United States Patent

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[54] **HYDRAULIC CONTROL SYSTEMS**
14 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **91/400,**
91/1, 91/436, 91/452, 91/461; 137/110, 137/491
[51] **Int. Cl.** **F15b 15/22,**
F15b 11/08, F15b 13/042
[50] **Field of Search** 91/400,
436(Cursory), 461(Cursory), 452(Cursory);
137/110, 108(Cursory), 491(Cursory)

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ABSTRACT: This disclosure relates to a hydraulic control system for a pressure responsive means such as a piston cylinder for a press. The control system employs three pressure responsive valves and a fourth manual actuating valve.

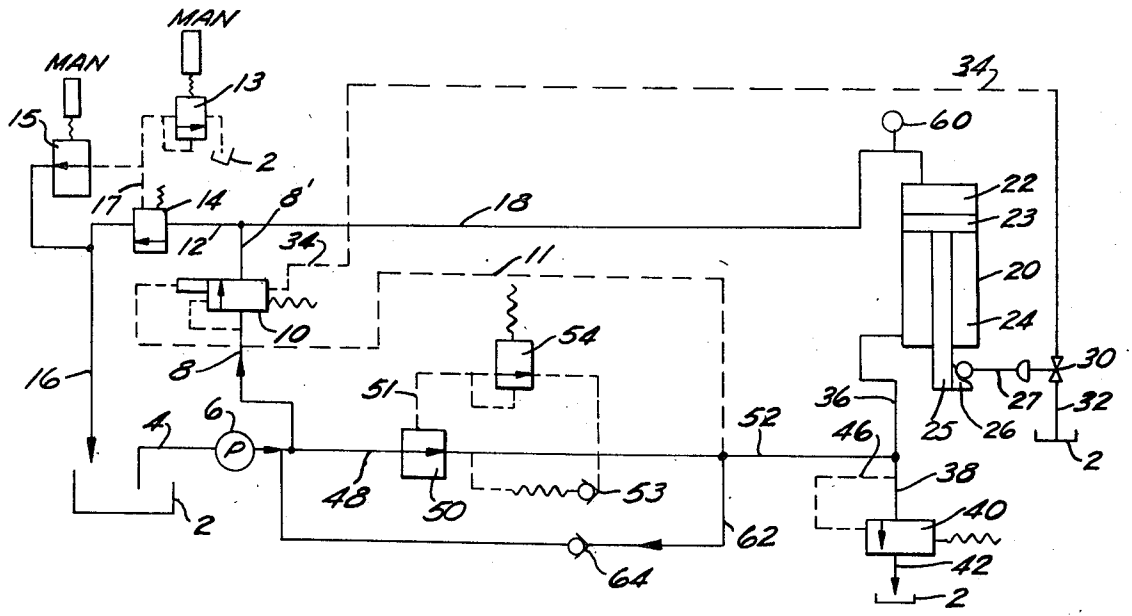
A fluid pressure source, such as a pump for example, supplies fluid pressure to a first pressure chamber, such as one end of a piston cylinder containing a piston which is attached to a hydraulic ram. A first pressure responsive valve in the line to the first pressure chamber opens responsive to a predetermined pressure in the line. A second manually operable valve in the line controls the pressure to the first pressure chamber.

Fluid pressure is applied through a second pressure responsive valve to a second pressure chamber, such as a second end of a piston cylinder. The second pressure responsive valve opens to allow the fluid pressure to communicate with the second pressure chamber when the pressure to the second pressure responsive valve is less than a second predetermined value.

A third pressure responsive valve is provided to release the pressure in the second pressure chamber when the pressure of the first pressure chamber exceeds a third predetermined value, or the pressure in the second chamber exceeds a fourth predetermined value.

Means are provided to release the pressure in the first chamber if a fifth predetermined pressure is exceeded.

Means are also provided to open the first pressure responsive valve when a piston in the piston chamber reaches the first end of the cylinder, *i.e.* the first pressure chamber.



