June 3, 1941. R. W. DINZL 2,244,420

CONTROL SYSTEM FOR HYDRAULIC PRESSES

Filed April 21, 1938 3 Sheets-Sheet 1

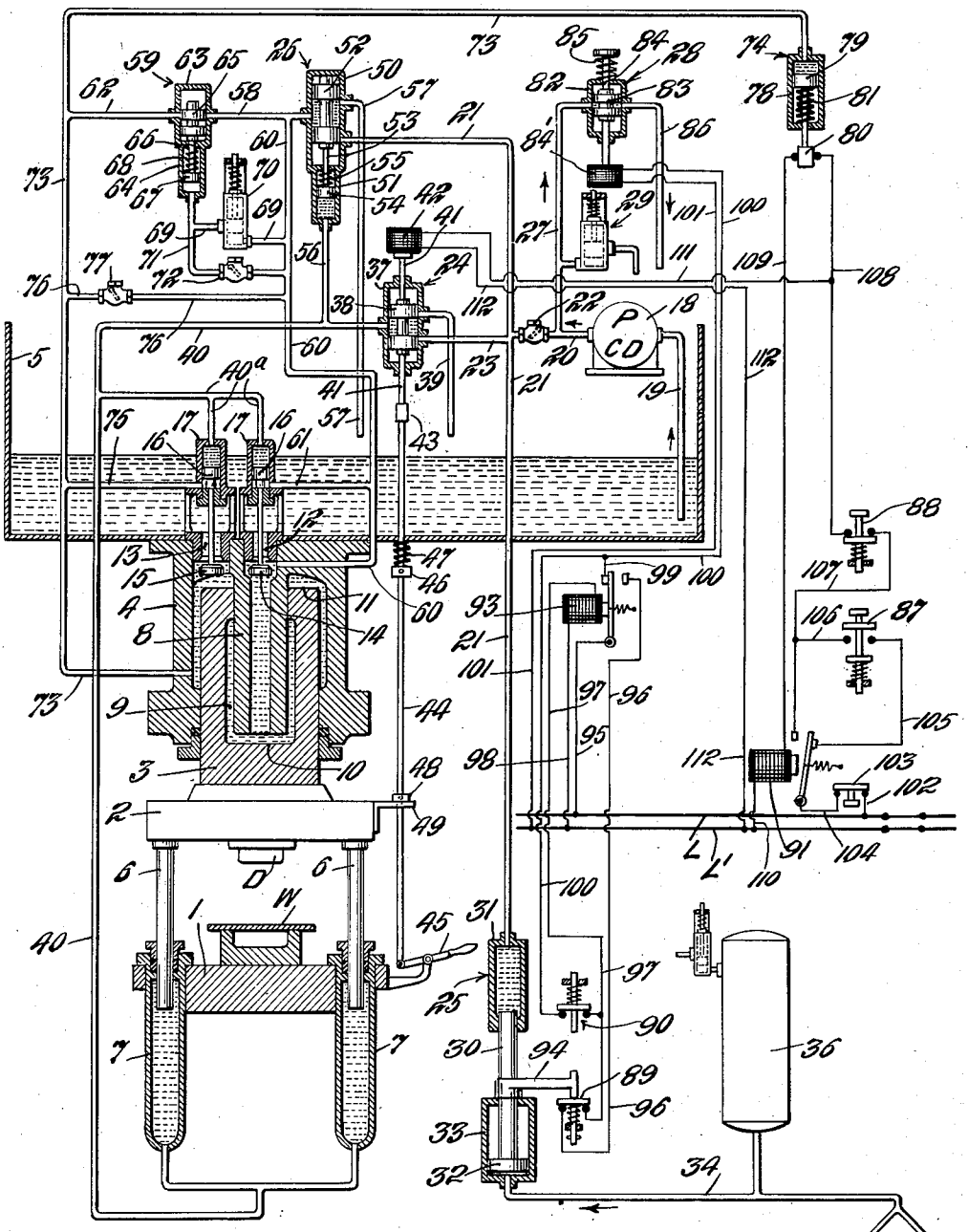


Fig. 1.

