March 8, 1960 R. SMILGES 2,927,558

HYDRAULIC PRESS AND CONTROL MEANS

Filed Jan. 16, 1956 4 Sheets-Sheet 1

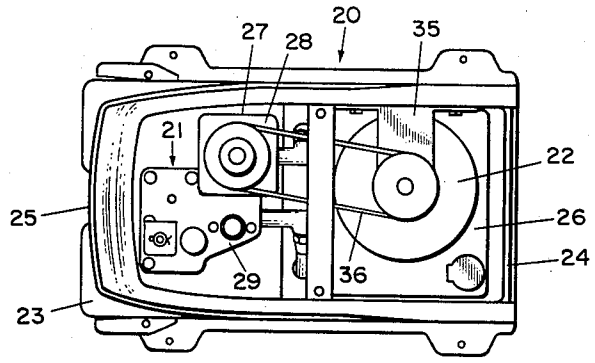


Fig - 3

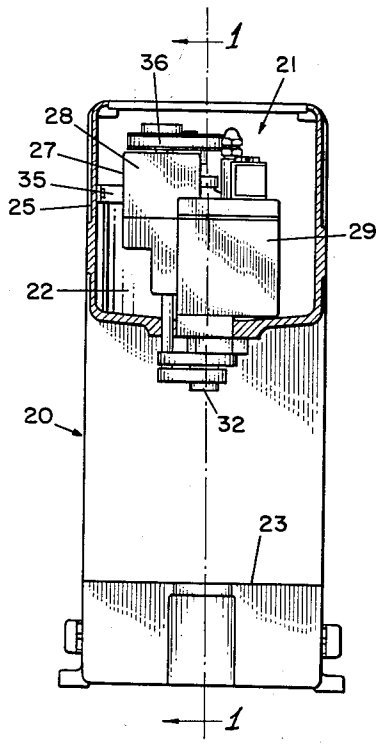


Fig - 2

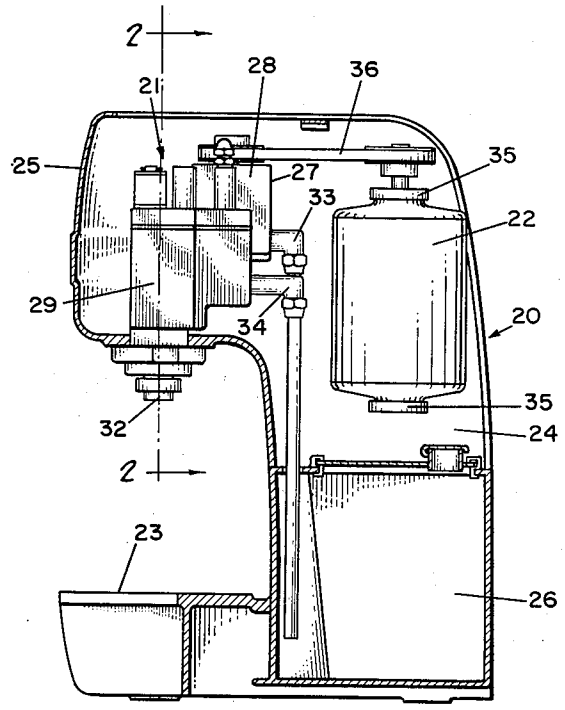


Fig - 1

INVENTOR.
ROBERT SMILGES

BY Donald J. Wetsch,

AGENT

