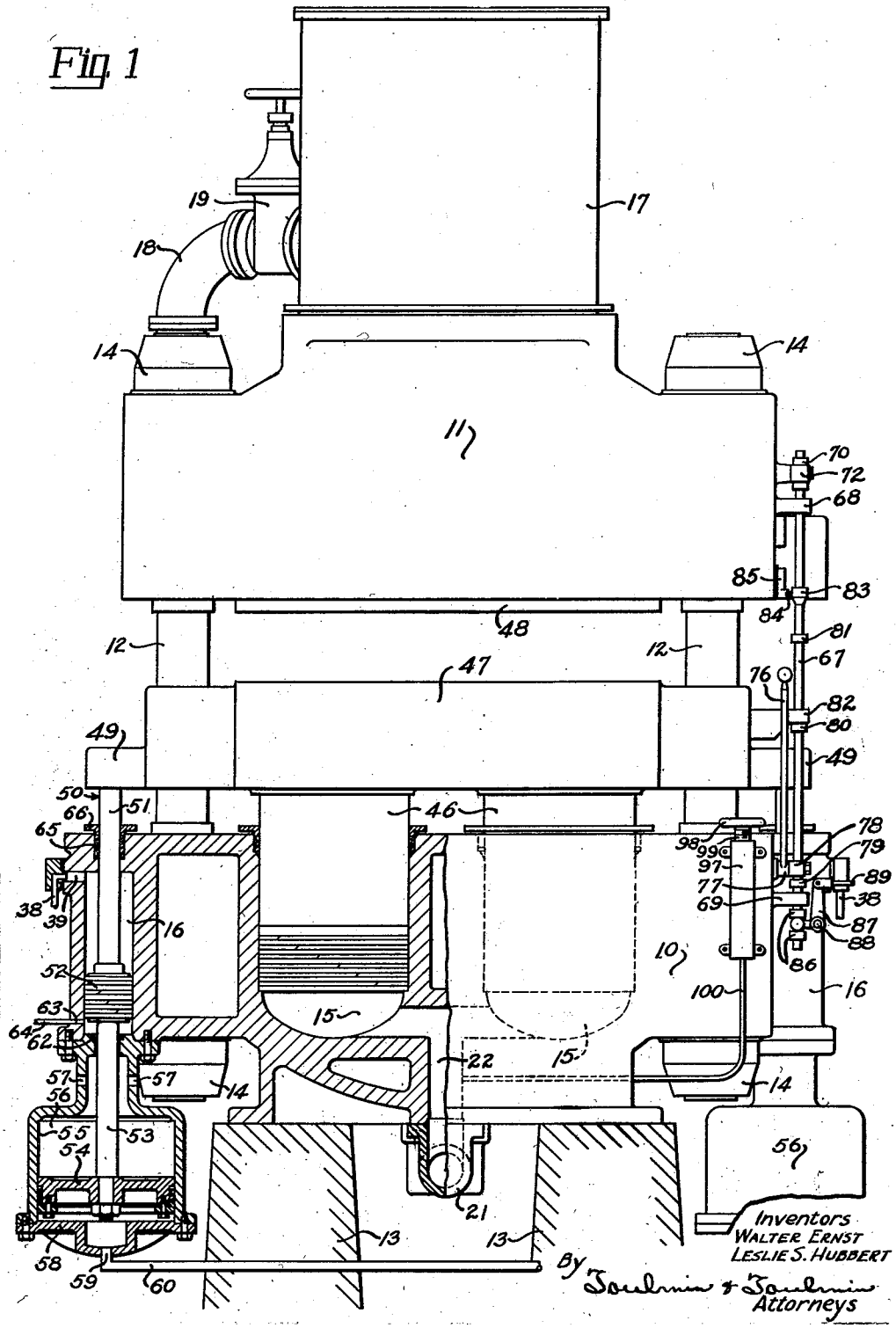
Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

