May 26, 1953 L. A. CAMEROTA 2,639,585

HYDRAULIC PRESS CYCLE CONTROL SYSTEM

Filed Dec. 15, 1951 6 Sheets-Sheet 1

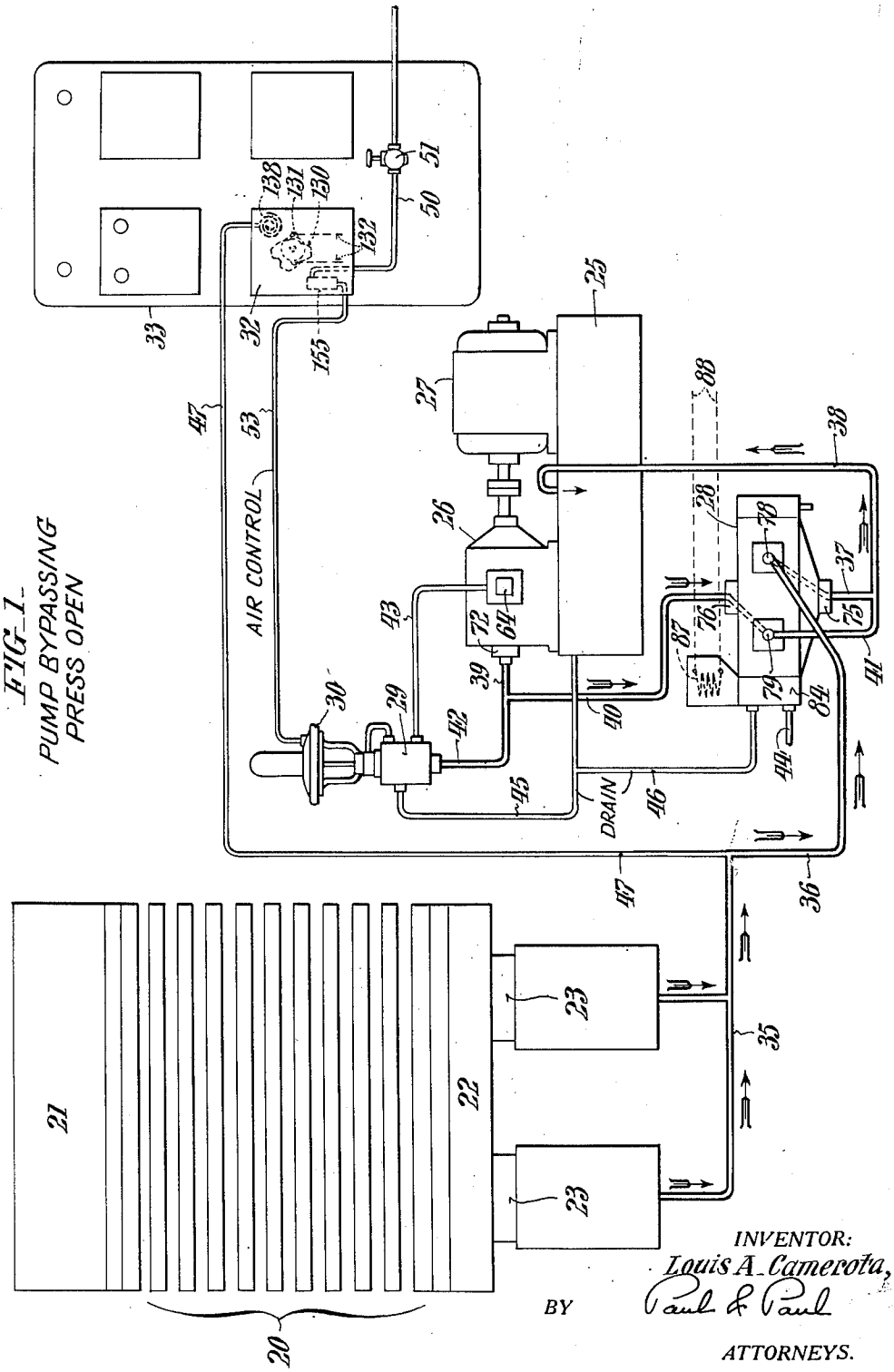


FIG. 1.
PUMP BYPASSING
PRESS OPEN

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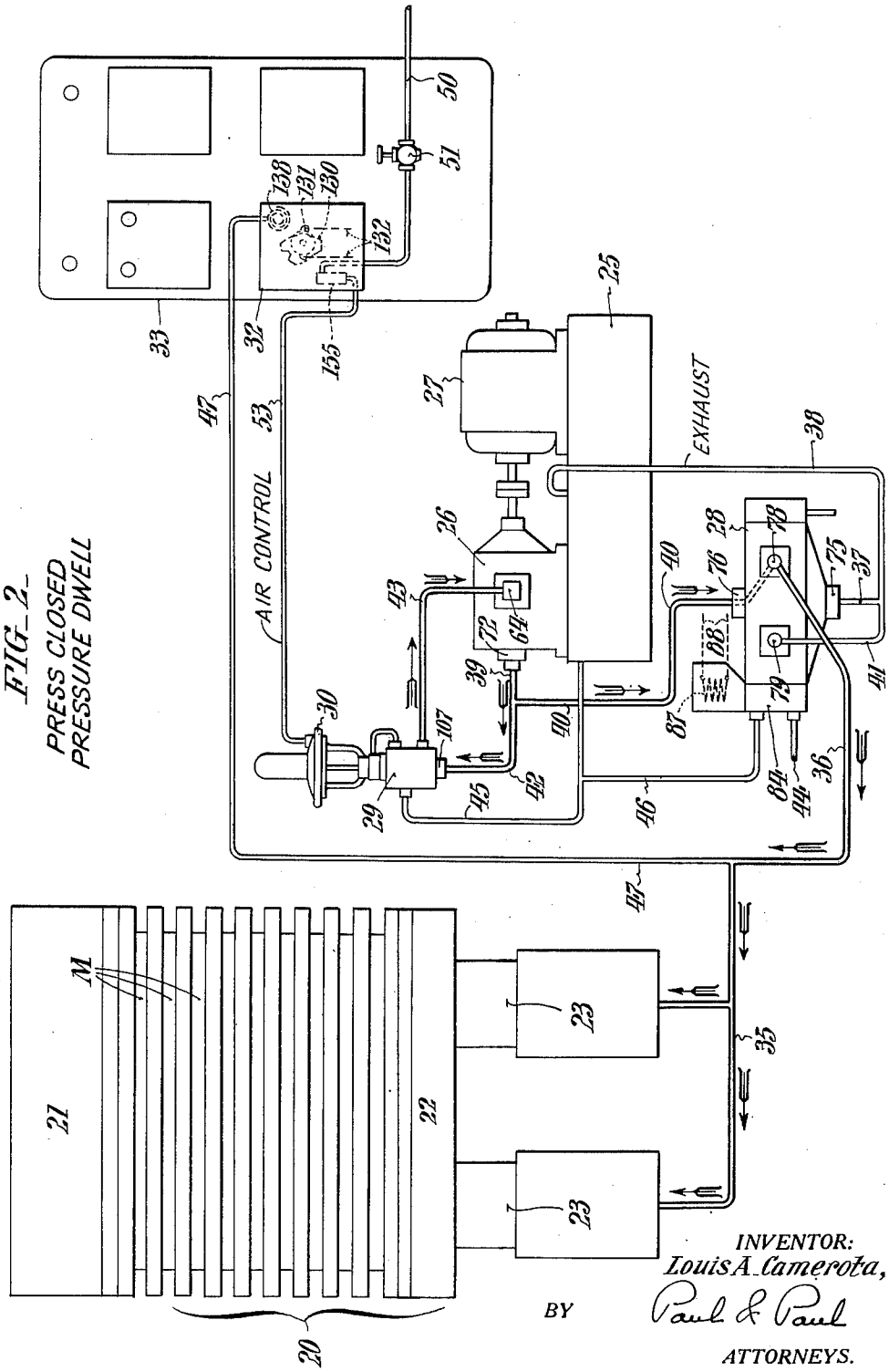


