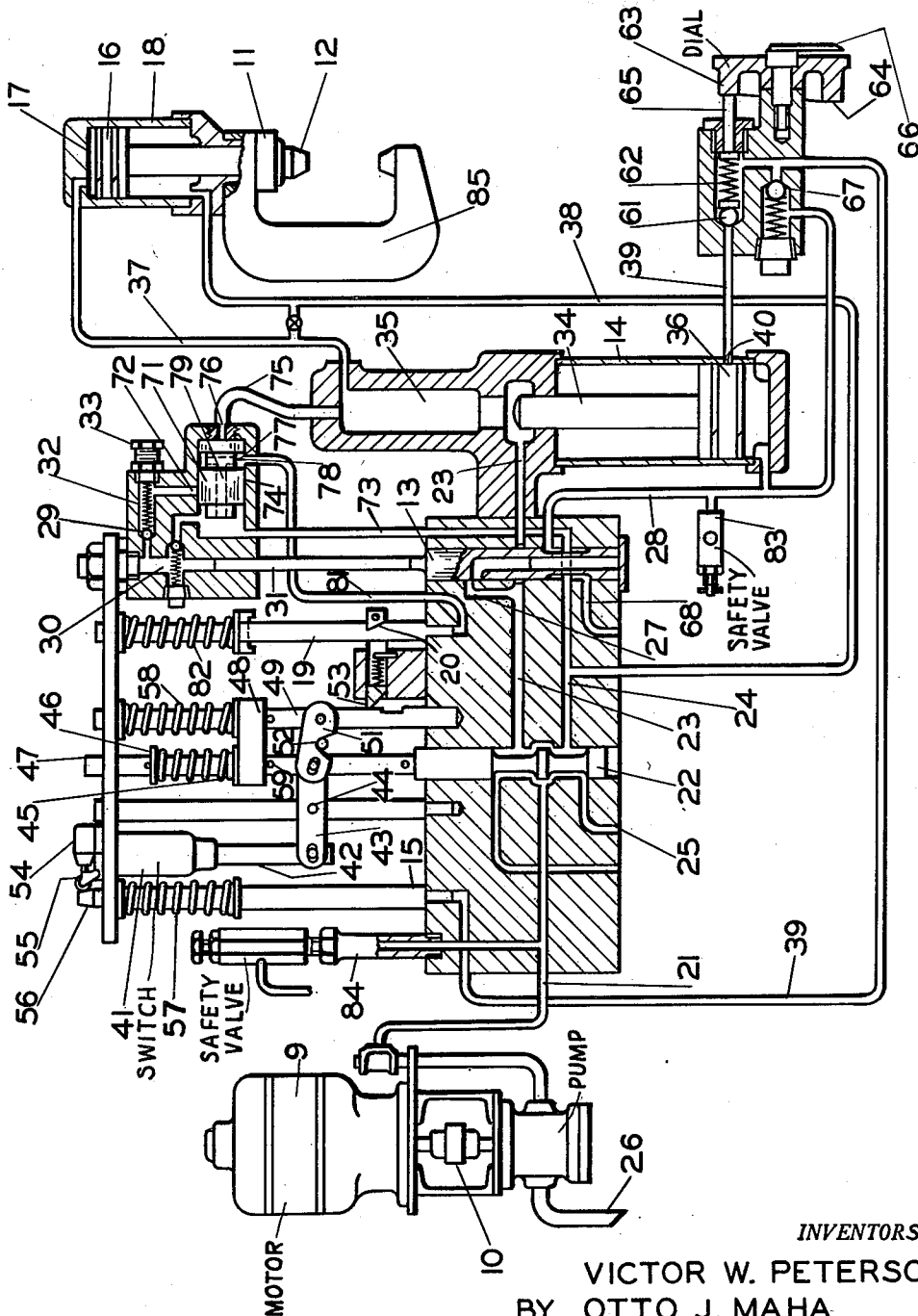


Oct. 7, 1952

V. W. PETERSON ET AL
MEANS FOR PROTECTING HYDRAULIC PRESSURE RESPONSIVE
DEVICES FROM THE EFFECTS OF FLUID SHOCK
Filed July 31, 1947

