder (the return stroke) *Fig. 163*

Valve (2) is introduced into the circuit in order to retract the cylinder. Fluid can flow freely through this valve from A to B. When the system is at zero pressure and logic element (2) is held closed by the load pressure (the weight of the press tool) in the control line *(yellow)*. *(Also see the chapter on "Directional functions" 2.1, Fig. 29).*

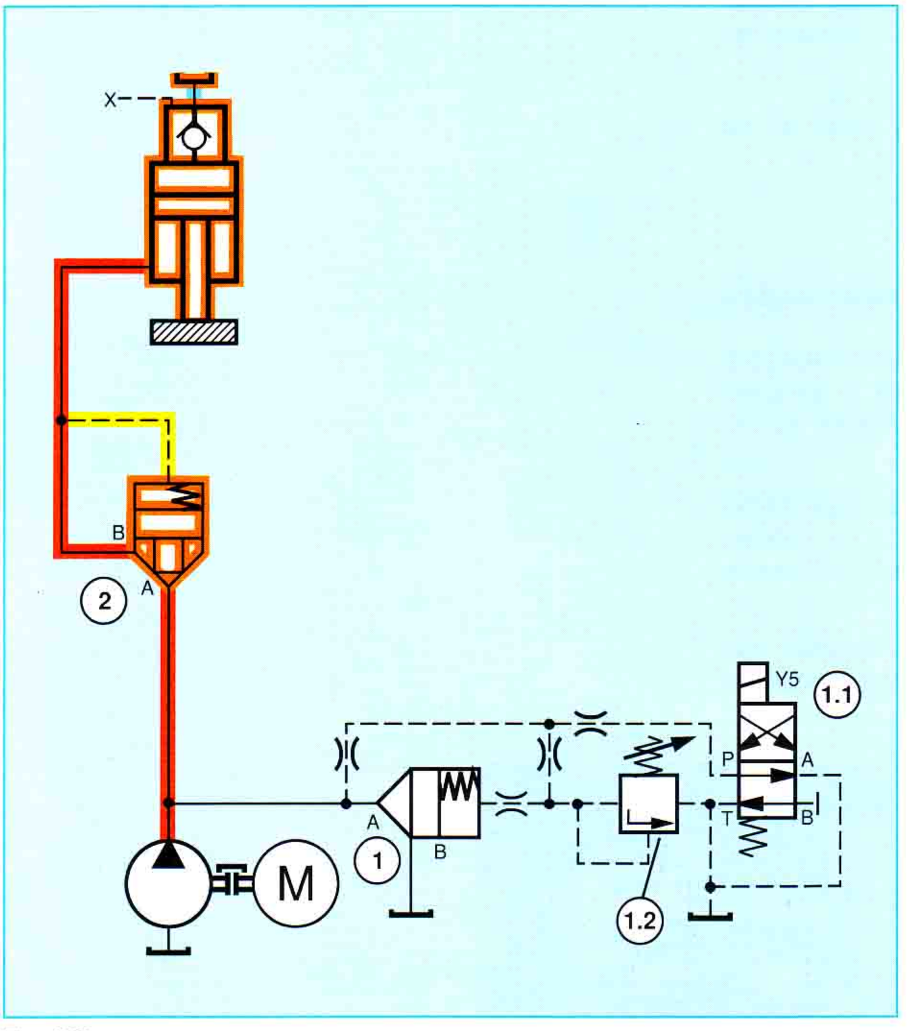

Fig. 163

Step Three

Decompression of the full bore of the cylinder before the return stroke

Before the cylinder can retract, the pressure present in the full bore of the cylinder resulting from the pressing operation must be dissipated in a controlled manner in order to prevent a decompression shock occurring. Logic element (3) with a damping nose and stroke limiter is used for this purpose.

In the starting condition shown in *Fig. 164*, logic element (3) is held closed by the 3/2 way directional valve. Operating solenoid Y2, releases pressure from the spring chamber of valve (3). Logic element(3) then opens under control from port A and unloads the cylinder. The orifice in the tank line of valve (3.1) influences the opening speed of the logic element.