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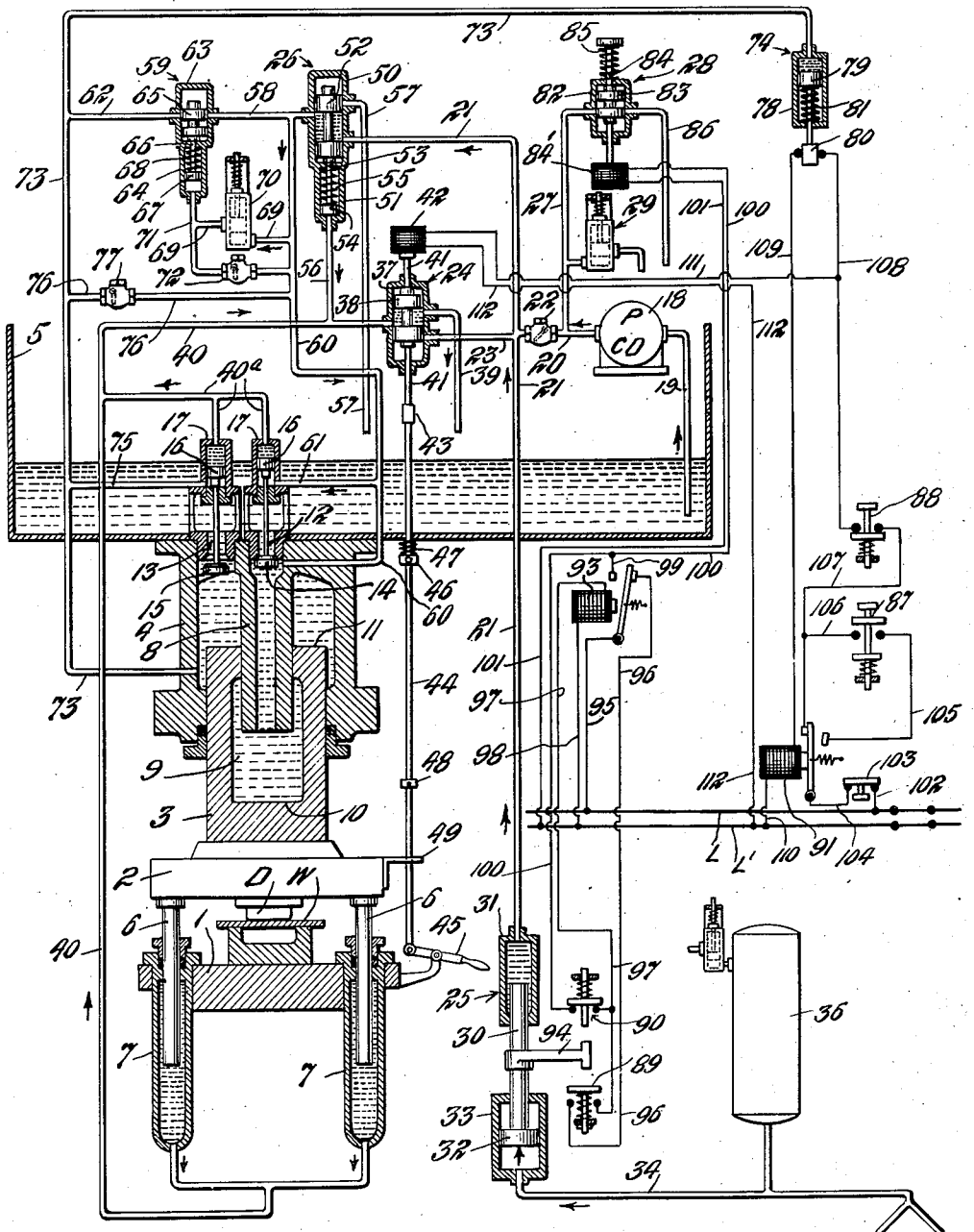


Fig. 2.

