1 Hydraulic Press Controls

Logic elements are being used more and more frequently in press controls, often grouped together into control modules.

In this sense, a module is either a closed or open loop control circuit incorporated into a manifold block. This can be extended or modified by the addition of a further module or extra hydraulic components.

A complete hydraulic control is produced by combining a number of modules. The functions of a basic module can be extended by the addition of other modules.

Logic elements covering directional and pressure functions built into modular units offer the following advantages over conventional piped systems:

- compactness
- individual elements may be matched to the flows required
- piping is very much reduced
- a number of circuit functions can be achieved with one arrangement of valves.

The function of logic elements in press circuits will be explained with the aid of the following hydraulic schematic diagram *(Figs. 170 to 174)* of a press module for a down stroking press. This press incorporates a prefill valve. Please not that this control does not comply with the safety regulations at present in force in the Federal Republic of Germany.

The control of this press module makes the following functions possible:

- Press stopped

  The press cylinder with its suspended mass remains in the position set. The pump flow is by-passed to tank.

- Fast approach

  The annulus of the press cylinder is connected to tank. The press cylinder and associated mass move downwards.

  The negative pressure created in the full bore of the cylinder opens the prefill valve and fluid is sucked from the header tank into the cylinder.

- Pressing

  As pressure in the full bore of the cylinder increases, the prefill valve closes and the full bore area of the cylinder is subject to pressure.

- Decompression

  By means of a decompression valve (which can be set as required), the compressed fluid is passed to tank in a controlled manner.

- Return

  The prefill valve is opened by means of pilot pressure and the pump flow is directed to the annulus side of the cylinder.

Press stopped

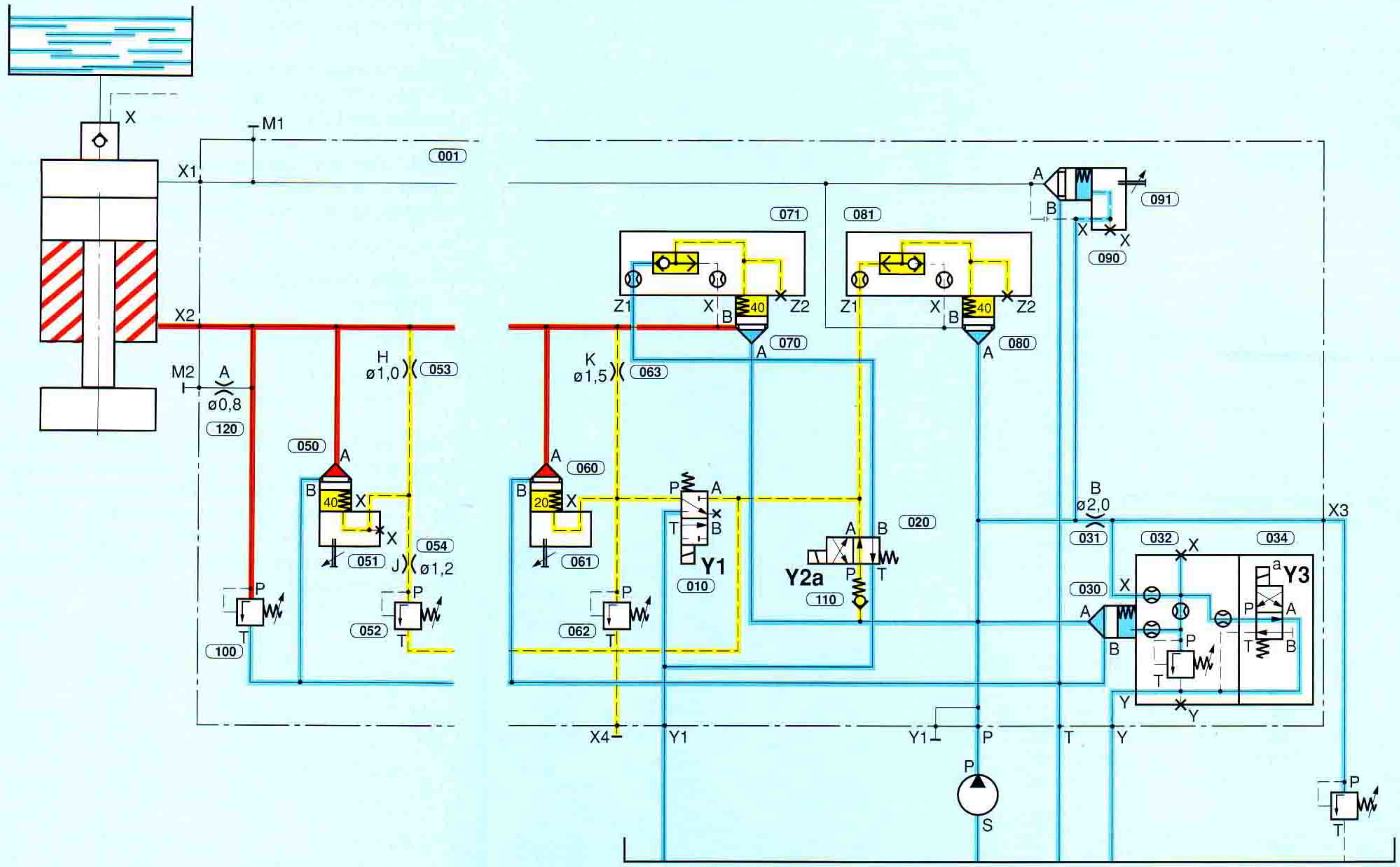
When the press is stopped, all pilot control valves are in the rest (start) position. Pump by-pass pressure is present on areas A_A of valves(items 070 and 080). By-pass pressure passes via the unoperated pilot valve (item 20) to the control surface of valve (item 080). Shuttle valve (item 081) blocks any connection between the pilot oil side and port B. By-pass pressure p_u multiplied by control surface area (A_x = 107%) plus spring force hold valve (item 080) closed against by-pass pressure p_u multiplied by the seat surface area (A_A = 100 %). In this way, the full bore of the cylinder is isolated from the pump.

