Aug. 23, 1966 F. M. WILLIAMSON 3,268,220

HYDRAULIC CUSHION FOR DIES

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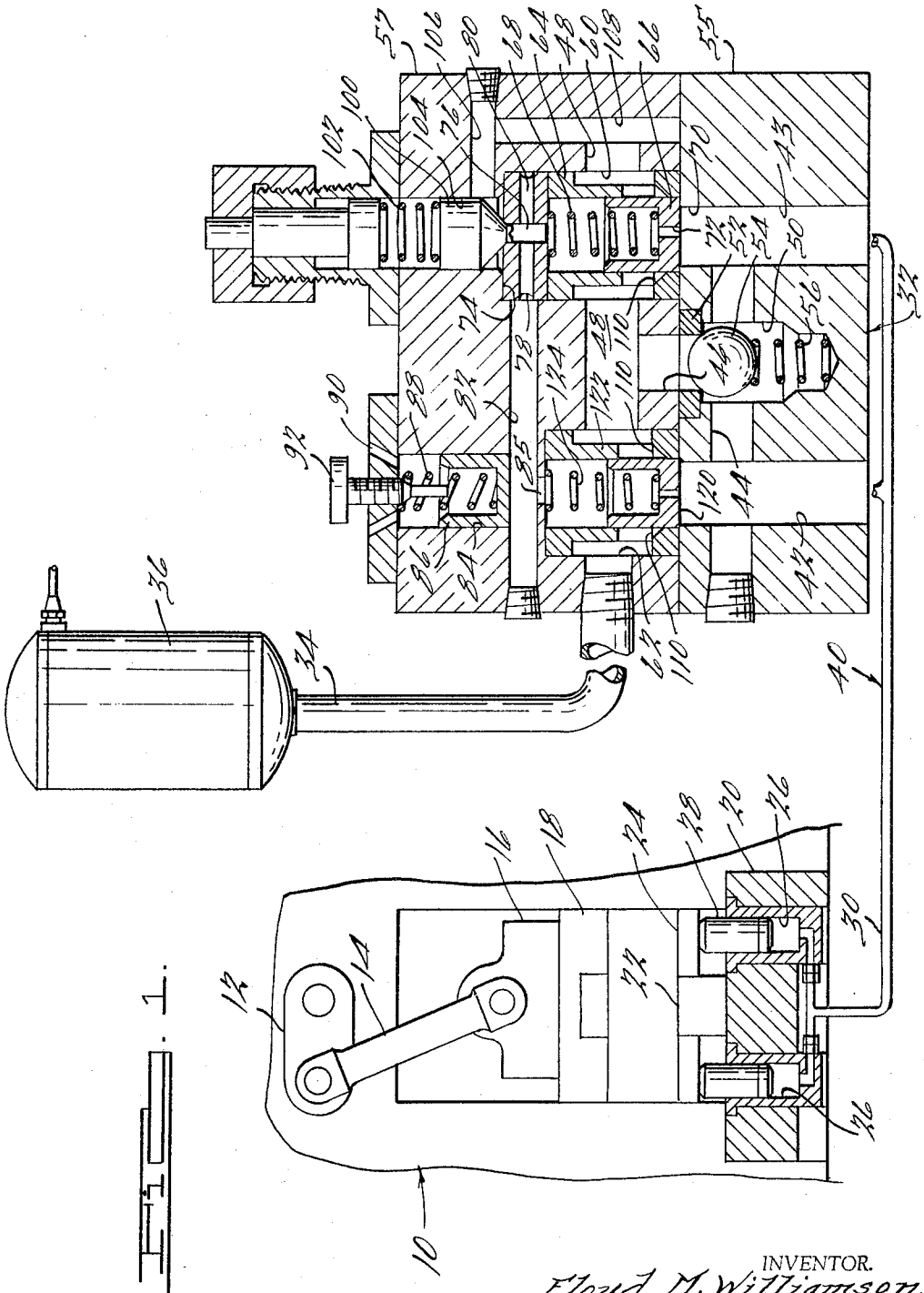


Fig. 1.