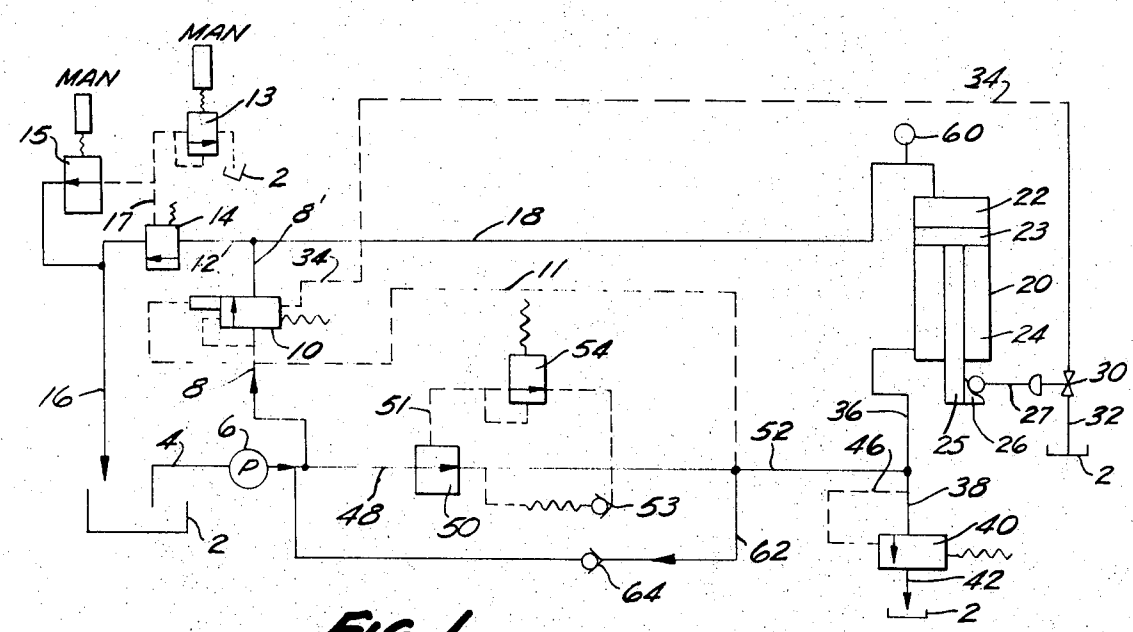


FIG. 1.

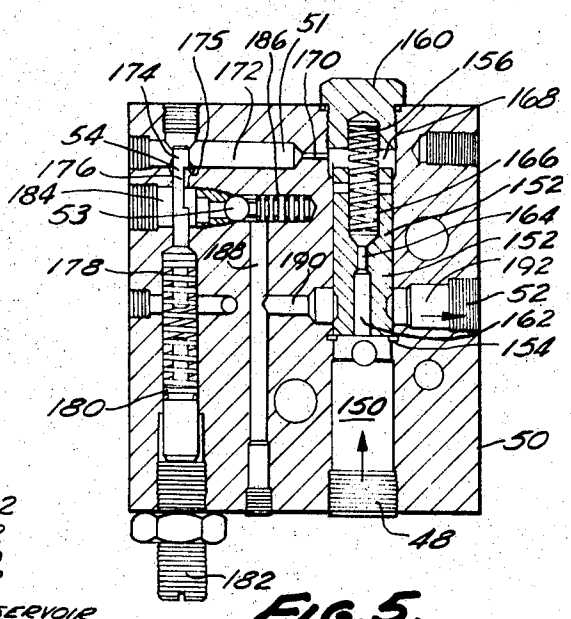


FIG. 5.

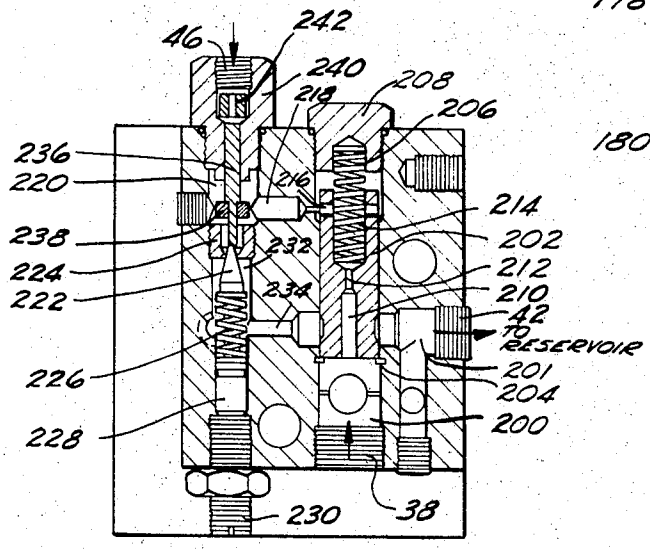


FIG. 6.

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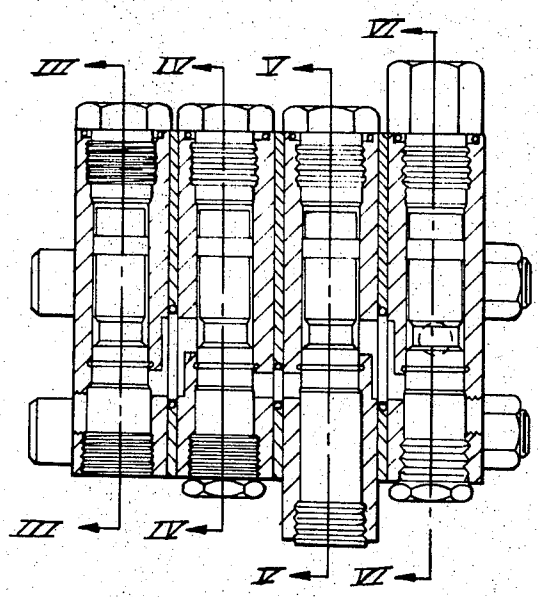


FIG. 2.