Filed May 23, 1938 6 Sheets-Sheet 1

Fig. 1

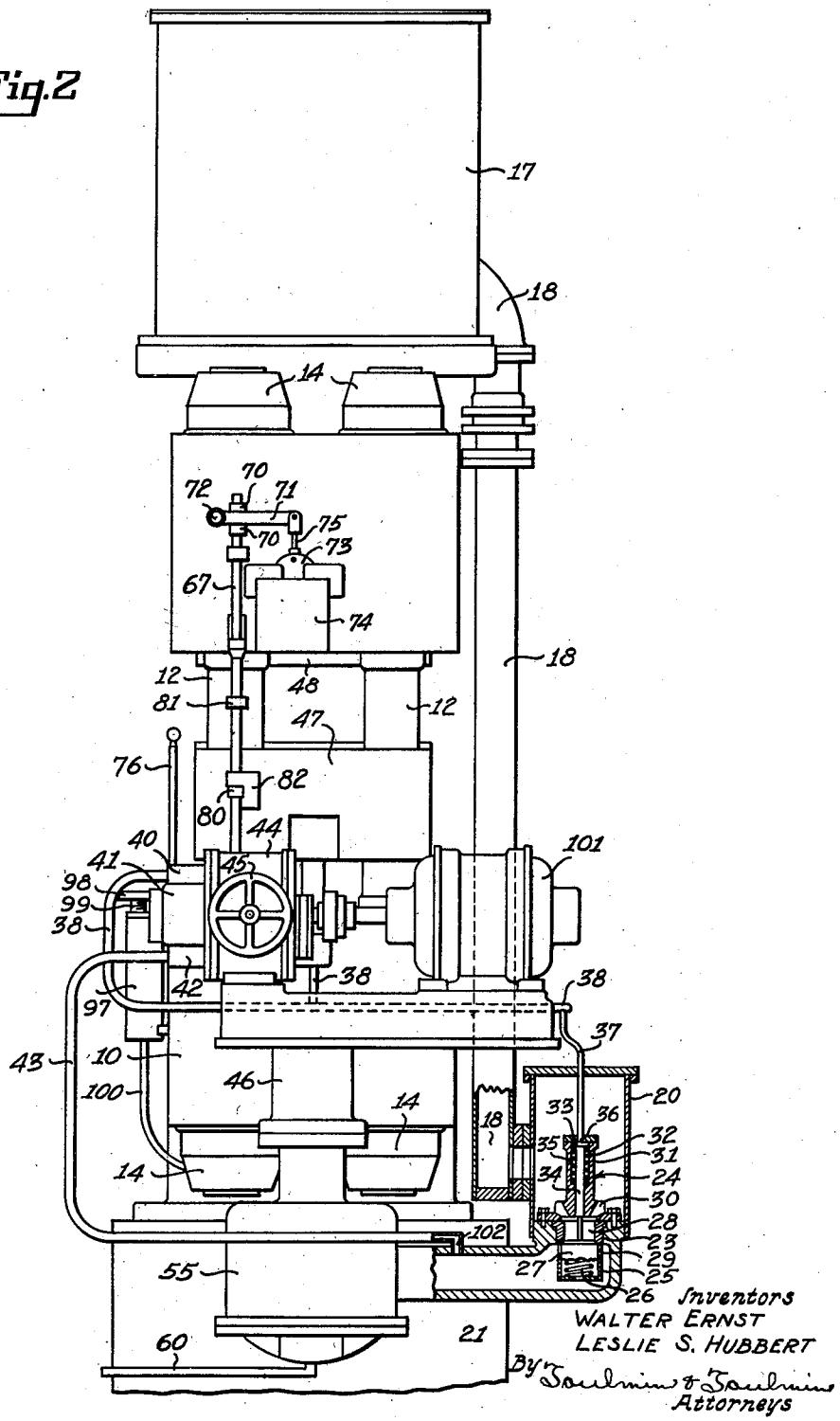


Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

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Fig. 2



Inventors
WALTER ERNST
LESLIE S. HUBBERT
By Toulmin & Toulmin
Attorneys

Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

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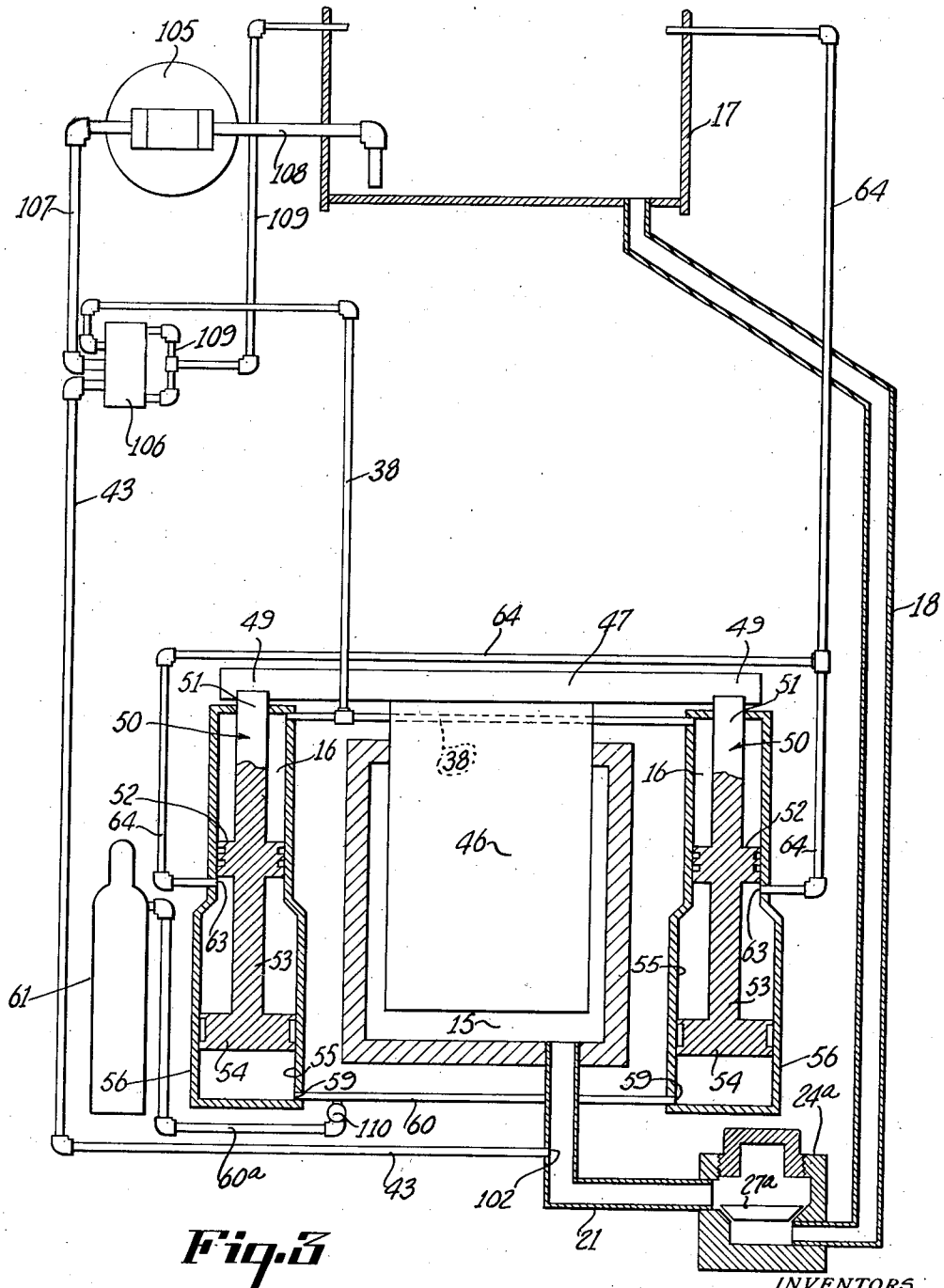


Fig. 3

INVENTORS
WALTER ERNST
LESLIE S. HUBBERT

BY Toulmin & Toulmin
ATTORNEYS

Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

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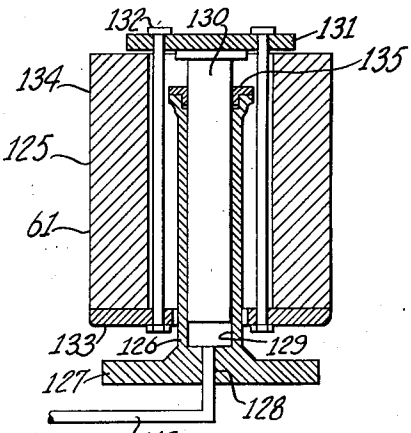