FIG. 2.
PRESS CLOSED
PRESSURE DWELL

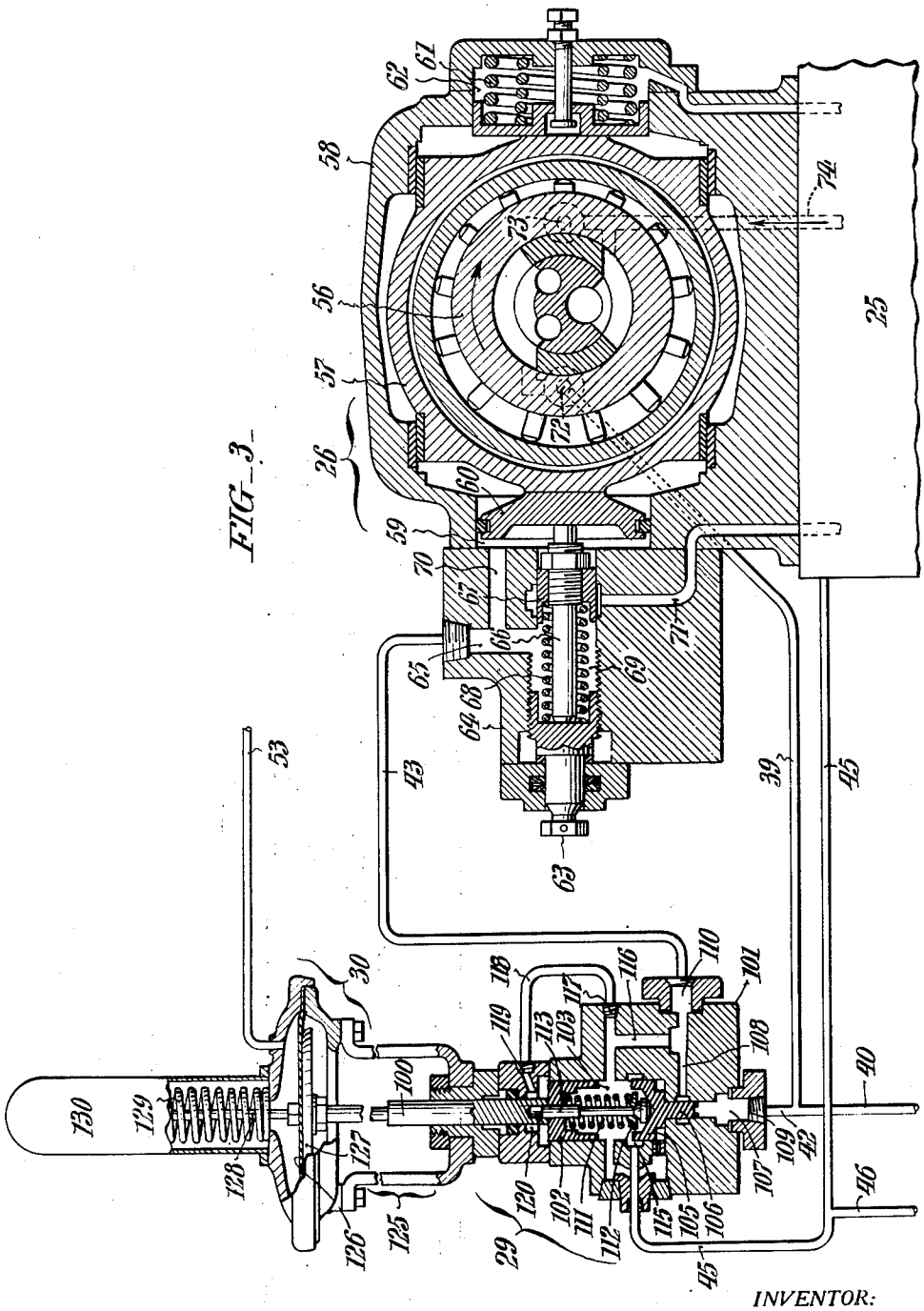
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HYDRAULIC PRESS CYCLE CONTROL SYSTEM

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FIG. 3.



