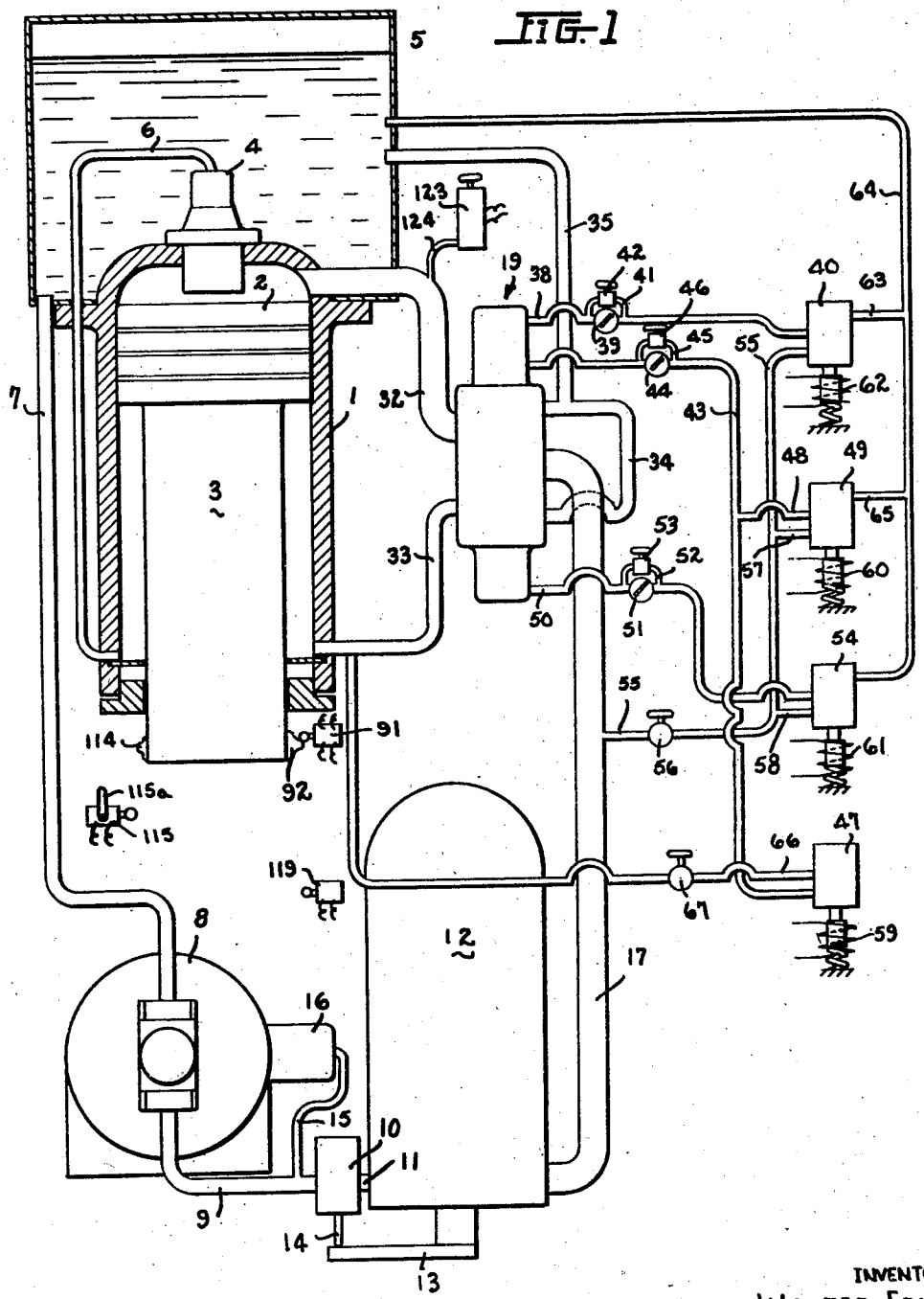
Nov. 26, 1946. W. ERNST 2,411,716

HYDRAULIC PRESS SYSTEM

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FIG. 1



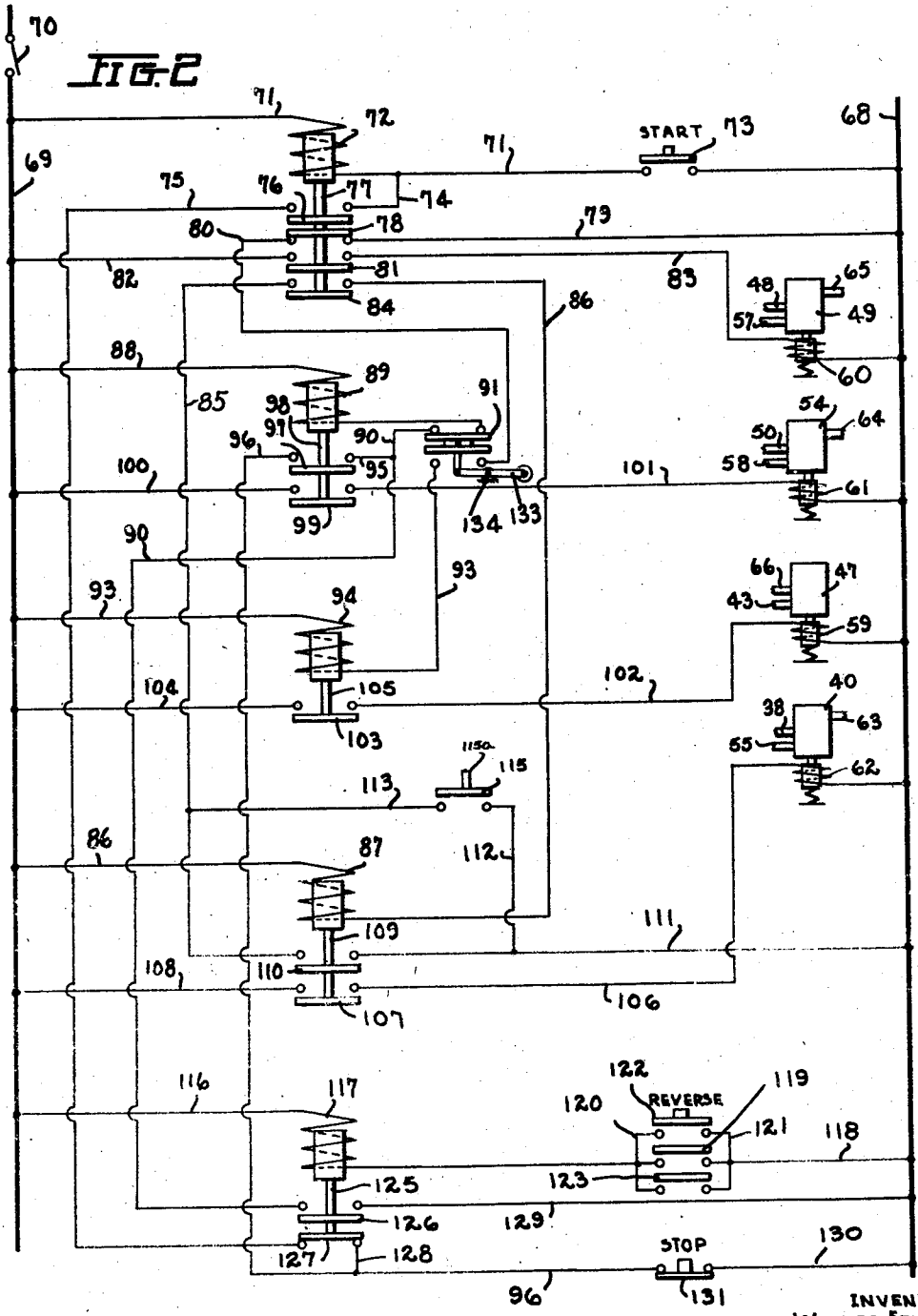

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FIG. 2




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FIG. 4

