Sept. 8, 1964 F. M. WILLIAMSON 3,147,962

TWO-STAGE HYDRAULIC CUSHIONS FOR DIES

Filed Sept. 10, 1962 2 Sheets-Sheet 1

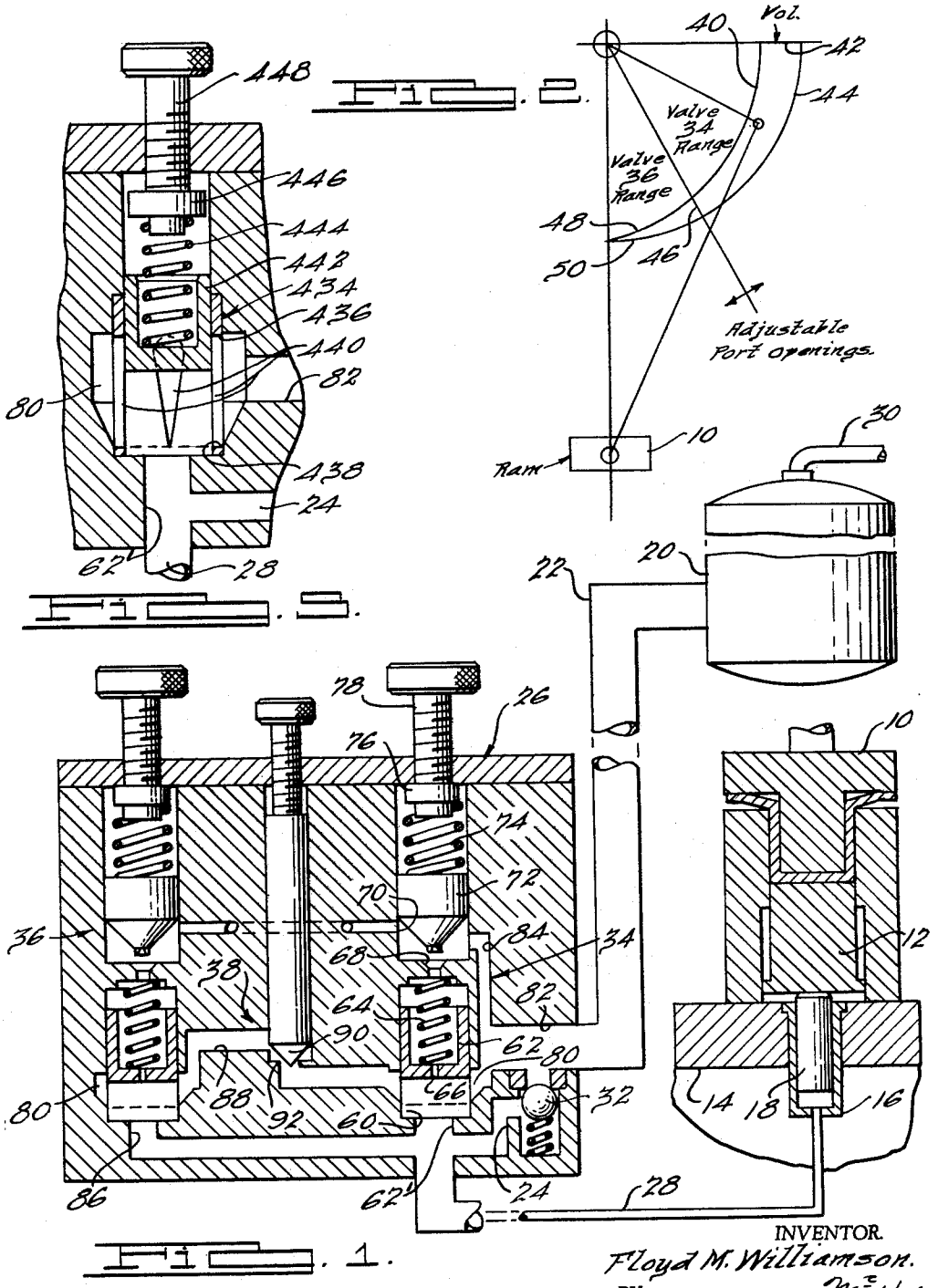

FIG. 1.