The weight of the press head and the piston rod generate a pressure (the holding pressure) in the annulus of the press cylinder. Valve (item 100), the annulus safety valve) is set to a pressure which is higher than the holding pressure. The cylinder annulus safety valve thus remains closed.

Pilot valve (item 052) is set slightly higher than the holding pressure (usually 10% higher). Holding pressure (p_H) is present on the control area and the base area of the pressure holding valve (item 050) and holds the valve closed due to the ratio of forces (control area=107 % x p_H) to (base area =100 % x p_H). Lowering valve (item 060)is also held closed with holding pressure on the control area and the base area, (pilot valve (item 010) in the rest position) as the pilot relief valve is set substantially above the holding pressure and it also has the same area ratio as the load holding valve (107% control area and 100% base area). Holding pressure also passes via shuttle valve (item 071) to the control area of valve (item 070)and closes the relevant valve against the holding pressure and the by-pass pressure.

In the rest position of valve (item 034) the control area A_x of valve (item 030) is unloaded. Valves (items 070 and 080) are closed as previously described. Pump by-pass pressure p_u opens valve (item 030) against the spring force. Pump flow passes to tank at a pressure determined by the closing spring of the by-pass valve (item 030) and by the installation (e. g. pipe resistance).

With the press stopped, it should be noted that valves (items 050 and 060) and the pilot valve (item 010) are not absolutely leak free and that the press cylinder can fall vary slowly over a long period.



Function	Y1	Y2a	Y2b	Y3
Stationary				
Fast approach	●	●		●
Pressing		●		●
Decompression				
Return				●