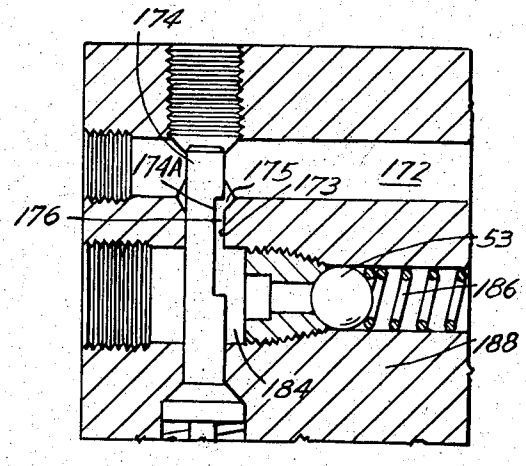


FIG. 5A.

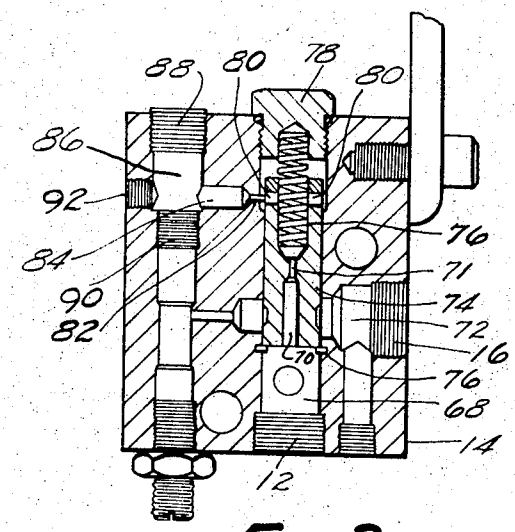


FIG. 3.

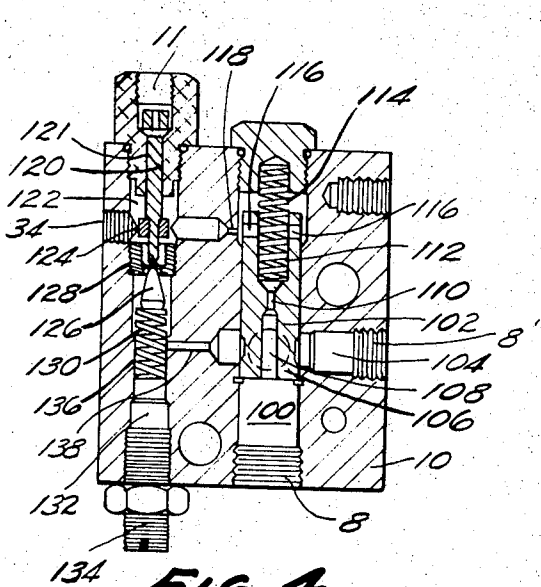


FIG. 4.

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HYDRAULIC CONTROL SYSTEMS

This invention relates to a control system for a pressure responsive device such as a piston operated hydraulic press. In one of its aspects it relates to a control system for a hydraulic press in which a pressure responsive valve is used to control the flow of fluid to one end of a piston chamber, a second pressure responsive valve is used to control the flow of fluid pressure to a second end of a piston cylinder and a third pressure responsive valve is used to control the release of pressure from a second end of a piston cylinder.

In another of its aspects the invention relates to a control system, as has been hereinbefore described, wherein means are provided to open the first pressure responsive valve and close the second pressure responsive valve when the piston reaches the first end of the cylinder.

In another of its aspects, the invention relates to a novel valve structure for the operation of the control system of the invention which valve structure is normally opened and adapted to close when the inlet pressure reaches a predetermined value.

Hydraulic presses are well known. Many kinds are used for a multitude of purposes. Some are single acting and some are double acting. The double acting presses utilize fluid pressure on either side of a piston in a piston cylinder to actuate movement of a piston which is generally attached to a platform or a ram.

There are many control systems for the hydraulic presses. Most of these control systems utilize a three or four-way valve. A three-way valve is conventionally employed in a single acting press, and a four-way valve is generally utilized in a double acting press. In this latter instance, when the presses switch from a pressing position to a retracted position, the pressure is supplied, for example, to one end of the piston and drained from the other end of the piston. When the valve is switched to the opposite position, a four-way valve merely reverses the connections in the different ends of the cylinder with relation to the pressure supply and pressure draining lines so that pressure can be supplied to the second end of the cylinder and drained from the first end of the cylinder. The valves are cam operated, pressure operated, or manually operated. It is desirable to provide a pressure sensitive system for controlling the press operation. If a pressure responsive valve is used to control the four-way valves, mechanical linkages and cam arrangements are required. While these systems are satisfactory in some instances, they are cumbersome and do not provide a sensitive, reliable system.