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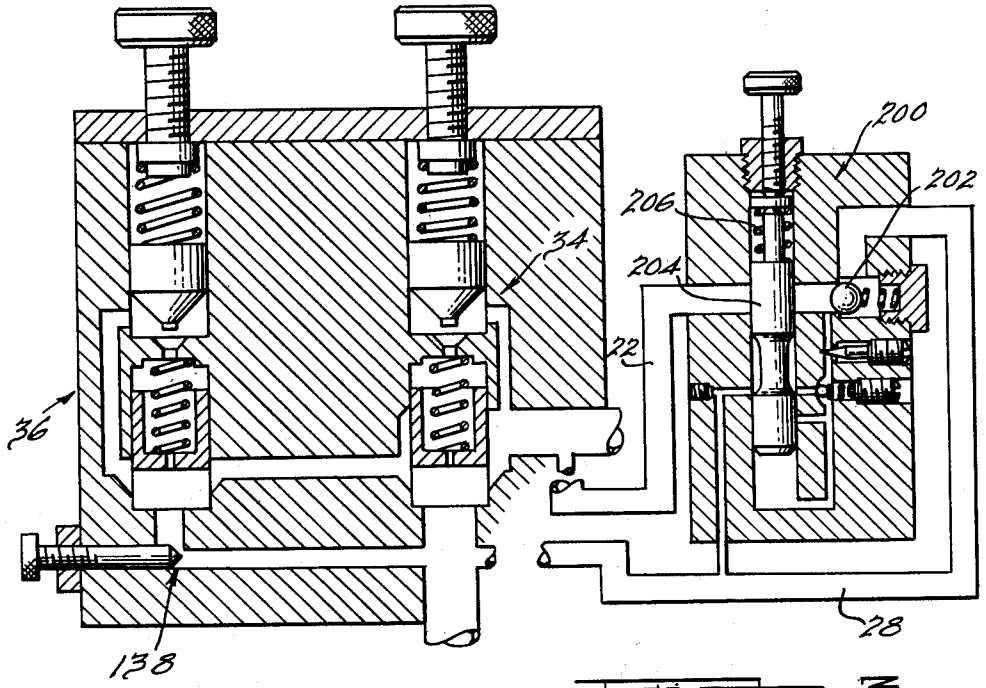

FIG. 3.

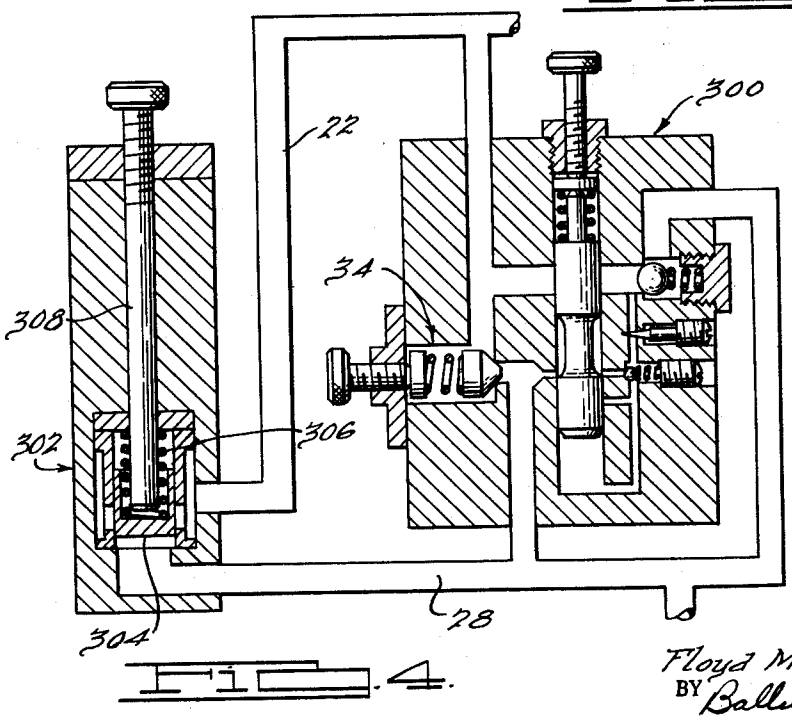

FIG. 4.

