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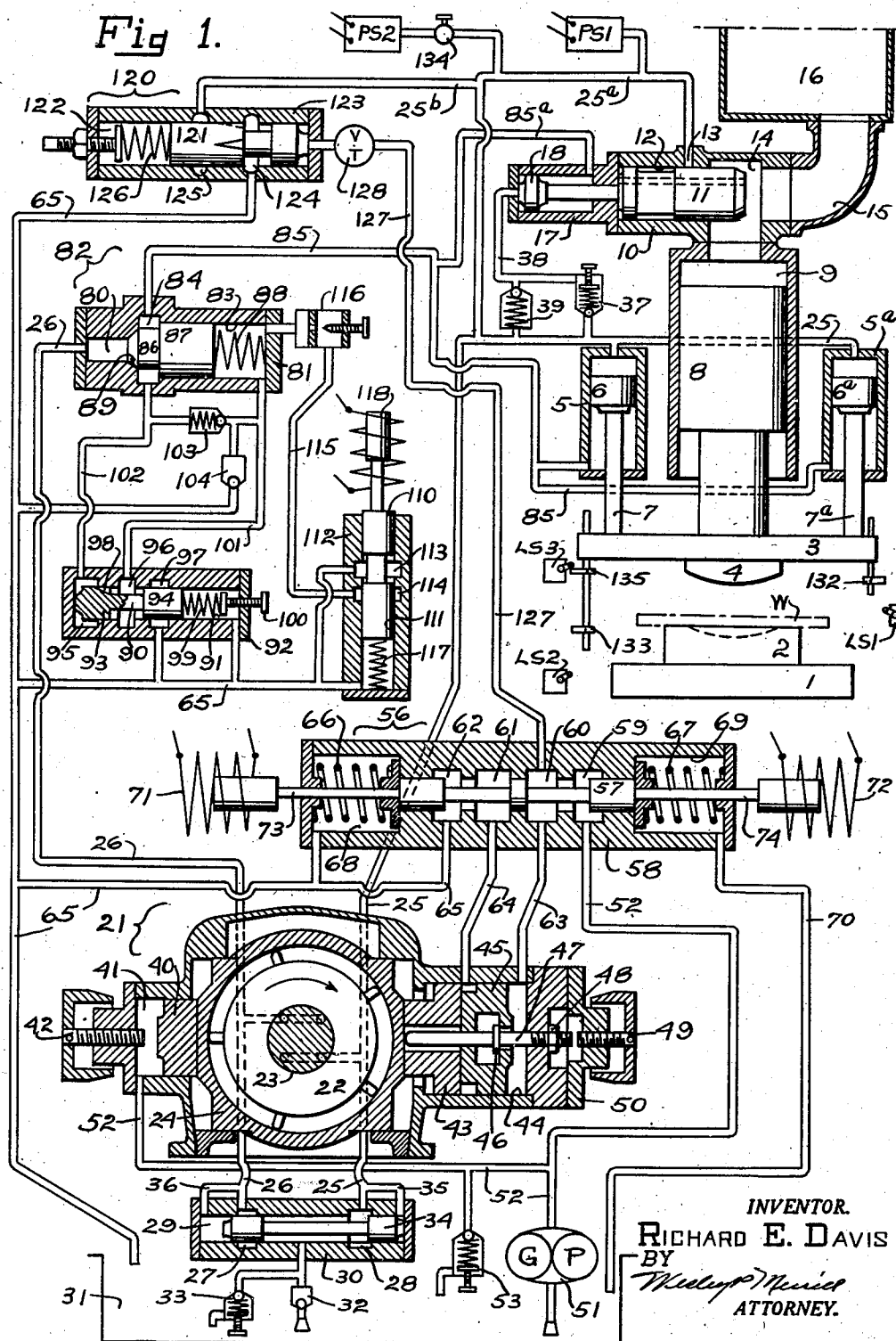
R. E. DAVIS

2,337,848

HYDRAULIC PRESS

Filed Nov. 25, 1940

2 Sheets-Sheet 1



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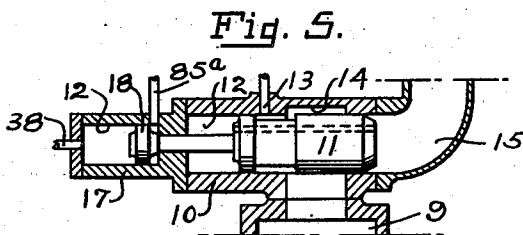
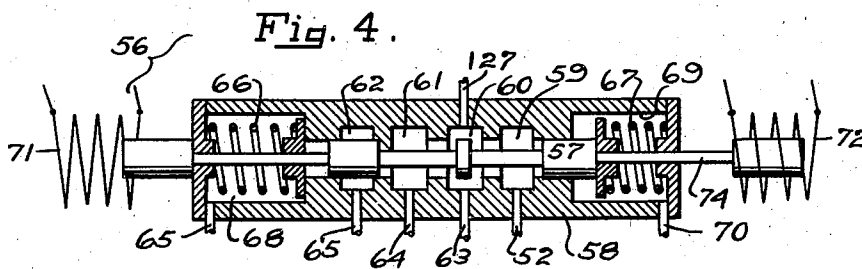
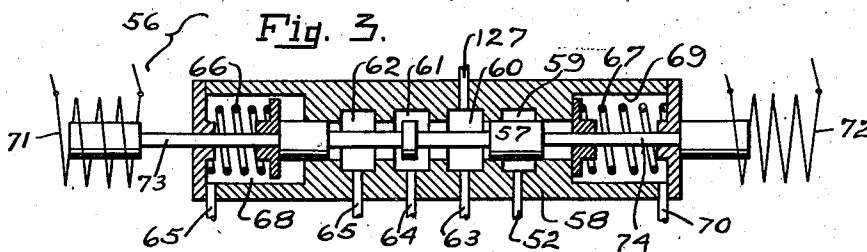
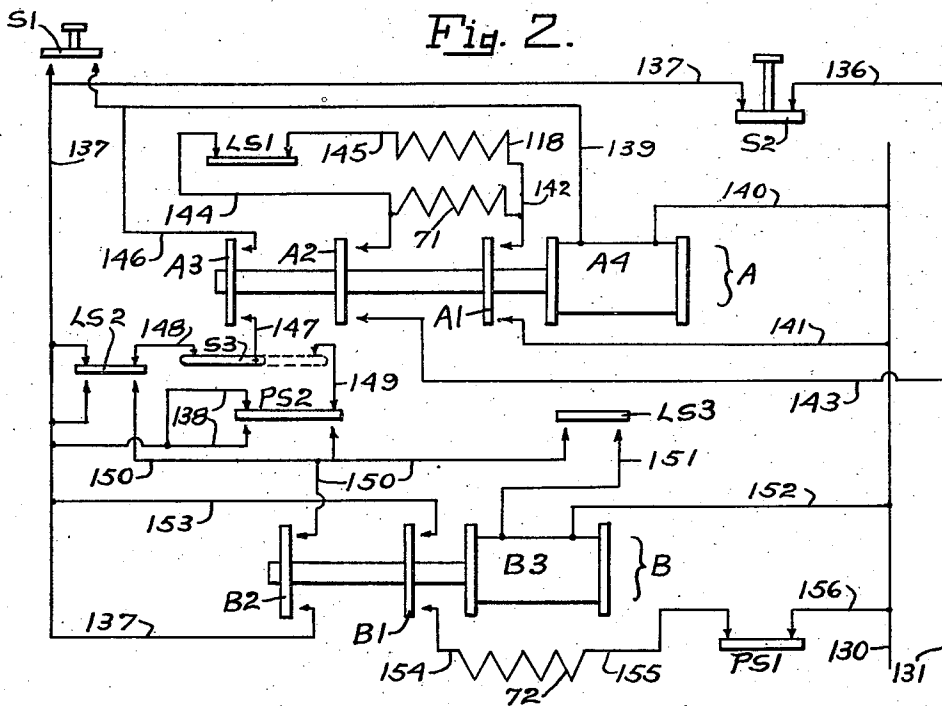
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,337,848

