Jan. 28, 1947. G. A. WALDIE ET AL 2,415,053

CONTROL SYSTEM FOR HYDRAULIC PRESSES

Filed Aug. 3, 1942 2 Sheets-Sheet 1

FIG. 1

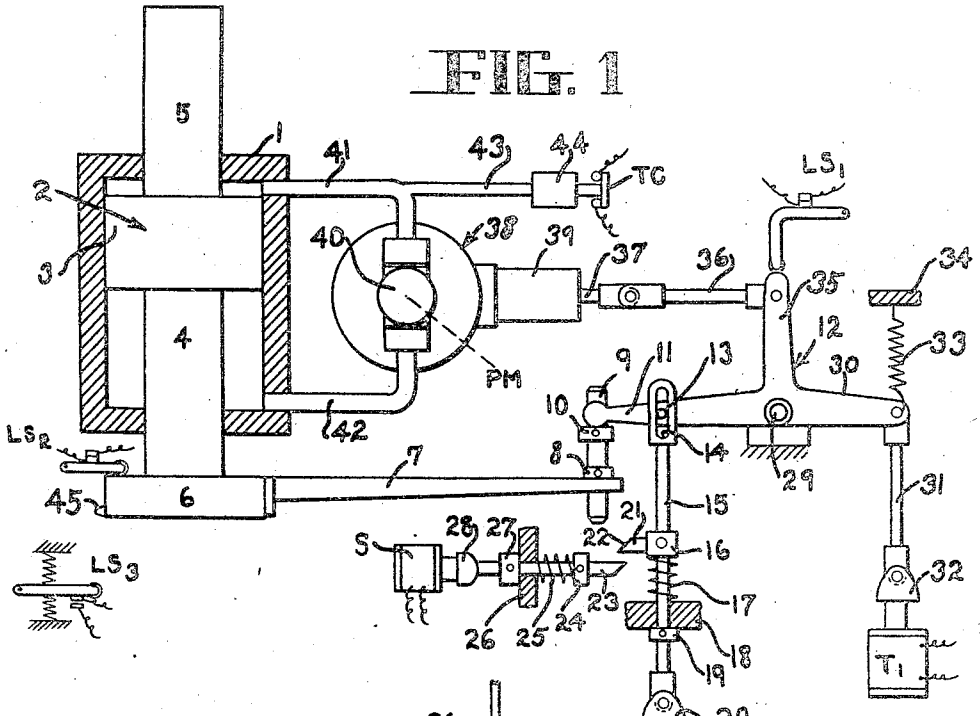
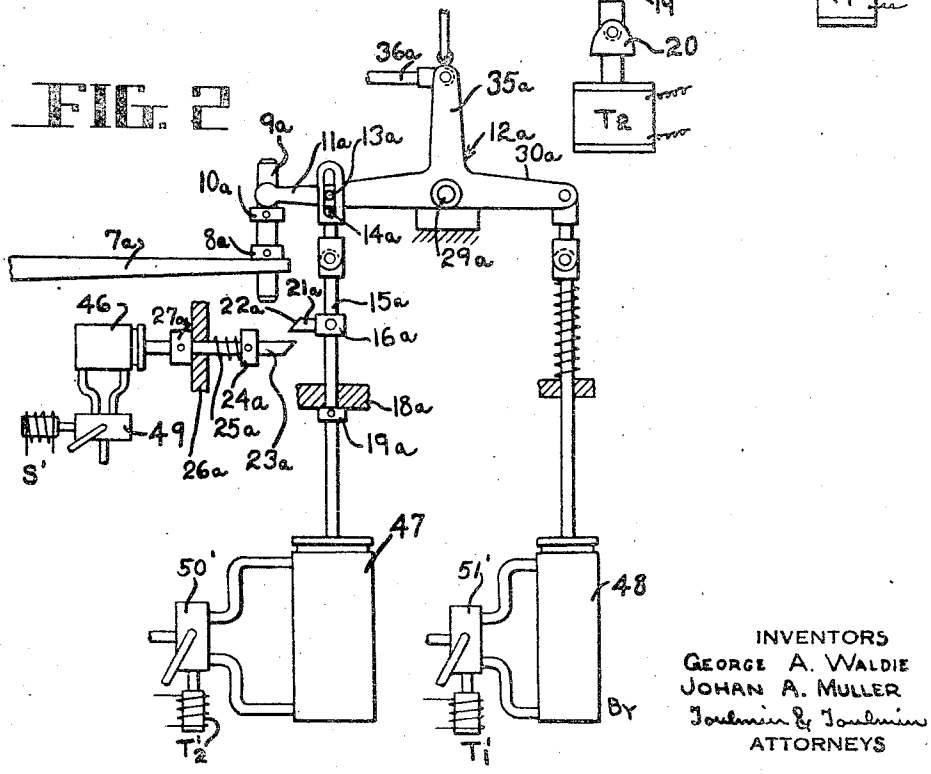