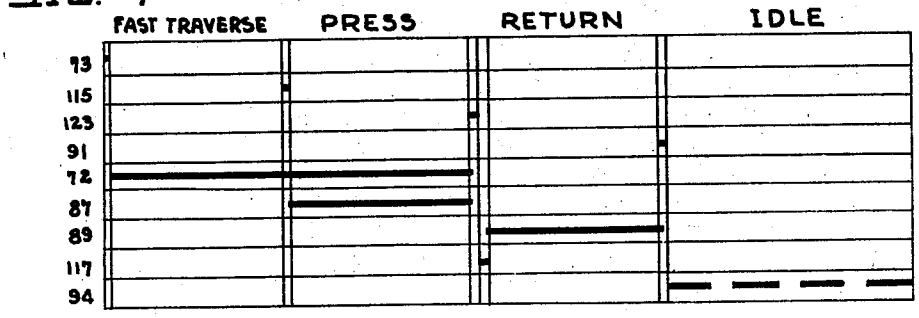



FIG. 3

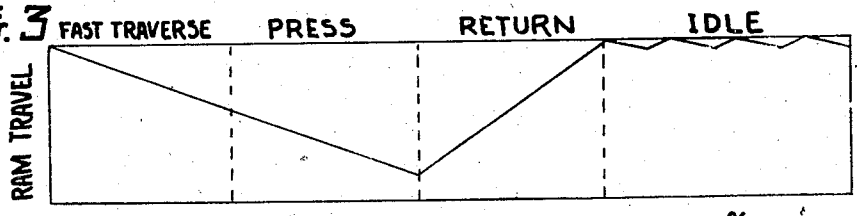



FIG. 5

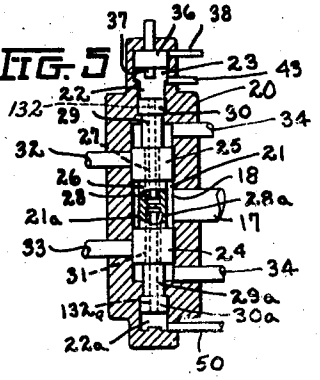



FIG. 6

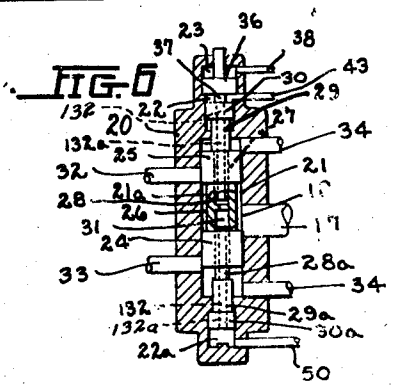



FIG. 7

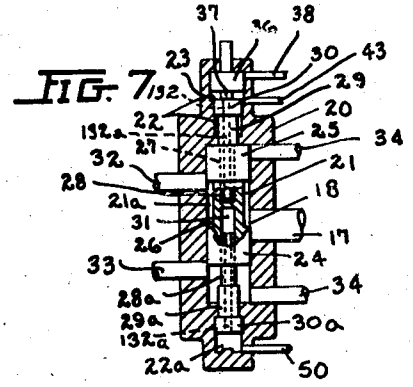
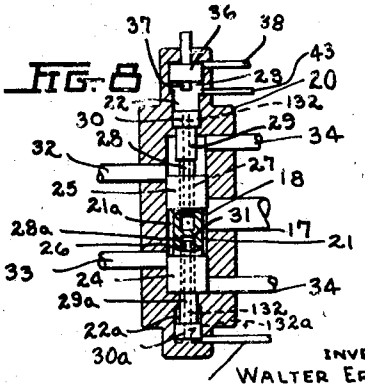