Fig.170:
Press module - functions: press stopped, pump by-passing

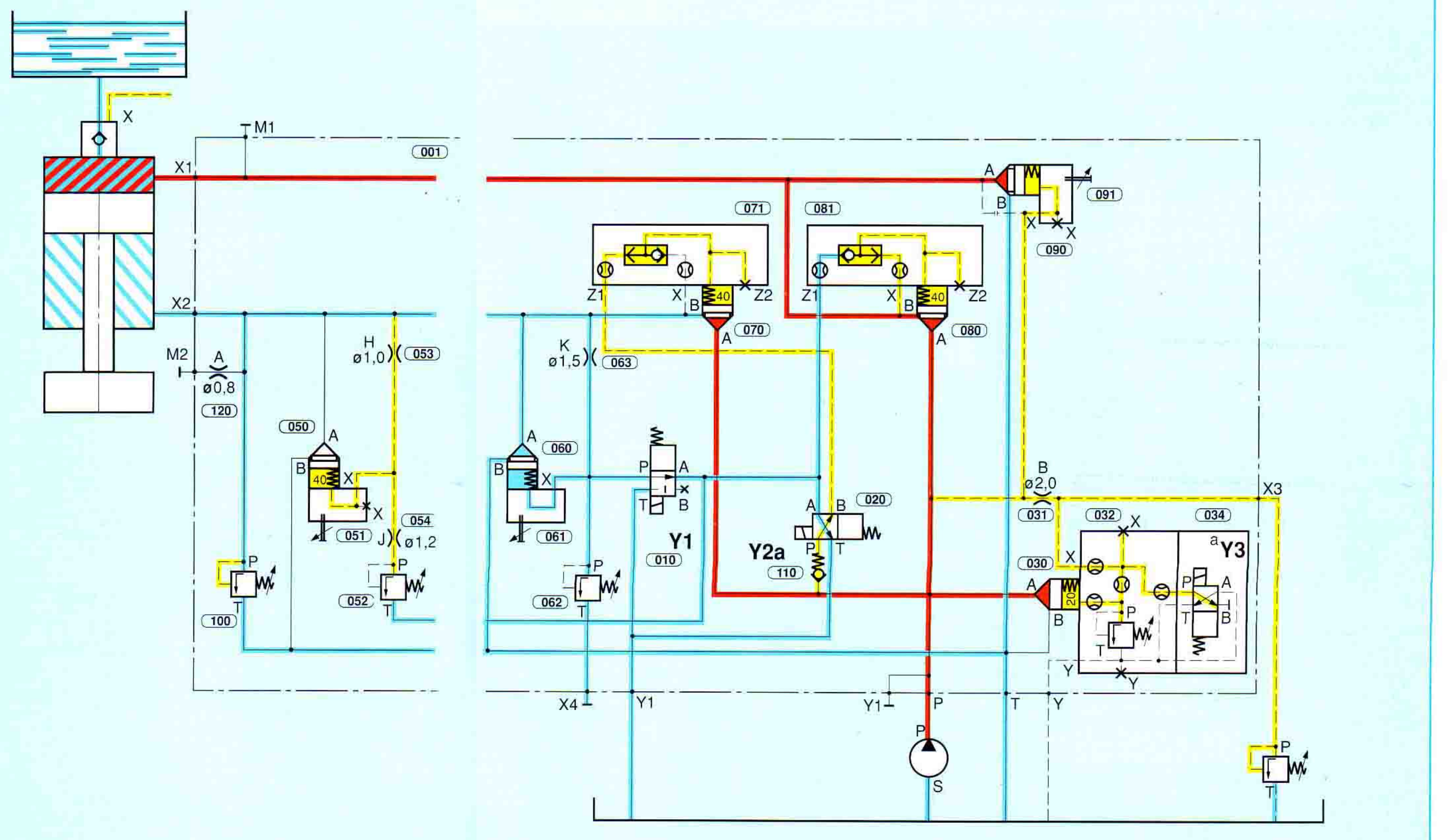
Fast approach

The fast approach operation permits the press to descend rapidly powered only by the weight of the weight of the piston, crosshead and press tools. At the start of the fast approach, pump flow is directed into the full bore of the cylinder. In this way, a delay in the change-over between fast approach to pressing speed is avoided. By operating pilot valve (item 034), pilot oil is passed to the control area of valve (item 030). Pilot oil pressure is therefore present at the P port of the pilot pressure relief valve (item 032). If the pilot pressure at this point rises above the pressure set at the pilot relief valve, oil flows along the control line to tank. This flow causes a pressure drop at orifice (item 031).

The pressure before the orifice is actually the pump pressure which is the same as the pressure at the base area A_A of valve (item 030). When pilot oil is flowing, the pressure at the control area A_X of valve (item 030) is the pump pressure minus the pressure drop across the orifice. As the pressure drop across the orifice (item 031) increases, the force balance across the control areas of the valve changes until the valve opens and operates as a pressure relief valve. The system pressure required can be set at the pilot valve (item 032).

With pilot valves (items 010 and 020) operated, the control area of valve (item 060) is unloaded to tank and the annulus area of the cylinder is also connected to tank. Pump flow passes to the full bore of the cylinder via valve (item 080). The weight of the piston rod etc. causes the press to fall and expels the oil in the annulus side of the cylinder to tank. The lowering speed of the press is controlled by setting the stroke limiter of valve (item 060) which acts as a throttle valve.

With the press descending rapidly, the pump flow is insufficient to fill the full bore of the cylinder. A negative pressure is therefore created within the cylinder bore, the prefill valve opens and fluid flows from the header tank into the cylinder.



Function	Y1	Y2a	Y2b	Y3
Stationary				
Fast approach	●	●		●
Pressing		●		●
Decompression				
Return				●

Fig.171: *Press module - function: fast approach*

Pressing

Only solenoids Y2a and Y3 remain energised during the pressing cycle. Pressure peaks during the change-over from fast approach to pressing speed should be minimised in order to make the change-over as smooth as possible.

Pilot control valve (item 034) remains in the operated position in order to hold the decompression valve (item 090) and the by-pass valve (item 030) closed. Pump pressure is limited to the value set at valve (item 032).

Pilot control valve (item 020) also remains in the operated position. Pump flow can thus forced to pass via valve (item 080) to the full bore of the press cylinder.

When the cylinder reaches a predetermined point and a signal is given to indicate this, pilot valve (item 010) moves back to its rest position. The lowering valve thus closes and the annulus of the press cylinder is no longer connected to tank.

The annulus pressure rises and the holding pressure valve (item 050) opens as soon as the pressure exceeds the holding pressure.

The opening stroke of the pressure holding valve is limited by a stroke limiter to permit only the oil flowing at pressing sped to pass. Due to this small opening, the holding valve cannot pass sufficient flow at higher press speeds. The pressure in the annulus of the cylinder thus rises even further until the pressure at the control area of the lowering valve (item 060) is connected to tank via pilot control valve (item 062) (the combination thus acts as a pressure relief valve —as valve (item 030)). The deceleration process is complete when the annulus pressure is once more practically the same as the set holding pressure.

When the press head speed has been reduced to the pressing speed, the prefill valve closes due to the build up of pressure in the full bore of the press cylinder. The oil flowing from the annulus of the cylinder is expelled to tank via the holding valve. The change-over to pressing speed is therefore stepless.