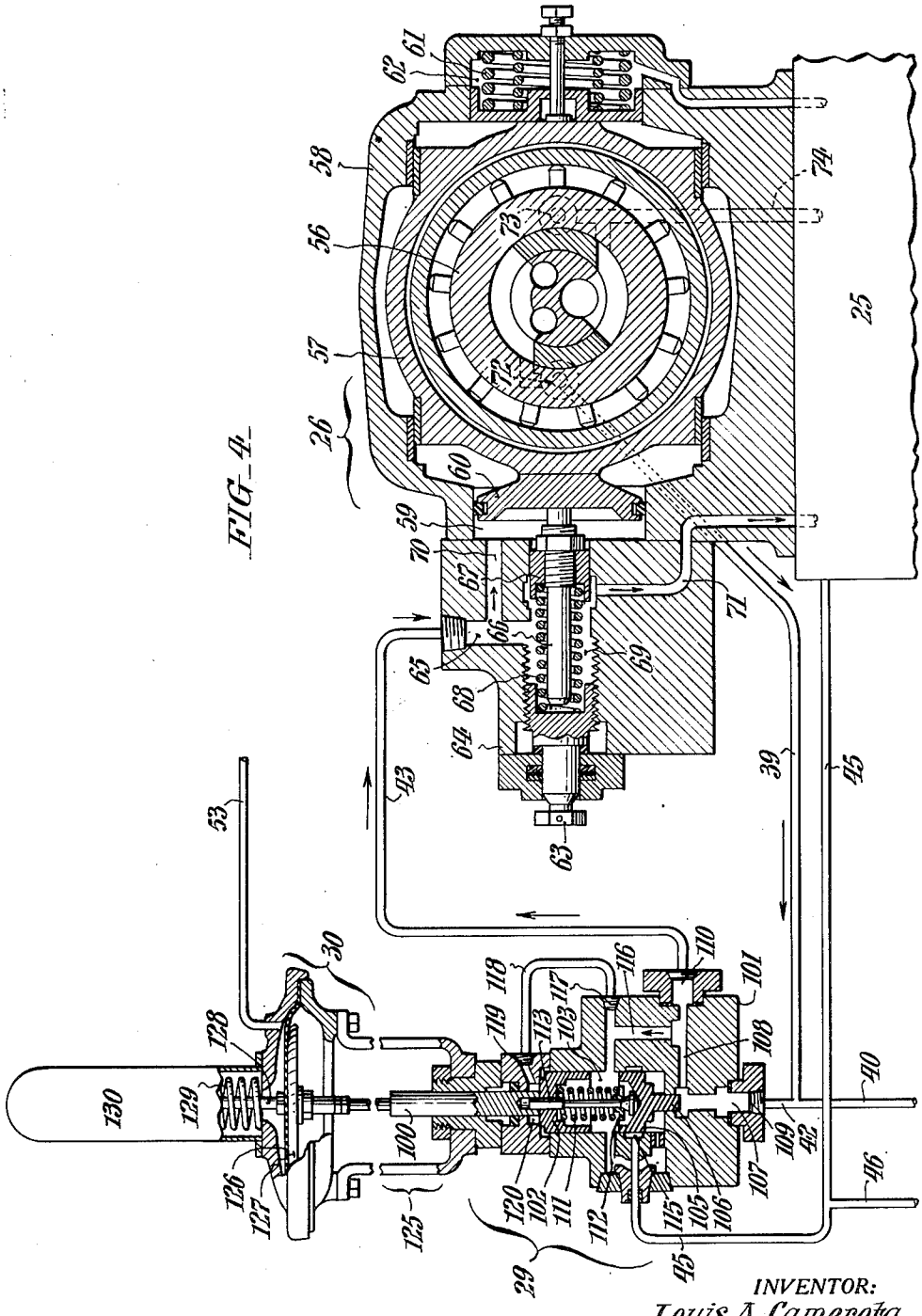
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HYDRAULIC PRESS CYCLE CONTROL SYSTEM

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FIG. 4



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HYDRAULIC PRESS CYCLE CONTROL SYSTEM

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FIG. 5.