HYDRAULIC PRESS

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17 Claims. (Cl. 60—52)

This invention relates to the control of reciprocating hydraulic motors of the type having large capacity working chambers and small capacity return chambers. For the purpose of illustration, the invention will be explained as applied to a hydraulic press but it is not limited to such use.

The force exerted by a press ram during its working stroke causes the pressure of the motive liquid to rise and the liquid in the working chamber to be compressed. If this compressed liquid is suddenly released, an undesirable shock will result. If the pump which powers the press is connected into a closed circuit with the working and return chambers, reversal of flow in the circuit will not cause the ram to be retracted until after the pump has pumped enough liquid from the working chamber to reduce the pressure therein to a low value, thereby causing a delay in reversing the ram. If the press is of the type in which the working chamber is connected to a surge tank through a surge valve, the high pressure in the working chamber at the end of the working stroke will make opening the surge valve difficult and some types of surge valves will not open until the pressure in the working chamber has been reduced. If the press is of the downward acting type, means must be provided for supporting the ram when the press is idle and this means is ordinarily a resistance valve through which liquid from the return chamber is forced during the working stroke, thereby causing power to be wasted and the motive liquid to become heated.

The invention has as an object to provide a press with a novel control having means for reducing the pressure in the working chamber after a working stroke of the ram has been completed and before a return stroke is initiated.

Another object is to provide a press of the downward acting type with a novel control having means for supporting the ram when the press is idle and with means for automatically rendering the supporting means ineffective during at least a part of the working stroke of the ram.

Other objects and advantages will appear from the description hereinafter given of a hydraulic press in which the invention is embodied.

According to the invention in its general aspect and as ordinarily embodied in practice, the working chamber of a press is opened to drain at the end of the working stroke of the ram, the flow in the circuit is simultaneously reduced to zero and maintained at zero until the pressure in the

working chamber has been reduced to a low value and then the flow in the circuit is reversed to effect reversal of the ram.

The invention also provides the press with a pressure responsive valve which when effective offers sufficient resistance to the discharge of liquid from the return chamber to support the ram when the press is idle and which is rendered ineffective to support the ram in response to liquid being directed to the working chamber to advance the ram.

The invention is exemplified by the press shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagram of the hydraulic circuit of a press in which the invention is embodied, the parts being shown in the positions occupied when the press is idle.

Fig. 2 is a diagram of the electric circuit of the press shown in Fig. 1.

Fig. 3 is a view showing the pump control valve in the position occupied during a working stroke of the press ram.

Fig. 4 is a view showing the pump control valve in the position occupied during a return stroke of the press ram.

Fig. 5 is a view showing the surge valve in position to direct motive liquid to the main press cylinder.

For the purpose of illustration, the invention has been shown applied to a downward acting speed press but it is not limited to presses of this type. Since such presses are well known and in extensive use, only so much of the press has been shown as is necessary to an explanation of the invention.

As shown, the press includes a stationary head or die block 1 for supporting a stationary die 2 and a movable head or platen 3 for moving a die 4 into and out of contact with a work piece W arranged upon die 2.

Platen 3 is adapted to be moved upward and is supported in its upper position by liquid supplied to the lower ends of two stationary rapid traverse cylinders 5 and 5^a having pistons 6 and 6^a fitted therein and connected by rods 7 and 7^a to platen 3 upon opposite sides of a large ram 8 fitted in a stationary main cylinder 9. It is adapted to be moved downward first at high speed either by gravity or by liquid supplied to the upper ends of cylinders 5 and 5^a, and it is then moved downward at a slow speed and upper die 4 is caused to exert a pressing force upon work W by liquid supplied to the upper ends of cylinders 5, 5^a and 9 which constitute work-

ing chambers while the lower ends of cylinders 5 and 5^a constitute return chambers.

Cylinder 9 is connected at its upper end with a surge valve casing 10 having a valve member 11 fitted in the bore 12 thereof to control communication between a pressure port 13 and a large annular groove or port 14, which is formed in the wall of bore 12 and communicates with the upper end of cylinder 9, and between port 14 and a passage 15 which connects one end of bore 12 to a surge tank 16.

When surge valve 11 is in the position shown in Fig. 1, communication between port 13 and cylinder 9 is blocked and liquid will be drawn from tank 16 through passage 15 and valve casing 10 into cylinder 9 by ram 8 as it moves downward and liquid will be expelled from cylinder 9 into tank 16 by ram 8 as it moves upward.

When surge valve 11 is shifted to the position shown in Fig. 5, communication between tank 16 and cylinder 9 is blocked and liquid may flow from port 13 through bore 12 and port 14 into cylinder 9. Surge valve 11 is adapted to be shifted by a servo-motor consisting of a cylinder 17 fixed to casing 10 and a piston 18 which is fitted in cylinder 17 and has its rod connected to valve 11.

Liquid for operating the press is supplied by a reversible variable displacement pump 21 which may be of the rolling piston type fully illustrated and described in Patent No. 2,074,068. It is deemed sufficient to state herein that pump 21 has its cylinders arranged radially in a cylinder barrel 22 which is journaled upon a stationary valve shaft or pintle 23 having ports and passages formed therein through which liquid flows to and from the cylinders, that the outer ends of the pistons react against the annular inner surface of a reaction member carried by a thrust member or slide block 24, that no liquid will be discharged by pump 21 when slide block 24 is in its central or neutral position at which time its axis coincides with the axis of cylinder barrel 22, and that pump 21 will deliver liquid in a direction and at a rate dependent upon the direction and distance slide block 24 is shifted from its neutral position. As shown, pump 21 is adapted to deliver liquid into one and have liquid returned to it through the other of two channels 25 and 26 which are connected to pintle 23 in communication with the passages formed therein.

Channel 25 is connected to the upper ends of cylinders 5 and 5^a and has a branch 25^a thereof connected to port 13 in surge valve casing 10. Channel 26 is connected to the lower ends of cylinders 5 and 5^a in a manner to be presently described.

Since motors 5-6 and 5^a-6^a are of the differential type so that, when operating, liquid is discharged therefrom at rates which are always either in excess of or less than the rate required to supply pump 21 with liquid, channels 25 and 26 communicate at points intermediate their ends with the passages in pintle 23 and have their lower ends connected, respectively, to two annular grooves or ports 27 and 28 formed in the wall of a bore 29 which is formed in a valve casing 30 and connected at a point between ports 27 and 28 with a reservoir 31 through a check valve 32 and a low pressure resistance valve 33. Each of channels 25 and 26 is also connected to a high pressure relief valve which has been omitted from the drawings to avoid crowding the view.