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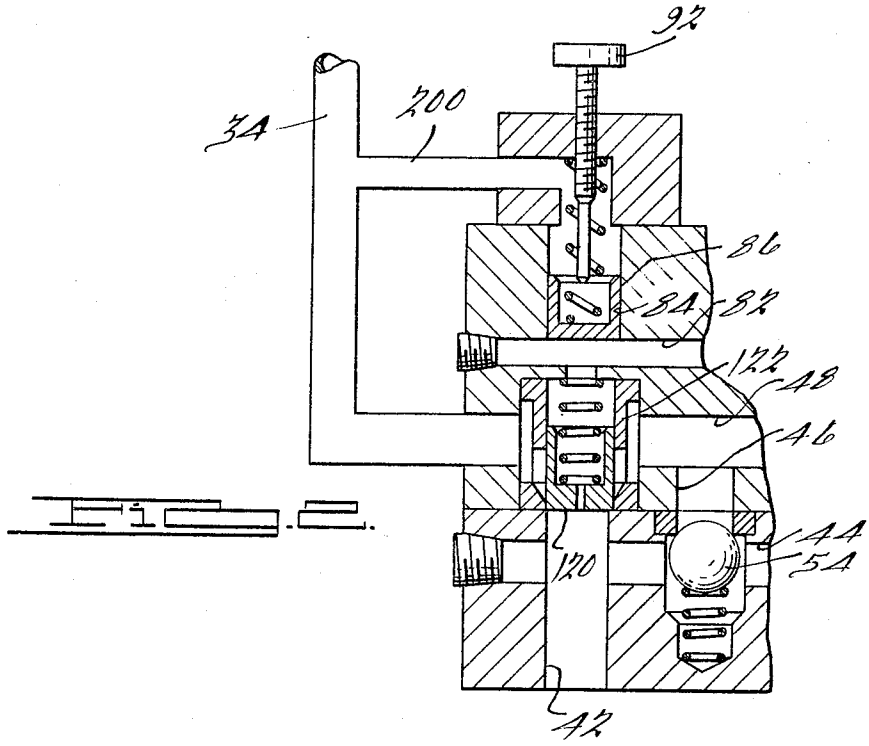


Fig. 1.