FIG. 2



INVENTORS
GEORGE A. WALDIE
JOHAN A. MULLER
Toulmin & Toulmin
ATTORNEYS

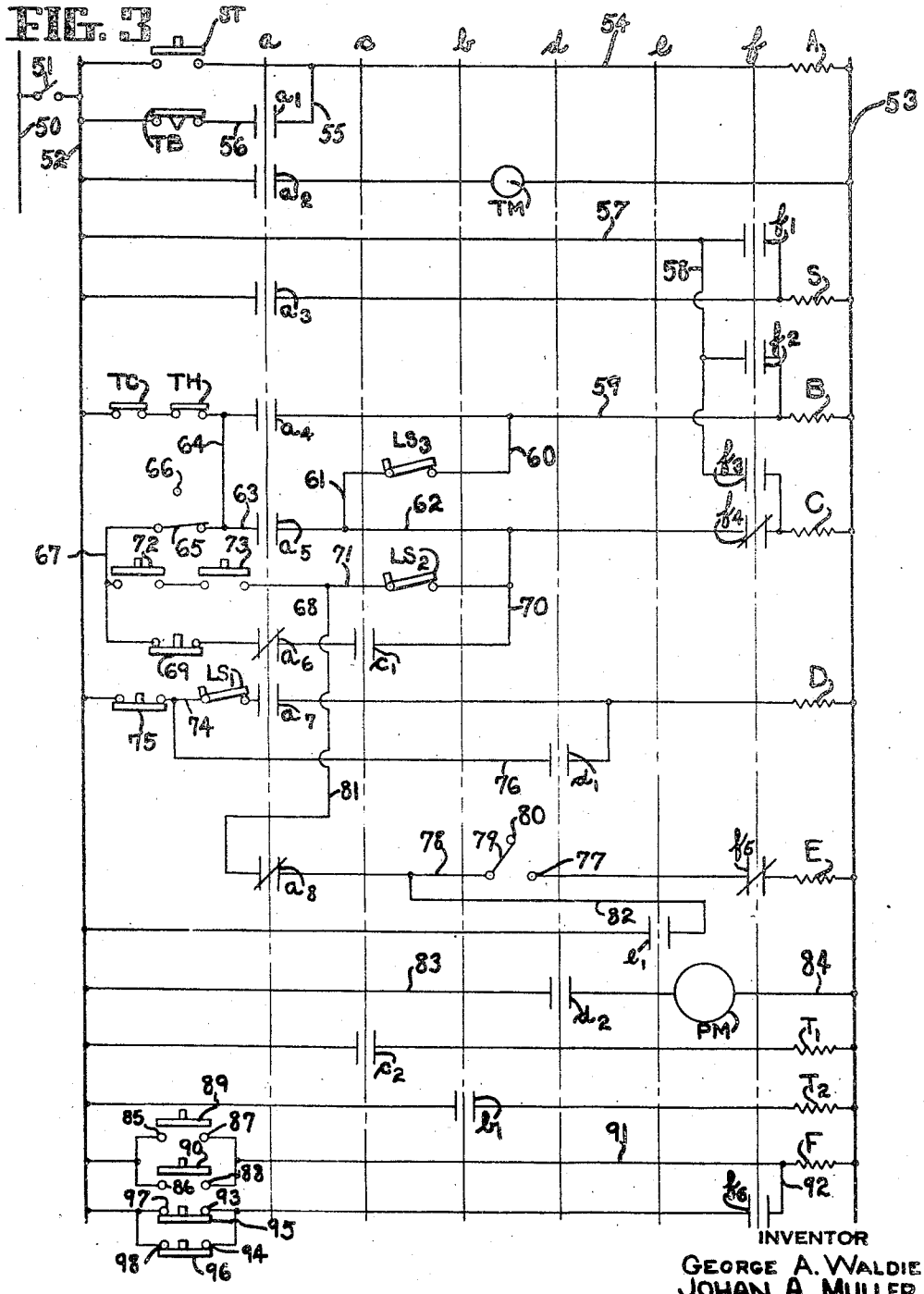
BY

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Filed Aug. 3, 1942 2 Sheets-Sheet 2

FIG. 3



INVENTOR
GEORGE A. WALDIE
JOHAN A. MULLER
Toulmin & Toulmin
ATTORNEYS

BY

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CONTROL SYSTEM FOR HYDRAULIC PRESSES

George A. Waldie, Edison, and Johan A. Muller, Dayton, Ohio, assignors to The Hydraulic Development Corporation, Inc., Wilmington, Del., a corporation of Delaware

Application August 3, 1942, Serial No. 453,376

11 Claims. (Cl. 60—52)

1

This invention relates to control systems and, in particular, to electric control systems for hydraulic machinery.

It is well known that when a hydraulic press stands idle for a relatively long period of time, the press ram gradually slides or creeps downwardly due to leakage around hydraulically operable driving means operatively connected with the press ram. When then the press is to be put into operation, the ram has first to be returned to its retracted or starting position. In case the driving fluid is supplied by a pump of the variable delivery type, it is customary, for the sake of simplicity, to positively connect the said pump with an electric motor for driving the pump, so that when the electric motor is started, also the pump is started, while substantially simultaneously the pump is automatically moved into return stroke position, if it does not already occupy the said return stroke position.

Since, under these circumstances, the electric motor has to start under full load when, after a relatively long period of idleness of the press, the ram has to be returned to its retracted or starting position, special starter means is required to protect the electric motor. Furthermore, the power required for this initial or conditioning operation is relatively high.

It is, therefore, an object of this invention to provide a control system which may be used in connection with hydraulic presses for remedying the above mentioned drawbacks.

It is another object of the invention to provide a control system for hydraulic machinery, such as presses, which includes a pressure fluid source of variable delivery and electric driving means therefor, and in which automatic means is provided adapted to allow the fluid source to supply its full delivery to the hydraulic machinery for actuating the same only after the driving means has been brought up to its full speed.

It is another object to provide a control system including a fluid source of variable delivery for supplying pressure fluid to a fluid operable plunger and electric driving means for driving said fluid source, in which starting of the driving means automatically causes the fluid source to deliver pressure fluid to said plunger after the driving means has been brought up to a desired speed, thereby causing the plunger to move to a predetermined point at which it stops automatically.

It is still another object to provide a control system including a fluid source of variable delivery for supplying pressure fluid to a fluid operable plunger and electric driving means for driving said fluid source, in which safety means is provided which prevents the plunger from starting a working cycle if the plunger occupies a position intermediate its end positions while the driving means is being started.

2

A further object of the invention consists in the provision of a control system for hydraulic machinery, which includes a fluid source of variable delivery for supplying pressure fluid to a fluid operable plunger, and in which the speed of the plunger is automatically slowed down when it approaches a predetermined point of travel and has its speed automatically increased again following the said slow down.

It is a still further object of the invention to provide a control system as set forth above, which includes stop means operable at any desired point of travel of a fluid operable plunger for halting the latter virtually instantaneously.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

Figure 1 diagrammatically illustrates a press circuit in connection with which the control system according to the invention may be used.

Figure 2 shows a variation of some details illustrated in Figure 1.