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TWO-STAGE HYDRAULIC CUSHIONS FOR DIES

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8 Claims. (Cl. 267—1)

This invention relates to hydraulic cushions for dies and has particular reference to certain improvements in such cushions for use on crank type presses whereby the cushion provides a relatively high resistance to the first part of the power stroke and a relatively low resistance during a succeeding part of the power stroke of the press. In press work it is often advantageous when deep drawing a part to have a relatively high resistance during the first part of the power stroke of the press so as to form the piece or set a bead and then to have a substantially lower resistance toward the end of the stroke so that the metal of the blank or work will not tear. This invention provides a novel, unique and adjustable variable pressure relief means which provides a relatively high pressure resistance to the initial discharge of hydraulic fluid from the cushion during the first part of the closing movement of the ram when the volume of flow of hydraulic fluid from the cushion is relatively high and a relatively low resistance to the discharge of hydraulic fluid from the cushion during the latter part of the closing movement of the press ram when such discharge of hydraulic fluid is decreasing rapidly.

A principal object of the invention is to provide a multiple pressure hydraulic die cushion for presses of the type in which the ram decelerates as it approaches closed position and wherein the resistance of the cushion decreases as the ram closes.

Another object of the invention is to provide a novel, simple and dependable variable pressure relief valve means for use in a system incorporating a hydraulic die cushion which is constructed and arranged so as to provide a high resistance to closing of the press ram during the initial part thereof, and a low resistance to the final closing movement of the press ram, and which is readily adjustable so that the range of the high pressure resistance may be adjusted with reference to the range of the low pressure resistance.

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 two sheets, which by way of illustration shown 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 schematic illustration of a crank type press having a hydraulic system embodying my invention associated therewith;

FIG. 2 is a diagrammatic view illustrating the relative volume of oil discharged by the cushion during the first and last portions of the stroke of the press ram;

FIG. 3 is a schematic view illustrating a modified form of the invention;

FIG. 4 is a schematic view illustrating a further modified form of the invention; and

FIG. 5 is a fragmentary view illustrating a further modification of the invention.

Referring now to FIG. 1, there is illustrated the ram 10 of a crank type press having a movable die pad 12 mounted on the bolster 14 of the press with a hydraulic cushion arranged to resist movement of the die pad 12 upon closing of the press ram and to return the die pad 12 to its extended position upon opening of the press.

The cushion comprises a hydraulic work cylinder 16 and a piston 18 reacting against the die pad 12. A tank 20 of hydraulic fluid under relatively low pressure, say, for example, 100 lbs. per square inch, is connected to the work cylinder 16 for supplying hydraulic fluid thereto under tank pressure, the tank 20 being connected to the cylinder 16 by hydraulic fluid flow and pressure transmitting connections which include the hydraulic pressure line 22, the passage 24 in the pressure relief valve means 26, and the hydraulic fluid line 28 which extends from the latter to the cylinder 16 so that the latter is always supplied with hydraulic fluid from the tank 20 under the pressure prevailing therein.

The upper part of the tank 20 is connected to a conventional air pressure line 30 so that the pressure at which the hydraulic fluid in the tank is maintained can be adjusted and maintained within relatively close limits. A check valve 32 in the passage 24 offers little or no resistance to flow of hydraulic fluid through the valve means 26 from the line 22 to the line 28 while preventing reverse flow through the passage 24. The pressure relief valve means 26 comprises in general an adjustable high pressure relief valve 34, a low pressure adjustable relief valve 36 and a metering valve or orifice indicated generally at 38. The valves 34 and 36 are in what might be termed a by-pass around the passage 24 so as to permit return flow of hydraulic fluid from the work cylinder 16 toward the tank 20 during the closing of the press ram when the pressure exceeds the set pressure of the valves 34 and 36, the valves 34 and 36 being disposed in parallel hydraulic fluid flow relation with respect to the discharge of hydraulic fluid from the work cylinder 16. Each of the pressure relief valves 34 and 36 is essentially of the construction disclosed and covered by my Patent No. Reissue 25,027, issued August 15, 1961, for "Circulating Systems for Hydraulic Liquid Between Tanks and Cylinders." However, in this instance the valve 34 is a high pressure valve while the valve 36 is a low pressure valve. Each of the valves 34 and 36, as well as the metering valve 38, includes provisions whereby the back pressure provided by such valve may be adjusted, as will be pointed out more specifically hereinafter. As shown in FIGURE 1, the die pad 12 and piston 16 are moved in the final portion of the closing stroke of the press ram and, in order to relieve the hydraulic fluid pressure thereby generated in the cylinder 16, both of the valves 34 and 36 are opened, whereby hydraulic fluid on the high pressure side of the valve 26 is permitted to escape past the valves 34 and 36 to the low pressure side and into the line 22, the valves 34 and 36 each providing a predetermined resistance to the displacement of hydraulic fluid from the work cylinder 16.