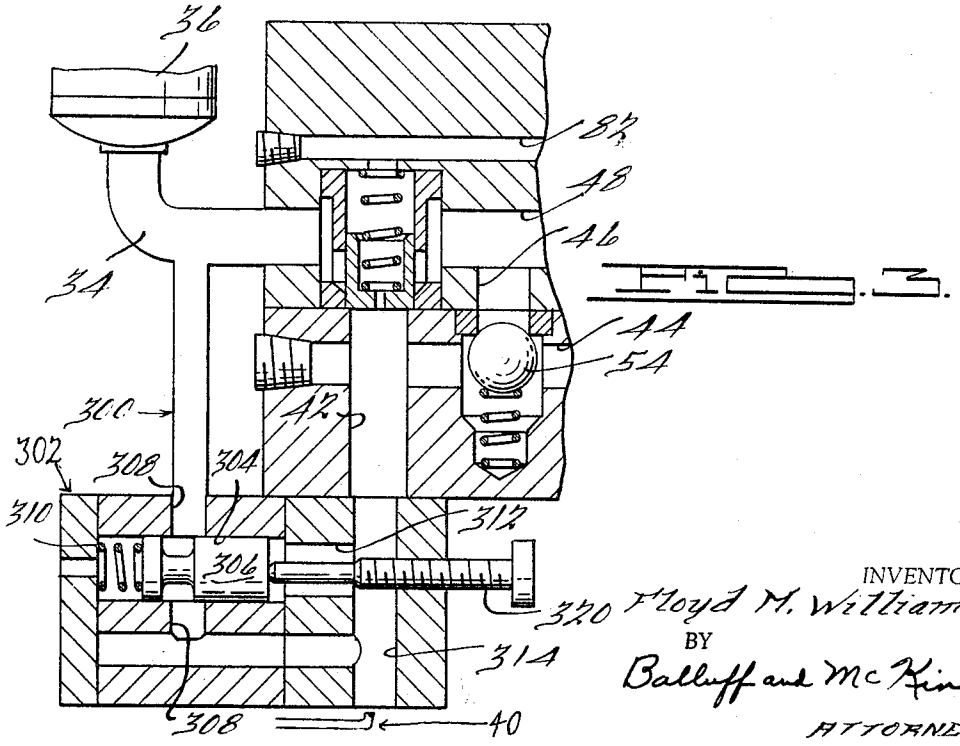


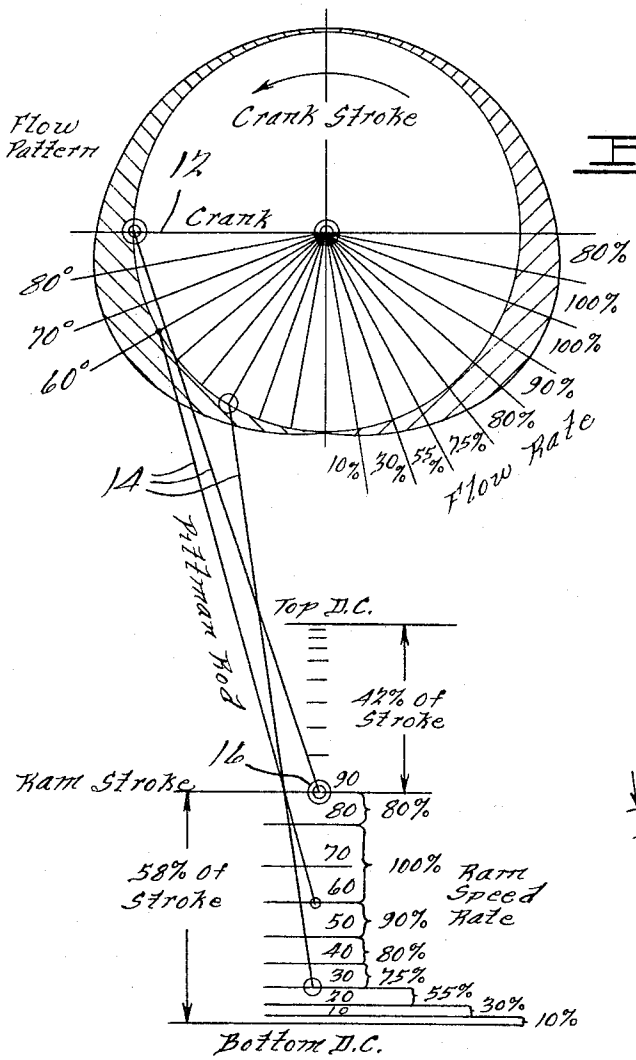
Fig. 2.

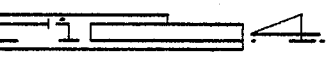
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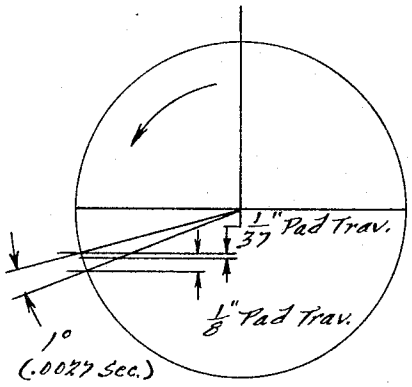
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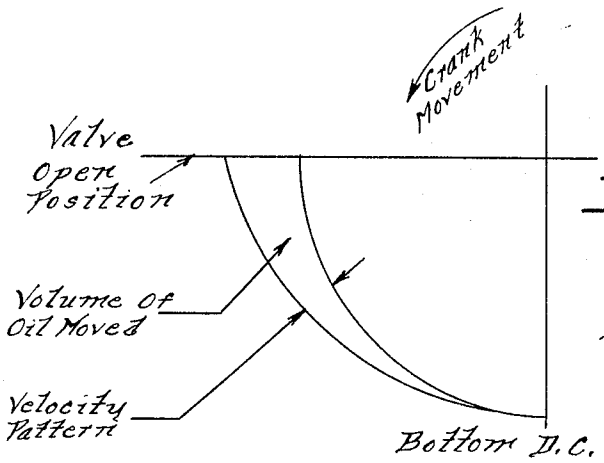
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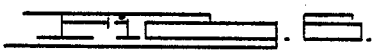
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3,268,220