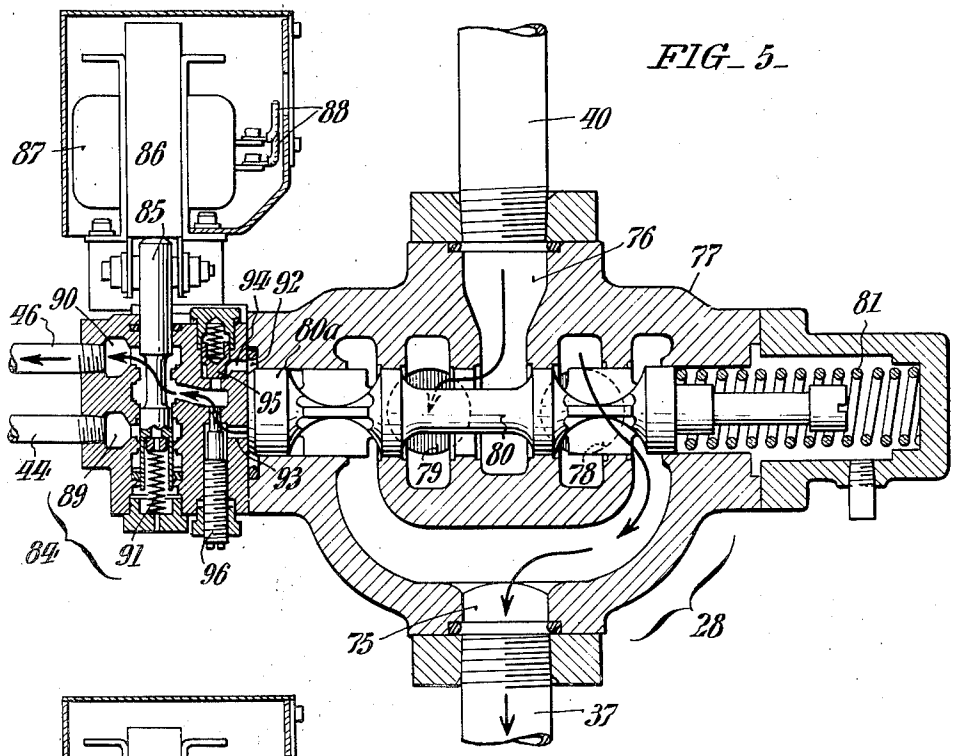
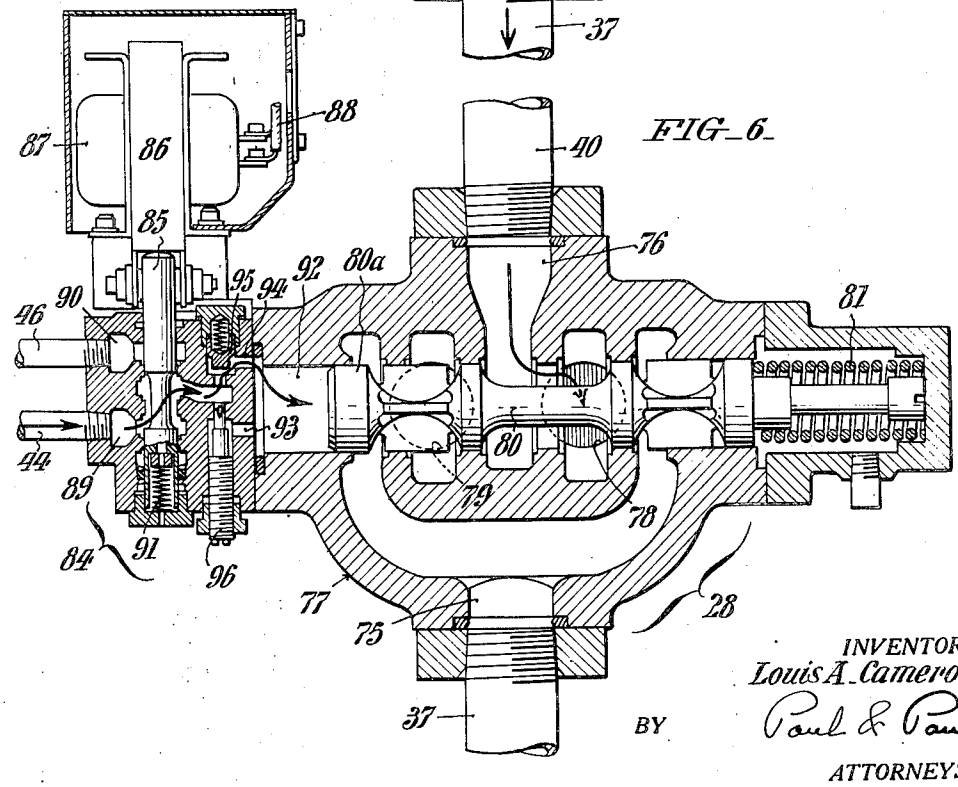


FIG. 6.



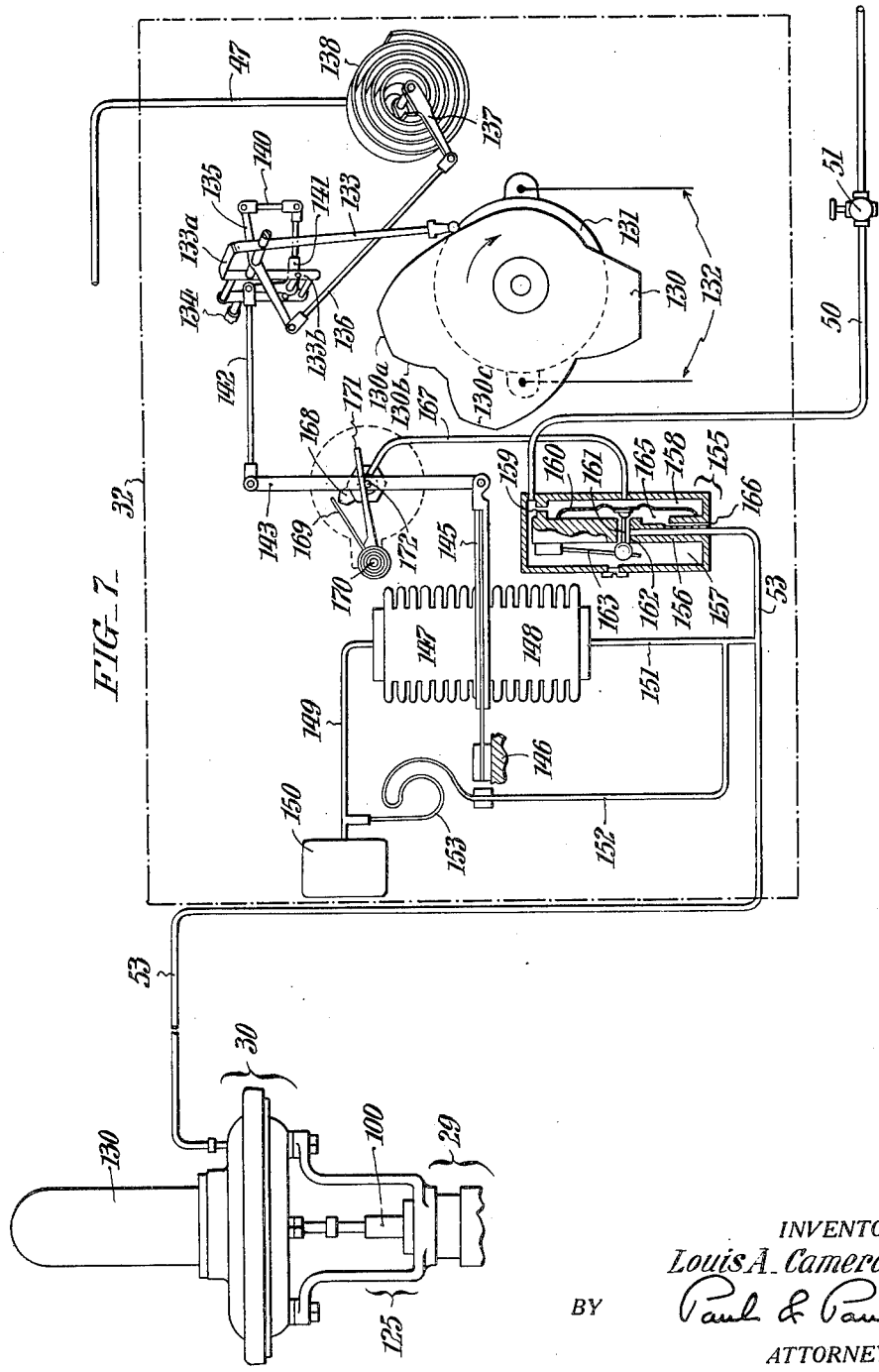
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HYDRAULIC PRESS CYCLE CONTROL SYSTEM

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FIG. 7.