I have now discovered a simple control system for hydraulic presses and the like, in which system three pressure responsive two-way valves and an actuation valve are employed. The system is completely pressure responsive and can be actuated by an operator or a timing mechanism.

By various aspects of this invention one or more of the following, or other objects, can be obtained.

It is an object of this invention to provide a control system for a pressure responsive device wherein the applied force can be accurately controlled by an operator.

It is a further object of this invention to provide an entirely pressure operated system for a pressure responsive device such as a hydraulic press.

It is a still further object of this invention to utilize three simple two-way pressure control valves in a control system for a hydraulic press.

It is a still further object of this invention to provide a novel valve structure for the operation of the control system of the invention.

It is yet another object of this invention to provide a control system for a hydraulic press wherein the maximum pressure applied by the press is effectively limited.

Other aspects, objects, and the several advantages of this invention are apparent to one skilled in the art from a study of this disclosure, the drawings, and the appended claims.

According to the invention, there is provided a control system for a pressure responsive device such as a hydraulic press. The control system employs three pressure responsive valves. A first pressure responsive valve controls the flow of fluid pressure to a first pressure chamber, which valve is adapted to open when a first predetermined pressure is supplied to the line connecting the first pressure chamber with a pressure supply source. A second pressure responsive valve controls the flow of fluid or the pressure supplied to a second pressure chamber, and the second pressure responsive valve is adapted to close when the pressure to the second pressure chamber is greater than a second predetermined value. A third pressure responsive valve exhausts the pressure in the second pressure chamber when the pressure in the first pressure chamber exceeds a third predetermined value or the pressure in the second pressure chamber exceeds a fourth predetermined value.

When used in connection with a hydraulic press, the control system provides for actuating the first pressure responsive valve when the press reaches its most retracted position to limit the movement of the press. In such a system, means are also provided to limit the maximum pressure which can be applied by the press.

The invention will now be described with reference to the drawings in which:

FIG. 1 is a schematic representation of the pressure control system of the invention;

FIG. 2 is a front elevational sectional view of a valve arrangement which can be used to operate the system shown in FIG. 1;

FIG. 3 is a sectional view of the valve of FIG. 2, taken along lines III–III of FIG. 2;

FIG. 4 is a sectional view of the valve shown in FIG. 2, taken along lines IV–IV of FIG. 2;

FIG. 5 is a sectional view of the valve shown in FIG. 2, taken along lines V–V of FIG. 2;

FIG. 5*a* is an enlarged view of a portion of the valve shown in FIG. 5; and

FIG. 6 is a sectional view of the valve shown in FIG. 2, taken along lines VI–VI of FIG. 2.

Referring now to the drawings, and in particular FIG. 1, hydraulic fluid in reservoir 2 is drawn off through line 4 by pump 6, and delivered to lines 8 and 48. The hydraulic fluid in line 8 passes through a first pressure responsive valve 10, which is adapted to open the valve when the pressure in line 8 reaches a first predetermined value. The fluid is passed through line 8' and into lines 12 and 18. The fluid in line 12 can pass through normally open valve 14 and through line 16 back into reservoir 2. Valve 14 is open when vent line 17 is open. A manually operable valve 15, which is normally open, is connected to line 17 and serves to control the pressure of fluid passing through valve 14. Valve 15 can vary pressure of fluid flowing through line 17 and thus vary pressure of fluid passing through valve 14. A pressure responsive valve 13 is also connected to vent line 17 to open valve 14 when the pressure in line 12 and 18 reaches a maximum desirable value. The pressure responsive valve will vent a sufficient amount of fluid to maintain the maximum pressure. The fluid in line 18 is passed to a first pressure chamber, in this case, to chamber 22 of piston cylinder 20. The pressure buildup in chamber 22 forces piston 23 containing ram 25 downwardly to exert pressure on a workpiece, for example.

Ram 25 has cam surface 26 attached thereto, which cam surface actuates cam follower 27 to open valve 30 to allow fluid pressure in line 34 to pass therethrough. The fluid pressure passing through valve 30 is in communication with a pressure sensitive means in valve 10 through line 34 to vent valve 10. When the ram reaches the top of its return cycle, cam 26 actuates cam follower 27 to open valve 30, thereby allowing fluid pressure to pass therethrough and through line 34 to vent valve 10. When the ram is in its extended position, no pressure will be passing through line 34, and valve 10 will be opened only by the pressure in line 8. Valve 10 can also be opened when a pressure in line 52 exceeds the pressure setting in valve 10. This pressure in line 52 is transmitted through line 11 to a pilot piston on valve 10.

Fluid pressure is also applied to a second pressure chamber 24, or the other end of the piston cylinder 20 through line 48 by way of a second pressure responsive valve 50, line 52 and line 36. The second pressure responsive valve 50 is normally open when fluid is passed through vent line 51, through a second pressure responsive valve 54, and through check valve 53. This condition will prevail when the pressure in line 48 is below a second predetermined value. When the pressure rises above the second predetermined value, valve 54 will close to stop the flow of fluid in line 51 and thereby close valve 50. In other words, the second pressure responsive valve 50 is adapted to close when the pressure in line 48 exceeds a second predetermined value. Valves 50 and 54 generally comprise a single valve structure.