Bore 29 contains a differential valve 34 having heads or pistons formed upon its ends and closely

fitted in bore 29 to block one or the other of ports 27 and 28, and opposite ends of bore 29 are connected by channels 35 and 36 to channels 25 and 26 respectively.

The arrangement is such that, when pump 21 discharges liquid into channel 26 to raise pistons 6 and 6^a, pressure will extend through channel 36 to the left end of bore 29 and shift valve 34 toward the right to the position shown to block the end of channel 26 and uncover the end of channel 25 so that the liquid expelled from cylinders 5 and 5^a by pistons 6 and 6^a in excess of the volume required by pump 21 may be discharged through resistance valve 33 into reservoir 31 and, when pump 21 discharges liquid into channel 25 to cause pistons 6 and 6^a to descend, pressure will extend through channel 35 to the right end of bore 29 and shift valve 34 toward the left to block the end of channel 25 and uncover the end of channel 26 so that pump 21 may draw liquid from reservoir 31 through check valve 32.

In order that surge valve 11 may be shifted automatically to the position shown in Fig. 5 when pressure rises due to die 4 engaging work W, channel 25 is connected through a resistance valve 37 and a channel 38 to the left end of servo-motor cylinder 17 and, in order that piston 18 may eject liquid from cylinder 17 when surge valve 11 is shifted to the position shown in Fig. 1, channel 38 is connected through a check valve 39 to channel 25.

When slide block 24 is shifted toward the right from its neutral position, pump 21 will discharge liquid into channel 25 and have liquid returned to it through channel 26 and, when it is shifted toward the left from its neutral position, pump 21 will discharge liquid into channel 26 and have liquid returned to it through channel 25.

Slide block 14 is at all times urged toward the right by liquid acting upon a piston 40 which is connected to or in engagement with slide block 24 and is fitted in a stationary cylinder 41 carried by the casing of pump 21.

An adjusting screw 42 is threaded through the head of cylinder 41 to limit the movement of piston 40 and slide block 24 toward the left. Turning screw 42 will adjust the rate at which pump 21 will discharge liquid into channel 26.

Slide block 24 is adapted to be moved toward the left by liquid acting upon a piston 43, which engages slide block 24 and is fitted in a stationary cylinder 44 carried by the pump casing, and by liquid acting upon a piston 45 which is fitted in cylinder 44 and adapted to engage the outer face of piston 43.

The movement of piston 45 toward the left is limited by a collar 46 fixed on a stop rod 47 which extends loosely through pistons 43 and 45 and through the head of cylinder 44. The inner end of rod 47 is adapted to engage slide block 24 and the outer end of rod 47 is provided with a nut 48 which is adjusted to so position collar 46 that piston 45 when energized will move slide block 24 exactly to its neutral position.

The outer end of rod 47 is adapted to engage an adjusting screw 49 which is threaded through a cap 50 fixed to the head of cylinder 44. Turning screw 49 adjusts the distance rod 47 and slide block 24 may be moved toward the right to thereby determine the rate at which pump 21 will deliver liquid into channel 25.

Pistons 43 and 45 are larger than piston 40 so that slide block 24 will be moved toward the left when liquid is simultaneously supplied to both of cylinders 41 and 44 at the same pressure.

Liquid for operating pistons 43 and 45 is supplied by a gear pump 51 which is ordinarily driven in unison with pump 21 and arranged in the casing thereof according to the usual practice.

Gear pump 51 draws liquid from reservoir 31 and discharges it into a branched supply channel 52 at a rate in excess of requirements, the excess liquid being exhausted through a relief valve 53 which enables gear pump 51 to maintain in channel 52 a pressure equal to the resistance of relief valve 53.

Supply channel 52 has one of its branches connected to the outer end of cylinder 41 so that piston 40 is constantly urged toward the right by a constant force which is proportional to gear pump pressure.

Delivery of liquid from gear pump 51 to cylinder 44 is under the control of a pump control valve 56 having a valve member or plunger 57 fitted in a valve casing 58 to control communication between four annular grooves or ports 59, 60, 61 and 62 formed in valve casing 58.

Port 59 has another branch of supply channel 52 connected thereto. Port 60 is connected by a channel 63 to cylinder 44 at or near the outer end thereof. Port 61 is connected by a channel 64 to cylinder 44 at a point between pistons 43 and 45. Port 62 is connected to a drain channel 65 which discharges into reservoir 31.

When valve member 57 is in its central position as shown in Fig. 1 pressure extends from channel 52 through valve casing 58 and channel 63 to the right end of cylinder 44 and holds piston 45 against collar 46 on stop rod 47, the space between pistons 43 and 45 communicates through channel 64 and valve casing 58 to drain channel 65 so that the pressure in cylinder 41 will cause piston 40 to hold slide block 24 against piston 43 and piston 43 against piston 45 in which position of slide block 24 pump 21 is at zero stroke and no liquid will be delivered thereby.

When valve member 57 is shifted toward the left to the position shown in Fig. 3, port 59 is blocked and channels 63 and 64 are open to drain channel 65 so that liquid supplied by gear pump 51 to cylinder 41 can cause piston 40 to move slide block 24 toward the right until rod 47 abuts adjusting screw 49 at which time pump 21 will discharge liquid into channel 25 at a rate determined by the adjustment of screw 49.

When valve member 57 is shifted toward the right to the position shown in Fig. 4, port 62 is blocked and channels 63 and 64 are open to port 59 so that liquid from gear pump 51 can flow through channel 52, valve casing 58 and channels 63 and 64 to cylinder 44 and cause pistons 43 and 45 to move slide block 24 toward the left until piston 40 abuts adjusting screw 42 at which time pump 21 will discharge liquid into channel 26 at a rate determined by the adjustment of screw 42.

Valve member 57 is normally held in its central or neutral position by two springs 66 and 67 arranged, respectively, in two chambers 68 and 69 which are formed in opposite ends of valve casing 58. Chamber 68 is connected to drain channel 65 and chamber 69 is connected to a drain channel 70 which discharges into reservoir 31.

Valve member 57 is adapted to be shifted in one direction or the other by one or the other of two solenoids 71 and 72 the cores of which are connected, respectively, to valve stems 73 and 74 which are fixed to opposite ends of valve member 57 and extend outward through chambers 68

and 69. Solenoids 71 and 72 are controlled in a manner to be presently described.

The other end of channel 26 is connected to a port 80 formed in the casing 81 of a resistance valve 82 which prevents platen 3 from descending when the press is idle.

Valve casing 81 has an axial bore 83 formed therein and an annular groove or port 84 formed in the wall of bore 83 at the left end thereof. Port 84 is connected to the lower ends of cylinders 5 and 5^a by a branched channel 85, and a branch 85^a thereof is connected to the right end of servo-motor cylinder 17.

Communication between ports 80 and 84 is controlled by a valve 86 fixed to a piston 87 which is larger in diameter than valve 85 and fitted in bore 83. A light spring 88 arranged in the right end of bore 83 urges piston 87 toward the left to hold valve 86 in contact with a valve seat 89 which is formed around port 80 in the end wall of bore 83.