HYDRAULIC CUSHION FOR DIES

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8 Claims. (Cl. 267—1)

This invention relates to hydraulic cushions for dies of crank type presses and is an improvement on the hydraulic cushions disclosed in my prior Patents Nos. 2,938,718, 2,901,238, and 2,890,669.

In hydraulic cushions the inertia of the mass of the movable components of the pressure relief valve creates resistance to opening movement of such components, resulting in back pressure in the system and other undesirable conditions or limitations which become more serious as the size of the valve and the speed of the press are increased.

A principal object of the invention is to provide a hydraulic cushion in which the movable components of the pressure relief valve are free to react so as to minimize, if not entirely eliminate, the above-referred to difficulties.

Another object of the invention is to provide a new and improved hydraulic cushion which is more efficient and dependable in operation and better adapted for use at higher press speeds and where greater valve capacity is required.

Other and further objects of the invention will be apparent from the following description and claims and may be understood by reference to the accompanying drawings, of which there are three sheets, which by way of illustration show preferred embodiments of the invention and what I now consider to be the best mode of applying the principles thereof. Other embodiments of the invention may be used without departing from the scope of the present invention as set forth in the appended claims.

In the drawings:

FIG. 1 is a somewhat schematic illustration of a hydraulic cushion embodying my invention, with certain parts of the system shown in section;

FIGS. 2 and 3 are fragmentary views illustrating modified forms of the invention;

FIG. 4 is a diagrammatic view of a crank type press relating ram speed and stroke with crank rotation and hydraulic fluid displacement from a hydraulic cylinder, the piston of which is connected to the crank by a pitman;

FIG. 5 is a diagram relating crank rotation to die pad travel; and

FIG. 6 is a diagram correlating hydraulic fluid displacement and velocity with crank movement.

As illustrated in FIG. 1, a hydraulic cushion embodying my invention is adapted for use in a crank type press indicated generally at 10 having a crank 12, a pitman 14, a reciprocating ram 16, a die 18 movable with the ram 16, a bolster 20, a fixed die 22 carried by the bolster, and a movable die or die pad 24 associated with die 22. The hydraulic cushion includes hydraulic cylinders 26 mounted on the bolster, each having a piston or plunger 28 movable therein arranged to react on the die 24 so as to bias it to its extended position as illustrated. The cylinders 26 are supplied with hydraulic fluid under relatively low regulated tank pressure (say, for example, 100 lbs. per square inch) through a hydraulic fluid connection indicated generally at 40 which includes conduit 30, certain passages in a valve indicated generally at 32 to which the conduit 30 is connected, and a conduit 34 which is connected at one end to the valve 32 and at its other end to the lower end of a pressure tank 36 in which hydraulic fluid is maintained under a regulated pressure. The hydraulic fluid connection 40 through which hydraulic fluid under tank pressure is supplied to the cylinders 26 includes bores 42 and 43, cross bore 44, bore 46, and cross bore 48 which interconnects the upper end of bore 46 and the conduit 34 leading to the tank 36. The bore 46 includes valve chamber 50 and an annular valve seat 52 for a ball check valve 54 which is biased to closed position on seat 52, the check valve 52, 54 permitting hydraulic fluid flow from the bore 48 through the bore 46 into the bore 44, but not in the reverse direction. The check valve 54 is seated by a relatively light spring 56.