It is to be understood that the cushion may include a plurality of cylinders like 16 each having a piston therein arranged to react upon the die pad 12.

FIG. 2 diagrammatically illustrates the decreasing volume of liquid displacement from the hydraulic cushion during the closing stroke of the press ram as the ram approaches its fully closed position. In crank type presses, during the closing of the press ram the movement of the ram 10 will be much faster during the first part of the closing movement than during the latter part due to the different angular positions of the crank during these periods whereby the ram decelerates as it approaches its closed position, whereby the displacement of hydraulic fluid from the cylinder 16 and the hydraulic cushion will be substantially higher during the first portion of the ram movement than during the final portion thereof. In FIGURE 2 the area enclosed by the lines 40, 42, 44 and 46 is intended to represent the volume of oil displacement from the hydraulic cushion during the initial part of the closing movement of the ram, while the area enclosed by the lines 46, 48 and 50 indicates the volume

during the final closing of the press ram and shows that, as the ram approaches the bottom of its stroke, the rate of oil displacement from the hydraulic cushion decreases to zero. The valves 34 and 36 are of such capacity and are so adjusted as to pass the relatively large volume of oil displaced from the hydraulic cushion during the initial closing of the press ram while providing the desired resistance to movement of the die 12 due to the closing of the press ram. At some point during the closing of the press ram, determined by the setting of valve 38 and the capacities of valves 34 and 36, the rate of discharge of hydraulic fluid from the hydraulic cushion will decrease to a value whereby such fluid may be handled solely by the low pressure valve 36 which will provide the desired resistance to the final movement of the die pad, but a resistance which is relatively low with respect to that provided during the initial part of the stroke by the valve 34, and high with respect to that provided by tank pressure.

As the valves 34 and 36 are of the same construction it will suffice to describe one, yet it is to be understood that the resistance offered by the valve 36 is substantially lower than that provided by the valve 34 due to the adjustment of the valve or the springs employed therein to provide resistance to opening movement of the valves. The valve 34 includes a valve bore 60 having a port 62' in open communication with the hydraulic line 28. A piston or spool valve 62 is reciprocable in the bore 60 and normally positioned by spring 64 so that the end of the piston 62 seats on the end wall of the bore 60 so as to close the inlet port 62' of the valve bore 60. The head of the piston is provided with a restricted orifice 66 therethrough so that hydraulic fluid on both sides of the piston 62 can be pressure equalized. The other end of the bore 60 has a port therein which opens through a valve seat 68 into a second valve bore 70 in which valve 72 is reciprocable, the valve 72 being biased by spring 74 so that the conical shaped end of the valve member 72 will seat on the valve seat 68 and shut off the communication between the bores 60 and 70. The spring 74 is backed up by an abutment 76 carried by an adjustable screw 78 whereby the effective force of the spring 74 may be varied so as to adjust the pressure at which the valve 72 will move off of its seat 68 under the influence of the pressure which is applied to the valve 72 by the hydraulic fluid in the bore 60 when the valve 72 is seated in its closed position. As the ram closes, the pressure in the cylinder 16 of the hydraulic cushion will increase until it is sufficient to lift the valve 72 from its seat 68, thus creating a pressure differential across the piston valve 62, whereupon the high pressure applied to the face of the piston valve 62 will move it off of its seat and open the exhaust port in the side of bore 60 to permit the escape of high pressure fluid from the bore 60 through such port and the outlet provided by the annular passage 80 which surrounds the bore 60 and communicates therewith when the piston valve 62 is open, as shown. The annular passage 80 communicates with passage 82 in the body of the valve 26 which in turn communicates with the hydraulic line 22. A passage 84 interconnects the valve bore 70 with the passage 82 so as to permit the flow of hydraulic fluid from the valve bore 70 into the passage 82 when the valve 72 opens, as above described. The advantages and further particulars of this type of pressure relief valve are set forth in my reissue patent above referred to.