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2,639,585

HYDRAULIC PRESS CYCLE CONTROL SYSTEM

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Application December 15, 1951, Serial No. 261,842

9 Claims. (Cl. 60—52)

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This invention relates to hydraulic press operating systems, that is to say, to systems for operating hydraulic presses under cyclic control.

The chief aims of my invention are to enable the use of a constant speed variable output rotary pump in an operating system for a hydraulic press, and to provide automatic means which can be relied upon to accurately control the pump, after closing of the press, in such manner that the material worked upon is subjected to a definite predetermined pressure or pressures during a cycle period of prescribed duration.

Other objects and attendant advantages will appear from the following detailed description of the attached drawings, wherein:

Fig. 1 is a more or less diagrammatic view of a hydraulic press with a cycle control means conveniently embodying my invention, the press being open and the pump idling.

Fig. 2 is a view like Fig. 1, with the press closed and the pump maintaining prescribed pressure upon the material undergoing compression.

Fig. 3 is a view drawn to a larger scale showing the pump and certain of the control elements in section, with the press open and the pump idling as mentioned above in connection with Fig. 1.

Fig. 4 is a view like Fig. 3 with the press closed and with certain of the control elements functioning under the conditions mentioned above in connection with Fig. 2.

Fig. 5 is a view in longitudinal section of a master valve included in the control means, showing the direction of fluid flow therethrough during idling of the pump and opening of the press.

Fig. 6 is a view like Fig. 5 showing the direction of fluid flow through the master valve during closing of the press; and

Fig. 7 is a diagrammatic view of a cycle governing instrument incorporated in the control, and the connections between said instrument and certain other elements of the control.

In Fig. 1, the press to be controlled is comprehensively designated 20, the same being, by way of example, of the multi-platen type with a fixed top head 21, and with a movable bottom head 22 arranged to be actuated by a pair of hydraulic ram cylinders 23. The hydraulic fluid, which may be oil, used to operate the press is drawn from a reservoir 25 by a variable delivery rotary pump 26 which is driven at constant speed by an electric motor 27. Introduction and exhaust of the oil into and from the press cylinders 23 is via a magnetically-actuated four way

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master valve 28; and the pressure of the oil delivered by said pump is governed, in turn, by an auxiliary or remote control valve 29 arranged to be controlled by a compressed air diaphragm motor 30, under governance of a cycle timing and pressure control instrument 32 on a control panel 33. During opening of the press, oil drains from the ram cylinders 23 by way of piping 35, 36, 37 and 38 back into reservoir 25, the delivery from pump 26 being also returned to said reservoir at the same time by way of piping 39, 40, 41 as shown by the arrows in Fig. 1. During closing of the press, the oil delivered under pressure by pump 26 is conducted to the ram cylinders 23 through piping 39, 40, 36 and 35, likewise by way of master valve 28, as indicated by the arrows in Fig. 2. Part of the pumped oil is conducted through a branch pipe 42 to auxiliary or remote control valve 29 and from thence returns to the pump by way of pipe 43. The purpose of the other pipe connections designated 44, 45, 46 and 47 will be explained later herein. Compressed air is used in the control, the same being delivered from a suitable source of supply (not shown) to the time pressure cycle control instrument 32 on panel 33 through a pipe line 50, the delivery pressure being regulatable by a pressure reducing valve 51 interposed in said line. There is also an air flow connection 53 between instrument 32 and the diaphragm motor 30.

Although the pump 26, the master valve 28, the auxiliary valve 29, the diaphragm motor 30 and the time-pressure cycle control instrument 32 are generally speaking, of known construction, they will be briefly described so that their concerted action in controlling press operation in accordance with my invention, will be more readily understood.

The pump

As exemplified in Figs. 3 and 4, pump 26 is of a type having a fixed axis rotor 56 which is housed within a slide block 57 which serves as the stator, and which is constrained to horizontal movement within the pump casing 58. The output of pump 26 is varied by shifting of slide block 57 relative to rotor 56, the shifting being accomplished in one direction upon admission of oil under pressure into a bore 59 in one side of casing 58 behind a piston 60 abutting said slide block. Upon relief of pressure in bore 59, a spring 61 within a hollow 62 at the opposite side of casing 58 acts to shift slide block 57 in the other direction. The maximum output of the pump can be changed by regulating the volume adjusting screw indicated at 63 which limits the

extent to which slide block 57 can be moved to the left by the action of spring 61. Screw 63 is threadedly engaged in an offset 64 on pump casing 58, and disposed between it and piston 60 in axial alignment, is a plunger 66 with a piston head 67 at one end thereof, said plunger being maintained in engagement with said piston by a spring 68. The oil for actuating piston 60 is delivered to a port 65 in offset 64 and through pipe 43 into the central chamber 69 of said offset and reaches the bore 59 by way of a connecting passage 70. As block 57 is moved to the right, plunger 66 urged by spring 68, follows with the result that, through attendant displacement of the piston head 67 on said plunger, the oil is permitted to flow from the central chamber 69 of offset 64 into storage tank 25 via the passage indicated at 71. As further shown in Figs. 3 and 4, the pipe 39 connects with the pressure port 72 of pump 26, and the suction port 73 of the latter is in communication with the storage reservoir by way of a passage 74.