2,612,756



INVENTORS

VICTOR W. PETERSON
BY OTTO J. MAHA
Roland C. Rehn
ATTORNEY

UNITED STATES PATENT OFFICE

2,612,756

MEANS FOR PROTECTING HYDRAULIC
PRESSURE RESPONSIVE DEVICES
FROM THE EFFECTS OF FLUID SHOCKVictor W. Peterson and Otto J. Maha, Chicago,
Ill., assignors to Hannifin Corporation, Chicago,
Ill., a corporation of Illinois

Application July 31, 1947, Serial No. 765,206

12 Claims. (Cl. 60—54.5)

1

This invention relates to improvements in the control of hydraulic or other pressure actuated devices and among other objects aims to provide means for increasing the range of pressure adjustments in pressure responsive systems for controlling such devices.

Another object is to provide means for protecting against hydraulic shock.

The nature of the invention may be readily understood by reference to one apparatus embodying the invention and illustrated in the accompanying drawing.

In the drawing, the figure is a schematic section, illustrating the general construction and operation of the apparatus.

For simplification in illustration and description of the invention, it is here shown applied to apparatus of the character described in greater detail in our prior Patent 2,308,712; but it will be apparent that the invention is not limited to this type of apparatus.

In hydraulic pressure actuated and pressure responsive apparatus, the hydraulic shock (caused by liquid inertia and the relatively incompressible character of the liquid) is often greater than operating pressures (at a given stage of a cycle), thereby causing premature and undesired operation of the pressure responsive control devices. To prevent this, it is generally the practice to set the pressure responsive controls for actuation at pressures higher than the shock pressures. This, however results in excessive stress or load on the pressure generating system and the apparatus in general, because of the high pressures it is necessary to build up in the system to cause actuation of the pressure responsive control devices. This in turn makes impossible any adequate range of adjustment of the pressure responsive devices to vary the maximum or other critical pressures according to the particular duty required of the apparatus.

The present invention, among other advantages, provides means for temporarily (at appropriate stages in the cycle when hydraulic shock occurs) rendering the pressure responsive controls insensitive, thereby protecting the apparatus and making it possible not only to adjust the pressure responsive devices for response at the lowest practicable pressures, but to increase the range of maximum or other critical pressures exerted by the apparatus.

For example, in the illustrative apparatus, a hydraulic pressure generator (e. g. a motor (9) driven hydraulic pump (10) supplies primary pressure to actuate a press (in this case a squeeze

2

riveter (11), to close the die (12) quickly on the rivet and to exert such heading pressure thereon as can be exerted by direct pump pressure. Thereupon, when substantially maximum pump pressure is developed, a valve (13) brings into operation a hydraulic intensifier (14) (by which the pump pressure is greatly multiplied, e. g. 5 times) to apply the final squeeze on the rivet. When a predetermined intensified pressure is reached (deemed adequate to head the rivet), a pressure operated control device (15) reverses the riveter tool (12) to withdraw it from the rivet. Upon reaching the fully returned position (engagement of the work piston (16) with the head end (17) of work cylinder (18)) a control device (19) responsive to the increased line pressure resulting from such engagement terminates the cycle.

At various stages in the cycle, inertia of the oil (due either to setting the oil in motion, arresting or reversing its motion etc.) creates shock pressures sufficient under conditions heretofore existing, prematurely to actuate the aforesaid pressure responsive devices. Additional shocks occur if the cycle be purposely interrupted (because of improperly placed rivets or for any other reason) or the work piston be reversed intermediate the ends of its stroke.

Before describing the means by which these shocks are rendered ineffective, a preliminary brief description of the illustrative apparatus will assist in an understanding of the principle of the invention.

Primary pump pressure is supplied through line (21) and distributed by the primary valve (22) which is longitudinally slidable to direct pressure fluid either through line (23) to the head end of the work cylinder, or to return line (24) to the plunger end of the cylinder, or to short circuit the fluid at practically no load or zero pressure through discharge line (25) to the reservoir from which the pump draws its oil through line (26). Thus in its intermediate position (that here illustrated) the pump operates at practically no load between successive cycles of the riveter. In its upper or lower positions, when directing fluid for advance or return of the work piston, respectively, the other lines (23 and 24) respectively, will be connected to discharge line (25).