Fig. 6

Fig. 4

INVENTORS
WALTER ERNST
LESLIE S. HUBBERT
BY Faulkner & Faulkner
ATTORNEYS

Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

Filed May 23, 1938 6 Sheets-Sheet 5

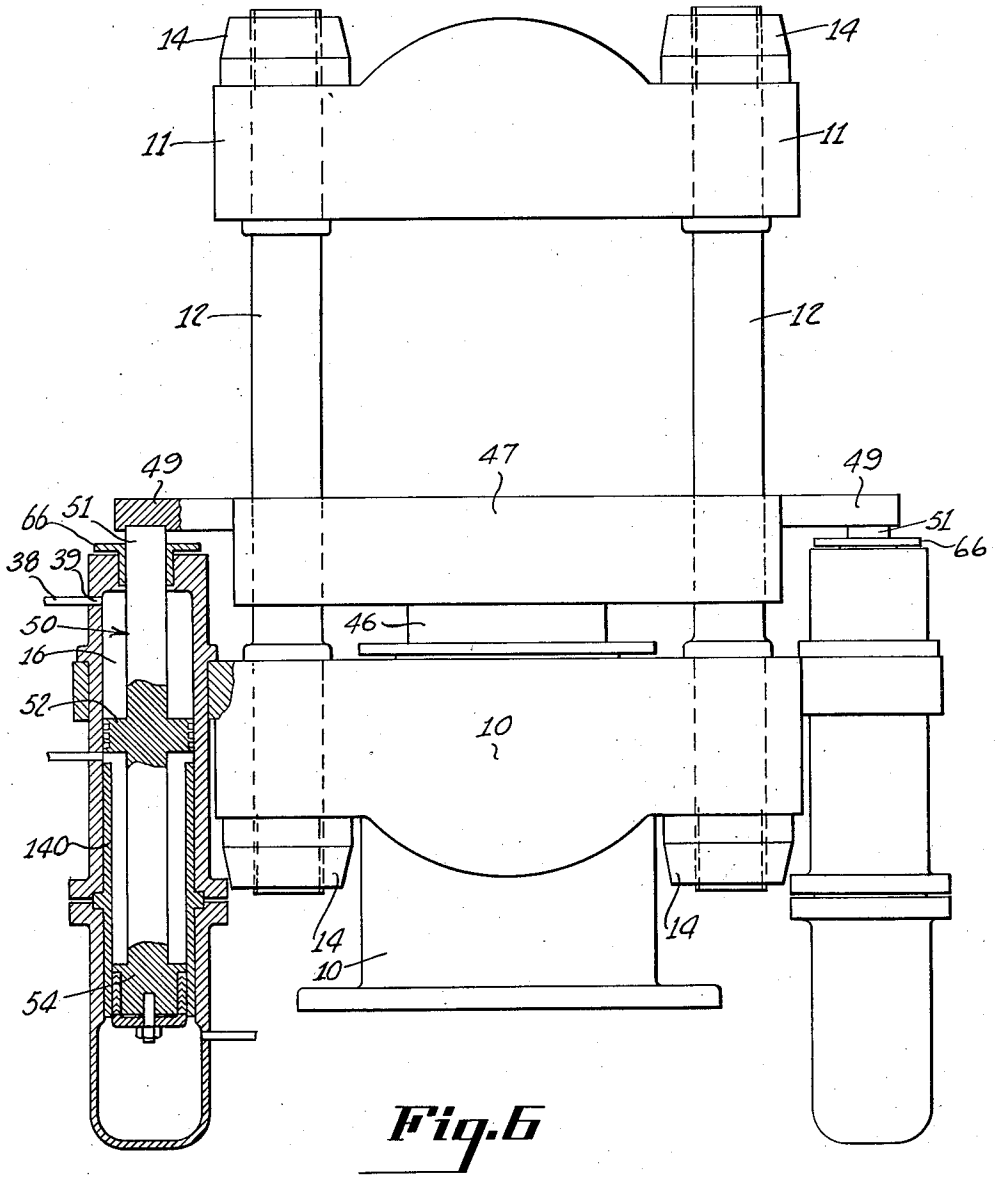


Fig. 6

BY

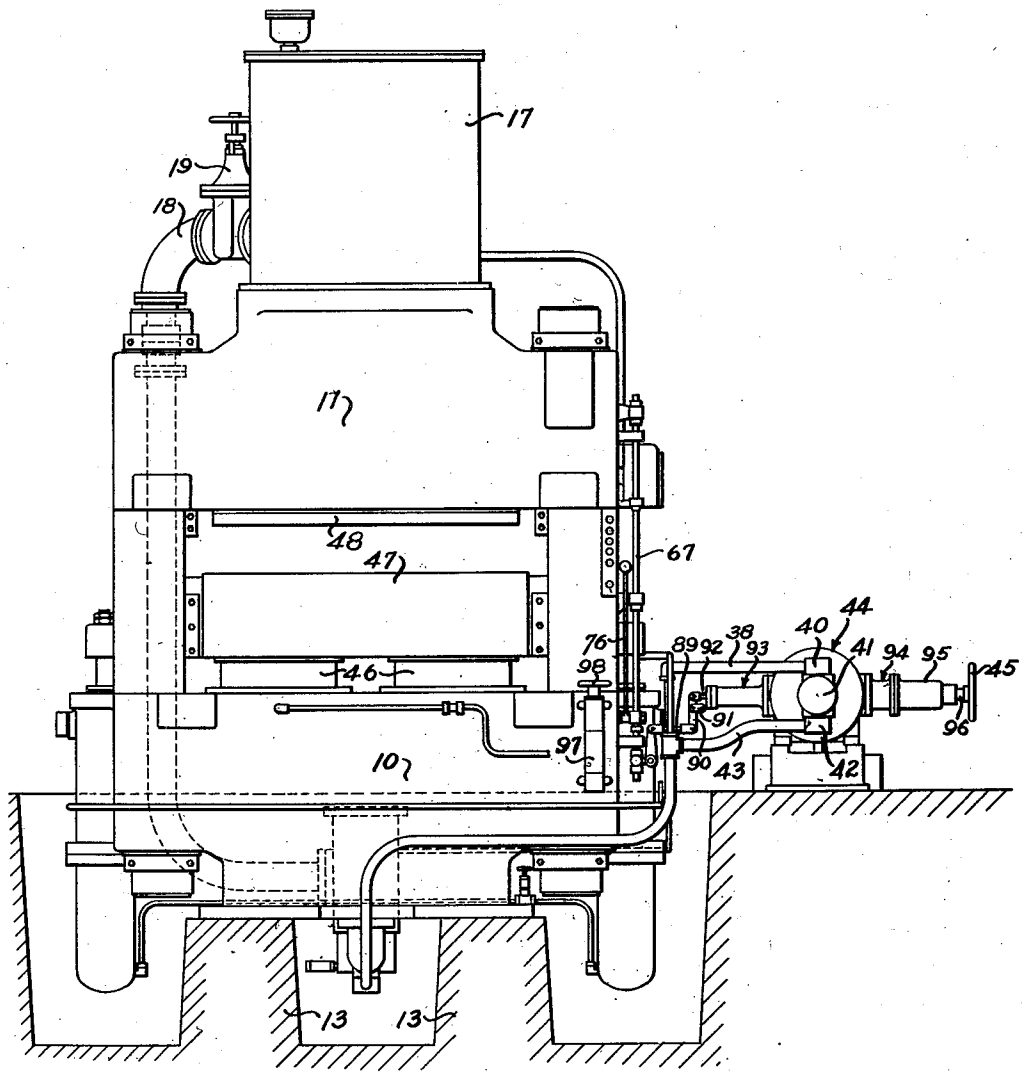
INVENTORS
WALTER ERNST
LESLIE S. HUBBERT
Baldwin & Baldwin
ATTORNEYS