The main volume of oil in the press cylinder can now be returned to tank via the prefill valve built on to the cylinder. Port X of the prefill valve is pressurised between 0,2 to 1 seconds later than the energisation of solenoid Y2.

Logic element (3) is equipped with a damping nose in order to extend the opening curve and enable the decompression to be more easily set. *(Also see the chapter "Directional Functions, Model variations; 3. Damping Noses")*. Stroke limiting is included if an extended decompression time (>1 sec) is required.

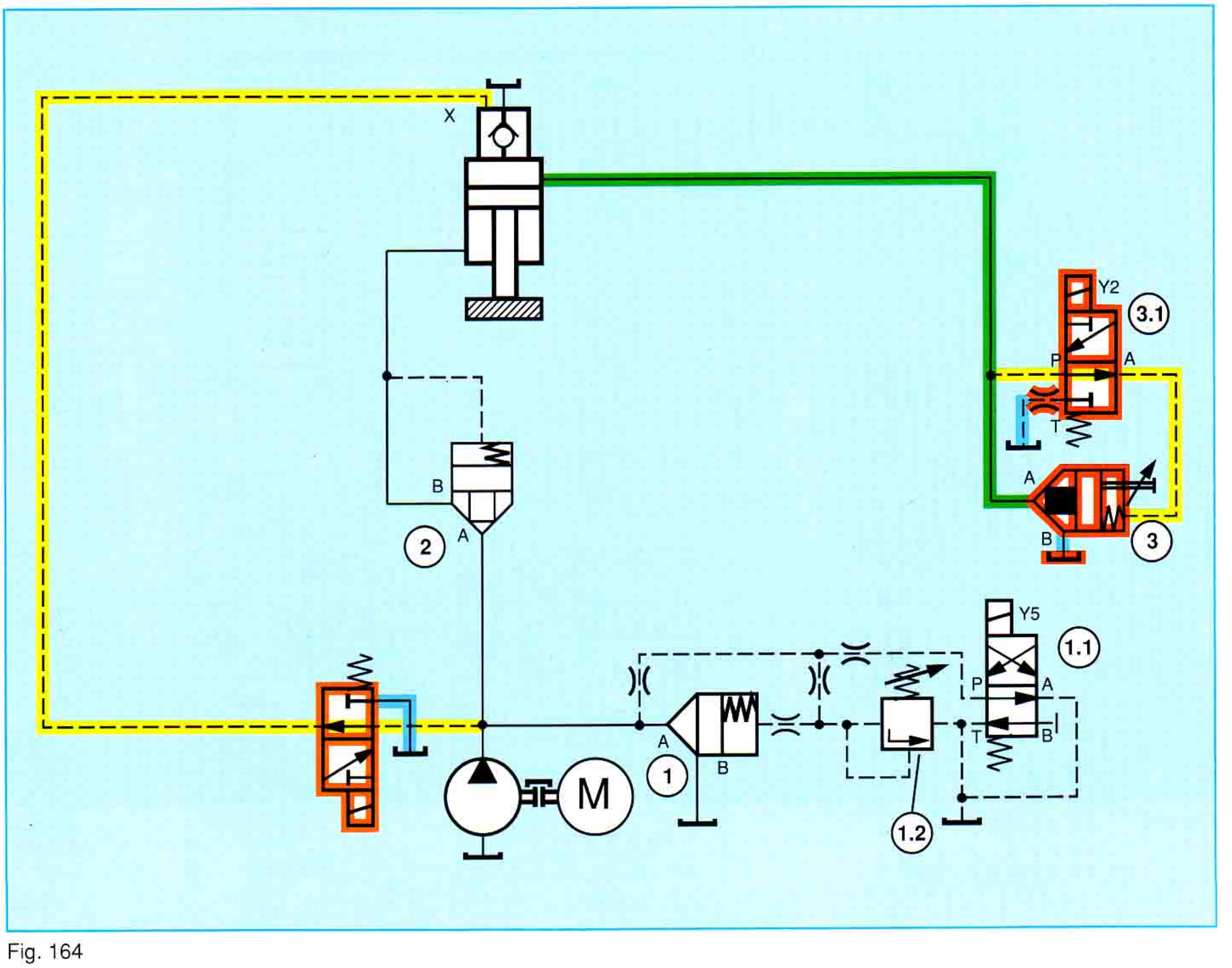

Fig. 164

Step Four

Connecting the pump to the full bore of the cylinder in order to extend the cylinder. *(Fig.165)*