When the ram 25 is moving downwardly, that is toward end 24 of cylinder 20, fluid pressure is drained from this end of the cylinder through line 36, line 52, line 62, and check valve 64 to join the oil coming from pump 6 to reduce the amount of oil required to be pumped.

When the pressure in line 36 exceeds a fourth predetermined pressure, valve 40 can open to drain the second pressure chamber 24. The pressure is transmitted to valve 40 through line 46 in this embodiment. Alternately, the valve 40 could be set to open when a third predetermined pressure was reached in chamber 22. To this end, a control line would connect line 18 with valve 40.

In order for the piston to operate automatically, the first predetermined pressure, *i.e.* the pressure in line 8 which opens valve 10 will generally be less than that predetermined pressure in line 48 which closes valve 50. Similarly, the pressure in lines 18 and 22 which would open valve 40, *i.e.* the third predetermined pressure, can be greater or less than the first predetermined pressure which opens valve 10. The fourth predetermined pressure opens valve 40, would have to be somewhat greater than the second predetermined pressure, which closes valve 50. The maximum pressure applied to piston 23 and cylinder 22, which is transmitted to valve 13, would of necessity have to be much greater than the first predetermined pressure which opens valve 10.

In the above described system, a pressure gauge 60 can be provided to indicate to an operator the pressure in the pressure cylinder 22 or can be calibrated to indicate the amount of force supplied by the press through ram 25. The feedback line 62 having a check valve 64 is provided to increase the rate of approach of the ram by cutting down the amount of oil required to be pumped.

In operation, hydraulic fluid is supplied by pump 6 to lines 8 and 48. When the ram 25 is in the uppermost position, valve 30 will be opened to allow fluid pressure to pass through line 34 and to open valve 10. A passage is provided in valve 10 between line 8 and line 34 as will be described hereinafter with reference to FIG. 4. The fluid will pass through line 8' through line 12, through valve 14, line 16, and back to reservoir 2. Since valve 15 is normally open, the fluid in line 17 will flow through valve 14 to maintain valve 14 open. In this condition, valve 50 is opened due to the low pressure in line 48. However, since valve 10 is open, the pressure on either side of piston 23 will be equalized. When it is desirable to operate the press, the operating valve 14 is closed by closing valve 15 by a manually operable lever. Closing of valve 15 stops the flow of fluid through line 17 to thereby close valve 14. Pressure builds up in lines 12, 18, and the first pressure chamber 22. As the ram starts its downward movement the piston will force fluid from the second pressure chamber 24 through line 62 to reduce the amount of fluid which must be supplied to chamber 22 by pump 6. After the piston leaves the top stroke position, valve 30 will close but valve 10 will be held open by the pressure on the pilot piston transmitted through line 11. When the ram contacts the work, the pressure rises above the second predetermined value in lines 8 and 48, and closes valve 50 accordingly. Valve 50 is closed when the pressure in line 48 reaches the second predetermined value. When the pressure in the chamber 24 reaches the fourth predetermined value, valve 40 opens to allow the fluid in the second pressure chamber 24 to be drained through line 36, line 38, and line 42 to reservoir 2.

As pressure is applied to the work, the pressure in line 18 and 12 builds up. As long as valve 15 is closed, the pressure will build up to the pressure maximum set for valve 13. This pressure is transmitted through line 12, valve 14, line 17 to valve 13. At this maximum pressure, valve 13 will open to permit venting through line 17 and valve 13 to the extent necessary to maintain the pressure in the line at the predetermined maximum.

Similarly, the operator, through varying the amount of fluid passing through valve 15, can vary the pressure or force applied by the ram, as seen by gauge 60. This sensitivity of operation is due to the fact that valve 14, 13, and 15 are all variable flow valves. Valve 14 can be throttled accordingly to the amount of fluid being vented through line 17.

When valve 15 is opened after the operation is completed, the pressure in the first pressure chamber 22 and in line 18 will drop to near tank pressure. In that case, valves 10 and 40 will close, and valve 50 will open, whereby fluid is pumped through line 48, through valve 50, through line 52 and line 36 to the second pressure chamber 24. The filling of the second pressure chamber causes the ram 25 and piston 23 to move upwardly through the upper end of cylinder 20. When the piston reaches the upper end of cylinder 20, cam 26 will cause cam follower 27 to open valve 30, thereby allowing fluid pressure to pass through line 34 to open valve 10. The opening of valve 10 will equalize the pressure in the first and second pressure chambers and stop the rise of ram 25. The cycle can then begin anew.