The maximum possible pressing force at the presshead is therefore:

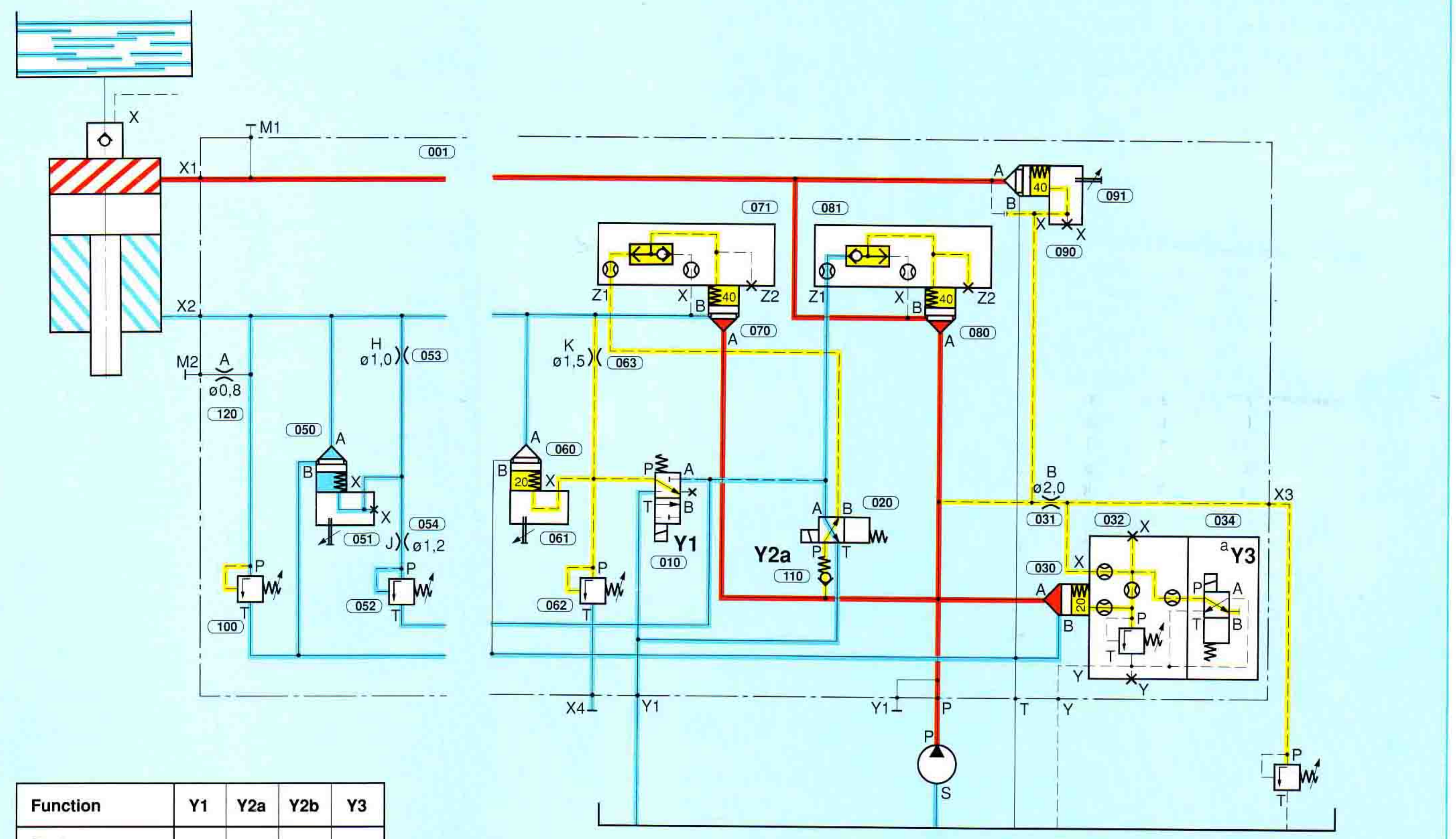
$$F_{press\,max.} = A_{K} \cdot p_0 + F_G - A_R \cdot p_H$$

A_K = piston area of cylinder
A_R = annular area of cylinder
p_0 = pressure set at valve item 032
p_H = holding (counterbalance pressure) set at valve item 052
F_G = Force due to weight of moving parts

Pilot control valve (item 034)also remains in the operated position during the pressing cycle in order to hold the decompression valve and the by-pass valves in the closed position.

The valves for the directional control of the press cylinder are separate switching elements which are controlled individually. For example, if the annulus area is blocked from the tank due to faulty operation of the valves while the full bore is still under pressure, pressure intensification occurs in the annulus of the cylinder (pressure ratio ≈ 1/ area ratio).

In order to avoid damage due to faulty operation, the annulus area is protected by a direct operated relief valve (item 100).



Function	Y1	Y2a	Y2b	Y3
Stationary				
Fast approach	●	●		●
Pressing		●		●
Decompression				
Return				●