When the tool (12) engages the work, resistance is encountered and pump pressure builds up either to the maximum safe pump pressure or other predetermined pump pressure. This pressure, reaching intensifier valve (13) through line (27), elevates the former and connects supply line

23 with line 28 leading to the lower end of the large intensifier cylinder 14. Actuation of the intensifier valve is regulated by the adjustable relief valve 29 controlling escape of oil from the chamber 30 wherein it is under compression of plunger 31 operated by the intensifier valve 13. Valve 29 is adjusted to yield when pump pressures reach the aforesaid maximum predetermined pressure. Adjustment of such valve is effected by varying the loading on valve spring 32 by means of the threaded adjusting element 33. Yielding of spring 32 permits the oil in chamber 30 to escape and thereby allowing the intensifier valve to move and cut in the intensifier as above described. When the small intensifier piston 34 enters the small intensifier cylinder 35, it cuts off further supply of direct primary pressure through line 23, intensifier chamber 35 and line 37 to the head end of the work cylinder 18. Because of the differential of area between the large intensifier piston 36 and that of the small piston 34 (e.g. five to one), the oil in cylinder 35 may be subjected to many times pump pressure which pressure, communicated through line 37 to the head end of the work cylinder supplies the intensified pressure on the work. The maximum intensified pressure available is the maximum pump pressure multiplied by the ratio of the intensifier pistons. If this ratio be 5 and the maximum operating pump pressure be 1,000 pounds per square inch, the intensified pressure will be 5,000 pounds per square inch.

When the intensified pressure reaches the desired value, the pressure responsive control device 15 is operated to allow primary valve 22 to be elevated as presently described, to reverse position, thus connecting the return line 24 with the pump and delivering pump pressure through line 38 to the plunger end of work cylinder 18. The head end of the cylinder is simultaneously connected to discharge. In the present instance, control device 15 is exposed to pump pressure through line 39 leading to a port in the large intensifier cylinder. Since there is a constant ratio between the pump pressure and the intensified pressure, the pump pressure during the intensifying stage of operation is a measure of the intensified pressure.

In the present instance, control device 15 operates to open an electric circuit controlling solenoid 41. When the solenoid is energized, its plunger 42 is elevated, thereby depressing or lowering primary valve 22 through lever 43 fulcrumed at 44. Solenoid 41 is preferably actuated by closing a conveniently located electric control switch (not shown). Downward movement of the primary valve is against the spring 45 lying between the collar 46 on valve rod 47 and bar 48 carried on plunger 49. Simultaneously with lowering of primary valve 22, rod 49 and bar 48 are elevated by lever 51 fulcrumed at 52, thereby further compressing spring 45. The purpose of the preloading of spring 45 is to provide energy for raising of the primary valve on deenergization of solenoid 41 to return position. When rod 49 is elevated, it is latched in elevated position by the spring latch 53 releasable by the pressure responsive control 19.

Solenoid 41 is energized by appropriate circuits under the control of the operator. The details of such circuits are conventional and need not be described. Included in the circuit is a switch such as a micro switch 54 whose plunger 55 is moved by the cam surface 56 on control device 15. The latter is held in its lower position by a relatively light spring 57.

When work piston 16 reaches the head end of its cylinder, the increased pump pressure, built up by resistance to further movement, elevates control device 19 whose cam surface 20 withdraws latch 53 and allows primary valve 22 to rise to its neutral, i. e., intermediate, position wherein the pump simply discharges into the reservoir at no load. The primary valve rod 47 falls with the bar 48 under the action of spring 58 which is somewhat compressed by the previous elevation of rod 49. Pressure of spring 58 is transmitted to the primary valve rod 47 through bar 48 bearing against the stop or pin 59 on rod 47. Spring 45 exerts no control over the primary valve during this operation since it is limited in its movement by pin 59 and the collar 46. In its extended position, it centers the valve in intermediate or neutral position.