The master valve

From Figs. 5 and 6, it will be noted that four way master valve 28 has axially-aligned ports 75 and 76 respectively at the bottom and top of its body 77 into which pipes 37 and 40 connect, and lateral ports 78 and 79 into which pipes 36 and 41 connect, see Figs. 1 and 2. During draining of ram cylinders 23 for press opening (Fig. 1) piston 80 of valve 28 is maintained in the position in which it is shown in Fig. 5 by a spring 81, so that oil flow will take place in the direction of the arrows, i. e. from pipe 36 via ports 78 and 75 into exhaust pipe 37. The flow from pipe 40 passes through ports 76 and 79 into pipe 41 and exhaust pipe 38 to reservoir 25. Upon shifting of piston 80 in opposition to spring 81 to the position of Fig. 6 when the press 20 is to be closed (Fig. 2), flow of the oil will take place from pipe 40 via ports 76 and 78 and pipe 36. The actuating means for master valve 28 is in the form of an associated pilot valve 84 whereof the plunger 85 is connected to the armature 86 of an operating solenoid 87 interposed in a circuit 88. As shown, pilot valve 84 has spaced ports 89 and 90 into which the pipes 44 and 46 respectively connect. Pipe 44 may lead from a pilot pressure source (not shown) associated with the pump, or from an entirely separate source of pressure fluid. Normally, plunger 85 of pilot valve 84 is held in the raised position of Fig. 5 by a spring 91 to permit exhausting of oil from the space 92 forward of the head 80*a* of piston 80 of valve 28 via the port at 93 to port 90 and pipe 46. Upon energization of solenoid 87 and depression of the plunger 85 of pilot valve 84, pressure fluid from pipe 44 passes through port 89 to the port at 94 and into the space 92 to shift piston 80 of valve 28 rightward to the position in which it is shown in Fig. 6. Normally port 94 is closed, as shown in Fig. 5, by a spring-backed stop 95 which yields to pressure and thus permits flow of oil into space 92 in the manner just explained. Flow through port 93 is regulatable by a screw 96 whereby the leftward movement of piston 80 of master valve 28 is controlled.

The auxiliary or remote control valve

Except as hereinafter pointed out, auxiliary or remote control valve 29 is of well known construction in that it has an upwardly protruding stem 100 which is axially slidable in the upper or neck end of the valve body 101. The lower end of the stem 100 bears upon a cup piston 102 in the upper portion of the main bore 103 of the valve body. Within the lower portion of the main bore 103 is a cup piston 105 with a diametrically-reduced pendant axial prolongation 106 which extends down into the correspondingly reduced bottom end 107 of the bore 103 to control oil flow through a lateral passage 108 between the ports 109 and 110 of valve 29. The cup pistons 102 and 105 are normally maintained in the positions in which they are shown in Fig. 3, by a helical compression spring 111. The lower end of spring 111 bears against a collar 112 at the corresponding end of a thrust pin 113 which, in turn, bears upon cup piston 105. Pin 113 is slidable independently of valve stem 100 with its top end passing through an axial aperture in cup piston 102 and capable of entry into an axial socket bore in the bottom end of said stem. At its top end, spring 111 bears directly upon cup piston 102. Upon moving upward, cup piston 105 shuts off communication between the port 115 and the main portion 103 of the valve bore and at the same time establishes communication between the ports 107 and 110. A vertical passage 116 connects the ports 110 and 117 within the valve body, and in accordance with my invention, the port 110 is in constant communication, through a by-pass pipe 118, with a port 119 which extends into a hollow 120 directly above cup piston 102 within the valve body. As a consequence of the latter provision, the oil pressure on opposite sides of cup piston 102 is equalized. As shown, port 109 of valve 29 is connected to the pressure port 72 of pump 26 by the pipes 42 and 39, and port 110 is connected to port 65 in the offset of the pump casing 53 by pipe 43. Associated with valve 29 and supported by a bracket 125 rigidly affixed to the upper or neck portion of said valve, is the actuating diaphragm motor 30. To the diaphragm 126 of motor 30 is affixed a disk 127 which, in turn, is secured to an extension 128 of stem 100 of remote control valve 29. Downward movement of valve stem extension 128 is yieldingly resisted by a helical compression spring 129 which is housed in a thimble cover 130 secured to the casing of motor 30.

The time-pressure cycle control instrument

In the time-pressure cycle control instrument 32, see Fig. 7, the rotary profile cam designated 130 is slowly rotated by an electric motor 131 interposed in an electric circuit 132; and against the periphery of said cam rides the distal or point end of a follower arm 133 which is arranged to swing in suspension about a fixed axis 134. Medially fulcrumed within the yoked portion 133*a* of cam follower arm 133 is a horizontal lever 135 whereof one extremity is coupled, by means of a link 136, with the arm 137 of a hydraulic pressure-responsive coil 138 which, through pipe 47 is connected to pipe 35 that leads to the ram cylinders 23. The other extremity of lever 135 is coupled, by means of a drop link 140, to one extremity of a bell crank 141 fulcrumed within another yoke portion 133*b* of cam follower arm 133. By means of a horizontal link 142, the other extremity of bell crank 141 is coupled with the top end of a vertically-arranged proportioning lever 143. At its lower end, proportioning lever 143 is pivotally connected to the distal end of a horizontally-arranged arm 145 which is fulcrumed on a fixed support 146. As shown, arm 145 lies between the reset and proportioning bellows 147 and 148 whereof the former is in communication, by way of a tube 149, with a capacity tank 150.

Extending between tube 149 and a tube 151 leading into the bottom of the proportioning bellows 148 is a shunt tube 152 wherein is interposed a capillary resistance coil 153. Further included in control instrument 32 is a relay 155 whereof the casing is subdivided, by a partition 156, into two chambers 157 and 158 which latter are in communication at the top by a narrow passage 159. Connecting into chamber 158 of relay 155, at the top, is pipe 50 through which compressed air is conducted from the supply source. A diaphragm 160 within the chamber 158 of relay 155 is relied upon to move a valve closure 161 toward and away from a transverse port 162 in partition 156, such movement being yieldingly resisted by a finger spring 163. The space 165 within the diaphragm is in communication with the exterior through a bleed port 166. Another tube 167 leads from chamber 158 of relay 155 to a nozzle 168, bleeding of air through the latter being regulated by a flapper 169 pivoted at 170. An arm 171 also pivoted at 170 in fixed relation to flapper 169, rests upon a stud 172 projecting laterally from proportioning lever 143.