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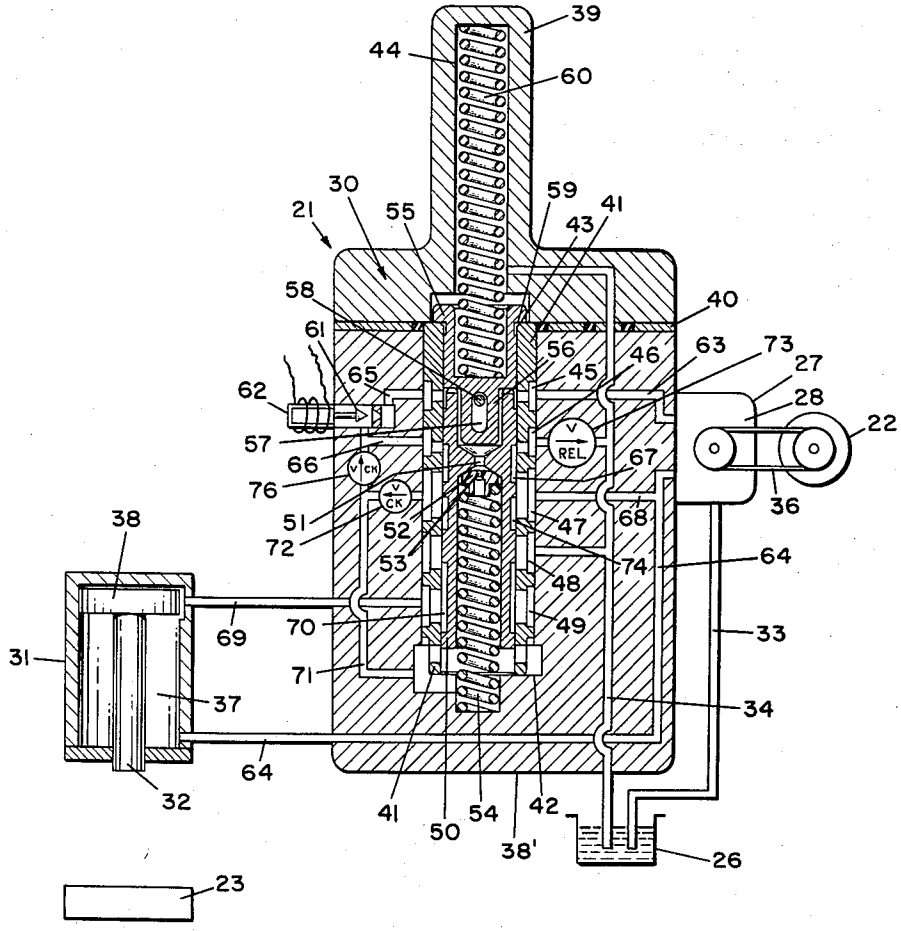


Fig - 4

INVENTOR.
ROBERT SMILGES

BY
Donald J. Dettrick,
AGENT

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HYDRAULIC PRESS AND CONTROL MEANS

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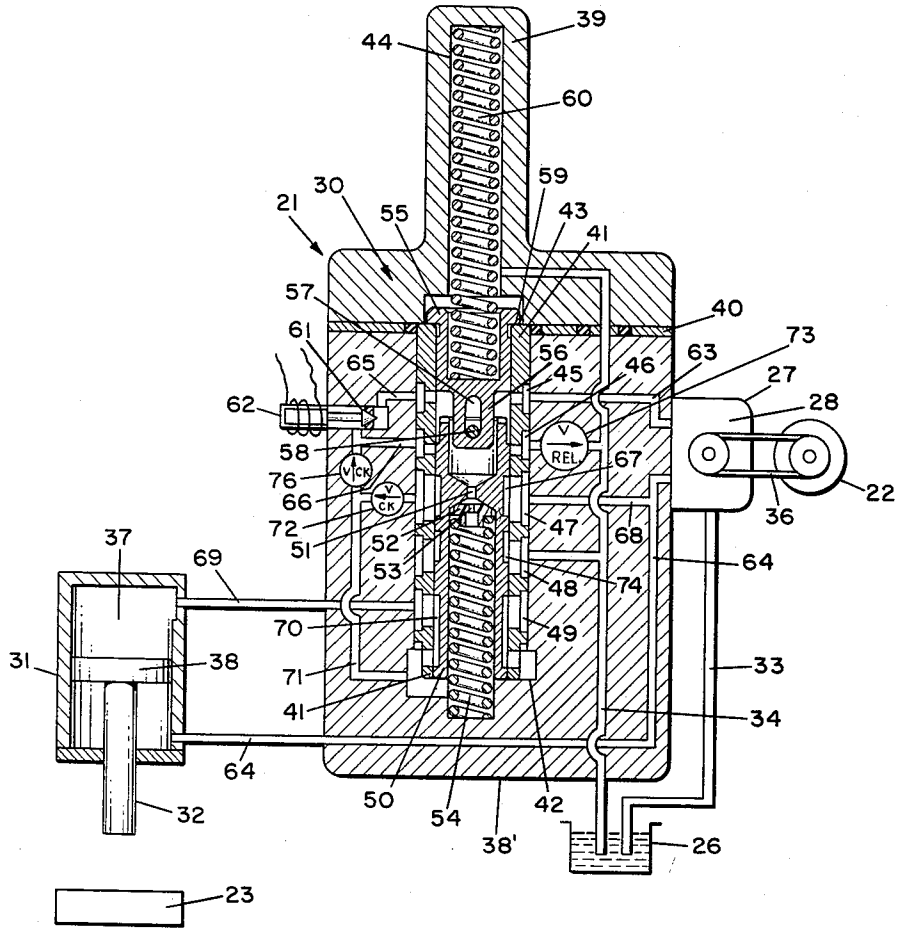