It is obvious to one skilled in the art that a separate line for draining the fluid from the second pressure chamber 24 could be provided in lieu of line 36. In other words, a line from the second pressure chamber 24 could be connected directly with line 38, and bypass line 36, if desirable.

It is also to be understood that although the invention has been described with references to a manually operated valve 15 on vent line 17, it is obvious that the valve 15 could be operated by a timing device, such as a mechanical cam or a pneumatic timing system.

The pump 6 is a fixed volume pump and can be continuously driven by an electric motor which rotates at, for example 1,800 r.p.m. The pump 6 can be a Dynex PF2006-1807 pump, which delivers 3.9 gallons per minute. Valve 10 can by any conventional pressure sensitive or unloading valve which opens when a predetermined pressure is supplied thereto when vented, and preferably which can also be opened responsive to a second pressure source.

Valve 14 can be any conventional pilot operated relief valve which is adapted to be opened responsive to a given pressure differential between the inlet and outlet and responsive to venting. For this purpose, a relief valve, such as valve 10, can be used for the valve through which the fluid flows. A lever operated, pressure sensitive remote control valve can be used as valve 15 to vent pressure from the flow through valve 14 and the second pressure responsive valve 13 can be a valve such as 15 with a screw adjustable setting. This valve is used as the overriding pressure controller for the flow-through valve 14.

Valve 30 can be any conventional normally closed two-way valve which is actuated to pass pressure therethrough responsive to a mechanical linkage actuator. Valve 40 can be any conventional valve which is adapted to open when a predetermined pressure is reached in line 38, or a predetermined pressure on auxiliary line, such as line 18, is reached.

As an example of how the system works, the first predetermined pressure to open valve 10 can be in the range of 200 to 400 p.s.i., the second predetermined pressure which closes valve 50 can be in the range of 400 to 600 p.s.i., the third predetermined pressure in lines 18 and 22 to open valve 40 can be in the range of 300 to 700 p.s.i., and the fourth predetermined pressure in the second pressure chamber 24 to

open valve 40 can be in the range of 500 to 800 p.s.i. The fifth predetermined pressure, or the pressure at which pressure controller 13 will open valve 14, can be in the range of 6,000 to 9,000 p.s.i. With the recycle line 62, the ram approach speed would be about 48 inches per minute. Without the recycle line 62, the ram approach speed would be about 30 inches per minute. The return ram speed would be about 80 inches per minute.

Whereas the invention has been described with reference to the vertical reciprocation with a ram pressing downwardly when the press is operating, it is obvious that other forms of presses can be employed with the control system. For example, a pressing platform could be actuated either vertically or horizontally, upwardly or downwardly by a piston within the scope of the invention.

Referring now specifically to FIGS. 2 through 6, a valve assembly is shown containing valves 10, 14, 40, and 50. With reference specifically to FIG. 3, line 12 is connected to port 68 which communicates to line 16 when the valve is open. The valve contains a pressure sensitive valve member 74 which seats against retaining ring 76 and is held in place through the action of spring 76' abutting against the cap 78. Valve element 74 has port 70 which communicates through a narrow channel 71 to port 80, port 82, bore 74, and bore 86. Channel 71 is smaller than port 82 which aids in the smooth operation of the valve. A seat (like 128) and a spring biased valve element (like 126, FIG. 4) is provided at 90 to close off one side of the bore 86. A plug 88 closes off the other side of bore 86. A port 92 is provided to connect to vent line 17. The valve element at 90 is set at the factory to open only when the maximum pressure allowable for the press is reached.

In operation, valve element 74 is biased by spring 78 against retaining ring 76. When fluid is passing through bore 70, channel 71, apertures 80, 82, and bore 84, a pressure differential will build up between port 68 and the other side of valve element 74 due to the fluid flow through of channel 71. When the pressure difference is sufficient, valve element 74 will slide open to allow the fluid to pass from 68 to 72 and out through line 16. In this manner, the valve can also be actuated by opening a vent which exhausts fluid through port 92.

Referring now specifically to FIG. 4, which valve is similar in structure and operation to the valve of FIG. 3, fluid from line 8 passes into port 100 and when the valve element 102 is retracted, passes through port 104 to line 8'. The valve element contains a central bore 108, narrow channel 110, bore 112, and aperture 116 for passing fluid and providing a communication path for fluid pressure to port 118, bore 120, and pressure chamber 122. Port 118 is about the same size as narrow channel 110. Spring 114 biases the valve element 102 against retaining ring 106 so that the valve is normally closed. Valve element 126 is biased by spring 130 against valve seat 128 by plug 132 which is adjustable through exterior screw member 134. When the pressure in chamber 122 builds up to a certain point, valve element 126 is moved away from valve seat 128 against the pressure of spring 130. When this occurs, fluid will flow through bore 108, channel 110, bore 112, through chamber 122, into chamber 135, through port 138 and out through 104 into line 8'. As the flow increases, valve element 102 will be forced from retaining ring 106 against the spring pressure of spring 112 due to the differential pressure between bore 100 and bore 112.