The valve 32 as illustrated is made up of two valve blocks 55 and 57 suitably fixed together. The block 57 is machined to provide two cylindrical valve chambers 60 and 62 which are intersected by the cross bore 48. One end of the chamber 60 communicates with the upper end of the bore 43, while one end of the valve chamber 62 communicates with the upper end of the bore 42. Each of the valve chambers 60 and 62 has a piston type, normally closed unloading valve therein, the valve in the chamber 60 comprising valve sleeve 64, valve piston 66, and valve spring 68. The valve sleeve 64 is recessed on its outer periphery so as to provide communication between the parts of the bore 48 on opposite sides of the chamber 60. The light spring 68 biases the piston valve member 66 against an annular shoulder 70, and the head of piston 66 is provided with a restricted orifice 72 which provides communication between the bore 43 and the space on the other side of the piston 66. Valve seat 74 is disposed in the chamber 60 above the sleeve 64 and is provided with a central bore 76, a peripheral groove 78, and a series of radial bores 80 which interconnect the central bore 76 and the peripheral groove 78. A cross bore 82 extends between the upper end of the valve chamber 60 and a bore 84 which also communicates through bore 85 with the upper end of the valve chamber 62. Thus the space within the sleeve 64 and above the piston 66 is in open communication with the bore 84 through bore 76, cross bores 80, peripheral groove 78, and bore 82. Bore 84 forms an expansible chamber in which a spring pressed piston 86 is disposed, a light spring 88 reacting on the piston 86 biasing the latter to its extended position at the bottom of the bore 84. The back side of the piston 86 is exposed to atmosphere through one or more ducts 90, and a set screw 92 provides an adjustable stop to determine the retracted position of the piston 86 and hence the maximum size of the expansible chamber provided by the bore 84. In view of the foregoing it will be evident that the chamber 84 is in open albeit restricted communication with the work cylinders 26. However, as previously noted, the spring 88 biases the piston 86 to its extended position as shown so that the volume of the expansible chamber is normally at its minimum.

The valve seat 74 at the upper end of the bore 76 provides an annular seat for a normally closed pilot valve member 100 biased to its seat on the valve seat 74 by a spring 102 which is adjustable whereby the relief pres-

sure of the valve may be adjusted. The pilot valve 74, 100 forms a part of a pressure relief valve means, the construction of which preferably is as disclosed in my Patent No. 2,901,238. The valve member 100 is reciprocable in a bore 104 which communicates by bores 106 and 108 with one end of the bore 48 so that the hydraulic fluid which is passed by the pilot valve 100, 74 when the latter opens is free to flow through the bore 48 back toward the tank 36. The spring 102 is adjustable so that the pilot valve 100, 74 will provide a predetermined resistance to displacement of hydraulic fluid from the cylinders 26 during the closing of the press ram so as to provide a hydraulic cushion of the desired resistance for the die 24. This resistance is substantially greater than the resistance afforded by the pressure in the tank 36.

The unloading valve 64, 66 which forms a part of the pressure relief valve means opens in response to a predetermined pressure differential across the piston 66 immediately following opening of the pilot valve 100, 74 and serves to by-pass hydraulic fluid from the high pressure or press side of the system to the low pressure or tank side so long as the pilot valve 100, 74 remains open. To this end the annular sleeve 64 is provided with a series of radially extending ports 110 which are exposed after the piston valve member 66 moves upwardly a predetermined amount in response to the pressure differential thereacross, whereby high pressure hydraulic fluid on the high pressure side of the valve 66, 64 is free to pass through the ports 110 and the chamber 60 into the bore 48 without having to pass through the pilot valve 100, 74. Thus the unloading valve 64, 66 is effective to quickly pass substantial quantities of hydraulic pressure liquid from the high pressure to the low pressure side of the system during the closing of the press ram under the pressure regulation provided by the pilot valve 100, 74. The unloading valve 64, 66 will close as soon as the valve member 100 seats on its seat 74.