FIG. 8




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FIG. 9

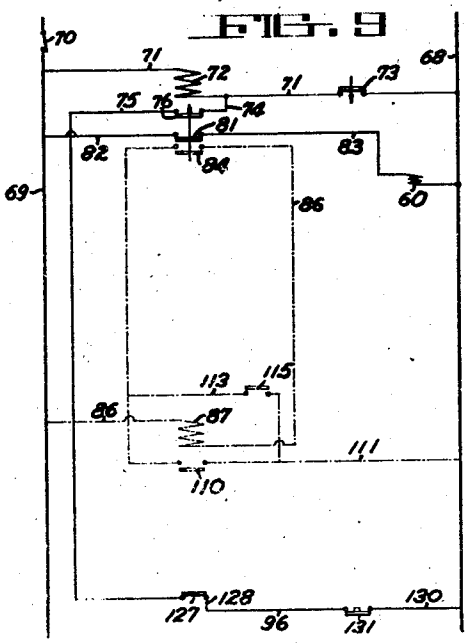



FIG. 10

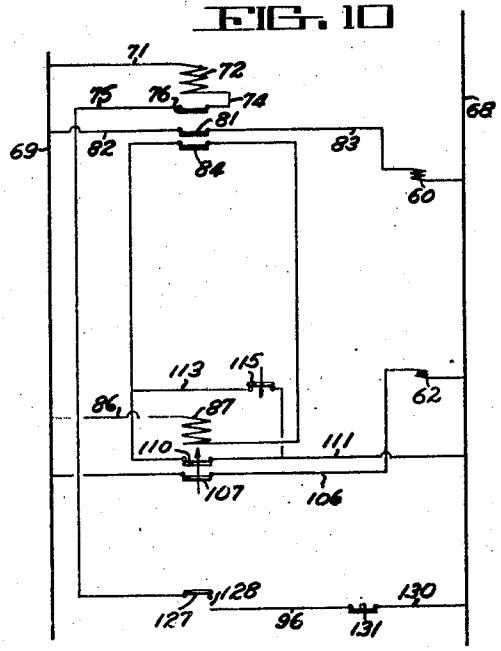



FIG. 11

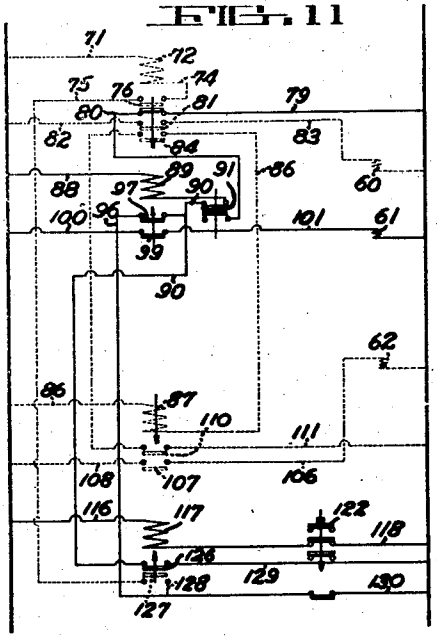
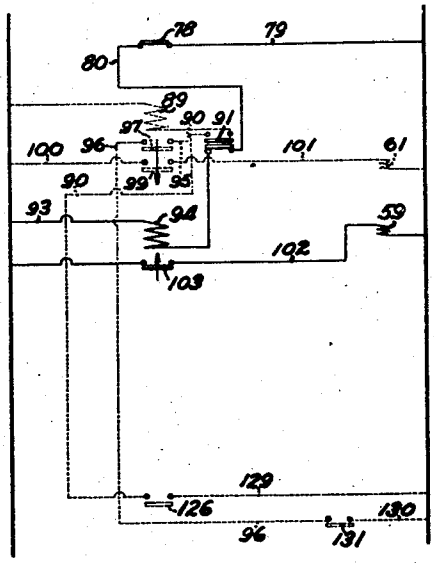



FIG. 12




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Patented Nov. 26, 1946 2,411,716

# UNITED STATES PATENT OFFICE

2,411,716

## HYDRAULIC PRESS SYSTEM

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Application December 5, 1941, Serial No. 421,732

9 Claims. (Cl. 60—52)

1

This invention relates to hydraulic machinery and, in particular, to hydraulic presses.

It is an object of the present invention to provide a hydraulic press system in which the press ram may instantaneously be stopped at any position it happens to occupy during the working cycle, and may be held in this position for any desired time.

It is another object of the invention to provide a hydraulic press system, in which the press ram may be held for any desired time at any position it may occupy during a working cycle, and may then selectively be advanced or retracted.

A further object of the invention consists in the provision of a press system comprising a fluid operable press ram, in which the supply and withdrawal of fluid to and from said ram respectively may instantaneously be stopped without affecting the source which supplies fluid to said ram.