Spring 88 has sufficient strength to overcome the friction of piston 87 and move it toward the left until valve 86 engages valve seat 89 but it is incapable of holding valve 86 against valve seat 89 when the end of valve 86, or the end of piston 87 is subjected to an appreciable amount of unbalanced pressure.

Resistance valve 82 is controlled in part by a pressure responsive valve 90 arranged in the bore 91 of a valve casing 92 and provided with two spaced apart heads or pistons 93 and 94 which are closely fitted in bore 91 to control communication between three annular grooves or ports 95, 96 and 97 formed in the wall of bore 91. Piston 93 has at least one small tapered groove 98 formed in its peripheral surface to provide a restricted passage from port 95 to port 96 when valve 90 is in the position shown, in which position it is normally held by a spring 99 which is arranged in the right end of bore 91 and it is adapted to have its tension adjusted by means of a screw 100.

Port 97 and the right end of bore 91 have drain channel 65 connected thereto, port 96 is connected by a channel 101 to the right end of bore 83 in resistance valve casing 81, and port 95 is open at all times to channel 85 as by being connected by a channel 102 to port 84 in resistance valve casing 81.

In order that liquid may be expelled from the right end of bore 83 when piston 87 is moved toward the right by pressure applied to the end of valve 86, the right end of bore 83 is connected to port 84 through a check valve 103 which has been shown connected between channels 101 and 102. In order that piston 87 may draw liquid into the right end of bore 83 when it moves toward the left, the right end of bore 83 is connected to drain channel 65 through a check valve 104 which is shown connected to channel 101.

Resistance valve 82 is also controlled in part by a pilot valve 110 which is arranged in the bore 111 of a valve casing 112 and controls communication between two annular grooves or ports 113 and 114 formed in the wall of bore 111. Port 114 is connected by a channel 115 and a throttle valve 116 to the right end of bore 83 while port 113 and the lower end of bore 111 have drain channel 65 connected thereto.

Valve 110 is normally held in position to block port 114 by a spring 117 arranged in the lower end of bore 111, and it is adapted to be moved to a position to open port 114 to port 113 by a

solenoid 118 which is energized simultaneously with solenoid 71 as will presently be explained.

In order that ram cylinder 9 may have the pressure therein reduced at the end of a working stroke of ram 8, it is connected to drain through a decompression valve 120 which is operated in response to the displacement of pump 21 being reduced to zero.

As shown, valve 120 has a valve member 121 fitted in the bore 122 of a valve casing 123 to control communication between two annular grooves or ports 124 and 125 which are formed in the wall of bore 122 and connected, respectively, to drain channel 65 and a branch 25^b of channel 25.

Valve member 121 is normally held in a position to block port 125 and thereby prevent escape of liquid from channel 25^b into channel 65 by a spring 126 arranged in one end of bore 122. The other end of bore 122 is connected by a channel 127 to port 60 in pump control valve 56 so that, when valve member 57 is shifted to the position shown in Fig. 1 to cause the displacement of pump 21 to be reduced to zero as previously explained, liquid will flow from gear pump 51 through channel 52, valve 56 and channel 127 to the end of bore 122 and move valve member 121 far enough to uncover port 125 so that liquid can escape from ram cylinder 9 and thereby reduce the pressure therein. The rate at which liquid may escape from cylinder 9 is preferably limited such as by providing a throttle valve 128 in channel 127 to limit the rate at which valve member 121 is moved and by providing suitable tapered grooves in the periphery of valve member 121 so that the rate of flow through valve 120 is gradually increased as valve member 121 moves toward the left.

The electric circuit

Referring now more particularly to Fig. 2, current for energizing solenoids 71, 72 and 118 is supplied thereto from a power line shown as consisting of two conductors 130 and 131. Solenoid 71 is controlled by a contactor switch A having three switches A1, A2 and A3 and a magnet A4 for operating its switches.

Solenoid 72 is controlled in part by a contactor switch B which consists of two switches B1 and B2 and a magnet B3 for operating its switches, and in part by a pressure switch PS1 which is connected to channel 25^a as shown in Fig. 1 and adapted to be held open by high pressure.

Solenoid 118 is controlled in part by contactor switch A and in part by a limit switch LS1 which is adapted to be operated near the end of a down stroke of ram 8 by an actuator 132 which is carried by platen 3 as shown in Fig. 1.

Contactor switch A is controlled in part by a normally open manually operable starting switch S1 and in part either by a limit switch LS2, which is adapted to be operated at the end of a down stroke of ram 8 by an actuator 133 (Fig. 1) carried by platen 3, or by a pressure switch PS2 which is connected to channel 25^a through a shut-off valve 134 as shown in Fig. 1.

Contactor switch B is controlled in part either by limit switch LS2 or by pressure switch PS2 and in part by a limit switch LS3 which is adapted to be operated at the end of an up stroke of ram 8 by an actuator 135 (Fig. 1) carried by platen 3.

In order to simplify the drawings, contactor switches A and B have been shown arranged

horizontally but in practice they are arranged vertically so that, when the magnets are deenergized, the switches will open by gravity to the positions shown.

In order that the press may be stopped at any time, a normally closed manually operable stop switch S2 is connected into one side of the circuit and, in order that platen 3 may be retracted either when it reaches a given point in its advanced movement or when the pressure in cylinder 9 reaches a given maximum, a manually operable selector switch S3 is connected between switches LS2 and PS2.

As shown, stop switch S2 has one of its terminals connected to power conductor 131 by a conductor 136 and its other terminal connected by conductor 137 to one terminal of starting switch S1, to two opposed terminals of limit switch LS2 and to one terminal of switch B2. Conductor 137 is also connected by a conductor 138 to two opposed terminals of pressure switch PS2. The other terminal of switch S1 is connected by a conductor 139 to one end of the winding of magnet A4 the other end of which is connected to power conductor 130 by a conductor 140 so that, when switch S1 is closed, magnet A4 will be energized and close switches A1, A2 and A3.

Switch A1 has one of its terminals connected by a conductor 141 to conductor 130 and its other terminal connected by a conductor 142 to one end of each of the windings of solenoids 71 and 118. Switch A2 has one of its terminals connected by a conductor 143 to conductor 131 and its other terminal connected by a conductor 144 to the other end of the winding of solenoid 71 and to one terminal of limit switch LS1 the other terminal of which is connected by a conductor 145 to the other end of the winding of solenoid 118.

Switch A3 has one of its terminals connected by a conductor 146 to conductor 139 and its other terminal connected by a conductor 147 to one terminal of selector switch S3. A second terminal of switch S3 is connected by a conductor 148 to the third terminal of limit switch LS2, and a third terminal of switch S3 is connected by a conductor 149 to the third terminal of pressure switch PS2.

Switch B2 has its other terminal connected to the fourth terminal of limit switch LS2, to the fourth terminal of pressure switch PS2 and to one terminal of limit switch LS3 by a conductor 150. The other terminal of limit switch LS3 is connected by a conductor 151 to one end of the winding of magnet B3 the other end of which is connected to conductor 130 by a conductor 152.