Dec. 17, 1940. W. ERNST ET AL 2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

Filed May 23, 1938 6 Sheets-Sheet 6

Fig. 7



Inventors
WALTER ERNST
LESLIE S. HUBBERT

By Toulmin & Toulmin
Attorneys

Patented Dec. 17, 1940 2,224,956

UNITED STATES PATENT OFFICE

2,224,956

PRESS WITH RAPID-CLOSING UPWARD-ACTING RAM

Walter Ernst, Mount Gilead, and Leslie S. Hubbert, Edison, Ohio, assignors to The Hydraulic Development Corp. Inc., Wilmington, Del., a corporation of Delaware

Application May 23, 1938, Serial No. 209,484

2 Claims. (Cl. 60—51)

This invention relates to presses, and in particular, to upwardly acting hydraulic presses.

One object of this invention is to provide a hydraulic press with an upwardly acting plunger, together with means for insuring the rapid closing of the press.

Another object of this invention is to provide a hydraulic press with an upwardly acting main plunger having mechanism actuated by a substantially constant pressure source for rapidly advancing the plunger to the pressing position, this pressure source being independent of the pressure source which operates the press.

Another object is to provide a hydraulic press with an upwardly acting main plunger having auxiliary plungers, which are actuated to rapidly advance the main plunger to the working position by means of pressure from an independent pressure source apart from the pressure source which operates the press.

Another object is to provide a hydraulic press with an upwardly acting main plunger of the type described above, wherein the independent pressure source for rapidly advancing the plunger to the working position consists of a gas-loaded or fluid-loaded accumulator.

Another object is to provide a hydraulic press with an upwardly acting main plunger, together with means for rapidly advancing the main plunger to the working position, and means, such as a surge valve, for replenishing the liquid required by the main cylinder as the plunger advances, preferably from an auxiliary tank at the base of the press, and supplied with fluid from a main surge tank at the top of the press.

Another object is to provide a hydraulic press with an upwardly acting main plunger of the type described in the preceding object, wherein the surge valve is double-acting with hydraulic connections for forcibly opening it in response to the commencement of the return stroke of the press, so as to permit the fluid from the main cylinder to pass immediately into the auxiliary tank, whence it may flow back to the main surge tank.

Another object is to provide an accumulator-actuated system for rapidly advancing an upwardly acting hydraulic plunger to the working position, together with means for preventing leakage of the gas for bringing about the rapid advance of the main plunger or platen, such as for example, by a gas-loaded accumulator which actuates an intermediate liquid for transmitting its force to the auxiliary plungers, which advance the main plunger or main platen.

In the drawings:

Figure 1 is a front elevation, partly in section, of a commercial form of hydraulic press having an upwardly acting platen, with means for rapidly advancing the platen to the working position, the hydraulic pump and gas-supplying means being omitted.

Figure 2 is a side elevation, partly in section, of the press shown in Figure 1.

Figure 3 is a diagrammatic view, mainly in section, of a simplified hydraulic circuit for rapidly advancing a main plunger or platen to the working position, employing the principles of the press shown in Figures 1 and 2.

Figure 4 is a fragmentary front elevation, partly in section, of a press employing a liquid to transmit the force from the accumulator to the auxiliary plungers for rapidly advancing the platen so as to prevent leakage of the gas.

Figure 5 is a fragmentary vertical section through a modification of Figure 4, employing a weight-loaded accumulator instead of a gas-loaded accumulator.

Figure 6 is a diagrammatic front elevation, partly in section, showing another modified form of press embodying the principles of the invention.

Figure 7 is a front elevation, partly in section, of a commercial form of press slightly modified from that shown in Figures 1 and 2, and disclosing the pump and its control system more clearly.

General arrangement

In general, the hydraulic press of this invention consists of a frame having an upwardly acting main plunger having a platen and auxiliary plungers for rapidly advancing the platen upwardly to the working position. In such presses, with upwardly acting platens and main plungers, the moving parts cannot be aided in their movement by gravity, as in the case of downwardly acting presses, hence, independent auxiliary plungers are provided according to the invention, to rapidly advance the platen to its working position despite the opposite pull of gravity.

The auxiliary plungers are actuated from a substantially constant pressure source, which is independent of the pressure source for operating the press. Preferably, this pressure source consists of a gas-loaded or weight-loaded accumulator adapted to exert a substantially constant pressure load standing against the platen substantially all of the time. The gas pressure for actuating the auxiliary plungers is either applied

directly to a pneumatic plunger connected to the auxiliary plungers, as in Figures 1, 2, 3 and 6, or else it exerts its force against an intermediate column of liquid which transmits this force to the auxiliary plungers. Figure 5 substitutes a weight-loaded accumulator for the gas-loaded accumulator in the circuit of Figure 4. The press shown in Figures 1, 2 and 3 employs a pneumatically actuated piston head of larger area than the hydraulically actuated piston heads of the auxiliary plungers, so that a lower gas pressure can be employed to counterbalance a considerably higher hydraulic pressure.