It is a still further object to provide a hydraulic press circuit, which comprises a control valve controlling the supply of fluid to and withdrawal of fluid from the press ram, and in which means is provided for by-passing said control valve, when in neutral position, to make up leakage which may occur in the press cylinder while the press ram is in its retracted position.

Still another object consists in the provision of a hydraulic press circuit, as set forth in the preceding paragraph, which comprises an electric control system for automatically controlling the control valve to cause the press ram automatically to perform a complete cycle.

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 system according to the invention.

Figure 2 is a wiring diagram of an electric control circuit for use in connection with the press system according to the invention.

Figure 3 is a graph illustrating the press ram travel during a cycle, and in idling position due to leakage occurring in the press cylinder.

Figure 4 is a graph illustrating the closing and opening of the various control switches during the various phases of travel of the press ram, as illustrated in Figure 3.

Figures 5, 6, 7 and 8 show various positions of the main control valve during a pressing cycle.

Figures 9, 10, 11 and 12 illustrate those portions of the wiring diagram shown in Figure 2 which become effective at the various phases of the press ram travel.

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*General arrangement*

The press system according to the present invention substantially comprises a fluid operable press ram, a fluid source, such as an accumulator, for supplying fluid to the press ram, and a main control valve through which the fluid passes from the fluid source to the press ram.

The control valve, which is preferably operable by fluid from the said fluid source, is shiftable into a predetermined position for interrupting fluid connection between the fluid source and the press ram, while simultaneously preventing the escape of fluid from the press ram to an exhaust so as to instantaneously stop the press ram without having to change the condition of the fluid source. The supply of pilot fluid from the said fluid source to the control valve for actuating the latter is preferably electrically controlled.

The press circuit according to the invention furthermore comprises valve means which automatically establishes a by-pass connection between the fluid source and the retraction side of the press ram when the latter, while in idling position, drops due to leakage occurring in the press cylinder.

*Structural arrangement*

The press system shown in Figure 1 comprises a press cylinder 1 having reciprocably mounted therein a press piston 2 with a ram 3 connected thereto.

Mounted in the upper portion of the press cylinder 1 is a surge valve 4 which may be of any desired type, preferably of the type described in the Ernst Patent No. 2,193,248. The surge valve 4 opens in response to a suction effect in the upper portion of the press cylinder 1 so as to admit fluid from the fluid reservoir or surge tank 5, mounted on top of the press cylinder 1, into the upper portion of the press cylinder 1. A pilot line 6 is connected with the surge tank 5 and the lower portion of the press cylinder 1 so as to convey pressure from the lower portion of the press cylinder 1, at the initiation of the retraction stroke of the press ram 3, to the surge valve 4 to open the latter and to allow fluid to escape therethrough from the upper portion of the press cylinder 1 into the tank 5.

Also connected with the fluid tank 5 is a suction line 7 leading to the suction side of a variable delivery pump 8, the pressure side of which is connected, by means of pressure line 9, with a normally open two-way valve 10. The valve 10, when in open position, establishes fluid connection between the conduit 9 and the conduit 11

connected to the accumulator 12. The accumulator 12 has a fluid cperable piston or floating member (not shown) therein, which is connected with an arm 13 which latter, when the accumulator is filled up, engages the shaft 14 of a valve member in the valve 10 so as to interrupt fluid connection between the conduits 9 and 11.

Branching off from the conduit 9 is a pilot line 15 leading to a servomotor 16 associated with the pump 8, which servomotor, in response to a predetermined pressure in the conduit 9, shifts the flow-control member of the variable delivery pump 8 to neutral or no delivery position. This kind of servomotor-controlled pump is well known in the art.

Connected with the lower part of the accumulator 12 is the pressure supply line 17 leading to the inlet port 18 of the four-way valve, generally designated 19. This valve is shown in section in Figures 5 to 8. As will be seen therefrom, the valve 19 comprises a casing 20 with a main bore 21 and two smaller bores 22 and 23 at one end of the casing and a small bore 22*a* at the other end of the casing 20.

Reciprocably mounted in the main bore 21 are two pistons 24 and 25 interconnected by a shaft 26 of smaller diameter than the pistons 24 and 25. The piston 25 has a longitudinal bore 27 therethrough which extends into the shaft 26. Passing through the bore 27 is an extension 28 of a piston rod 29 connected to the piston 30. The piston 30, piston rod 29 and extension 28 have a longitudinal bore 132 therethrough so as to admit fluid from the bore 22 into the bore 27 in the shaft 26. Similarly, the piston 30*a* is reciprocably mounted in the bore 22*a* and has a piston rod 29*a* with an extension 28*a* passing through a corresponding bore in the piston 24 into the bore 31 in the shaft 26.

The annular chamber 21*a*, confined by the shaft 26, the pistons 24 and 25 and the casing 20, is in continuous connection with the pressure supply line 17 and is adapted to communicate with the conduit 32 leading to the upper portion of the press cylinder 1 when the pistons 24 and 25 move upwardly, with regard to Figures 5 to 8. When the pistons 24 and 25 move downwardly, fluid connection is established between the conduit 17 and the conduit 33 leading to the lower portion of the press cylinder 1.

Connected with the lower end of the main bore 21 is a conduit 34 which leads to an exhaust line 35 connected with the upper end of the main bore 21.

Reciprocably mounted in the bore 23 of the casing 20 is a fluid operable stop piston 36 adapted, by means of an abutment 37, to engage and stop the piston 30. Leading to the upper side of the stop piston 36 is a conduit 38 comprising a check valve 39 and leading to a three-way valve 40. The check valve 39 allows fluid to flow freely from the valve 40 into the bore 23 of the four-way valve 19, while preventing the flow of fluid in the opposite direction. The check valve 39 is bypassed by a line 41 with a choke valve 42.