The low pressure relief valve 36 is of similar construcuture and includes an inlet port 86 which communicates with the hydraulic line 28 on the high pressure side of the valve. A hydraulic fluid line or passage 88 interconnects the annular passage 80 of the valve 36 with the annular passage 80 of the valve 34 whereby the hydraulic fluid which is passed by the valve 36 is free to flow back to the line 22. However, metering valve 38 is interposed in the line 88 and comprises an adjustable valve member 90 which is cooperable with an annular valve seat 92 to provide a metering orifice in series flow relation with the low pressure valve 36. Upon closing of the press ram, the low pressure valve 36 opens first since it provides a substantially lesser resistance to the displacement of hydraulic fluid from the cylinder 16 of the cushion than the valve 34 and, were it not for the valve 38, the valve 34 would never open. However, the valve 38 provides sufficient resistance to the displacement of hydraulic fluid so that the valve 34 will open and pass most of the hydraulic fluid displaced from the hydraulic cushion during the initial closing movement of the press ram. However, at some point during the closing movement of the press ram after the rate of discharge of hydraulic fluid from the hydraulic cushion has substantially decreased, the valve 34 will close and the valve 36 will provide the resistance during the final closing movement of the ram. The valve member 90 of the valve 38 is on one end of a threaded stem 96 whereby the size of the metering orifice provided between the conical end of the valve member 90 and the seat 92 therefor may be adjusted so as to control the range of high pressure resistance provided by the valve 34 with respect to the range of low pressure resistance provided by the valve 36. In FIGURE 2 the line 46 indicates the metering orifice provided by the valve 38 and the adjustability thereof.

The arrangement illustrated in FIGURE 3 is a modification of that illustrated in FIGURE 1 and differs therefrom in that the metering valve 138 which corresponds with metering valve 38 in FIGURE 1 is located ahead of the low pressure valve 36 instead of between the valves 36 and 34, as shown in FIGURE 1. In addition, the modification illustrated in FIGURE 3 incorporates a pad delay valve indicated generally at 200 which is equivalent in construction and operation to the pad delay valve shown in my Reissue Patent No. 25,027 above referred to. In this case a check valve 202 corresponding to the check valve 32 forms a part of the pad delay valve structure. The pad delay 200 is disposed in the connection between the tank 20 and the cylinder 16 of the hydraulic cushion and functions to delay the recharging of the cylinder 16 of the cushion upon the opening of the press ram. The pad delay includes a normally open spool type valve 204 which is shifted to block the fluid flow and pressure transmitting connection between the tank 20 and the cylinder 16 during the closing of the press ram so as to prevent the recharging of the cylinder 16 until after the ram has moved to an open position. The spring 206 functions to shift the spool valve to its open position so that when the spool valve is in such position hydraulic fluid is free to flow from the tank 20 through conduit 22 and then through the valve 200 into the line 28 leading to the cylinder 16. Further particulars concerning the construction and operation of this valve are set forth in my Reissue Patent No. 25,027. Except in the particulars noted, the consrtuction and operation of the modified system as shown in FIGURE 3 is the same as that for the system illustrated in FIGURE 1.

FIGURE 4 is a modification of FIGURE 3 in which the pad delay valve 200 is integrated with the high pressure valve 34, the latter being shown only schematically in FIGURE 4, it being understood that the valve 34 as shown in FIGURE 4 is of the same construction as illustrated in FIGURE 3. The pad delay 300 of FIGURE 4 functions in the same manner as the pad delay in FIGURE 3. However, instead of using a low pressure valve 36 as shown in FIGURE 3, a valve 302 is employed. The valve 302 is essentially a check valve of the piston type and includes a piston valve member 304 which is movable against a spring 306 to open the valve 302 and thereby permit communication between the high pressure line 28 and the low pressure line 22. A pin 308 threadedly secured in the threaded opening in a block of the valve 302 provides an adjustable stop to limit the opening movement of the valve 304 and thus serves a similar purpose to the valves 38 and 138 of the other modifica-

tions. The valve 302 provides little or no resistance to the displacement of hydraulic fluid from the high pressure side of the system, the pressure prevailing in the tank 20 being relied upon to provide the desired resistance during the final closing movement of the press ram.