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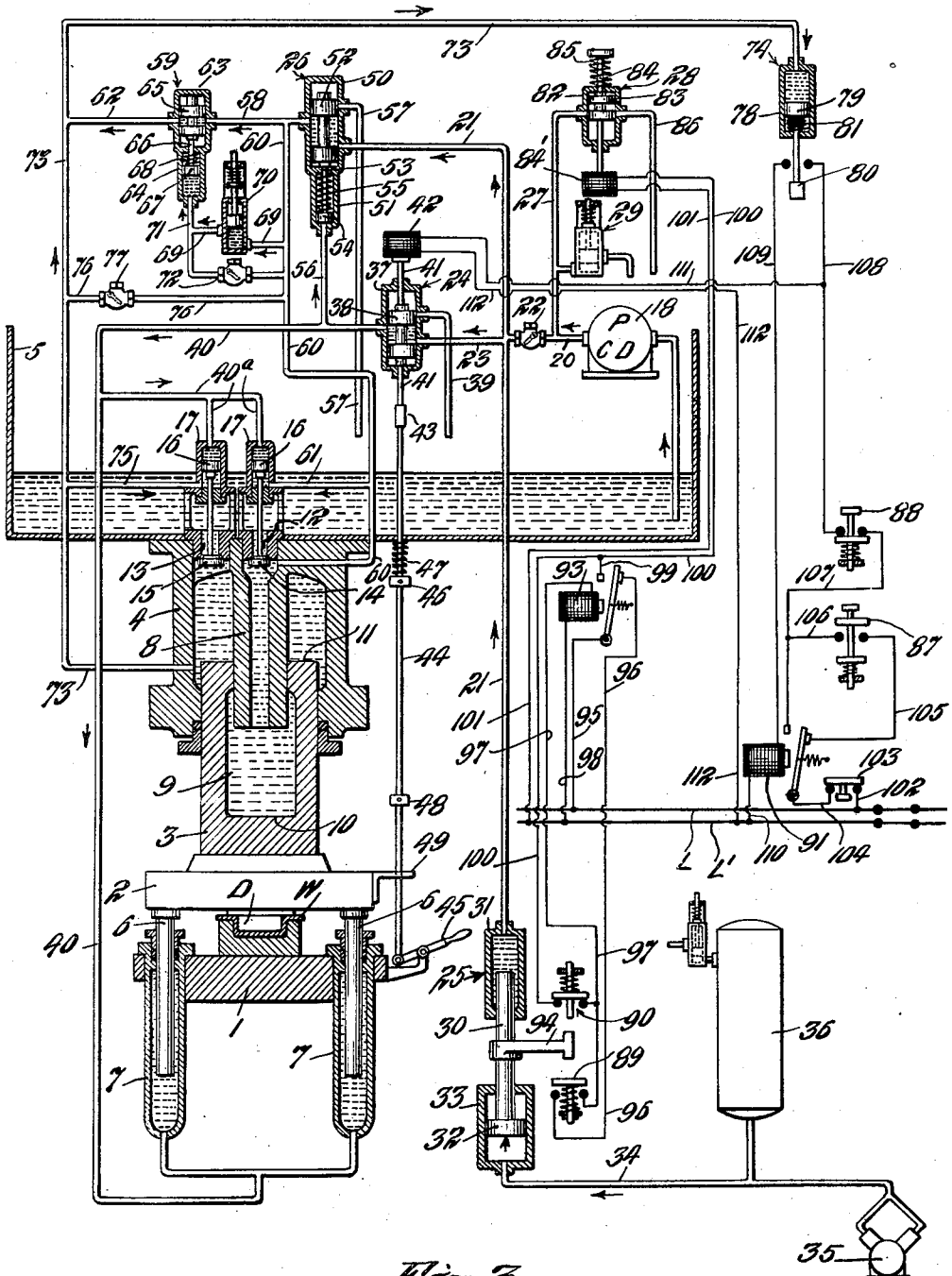


Fig. 3.

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CONTROL SYSTEM FOR HYDRAULIC PRESSES

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Application April 21, 1938, Serial No. 203,301

4 Claims. (Cl. 60—52)

This invention relates more particularly to improvements in press apparatus of the type wherein a reciprocable press head is advanced on a working stroke by a hydraulically operated mechanism and, after completion of the pressing operation, is retracted automatically by another hydraulically operated mechanism, the operation of said mechanisms being controlled by a hydraulic circuit including a pump. Usually, in such an apparatus, a complicated and costly pump of a variable delivery, or variable stroke, type has been required to supply the said advancing and retracting mechanisms with hydraulic pressure. Important objects of the present invention are to provide, for such a press, an improved control system designed for satisfactory employment of a simple and inexpensive constant delivery pump, and to provide for employment of the pump to build up hydraulic pressure in an accumulator during the idle periods between working strokes of the press head. Provision is made for employment of the pressure so accumulated in combination with pressure supplied directly by the pump to operate the press head.

Other objects of the invention will appear hereinafter.

In the drawings,

Fig. 1 is a diagrammatic sectional view of the press apparatus, with the reciprocable press head in retracted position and with the control system in condition to maintain the press head idle;

Fig. 2 is a view similar to Fig. 1, with the control system in condition to cause advance of the reciprocable press head and with the latter advanced sufficiently to commence the pressing operation, and

Fig. 3 is a view similar to Figs. 1 and 2, with the reciprocable press head advanced sufficiently to complete the pressing operation, and with parts of the control system positioned to cause retraction of the press head.