Hydraulically connected with the lower side of the stop piston 36 is a conduit 43 with a check valve 44 and a by-pass line 45 comprising a choke valve 46. The check valve 44 allows free flow of fluid into the bore 22, while preventing the flow of fluid in the reverse direction through the check valve 44. The conduit 43 leads to a two-way valve 47. Branching off from the conduit 43 is a conduit 48 leading to a three-way valve 49. Connected with the bore 22*a* is a conduit 50 having a check valve 51 by-passed by a line 52 with a choke valve 53. The conduit 50 leads to a three-way valve 54.



Branching off from the pressure supply line 17 is a conduit 55 comprising a choke valve 56 and leading to the three-way valve 40. The conduit 55 is furthermore connected by line 57 with the three-way valve 49 and by line 58 with the three-way valve 54. The valves 40, 49, 54 and 47 have their valve members controlled by solenoids 62, 60, 61 and 59 respectively.

When the solenoid 62 is not energized, fluid connection is established between the conduits 38 and 55, whereas energization of the solenoid 62 causes the valve member pertaining to the valve 40 to interrupt fluid connection between the conduits 38 and 55 and to establish fluid connection between the conduit 38 and the conduit 63, which latter is connected to the exhaust line 64 leading to the tank 5. Similarly, deenergization of the solenoid 60 effects fluid connection between the conduits 48 and 57, whereas energization of the solenoid 60 causes interruption of the fluid connection between conduits 48 and 57, while fluid connection is established between the conduit 48 and the conduit 65 connected to the conduit 64. When the solenoid 61 is deenergized, fluid connection is established between the conduits 50 and 58, whereas energization of the solenoid 61 causes interruption of the fluid connection between conduits 50 and 58, while establishing fluid connection between the conduits 50 and 64.

With regard to the valve 47, this is normally in open position, i. e., fluid connection exists between the conduit 43 and the conduit 66, which latter comprises a choke valve 67 and leads to the conduit 33. However, when the solenoid 59 is energized, hydraulic communication is interrupted between the conduit 43 and the conduit 66.

The electric control circuit governing the solenoids 59, 60, 61 and 62 is illustrated in Figure 2. The diagram of Figure 2 shows the main supply lines 68 and 69, with a main switch 70 in the latter. Connected with the main supply line 69 is a line 71 comprising a solenoid 72 and leading to one pole of the starter switch 73, the other pole of which is connected with the main supply line 68. Branching off from the line 71 is a line 74 adapted to be connected with the line 75 by a switch blade 76 connected to the armature 77, which is controlled by the solenoid 72. Also connected to the armature 77 is a switch blade 78 normally connecting the line 79 with the line 80. The armature 77 has furthermore connected thereto a switch blade 81 adapted to establish electric connection between the lines 82 and 83, which latter comprises the solenoid 60 and is connected to the main supply line 68. A fourth blade, namely blade 84, connected to the armature 77, is adapted to establish electric connection between the line 85 and the line 86, which latter comprises the solenoid 87 and is connected to the main supply line 69. Also connected to the main supply line 69 is a line 88 comprising the solenoid 89 and being normally connected with line 90 through the limit switch 91, i. e., when the press ram 3 is not in its uppermost position.

When the limit switch 91 is actuated by the cam 92 (Figure 1) on the press ram 3, the cam 92 moves the lever 133 in clockwise direction about the pivot 134 so that the switch 91 interrupts electric connection between the lines 88 and 90 and establishes electric connection between the line 80 and the line 93, which latter comprises the solenoid 94 and is connected with

the main supply line 69. When the cam 92 disengages the lever 133, the switch 91 automatically, for instance, by means of a spring (not shown), moves back into its upper position where it establishes connection between the lines 85 and 96.

Branching off from the line 90 is a line 95 adapted to be connected with the line 96 by a switch blade 97 connected to the armature 98, operation of which is controlled by the solenoid 89. Also connected to the armature 98 is a switch blade 99 adapted to establish electric connection between the line 100 connected to the main supply line 69 and the line 101 comprising the solenoid 61 and connected to the main supply line 68. Also connected to the main supply line 68 is a line 102 comprising the solenoid 59 and adapted to be connected by switch blade 103 with the line 104 leading to the main supply line 69. The switch blade 103 is supported by the armature 105 controlled by the solenoid 94. Furthermore connected with the main supply line 68 is a line 106 comprising the solenoid 82 and adapted, by means of switch blade 107, to be connected with line 108 leading to the main supply line 69.

The switch blade 107 is supported by the armature 109, which latter is controlled by the solenoid 87 and carries a second switch blade 110 adapted to establish electric connection between the line 85 and the line 111 leading to the main supply line 68. Branching off from the line 111 is a line 112 adapted to be connected with the line 113 leading to the line 95 when the cam 114 (see Figure 1) on ram 3 closes the limit switch 115. The limit switch 115 is also manually operable when desired by means of an arm 115a.

Furthermore connected with the main supply line 69 is a line 116 comprising a solenoid 117 and adapted to be connected with the line 118 by closure of the position limit switch 119, which latter is adapted to be closed by the cam 92 on the press ram 3 and is preferably so arranged that it may selectively be moved out of the path of the cam 92, if it is not to be used. The line 116 is also connected with a line 120 adapted to be connected with the line 121 connected to line 118 by closure of the reverse switch button 122 or by closure of the tonnage control switch 123.