Valve chamber 62 is provided with a similar unloading valve comprising piston valve member 120, valve sleeve 122, and valve spring 124, and which functions like unloading valve 64, 66. One or more of such unloading valves may be used, depending upon the amount of fluid to be displaced during the closing of the press ram and the time avaliable for such displacement. By using multiple unloading valves of the type illustrated, it is possible to make the movable components of the pressure relief valve small and light as compared with the size and weight required for a single pressure relief valve.

As illustrated in FIG. 4, it will be evident that when the crank 12 has moved half way through its power stroke, the ram has moved through less than 50% of its power stroke, and that the ram speed will reach its maximum rate at some point during the last half of the power stroke of the crank. Thus, ram speed will increase from the time that the crank is half way through its power stroke to a maximum and then decrease to zero as the crank completes its power stroke, the maximum ram speed being achieved in the illustration given after the crank has traveled about 20% through the last 90° of travel of its power stroke. The shaded area in FIG. 4 indicates the flow pattern of hydraulic fluid in and out of a hydraulic cylinder during one revolution of the crank where the piston for such cylinder is connected to the pitman 12 and reciprocates throughout crank revolution.

However, in a hydraulic cushion there will be no actual displacement until after the ram 16 has closed the dies and caused the die pad 24 to react on the pistons 28 so as to begin moving the same toward their retracted position. The shaded area of FIG. 4 indicates that as the crank moves through the last half of its power stroke, the displacement of hydraulic fluid will increase and then gradually decrease to zero. The average pad movement is about the last 25% of the ram movement, resulting in a decreasing volume and velocity pattern for the hydraulic fluid displaced from the cylinders 26 as shown in FIG. 6.

To minimize back pressure in the circuit on the press side of the valve 32 during closing of the press ram it is desirable to open the pressure relief valve to its full open position as promptly as possible, if not instantaneously, after the die 24 begins to retract under the influence of the press ram and the bleed off pressure of the pressure relief valve has been attained. The unloading valve arrangement disclosed expedites the full opening of the pressure relief valve over conventional arrangements, after the pilot valve 100, 74 opens. In a press with an eleven inch stroke operating at the rate of 60 strokes per minute, one degree of crank travel will require .0027 second and will move the die pad about one-eighth of an inch as indicated in FIG. 5. However, about one-fourth of a degree of crank travel (1/32 of an inch of pad travel) which occurs in .0007 second will raise the pressure in the cushion cylinders 26 from normal tank pressure (about 100 lbs. per square inch) to about 3000 lbs. per square inch. Event though the unloading valve arrangement operates much faster than conventional pressure relief systems, it has limitations, particularly at higher press speeds and where greater valve capacity is required because the size and mass of the movable components delay opening thereof until after undesirably high back pressure has been generated. Opening movement of the unloading components 66 and 120 is also normally retarded by the hydraulic fluid between such components and the pilot valve 100 which will have to pass through the orifice provided by opening movement of pilot valve 100.

In accordance with the present invention, means are provided to reduce the resistance to opening movement of the movable components of the pressure relief valve prior to the opening thereof so as to reduce, if not substantially eliminate, the generation of undesirable back pressure on the high pressure side of the pressure relief valve 32. This makes the cushion more efficient and dependable in operation at higher press speeds and where greater valve capacity is required. In the arrangement as illustrated in FIG. 1, the expansible chamber 84 has a volume approximating that of the hydraulic fluid displaced by the piston valve members 66 and 120 in their movement prior to opening thereof, i.e., prior to uncovering of the ports 110. Thus the valve members 66 and 120 are free to begin their opening movement under a pressure differential sufficient to overcome the light springs 68, 124 prior to opening movement of pilot valve 100, 74. This shifts valve members 66 and 120 to open position as soon as the bleed off pressure of pilot valve 100 is attained and without the generation of back pressures substantially in excess of the pressure of the valve 74, 100.