Figure 3 is an electric control system according to the invention.

General arrangement

The electric circuit according to the invention is illustrated by way of example in connection with the control mechanism shown in Figures 1 and 2, which control mechanism comprises two thrustors connected with a variable delivery pump in such a manner that actuation of one thrustor shifts the pump into full stroke delivery position, whereas the other thrustor, when moved into a first position, causes a reduction in the delivery of the pump and, when moved into a second position, causes the pump to move into substantially neutral or no delivery position.

When the control system according to the invention is used in connection with a hydraulic press supplied with pressure fluid from a variable delivery pump, and the press ram, after a period of idleness, is to be returned from a position intermediate its end positions to its initial or starting position, a starter or conditioning switch is actuated. The actuation of this switch automatically causes first the second mentioned thrustor to positively move the pump into or hold

the same in its neutral position, and thereafter starts the driving motor for the pump. When the driving motor has been brought up to full speed, the pump is automatically shifted into full delivery retraction stroke position, thereby returning the press ram to its retracted or starting position. When the ram has reached this position, it automatically comes to a stop, irrespective of whether or not the press has previously been conditioned for full automatic operation, i. e., automatically to start a working cycle whenever the press ram has been returned to its retracted or starting position.

To start a working cycle of the press ram, an electric circuit is closed by actuation of a switch, whereupon the press ram automatically advances at high speed to a predetermined point where it is automatically slowed down for a very brief period of time. Thereupon, the speed of the ram is again automatically increased and the ram continues its stroke up to a desired point. When the ram reaches this point, its movement is automatically reversed and the ram is returned to its retracted or starting position.

If the press was conditioned for semi-automatic operation, the ram comes to a stop at its retracted position, whereas it immediately starts a new cycle in case the press was conditioned for full automatic operation.

The electric control system according to the invention also includes means which may be operated at any desired point of travel of the ram for bringing the latter to a substantially instantaneous stop.

Structural arrangement

Referring now to the drawings in detail, the press system shown in Figure 1 comprises a press cylinder 1 having reciprocably mounted therein a press ram, generally designated 2, including a piston 3 and piston rods 4 and 5.

Connected to the piston rod 4 is a platen 6 with a platen arm 7, which latter is adapted to cooperate with a collar 8 adjustably mounted on a push rod 9. The push rod 9 is guided on the press frame in any conventional manner, not shown in the drawings.

Also adjustably connected to the push rod 9 is a collar 10 for cooperation with an arm 11 of a three arm lever, generally designated 12. The arm 11 carries a pin 13 extending into a slot 14 of a control or thrustor rod 15. The rod 15 has adjustably connected thereto an abutment 16 engaged by the upper end of a spring 17, the lower end of which engages a portion 18 connected to a stationary member, which may, for instance, be the press frame. The rod 15 has also adjustably connected thereto a collar 19 for abutment with the portion 18. The lower end of the control or thrustor rod 15 is pivotally connected to an element 20 adapted to be actuated by an electrically controlled thrustor T_2.

The adjustable abutment 16 has connected thereto an arm 21 with an inclined end surface 22 which is adapted to cooperate with a similarly shaped rod 23. The rod 23 has adjustably mounted thereon an abutment 24 engaged by one end of a spring 25, while the other end of this spring engages a stationary element 26. The rod 23 also carries, adjustably mounted thereon, a collar 27 adapted to abut the stationary element 26. The rod 23 has connected thereto an armature 28, controlled by a solenoid S. The arrangement is such that when the rod 23 occupies its outermost right hand position with regard to Figure 1, it will engage and stop the arm 21 when the latter moves downwardly from the position shown in Figure 1.

The three arm lever 12 is shiftable about a pivot 29 and has its arm 30 pivotally connected to a control or thrustor rod 31, which latter is pivotally connected to the element 32 pertaining to an electrically controlled thrustor T_1. The right hand end of the lever arm 30 has connected thereto one end of a spring 33, the other end of which is connected to a stationary element 34.

The third arm 35 of the three arm lever 12 is pivotally connected to a link 36 which is pivotally connected to a flow control rod 37 pertaining to a variable delivery pump, generally designated 38, and provided with a servomotor 39. The pump 38 is adapted to be driven by a prime mover PM, such as an electric motor.

The pump 38 has associated therewith a pilot pump 40. The pumps 38 and 40 are driven by one and the same shaft, and may be arranged in the manner disclosed in the Ernst Patent No. 2,168,669.

The pump 38 is preferably of the type shown in the Ernst Patent No. 2,184,665, in which fluid from the pilot pump is adapted to shift the flow control rod 37 selectively into forward or return stroke position. Furthermore, centering springs, not shown in the drawings, are provided in a manner similar to that disclosed in the said Ernst Patent No. 2,184,665, which springs tend to hold the pump in neutral or no delivery position.

From the above it will be clear that when the motor PM is started, also the pumps 38 and 40 are started. The pump 38 has hydraulic connections 41 and 42 respectively leading to the upper and lower portions of the press cylinder 1. The hydraulic connection 41 communicates with a conduit 43 leading to a tonnage control valve 44 of any conventional type, for instance, of the type disclosed in the Ernst Patent No. 2,224,957. This tonnage control valve 44 is adapted, in response to a predetermined pressure, to open the tonnage control switch TC.

The platen 6 is adapted, when in its retracted or starting position, to close a normally open limit switch LS_2. The platen 6 carries a cam 45 adapted, at a predetermined point of travel of the ram, to close a normally open limit switch LS_3.

The control circuit according to the invention also comprises a limit switch LS_1, which is closed when the three arm lever 12 occupies a position corresponding substantially to the neutral or no delivery position of the pump 38. In other words, when the pump 38 is substantially in neutral or no delivery position, the arm 35 of the three arm lever 12 closes the limit switch LS_1.