Fig - 5

INVENTOR.
ROBERT SMILGES

BY Donald J. Ostruch,

AGENT

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HYDRAULIC PRESS AND CONTROL MEANS

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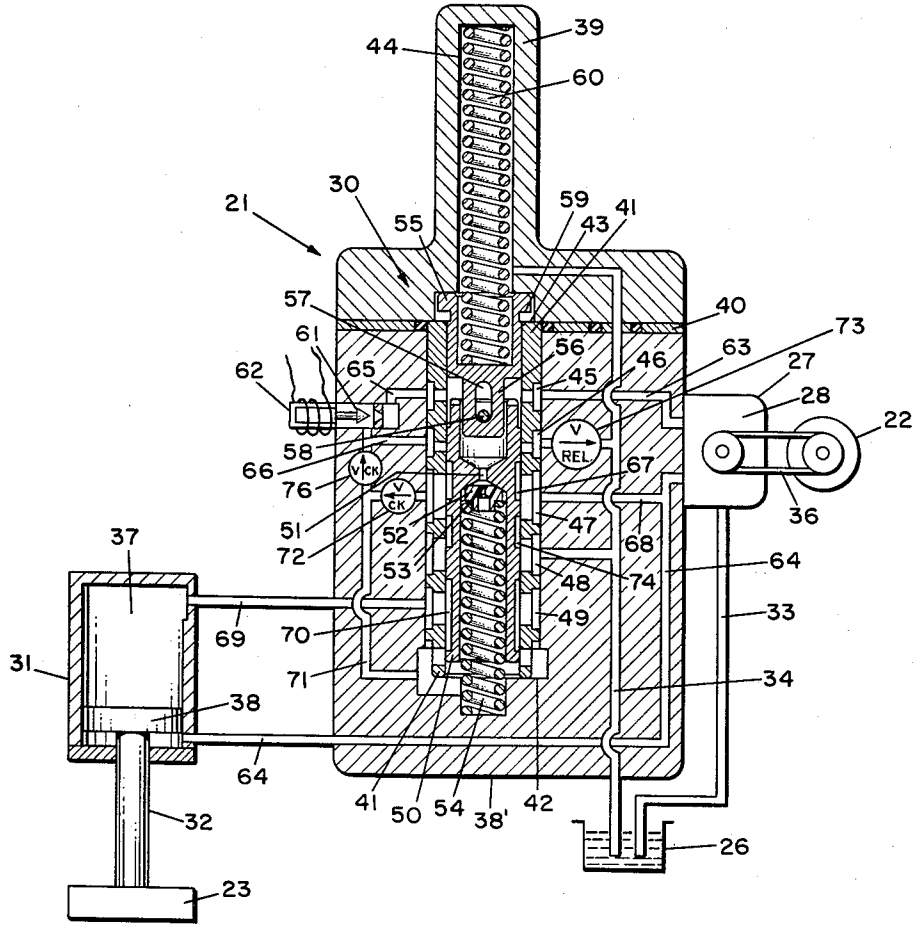


Fig - 6

INVENTOR.
ROBERT SMILGES

BY Donald J. Hetrick,

AGENT

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2,927,558

HYDRAULIC PRESS AND CONTROL MEANS

Robert Smilges, Columbus, Ohio, assignor, by mesne assignments, to American Brake Shoe Company, New York, N.Y., a corporation of Delaware

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4 Claims. (Cl. 121—150)

This invention relates to hydraulic apparatuses and it may be applied with facility and advantages to hydraulic apparatuses in the nature of presses.

An object of the invention is to provide improved hydraulic apparatus of the type hereinafter described.