In these presses the main plunger is retracted by hydraulic pressure supplied to the auxiliary plungers from a pump. These auxiliary plungers are forced downwardly against the resistance of the force coming from the accumulator so that this force is accumulated in the form of potential energy, which is ready at any moment to be utilized for advancing the main plunger. In this manner no energy is lost in the means for rapidly advancing the main plunger to the working position, aside from the slight losses due to friction, etc. because the moving parts are, in effect, floated by the pressure of confined air or other gas. When the platen is retracted, pistons, actuated by the return of the platen, restore the compression to the air or actuate a weight-loaded accumulator so that no energy is wasted. In this manner a rapid response and high speed of action are obtained because the compressed gas is quick to act. Furthermore, a small pump suffices to supply pressure fluid to the main plunger because the pump is not depended upon for rapid advancing of the main plunger to the working position.

Hitherto, in upwardly acting hydraulic presses, it has been difficult to cause the platen to rapidly approach the working position. Ordinarily, a considerable portion of the movement of the main plunger and platen of a hydraulic press is expended merely in bringing the platen into working position, where it begins to exert pressure upon the workpiece. During this approach motion little or no force is required to move the plunger other than that which is necessary to lift the moving parts. As no useful work is performed during this approach period, it is desirable to keep the time of this movement as short as possible. Furthermore, for many kinds of work heavy pressing pressure is required only during a very small portion of the stroke of the main plunger, sometimes, indeed, for only a fraction of an inch of motion.

Due to this small motion required, a comparatively small hydraulic pump would suffice to supply pressure fluid in such cases, because the movement under high pressure is very small, and hence, a relatively small amount of fluid is required to build up a high pressure in the press cylinder and perform the desired work. A small pump, however, if depended upon for raising the main plunger and platen of a large press to the working position would require a long period of time. If auxiliary plungers and auxiliary cylinders are employed, a small pump will give a much more rapid speed of advance than if acting upon the much larger area of the main plunger. In order to utilize such auxiliary plungers, however, additional valve equipment must be supplied for changing the flow of pressure fluid from the main cylinder to the auxiliary cylinders, and vice versa. Furthermore, the energy expended for lifting the heavy moving parts by means of these auxiliary plungers is entirely wasted under these circumstances.

In our invention, as stated above, this energy is not wasted because it is stored up in an accumulating device when the main plunger is retracted. No superfluous valve equipment is required because an entirely independent source of energy is relied upon for advancing the platen to the working position. The pump is depended upon merely for supplying pressure fluid to the main plunger during the short pressing stroke after the platen has advanced to the working position, and also for retracting the main plunger by means of auxiliary plungers.

Press construction

Referring to the drawings in detail, Figures 1 and 2 show a commercial embodiment of the invention, consisting of an upwardly acting hydraulic press. This press includes a bed **10** and a head **11**, interconnected by strain rods **12** and resting upon a foundation **13**. The strain rods **12** have nuts **14** at their opposite ends for holding this assembly together. Formed integral with the bed **10** are main cylinders **15** and auxiliary cylinders **16**. For supplying fluid to these cylinders the press head **11** supports a surge tank **17**, connected by a conduit **18** with a valve **19** to the auxiliary tank **20**. The valve **19** is supplied merely to cut off the surge tank **17** to prevent loss of fluid in the event that the piping is disconnected at lower levels so that it will not be necessary to drain the main tank.

Running from the auxiliary tank **20** to the main cylinders **15** is a conduit **21** communicating with a passageway **22** in the bed **10** of the press. This passageway **22** is T-shaped and communicates at its upper ends with the two main cylinders **15**. While two main cylinders are shown, the invention is equally applicable to an installation employing either a single main cylinder or multiple main cylinders, according to the particular pressing requirements encountered. Mounted in a port **23** between the auxiliary tank **20** and the conduit **21** is a double-acting surge valve **24** (Figure 2). The details of this surge valve form no part of the present invention, and are disclosed in the patent to Ernst, No. 1,892,568, of December 27, 1932.

This surge valve is provided for the purpose of prefilling the main cylinders **15** during the advancing stroke, and also of permitting the direct emptying thereof during the retraction stroke. For this purpose the surge valve **24** is provided with a valve casing **25** having a spring **26**, urging a valve member **27** upwardly into position for closing the valve port **28**. The spring **26** exerts a gentle pressure so that the valve member **27** is easily opened whenever suction is created in the conduit **21** in response to the suction created in the main cylinders **15** during the advancing stroke of the press. Under these circumstances, fluid may flow directly from the auxiliary tank **20**, through the valve port **28**, into the conduit **21**, and thence through the passageway **22**, into the main cylinders, displacing the valve member **27** downwardly against the slight pressure of the spring **26**. For permitting the passage of fluid through the surge valve **24** the valve casing **25** is provided with lateral ports **29**, below the valve member **27**, and also with ports **30** thereabove.

Means is also provided in the surge valve **24** for forcibly opening the valve during the retraction stroke of the press. For this purpose there is mounted above the valve casing **25** a

hydraulic cylinder 31 containing a cylinder bore 32, within which a piston head 33 is reciprocable. The piston head 33 is mounted upon a piston rod 34, the lower end of which emerges from the cylinder 31 and engages the top of the valve member 27. A coil spring 35 within the cylinder bore 32 normally urges the piston head 33 upwardly to permit the closing of the valve member 27 by the coil spring 26. Connected to a port 36 in the top of the cylinder bore 32 is a conduit 37 leading to the retraction line 38, which runs to the ports 39 in the upper ends of the auxiliary cylinders 16. The retraction line 38 is connected at its opposite end to the junction 40 upon the conduit connection 41, having a junction 42. Running from the latter is the conduit 43 (Figure 2) leading to the conduit 21. The conduit connection 41 is secured to the side of a reversible variable delivery pump 44 having a hand wheel 45 for controlling its action, as hereinafter disclosed more in detail. The details of the pump 44 form no part of the present invention, and any suitable type of pump may be employed. The conduit 43 supplies pressure fluid to the main cylinders 15 to cause the completion of the working stroke after the press has been advanced to the working position by the devices of the present invention.