The arrangement of Figure 2 differs from that of Figure 1 merely in that the solenoid S and thrustors T_2 and T_1 are replaced by hydraulically operable cylinder-piston-assemblies 46, 47 and 48. These cylinder-piston-assemblies are supplied with fluid from a pressure fluid source independent of the pump 38, and the flow of fluid to and from the said cylinder-piston-assemblies is respectively controlled by four-way valves 49, 50' and 51'. The valves 49, 50' and 51' are in their turn controlled by the solenoids S', T'_2 and T'_1. Since otherwise the structure of Figure 2 fully corresponds to that of Figure 1, similar elements in Figure 2 have been designated with the same reference numerals they have in Figure 1, however, with the additional letter *a*.

Referring now to Figure 3, showing the electric

control system according to the invention, the switches controlled by one and the same contactor are arranged in a vertical column which is designated by a small letter corresponding to the capital letter allotted to the respective contactor, while the individual switches are designated with the small letter of the respective column, but with different indices.

The electric circuit of Figure 3 comprises a main supply line **50** adapted to be connected, by closure of the master switch **51**, with a line **52**, and also comprises a main supply line **53**. The line **52** is adapted, by closure of the starter or conditioning switch ST, to be connected with a line **54** leading to one end of the contactor A, the other end of which is connected to the main supply line **53**.

Branching off from the line **54** is a line **55** adapted, by closure of the switch a_1, to be connected with a line **56**, which latter is connected with the line **52** through the time blade TB when the latter is in closed position. The time blade TB is controlled by a timer motor TM having one terminal connected to the main supply line **53**, while the other terminal is adapted to be connected with the line **52** by closure of the switch a_2. Also connected with the line **52** is a line **57** adapted, by closure of the switch f_1, to be connected with one end of the solenoid S, the other end of which is connected to the main supply line **53**. The solenoid S is also adapted to be connected with the line **52** by closure of the switch a_3.

Branching off from the line **57** is a line **58** adapted, by closure of the switch f_2, to be connected with one end of a contactor B, the other end of which is connected with the main supply line **53**. The contactor B is also adapted to be connected with the line **52** through the line **59**, the switch a_4, temperature switch TH and the tonnage control switch TC, when the said switches are in their closed position.

Branching off from the line **59** is a line **60** adapted, by closure of the limit switch LS_3, to be connected with the line **61** leading to the line **62**. The line **62** is adapted electrically to communicate through the normally closed switch f_4 with one end of the contactor C, the other end of which communicates with the main supply line **53**. The contactor C is also adapted, by closure of the switch f_3, to be connected with the line **58**. The line **62** is adapted to be electrically connected with the line **63** by closure of the switch a_5. The line **63** is adapted electrically to communicate with the line **52** through the line **64** and the closed switches TH and TC.

Connected with the line **63** is a hand-automatic operation switch **65** which, when in closed position, conditions the press circuit for automatic operation, whereas the switch **65**, when in open position, conditions the press circuit for hand operation. **66** indicates a dead contact which may be engaged by the switch **65** when the latter is in open position.

Connected with the switch **65** is a line **67** adapted to be connected with a line **68** through the reversing switch **69** and the switch a_6 when these switches are in closed position. It should be noted that the switch a_6 is normally closed. The line **68** is adapted, by closure of the switch c_1, to be connected with the line **70** leading to the line **62**. The line **67** may also be connected with the line **70** through the limit switch LS_2, the line **71** and the forward push button switches **72** and **73** when the said three switches are in closed position.

Connected with the main supply line **53** is one end of a contactor D, the other end of which may be connected through closure of the switch a_7 with one terminal of the limit switch LS_1, the other terminal of which is connected to a line **74** which, by closure of the motor stop switch **75**, is connected with the line **52**.

Branching off from the line **74** is a line **76** adapted, by closure of the switch d_1, to be connected with the contactor D.

Connected with the main supply line **53** is a contactor E adapted to electrically communicate with the terminal **77** through the normally closed switch f_5. The terminal **77** is adapted to be connected with the line **78** by closure of the switch **79**. When the switch **79** engages the terminal **77**, the press circuit is conditioned for full automatic operation, i. e., for the performance of an indefinite number of cycles, whereas when the switch **79** is open, the press circuit is conditioned for semi-automatic operation, i. e., for the performance of a single cycle, after which the press automatically stops. When the switch **79** is open, it may engage the dead contact **80**.

The line **78** is adapted through the normally closed switch a_8 to communicate with the line **81** leading to the line **71**. Branching off from the line **78** is a line **82** adapted, by closure of the switch e_1, to communicate with the line **52**. Connected with the line **52** is a line **83** which, by closure of the switch d_2 may communicate with one terminal of the prime mover or motor PM, the other terminal of which is connected through the line **84** with the main supply line **53**.

Connected to the main supply line **53** is the electrically controlled thrustor T_1 adapted, by closure of the switch c_2 to communicate with the line **52**. The thrustor T_2 has one terminal connected to the main supply line **53**, and is adapted to be electrically connected, through closure of the switch b_1, with the line **52**. Connected to the line **52** are two terminals **85** and **86** adapted respectively to be connected to the terminals **87** and **88** by closure of the emergency stop buttons **89** and **90**. The terminals **87** and **88** are connected through line **91** with one end of the contactor F, the other end of which is connected to the main supply line **53**.

Connected to the line **91** is a line **92** adapted, by closure of the switch f_6, to be connected with the terminals **93** and **94**, which terminals are adapted, by closure of the restarter buttons or switches **95** and **96** respectively to be connected with the terminals **97** and **98**, which in their turn are connected to the line **52**.

Operation

It may be assumed that all parts of the system described above occupy the position shown in Figures 1 and 3 with the exception of the press piston **3**, which occupies a position intermediate its uppermost and lowermost positions.

It may furthermore be assumed that the centering springs associated with the pump **38** hold the latter in substantially neutral or no delivery position.

If it is now desired to put the press into operation, it is necessary first to return the piston **3** to its uppermost position shown in Figure 1. To this end, the operator closes the master switch **51**, and furthermore closes the starter or conditioning switch ST. As a result thereof, electric current flows from the main supply line **50** through switch ST line **54** and contactor A to the main supply line **53**. In this way, the contactor A is

energized so that the switches a_1, a_2, a_3, a_4, a_5 and a_7 close, whereas the switches a_6 and a_8 open.