The tonnage control switch 123 is a pressure responsive switch connected by conduit 124 with the conduit 32 (Figure 1), and may, for instance, be of the type described in the Ernst Patent No. 2,224,957.

The solenoid 117 controls an armature 125 with two switch blades 126 and 127, of which the switch blade 127 connects the line 75 with a line 128, leading to line 96 when the solenoid 117 is not energized. When the solenoid 117 is in energized condition, the switch blade 127 breaks the connection between the conduits 75 and 128, while the switch blade 126 connects the line 90 with a line 129 leading to the main supply line 68. Also connected with the main supply line 68 is a line 130 which is normally connected with the line 96 by the stop button 131.

Referring now to the energization chart shown in Figure 4, the same comprises a plurality of horizontal columns which, counting from top to bottom and with reference to the press ram travel shown in Figure 3, illustrates in heavy lines the time period of closure of the starter switch 73, the limit switch 115, tonnage control switch 123 and limit switch 91, and also the period of energization of the solenoids 72, 87, 89, 117 and 94.

More specifically, it will be seen from Figures 3 and 4 for instance that, at the very beginning of the fast traverse stroke of the press ram, the starter switch 73 has closed, and that, immediately after closure of the switch 73, the solenoid 72 is energized and stays energized up to the end of the actual pressing stroke. It will furthermore be noted that shortly before the actual pressing stroke begins, the limit switch 115 is temporarily closed and that soon after the closure of the limit switch 115, the solenoid 87 is energized and stays energized up to the end of the actual pressing stroke, at which time the tonnage control switch 123 is closed.

As will furthermore be seen from Figure 4, shortly after the closure of the tonnage control switch 123, the solenoid 89 is energized and stays energized until the end of the return stroke, when the limit switch 91 will be closed.

Figure 4, in connection with Figure 3, also indicates that when during the idling stroke the press ram starts dropping, for instance due to leakage occurring in the press cylinder, the solenoid 117 is first energized, whereupon the solenoid 94 is energized to return the ram to its retraction stroke position.



*Operation*

Assuming that the press ram 3 is in its uppermost position, i. e., slightly higher than shown in Figure 1 while the accumulator 12 is loaded, and that it is now desired to perform a working cycle, the operator closes the main switch 70 and the starter switch 73. As a result thereof the circuit shown in heavy lines in Figure 9 is established according to which current flows from the main supply line 69 through line 71 and now closed starter switch 73 to the main supply line 68. This causes energization of the solenoid 72 so that the armature 77 is moved upwardly with regard to Figure 2.

As a result thereof, a holding circuit is established for the solenoid 72, which holding circuit comprises main supply line 69, lines 71, 74 and 75, switch blade 127, lines 128, 96 and 130 and the main supply line 68. The solenoid 72, therefore, remains energized when the operator takes his hand off the starter switch 73, so that the latter again opens.

Energization of the solenoid 72 also causes the switch blades 81 and 84 respectively to effect electric connection between the lines 82 and 83 and between the lines 85 and 86. While closure of the switch blade 84 does not close a new circuit, closure of the switch blade 81 closes a circuit comprising main supply line 69, lines 82 and 83 and the main supply line 68. As a result thereof, the solenoid 60 is energized so that the valve member pertaining thereto establishes fluid connection between the conduit 48 and the conduit 65, while interrupting fluid connection between the conduits 48 and 57. Consequently, the conduit 43 is connected with the tank 5 and, therefore, also the bore 27 is connected through the bore 132 and by-pass line 45 with the tank 5. Since, on the other hand, pressure fluid is conveyed from the pressure supply line 17 through conduit 55, valve 40 and conduit 38 to the upper portion of the bore 23 in the valve casing 20, the piston 36 moves into the position shown in Figure 6.

It will also be noted from Figure 1 that fluid pressure is conveyed from the pressure supply line 17 through conduit 55, valve 54 and conduit 50 into the bore 22a from where it flows through the longitudinal bore 132a in the piston 30a, piston rod 29a and extension 28a into the bore 31.

Since, as mentioned before, the bore 27 is connected to the tank 5, the pressure prevailing in the bore 31 moves the shaft 26 with the pistons 24 and 25 upwardly, thereby also moving the piston 30 upwardly.

When the piston 30 is engaged by the abutment 37 of piston 36, the pistons 24 and 25 are halted and then occupy the position shown in Figure 6. In this position hydraulic communication is established between the conduit 33 and the conduit 34, which latter is connected through conduit 35 with the tank 5. Therefore, the lower portion of the press cylinder 1 is connected with the tank 5 through conduit 33, and the ram 3 now moves downwardly by gravity. The suction now exerted in the upper portion of the press cylinder 1 holds the surge valve 4 open so that, while the press ram 3 moves downwardly, the upper portion of the press cylinder 1 is filled by fluid passing from the surge tank 5 through the surge valve 4 into the cylinder 1.

As soon as the ram 3 has started its downward movement, the cam 92 releases the limit switch 91 so that the latter breaks electric connection between the lines 80 and 93, while establishing electric connection between the lines 88 and 90. This however, does not close a new circuit, since the solenoid 117 is not energized and, therefore, the switch blade 126 is in open position.

On the other hand, the circuit shown in Figure 9 is pre-conditioned. This circuit is closed by the limit switch 115 as soon as the ram, by means of its cam 114, actuates the limit switch 115, and comprises main supply line 69, line 86, solenoid 87, now closed switch blade 84, line 85, line 113, now closed limit switch 115, lines 112, 111 and the main supply line 68. As a result thereof, the solenoid 87 is energized.