My improved control system is shown in connection with a press having a fixed lower press head 1 and a reciprocable upper press head 2. The head 2 has an upwardly extending ram 3 reciprocable in a fixed, vertical hydraulic cylinder 4. A surge tank 5 is mounted upon the upper end of said cylinder and is in valved communication therewith. Hydraulic push-back mechanism is provided to retract, or elevate, the press head 2. This mechanism includes depending rams or plungers 6 borne by the press head 2 and reciprocable in fixed, vertical, hydraulic cylinders 7.

The main press cylinder 4 is formed with a central tubular extension 8 depending from its upper end and extending into a central cylindrical recess 9 in the ram 3. Said tubular extension has a close sliding fit in the upper end of recess 9 and it serves to conduct hydraulic pressure to the bottom area 10 of the recess. An upper end area 11 of the ram, surrounding the tubular extension 8, is subject to the fluid pressure admitted to the main cylinder. The surge tank communicates with the bore of the tubular extension 8 through a port 12 and communicates with the cylinder 4 through a port 13. Downwardly opening surge valves 14 and 15 control flow through the ports 12 and 13 respectively. These valves are hydraulically operated. Each has an upwardly extending stem bearing a piston 16 working in a small fixed cylinder 17. By admission of hydraulic pressure to these cylinders the valves are opened and closed, as will be explained hereinafter.

A constant delivery pump 18 supplies hydraulic pressure for operating the mechanisms for advancing and retracting the press head 2. This pump is shown diagrammatically. It may be of a simple conventional type and it is continuously power driven while the press head is being moved and also while it is idle between pressing operations. A pipe 19 conducts fluid from the surge tank to the pump inlet. Preferably the fluid is oil. A discharge pipe 20 leads from the pump outlet, is connected to a pipe 21 and has a check valve 22 opening toward the latter pipe. From pipe 21 a pipe 23 leads to a main control valve device 24. One end of pipe 21 is connected to a hydraulic pressure accumulator 25 and the opposite end of the pipe is connected to an auxiliary valve device 26. From a point between the pump and check valve 22 a pipe 27 leads from the pump discharge pipe 20 to a valve device 28 for bypassing the pump discharge back to the surge tank, as will be explained hereinafter. A safety valve device 29 is also connected to pipe 27 at an intermediate point.

The accumulator 25 is of a hydro-pneumatic type. A plunger 30 has one end reciprocable in a hydraulic pressure cylinder 31. The opposite end of the plunger bears a piston 32 of liberal diameter fitted to reciprocate in an air cylinder 33. A supply pipe 34 leads to the outer end of the air cylinder and has a power driven air pump 35 and an air storage tank 36 connected thereto for maintaining a constant pneumatic pressure upon the outer face of piston 32. This pressure urges the plunger 30 into the hydraulic cylinder 31 to exert pressure upon the oil therein.

Main control valve device 24 comprises a vertical cylindrical casing 37 within which a double-headed piston valve 38 is fitted to reciprocate. Communication between pipe 23 and the interior of the valve casing is opened and closed by reciprocation of one of the piston heads. Reciprocation of the other head opens and closes communication between the interior of the casing and a discharge pipe 39 leading from the casing and directed to discharge into the surge tank. A pipe 40 leads from the casing at a point between the valve heads and has, at its farther end, branch piping connecting it to the lower ends of the push-back cylinders 7. Pipe 40 also has branch piping 40a connecting it to the upper ends of the small surge valve cylinders 17. The control valve has a stem 41 extending from opposite ends of the casing. The upper end portion of said stem forms a core for a solenoid coil 42. At 43 a vertical extension rod 44 is joined to the lower end of the valve stem, extends downwardly to a point near the lower press head and is connected to a lever 45 for manual operation of the control valve when desired. At a point below the surge tank, rod 44 bears an adjustable abutment 46, and a spring 47 acts upon said abutment to constantly urge the rod and the control valve downwardly. Another abutment 48 is borne by the rod for vertical adjustment thereon and is engageable by an abutment 49, borne by the reciprocable press head, to force the rod and the control valve upwardly when the press head rises to a certain height.

Auxiliary valve device 26 includes a casing forming two end to end cylinders 50 and 51. A double-headed piston valve 52 is fitted to reciprocate in cylinder 50 and has a stem 53 extending into cylinder 51 and bearing a piston 54. A spring 55 is interposed between piston 54 and the upper end of cylinder 51 and constantly urges said piston and the valve downwardly, with reference to the drawings. The piston and valve are forced upwardly against the resistance of the spring by admission of fluid pressure from pipe 40 through a branch pipe 56 to the lower end of cylinder 51. Reciprocation of the valve opens and closes communication between pipe 21 and the interior of cylinder 50, and also between the interior of said cylinder and a discharge pipe 57 directed to discharge into the surge tank. A pipe 58 leads from cylinder 50, at a point between the valve heads, and is connected to another auxiliary valve device 59. A branch pipe 60 leads from pipe 58 to the upper end of the bore in the tubular extension 8 of the main press cylinder. A branch pipe 61 also leads from the pipe 60 to the lower end of small cylinder 17 associated with the surge valve 14. Pipe 60 also has other branches whose purpose will be explained hereinafter.