Closure of the switch a_1 establishes a holding circuit for the contactor A, which holding circuit comprises main supply line **50**, line **52**, time blade TB, switch a_1, lines **55** and **54**, contactor A and main supply line **53**.

Closure of the switch a_2 establishes the energizing circuit for the timer motor TM, which circuit comprises main supply line **50**, line **52**, switch a_2, timer motor TM and main supply line **53**. In this way, the timer motor TM starts to operate.

Closure of the switch a_3 closes a circuit comprising main supply line **50**, line **52**, switch a_3, solenoid S and main supply line **53**. As a result thereof, the solenoid S is energized and moves the rod **23** (Figure 1) toward the left so as to move the latter out of the path of the arm **21**.

Closure of the switch a_4 establishes a circuit comprising main supply line **50**, line **52**, switches TC, TH and a_4, line **59**, contactor B and main supply line **53**. As a result thereof, the contactor B is energized and causes the switch b_1 to close. Closure of the switch b_1 establishes an energizing circuit for the thrustor T_2, which circuit comprises main supply line **50**, line **52**, switch b_1, thrustor T_2 and main supply line **53**. As a result thereof, the thrustor T_2 causes the rod **15** (Figure 1) to move all the way down as far as the coils of spring **17** will permit. When this happens, the upper end of the slot **14** has, by means of the pin **13**, moved the lever **12** into the position shown in Figure 1, thereby positively holding the pump **38** in substantially neutral or no delivery position. As previously mentioned, in this position of the three arm lever **12**, the limit switch LS_1 is closed.

Closure of the switch a_5 causes energization of the contactor C through the main supply line **50**, line **52**, switches TC and TH, lines **64** and **63**, switch a_5, line **62**, normally closed switch f_4, contactor C and main supply line **53**. Energization of the contactor C causes the switches c_1 and c_2 to close. Closure of the switch c_1 has no effect at this time, since the switch a_6 is open. Closure of the switch c_2 causes energization of the thrustor T_1 through main supply line **50**, line **52**, switch c_2, thrustor T_1 and the main supply line **53**. As a result thereof, the thrustor T_1 tends, by means of the rod **31** (Figure 1), to move the three arm lever **12** in clockwise direction. However, since the thrustor T_2 is stronger than the thrustor T_1, the lever **12** remains in the position into which it was moved by energization of the thrustor T_2. Consequently, also the pump **38** remains positively held in its substantially neutral or no delivery position.

Closure of the switch a_7 at the time when this closure occurs, does not energize the contactor D, since, at this time, the limit switch LS_1 is open. However, when, due to the energization of the thrustor T_2, the thrustor rod **15** has shifted the three arm lever **12** into the position shown in Figure 1 and has, thereby, closed the limit switch LS_1, the energizing circuit for the contactor D is closed. This energizing circuit comprises main supply line **50**, line **52**, switches **75**, LS_1 and a_7, contactor D and the main supply line **53**. Energization of the contactor D causes closure of the switches d_1 and d_2. Closure of the switch d_1 establishes a holding circuit for the contactor D, which holding circuit comprises the main supply line **50**, line **52**, switch **75**, line **76**, switch d_1, contactor D and the main supply line **53**.

Closure of the switch d_2 closes the energizing circuit for the motor PM, which circuit comprises main supply line **50**, line **52**, line **83**, switch d_2, motor PM and main supply line **53**. As a result thereof, the motor PM starts and, due to its driving connection with the pump **38** and the pilot pump **40**, also starts these pumps. However, since the pump **38** is positively held in substantially its neutral or no delivery position, as mentioned above, pilot fluid from the pilot pump is prevented from shifting the pump **38** on stroke. The fluid delivered by the pilot pump **40**, for the period during which the motor PM is brought up to its desired speed, is by-passed. A predetermined time thereafter the timer motor TM has reached its full speed and, having been set accordingly, opens the time blade TB.

Opening of the time blade TB breaks the energizing circuit for the contactor A, so that the switches a_1, a_2, a_3, a_4, a_5 and a_7 open, whereas the switches a_6 and a_8 close. Opening of the switch a_1 prevents reenergization of the contactor A when the time blade TB automatically returns to its closing position shortly after it moved into its open position.

Opening of the switch a_2 breaks the energizing circuit for the timer motor TM, so that the latter stops. Opening of the switch a_3 breaks the energizing circuit for the solenoid S. Opening of the switch a_4 breaks the energizing circuit for the contactor B, so that the switch b_1 opens. Opening of the switch b_1 causes deenergization of the thrustor T_2. Opening of the switch a_5 breaks the energizing circuit for the contactor C, so that the switches c_1 and c_2 open. Opening of the switch c_1 prevents reenergization of the contactor C when the switch a_6 closes. Opening of the switch c_2 deenergizes the thrustor T_1.

Opening of the switch a_7 has no particular effect, since the switch a_7 is by-passed through the line **76** and the switch d_1 which, at this time, is closed so that the contactor D and the motor PM remain energized. Since, as mentioned above, the thrustors T_1 and T_2 are deenergized, the spring **33** is now free to shift the three arm lever **12** in anti-clockwise direction, so that fluid from the pilot pump shifts the pump **38** into full delivery retraction stroke position. Thereafter the delivery of the pilot pump is again by-passed to an exhaust. Since, at the time when this shifting of the pump **38** into full delivery retraction stroke position is effected, the motor PM and pump **38** are at full speed, movement of the pump **38** into its retracted position is carried out smoothly without undue load on the motor PM.