If, for some reason, it were desired to stop the press ram instantaneously during the fast traverse stroke, i. e., before the switch 115 is closed by the cam 114, it is merely necessary to open the stop button 131, which breaks the holding circuit for the solenoid 72. This immediately breaks the energizing circuit for the solenoid 60 so that the valve 49 reestablishes fluid connection between the conduits 48 and 57, while breaking connection between the conduits 48 and 65. Consequently, fluid pressure is again conveyed from the pressure supply line 17 through conduits 55, 57, 48 and 43 into the bore 22 where it acts upon the upper surface or effective area of piston 30. Since this effective area is larger than the effective area acted upon by pressure fluid in the bore 31, the pressure acting upon the upper surface of piston 30 moves the latter downwardly, thereby moving the pistons 24 and 25 likewise downwardly until the piston 24 is stopped by the piston rod 29a. The pistons 24 and 25 then again occupy the position shown in Figure 5, in which fluid connection is interrupted between the pressure supply line 17 and the press cylinder 1. The ram 3, therefore, comes to an instantaneous stop. It will be appreciated that when, during the downward movement of piston 30, the latter disengages the abutment 37, fluid pressure is also conveyed through bore 132 into the bore 27 where it counteracts the pressure in bore 31.

The stop button 131 may immediately after its actuation be released and then returns automatically to its closed position. The circuit will then be in the same condition as it was prior to the beginning of the downward stroke of the ram 3, with the exception that the switch 91 does not interconnect the lines 80 and 93 but connects the lines 90 and 88. The downward stroke of the ram may then, at any desired time, be continued by closing the starter switch 73 in the manner previously described.

Assuming now that, as previously mentioned, the press ram had advanced downwardly to such an extent that the switch blade 115 is closed and the solenoid 87 energized as described above, this will cause the switch blades 110 and 107 to move into closing position. Closure of the switch blade 110 establishes a holding circuit for the solenoid 87, which holding circuit comprises main supply line 69, lines 84 and 85, switch blade 110, line 111, and main supply line 68, so that the solenoid 87 remains energized when, during its further advancing movement of the press ram 3, the cam 114 again releases the switch 115.

As will be seen from Figures 3 and 4, closure of the switch 115 and energization of the solenoid 87 takes place when the actual pressing stroke is about to begin. Closure of the switch blade 107 establishes a new circuit as shown in Figure 10, which circuit comprises main supply line 69, line 108, switch blade 107, line 106 with solenoid 62, and main supply line 68. As a result thereof, the solenoid 62 is energized so that fluid connection is interrupted between the conduits 55 and 38, whereas fluid connection is established between the conduit 38 and the conduit 63 connected to the exhaust line 64. Therefore, the upper portion of the bore 23 in the valve casing 20 is connected to the tank 5 so that the pressure prevailing in the bore 31 moves the pistons 24 and 25 further upwardly into the position shown in Figure 7. In this position, fluid connection is established between the pressure supply line 17 and the conduit 32 so that the accumulator 12 unloads into the upper portion of the press cylinder 1 and causes the press ram 3 to carry out its actual pressing stroke.

If, for some reason, it is desired instantaneously to stop the press ram 3 during its actual pressing stroke, it is merely necessary to open the stop button 131. This will immediately break the holding circuit for the solenoids 72 and 87, thereby causing deenergization of the solenoids 60 and 62. Consequently, fluid pressure is again conveyed from the pressure supply line 17 to the upper portion of bore 22 and into the lower portion of bore 23 and furthermore into the bore 27 so that the pistons 24 and 25 return to their intermediate position shown in Figure 5, thereby interrupting fluid connection between the pressure supply line 17 and the press cylinder 1. The press ram 3, therefore, comes to a halt.

When, at the end of the pressing stroke, a predetermined pressure acts upon the piston 2, this pressure is conveyed through conduits 32 and 124 to the tonnage control switch 123, causing the latter to interconnect the lines 120 and 121. This closes a circuit comprising the main supply line 69, line 116, solenoid 117, line 120, tonnage control switch 123, lines 121 and 118 and the main supply line 68. If, instead of the tonnage control switch 123, the position limit switch 119 were used, the same circuit just described would be closed by the position limit switch 119. As a result of the closure of the above mentioned circuit, solenoid 117 is energized, causing switch blade 126 to establish electric connection between the lines 90 and 129, while the switch blade 127 is actuated so as to interrupt electric connection between the lines 75 and 128.

The interruption of the electric connection be-

tween the lines 75 and 128 breaks the holding circuit for the solenoid 72, so that the latter is deenergized and the blades 76, 78, 81 and 84 return to their position shown in Figure 2. As a result thereof, the solenoid 60 is deenergized and fluid connection is again established between the conduits 48 and 57. The return of the switch blade 84 into its open position also breaks the energizing circuit for the solenoid 87 so that also the switch blades 110 and 107 return to their position shown in Figure 2, with the result that the solenoid 62 is likewise deenergized and fluid connection is again established between the conduits 55 and 38. Therefore, pressure fluid is now conveyed from pressure supply line 17 through conduits 55, 57, 48 and 43 into the bore 22 and from there into the bore 27. Likewise, pressure fluid is conveyed from the pressure supply line 17 through conduits 55 and 38 into the upper portion of the bore 23.