A port 124 is also connected to chamber 122 to provide a communication means for the vent line 34. Thus, when the pressure in line 34 is vented, it will cause valve element 102 to open. Also a piston member 120 slides in bore 121 responsive to pressure in line 11 to push against valve element 126. Where the pressure in line 11 exceeds a certain value, element 126 will be unseated and the valve 102 will open. Thus, valve 10 operates under three conditions. The first condition is when the pressure in line 8 and bore 100 reaches a first predetermined value. The second condition is when the pressure in line 11 reaches another predetermined value to open valve element 126. In other words, valve 102 can be opened even though the pressure in line 8 is below the first predetermined value. The third condition is when line 34 is vented.

Referring now to FIG. 5 and FIG. 5a line 48 communicates with bore 150, which in turn communicates with bore 192 and line 52 when valve element 152 is retracted. Valve element 152 is similar in construction and operation to valve element 74 and 102 of FIGS. 3 and 4, respectively. Valve element 152 is biased against retaining ring 154 by spring 156 acting against valve 160. A central bore 162 of valve element 152 communicates with a narrow channel 164, bore 166 to chamber 168, which in turn communicates to a pressure chamber 172 through narrow passage 170. A bore 173 extends between chamber 172 and bore 184. The top of the bore 173 tapers outwardly in a conical manner to form a valve seat 175. A piston 174 having a cutaway central portion 174*a* is positioned in the bore 173. When the piston is in the up position as illustrated in FIGS. 5 and 5*a*, the top of the cutaway portion 174*a* is upwardly of valve seat 175, permitting fluid to flow therebetween. An aperture or slot 176 is formed between the cutaway portion 174*a* and the bore 173 for the passage of fluid. The fluid in chamber 172 can flow through an aperture 176, to chamber 184, through ball valve 53 held in place by spring 186, through port 188, port 190, and port 192 when piston 174 is away from valve seat 175. Piston 174 is biased away from valve seat 175 by spring 178 acting against plug 180 which is adjustable through screw member 182. Thus, when the fluid pressure in chamber 172 builds up to a certain value, which can be set by screw member 182, this pressure will cause the top of the cutaway portion 174*a* to close against valve seat 175, thereby shutting off the flow through the valve element 152. Thus, valve 50 is pressure responsive and adapted to close when a predetermined pressure is reached in line 48 and bore 150. The shape of the piston 174 and slot 176 enables the valve to snap shut. The fact that the closing area is about the same as piston 174 enables a sensitive operation of the valve so that the pressure differential opening and closing of the valve is relatively small. This novel valve structure shown in FIG. 5 operates such that the valve will close when the inlet pressure reaches a predetermined value which is adjustable through screw member 182.

Referring now to FIG. 6, fluid in line 38 passes into bore 200 and is adapted to flow into line 42 when valve element 202 is retracted from retaining ring 204. The operation of valve element 202 is similar to the operation of valve elements 152, 102, and 74 in FIGS. 5, 4, and 3, respectively. Valve element 202 contains a central bore 210, which communicates through passage 212 to bore 214, through aperture 216 to bore 218 and into pressure chamber 220. A valve element 222 is biased by spring 226 acting against plug 228 to effectively prevent fluid from passing from chamber 220 into chamber 232. The spring pressure of spring 226 is adjustable through screw member 230. The operation of this valve is basically the same as the operation of the valve shown in FIG. 4. Namely, when the pressure in bore 200 (in line 38) reaches a predetermined value, the pressure acting against valve member 222 and against spring 226 will open the passage from chamber 220 to 232 and allow fluid to pass through chamber 234. Thus, the fluid flow through valve element 202 will cause valve 202 to retract against the spring pressure and open the valve to allow pressure to flow from line 38 to line 42.

Alternately, a piston member 236 having a stop member 238 can be provided to abut against valve element 222. Piston 236 can be responsive to pressure in a line connected to line 18 which is connected to collar 240. The fluid pressure in this line acts against pressure receiver 242 to actuate piston 236. Thus, when the pressure in line 18 reaches a predetermined value, it will move piston 236 down to allow fluid to pass through the valve seat 224 into chamber 232 and thereby open the valve. When this latter system is not desired collar 240 will be closed off.

The pressure controller 13 can be a pressure responsive valve, similar to the valve shown in FIG. 4, wherein the vent line 17 from port 124 is connected to a port corresponding to port 100 of the corresponding pressure actuated valve.

Reasonable variation and modification are possible within the scope of the foregoing disclosure, the drawings, and the appended claims to the invention without departing from the spirit thereof.