Pressure fluid delivered by the pump **38** now passes through conduit **42** into the lower portion of the press cylinder **1**, while fluid is withdrawn from the upper portion of the cylinder **1** by the pump **38** through conduit **41**. Consequently, the ram **2** now moves upwardly. When the ram, during this upward movement, approaches the position shown in Figure 1, the platen arm **7** engages the collar **8** and lifts the push rod **9** so that the collar **10** engages the left end of the lever arm **11**, thereby moving the lever **12** in clockwise direction. When the ram **2** has reached the position shown in Figure 1, the lever **12** is likewise in the position of Figure 1, in which position it has caused the flow control rod **37** to bring about movement of the pump **38** to its neutral or no delivery position. As a result thereof, the press ram is halted in the position shown in Figure 1.

It may now be assumed that the operator desires to cause the press automatically to carry out a plurality of pressing cycles. In other words, the press is to be conditioned for full automatic operation. To this end, the switch **65** is closed so as to interconnect the lines **67** and **63**. This conditions the press for automatic operation. To condition the press for full automatic operation, the operator additionally closes the switch **79** so as to connect the lines **77** and **78** with each other.

To start the first pressing cycle, both forward push button switches **72** and **73** are closed. This immediately causes energization of the contactor C through main supply line **50**, line **52**, switches TC and TH, line **64**, switches **65**, **72**, **73**, LS_2, line **70**, switch f_4, contactor C and main supply line **53**. It should be noted that this energization of the contactor C depends upon the platen having been returned to its uppermost position at which, as previously mentioned, the platen **6** closes the limit switch LS_2. It may also be mentioned that this switch LS_2 is the switch which is adapted to bring about repeat strokes of the press when the latter is conditioned for full automatic operation.

Energization of the contactor C closes the switches c_1 and c_2, of which the switch c_1 establishes a holding circuit for the contactor C, as previously mentioned, while the closure of switch c_2 causes energization of the thrustor T_1. Energization of the thrustor T_1 moves the element **32** downwardly against the thrust of the spring **33**, thereby shifting the pump **38** into full delivery forward stroke position. Pressure fluid is now delivered by the pump **38** through conduit **41** into the upper portion of the press cylinder **1**, while fluid is withdrawn from the lower portion of the press cylinder **1**. Consequently, the press ram **2** moves downwardly.

In addition to bringing about energization of the contactor C, the closure of the forward push button switches **72** and **73** also sets up another actuating circuit, which circuit comprises main supply line **50**, line **52**, switches TC and TH, line **64**, switches **65**, **72** and **73**, line **81**, switches a_8, **79** and f_5, contactor E and main supply line **53**. As a result thereof, the contactor E is energized and causes the switch e_1 to close. Closure of the switch e_1 establishes a holding circuit for the contactor E, which holding circuit comprises main supply line **50**, line **52**, switch e_1, line **78**, switches **79** and f_5, contactor E and main supply line **53**, so that the contactor E remains energized when, after starting of the pressing cycle, the forward push button switches **72** and **73** are released and automatically returned to their open position.

It will also be noted that this circuit brings about the automatic initiation of the next cycle when the press platen **6**, at the end of the present cycle, closes the limit switch LS_2, so that current flows from the main supply line **50** through line **52**, switches e_1, a_8, LS_2 and f_4 and through contactor C to the main supply line **53**.

When the ram is about to reach its work piece engaging position, the cam **45** closes the limit switch LS_3, thereby closing the energizing circuit for the contactor B, which energizing circuit comprises the main supply line **50**, line **52**, switches TC and TH, line **64**, switches **65**, **69**, a_6, and c_1, lines **70**, **62** and **61**, switch LS_3, lines **60** and **59**, contactor B and main supply line **53**. Energization of the contactor B closes the switch B_1, which latter closes the energizing circuit for the thrustor T_2, as previously described.

Inasmuch as the thrustor T_2 is stronger than the thrustor T_1, as mentioned above, the armature **20** causes the thrustor rod **15** to shift the three arm lever **12** in anti-clockwise direction through the intervention of the pin **13**. The downward movement of the rod **15** and, thereby also the movement of the three arm lever **12** in anti-clockwise direction comes to a halt when the arm **21** engages the rod **23**. When this occurs, the lever **12** has shifted the pump **38** into a restricted delivery position so that now only a reduced quantity of fluid is supplied by the pump **38** through the conduit **41** into the upper portion of the press cylinder **1**, and a corresponding reduced quantity of fluid is withdrawn from the lower portion of the cylinder **1**. Consequently, the downward movement of the press platen **6** is being slowed down. The period for which the platen **6** is being slowed down depends on the shape of the cam **45** and the restricted delivery position of the pump **38**. When the cam **45** of the platen **6**, during the downward movement of the latter, releases the switch LS_3, this switch automatically returns to its open position, thereby breaking the energizing circuit for the contactor B. Consequently, the switch b_1 opens and the thrustor T_2 becomes deenergized. Since the thrustor T_1 is still energized, it again shifts the three arm lever **12** in clockwise direction so as to move the pump **38** again into its full delivery forward stroke position. Therefore, the delivery of the pump **38** to the upper portion of the press cylinder **1** is again increased, thereby restoring the advancing speed of the press ram.

When, at the end of the actual pressing operation, a predetermined pressure has been established in the conduit **41**, this pressure is conveyed through conduit **43** to the tonnage control valve **44** and brings about opening of the tonnage control switch TC. This breaks the holding circuit for the contactor C and, thereby, causes deenergization thereof. Deenergization of the contactor C causes the switches c_1 and c_2 to return to their open position.

Opening of the switch c_1 prevents reenergization of the contactor C when the tonnage control switch C automatically returns to its closing position shortly after it was opened by the tonnage control valve **44**. Opening of the switch c_2 breaks the energizing circuit for the thrustor T_1, thereby allowing the spring **33** to move the three arm lever **12** in anti-clockwise direction so as to move the pump **38** into full stroke retraction position. The pump **38** then delivers pressure fluid through the conduit **42** to the lower portion of the press cylinder **1**, while fluid is withdrawn from the upper portion of the cylinder **1** through the conduit **41**. As a result, the ram **2** now moves upwardly. When the ram reaches the position shown in Figure 1, it has again closed the limit switch LS_2 and, since the contactor E is still energized, the closure of the limit switch LS_2 closes the energizing circuit for the contactor C, as previously described, so that the press automatically starts a new cycle.