Auxiliary valve device 59 is similar to valve device 26 in structure except that it controls communication only between pipe 58 and a pipe 62. It includes a casing forming end to end cylinders 63 and 64. A double-headed piston valve 65 is fitted to reciprocate in cylinder 63 and has a stem 66 extending into cylinder 64 and bearing a piston 67. A spring 68 constantly urges piston 67 and valve 65 downwardly, with reference to the drawings, to close communication between pipes 58 and 62. The piston and valve are forced upwardly against the resistance of the spring to open communication between pipes 58 and 62 by admission of hydraulic pressure to the lower end of cylinder 64. Said pressure is admitted from pipe 60 through a branch pipe 69. The latter has a spring-loaded valve device 70 to resist flow to cylinder 64. Return branch piping 71 leads from pipe 69 and cylinder 64 back to pipe 60. This piping by-passes the valve device 70 and has a check valve 72 opening toward pipe 60.

Pipe 62, which leads from auxiliary valve device 59, is connected to a pipe 73. One end of pipe 73 leads to the main press cylinder 4 for delivery of pressure to act upon the ram surface 11. The opposite end of pipe 73 is connected to a pressure limiting device 74. A branch pipe 75 leads from pipe 73 to the lower end of the small cylinder 17 associated with surge valve 15. Another branch pipe 76 leads from pipe 73 to pipe 60 and has a check valve 77 opening toward the latter.

The pressure limiting device 74 includes a cylinder 78 into one end of which the pipe 73 opens. A piston 79 fitted to reciprocate in said cylinder has a stem extending from the opposite end of the cylinder and bearing an electrical switch element 80. Reciprocation of piston 79 and switch member 80 effects circuit opening and closure as will be described hereinafter. A spring 81 constantly urges the piston toward the end of the cylinder to which pipe 73 is connected.

The valve device 28 for by-passing the pump discharge includes a cylindrical casing 82. A piston valve 83 is fitted to reciprocate in the cylinder and has a stem 84 projecting from the opposite ends of the cylinder. At one end of the cylinder there is a spring 85 acting upon the valve stem to constantly urge the valve to close communication between pipe 27 and a discharge pipe 86 directed to discharge into the surge tank. The opposite end portion of the valve stem 84 forms a core for a solenoid coil 84'. By energizing said coil the valve is shifted to open communication between pipes 27 and 86.

The operation of the main control valve device 24 and the operation of the pump by-pass valve device are controlled by an electrical system. This system includes manually operable push button switches 87 and 88, switches 89 and 90 operable by reciprocation of the accumulator plunger 30, the switch element 80, relays 91 and 93, line wires L and L' and wiring which will be traced in the following description of the operation of the press apparatus.

Assume that the various parts of the apparatus are in the positions shown in Fig. 1, except that by-pass valve 83 is in position to close communication between pipes 27 and 86, the accumulator plunger is elevated and the relay 93 is open. Then the pump 18 will charge the accumulator by drawing oil from the surge tank through pipe 19 and discharging the oil through pipes 20 and 21 to the cylinder 31 of the accumulator. As hydraulic pressure is built up in the latter it will overcome the pneumatic pressure at the under side of piston 32 and force the plunger 30 downwardly. When the accumulated pressure reaches the maximum permissible limit it will force the plunger down to the position shown in Fig. 1. In that position the plunger effects closure of switch 89. The latter is normally spring-urged to open position. It is closed by engagement of an arm 94 borne by the accumulator plunger.