In order to supply pressurised oil to the full bore of the cylinder, the circuit is extended to include logic element (4). When directional valve (4.1) is in the start position, logic element (4) is held firmly closed either by the directional valve or via shuttle valve (4.2) and control line (4.4), whichever is the higher pressure.

Orifice (4.5) influences the closing time of the logic element.

Directional valve (4.1) is not installed between the shuttle valve and the spring chamber of the logic element as shown in chapter " *Directional functions; 4. Control from ports A and B"*. It is used simply to isolate the control line from the main port A. In this way, logic element (4) can be opened to flow from A to B but never to allow flow from B to A. The valve thus acts as a non return valve which can be held closed when required.

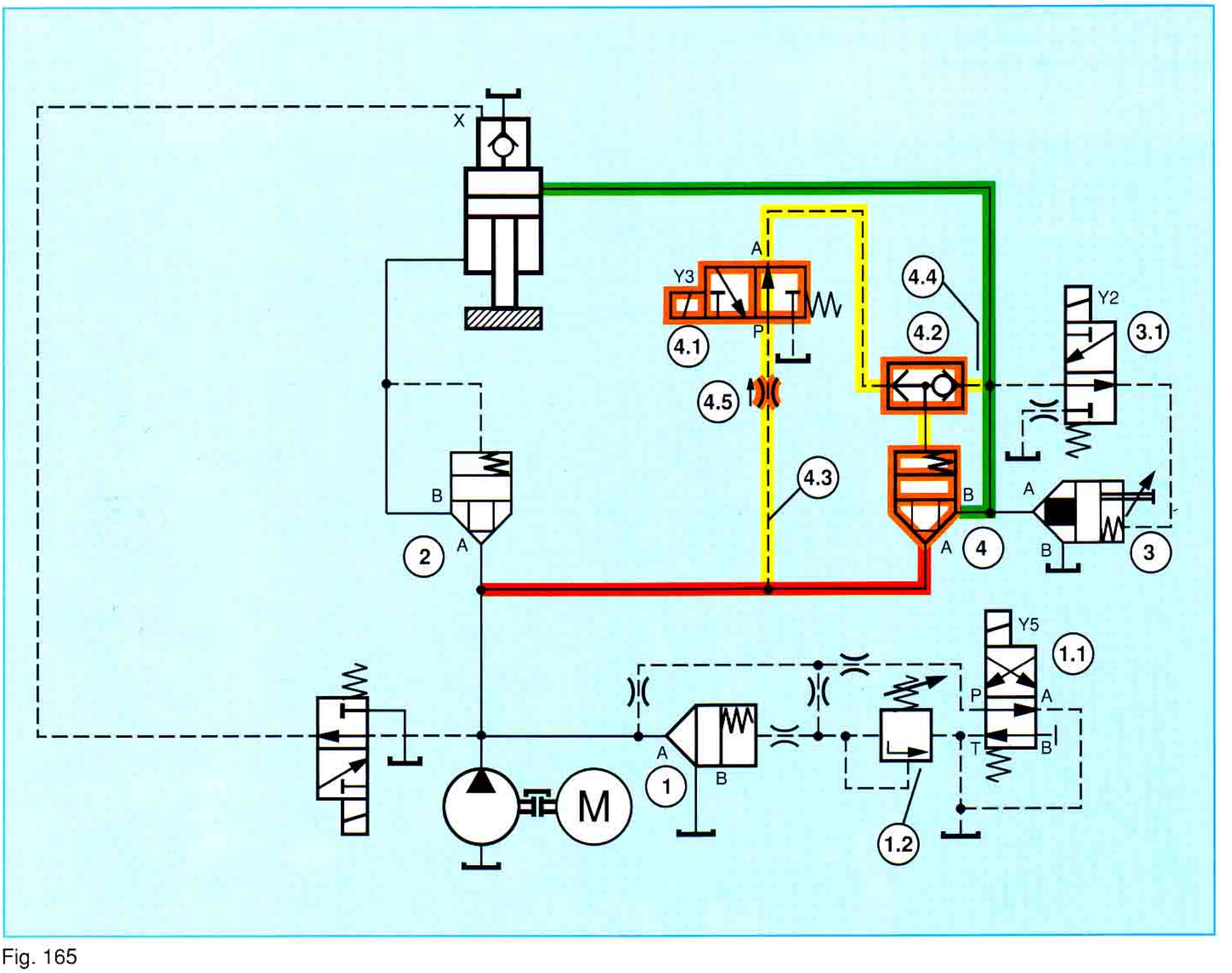

Fig. 165

Step Five

Reliable closing of valve (2) when extending the cylinder *(Fig. 166).*

In order to ensure reliable closing of valve (2) when the cylinder is being extended and to ensure that it cannot be opened by pump pressure, the latter must also be present in the spring chamber of this valve. This is achieved by pressure passing via control line (2.3), directional valve (2.1) and shuttle valve (2.2).

In order to be able to retract the cylinder, solenoid Y1 must be energised. Control line (2.3) is then at zero pressure. Fluid can now flow from A to B through logic element (2) but not from B to A.