Fig.172: *Press module - function: pressing*

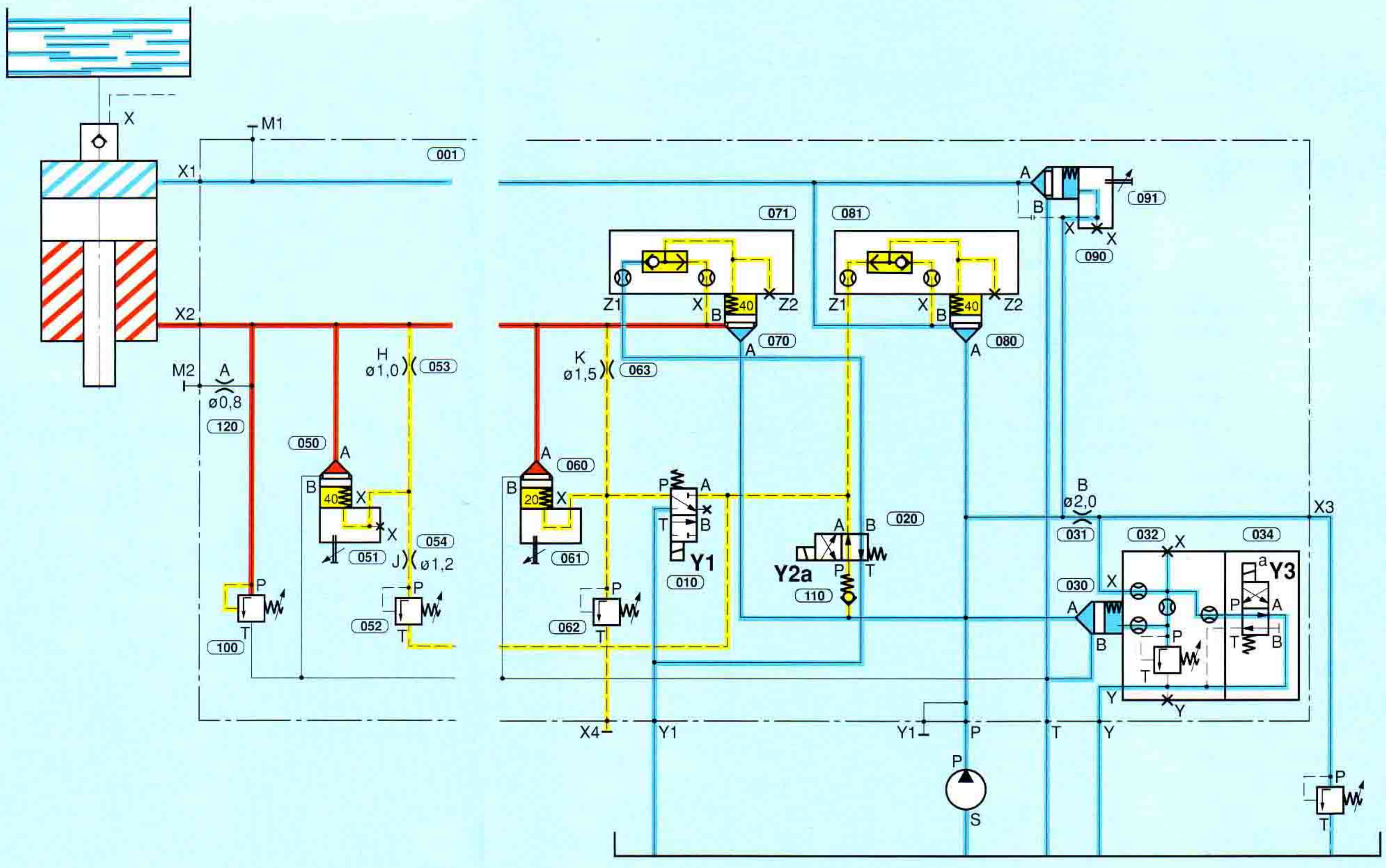
Decompression

When the pressing operation is finished, oil compressed within the cylinder and the pipework must be released smoothly, before the press is signalled to return, in order to prevent unnecessary loading on seals, valves and pipes due to decompression shocks in the system and in particularly in the tank line. At the same time, the pump flow is by-passed to tank during this operation.

When the press is stopped, all pilot valves are in the rest position.

The valve poppet of the by-pass valve (item 030) opens as its control chamber is connected to tank via pilot control valve (item 034). When the pump is switched to by-pass, the control area of the decompression valve (item 090) is also connected to tank. The base area A_A of the decompression valve (item 090) is under pressing pressure at this time.

Pressing pressure opens the decompression valve (item 090). The compressed oil volume in the full bore of the press cylinder is decompressed. The rate of decompression and the decompression time can be set by the stroke limiter of the decompression valve to suit the particular press (cylinder size, pressing pressure etc.)



Function	Y1	Y2a	Y2b	Y3
Stationary				
Fast approach	●	●		●
Pressing		●		●
Decompression				
Return				●

Fig.173: *Press module - function: decompression*

Return

The prefill valve is opened by means of an external prefill valve.