Switch B1 has one of its terminals connected to conductor 137 by a conductor 153 and its other terminal connected to one end of the winding of solenoid 72 by a conductor 154. The other end of the winding of solenoid 72 is connected by a conductor 155 to one terminal of pressure switch PS1 the other terminal of which is connected by a conductor 156 to conductor 130.

Operation

If platen 3 is to be reversed when it has advanced die 4 to a given point, selector switch S3 is adjusted as shown in full lines, shut-off valve 134 is closed and actuator 133 is so adjusted that it will operate limit switch LS2 when die 4 reaches that point. If platen 3 is to be reversed when die 4 has exerted a predetermined force upon work W, selector switch S3 is adjusted as shown

in dotted lines, actuator 133 is so adjusted that it will not operate limit switch LS2 and shut-off valve 134 is opened so that pressure switch PS2 will be operated when the pressure in cylinder 9 reaches a predetermined maximum.

When the press is idle, the parts are in the positions shown in Fig. 1 and the weight of platen 3 and the parts movable therewith cause pistons 6 and 6^a to create pressure in the lower ends of cylinders 5 and 5^a and this pressure will extend through channel 85 to port 84 in resistance valve 82 and tend to move piston 87 toward the right due to the pressure acting upon the left end thereof.

However, the pressure also extends from port 84 through channel 102, port 95, groove 98, port 96 and channel 101 to the right end of bore 83 and acts upon the right end of piston 87 the effective area of which is greater than the effective area of the left end by an amount equal to the area of valve 86. Consequently, the preponderance of force acting upon the right end of piston 87 will hold valve 86 against seat 89 so that platen 3 is positively prevented from descending.

When pumps 21 and 51 are started, pressure will extend from gear pump 21 to the right end of control cylinder 44 and hold pump 21 at zero stroke so that no liquid is delivered thereby as previously explained, and liquid from gear pump 51 will flow through channel 52, valve casing 58 and channel 127 to valve 120 and shift its plunger 121 which will have no effect at this time.

To start the press, starting switch S1 is closed to establish a circuit (131—136—S2—137—S1—139—A4—140—139) to energize magnet A4 which closes switches A1, A2 and A3. Closing switch A3 establishes a holding circuit to keep A4 energized and switches A1, A2 and A3 closed. If platen 3 is to be reversed when it has advanced die 4 to a given point, the holding circuit will extend from power conductor 131 through 136—S2—137—LS2—148—S3—147—A3—146—139—A4 and 140 to power conductor 130. If platen 3 is to be reversed when die 4 has exerted a predetermined force upon work W, the holding circuit will be the same except that from conductor 137 it will extend through 138—PS2—149—S3 and 147 to A3 instead of from 137 through LS2—148—S3 and 147 to A3.

Closing switch A1 and A2 establishes a circuit (130—141—A1—142—71—144—A2—143—131) to energize solenoid 71 and also establishes a circuit (130—141—A1—142—118—145—LS1—144—A2—143—131) to energize solenoid 118.

Energizing solenoid 71 will cause it to shift control valve member 57 to the position shown in Fig. 3, thereby causing pump 21 to discharge liquid into channel 25 and to receive liquid from channel 26 as previously explained. Shifting control valve member 57 to the position shown in Fig. 3 also opens channel 127 to drain channel 65 to permit spring 126 to move decompression valve member 21 toward the right to block channel 25^b.

Energizing solenoid 118 will cause it to shift pilot valve 110 to open port 114 to port 113 and then the pressure created by pistons 6 and 6^a due to the weight of platen 3 and associated parts will act upon the left end of plunger 87 and move it and valve 86 toward the right, only a low pressure being required to move plunger 87 for the reason that it can expel liquid from the right end of bore 83 through throttle valve 116, channel 115 and pilot valve casing 112

at a rate determined by valve 116 which is provided to prevent plunger 87 from moving too rapidly.

As soon as valve 86 moves away from its seat 89, the pressure acts upon the combined areas of valve 86 and piston 87 so that only a very low pressure is required to move valve 86 so far from seat 89 that it offers no resistance to the flow of liquid through resistance valve 82.

If the resistance to the downward movement of platen 3 is sufficient to prevent it from descending by gravity, pump 21 will tend to discharge through resistance valve 33 the resistance of which will cause pressure to rise and liquid to flow through channel 35 to the right end of bore 29 and shift valve 34 toward the left to block port 28 and uncover port 27. The liquid discharged by pump 21 will then flow through channel 25 to the upper ends of cylinders 5 and 5^a and cause pistons 6 and 6^a to move platen 3 downward at a high speed which is proportional to the displacement of pump 21. Pistons 6 and 6^a will expel liquid from cylinder 5 and 5^a through channel 85, resistance valve 82 and channel 26 to pump 21 which will draw the additional liquid it requires from reservoir 31 through check valve 32, bore 29 and channel 26.

If platen 3 and the parts movable therewith have sufficient weight to cause descent by gravity, pistons 6 and 6^a will expel liquid from cylinder 5 and 5^a through channel 85 and resistance valve 82 into channel 26 and a part of this liquid will tend to flow through bore 29 and resistance valve 33 into reservoir 31 but differential valve 34 at this time blocks port 27 and prevents the discharge of liquid into reservoir 31, thereby causing pump 21 to meter the discharge from cylinders 5 and 5^a so that platen 3 descends at a high speed which is proportional to the displacement of pump 21. Liquid to make up the difference between the volume discharged by pump 21 and the volume required to fill the upper ends of cylinders 5 and 5^a is drawn from reservoir 31 through check valve 32 and bore 29 into channel 25.

As soon as platen 3 starts to move downward, actuator 135 will move out of engagement with limit switch LS3 and permit it to close. During downward movement of platen 3, cylinder 9 will be supplied with liquid from tank 16 through passage 15 and surge valve casing 10. Platen 3 will continue downward at high speed until die 4 engages work W unless work W is of such nature that it might be damaged by die 4 striking it at high speed in which case actuator 132 and limit switch LS1 are so arranged that actuator 132 will open switch LS1 just before die 4 engages work W.

If platen 3 is descending by gravity so that differential valve 34 is in the position shown in Fig. 1, the engagement of die 4 with work W or the closing of valve 86 due to the operation of limit switch LS1 will cause pump 21 to tend to discharge through resistance valve 33 the resistance of which will cause pressure to rise and liquid to flow through channel 35 to the right end of bore 29 and shift differential valve 34 toward the left to block port 28 and uncover port 27.

If limit switch LS1 is not operated before die 4 engages work W, the resistance of work W will cause pump pressure to rise until it becomes high enough to open resistance valve 37 and then liquid will flow therethrough and through channel 38 to cylinder 17 and cause piston 18 to

shift surge valve 11 to the position shown in Fig. 5 to block communication between cylinder 9 and surge tank 16 and to open cylinder 9 to port 13. The liquid from pump 25 will then flow through channel 25 and 25^a and surge valve casing 10 to cylinder 9 so that platen 3 is moved downward at a slow speed by liquid acting upon the combined areas of ram 8 and pistons 6 and 6^a.