Switch 89 closes a circuit including line wire L, conductor 95, the armature of relay 93, conductor 96, switch 89, conductor 97, the winding of relay 93, conductor 98 and line wire L'. Current through said relay winding closes relay 93

and thereby a circuit is established including, as shown in Fig. 1, line wire L, conductor 95, the armature of relay 93, conductor 99, conductor 100, solenoid coil 84', conductor 101 and line wire L'. Current through coil 84' causes shift of the valve 83 to open communication between pipe 27 and pipe 86 to thereby by-pass the pump discharge to the surge tank. The relay 93 is retained closed by a holding circuit including line wire L, conductor 95, the armature of relay 93, conductors 99 and 100, switch 90, which is normally spring-held in closed position, conductor 97, the winding of relay 93, conductor 98 and line wire L'. Thereby, valve 83 is held open to by-pass the pump discharge until the arm 94, by rise of the accumulator plunger, engages and opens the switch 90. That breaks said holding circuit so that the relay 93 opens and breaks the circuit through solenoid 84'. Spring 85 then closes the pump by-pass valve so that the pump can recharge the accumulator.

As shown in Fig. 1, the press head 2 is held elevated by hydraulic pressure in the push-back cylinders 7, the pressure being trapped in said cylinders by the control valve 38 which is in position to close communication between pipe 40 from the push-back cylinders, and the discharge pipe 39. The push-back pressure is transmitted from pipe 40 through the piping 40a to the upper ends of the small cylinders 17 so that the surge valves 14 and 15 are held open. At the same time, push-back pressure transmitted through pipes 40 and 56 holds valve 52 up to shut off admission of pressure from supply pipe 21 to piping 58 and 60 leading to the area 10 of the ram 3. Since valve 65 is dependent upon pressure in pipe 60 to open it and since pressure is shut off from said pipe, the valve is held closed by its spring against admission of pressure to the main press cylinder through pipes 62 and 73.

If, while the parts are in the positions shown in Fig. 1, the push-back pressure in cylinders 7 should leak down the press head will depress slightly and move the abutment 49 downward. That will permit the spring 47 to shift the control valve downward to open communication between the pipe 23 and pipe 40 so that the pump and the accumulator can restore the pressure in the push-back cylinders. Consequent rise of the press head 2 will cause the abutments 49 and 48 to restore the control valve to the Fig. 1 position and stop the upward movement of the press head.

Downward movement of press head 2 for a pressing operation is caused by pressing the switch 87. This switch is normally held by a spring in circuit-opening position. Pressure upon the switch shifts it to circuit-closing position. Switch 88 is normally held by a spring in circuit-closing position. Switch 87 is a starting switch and switch 88 is an emergency switch.

Pressing of switch 87 momentarily closes a circuit including line wire L, conductor 102, a normally closed switch 103, conductor 104, the armature of relay 91, conductor 105, switch 87, conductor 106, conductor 107, switch 88, conductor 108, switch element 80, conductor 109, the winding of relay 91, conductor 110 and line wire L'. Said relay is closed thereby and establishes a circuit to hold it closed. This holding circuit includes, as shown in Fig. 2, line wire L, switch 103, conductor 104, the armature of relay 91, conductor 107, switch 88, conductor 108, switch element 80, conductor 109, the winding of relay 91, conductor 110 and line wire L'. The closed relay 91 establishes and holds a control valve operating circuit including a conductor 111 leading from conductor 108 of said holding circuit, the winding of solenoid 42, conductor 112 and line wire L'. Energization of solenoid 42 raises control valve 38, against the resistance of spring 47, to a position for discharge of pressure from the push-back cylinders and admission of pressure for advancing the press head 2 downwardly.

As shown in Fig. 2 the upwardly shifted control valve 38 permits discharge from the push-back cylinders 7 through pipe 40 and pipe 39 to the surge tank. That permits the press head 2 to descend by gravity. During its descent it maintains pressure in the push-back cylinders and pipe 40 and this pressure, through the piping 40 and 40a to the cylinders 17, holds the surge valves open. Said pressure, acting through the piping 40 and 56, also holds the auxiliary valve 52 in the position shown in Fig. 1 to cut off communication between the pressure supply pipe 21 and the piping 58 and 60 so that the pump and the accumulator are cut off from the press cylinder during said descent of the ram. When, however a die D borne by the press head 2 contacts with the work W borne by the press head 1, and the resistance of the work is sufficient to arrest descent of the head 1, pressure in the push-back cylinders and in the connected piping 40 and 56 falls. Thereby the spring 55 is permitted to shift the auxiliary valve 52 to the position shown in Fig. 3, and open communication between the pressure supply pipe 21 and the pipe 60 so that pump pressure and accumulator pressure are admitted to the bore of the tubular extension 8 in the press cylinder. Simultaneously, pressure is delivered by pipes 60 and 61 to the lower end of the small cylinder 17 associated with the surge valve 14. This pressure can close the surge valve since the pressure for opening it is being relieved through piping 40 and 40a along with relief of push-back pressure. Closure of surge valve 14 renders the pressure admitted to the ram surface 10 effective for the first portion of the pressing operation. Closing of surge valve 15 and admission of pressure to the main press cylinder to act against ram surface 11 are delayed until the pressing operation has progressed to a certain degree. Then the pressure build-up within the ram recess 9 registers in pipes 60 and 69, and when the pressure becomes sufficient it operates the spring-loaded valve device 70 for admission of pressure to cylinder 64 of auxiliary valve device 59. The pressure admitted to cylinder 64 shifts valve 65 against the resistance of spring 68 to admit pump and accumulator pressure from pipe 58 to pipe 62 and pipe 73. Pipe 73 leads to the main press cylinder 4, and its branch 75 leads to the lower end of the small cylinder 17 associated with surge valve 15. Pressure so admitted to the small cylinder closes surge valve 15 so that the pressure admitted to the press cylinder can become effective against the ram surface 11. Pressure supplied by the pump and the accumulator simultaneously then acts upon both ram surfaces 10 and 11 to force the press head 2 to complete the pressing operation.