Reciprocable in the main cylinders 15 are main plungers 46, connected at their upper ends to a platen 47 arranged to be advanced into engagement with the thrust portion 48 upon the press head 11. Connected to the platen arms 49, at the ends of the platen 47, are auxiliary plungers 50, consisting of piston rods 51 having piston heads 52 thereon, reciprocable within the auxiliary cylinders 16. The lower ends of the piston heads 52 are engaged by the upper ends of separate piston rods 53, having on their lower ends piston heads 54, reciprocable in cylinder bores 55 within the pneumatic cylinders 56. The pneumatic cylinders 56 are secured to the bed 10 of the press, immediately below the auxiliary cylinders 16. Ports 57 are provided for the escape of air above the piston heads 54. The pneumatic cylinders 56 are closed by cylinder heads 58, having ports 59 therein communicating with the line 60 leading to a pressure source or accumulator 61 (Figures 3, 4 and 5). Around the piston rods 53 are oil seals 62 for preventing the oil within the cylinders 16 from leaking downwardly into the cylinder bores 55. For returning such leakage fluid to the auxiliary tank 20 ports 63 are connected to a conduit 64 leading from the lower ends of the auxiliary cylinders 16, beneath their piston heads 52. Packings 65 and glands 66 similarly prevent leakage from around the upper ends of the piston rods 51.

For supplying gas to the pneumatic cylinders 56 through the line 60, any suitable source of gas pressure may be used, such as an ordinary gas storage tank or cylinder, as shown in Figure 3, a hydropneumatic accumulator, as shown in Figure 4, or a weight-loaded accumulator, as shown in Figure 5. The pressure source 61 is preferably of ten or more times the combined displacement of the stroke of the pneumatic pistons 54, so that the latter may make their strokes without seriously decreasing the pressure within the pressure source 61. It will be understood that means (not shown) is provided for adding air or other gas to the pressure source 61 from time to time, as may be required to make up for any leakage which may occur past the pistons 54, or at any other points in the system, so as to maintain the desired working pressure.

The control system for the press includes a control rod 67, reciprocably mounted in brackets 68 and 69 on the head 11 and bed 10, respectively. The control rod 67 at its upper end carries spaced collars 70, which are engaged by a yoke-shaped lever 71, pivotally mounted as at 72, upon the head 11 of the press and having the armature 73 of a solenoid 74 pivotally connected to its outer end by means of the connecting rod 75 (Figure 2). When the solenoid 74 is energized it pulls the outer end of the yoke-shaped lever 71 downwardly, and likewise moves the control rod 67 downwardly. To oppose this action the control rod 67 is normally urged upwardly by a spring (not shown). The control rod 67 may likewise be actuated by means of a hand lever 76, pivotally mounted as at 77 (Figure 1) upon the bed 10 of the press, and having an arm 78, the outer end of which is arranged to engage the collar 79 upon the control rod 67. The control rod 67 likewise carries adjustable collars 80 and 81, arranged to be engaged by the opposite sides of a platen extension 82 as the platen 47 moves up and down. The control rod 67 further carries a cam 83 adapted to engage the switch lever 84 of a limit switch 85, connected in the energization circuit of the solenoid 74.

On the lower end of the control rod 67 are spaced collars 86, arranged to engage the yoke-shaped end of a bellcrank 87, pivotally mounted as at 88. Pivotally connected to the upper end of the bellcrank 87 is a connecting rod 89, the opposite end of which (Figure 7) is pivotally connected to the lower end of a lever 90, pivotally mounted on the floating fulcrum link 91 and pivotally connected at its upper end to the servomotor valve control rod 92. The latter controls the operation of the servomotor valve, generally designated 93, attached to the pump 44. The servomotor valve 93 controls the direction of actuation of the pump servomotor, generally designated 94, for moving the flow-varying member of the pump to and fro in order to vary or reverse the delivery of the pump 44. Also mounted upon the pump 44 is the pump control casing 95, containing a spring arrangement (not shown) for adjusting the pressure at which the pump control becomes operative to shift the flow-control member of the pump to its neutral position and thus cut down the delivery of the pump to zero. Emerging from the pump control casing 95 is a shaft 96, carrying the previously-mentioned hand wheel 45. By rotating the hand wheel 45 and the shaft 96, the spring tension within the pump control casing 95 may be varied for varying the pressure at which the pump 44 is automatically placed in a neutral or zero delivery condition.

Also mounted upon the bed 10 of the press is the tonnage controller 97, having a hand wheel 98 for rotating the screw shaft 99 in order to regulate the pressure at which the press circuit is reversed to commence the retraction stroke. The tonnage controller 97 is, in effect, a pressure switch connected in circuit with the solenoid 75, and arranged to break the energization circuit thereof when the pressure in the main cylinders 15 reaches a predetermined amount. For this purpose the tonnage controller 97 is connected to the passageway 22 leading to the main cylinders 15 by means of the conduit 100. The rotation of the hand wheel 98, therefore, regulates the pressure at which the pressure switch

within the tonnage controller 97 becomes operative by pressure reaching it through the conduit 100. The pump 44 is driven by an electric motor 101.

Operation

In the operation of the press shown in Figures 1 and 2, let it be assumed that the various moving parts of the press are in the positions shown in these figures. To start the press the operator either pushes upon the hand lever 76 or closes an electrical switch which energizes the solenoid 74. Either of these operations causes the control rod 67 to be moved downwardly, thereby shifting the servomotor control rods 89 and 92 to move the shift ring, or other flow-control member of the pump 44, so as to cause the pump to exhaust oil from the connection 40 and the line 38, leading to the auxiliary cylinders 36 above the auxiliary piston heads 52. The oil thus withdrawn is pumped through the connection 42 and conduit 43, into the conduit 21 at the port 102 (Figure 2).

As fast as the oil is removed from the auxiliary cylinders 16 by means above described, the auxiliary piston heads 52 are moved upwardly by the air pressure beneath the pneumatic piston heads 54. This action causes the piston rods 53 to raise the pistons 52, the piston rods 51, the platen arms 49, the platen 47 and the main plungers 46, creating a suction within the main cylinders 15. This suction causes the valve member 27 of the surge valve 24 to move downwardly into its open position, thereby withdrawing oil through the valve ports 30, 28, and 29 from the auxiliary tank 20, so as to fill the main cylinders 15 and relieve this suction. Meanwhile, the auxiliary tank 20 is replenished by oil reaching it through the conduit 18 from the main surge tank 17 upon the head 11 of the press.