If the press had not been conditioned for full automatic operation, but only for semi-automatic operation, the switch **79** would be in open position and the contactor E would not be energized when the platen **6** closes the limit switch LS_2 at the end of its retraction stroke. In this instance the press would stop since, at the end of its retraction stroke, the platen arm **7** engages the

collar 8 and, thereby, lifts the push rod 9 so that the latter shifts the three arm lever 12 into the position shown in Figure 1, thereby also moving the pump to substantially neutral or no delivery position.

If it should happen that, during the operation of the press, the operating fluid, which in general is oil, reaches an undue temperature, the temperature switch TH automatically opens, thereby breaking the energizing circuits for the contactors B and C, so that the press is automatically returned to its initial or starting position. The operator, noticing this automatic reversal, may then either open the switch 79, if it is not open at that time, to cause the press to stop at the end of its retraction stroke in the manner described above, or he may close the emergency stop buttons 89, 90 to virtually instantaneously stop the press.

Closure of the emergency stop buttons 89, 90 brings about energization of the emergency contactor F through the main supply line 50, line 52, switches 89 and 90, line 91, contactor F and main supply line 53. Energization of the contactor F causes the switches f_1, f_2, f_3 and f_6 to close and the switches f_4 and f_5 to open. Closure of the switch f_6 establishes a holding circuit for the contactor F, which holding circuit comprises the main supply line 50, line 52, restarter button or switch 95, switch f_6, line 92, contactor F and the main supply line 53.

Closure of the switches f_1, f_2 and f_3 brings about energization of the solenoid S and contactors B and C. As a result thereof, also the thrustors T_1 and T_2 are energized. Therefore, the solenoid S withdraws the rod 23 from the path of the arm 21, and the thrustor T_2 shifts the three arm lever 12 in anti-clockwise direction so as to cause the pump 38 to move into neutral position in the manner previously described.

Energization of the thrustor T_1 is ineffective at this time since, as mentioned above, the thrustor T_2 is stronger than the thrustor T_1. Consequently, no fluid is supplied to or withdrawn from the cylinder 1 so that the press ram comes to a halt. If, after such emergency stop, the press is to be restarted, the emergency contactor F is to be deenergized by opening of the restarter buttons or switches 95 and 96. It is to be noted that the pressing of the emergency stop buttons 89 or 90 is effective substantially simultaneously to bring the ram to a halt whether it is moving on its upward or downward stroke. Thereafter, the deenergization of the emergency contactor F by the opening of the switches 95 and 96 will be effective to cause the ram to return to its fully retracted position. This is due to the fact that the contactor C will be de-energized upon deenergization of F and will not close again upon closing of the contacts $f4$ because the holding circuit including the blades $c1$ is also open. The contactor E can be again energized to place the press in full automatic operation by closing the start buttons 72 and 73. It will be apparent that this arrangement provides for clearing the circuit each and every time it is necessary to make an emergency stop whereby the ram will not automatically recycle after its return to fully retracted position after an emergency stopping thereof. The reversing of the ram in the usual manner by pressure or by the switch 69 does not operate to clear the circuit of its full automatic conditioning, but provides for automatic recycling so long as the contactor E remains energized.

If it is desired to control the press by hand rather than automatically, the switch 65 is opened, thereby preventing energization of the contactors B and C and, thereby, also of the thrustors T_2 and T_1. In other words, the electric control circuit, as far as it controls the press during its cycle, is dead, and the pump may then be controlled manually in conventional manner for operation of the press.

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

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

1. In a control system, a fluid motor, a fluid source of variable delivery for supplying said motor, a prime mover connected to drive said source, said motor having a movable element continuously urged in one direction and being adapted during the movement thereof in the other direction to move said source to neutral, means continuously urging said source toward position to deliver to said motor in a direction to move said element in said other direction, first control means operable to move said source to neutral, means responsive to the actuation of said first control means to start said prime mover, second control means operable to make said first control means ineffective while maintaining said prime mover in operation, and a control circuit operable automatically to actuate said first control means and after a predetermined time delay to actuate said second control means.

2. In a control system, a fluid motor having a movable element continuously urged in its advancing direction, a fluid source for supplying said motor and having a flow control member, means operated by said element during movement in its retracting direction for moving said member to neutral, yielding means continuously urging said member to cause said source to deliver to said motor in a direction to move said element in its retracting direction, an electrically controlled prime mover drivingly connected with said source, first control means operable to position, said member in neutral, means operable automatically upon the actuation of said first control means to energize said prime mover, second control means operable to make said first control means ineffective, and an electrical control circuit energizable to actuate said first and second control means automatically and in sequence, and to maintain said prime mover energized following the actuation of said second control means.

3. In a control system, a vertically reciprocable plunger, a variable delivery pump connected to supply said plunger, said plunger being adapted in its uppermost position to move said pump to neutral, an electric motor positively connected to drive said pump, a first thrustor operable to urge said pump into position to deliver to the upper end of said plunger, a second thrustor operable to position said pump in neutral against the thrust of said first thrustor, control means selectively operable for actuating both of said thrustors to position said pump in neutral, means automatically operable when said pump is in neutral for energizing said motor, and means automatically operable a predetermined time after said motor is energized for making said thrustors ineffective.

4. In a control system, a vertically reciprocable plunger having advancing and retracting means,

a variable delivery pump connected to supply actuating fluid to said means, an electric motor positively drivingly connected with said pump, yielding means continuously urging said pump to deliver to said retracting means, means operated by the plunger in its fully retracted position for moving said pump to neutral, first electrically controlled means operable to move said pump into position to deliver to said advancing means, second electrically controlled means operable to move said pump to neutral against the thrust of said first electrically operable means when said electric motor is to be started, means for energizing both of said electrically controlled means for positively positioning said pump in neutral, means automatically operable in response to the positioning of said pump in neutral for energizing said electric motor, and means comprising time delay means operable automatically after a predetermined period following the energization of said motor for de-energizing said first and second electrically controlled means.