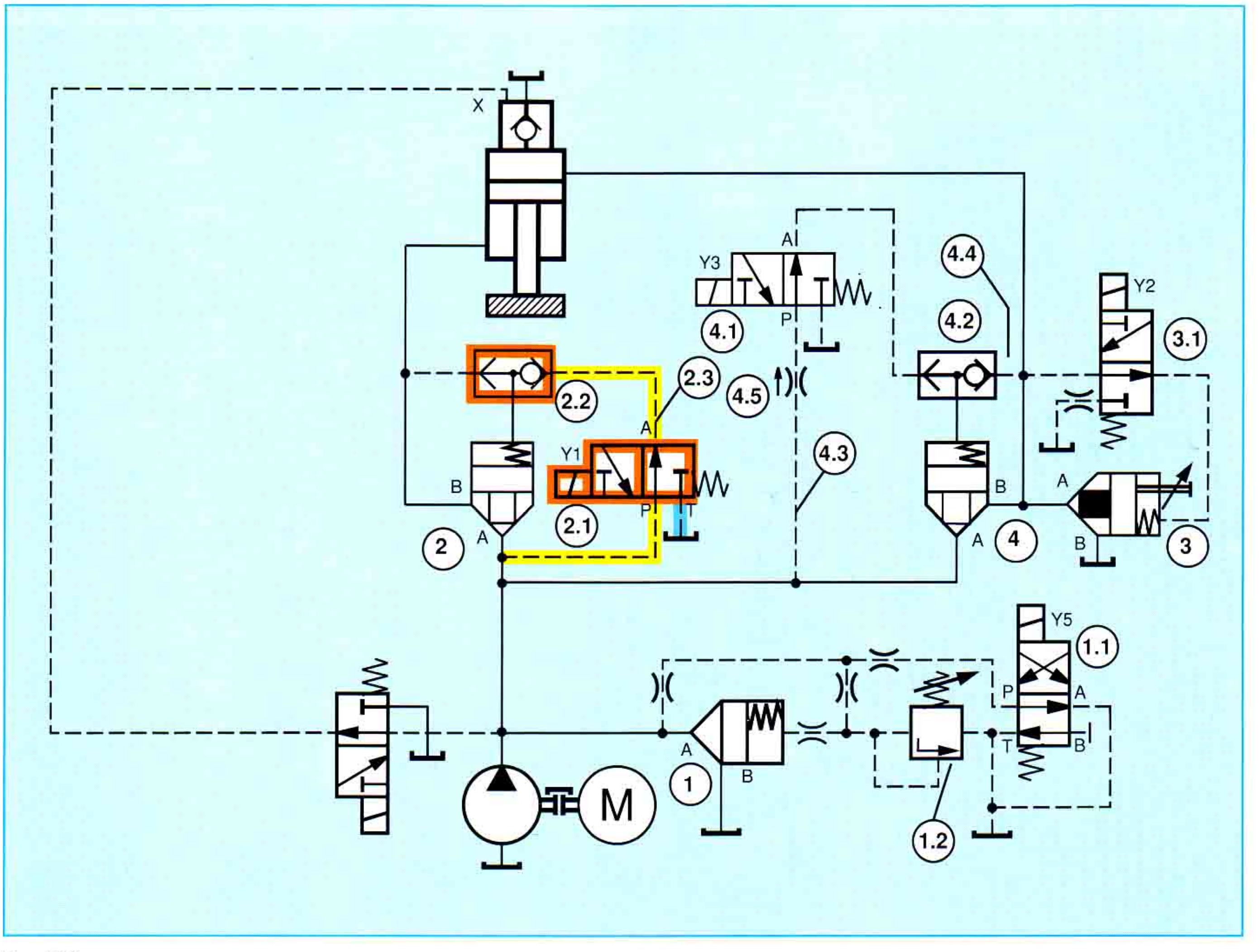

Fig. 166

Step Six

Lowering the cylinder (fast approach) *(Fig. 167)*

The connection of the pump to the full bore of the cylinder was explained in step four. In addition to this, fluid in the annulus of the cylinder must be able to flow to tank. At the same time, a back pressure must be held within the fluid flowing from the annulus area in order to produce a controlled descent of the cylinder i.e the flow must be throttled. This can be achieved by means of logic element (5). At first, this valve is held closed by directional valve (5.1). By energising (solenoid Y4, the spring chamber of valve (5) is de-pressurised and fluid can pass from A to B.The lowering speed (fast approach) can be set by the stroke limiter fitted to logic element (5).