When the platen 47 reaches its working position and engages the workpiece, or otherwise meets such resistance that it can no longer be pushed upwardly by air pressure, the flow of oil from the pump 44, through the line 43, builds up pressure within the conduit 21, the passageway 22 and the main cylinders 15 so that the surge valve 24 closes and the main plungers 46 are moved upwardly in response to the pressure from the pump 44.

The press may be arranged for any desired type of reversal, the circuit shown being arranged for pressure reversal. When the pressure in the main cylinders 15 reaches a predetermined value, depending upon the setting of the tonnage controller 97, the switch within the latter opens in response to the pressure reaching it along the line 100, and deenergizes the solenoid 74. With the solenoid 74 deenergized, the control rod 67 is free to move upwardly, and a spring associated with the servomotor 96 pulls the flow-control member or shift ring of the pump 44 to its reverse position, thereby creating suction at the connection 42 and pressure at the connection 40. In response to this reversal of the pump 44, oil under pressure is now pumped through the line 38, into the auxiliary cylinders 16 above the piston heads 52, forcing them downwardly against the pneumatic pressure being exerted against the pneumatic piston heads 54 within the pneumatic cylinders 56.

At the same time oil under pressure passes along the conduit 38, through the conduit 37 to the cylinder bore 32 within the cylinder 31 of the surge valve 24, forcing the piston rod 34 downwardly and forcibly opening the valve member 27 of the surge valve 24. This action permits the oil to escape from the main cylinders 15, through the passageway 22, conduit 21 and surge valve ports 29, 28 and 30 directly into the auxiliary tank 20. The suction created in the line 43 also assists in withdrawing some of this oil from the conduit 21 by way of the port 102 (Figure 2). The gas that is forced out from beneath the pistons 54 in the pneumatic cylinders 56 is returned to the gas pressure source 61. This gas may be air or any other suitable gas, nitrogen being also found satisfactory for this purpose. If there has been no leakage of gas, therefore, there is now just as much pressure in the gas tank or gas source 61 as there was originally therein. It will be observed, therefore, that the energy required to lift the weight of the platen 47, main plungers 46 and the other moving parts, is restored upon their down strokes.

In series with the switch within the tonnage controller 97 is the normally open limit switch 85, this switch being held closed by the cam 33. If, however, the operator carelessly operates the press without a workpiece or dies in the press, the platen, through the extension 82, will strike the collar 81 and lift the control rod 67 so that the cam 83 moves off of the switch lever 84 and permits the limit switch 85 to open, thereby deenergizing the solenoid 74 and reversing the press. The same arrangement may likewise be used for position reversal of the platen at a predetermined position, if it is not desired to employ pressure reversal.

Modified press arrangement employing open circuit control

The modified circuit shown in Figure 3 is a simplified arrangement, utilizing the same principles already described in connection with Figures 1 and 2. Instead of the closed circuit of Figures 1 and 2 and a reversible variable delivery pump for operating the circuit, the construction of Figure 3 employs an open circuit with a pump 105, arranged to deliver pressure fluid to a four-way valve 106 by means of the pressure line 107, and to withdraw fluid from the surge tank 17 by means of the suction line 108. It will, of course, be understood that the pump 105 may withdraw pressure fluid from an auxiliary tank, such as the tank 20 shown in Figure 1, this having been omitted from Figure 3 to simplify the showing.

From the four-way valve 106 the discharge line 109 likewise leads back to the surge tank 17, or other receptacle. The four-way valve 106 is arranged in one position to connect the press retraction line 38 to the pump pressure line 107, while connecting the press advancing line 43 to the discharge line 109; and in another position to connect the press advancing line 43 to the pump pressure line 107, while connecting the press retraction line 38 to the discharge line 109. The operation of the circuit of Figure 3 is therefore similar to that of Figure 1, except that the reversal of the circuit is brought about by reversing the position of the four-way valve 106 rather than by reversing the pump itself. The four-way valve 106 is operated either manually or by a solenoid, as by mechanism similar to the control valve 67 shown in Figures 1 and 2. In place of the surge valve 24 an ordinary check valve 24a is shown by way of simplification, and is provided with a valve member 27a.

The gas pressure source in Figure 3 is represented as consisting of a simple gas cylinder 61 with gas therein, under pressure. It will be

understood that a gas storage tank is preferably interposed in the line 60, the line 60a from the gas cylinder 61 being employed for replenishing the gas in this tank, which has been omitted for simplicity of showing. A valve 110 between the line 60 and the line 60a regulates the admission or replenishment of gas.

In the operation of the circuit shown in Figure 3, to start the press upon a working stroke the valve 106 is shifted to connect the pump pressure line 107 with the line 43 and to connect the retraction line 38 with the discharge line 109. The fluid thus released from the auxiliary cylinders 16 passes into the surge tank 17 by way of the line 38, the valve 106 and the line 109, under the urge of the auxiliary piston heads 52, which are being moved upwardly by the pneumatic piston heads 54 in the pneumatic cylinders 56. In Figure 3, for simplification, the piston rod 53 is shown integral with the piston rod 51. As the moving parts rise, under the influence of the compressed gas within the pneumatic cylinder bores 55, the suction thereby created in the main cylinder 15 opens the valve member 27a of the check valve 24a and permits fluid to be drawn into the main cylinders 15 from the surge tank 17 by way of the conduits 18 and 21 and the check valve 24a. When the platen 47 encounters the workpiece, or other resistance, the pressure built up in the conduit 21 from the fluid delivered thereto by the pump 105, through the lines 107 and 43 and the four-way valve 106, causes the check valve member 27a to seat and close. Subsequently the pump 105, therefore, delivers pressure fluid to force the main plunger 46 upwardly to complete the working stroke.