A new cycle may be started by energizing solenoid 41 as above described and depressing primary valve 22. Operation of the work piston may be interrupted at any stage in the cycle simply by de-energizing solenoid 41. It is unnecessary for the work piston 16 to return to its extreme position before starting a new cycle. A new cycle may be started by the operator simply by closing said control switch (not shown) to energize solenoid 41. It is true that under such circumstances, rod 49 and bar 48 will still be latched in their upper position but this will not prevent depression of the primary valve to its lower position. It simply makes unnecessary the simultaneous compression of spring 58 by means of the lever 51. The latter is free to ride above fulcrum pin 52 with the upward movement of either of the pivots on rods 47 and 49.

Premature or undesired operation of the illustrative control devices is prevented according to the present invention by blocking communication of pressure to such devices at periods in the cycle during which shock or excessive pressures may occur. The manner of applying the principle varies depending upon whether movement of a plunger or other element of the existing apparatus may be utilized to block and unblock a port or ports for establishing or cutting off communication of pressure. When such movement cannot be utilized, a separate pressure or other actuated elements is introduced into the line of hydraulic communication to block and unblock access of pressures to the pressure responsive device.

The first method is illustrated in connection with operation of device 15 controlling termination of the high pressure or squeezing stage of the cycle. If unprotected, this device would respond to shock pressures during the intensification stage of the cycle. As stated above, shock pressures may occur at the beginning of intensification, i. e. when the large intensifier piston 36 is at the lower or head end of the cylinder. The intensifier piston skirt is therefore advantageously used to block the passage leading from the pressure line 28 to control device 15. As here shown, line 39 leads to a port 40 the lower end of the large intensified cylinder where it is blocked from communication with the pressure in line 28 until it is uncovered by a short rise of the intensifier piston. At this time, the danger of shock pressure has passed.

In the present case, an adjustable relief valve 61 is interposed in line 39. Such valve comprises in the present instance a simple spring-loaded ball valve wherein the load on spring 62 may be adjusted. The adjusting means comprises a hand operated knob 63, having a cam surface

64 bearing on the spring plunger 65 to permit movement of the latter in or out to vary the loading on spring 62 and therefore the pressure at which the valve will open to expose device 15 to operating pressures from the large intensifier cylinder. The knob 63 may advantageously have on its front face a graduated dial which in conjunction with the stationary index 66 will indicate the intensified pressure at which the ball valve will open to operate the pressure responsive device 15. The protection afforded by blocking line 39 during the period of shock pressures, makes it unnecessary to load spring 62 greatly in excess of what would ordinarily be necessary to prevent premature operation of device 15. This makes it possible to permit easy manual adjustments of the maximum intensifier pressure in accordance with the necessities of the operation to be performed. Spring 57 is made relatively light and sufficient only to return the device 15 to initial position at the end of the cycle when pump pressures drop practically to zero. A check valve 67, in line 39, permits escape of the small amount of oil displaced by device 15 on return to its initial position, into line 28 and thence to discharge through line 68 when pump pressures are reduced to zero.

The method of embodying the invention in control devices wherein no existing movable parts can be used to block and unblock communication with the source of pressure is illustrated in connection with the intensifier valve 13 and the control device 19 for restoring the primary valve to neutral position at the end of a cycle. In the present instance, these devices are advantageously effected by a single movable element 71 here shown in the form of a spool or shuttle valve, which, at one stage of the cycle blocks a line controlling the operation of the intensifier valve and at another stage in the cycle, blocks a line controlling operation of control device 19.

As here shown, at the beginning of the cycle, valve 71 blocks passage 72 leading from the intensifier operating valve 29 to discharge line 73. Thus the oil in passage 72 prevents valve 29 from leaving its seat and therefore prevents operation of the intensifier by shock pressures occurring at the beginning of a cycle whether such cycle starts with the work piston in mid-stroke or at the head end of its stroke. Spool 71 is longitudinally slidable in its cylinder 74 and in this instance is moved to unblocking position by line pressure delivered thereto through line 75 as the work piston starts its forward stroke. The rate of such movement is limited by interposing in line 75 a restricted orifice 76 (in this case in the form of a plug inserted in the end of cylinder 74), thereby delaying the unblocking of passage 72 until the work piston 16 has advanced well beyond any point at which shock pressures could occur. When spool 71 reaches the limits of its retarded movement a passage therein (here provided by a circumferential groove 77 in the spool) registers with passage 72 to connect the latter with passage 73. In the present case, groove 77 communicates with radial and axial passages 78 and 79 in the spool to provide a continuous passage from line 72 to line 73.