Operation

Assuming the press to be open as in Fig. 1, the plunger 80 of master valve 28 to be positioned as in Fig. 5, and pump 26 to be driven by motor 27 and idling, the press attendant, through suitable switch means (not illustrated), causes the circuits 88 and 132 to be closed. By consequent energization of solenoid 87, piston 85 of pilot valve 84 is depressed as in Fig. 6, permitting actuating pressure fluid delivered by way of pipe 44 to enter cylinder 92 as a result plunger 80 of said master valve is shifted rightward against the resistance of spring 81 as in Fig. 6 to establish communication between ports 76 and 78. The pressurized oil then flows from pump 26 through pipes 39, 40, through ports 76 and 78 of master valve 28, and through pipes 36, 35 to ram cylinders 23 to lift the movable press head 22 until the material M to be compressed is contacted as in Fig. 2. As the pressure builds up in ram cylinders 23, it also rises at port 107 of auxiliary remote control valve 29. When the pressure at port 107 of valve 29 attains a value such that the upward force (hydraulic pressure times the area of valve piston 106) just balances the downward force (air pressure from the pressure control instrument 32 times the area of diaphragm 126 in motor 30), the hydraulic pressure from the system is applied via ports 107 and 110 of valve 29 and passage 70 in offset 64 of pump housing 58, whereby the piston 60 and slide block 57 of pump 26 are shifted rightward to reduce the delivery of said pump to a point just sufficient to provide enough oil to compensate for any leakage in the system. As the slide-block 57 moves toward center position, the plunger 66 follows until the passage 71 is uncovered eventually to allow excess oil to bleed back into storage tank 25. Due to closing of circuit 132 at the initiation of the cycle, cam 130 of time-pressure control instrument 32 is started in clock-wise rotation as indicated by the arrow thereon in Fig. 7, whereby follower arm 133 is gradually moved rightward by the rise of the lobe 130a of said cam. If at this time, the arm 137 of pressure responsive coil 138 remains stationary, proportioning lever 143 will likewise be displaced to the right by motion imparted thereto, through parts 136, 135, 141, and 142. Flapper 169 will thereby be positioned to more nearly cover nozzle 168 and thus restrict air leakage, by way of tube 167, from chamber 158 of relay 155, with consequent increase of the pressure on the corresponding side of diaphragm 160 and wider opening of valve 161 to allow more air to pass through tube 53 to the diaphragm motor 30 of auxiliary control valve 29.

When the press is closed and the hydraulic pressure in the system begins to rise, arm 137 of the pressure-responsive coil 138 in instrument 32 is moved counter-clockwise whereby, through the interposed linkage, proportioning lever 143 is displaced, this time to the left. As a result, flapper 169 is moved away from nozzle 168, with attendant decrease of pneumatic pressure on relay 155 and movement of valve 161 toward closed position. Under these conditions, excess air from the diaphragm motor 30 of remote control valve 29 will bleed through orifice 166 to the atmosphere. Assuming that instrument 32 has been on successful control and that conditions are so balanced that a pressure exists in the proportioning and reset bellows 147 and 148, the same pressure will exist in pipe 53 to the motor 30 of remote control valve 29. If a disturbance occurs, for example, when the depression 130b of rotary cam 130 passes the contacting end of follower arm 133, proportioning lever 143 will be moved to the left about its pivotal connection with arm 145, thereby causing flapper 169 to be retracted from nozzle 168 with attendant decrease in the pneumatic pressure upon the right side of relay diaphragm 160. Valve 161 of relay 155 is thereby moved toward closed position and so allows exhaust of air from proportioning bellows 148 through orifice 166 as a result of which arm 145 is forced downward by bellows 147 to lower proportioning lever 143. Flapper 169 is thereby moved to more nearly cover nozzle 168 once more. Then, due to decrease in the output pressure, air is allowed to bleed through the resistance coil 153 from the reset bellows 147, whereupon proportioning lever 143 will be lifted to retract flapper 169 from nozzle 168. The pressure in control relay chamber 158 will thus be decreased and valve 161 will therefore pass less air to tube 53 leading to diaphragm motor 30 until the decreased pressure in proportioning bellows 147 causes it to lower proportioning lever 143 and thereby allows flapper 169 to approach closer to nozzle 168 once more. This re-setting effect will continue until the pressure on the diaphragm of motor 30 has decreased sufficiently to produce the required air pressure which will permit the hydraulic pressure in the system to decrease to a value determined by the position of follower arm 133 on rotary cam 130. When, and only when this condition obtains will the pressures in the proportioning and re-set bellows 147 and 148 become equal and equilibrium be restored. All of the above controlled actions actually take place simultaneously. As the pneumatic pressure on the diaphragm motor 30 is increased, the stem 109 of remote control valve 29 will be depressed to increase the force of spring 111 and prevent rise of piston 105; while as the pressure on said motor is relieved, said piston will be raised by the hydraulic pressure in the system to shut off oil flow at 115 and clear passage 108 to permit flow of oil from pump 26 to bore 59 in the pump casing 58 as indicated by the arrows in Fig. 4. Slide block 57 is accordingly shifted rightward toward center to decrease the output of pump 26. Due to the shunt pipe 113, the pressure on opposite sides of the piston 102 of valve 29 is equal-

ized as has already been pointed out hereinbefore. Piston 102 will therefore respond easily and quickly to the dictates of diaphragm motor 30. As shown, cam 130 of control instrument 32 (Fig. 7) may be provided with additional lobes 130b and 130c with intervening valleys, to determine imposition of further pressure upon the material M at spaced intervals, and the control cycle may involve either a single revolution or several revolutions of said cam depending upon the character of the material and the effect desired. Upon breaking of the circuits 88 and 132 by automatic means or by the press attendant at the completion of a cycle, the system will be returned to the condition of Fig. 1 whereupon the oil in the ram cylinders 23 will drain by way of the piping 35, 36, master valve 28, and piping 37, 38, back into storage tank 25 and so allow the press 20 to open by action of gravity upon the movable head 22 and on the ram pistons.