FIG. 5 illustrates a modification of FIG. 1 in which the variable resistance to the discharge of hydraulic fluid from the work cylinder of the hydraulic cushion is provided by a single pressure relief valve 434 which takes the place of the valves 34, 36 and 38 of the system as illustrated in FIG. 1. As shown in FIG. 5, the valve 434 comprises a sleeve 436 disposed in a valve bore 438 and having a series of valve ports 440 spaced around the sleeve 436 and providing communication between the interior of the sleeve 436 and the annular chamber 80 which is in open communication with the passage 82 leading to the tank 20. The passage 62' communicates with the bottom end wall of the bore 438 while the passage 24 provides a by-pass around the pressure relief valve as in FIG. 1 with a check valve 32 therein. A piston valve member 442 is reciprocable in the sleeve 436 and biased by spring 444 so as to shut off the communication between the passage 62' and the interior of the sleeve 436. The spring 444 at one end reacts on the piston 442 and at its other end is backed up by an adjustable stop 446 carried by an adjustable screw 448 similar to the stop 76 and adjustable screw 78 of FIG. 1. It will be noted that the ports 440 taper in width so that as the valve member 442 moves upwardly the effective cross section of the orifices provided by the ports 440 will increase, and that as the valve 442 moves toward its closed position the extent of opening of the orifices provided by the ports 440 will decrease.

The valve 434 is normally closed and the spring 444 thereof is of such size and strength as to provide an initial relatively high pressure resistance to discharge of hydraulic fluid from the work cylinder. However, as the rate of fluid displacement from the hydraulic cushion decreases, the spring 444 will move the valve 442 toward its closed position thereby reducing the extent of opening of the valve due to the tapered form of the ports 440. As the spring 444 is extended as the valve 442 moves toward its closed position, the force of the spring will be reduced and thus the valve 442 will offer a reduced resistance to the discharge of hydraulic fluid from the hydraulic cushion as the rate of discharge of hydraulic fluid from the work cylinder decreases.

The pressure relief valve 434 of FIG. 5 may, if desired, be of the pilot valve type as per valve 34 of FIG. 1, in which event the spring 444 will react against the upper end of the bore 438.

The arrangement as illustrated in FIG. 5 will provide a variable resistance to the discharge of hydraulic fluid from the hydraulic cushion during the closing of the press ram. It will be understood that the variable resistance so provided will depend upon the force of the spring 444 and the effective area of the ports 440 which are exposed by the piston valve 442.

This application is a continuation-in-part of my prior co-pending application Serial No. 112,439, filed May 24, 1961, for "Hydraulic Control System for Die Pads in Presses."

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 high speed crank type press wherein a die pad is engaged by the work upon the closing of the press ram and the ram decelerates as it approaches its closed position, a hydraulic cushion arranged to resist movement of said die pad upon closing of the press ram and to return the die pad to its extended position upon opening of the press, said hydraulic cushion comprising a hydraulic system which includes a hydraulic work cylinder and piston reacting against said die pad and discharging hydraulic fluid therefrom at a decreasing rate as the ram closes, a tank of hydraulic fluid under relatively low pressure, hydraulic fluid flow and pressure transmitting connections between said tank and cylinder for supplying hydraulic fluid to the latter under tank pressure and normally closed hydraulic fluid pressure relief means disposed in said hydraulic connections between said tank and work cylinder, said relief means being constructed and arranged to open directly in response to a predetermined pressure of the hydraulic fluid discharged from said work cylinder so as to create a decreasing resistance to the discharge of hydraulic fluid from said work cylinder upon and during closing of the press ram, that improvement wherein said pressure relief means comprises a relatively low pressure operated hydraulic fluid pressure relief valve and a relatively high pressure operated hydraulic fluid pressure relief valve disposed in parallel hydraulic fluid flow relation with respect to such discharge of hydraulic fluid from said work cylinder through said hydraulic connections as the ram closes, the flow capacities of said pressure relief valves being such that both of said pressure relief valves must open to pass the amount of hydraulic fluid discharged from said work cylinder and provide the desired resistance to such discharge during the first portion of the closing of the press ram, and flow resistance means responsive to the rate of discharge of hydraulic fluid from said work cylinder to control such flow of hydraulic fluid through said high and low pressure relief valves relative to each other whereby as the rate of discharge of hydraulic fluid from the work cylinder decreases the high pressure relief valve closes and only the low pressure relief valve remains open during the final portion of the discharge of hydraulic fluid from the work cylinder, said flow resistance means forming a fluid flow conducting part of the hydraulic system and being in series flow relation with said low pressure relief valve.

2. That improvement according to claim 1 wherein said flow resistance means comprises a metering orifice in series flow relation with and on the discharge side of said low pressure relief valve.