In its extreme position, as aforesaid, spool 71 blocks communication of line 73 with line 81 leading to control device 19, and the latter is therefore cut off from any shock pressures developed at the beginning of the reverse or re-

turn travel of the work piston and existing in return line 24 with which line 73 communicates. Pressure in the latter line moves spool 71 to its initial position by displacing oil through the restricted orifice 76 which therefore retards such movement and the unblocking of line 81 until danger of development of shock pressures has passed. When the spool reaches its initial position wherein passage 77 communicates with line 81 (which occurs after the work piston 16 is well along on its return stroke) line 81 and control device 19 are placed in communication with and made responsive to the pressures in return line 24. Spring 82 controlling the operation of device 19 is set to allow the latter to move when pump pressure builds up (and is communicated to plunger 19 through lines 73 and 81) as a result of the work piston reaching the head end of its stroke. The setting of the latter spring need not require the development of excessive pressure but instead may be adjusted to permit actuation by pressures which are only nominally higher than line pressures required for return of the work piston. This again minimizes unnecessary load on the pressure generator.

Protection of intensifier operating valve 29 also permits setting of this valve for operation at any desired pump pressure without regard to the problem of shock pressures.

Where, as in the present apparatus, the means for reversing the work piston is responsive to pump pressure (and not to intensifier pressure), an auxiliary safety valve 83 is advantageously employed to protect the apparatus against development of excessive pressures in the event of failure of operation of solenoid 41 or other electric controlling elements. Such auxiliary safety valve is in the secondary circuit, e. g., line 28, and would respond more quickly in case of failure of switch 54 or solenoid 41 than would the main safety valve 84, and more quickly than the usual overload devices with which the pump motor is regularly equipped. The main safety valve, on the other hand, affords protection during portions of the cycle wherein auxiliary valve 83 is ineffective. However, it is advantageously set to operate somewhat above normal maximum pump pressure so that it will not be responsive to the incidental shocks occurring during the cycle. For example, if the normal maximum pump pressure be 1,000 pounds per square inch, valve 84 is advantageously set to operate at 1500 pounds per square inch.

The foregoing will serve to illustrate the principle of the invention and the manner in which it may be adapted for various hydraulic pressure systems controlled by pressure responsive devices and wherein the latter devices may be subjected to shock pressures.

The improved apparatus thus makes possible a much wider range of adjustment than has heretofore been possible.

Obviously, the invention is not limited to details of the illustrative apparatus since these may be variously modified. Moreover, it is not indispensable that all features of the invention be used conjointly since various features may be used to advantage in different combinations and sub-combinations.

Having described our invention, we claim:

1. In hydraulic pressure actuated apparatus the combination comprising a work cylinder and piston, an intensifier piston and cylinder for supplying intensified hydraulic pressure to said work cylinder during a portion of its cycle, pressure

7

supply means for supplying hydraulic pressure to said intensifier cylinder, a hydraulically actuated control device operable to interrupt supply of pressure to said intensifier cylinder, a hydraulic line leading from said intensifier cylinder to said control devices to supply the latter with actuating hydraulic pressure, a normally closed valve in said line and responsive to pressure in said intensifier cylinder and adapted to open to permit hydraulic pressure from said intensifier cylinder to operate said control device, said valve being adjustable to vary the pressure at which it opens thereby to limit the maximum pressure in said intensifier cylinder and correspondingly to limit the maximum intensified pressure in said work cylinder, and a line connecting said valve to said intensifier cylinder at a point where it is covered and blocked by said intensifier piston during the initial portion of the stroke of the latter thereby to prevent access of shock pressures to said valve during the initial portion of intensifier operation.