If limit switch LS1 is operated before die 4 engages work W, it will deenergize solenoid 118 and thereby permit spring 117 to shift pilot valve 113 upward to block port 114. The pressure prevailing in channel 85 and port 84 will then extend through channel 102, port 95, slot 98 in pressure responsive valve 90, port 96 and channel 101 to the right end of bore 83 so that piston 87 is hydrostatically balanced and spring 88 is then able to move valve 86 against its seat 89 to close port 80.

With port 80 closed, the downward movement of pistons 6 and 6^a causes the pressure in port 84 to rise and extend through channel 102 and act upon piston 93 of pressure responsive valve 90. The pressure will continue to rise until it becomes high enough to overcome the resistance of spring 99 and then it will move valve 90 toward the right until port 97 is opened to port 96, thereby opening the right end of bore 83 to drain and permitting the pressure in port 84 to move piston 87 and valve 86 toward the right to open port 80 so that liquid can flow from the lower ends of cylinders 5 and 5^a through channel 85 and resistance valve 82 into return channel 26.

The pressure required to shift valve 90 is at least as great as the pressure required to open resistance valve 37 so that valve 37 opens and permits liquid to flow therethrough and shift surge valve 11 to direct liquid from pump 21 to cylinder 9 and cause platen 3 to move downward at slow speed before resistance valve 22 opens.

In order that solenoid 72 may not be operated and initiate an upstroke of platen 3 when limit switch LS2 or pressure switch PS2 is operated at the end of the down stroke, pressure switch PS1 is so adjusted that it will open and break the connection between solenoid 72 and power conductor 130 before the pressure becomes high enough to open resistance valve 37.

Platen 3 will continue downward at slow speed and cause die 4 to operate upon work W until either limit switch LS2 or pressure switch PS2 is operated depending upon the adjustment of the press as previously explained.

Operating limit switch LS2 or pressure switch PS2 will cause magnet B3 to be energized and close switches B1 and B2. If limit switch LS2 is operated, the circuit (131-136-S2-137-LS2-150-LS3-151-B3-152-130) for energizing magnet B3 will extend therethrough. If pressure switch PS2 is operated, the circuit for energizing magnet B3 will be the same except that it will extend therethrough and through conductor 138 instead of through limit switch LS2.

Closing switch B2 establishes a circuit (131-136-S2-137-B2-150-LS3-151-B3-152-130) to keep magnet B3 energized and switches B1 and B2 closed. Closing switch B1 has no effect for the reason that pressure switch PS1 is open.

Operating limit switch LS2 or pressure switch PS2 also breaks the circuit through magnet A4 to deenergize it and thereby permit switches A1, A2 and A3 to open. Opening switch A1 has no effect as the circuit therethrough was broken by limit switch LS2 or by pressure switch PS2.

Opening switches A2 and A3 breaks the circuit through solenoid 71 to deenergize it. If limit switch LS1 is not employed or has not been operated, opening switches A1 and A2 will also deenergize solenoid 118 to permit pilot valve 110 to close as previously explained.

Deenergizing solenoid 71 permits spring 66 to shift control valve member 57 to the position shown in Fig. 1 so that the displacement of pump 21 is reduced to zero as previously explained and liquid from gear pump 21 may flow through channel 52, valve casing 58 and channel 127 to bore 122 and shift valve member 121 to open channel 25^b to drain channel 65. Liquid may now escape from cylinder 9 through surge valve casing 10, channels 25^a and 25^b and decompression valve 120 into drain channel 65 until the pressure in cylinder 9 drops sufficiently to permit pressure switch PS1 to close.

Closing pressure switch PS1 establishes a circuit (131-136-S2-137-153-B1-154-72-155-PS1-156-130) to energize solenoid 72 which will shift control valve member 57 to the position shown in Fig. 4 to thereby cause pump 21 to discharge liquid into channel 26 as previously explained.

The liquid discharged by pump 21 will first shift differential valve 34 to the position shown in Fig. 1 and then it will flow through channel 26, open resistance valve 32 and flow therethrough and through channel 85 to the lower ends of cylinders 5 and 5^a and tend to raise pistons 6 and 6^a but the weight of platen 3 and associated parts will cause pressure to rise and liquid to flow through channel 85^a to cylinder 17 and cause piston 18 to shift surge valve 11 to the position shown in Fig. 1, thereby blocking port 13 and opening port 14 to passage 15. The liquid delivered to the lower ends of cylinders 5 and 5^a will then cause pistons 6 and 6^a to raise platen 3, and ram 8 will eject liquid freely from cylinder 9 through surge valve casing 10 and passage 15 into tank 16.

If pressure switch PS2 is effective, it will operate as soon as the pressure in cylinder 9 is reduced and, if limit switch LS2 is effective, it will operate as soon as platen 3 starts upward but solenoid 72 will not be deenergized for the reason that magnet B3 is kept energized by the circuit through switch B2. As platen 3 moves upward, actuator 132 permits limit switch LS1 to close but it cannot cause solenoid 118 to be energized for the reason that switches A1 and A2 are open. When platen 3 reaches the end of its up stroke, actuator 135 opens limit switch LS3 to deenergize magnet B3 which permits switches B1 and B2 to open.

Opening switch B1 deenergizes solenoid 72 and permits spring 67 to shift control valve member 57 to its neutral position as shown in Fig. 1 and thereby cause the displacement of pump 21 to be reduced to zero so that no liquid is delivered thereby as previously explained. The press has now completed a cycle of operation and it comes to rest with the parts in the positions shown in Fig. 1 except that, as soon as valve member 57 is shifted to its neutral position, decompression valve 120 is opened by gear pump liquid and held open thereby until another cycle of operation is initiated or the pump is stopped.

The invention herein set forth is susceptible of various modifications and adaptations without departing from the scope thereof as hereafter claimed.

The invention is hereby claimed as follows:

1. The combination with cylinder means having a work chamber and a return chamber, ram means mounted in said cylinder means and a pump connected to both of said chambers, of means including a central valve for controlling the delivery of liquid to said chambers, means for operating said control means to direct liquid from said pump to said work chamber and from said return chamber to said pump to effect a working stroke of said ram means, means operable at the end of said working stroke for effecting operation of said control means to stop delivery of liquid to said work chamber, a normally closed decompression valve adapted when opened to permit liquid to escape from said work chamber to reduce the pressure therein, means including said control valve for directing liquid to said decompression valve to open the same upon said control means being operated to stop delivery of liquid to said cylinder means, means responsive to a reduction in pressure in said work chamber for operating said control means to direct liquid from said pump to said return chamber to effect a return stroke of said ram means, and means responsive to said ram means reaching the end of said return stroke for operating said control means to stop delivery of liquid to said return chamber and bring said ram means to rest.

2. The combination with cylinder means having a work chamber and a return chamber, ram means mounted in said cylinder means and a pump connected to both of said chambers, of means including a control valve for controlling the delivery of liquid to said chambers, means for operating said control means to direct liquid from said pump to said work chamber and from said return chamber to said pump to effect a working stroke of said ram means, means responsive to the pressure in said work chamber reaching a predetermined maximum during said working stroke for effecting operation of said control means to stop delivery of liquid to said work chamber, a normally closed decompression valve adapted when opened to permit liquid to escape from said work chamber to reduce the pressure therein, means including said control valve for directing liquid to said decompression valve to open the same upon said control means being operated to stop delivery of liquid to said cylinder means, means responsive to a reduction in pressure in said work chamber for operating said control means to direct liquid from said pump to said return chamber to effect a return stroke of said ram means, and means responsive to said ram means reaching the end of said return stroke for operating said control means to stop delivery of liquid to said return chamber and bring said ram means to rest.