3. That improvement according to claim 2 including means for adjusting the flow resistance of said orifice.

4. In a high speed crank type press wherein a die pad reacts on the work upon the closing of the press ram and the ram decelerates as it approaches its closed position, a hydraulic cushion arranged to resist movement of said die pad upon closing of the press ram and to return the die pad to its extended position upon opening of the press, said hydraulic cushion comprising a hydraulic system which includes a hydraulic work cylinder and piston reacting against said die pad and discharging hydraulic fluid therefrom at a decreasing rate as the ram closes, a tank of hydraulic fluid under pressure, hydraulic fluid flow and pressure transmitting connections between said tank and cylinder for supplying hydraulic fluid to the latter under tank pressure and normally closed hydraulic fluid pressure relief valve means associated with said hydraulic connections so as to create a varying resistance to the discharge of hydraulic fluid from said work cylinder upon and during closing of the press ram, said relief means being constructed and arranged to open directly in response to a predetermined pressure of the hydraulic fluid discharged from said work cylinder, that improvement wherein said pressure relief valve means comprises two pressure relief valves of different pressure settings disposed in parallel fluid flow relation with respect to the discharge of hydraulic fluid from said work cylinder and a metering control orifice in series fluid flow relation with the pressure relief valve having the lower pressure relief setting, said low pressure relief valve being of insufficient capacity to pass the amount of hydraulic fluid

discharged from said cylinder during the relatively fast movement of the die pad which occurs in the first portion of the die pad movement during closing of the press ram, said metering control orifice providing greater resistance to fluid flow than the high pressure relief valve whereby said high and low pressure relief valves open during said first portion of die pad movement so as to permit the resulting discharge of hydraulic fluid from said work cylinder under a pressure as determined by the high pressure relief valve and said orifice, said low pressure relief valve having sufficient capacity to accommodate the discharge of hydraulic fluid from said work cylinder at a decreased rate during the succeeding relatively slower closing movement of the press ram whereby as the rate of discharge of hydraulic fluid from the work cylinder drops to such decreased rate, the high pressure relief valve closes and the low pressure relief valve remains open to permit the resulting discharge of hydraulic fluid from the work cylinder under the pressure as determined by the low pressure relief valve.

5. That improvement according to claim 4 wherein said metering control orifice is adjustable in size for varying the extent of the portion of die pad movement during which said high pressure resistance is provided.

6. That improvement according to claim 4 wherein said pressure relief valves and said orifice are adjustable for varying the extent of the portion of die pad movement during which said high pressure resistance is provided and the value of said high pressure resistance.

7. That improvement according to claim 4 wherein said pressure relief valves and said orifice are adjustable for varying the relative extent of the portions of die pad movement during which said high and low pressure resistances are provided.

8. In a high speed crank type press wherein a die pad reacts on the work upon the closing of the press ram and the ram decelerates as it approaches its closed position, a hydraulic cushion arranged to resist movement of said die pad upon closing of the press ram and to return the die pad to its extended position upon opening of the press, said hydraulic cushion comprising a hydraulic system which includes a hydraulic work cylinder and piston reacting against said die pad and discharging hydraulic fluid therefrom at a decreasing rate as the ram closes, a tank of hydraulic fluid under pressure, hydraulic fluid flow and pressure transmitting connections between said tank and cylinder for supplying hydraulic fluid to the latter under tank pressure and normally closed hydraulic fluid pressure relief valve means associated with said hydraulic connections so as to create a varying resistance to the discharge of hydraulic fluid from said work cylinder upon and during closing of the press ram, said relief means being constructed and arranged to open directly in response to a predetermined pressure of the hydraulic fluid discharged from said work cylinder, that improvement wherein said pressure relief valve means comprises two pressure relief valves of different pressure settings disposed in parallel fluid flow relation with respect to the discharge of hydraulic fluid from said work cylinder, the low pressure relief valve being of insufficient capacity at the pressure for which it is set to pass the amount of hydraulic fluid discharged from said cylinder during the relatively fast movement of the die pad which occurs in the first portion of the die pad movement during closing of the press ram whereby the low and high pressure relief valves open during said first portion of die pad movement so as to permit the resulting discharge of hydraulic fluid from said work cylinder under a pressure as determined by the high and low pressure relief valves, said low pressure relief valve having sufficient capacity to accommodate the discharge of hydraulic fluid from said work cylinder at a decreased rate during the succeeding relatively slower closing movement of the press ram whereby as the rate of discharge of hydraulic fluid from the work cylinder drops to such decreased rate, the high pressure relief valve closes and the low pressure relief valve remains open to permit the resulting discharge of hydraulic fluid from the work cylinder.

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