Another object of the invention is to provide improved structure which when applied to a hydraulic press, for example, imparts improved modes of operation thereto.

Another object of the invention is to provide improved and simplified apparatus for use, for example, in a hydraulic press which will cause the ram thereof to have high traverse speeds with maximum of expended pressing energy and in which a low horsepower motor may be employed as the prime mover.

Another object of the invention is to provide improved apparatus which imparts an improved mode of operation to the ram of a hydraulic press, for example, and which is fully automatic in controlling the operation of the press ram during each stroke or cycle of the latter once the stroke or cycle is initiated.

Another object of the invention is to provide improved apparatus in a hydraulic press, for example, whereby the press ram is caused to descend at a rapid rate until it engages work on the press bed and then to descend at a slower or working rate while increasing its working pressure to a predetermined limit and when such pressure is reached to reverse its direction of travel and travel at a high rate of speed to its starting position.

Another object of the invention is to provide improved apparatus as set forth in the foregoing object wherein the press ram may be caused to dwell against the work after said predetermined ram pressure has been reached and in which, after said dwell perior is completed the ram returns to its starting position at a high rate of speed.

Another object of the invention is to provide an improved hydraulic apparatus for operating the ram of a press, for example, wherein the ram is operated by two separate volumes of hydraulic liquid derived from two sources and which volumes of liquid are first merged and directed to the ram motor to cause the ram to travel toward the press bed at a high rate of speed, then to separate to cause one of said volumes of liquid to be directed to said ram motor to do the pressing work, and then to re-merge and be re-directed to the ram motor to cause it to return the ram to its starting position at a high rate of speed.

Another object of the invention is to provide improved apparatus as set forth in the foregoing object and wherein hydraulic fluid displaced by the ram motor when the latter is operating to move the ram at a high speed is added to the hydraulic liquid being supplied to said motor to increase speed of operation of the latter.

Another object of the invention is to provide improved valve structure for the purposes set forth in the foregoing objects which includes a spool which is moved from one position to another by different pressures created at its opposite ends by hydraulic liquid flowing through it and

in which there is improved means for causing said different pressures.

Still another object of the invention is to provide improved orifice means for causing liquid flowing therethrough to create different pressures at opposite sides thereof which includes a pair of orifice means of different sizes and a valve means between them responsive to the pressure of fluid applied to the first orifice means to bypass the second and smaller orifice means.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the invention is clearly shown.

In the accompanying drawings:

Fig. 1 is a side view of a hydraulic press including the features of the invention, the view showing the press frame in section, which section is taken on line 1—1 of Fig. 2, looking in the direction of the arrows;

Fig. 2 is a front view of the hydraulic press seen in Fig. 1 with the frame broken away to the plane indicated by the line 2—2 in Fig. 1;

Fig. 3 is a view in plan of the hydraulic press seen in Figs. 1 and 2, and

Figs. 4, 5 and 6 are diagrammatic views showing the structure of the hydraulic apparatus or power unit of the press seen in Figs. 1, 2 and 3 and illustrating its novel features and operation.

The hydraulic press shown in Figs. 1 through 3 of the drawings has a frame 20 of the open gap or C type which may be formed as by casting or by fabrication from plates which are cut and shaped and then welded into an integral unit. The frame 20 is hollow for the purpose of receiving and housing the hydraulic apparatus or power unit 21 and the electric motor 22 of the press and it includes a bed 23, an upright open backed portion 24 and a head portion 25 which extends from the top of the upright back portion 24 forwardly over the bed 23. The bottom part of the upright portion 24 forms a tank or reservoir 26 for storing hydraulic liquid, preferably oil, which is employed in the hydraulic apparatus or power unit 21 of the press.

As clearly shown in Figs. 1 through 3 of the drawings, the hydraulic apparatus or power unit 21 of the press is a compact assembly which is contained substantially wholly within the head portion 25 of the frame 21 and above the bed 23. The power unit 21 (Figs. 4–6) includes a body, casing or housing formed of two separate housings or casings, namely, a body, casing or housing 27 for a pump 28 and a body, casing or housing 29 for control mechanism 30 and a hydraulically operated ram motor 31.