When the hydraulic pressure acting upon the ram 3 reaches a maximum permissible limit, automatic retraction of the press head 2 is effected by the control system. Said maximum pressure is transmitted through pipe 73 to the pressure limiting device 74. There it shifts piston 79 against the resistance of spring 81 and moves

switch element 80 to break the electrical connection between conductors 108 and 109. Since the previously described holding circuit for relay 91 is dependent upon said connection, breaking of the latter causes the relay to open and thereby open the circuit through solenoid 42 of the control valve. Spring 47 then shifts the control valve down to the position shown in Fig. 3.

In Fig. 3 the control valve has just been shifted for press head retraction but the auxiliary valves 52 and 65 are still in position to cause the pressing operation. Their shift back to Fig. 1 position is caused by said downward shift of control valve 38. The latter then admits pump pressure and accumulator pressure from pipe 23 to pipe 40 which leads to the push-back cylinders 7. This pressure is also transmitted through pipe 56 for shifting valve 52 to permit relief of pressure in the ram recess 9, through pipes 60 and 57 to the surge tank. Since pipe 73 is connected by pipe 76 to pipe 60, the pressure in the press cylinder 4 is also relieved through pipes 73 and 76, past check valve 77 to pipe 60 and thence through valve device 26 to the surge tank. The surge valves 14 and 15 are opened by relief of pressure in the lower ends of cylinders 17 through pipes 61 and 75 to the vented pipes 60 and 73 respectively, and admission of push-back pressure from pipe 40 through the piping 40a to the upper ends of the small cylinders. It will be noted that there is exhaust of fluid from the press head advancing mechanism through the pipe 57 and also through the ports 12 and 13. This distribution of exhaust reduces turbulence in the surge tank. Venting of the press-head-advancing mechanism through the pipe 57 also assists opening of the surge valves by relieving the pressure at the under side of the valves, tending to hold them closed.

Since the pipe 71 leading to the auxiliary valve device 59 is connected to the vented pipe 60, hydraulic pressure in cylinder 64 of said device will be relieved through pipe 71 and past check valve 72 to pipe 60. That will permit spring 68 to shift valve 65 to closed position cutting off communication between pipes 58 and 62. Thereby said valve is reset for another operation of the press. Relief of pressure in the press head advancing mechanism relieves pressure also in the pressure-limiting device 74 through the pipe 73 and the aforesaid connections of the latter with the discharge pipe 57. The spring 81 can then shift the switch element back to the position shown in Fig. 1.

The relief of pressure in the press head advancing mechanism and the admission of pressure to the retracting, or push-back mechanism causes elevation or retraction of the press head 2. Retraction continues until abutment 49 borne by the press head engages abutment 48 borne by valve-operating rod 44 and causes shifting of the control valve 38 back to the position shown in Fig. 1. This shift is effected against the resistance of spring 47.

If it be desired to stop advance of the press head 2 and retract it before completion of its working stroke the emergency switch 88 is pressed to open the aforesaid holding circuit for relay 91. The latter then opens and breaks the circuit through solenoid 42 of the main control valve. Spring 47 can then shift the control valve 38 downwardly, for press head retraction.

It will be noted that switch 103 is included in all of the circuits employed for controlling the operations of the press head 2. Therefore by opening this switch said circuits are disabled for control of the press operations by means of the hand lever 45.