2. In hydraulic pressure actuated apparatus the combination comprising a work cylinder and piston, pressure means for supplying pressure to opposite ends of said work cylinder for advancing said piston on its work stroke and returning the same at the conclusion of its work stroke, a pressure responsive control device for interrupting supply of pressure to said work cylinder when the work piston reaches the end of its return stroke, a line connecting said pressure responsive device with the line for supplying pressure for returning said work piston and adapted to supply pressure fluid for operating said control device at a predetermined pressure, a slidable valve in said line blocking transmission of pressure to said control device during the intermediate portion of the return stroke of said work piston, and means for supplying pressure fluid to move said valve to unblocking position at a limited rate but sufficient to move said valve to unblocking position by the time said work piston reaches the end of its return stroke.

3. In hydraulic pressure actuated apparatus the combination comprising a double acting work cylinder and piston, means for supplying pressure fluid to the opposite ends of said work cylinder to advance said piston on its work stroke and return the same on completion of its work stroke, a pressure actuated pressure responsive control device for controlling an operation during the work stroke of said piston in response to predetermined pressure in said work cylinder, and other pressure actuated pressure responsive control device for interrupting supply of pressure for returning said work piston upon predetermined pressures generated when said work piston reaches the end of its return stroke, means, including fluid lines for subjecting said respective control devices to the pressures existing respectively in the work cylinder on the work stroke and on the return stroke, a slidable valve and cylinder in said lines and constructed and arranged to block the line leading to said first mentioned control device during the first portion of the work stroke of the work piston so as to prevent operation of said first named control device in response to shock pressures during the first portion of the stroke of said work piston, said slidable valve being movable during the work stroke of said piston to a position blocking the line leading to said second named control device, and lines for supplying pressure to opposite ends of the latter cylinder from the pres-

8

sure supplied to said work cylinder for the respective work and return strokes of said work piston so as to move said slidable valve during the work stroke from its position blocking operation of said first named control device to a position blocking the second named control device and in the opposite direction during the return stroke of said work piston.

4. In hydraulic pressure actuated apparatus, the combination comprising a work cylinder and piston, means for supplying pressure to said work cylinder and piston, a pressure responsive control device for controlling a portion of the cycle of operation of said work piston and adapted to operate in response to predetermined pressure, a line leading from said control device to discharge and filled with hydraulic fluid preventing movement of said control device until displaced thereby, a slidable cylindrical valve closing said line at the beginning of the work piston stroke to prevent displacement of said fluid to discharge and thereby preventing operation of said control device, means for subjecting said valve to pressure delivered to said work cylinder tending to open said valve, and a throttling orifice for limiting the rate of fluid flow to said valve to retard its movement to open position until the work piston has substantially advanced on its work stroke.

5. In hydraulic pressure actuated apparatus, the combination comprising a work cylinder and piston, means for supplying hydraulic pressure to said work cylinder, an intensifier piston and cylinder for intensifying the pressure in said work cylinder during a portion of its stroke, a pressure responsive valve movable on a predetermined pressure in said work cylinder for connecting the pressure supply to said intensifier cylinder, a line connected with said pressure responsive valve for the escape of hydraulic fluid necessary for the opening of said valve, a slidable cylindrical element closing said line at the beginning of the stroke of the work piston to prevent said escape and thereby prevent opening of said valve, a line connecting said slidable element with the pressure in said work cylinder to move said element to open position, and a restricted orifice in said line to limit the rate of movement of said cylindrical element to open position until the work piston has substantially advanced on its work stroke.

6. In pressure actuated apparatus, the combination comprising a work cylinder and piston, a pressure responsive control device for controlling an operative movement of said work piston in response to predetermined pressure in said work cylinder, a line subject to shock pressures exceeding said predetermined pressure for communicating pressure to said control device to actuate the latter at said predetermined pressure, a movable device insensitive to the pressure in said line and closing said line during portions of said work piston stroke when shock pressures occur in said line, thereby to prevent operation of said control device during said periods of the cycle, a passage for supplying pressure to said movable device to move the latter to open position to open said line, and means for regulating the rate of said movement of said movable device.

7. In hydraulic pressure actuated apparatus subjected to shock pressures during certain periods of its cycle of operations, the combination comprising a work cylinder and piston, means for supplying hydraulic pressure to said work cylinder, a pressure responsive control device insensi-

tive to said shock pressures for controlling a portion of the cycle of operation of said work piston and adapted to operate in response to predetermined pressure, a hydraulic line connected to said pressure responsive device for carrying of hydraulic fluid displaced by the operation of said device, a valve closing said line to prevent displacement of said hydraulic fluid and insensitive to said shock pressures for preventing operation of said device during periods of shock pressure, and a passage for communicating pressure from said work cylinder to said valve to open the same during other periods in the cycle of operation to permit displacement of said hydraulic fluid.