In the arrangement of FIG. 2, the piston 86 of the expansible chamber 84 is backed up by tank pressure through line 200 instead of by atmospheric pressure as in FIG. 1, but is otherwise the same as FIG. 1.

In the modified arrangement of FIG. 3, a normally open by-pass 300 is provided between the tank and cylinder sides of the pressure relief valve 32 which otherwise is of the same construction as that illustrated in FIG. 1. By-pass 300 includes normally open valve 302 comprising valve bore 304, spool valve 306, valve ports 308, and spring 310. One end of valve 306 is exposed to the hydraulic fluid on the high pressure side of the valve through port 312, and passage 314 so that when the pressure of the hydraulic fluid on the press side of the pressure relief valve rises, it will immediately shift valve 306 to close ports 308 and close the by-pass in synchronization with the opening of the pressure relief valve. However, the open by-pass 300 will unload sufficient hydraulic fluid from the high pressure side of the system as the pressure rises therein so as to prevent the generation of undesirable back pressure prior to the full opening of the pressure relief valve components due to the inertia and resistance to opening movement thereof, as previously ex-

plained. An adjustable stop **320** is provided for the valve **306** so that it can be set in its normally open position to provide a resistance to fluid flow through the by-pass **300** to create a pressure equal to the relief valve setting before the pressure relief valve components start to open. Since the pressure as it develops on the high pressure side of the system is applied to both the normally open valve **306** and the movable components of the pressure relief valve tending to close the former and open the latter, the movement of such valve elements can be synchronized so that the pressure relief valve will fully open as the valve **306** closes. The valve **306** will remain closed while pressure exists, while the pressure relief valve will gradually close as it follows the pattern of the fluid displaced from the cylinders **26** as shown in FIG. 6 as the ram moves to bottom dead center position.

While I have illustrated and described preferred embodiments of my invention, it is understood that these are capable of modification, and I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes and alterations as fall within the purview of the following claims.

I claim:

1. In a press having a ram, a die, a hydraulic cushion for said die including at least one hydraulic cylinder provided with a reciprocating piston therein arranged to react on said die so as to bias it to its extended position; a tank of hydraulic fluid under regulated relatively low pressure, a hydraulic fluid connection between said tank and said cylinder whereby hydraulic fluid under tank pressure is supplied from said tank to said cylinder and piston for biasing said die to its extended position but return flow through such connection is prevented, a second hydraulic fluid connection between said tank and cylinder having normally closed pressure relief valve means therein including a pilot valve and other valve means adapted to provide a bypass in the second fluid connection around the pilot valve on opening of the other valve means whereby a predetermined resistance to displacement of hydraulic fluid from the cylinder is provided so as to form a hydraulic cushion for said die upon closing of the press ram, and means to reduce the back pressure in said second fluid connection on the cylinder side of said pressure relief valve means due to resistance to opening movement of said pressure relief valve means prior to the opening of said pressure relief valve means including an accumulator chamber cylinder having a portion at one end in communication with said pressure relief valve means of substantially the same volume as the volume displaced by said other valve means before opening thereof, a piston in the accumulator chamber and resilient means engaged with the accumulator piston urging the piston in a direction to reduce the portion of the accumulator chamber in communication with the pressure relief valve means.

2. Structure as set forth in claim **1** and further including means operably associated with the resilient means and accumulator piston for adjusting the pressure of the resilient means on the piston.