What I claim is:

1. A press apparatus having press head advancing mechanism and press head retracting mechanism, both operable by hydraulic pressure, a surge tank associated with said advancing mechanism and pressure supply means to withdraw liquid from the surge tank for supply of hydraulic pressure to said mechanisms, the advancing mechanism having an area subject to hydraulic pressure for a portion of the press head advance and an area subject to hydraulic pressure for a following portion of the advance to augment the pressure on said first area, a surge valve to control communication between the surge tank and said first area and a surge valve to control communication between the surge tank and said second area, a main control valve device operable to admit pressure to the retracting mechanism and exhaust it therefrom to the surge tank, an auxiliary control valve constantly urged to admit pressure from said supply means to the advancing mechanism and responsive to admission of pressure to the retracting mechanism to exhaust pressure from said first area of the advancing mechanism, the first surge valve having operating means responsive to said pressure admission by said auxiliary valve to close the surge valve, and a second auxiliary valve responsive to said pressure admission by the first auxiliary valve to admit pressure from the latter to said second area, the second surge valve having operating means responsive to the latter admission to close the surge valve, and said operating means for the two surge valves being responsive to pressure admission to the retracting mechanism to open the surge valves.

2. In a hydraulic press apparatus having press-head-advancing mechanism and press-head-retracting mechanism, both operable by hydraulic pressure, a hydraulic pressure accumulator, a constant delivery pump having a receiving connection with a source of liquid and a delivery connection with said accumulator to charge the latter when the press is idle, means responsive to a predetermined degree of charging of the accumulator to direct the pump discharge to said liquid source to limit charging of the accumulator, control valve means operable to admit hydraulic pressure to said retracting mechanism and operable also to relieve hydraulic pressure in the retracting mechanism, means responsive to relief of pressure in the retracting mechanism to place said pump and accumulator in delivery communication with said advancing mechanism for performing a pressing operation, means responsive to pressure admitted to the retracting mechanism to relieve hydraulic pressure in said advancing mechanism for press head retraction, and means responsive to a predetermined hydraulic pressure in the advancing mechanism to operate said control valve means to cause said admission of hydraulic pressure from the pump and accumulator to the retracting mechanism, for press head retraction.

3. In a hydraulic press apparatus including press-head-advancing mechanism and press-head-retracting mechanism, both operable by hydraulic pressure, hydraulic pressure supply means, a surge tank and a surge valve to control communication between said tank and said advancing mechanism, a main control valve having

hydraulic connections with said supply means and with said retracting mechanism and operable to place said connections in communication for admission of hydraulic pressure to the retracting mechanism and operable also to break said communication and relieve hydraulic pressure in the retracting mechanism, an auxiliary control valve having hydraulic connection with said supply means and a hydraulic connection with said advancing means both independent of said main control valve, means constantly urging said auxiliary valve to place its said connections in communication, hydraulic operating means for said auxiliary valve having a hydraulic connection with the retracting mechanism independent of the main control valve to operate the auxiliary valve against the resistance of said constant urging means to relieve hydraulic pressure in the advancing mechanism in response to build up of hydraulic pressure in the retracting mechanism, and operating means for the surge valve responsive to build up of hydraulic pressure in the retracting mechanism to open the surge valve and responsive to relief of pressure in the retracting mechanism to close the surge valve, whereby relief of hydraulic pressure in the retracting mechanism through the main control valve will cause press head advance, and build up of hydraulic pressure in the retracting mechanism through the main control valve will cause press head retraction.

4. A hydraulic press comprising in combination a two step hydraulically operable press plunger, a press cylinder operatively associated with said press plunger so as to form two separate chambers therewith, pressure fluid supply means, including a constant delivery pump and an accumulator, for supplying pressure fluid to said chambers to actuate said press plunger, fluid storage means, two surge valves respectively associated with said chambers and adapted selectively to effect or interrupt hydraulic communication between said chambers and said fluid storage means in response to the pressure conditions in said chambers, push back means for retracting said press plunger after completion of its working stroke, main valve means controlling the supply of pressure fluid from said pressure fluid supply means to said push back means and being operable to connect said push-back means to an exhaust, while interrupting hydraulic communication between said push back means and said pressure fluid supply means, auxiliary valve means controlling the supply of fluid from said fluid supply means to one of said chambers, yielding means constantly urging said auxiliary valve means to effect hydraulic communication between said one chamber and said fluid supply means, hydraulic operating means adapted in response to a predetermined push back pressure to counteract said yielding means so as to cause said auxiliary valve means to relieve hydraulic pressure in said chambers to exhaust, and controlling means adapted in cooperation with said auxiliary valve means to control the supply of pressure fluid from said fluid supply means to the other of said two chambers in response to a predetermined pressure in said first mentioned chamber.

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