3. The combination with cylinder means having a work chamber and a return chamber, ram means mounted in said cylinder means and a pump connected to both of said chambers, of means including a control valve for controlling the delivery of liquid to said chambers, means for operating said control means to direct liquid from said pump to said work chamber and from said return chamber to said pump to effect a working stroke of said ram means, means operable by said ram means at the end of said working stroke for effecting operation of said control means to stop delivery of liquid to said work chamber, a normally closed decompression valve adapted when opened to permit liquid to escape from said work chamber to reduce the pressure

therein, means including said control valve for directing liquid to said decompression valve to open the same upon said control means being operated to stop delivery of liquid to said cylinder means, means responsive to a reduction in pressure in said work chamber for operating said control means to direct liquid from said pump to said return chamber to effect a return stroke of said ram means, and means responsive to said ram means reaching the end of said return stroke for operating said control means to stop delivery of liquid to said return chamber and bring said ram means to rest.

4. In a downward acting hydraulic press provided with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, a surge tank, a normally open surge valve for controlling communication between said tank and said work chamber, and a servo-motor for operating said surge valve, the combination of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and being adjustable to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, means for causing said pump to deliver liquid in a direction to effect a working stroke of said ram means, means for causing said servo-motor to close said surge valve in response to said ram means approaching the end of said working stroke to thereby enable said pump to create pressure in said work chamber, means operable at the end of said working stroke for causing the delivery of said pump to be reduced to zero, means responsive to operation of said last named means for permitting liquid to escape from said work chamber to reduce the pressure therein, means operable after said last named means has been operated for causing liquid from said pump to flow to said servo-motor and cause it to open said surge valve and then flow to said return chamber and effect a return stroke of said ram means, and means operable in response to said ram means reaching the end of said return stroke for causing the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

5. In a downward acting hydraulic press provided with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, a surge tank, a normally open surge valve for controlling communication between said tank and said work chamber, and a servo-motor for operating said surge valve, the combination of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and being adjustable to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, means for causing said pump to deliver liquid in a direction to effect a working stroke of said ram means, means for causing said servo-motor to close said surge valve in response to said ram means approaching the end of said working stroke to thereby enable said pump to create pressure in said work chamber, means operable at the end of said working stroke for causing the delivery of said pump to be reduced to zero, means responsive to operation of said last named means for permitting liquid to escape from said work chamber to reduce the pressure therein, means responsive to the pressure in said work chamber reaching a predetermined minimum for causing liquid from said pump to flow to said

servo-motor and cause it to open said surge valve and then flow to said return chamber and effect a return stroke of said ram means, and means operable in response to said ram means reaching the end of said return stroke for causing the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

6. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and having control means adjustable to cause it to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, said control means including a control valve which is normally in a neutral position in which it effects reduction of pump delivery to zero and simultaneously directs liquid to said decompression valve to open the same and which is shiftable to one or the other of two positions to cause said pump to deliver liquid to one or the other of said chambers, means for shifting said control valve to a position to cause said pump to deliver liquid to said work chamber and to draw liquid from said return chamber to effect a working stroke of said ram means, means operable at the end of said working stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero and to simultaneously cause said decompression valve to open, means operable after said decompression valve has opened for shifting said control valve to a position to cause said pump to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

7. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and having control means adjustable to cause it to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, said control means including a control valve which is normally in a neutral position in which it effects reduction of pump delivery to zero and simultaneously directs liquid to said decompression valve to open the same and which is shiftable to one or the other of two positions to cause said pump to deliver liquid to one or the other of said chambers, means for shifting said control valve to a position to cause said pump to deliver liquid to said work chamber and to draw liquid from said return chamber to effect a working stroke of said ram means, means operable at the end of said working stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero and to simultaneously cause said decompression valve to open, means responsive to the pressure in said work chamber reaching a predetermined minimum for shifting said control valve to a position to

cause said pump to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for returning said valve to neutral to cause the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

8. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and having control means adjustable to cause it to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, said control means including a control valve which is normally in a neutral position in which it effects reduction of pump delivery to zero and simultaneously directs liquid to said decompression valve to open the same and which is shiftable to one or the other of two positions to cause said pump to deliver liquid to one or the other of said chambers, means for shifting said control valve to a position to cause said pump to deliver liquid to said work chamber and to draw liquid from said return chamber to effect a working stroke of said ram means, means responsive to the pressure in said work chamber reaching a predetermined maximum during said working stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero and to simultaneously cause said decompression valve to open, means operable after said decompression valve has opened for shifting said control valve to a position to cause said pump to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

9. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and having control means adjustable to cause it to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, said control means including a control valve which is normally in a neutral position in which it effects reduction of pump delivery to zero and simultaneously directs liquid to said decompression valve to open the same and which is shiftable to one or the other of two positions to cause said pump to deliver liquid to one or the other of said chambers, means for shifting said control valve to a position to cause said pump to deliver liquid to said work chamber and to draw liquid from said return chamber to effect a working stroke of said ram means, means operable by said ram means at the end of said working stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero and to simultaneously cause said decompression valve to open, means operable after said decompression valve has opened for shifting said control valve to a position to cause said pump

to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for returning said control valve to neutral to cause the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

10. In a downward acting hydraulic press, the combination with cylinder means having a work chamber and a return chamber, ram means mounted in said cylinder means and a pump connected to both of said chambers, of means for controlling the delivery of liquid to said chambers, a normally closed resistance valve connected in series with said return chamber, means responsive to pressure in said return chamber for holding said resistance valve closed to prevent the discharge of liquid from said return chamber and thereby support said ram means when said press is idle, means for operating said control means to direct liquid from said pump to said work chamber to effect a working stroke of said ram means, means operable in unison with said control means for rendering said holding means ineffective to thereby permit said resistance valve to open, means operable at the end of said working stroke for effecting operation of said control means to stop delivery of liquid to said work chamber, means responsive to operation of said last named means for permitting liquid to escape from said work chamber to reduce the pressure therein, means responsive to a reduction in pressure in said work chamber for operating said control means to direct liquid from said pump to said return chamber to effect a return stroke of said ram means, and means responsive to said ram means reaching the end of said return stroke for operating said control means to stop delivery of liquid to said return chamber and bring said ram means to rest.

11. In a downward acting hydraulic press, the combination with cylinder means having a work chamber and a return chamber, ram means mounted in said cylinder means and a pump connected to both of said chambers, of means for controlling the delivery of liquid to said chambers, a normally closed resistance valve connected in series with said return chamber, means responsive to pressure in said return chamber for holding said resistance valve closed to prevent the discharge of liquid from said return chamber and thereby support said ram means when said press is idle, means for operating said control means to direct liquid from said pump to said work chamber to effect a working stroke of said ram means, means operable in unison with said control means for rendering said holding means ineffective to thereby permit said resistance valve to open, means responsive to said ram means reaching a given point during said working stroke for rendering said holding means effective and thereby cause said resistance valve to offer resistance to further downward movement of said ram means, means operable at the end of said working stroke for effecting operation of said control means to stop delivery of liquid to said work chamber, means responsive to operation of said last named means for permitting liquid to escape from said work chamber to reduce the pressure therein, means responsive to a reduction in pressure in said work chamber for operating said control means to direct liquid from said pump to said return chamber to effect a return stroke of said ram means, and means responsive to said ram means reaching the end of said return stroke for operating said control

means to stop delivery of liquid to said return chamber and bring said ram means to rest.

12. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and being adjustable to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed resistance valve connected in series with said return chamber, means responsive to pressure in said return chamber for holding said resistance valve closed to prevent the discharge of liquid from said return chamber and thereby support said ram means when said press is idle, means for causing said pump to deliver liquid to said work chamber to effect a working stroke of said ram means, means operable in unison with said last named means for rendering said holding means ineffective to thereby permit said resistance valve to open, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, means operable at the end of said working stroke for causing the delivery of said pump to be reduced to zero and for simultaneously causing said decompression valve to open and permit liquid to escape from said work chamber to thereby reduce the pressure therein, means responsive to the pressure in said work chamber reaching a predetermined minimum for causing said pump to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for causing the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

13. The combination, with cylinder means having a work chamber and a return chamber and ram means mounted in said cylinder means, of a reversible pump having one side thereof connected to said work chamber and the other side thereof connected to said return chamber and being adjustable to deliver liquid to one or the other of said chambers or to have its delivery reduced to zero, a normally closed resistance valve connected in series with said return chamber, means responsive to pressure in said return chamber for holding said resistance valve closed to prevent the discharge of liquid from said return chamber and thereby support said ram means when said press is idle, means for causing said pump to deliver liquid to said work chamber to effect a working stroke of said ram means, means operable in unison with said last named means for rendering said holding means ineffective to thereby permit said resistance valve to open, means responsive to said ram means reaching a given point during said working stroke for rendering said holding means effective and thereby cause said resistance valve to offer resistance to further downward movement of said ram means, a normally closed decompression valve adapted when open to permit liquid to escape from said work chamber to reduce the pressure therein, means operable at the end of said working stroke for causing the delivery of said pump to be reduced to zero and for simultaneously causing said decompression valve to open and permit liquid to escape from said work chamber to thereby reduce the pressure therein, means responsive to the pressure in said work chamber reaching a predetermined minimum for

causing said pump to deliver liquid to said return chamber to effect a return stroke of said ram means, and means operable at the end of said return stroke for causing the delivery of said pump to be reduced to zero to thereby bring said ram means to rest.

14. In a downward acting hydraulic press having cylinder means including a work chamber and a return chamber, ram means mounted in said cylinder means, means including a pump for supplying motive liquid to said cylinder means, and control means for directing liquid from said pump to said chambers selectively to effect working and return strokes of said ram means, the combination of a resistance valve connected in series with said return chamber, means for holding said resistance valve closed to prevent the discharge of liquid from said return chamber and thereby support said ram means when said press is idle, means operated in response to said control means being operated to direct liquid to said work chamber for rendering said holding means ineffective to thereby permit said resistance valve to open, and means responsive to said ram means reaching a given point during said working stroke for rendering said holding means effective and thereby cause said resistance valve to offer resistance to further downward movement of said ram means.

15. In a downward acting hydraulic press having cylinder means including a work chamber and a return chamber, ram means mounted in said cylinder means, means including a pump for supplying motive liquid to said cylinder means, and control means for directing liquid from said pump to said chambers selectively to effect working and return strokes of said ram means, the combination of a resistance valve having an axial bore closed at one end and an axial port and a peripheral port arranged at the other end of said bore, a piston fitted in said bore, a valve member fixed to said piston to control communication between said ports, a spring normally urging said valve member against said axial port to close the same, fluid channels connecting said axial port and said peripheral port to said pump and said return chamber respectively, channel means connecting said peripheral port to the closed end of said bore to thereby cause the pressure in said peripheral port to act upon said piston and urge said valve member against said axial port, choke means arranged in said channel means for limiting the flow of liquid therethrough, a normally closed pilot valve connected to the closed end of said bore and adapted when open to permit liquid to escape therefrom and thereby permit the pressure in said peripheral port to shift said valve member and open communication between said ports, and means operated in response to said control means being operated to direct liquid to said work chamber for opening said pilot valve.

16. In a downward acting hydraulic press having cylinder means including a work chamber and a return chamber, ram means mounted in said cylinder means, means including a pump for supplying motive liquid to said cylinder means, and control means for directing liquid from said pump to said chambers selectively to effect working and return strokes of said ram means, the combination of a resistance valve having an axial bore closed at one end and an axial port and a peripheral port arranged at the other end of said bore, a piston fitted in said bore, a valve member fixed to said piston to control

communication between said ports, a spring normally urging said valve member against said axial port to close the same, fluid channels connecting said axial port and said peripheral port to said pump and said return chamber respectively, channel means connecting said peripheral port to the closed end of said bore to thereby cause the pressure in said peripheral port to act upon said piston and urge said valve member against said axial port, choke means arranged in said channel means for limiting the flow of liquid therethrough, a normally closed pilot valve connected to the closed end of said bore and adapted when open to permit liquid to escape therefrom and thereby permit the pressure in said peripheral port to shift said valve member and open communication between said ports, means operated in response to said control means being operated to direct liquid to said work chamber for opening said pilot valve, means responsive to said ram means reaching a given point during a working stroke for closing said pilot valve to thereby cause said valve member to close said axial port, and pressure responsive means for permitting said valve member to be moved away from said seat upon the pressure in said peripheral port reaching a predetermined maximum.

17. In a downward acting hydraulic press having cylinder means including a work chamber and a return chamber, ram means mounted in said cylinder means, means including a pump for supplying motive liquid to said cylinder means, and control means for directing liquid from said pump to said chambers selectively to effect working and return strokes of said ram means, the combination of a resistance valve having an axial bore closed at one end and an axial port and a peripheral port arranged at the other end of said bore, a piston fitted in said bore, a valve member fixed to said piston to control communication between said ports, a spring normally urging said valve member against said axial port to close the same, fluid channels connecting said axial port and said peripheral port to said pump and said return chamber respectively, channel means connecting said peripheral port to the closed end of said bore to thereby cause the pressure in said peripheral port to act upon said piston and urge said valve member against said axial port, a pressure responsive valve arranged in said channel means and providing a choke for limiting the flow of liquid from said peripheral port to the closed end of said bore, a normally closed pilot valve connected to the closed end of said bore and adapted when open to permit liquid to escape therefrom and thereby permit the pressure in said peripheral port to shift said valve member and open communication between said ports, means operated in response to said control means being operated to direct liquid to said work chamber for opening said pilot valve, and means responsive to said ram means reaching a given point during a working stroke for closing said pilot valve to thereby cause said valve member to close said axial port, said pressure responsive valve being adapted to open the closed end of said bore to drain in response to the pressure in said peripheral port reaching a predetermined maximum to thereby permit the pressure in said peripheral port to move said valve member away from said axial port so that liquid from said return chamber may flow therethrough.

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