I claim:

1. A control system for a pressure responsive device comprising:

A. a pressure supply source for a hydraulic fluid;

B. a first pressure responsive valve means having an inlet connected to said pressure supply source and adapted to open when a first predetermined pressure is supplied to said inlet thereof;

C. means to supply fluid pressure to a first fluid pressure chamber, from said pressure supply source through said first pressure responsive valve;

D. valve means in said means of C to release the fluid pressure therein;

E. means to supply fluid pressure to a second pressure chamber;

F. a second pressure responsive valve means, in said means of E adapted to control the flow of fluid through said means of E, said second pressure responsive valve means adapted to close when the pressure in said valve reaches a second predetermined pressure; and

G. valve means to release fluid pressure in said second pressure chamber, said valve means being responsive to open and release said pressure in said second fluid pressure chamber when said fluid pressure in said first fluid pressure chamber reaches a third predetermined value or said fluid pressure in said second fluid pressure chamber reaches a second predetermined value.

2. A control system according to claim 1, wherein there is further provided a means to release the fluid pressure in said first pressure chamber when the pressure in said first pressure chamber reaches a fifth predetermined value.

3. A pressure control system according to claim 1, wherein said device is a double acting press, said first pressure chamber is one end of a piston cylinder containing a piston attached to a pressing means, said second pressure cylinder is a second end of a piston cylinder.

4. A control system according to claim 3, wherein means are provided to open said first pressure responsive valve of B when said piston is at the end of said first pressure chamber.

5. A control system according to claim 4, wherein said opening means comprises a cam on said pressing means to actuate a valve to vent fluid pressure from said first pressure responsive valve to open the same when said pressing means reaches its most retracted position

6. A control system according to claim 1, wherein said valve means of D is a manually operated valve, and actuation of said valve actuates the reciprocation of said press.

7. A control system according to claim 1, wherein said pressure supply source of A is a hydraulic pump which supplies pressure to said means of C through said first pressure responsive valve means and to said means of E through said second pressure responsive valve means, and wherein said second predetermined pressure is less than said first predetermined pressure.

8. A control system according to claim 1, wherein said first predetermined pressure is less than said second predetermined pressure.

9. A control system according to claim 7, wherein there is provided means to recycle fluid from said means of E downstream of said second pressure responsive valve means to said pressure supply source of A downstream thereof, and means in said recycle means to prevent the flow of fluid from said pressure supply source through said recycle means, and means in said mean of E to supply pressure to said pressure responsive valve means of B to open said valve means where sufficient pressure in said means of E is reached.

10. A control system according to claim 1, wherein said valve means of F comprises:

1. a valve housing containing an inlet and outlet and at least one bore in said housing communicating between said inlet and said outlet;
2. a spool member having a narrow passage therethrough communicating with said inlet at one end thereof, said spool member being reciprocatable in said bore to open said valve when fluid flows through said spool, and said spool member being biased in said bore to block flow between said inlet and said outlet;
3. a second valve means containing an inlet end and an outlet end, said second valve means having a piston reciprocatable to open and close said valve;
4. means to bias said piston in the open position in said second valve means;
5. means communicating with the outlet from said second valve means, and said outlet of 1; and
6. means communicating with said inlet of said second valve of 1 and an end of said piston such that pressure in said communication means of 6 tends to act against said biasing means of 3 in such a way that when the pressure in said inlet of said second valve reaches a predetermined value, said piston will close said second valve means to stop the flow of fluid therethrough, and thereby cause said spool member of 2 to close said bore of 1 between said inlet and said outlet of 1.

11. A fluid pressure responsive valve comprising:

1. a valve housing containing an inlet and an outlet and at least one bore in said housing communicating between said inlet and said outlet;
2. a spool member having a narrow passage therethrough communicating with said inlet at one end thereof, said spool member being reciprocatable in said bore to open said valve when fluid flows through said spool, and said spool member being biased in said bore to block flow between said inlet and said outlet in the absence of fluid flowing through said narrow passage in said spool member;
3. a second valve means containing an inlet end and an outlet end, said second valve having a piston reciprocatable to open and close said valve means;
4. means to bias said piston in the open position;
5. means communicating with the outlet from said second valve means, and said outlet of 1; and
6. means communicating with said inlet of said second valve means and an end of said piston and with said narrow passage of said spool member, said end of said piston being so shaped such that pressure in said communication means of 6 tends to act against said biasing means of 3 in such a way that when the pressure in said inlet end of said second valve means reaches a predetermined value, said piston will close to stop the flow of fluid through said second valve, and thereby cause said spool member to close said bore of 1 between said inlet and said outlet of 1.

12. a fluid pressure responsive valve according to claim 11, wherein said means of 6 contains a check valve to prevent the flow of fluid from said outlet of 1 to said second valve outlet.

13. A fluid pressure responsive valve according to claim 11, wherein said biasing means of 4 is adjustable to control the pressure at which said pressure responsive valve will close.

14. A fluid pressure responsive valve according to claim 11, wherein said piston of 3 is slightly larger than the valve seat which it contacts a stop the flow of fluid through said second valve means, and there is provided a narrow channel between said communicating means of 5 and said communicating means of 6, which narrow passage is cut off when said piston is seated on said valve seat.