5. In a control system, a vertically reciprocable plunger having a downward acting advancing area and an upward acting retracting area, a reversible variable delivery pump connected to supply said areas, means operated by said plunger as it approaches its fully retracted position for moving said pump toward neutral, an electric motor directly coupled with said pump, yielding means continuously urging said pump toward position to deliver to said retracting area, a first thrustor operable to move said pump into position to deliver to said advancing area, a second thrustor operable to move said pump to neutral against the thrust of said first thrustor, and means operable when said motor is to be started and said plunger is below its fully retracted position for actuating both of said thrustors to position said pump in neutral thereby to prevent its delivery to said plunger, means automatically operable thereafter for energizing said motor, means responsive to a predetermined time delay following the energization of said motor for rendering said thrustors ineffective, and means selectively operable thereafter for actuating or rendering ineffective said first thrustor for reciprocating said plunger.

6. In a control system, a vertically reciprocable plunger having a downward acting advancing area and an upward acting retracting area, a reversible variable delivery fluid source adapted to supply actuating fluid to said areas, yielding means continuously urging said source to deliver to said retracting area, means operated by said plunger as it approaches its fully retracted position for moving said source toward neutral, an electric motor positively drivingly connected with said source so that both are placed into operation simultaneously, a first electrical thrustor operable to place said pump in position to deliver to said advancing area, a second and larger electrical thrustor adapted to place said pump in neutral when said first thrustor is energized, and electric control circuit means operable when said motor is to be started and said plunger is below its fully retracted position for positively preventing the energization of said motor prior to the placing of said pump in neutral, said control circuit means being adapted automatically first to energize both of said thrustors, thereafter to energize said motor, and finally to de-energize said thrustors while continuing the energization of said motor.

7. In combination with a hydraulic system in-

cluding a plunger vertically reciprocable by a downward acting advancing area and an upward acting retracting area and also including a variable delivery pump which is continuously urged by yielding means to deliver to said retracting area and which is positively drivingly connected with an electric motor, means operated by the plunger in its fully retracted position to move the said pump to neutral, electric control circuit means operable automatically to start said electric motor and said pump while simultaneously preventing fluid connection between said pump and said advancing and retracting areas, and a predetermined time thereafter to establish fluid connection to cause said plunger to return to its retracted or starting position from a position intermediate its end positions, means operatively connected with said electric control circuit means for conditioning said hydraulic system to cause said plunger to initiate automatically a plurality of cycles thereof, and means associated with said electric control circuit means for preventing said plunger from automatically starting an advancing stroke following the movement of said plunger from the said intermediate position to its retracted or starting position.

8. In a control system including a plunger having associated therewith fluid operable advancing and retracting means for reciprocating the same and also including conditioning means for conditioning said control system for full automatic operation so as to cause said plunger automatically to start another cycle following the completion of one cycle, a variable delivery pump for supplying pressure fluid selectively to said advancing or retracting means, yielding means continuously urging said pump to deliver to said retracting means, electric motor means positively drivingly connected with said pump for starting the same simultaneously with the starting of said motor means, first control means for moving said pump to neutral while said pump and said motor means are being started and brought up to a predetermined speed, second control means actuated automatically after a predetermined delay during which said pump and said motor means have reached predetermined speed for making said moving means inoperative while continuing said pump and motor in operation, whereby said yielding means may move said pump to deliver to the retracting means if the plunger has moved away from its retracted position, third control means responsive to the return of said plunger to said retracted position for shifting said pump to substantially neutral or no delivery position and maintaining said pump in this position irrespective of the conditioning of said control system for full automatic operation, and electric circuit means for automatically and successively actuating said first and second control means.

9. In a control system for a plunger having advancing and retracting areas and a pump connected therewith continuously urged to deliver to said retracting area, said pump having a prime mover positively connected therewith, means to condition said control system for full automatic cycling of said plunger, first control means for interrupting delivery of said pump to said plunger while said prime mover and pump are brought up to speed, second control means for making said first control means ineffective while maintaining said prime mover in operation, third control means responsive to the movement of said plunger to fully retracted position to interrupt delivery of said pump to said plunger,

emergency stop means selectively operable substantially instantaneously to halt the movement of the plunger during the cycling thereof, and additional means operable to de-energize the emergency stop means and cause the plunger to be retracted and remain in retracted position regardless of the conditioning of the system.

10. In a control system for a plunger having advancing and retracting areas and a pump connected therewith continuously urged to deliver to said retracting area, said pump having a prime mover positively connected therewith; means to condition said system for full automatic cycling of said plunger, first control means for interrupting delivery of said pump to said plunger while said prime mover and pump are brought up to speed, second control means for making said first control means ineffective while maintaining said prime mover in operation, third control means responsive to the movement of said plunger to fully retracted position to interrupt delivery of said pump to said plunger, emergency electrical means selectively energizeable substantially instantaneously to halt the movement of said plunger during the cycling thereof, means responsive to the deenergization of said emergency means to return said plunger to its fully retracted position, and means responsive to the actuation of said emergency means when said system is conditioned for full automatic operation for altering the said conditioning so that the said plunger comes to a halt in its retracted position.

11. In a control system for a plunger having advancing and retracting areas and a source of pressure fluid connected therewith which is continuously urged to deliver to said retracting means, said source having a prime mover positively connected therewith, means of conditioning said control system for full automatic cycling of said plunger, first control means for moving said source to neutral delivery position while said prime mover and source are brought up to speed, second control means for making said first control means ineffective while maintaining said prime mover in operation, third control means responsive to the movement of said plunger to fully retracted position to move said source to neutral delivery position, an electrical circuit operable to energize said first and second control means automatically and in sequence, emergency stop means selectively operable substantially instantaneously to halt the movement of said plunger during the cycling thereof, means operable after the operation of said stop means for returning said plunger directly to its retracted position, and means for maintaining said plunger in its fully retracted position irrespective of the conditioning of said circuit when moved thereto following the starting of said prime mover or the actuation of said stop means.

GEORGE A. WALDIE.
JOHAN A. MULLER.