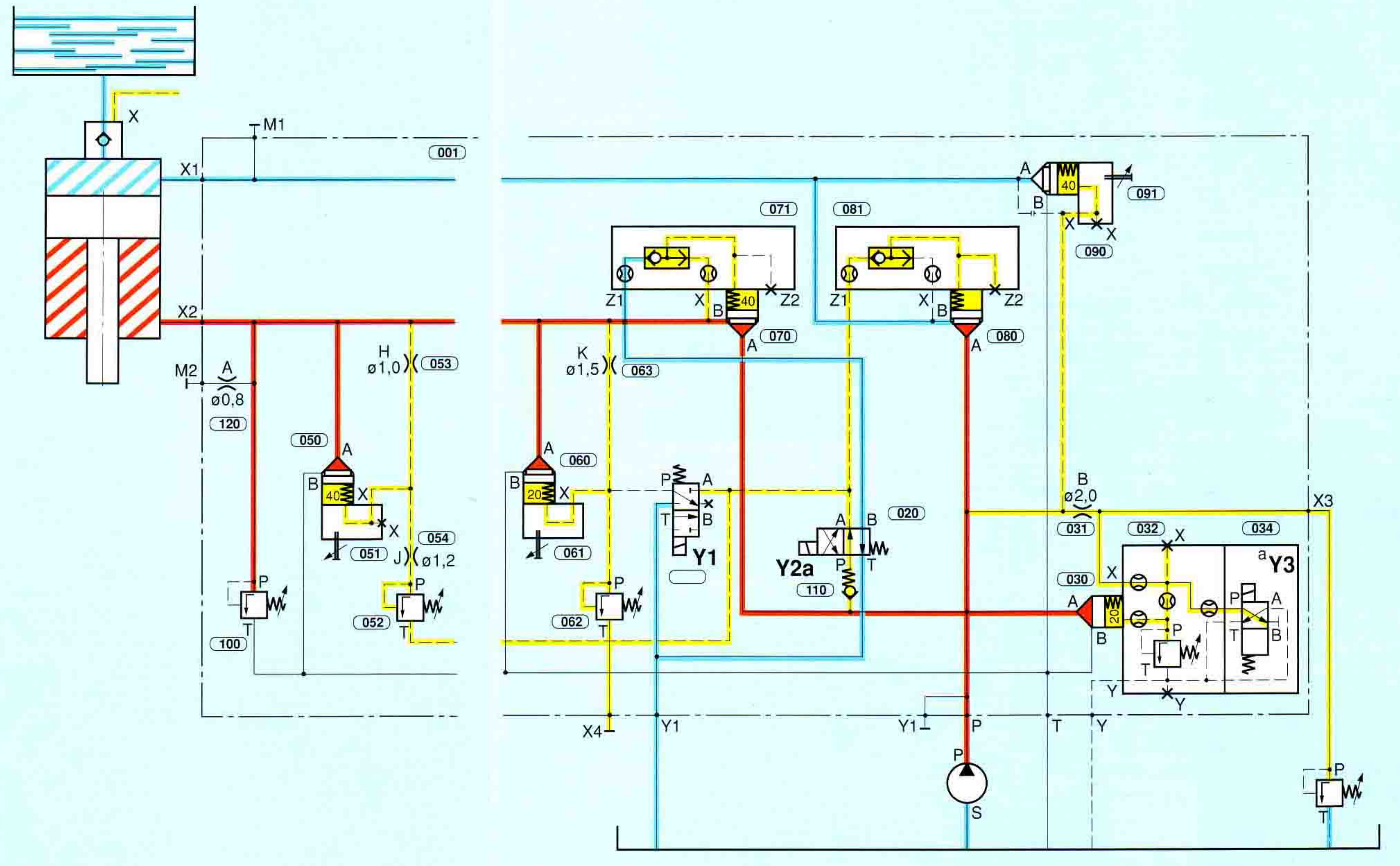
The press cylinder complete with hanging load is then returned to the upper start position.

The pump flow is fed directly into the annulus of the cylinder.

Pilot control valve (034) is operated and the by-pass valve (item 030) closes. Pump flow can no longer flow to tank. Fluid is then forced into the cylinder thus raising the press head.

Pilot valves (items 020 and 010) are in the rest position. Logic elements (items 060 and 080) are therefore held closed.

Pump pressure is present at the base area A_A of valve (item 070) and pressure rises unit fluid on the control face of valve (item 070) is forced through to the annulus area of the cylinder via the shuttle valve Thus opening logic element (item 070) fully for pump flow to pass through to the cylinder. The piston then moves upwards. Logic elements (items 050 and 060) are held closed due the pressure in the cylinder annulus. Fluid from the full bore of the cylinder p[asses to tank vie the prefill valve. The return stroke is discontinued when the upper rest point is reached. Before a new press cycle is initiated, all the pilot valves are returned to the start (or rest) position.



Function	Y1	Y2a	Y2b	Y3
Stationary				
Fast approach	●	●		●
Pressing		●		●
Decompression				
Return				●

Fig.174: *Press module - function: return*

2 The control of a vertical external broaching machine

The circuit for this machine was designed as a manifold block with built-on valves.

The reason for the use of logic elements is the mixture of valve sizes necessary to cope with the widely varying requirements and speeds from machine to machine.

Flows lie in the range 50 L/min to 1900 L/min.

Function

Fluid is supplied to the system by a variable pump with electrical control of both pressure and flow.

At the start, none of the control elements are operated. When the pump is started, pressure builds up at port A of logic elements (1.0) and (3.0). At the same time, pressure passes through the control line *(yellow)*, non return valve (4) and pilot valve(1.1)on to port T of pressure relief valve (2.1) which is then held closed. Pressure also passes via valve (1.1)(P to B) into the spring chamber of valve (1.0) and also via valve (1.1) (P to A) and (3.1) into spring chamber (3.0). Both logic elements are thus blocked to flow from A to B. Pressure in the cylinder due to the weight of the piston and broaching tools holds the logic valve closed via control line (6).