From the foregoing it will be seen that, after the press closes upon the work, the time pressure control instrument 32 takes over to determine, through the motor 30 and valve 29, the pressure or pressures to which the material is to be subjected within the definite time range of the cycle.

Having thus described my invention, I claim:

1. In combination, a hydraulic press having relatively movable heads and an actuating ram cylinder; a constant speed rotary pump having a stator and a relatively shiftable rotor, yielding means tending to shift the rotor into eccentric relation to the stator, and hydraulic pressure-responsive means for shifting the rotor in opposition to the yielding means to vary the output of the pump; piping between the ram cylinder of the press and the pump; an interposed master valve allowing, upon actuation, delivery of pressure fluid by the pump to the ram cylinder of the press to close the latter; and an automatic cycle control means operative, upon closing of the press, to thereafter govern the action of hydraulic pressure-responsive rotor-shifting means of the pump and so regulate the latter for imposition of prescribed variable pressures repeatedly upon the material under compression for a definite time interval, said control means including an auxiliary valve interposed in a branch conduit between the piping and the hydraulic pressure-responsive rotor shifting means of the pump, motor means tending to hold the auxiliary valve closed against the hydraulic pressure, and means for governing the motor means to allow the auxiliary valve to open when the prescribed pressure is attained.

2. In combination, a hydraulic press having relatively movable heads and an actuating ram cylinder; a constant speed rotary pump having a stator and a relatively shiftable rotor, yielding means tending to shift the rotor into eccentric relation to the stator, and hydraulic pressure-responsive means for shifting the rotor in opposition to the yielding means to vary the output of the pump; piping between the ram cylinder of the press and the pump; an interposed master valve allowing upon actuation, delivery of pressure fluid by the pump to the ram cylinder of the press to close the latter; and an automatic cycle control means operative, upon closing of the press, to thereafter govern the action of hydraulic pressure-responsive rotor-shifting means of the pump and so regulate the latter for imposition of prescribed variable pressures repeatedly upon the material under compression for a definite time interval, said control means including an auxiliary valve interposed in a branch conduit between the piping and the hydraulic pressure-responsive rotor-shifting means of the pump, pressure fluid-responsive motor means tending to hold the auxiliary valve closed against the hydraulic pressure, a rotary profile cam and a follower arm associated therewith, and means actuated through the follower arm to vary the flow of pressure fluid to the motor means and thereby allow said auxiliary valve to open when the prescribed pressure upon the material is attained.

3. In combination, a hydraulic press having relatively movable heads and an actuating ram cylinder; a constant speed rotary pump having a stator and a relatively shiftable rotor, yielding means tending to shift the rotor into eccentric relation to the stator, and hydraulic pressure-responsive means for shifting the rotor in opposition to the yielding means to vary the output of the pump; piping between the ram cylinder of the press and the pump; an interposed master valve allowing, upon actuation, delivery of pressure fluid by the pump to the ram cylinder of the press to close the latter; and an automatic cycle control means operative, upon closing of the press, to thereafter govern the action of hydraulic pressure-responsive rotor-shifting means of the pump and so regulate the latter for imposition of prescribed variable pressures repeatedly upon the material under compression for a definite time interval, said control means including a normally-closed auxiliary valve interposed in a branch conduit between the piping and the hydraulic pressure-responsive rotor-shifting means of the pump; a pneumatic diaphragm motor tending to hold the auxiliary valve closed against the hydraulic pressure, a rotary profile cam and a follower arm associated therewith, and means actuated through the follower arm to vary the flow of compressed air to the motor and thereby allow said auxiliary valve to open when the prescribed pressure upon the material is attained.

4. The invention according to claim 1, wherein the master valve is of the piston type and provided with yielding means operative to keep the piston normally positioned for flow of fluid in the system in a direction to keep the press open; and wherein an associated magnetically-actuated pilot valve controls access of pressure fluid to the piston of the master valve to shift the latter in opposition to the yielding means so that fluid flow in the system will be in the direction to close the press.

5. The invention according to claim 2, wherein the automatic valve has a main bore, a closure element slidable in the bore, a compression spring urging the closure toward closed position, a piston-like backing element for the spring also within the bore adapted to be acted upon by the motor means, and a by-pass for equalization of pressure upon opposite sides of said piston-like element.

6. In combination, a hydraulic press having relatively movable heads and an actuating ram cylinder; a constant speed rotary pump having a pressure port, a suction port, a stator and a relatively shiftable rotor, yielding means tending to urge the rotor into eccentric relation to the stator, and hydraulic pressure responsive means opposing the yielding means for shifting the rotor to vary the output of the pump; a storage tank for operating fluid in communication with the suction port of the pump; a master valve allowing, upon actuation, delivery of pressure fluid from the pump to the ram cylinder of the press; a pipe line extending from the pressure port of the pump to the master valve; flow and return

pipe lines respectively extending from the master valve to the ram cylinder and to the storage tank; a branch pipe extending from the first mentioned pipe line to the hydraulic pressure-responsive rotor-shifting means of the pump; an auxiliary valve interposed in the branch pipe having a piston subject to fluid pressure in the system for controlling fluid flow through the branch pipe; a motor tending to keep the piston of the control valve in closed position against the hydraulic pressure; and means operative, upon actuation of the master valve and closing of the press, to govern the motor means and thereby allow the auxiliary valve to open when the prescribed pressure upon the material is attained.

7. The invention according to claim 6, wherein the motor means is operable by compressed air; and wherein the governing means varies the flow of compressed air to said motor during the cycle.

8. The invention according to claim 6, wherein the motor means is operable by compressed air; and wherein the governing means includes a valved relay interposed in a compressed air pipe line extending to the motor and having a bleed outlet; a rotary profile cam with an associated follower arm, and means actuated through linkage connections with said arm for controlling bleed discharge from the relay.

9. The invention according to claim 6, wherein the motor means is operable by compressed air; and wherein the governing means includes a valved relay interposed in a compressed air pipe line extending to the motor and having a bleed outlet; a rotary profile cam with an associated follower arm, and means actuated through linkage connections with said arm for controlling bleed discharge from the relay; and means responsive to fluid pressure in the system and influential upon the linkage incident to fluid pressure changes to modify the relief of the relay through the bleed outlet.

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