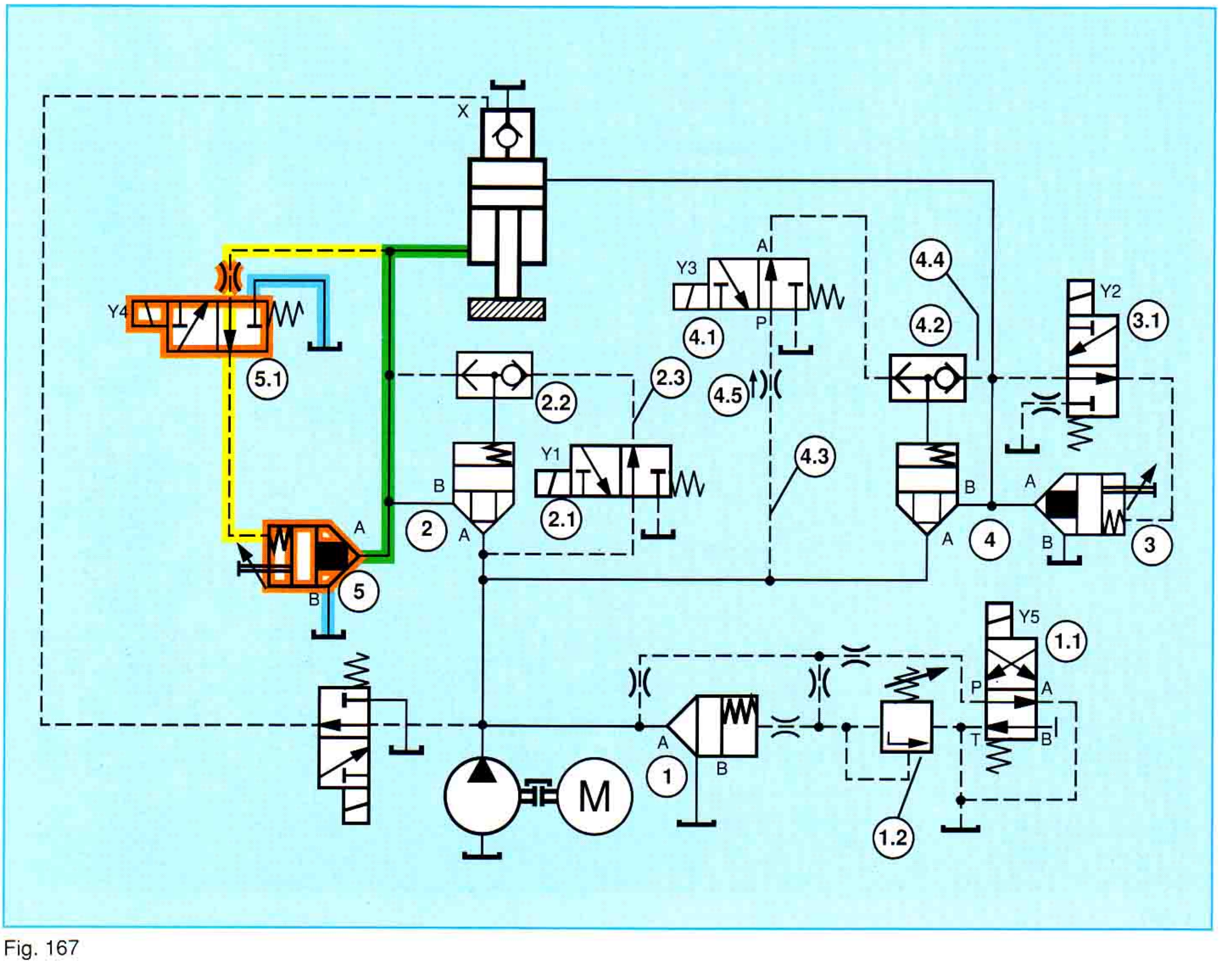

Fig. 167

Step Seven

Lowering the cylinder (slow speed), counterbalance and deceleration pressure *(Fig. 168)*

By operating directional valve (5.1) into the rest position, valve (5) starts to close. At the same time, logic element (6) (with damping nose (6.1)) starts to open). This occurs as the counterbalance pressure rises to the pressure set at pressure relief valve (6.2). The holding pressure set corresponds to the weight of the press head supported on the annulus of the press cylinder. This annulus pressure during the deceleration process cannot rise any higher than the pressure set at pressure relief valve (6.3). Deceleration pressure (valve 6.3) is set higher than the counterbalance pressure (valve 6.2). Dependent upon the deceleration pressure set, the following characteristics can be set:

p high → change-over from fast approach to slow speed (pressing speed) short

p low → change-over from fast approach to slow speed (pressing speed) long

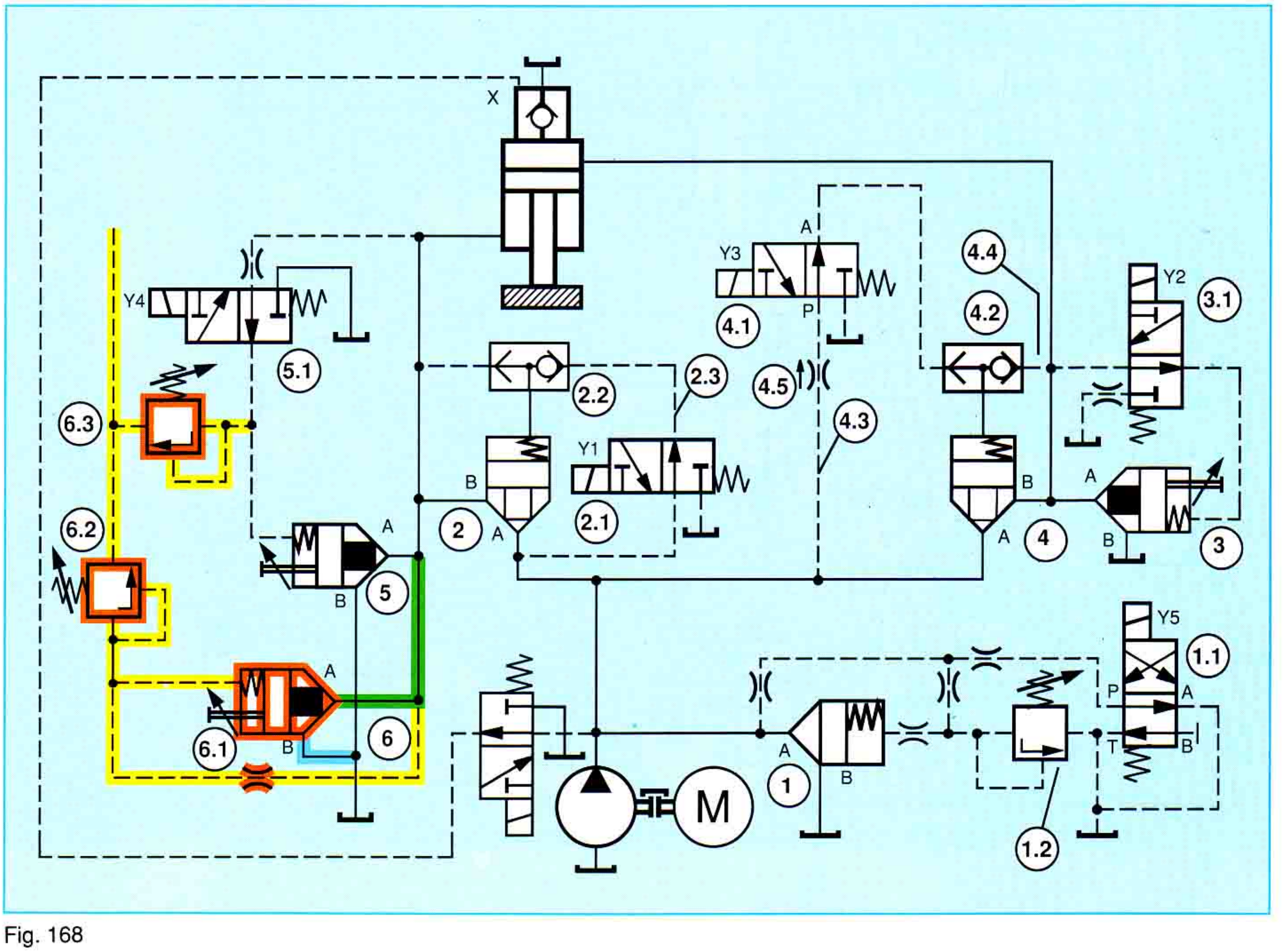

Fig. 168

Protection against pressure intensification and exact control over the closing of valves (5) and (6) on stopping *(Fig. 169)*.

In order to protect the system against pressure intensification, pressure relief valve (7) is also installed. It is set at approximately 10% above the system pressure (p_{max}).

In order to ensure that valves (5) and (6) remain closed and do not open inadvertently or immediately close on stopping, the T ports of pressure relief valves (6.2) and (6.3) are not connected separately to tank but are grouped with the control line of valve (4.1) via line (6.4). If valve (4.1) is in the start position (which is the case during the return stroke and during decompression) the pressure valves are blocked by pressure in the control line (6.4). Logic elements (5) and (6) remain closed.

When Y3 is energised, which is the case when the press is descending, pilot line (6.4) is connected to tank via directional valve (4.1). The pressure settings at these valves is then effective.

At this point, non return valve (8) must also be discussed. Should an emergency stop be necessary, logic elements (5) and (6) must close immediately.

Non return valve (8) ensures this occurs even if the system pressure falls due to logic element (1) unloading the system.