8. In hydraulic pressure actuated apparatus, the combination comprising a cylinder and piston, means for supplying hydraulic pressure to said cylinder to advance said piston, a hydraulically actuated control device for interrupting supply of pressure to said cylinder, a normally closed valve responsive to pressure in said cylinder and adapted to open under hydraulic pressure in said cylinder to admit hydraulic pressure to said control device to actuate the latter, a hydraulic line connecting said valve with said cylinder through a port in the latter to deliver cylinder pressure to said valve, said port being positioned so that it is closed by said piston for a portion of its stroke to render said valve during such portion of the stroke insensitive to pressure in said cylinder, said valve being adjustable to vary the pressure at which it opens, thereby to vary the maximum operating pressure in said cylinder.

9. In hydraulic pressure actuated apparatus, the combination comprising a working member movable in a cylinder by hydraulic pressure, means for supplying hydraulic pressure to said cylinder to move said member, a hydraulically actuated control device for interrupting supply of pressure to said work cylinder, a normally closed valve responsive to pressure in said work cylinder to admit hydraulic pressure to said control device, a hydraulic line connecting said valve with said cylinder through a port in the latter to deliver cylinder pressure to said valve, said port being positioned so that it is closed by said work member for a portion of its movement to render said valve during said portion of movement insensitive to pressure in said work cylinder.

10. In hydraulic pressure apparatus subjected to pressure shocks in excess of normal operating pressures during a portion of the cycle of operations, the combination comprising a work piston, a supply of hydraulic pressure, a pressure responsive device sensitive to said pressure shocks for controlling supply of pressure to said work piston and adapted to be actuated when operating pressures rise to a predetermined value in the apparatus, means for automatically closing communication of pressure to said pressure responsive device during the portion of the cycle of operation of said piston wherein pressure shocks occur to render said device insensi-

tive and inoperative, and means for unblocking said communication during other portions of said cycle so that during said other portions of the cycle said device is operative to control supply of pressure to said work piston in response to operating pressures.

11. In hydraulic pressure apparatus subjected during a portion of the cycle of operations to pressure shocks in excess of normal operating pressures, the combination comprising a supply of hydraulic pressure, a cylinder with piston therein actuated by said pressure, a pressure responsive device sensitive to said pressure shocks and adapted to be actuated when operating pressures rise to a predetermined pressure to control an operative movement of said piston, a hydraulic line connecting said cylinder with said pressure responsive device to subject the latter to the hydraulic pressure in said cylinder, said line being connected with said cylinder at a point covered by said piston during the said portion of the cycle, thereby to cut off connection of pressure to said pressure responsive device during said portion of the cycle wherein said shocks occur.

12. In hydraulic pressure apparatus subjected during a portion of the cycle of operations to pressure shocks in excess of normal operating pressures, the combination comprising a supply of hydraulic pressure, a cylinder with piston therein actuated by said pressure, a pressure responsive device adapted to be actuated when operating pressures rise to a predetermined pressure to control an operative movement of said piston, a hydraulic line connecting said cylinder with said pressure responsive device to subject the latter to the hydraulic pressure in said cylinder, said line being connected with said cylinder at a point covered by said piston during the said portion of the cycle of operation of said piston, thereby to cut off connection of pressure to said pressure actuated device during said portion of the cycle, and means associated with said pressure responsive device to vary the predetermined pressure at which said device will operate.

VICTOR W. PETERSON.
OTTO J. MAHA.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
902,723	Gauer	Nov. 3, 1908
1,660,720	Osborne	Feb. 28, 1928
1,847,889	Osborne	Mar. 1, 1932
2,113,161	Osborne	Apr. 5, 1938
2,308,712	Peterson et al.	Jan. 19, 1943
2,437,077	Cole	Mar. 2, 1948
2,459,902	Tucker	Jan. 25, 1949
2,465,758	Sedgwick	Mar. 29, 1949