To reverse the press, the operator shifts the control valve 106 and causes pressure fluid to be delivered from the pressure line 107 of the pump 105 to the retraction line 38, whence it flows into the auxiliary cylinders 16 above the piston heads 52, forcing the latter downwardly. This action compresses the air in the pneumatic cylinders 55 by forcing their pistons 54 downwardly, thereby storing up potential energy which becomes available upon the next advancing stroke of the press for raising the moving parts into the working position. While this is going on, the fluid within the main cylinder 15 is being discharged through the lines 43 and 109 and the four-way valve 106. It will be understood, however, that a double-acting check valve, similar to the check valve 24 in Figure 2, may be used in place of the simple check valve 24a, so that it will be forcibly opened upon the retraction stroke, and permit fluid to pass directly from the main cylinder 15, through the conduits 21 and 18, into the surge tank 17. Any leakage of gas past the pistons 54 will escape through the conduits 64, into the surge tank 17, and thence into the atmosphere.

The spaces above the pneumatic piston heads 54 serve as slippage reservoirs, with the outlets 63 so arranged that a small amount of oil leaking past the piston heads 52 will always remain above the piston heads 54 for lubrication purposes. Any excess leakage of oil, however, returns to the surge tank 17 by way of the conduits 64, when the pistons 54 are in their uppermost positions.

Modified construction for reducing gas leakage

In the modification shown in Figure 4, means is provided for preventing the leakage and consequent loss of gas past the piston heads 54. This is accomplished by employing a liquid to transmit the force from the gas, instead of using the gas directly. In Figure 4 the auxiliary cylinders 16 are closed at their lower ends by cylinder heads 111, having ports 112 therein communicating with a conduit 113, leading to a hydropneumatic accumulator, generally designated 114. The hydropneumatic accumulator consists of a casing 115 having a cylinder bore 116, in its upper end and the slightly enlarged cylinder bore 117 reciprocably accommodating a piston head 118 in its lower portion. The upper end 119 is closed and the lower end is provided with a head 120 with a port 121, to which the conduit 113 is attached. The cylinder bore 116 is provided with a port 122, to which a conduit 123 leads from a source of gas.

In the operation of the circuit shown in Figure 4, a small quantity of oil is placed on top of the piston head 118 for lubrication purposes, and the bore 117, the conduit 113 and the chambers 124 beneath the piston heads 52 are filled with oil. The compressed gas within the upper cylinder bore 116, acting against the piston head 118, tends to force the oil out of the lower cylinder bore 117, through the conduit 113, into the chambers 124 whenever the oil is released from the auxiliary cylinders 16 above the auxiliary piston heads 52. When the piston heads 52 are forced downwardly in retracting the platen 47, however, the oil is forced back into the lower cylinder bore 117, causing the piston head 118 to rise and compress the gas in the upper cylinder bore 116, thereby storing up potential energy for the next rapid advance stroke of the main plunger 46. Gas leakage cannot occur in the circuit of Figure 4 unless pressure completely disappears in the lower cylinder bore 117, a situation which is unlikely to occur with a proper design of construction.

The modification shown in Figure 5 is similar to that shown in Figure 4, except that a weight-loaded accumulator, generally designated 125, replaces the gas-loaded accumulator 114. The weight-loaded accumulator of Figure 5 consists of a cylinder 126, mounted upon a base 127 in which there is a port 128 connecting the line 113 with the cylinder bore 129. Reciprocable in the cylinder bore 129 is a plunger 130, upon the upper end of which is mounted a head 131 having tie rods 132 depending downwardly therefrom to support an annular platform 133, upon which an annular counterweight 134 rests. A gland 135 prevents the escape of fluid around the plunger 130.

In the operation of the modification shown in Figure 5, when the main plunger 46 and platen 47 are retracted by forcing oil into the auxiliary cylinders 16, the fluid displaced from the chambers 124 passes through the conduit 113 and port 128, into the cylinder bore 129, raising the plunger 130 and with it the counterweight 134. This action stores up potential energy which is available to effect the rapid advance of the platen 47 and main plunger 46, when fluid is released from the auxiliary cylinders 16 above the piston heads 52.

The modification shown in Figure 6 is similar to that shown in Figure 3, and merely discloses a commercial form of the press shown diagrammatically in Figure 3. The construction of this press is similar in general to the forms already described, except that a lining sleeve 140 is inserted in the lower end of the auxiliary cylinder 16 and the pneumatic piston heads 54 are of lesser diameter than the auxiliary piston heads 52, as in Figures 1 to 3, inclusive. In the arrangement of Figure 6, therefore, a much higher gas pressure must be used to raise the moving parts,

and consequently the circuit requires greater care in guarding against excess leakage of gas.

The modified circuit shown in Figure 7 is similar to that shown in Figure 6, and represents a commercial form of press having but slight variations from that shown in Figure 1. The press in Figure 7, however, represents the pump control system in more clarity of disclosure than is shown in Figures 1 and 2, where the pump and its associated parts are mounted upon the side of the press bed 10.

It will be understood that we desire to comprehend within our invention such modifications as come within the scope of the claims and the invention.

Having thus fully described our invention, what we claim as new and desire to secure by Letters Patent, is:

1. In combination, a main cylinder having an upwardly acting main plunger therein, an auxiliary plunger connected to said main plunger and offset laterally therefrom for retracting said main plunger, pressure fluid supply means for alternately actuating said main and said auxiliary plungers, an expansive fluid plunger directly connected to said auxiliary plunger and in tandem arrangement therewith for rapidly advancing said main plunger, a source of expansive fluid under pressure constantly connected to said expansive fluid plunger and operating to force the said expansive fluid plunger in the same direction as said main plunger, the retracting operation of said auxiliary plunger operating through said expansive fluid plunger to compress said expansive fluid within said source.

2. In combination, a main cylinder having an upwardly acting main plunger therein, an auxiliary plunger connected to said main plunger and offset laterally therefrom for retracting said main plunger, pressure fluid supply means for alternately actuating said main and said auxiliary plungers, an expansive fluid plunger directly connected to said auxiliary plunger and in tandem arrangement therewith for rapidly advancing said main plunger, a source of expansive fluid under pressure constantly connected to said expansive fluid plunger and operating to force the said expansive fluid plunger in the same direction as said main plunger, the retracting operation of said auxiliary plunger operating through said expansive fluid plunger to compress said expansive fluid within said source, said expansive fluid plunger having a larger head area than said auxiliary plunger.

WALTER ERNST.
LESLIE S. HUBBERT.