The power unit 21 will be described in detail hereinafter, but it is pointed out here that it includes a piston shaft which forms the ram 32 of the press and that it is so mounted in the head portion 25 of frame 20 that the ram 32 thereof projects downwardly through the bottom wall of the head portion 25 and extends toward the center of the bed 23. Hydraulic liquid is supplied to and exhaused from the power unit 21 by conduits 33 and 34, respectively, which extend into the tank or reservoir 26. The electric motor 22 is mounted in the upper portion of the upright frame portion 24 above the tank or reservoir 26 by brackets 35 and it drives the pump 28 through sheaves and a belt 36.

The hydraulic apparatus or power unit 21 of the press is shown diagrammatically in Figs. 4, 5 and 6. This apparatus includes the hydraulically operated press ram 32 which, as shown, is formed by the piston rod of the reciprocatory hydraulic ram operating motor 31. Motor 31 includes a cylinder 37 and a piston 38. The hydraulic apparatus or power unit 21 also includes the control

mechanism indicated generally by the numeral 30, the pump 28 which is driven by the electric motor 22 and the reservoir or tank 26.

The control mechanism 30 and the ram motor 31 are contained within the body, casing or housing 29 which is formed by a body or casting 38' and a cap 39 secured together in fluid tight relation by bolts or screws, not shown, and a gasket 40. The body 38' includes a central bore in which a sleeve 41 is pressed axially and clamped against a shoulder 42 in body 38' by a shoulder 43 surrounding the mouth of a stepped bore 44 in cap 39. Sleeve 41 includes a plurality of external channels or grooves 45, 46, 47, 48 and 49 separated by lands which engage the walls of the bore in body 38' whereby the channels 45 through 49 form passages through which hydraulic fluid may pass circumferentially around the sleeve 41. Each of the channels or grooves 45 through 49 is connected to the interior of the sleeve 41 through ports and these ports are controlled by lands and grooves on a hollow valve piston or spool 50 which is slidable axially within the sleeve 41.

Spool 50 includes an internal wall or partition which forms an orifice 51 and a valve seat against which a poppet 52 having a central orifice 53 seats. Poppet 52 is preferably, but not necessarily, made of nylon and it is urged by a spring 54 contained within the lower portion of the spool 50 to seat against the partition as above described. This spring 54 acts through the poppet 52 to urge the spool upwardly to the position shown in Fig. 4 of the drawings where the upper end of spool 50 abuts a shoulder on an unloading piston 55 which is slidably positioned in the upper end of the bore in sleeve 41.

The unloading piston 55 includes an extension 56 which extends into the upper end of the piston 50 and which is slotted at 57 to receive a pin 58 which extends therethrough and is secured to the piston 50. The function of the lost motion connection provided by the pin 58 and slot 57 will be made apparent hereinafter. Unloading piston 55 is also provided with an annular lip 59 adapted to abut the upper end of sleeve 41 to limit its inward movement into the sleeve 41 and it is urged downwardly to the position shown in Fig. 4 of the drawings by a compression spring 60 contained within the bore 44 of cap 39. The body 38' also houses a valve 61 which is normally open and is urged to a closed position by a solenoid, for example, indicated diagrammatically at 62.

In Fig. 4 of the drawings, the parts of the above described structure are shown in the positions which they occupy when the ram 32 is held in its "up" position. Before describing the operation of the apparatus, it should be stated that the pump 28 has two outlet or output ports which are connected respectively to conduits or lines 63 and 64 formed in the body 38' and that the volume of fluid delivered to the lines 63 and 64 are preferably, but not necessarily, different. In one embodiment of the invention, the output volume of liquid to line 63 is approximately one gallon per minute and the output volume of liquid to line 64 is approximately two gallons per minute. While pump 28 is herein shown and described as one unit having dual outlets, it is to be understood that two separate pumps may be employed if desired.

As shown in Fig. 4, hydraulic liquid flows from the reservoir or tank 26 through the conduit 33 to the pump 28 where it is divided as aforesaid and flows to lines 63 and 64 under pressure. Liquid from the low volume output port of pump 28 flows through line 63 to groove 45 in sleeve 41 and from this groove 45 it passes to the interior of the upper end of spool 50 and also to a conduit, line or passage 65, the valve 61, a conduit, line or passage 66 to groove 46 in sleeve 41, and through an annular groove 67 in spool 50 to groove 47 in sleeve 41. From groove 47 liquid flows through a conduit, line or pipe 68 to conduit, line or pipe 64 where it combines or merges with liquid discharged from the high volume output port of pump 28. Because pressure of the liquid will pass through the partition in valve spool 50, the spring 54 will maintain the valve spool 50 in the position shown in Fig. 4 of the drawings until the valve 61 is closed.