3. Structure as set forth in claim **2** wherein the accumulator chamber is connected to atmosphere at the other end.

4. Structure as set forth in claim **2** wherein the accumulator chamber is connected to the tank at the other end.

5. In a press having a ram, a die, a hydraulic cushion for said die including at least one hydraulic cylinder provided with a reciprocating piston therein arranged to react on said die so as to bias it to its extended position; a tank of hydraulic fluid under regulated relatively low pressure, a hydraulic fluid connection between said tank and said cylinder whereby hydraulic fluid under tank pressure is supplied from said tank to said cylinder and piston for biasing said die to its extended position but return flow through such connection is prevented, a second hydraulic fluid connection between said tank and cylinder having normally closed pressure relief valve means therein whereby a predetermined resistance to displacement of hydraulic fluid from the cylinder is provided so as to form a hydraulic cushion for said die upon closing of the press ram, and means to reduce the back pressure in said second fluid connection on the cylinder side of said pressure relief valve means due to resistance to opening movement of said pressure relief valve means prior to the opening of said pressure relief valve means including a third hydraulic fluid connection between the tank and cylinder, a spool valve positioned in said third hydraulic fluid connection, resilient means biasing said spool valve into a normally open position with no back pressure applied to the pressure relief valve and a fourth hydraulic fluid connection between the spool valve and the second hydraulic fluid connection between the cylinder and pressure relief valve for urging the spool valve into a closed position in response to back pressure applied to the pressure relief valve.

6. Structure as set forth in claim **5** and further including means for adjusting the open position of the spool valve.

7. In a crank type press having a ram, a die, a hydraulic cushion for said die including at least one hydraulic cylinder provided with a reciprocating piston therein arranged to react on said die so as to bias it to its extended position; a tank of hydraulic fluid under regulated, relatively low pressure, a hydraulic fluid conduit between said tank and said cylinder, valve structure positioned between said tank and hydraulic cylinder in said hydraulic fluid conduit for regulating the flow of hydraulic fluid between said tank and said cylinder including a first passage extending therethrough in communication at the opposite ends thereof with said conduit, a check valve in said first passage for permitting hydraulic fluid flow only from said tank to said cylinder, a second passage in said valve structure in communication at the opposite ends thereof with said conduit, a pressure relief valve in said second passage including a cylindrical valve sleeve, a valve member reciprocably mounted in said valve sleeve, means biasing the valve member into closed position with respect to said second passage responsive to high pressure in said cylinder to open said second passage, a restricted opening through said valve member, a third passage in said valve structure connecting the pressure relief valve on the side opposite said cylinder to the tank, pilot valve means in said third passage for regulating the opening of the pressure relief valve, an accumulator chamber cylinder in said valve structure having one end in communication with said third passage between the pressure relief valve and pilot valve, said accumulator chamber and pressure relief valve sleeve having approximately equal volume, piston means in said accumulator chamber and resilient means urging said piston means toward the one end of the accumulator chamber whereby back pressure in said second passage between the pressure relief valve and the cylinder is relieved on buildup of pressure in said hydraulic cylinder.

8. In a crank type press having a ram, a die, a hydraulic cushion for said die including at least one hydraulic cylinder provided with a reciprocating piston therein arranged to react on said die so as to bias it to its extended position; a tank of hydraulic fluid under regulated, relatively low pressure, a hydraulic fluid conduit between said tank and said cylinder, valve structure positioned between said tank and hydraulic cylinder in said hydraulic fluid conduit for regulating the flow of hydraulic fluid between said tank and said cylinder including a first passage extending therethrough in communication at the opposite ends thereof with said conduit, a check valve in said first passage for permitting hydraulic fluid flow only from said tank to said cylinder, a second passage in said valve structure in communication at the opposite ends thereof with

said conduits, a pressure relief valve in said second passage including a cylindrical valve sleeve, a valve member reciprocally mounted in said valve sleeve, resilient means biasing the valve member into closed position with respect to said second passage responsive to high pressure in said cylinder to open said second passage, a restricted opening through said valve member, a third passage in said valve structure connecting the pressure relief valve on the side opposite said cylinder to the tank, pilot valve means in said third passage for regulating the opening of the pressure relief valve, a fourth passage bypassing said pressure relief valve, a spool valve positioned within said fourth passage in communication at one end with said hydraulic cylinder and spring means urging said spool valve toward said one end into an open position providing communication between said cylinder and tank.

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