At the start of the broaching operation, solenoids a on both valves (1.1) and (2.1) are energised and the required settings of pressure and flow are set at the pump. Pilot pressure passes via valve (1.1) (P to B) to port X of valve (1.0) which therefore remains closed. On the other hand, the spring chamber of logic element (3.0) and port T of valve (2.1) are both unloaded. Fluid passes from the pump to port A *(red)* and port (B) *(green)* to the rod end of the cylinder. This then moves downward in the broaching operation.

Fluid flowing from the full bore of the cylinder is expelled to tank via the logic element at the pressure set at pilot valve (2.1) (counterbalance pressure 24 bar).

On the return stroke, solenoid b of valve(1.1) and solenoid a of valve (3.1) are energised. Pressure relief valve (2.1) is blocked. At the same time, the spring chamber of valve (1.1) is unloaded.

Pump flow now passes from A to B and to the full bore side of the cylinder. Logic element (2.0) is closed. The cylinder extends giving the return stroke of the broaching tool. Fluid from the rod end of the cylinder passes against the spring through valve (3.0) from B to A back into the pump line. This is therefore a regenerative circuit.

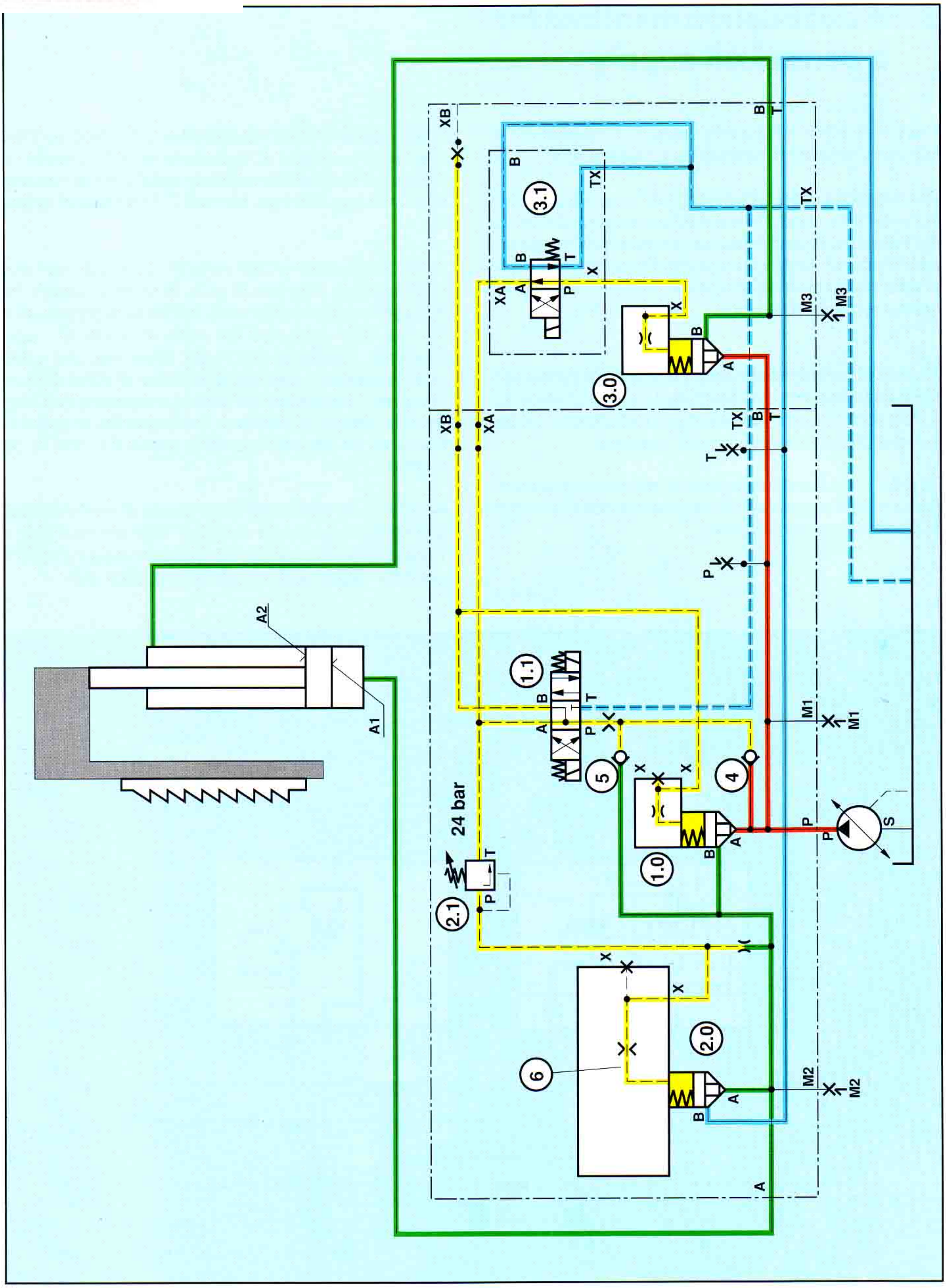


Fig. 175

3 A connection manifold for a central oil supply

The circuit *(Fig.176)* shows a connection manifold for a ring main installation, (usually on a machine tool).