The liquid flowing from conduit 68, as previously mentioned, merges or mixes with the liquid flowing in conduit 64 and thus, at this time, the total or combined output volumes of pump 28 is supplied through conduit 64 to the bottom of cylinder 37 to elevate the piston 38 and ram 30. When piston 38 is in its uppermost position, liquid entering the cylinder 37 from conduit 64 is discharged from the cylinder 37 through a conduit 69 which leads to groove 49 in sleeve 41. From groove 49, this liquid flows through a groove or channel 70 in piston 50 to channel or groove 48 in sleeve 50 and through drain or exhaust line 34 to reservoir or tank 26.

When it is desired to start the ram 32 to descend the press bed the solenoid 62 of valve 61 is energized to cause valve 61 to close. With reference to Fig. 4, when valve 61 closes, hydraulic liquid flowing in conduit 63 passes through groove 45 in sleeve 41 and from this groove to the interior of the upper end of valve spool 50 and also to valve 61 where its flow is blocked. The pressure of the fluid flowing from groove 45 to the interior of valve spool 50, however, will increase and force the fluid to flow through the orifice 51 in spool 50 and the orifice 53 in poppet 52 to the interior of the lower portion of spool 50. From the bottom of spool 50, liquid flows through conduit 71 through a check valve 76, conduit 66, groove 46, groove 67 in spool 50 to groove 47, and conduit 68 to conduit 64. The liquid flowing through orifices 51 and 53, of course, creates a pressure differential between the upper and lower ends of the valve spool 50 and the spool 50 is thereby caused to compress the spring 54 and move spool 50 downwardly to the position shown in Fig. 5 of the drawings. This action or movement of the spool 50 occurs very quickly when liquid flows through the orifices 51 and 53. After spool 50 moves downwardly, liquid flows from the bottom of spool 50 through openings or ports in the bottom of sleeve 41 to channel 70 in spool 50, groove 49 in sleeve 41 and conduit 69 to the top of cylinder 37 and piston 38.

When the valve spool 50 is moved downwardly, as above described, to the position shown in Fig. 5, hydraulic liquid flowing from the high volume output port of pump 28 in conduit 64 travels through conduit 68 to groove 47 in sleeve 41 and from it through a check valve 72 and conduit 71 to the bottom of spool 50 where it combines or merges with the output from the low volume output port of pump 28 and flows through the passages described to the top of the cylinder 37 and piston 38. This liquid, of course, will move the piston 38 downwardly and the liquid below the piston 38 will be expelled through conduit 64 and be combined or merged with the fluid entering the conduit 64 from the high volume output port of pump 28. It will thus be seen that the piston 38, which is an unbalanced piston, will be moved downwardly rapidly since the combined output volumes of both of the output ports of pump 28 and the output from the bottom of cylinder 37 are merged and supplied to the top of the piston 38.

It should be noted that once the spool 50 has been moved to the position shown in Fig. 5 that valve 61 may be opened since the output line 66 thereof is closed by the isolation of groove 46 from the interior of sleeve 41 by a land on the spool 50. In other words, there is present two valves connected in series and either may function to block the flow of liquid from the groove 45 and the upper end of valve spool 50. It should also be noted that the maximum pressure in the top of cylinder 37 is controlled by an adjustable relief valve 73.

The ram 32 will travel freely toward the press bed 23 at a "fast traverse" speed until the ram 32 engages work on the bed, for example, after which, of course, very little liquid will be displaced from the bottom of cylinder

37. The resistance offered to the movement of the ram 32 upon engaging work on the bed 23 will cause the pressure in the cylinder 37 to increase and this increase in pressure will be reflected to the top of valve spool 50 to cause the unloading piston 55 to move upwardly to compress spring 60 and rest upon a shoulder or stop in the bore 44 in cap 39.