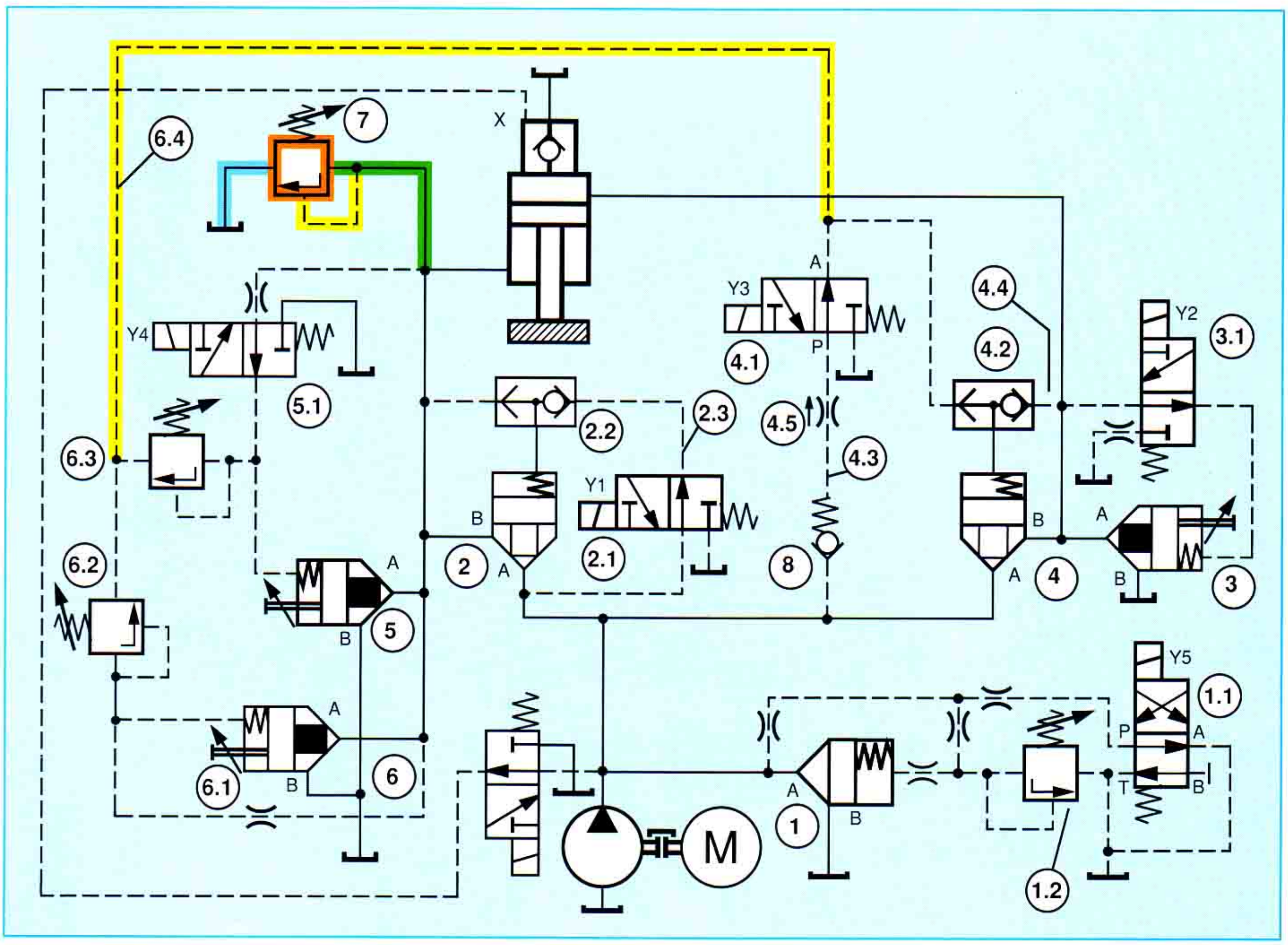

Fig. 169

You should now try to follow the overall functional sequence of the press. The switching sequence and the effect of each switching operation are shown in table 6.

Function	Y1	Y2	Y3	Y4	Y5	X
Fast approach			●	●	●	
Pressing			●		●	●
Decompression		●				
Return	●				●	

Table 6

(The change-over from fast approach to pressing speed is by means of a limit switch).