In a central oil supply system (ring main) e.g. on a transfer line, a central power unit supplies pressurised oil to all of the machines instead of having individual power units on each machine. All the machines are therefore connected via the ring main lines (P = pump and T = tank) to the central hydraulic power unit.

As each of the individual machines all operate at different flows and pressures, and because it must be possible to isolate each machine, suitable control elements must be built into the branch lines to each machine.

In order to have a common form of connection in spite of the varying pressures and flows, a connection block with logic elements was designed.

The machine is either connected to or isolated from the ring main by means of logic element (1.0) (directional function). Flow from the ring main at port A of the manifold block and port B of logic element (1.0) is blocked at port B.

In the start position of pilot valve (1.1), the logic element is closed leak free from B to A. In order to ensure no leakage through the pilot valve, a directional poppet valve is used here. (see also the notes on *page 47*, Logic Elements, directional functions.) When the pilot valve (1.1) is operated, the spring chamber of valve (1.0) is unloaded. The logic element opens and permits flow from the ring main to the machine. The stroke limiter built into the cover of the logic elements allows the flow to be throttled.

In order to be able to set the pressure at each machine separately, a "pressure reducing" logic element (2.0)is installed *(also see section 2.2, pressure reducing valves, normally closed, with manual setting, page 92)*.

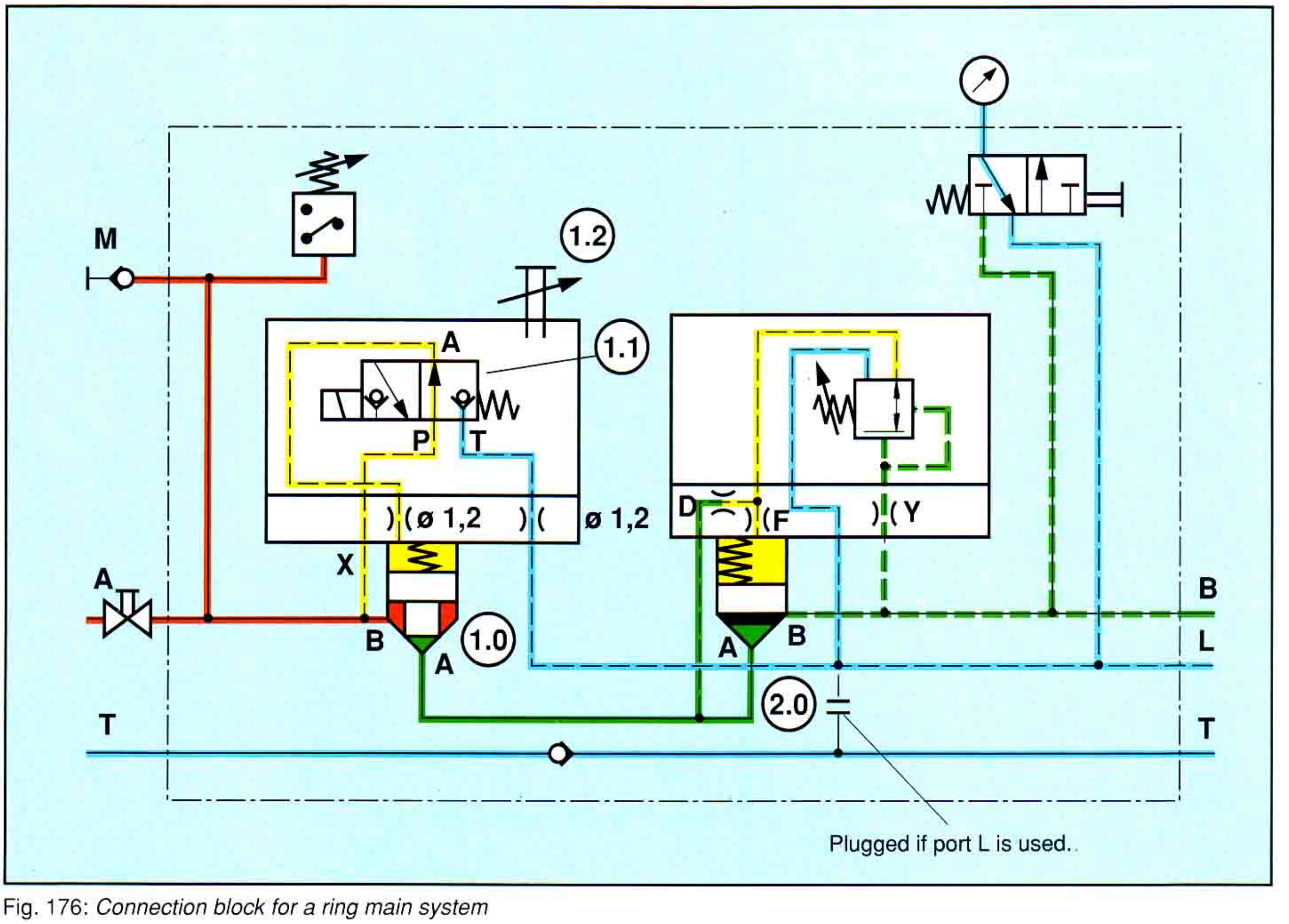


Fig. 176: *Connection block for a ring main system*