As the unloading piston 55 moves upwardly, the lost motion connection provided by the slot 57 in extension 56 and pin 58 lifts the valve spool 50 to the position shown in Fig. 6 of the drawings, and when the parts of the control unit 21 are in the position shown in said Fig. 6 only the pressure supplied from the low volume output port of pump 28 through conduit 63 is applied to the top of the piston 38. For this reason, substantially all of the energy of motor 22 is employed to drive pump 28 against the pressure of its low volume output port in conduit 63.

Upon the movement of valve spool 50 to the position shown in Fig. 6, all of the high volume output of pump 28 flowing in line 64 as well as the chamber formed in the bottom of cylinder 37 below piston 38 is connected to tank 26 through the conduit 68, groove 47 in sleeve 41, a groove 74 in spool 50, groove 48 in sleeve 41 and drain conduit 34. At this time all of the low volume pump output flowing in conduit 63 is directed to the top of piston 38 through the channel or groove 45, the center of spool 50 to the chamber at the bottom thereof and through grooves 70 and 49 to conduit 69 which leads to the cylinder 37 at the top of piston 38. At this time the entire top area of said piston is effective to do work because the smaller bottom area thereof is exposed to tank pressure as described above.

The maximum pressure that can build up in the cylinder 37 above piston 38 is controlled by the adjustable relief valve 73. When the ram 32 encounters a resistance in its movement toward the press bed 23 sufficient to cause valve 73 to open, the ram movement stops and the full flow of liquid from the low volume output port of pump 28 flowing in conduit 63 is directed through groove 45, line 65, valve 61, conduit 66, groove 46 to relief valve 73 and drain conduit 34 to tank 26. Becasue the motion of ram 32 has stopped, there will be substantially no flow of liquid through the orifices 51 and 53 and the spool 50 will be returned to the positoin shown in Fig. 4 of the drawings by the spring 54 whereby the ram 32 will be moved at a rapid rate of speed to its "up" position and the parts of the control unit 21 will be placed in readiness for the next cycle of operation of the press ram.

As previously set forth, the pump 28 delivers two output volumes and as stated, in one embodiment of the invention these output volumes are one and two gallons per minute. It has been found in practice, however, that as the output pressures of the pump increase the output volumes will decrease due to inefficiencies of the pump and leakages of fluid therein. Because of this fact, the poppet 52 including the orifice 53 is provided in spool 50. The orifice 53 in poppet 52 is of less diameter than the orifice 51 in the partition in spool 50 and when the output pressure of the low volume output port of pump 28 is low and valve 61 is first closed, as described in connection with Fig. 4, the volume and pressure of liquid flowing to the top of valve spool 50 is such that it will pass through the orifice 51 and lift the poppet 52 off of its seat while moving the piston 50 downwardly without lifting the unloading piston 55. As the volume of liquid pumped to the top of piston 50 decreases due to increased pressure, the poppet 52 which is being urged to its closed position by spring 54 causes orifice 53 to become effective to restrict the flow of liquid and thereby provide the necessary pressure differential between the opposite ends of spool 50 to hold it in the position seen in Fig. 5. It will thus be seen that the poppet 52 and orifices 51 and 53 cooperate to provide an assembly including variable orifice means which is responsive to provide the necessary pressure differential at opposite ends of the spool 50 even though both the pressure and volume of liquid supplied to the top of spool may vary.

It is pointed out that if the valve 61 is held in its closed position that the automatic reversal feature of the apparatus which occurs when valve 73 opens will be prevented from becoming operative until the valve 61 is permitted to open. Thus, a press operator by keeping the solenoid 62 energized may cause the ram 20 to "dwell" upon the work. When the valve 61 is held closed the low volume output of pump 28 flows through conduit 63, the groove 45, the center of spool 50 to the chamber at the bottom thereof, the conduit 71, check valve 76, conduit 66, groove 46, relief valve 73 and conduit 34 to tank 26.

From the foregoing description, it will be seen that the invention provides a control unit 21 which may be employed with facility, for example, in a hydraulic press to cause the press to "idle" with its ram held in a retracted position and that to initiate a cycle of operation of the ram it is necessary only to close the valve 61 momentarily, or until the valve spool 50 shifts from the position seen in Fig. 4 to the position seen in Fig. 5 of the drawings and that thereafter a cycle of operation, namely a rapid approach of the ram to the work, a build-up of ram pressure to the setting of valve 73, and a rapid return of the ram to its "up" or press "idling" position will be completed automatically.

It will also be obvious that when the ram is travelling toward the work that both volumes of liquid pumped by the pump and liquid displaced from below the piston 38 are merged and supplied to the top of cylinder 37 to force the piston 38 downwardly at a high rate of speed and that when in its downward movement the ram 32 meets sufficient resistance to increase the hydraulic pressure above the piston 38 and spool 50 to lift the unloading piston 55 and spool 50, that only the smaller output volume of pump 28 flowing in conduit 63 is applied to the top of piston 38 and the higher output volume of pump 28 flowing in conduit 64 and the bottom of the motor cylinder 37 are connected to exhaust.

This condition will continue to exist until the hydraulic pressure above the piston 38 increases and opens valve 73 at which time the spring 54 will return spool 50 to the position seen in Fig. 4 of the drawings wherein both volumes of hydraulic liquid being pumped by pump 28 will be merged and supplied to the bottom of piston 38 to elevate or retract the ram 32 at a high rate of speed.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. In a hydraulic press, a hydraulic ram operating motor including a cylinder, a ram operating piston in said cylinder having opposite faces of unequal areas whereby equal hydraulic pressures applied to said faces causes said piston to move from a first position in said cylinder, means for directing liquid to said motor to cause movement of said piston in opposite directions, said means including means for delivering two separate volumes of liquid, pressure differential operated valve means for first directing both of said volumes of liquid to said motor thereby urging said piston to said first position, means operative to create a pressure differential for operating said valve means whereby the latter directs both of said volumes to said motor to cause the piston thereof to move toward a second position, means for merging liquid displaced from said motor by movement of said piston with said two volumes while said piston is moving from said first to said second position, and means responsive to an increase in pressure in said motor after said piston has moved from said first position to cause said valve means to direct one of said volumes to said mo-

tor and the other to exhaust, said valve means being responsive to a decrease in said pressure differential for re-directing both of said volumes to said motor to return said piston to said first position.

2. In a hydraulic press, a hydraulic ram operating motor including a cylinder, a ram operating piston in said cylinder, means for directing liquid to said motor to cause movement of said piston in opposite directions said means including means for delivering two separate volumes of liquid, pressure differential operated valve means for first directing both of said volumes of liquid to said motor thereby urging said piston to a first position, means operative to create a pressure differential for operating said valve means whereby the latter directs both of said volumes to said motor to urge the piston thereof to move toward a second position, and means responsive to an increase in pressure in said motor after said valve means has operated as aforesaid to cause said valve means to direct one of said volumes to said motor and the other to exhaust, and means acting upon a decrease in said pressure differential for causing said valve means again to direct both of said volumes to said motor to return said piston to said first position.

3. In a hydraulic press, a hydraulic ram operating motor including a cylinder, a ram operating piston in said cylinder having opposite faces of unequal areas whereby equal hydraulic pressures applied to said faces causes said piston to move from a first position in said cylinder, means for directing liquid to said motor to cause movement of said piston in opposite directions said means including means for delivering two separate volumes of liquid, valve means for first directing both of said volumes of liquid to said motor thereby urging said piston to said first position, means for operating said valve means whereby the latter directs both of said volumes to said motor to cause the piston thereof to move toward a second position, means for merging liquid displaced from said motor by movement of said piston with said two volumes, means responsive to an increase in pressure in said motor when said piston moves to said second position to cause said valve means to direct one of said volumes to said motor and the other to exhaust, and means responsive to a decrease in the flow of fluid to said motor for causing said valve means again to direct both of said volumes to said motor to return said piston to said first position.

4. In a hydraulic press, a hydraulic ram operating motor including a cylinder, a ram operating piston in said cylinder, means for directing liquid to said motor to cause movement of said piston in opposite directions said means including means for delivering two separate volumes of liquid, valve means for first directing both of said volumes of liquid to said motor thereby urging said piston to a first position, means for operating said valve means whereby the latter directs both of said volumes to said motor to cause the piston thereof to move toward a second position, means responsive to an increase in pressure in said motor when said piston moves to said second position to cause said valve means to direct one of said volumes to said motor and the other to exhaust, and means responsive to a decrease in the flow of fluid to said motor for causing said valve means again to direct both of said volumes to said motor to return said piston to said first position.

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