Closure of the switch blade 126, due to the energization of solenoid 117, closes a circuit comprising the main supply line 69, line 88, solenoid 89, limit switch 91, which latter is now in the upper position, line 90, switch blade 126, line 129 and main supply line 68. In this way, solenoid 89 is energized, moving the switch blades 97 and 99 into their closing position, as shown in Figure 11.

Closure of the switch blade 97 establishes a holding circuit for the solenoid 89, which circuit comprises the main supply line 69, line 88, solenoid 89, limit switch 91, lines 90 and 95, switch blade 97, line 96, stop button 131, line 130 and the main supply line 68. Closure of the switch blade 99 closes a circuit comprising main supply line 69, lines 100 and 101 and main supply line 68, thereby energizing the solenoid 61. Energization of the solenoid 61 causes valve 54 to interrupt the fluid connection between the conduits 58 and 50, while establishing fluid connection between the conduit 50 and the exhaust line 64. Therefore, the bores 22a and 31 are connected with the fluid tank 5 and, since, as previously mentioned, the bores 22 and 27 receive pressure from the accumulator 12, the pistons 24 and 25 move downwardly into the position shown in Figure 8. In this position, fluid connection is interrupted between the pressure supply line 17 and the conduit 32, while the latter now communicates with the exhaust line 35. On the other hand, fluid connection is now established between the pressure supply line 17 and the conduit 33 so that pressure fluid is conveyed from the accumulator 12 into the lower portion of the press cylinder 1 and causes the press ram 3 to perform its retraction stroke. Simultaneously, pressure is conveyed from the lower portion of the press cylinder 1 through conduit 6 to the surge valve 4 so as to open the latter and to allow fluid to escape from the upper portion of the cylinder 1 directly into the tank 5.

If, for some reason, it is desired instantaneously to stop the ram 3 during its retraction stroke, all that is required is merely momentarily to open the stop button 131. This immediately breaks the holding circuit for the solenoid 89 so that the latter becomes deenergized and the switch blade 99 breaks the energizing circuit for the solenoid 61. In this instance, fluid connection between the conduits 50 and 64 is interrupted, and fluid connection between the conduits 50 and 55 is established so that pressure fluid from the accumulator 12 is conveyed through conduits 17, 55, 58 and 50 into the bore 22a and from there into the bore 132a. Since, at this time, the solenoid 72 is deenergized and, therefore, also the solenoid 60 is deenergized, fluid connection prevails between conduits 57, 48 and 43. Pressure fluid is therefore also conveyed from conduit 17 through conduits 55, 57, 48 and 43 into the upper portion of bore 22 and through bore 132 into the bore 27. Since at this time the piston 30 abuts the lower end of the bore 22 so that it cannot move further downwardly, and inasmuch as the pressure in bore 27 is substantially balanced by the pressure in bore 31, it will be clear that the pressure acting upon the lower surface of piston 30 moves the latter upwardly, thereby returning the pistons 24 and 25 to their Figure 5 position, in which the further upward movement of pistons 24 and 25 is stopped by the piston rod 29. In other words, the pressure acting upon the upper surface of piston 30, plus the pressure acting upon the closed side of bore 27, is balanced by the pressure acting upon the lower surface of piston 30a plus the pressure acting on the closed side of bore 31. When the pistons 24 have reached Figure 5 position, the fluid connection between the pressure supply line 17 and the conduit 33 is interrupted. Since, therefore, no more pressure fluid is supplied to the lower portion of the press cylinder 1, the ram 3 immediately comes to a stop.

If now it is desired to return the ram 3 to its full retraction position, it is merely necessary to release the stop button 131 and temporarily to close the reverse switch button 122. Closure of the reverse switch button 122 will close a circuit comprising the main supply line 69, line 116, solenoid 117, line 120, reverse switch button 122, lines 121 and 118 and the main supply line 68. The energization of the solenoid 117 will then establish the energizing circuit for the solenoids 39 and 61, as previously mentioned, with the result that the pistons 24 and 25 again move into Figure 8 position and fluid pressure is again conveyed from the pressure supply line 17 to the lower portion of the press cylinder 1, moving the latter upwardly.

When the press ram 3, during its upward stroke, temporarily closes the limit switch 115, nothing happens, since the solenoid 72 is deenergized. When the ram 3 reaches the end of its retraction stroke, the cam 92 shifts the arm 133 in anticlockwise direction so as to cause the limit switch 91 to break electric connection between the lines 88 and 90, and to establish electric connection between the lines 80 and 93. Since the solenoid 117 becomes immediately deenergized again as soon as the reverse switch button 122 is released and, thereby automatically returns to open position or as soon as, after the initiation of the retraction stroke, the tonnage control switch 119 opens again, the holding circuit for the solenoid 89 is broken and the solenoid 89 becomes deenergized.

Deenergization of the solenoid 89 causes switch blade 99 to break the energizing circuit for the solenoid 61 so that the valve 54 breaks the fluid connection between the conduits 60 and 54, while establishing fluid connection between the conduits 55 and 50. Consequently, pressure fluid is again conveyed from the pressure supply line 17 to the bores 22a and 31 so that the pistons 24 and 25 are again moved into their intermediate position shown in Figure 5. This instantaneously interrupts the fluid connection between the pressure supply line 17 and the press cylinder 1 so that the

press ram 3 comes to a halt. The press ram is now in its full retracted position.

On the other hand, due to the interconnection of lines 80 and 93 by switch 91, a new circuit is established, as shown in Figure 12. This circuit comprises main supply line 69, line 93, solenoid 94, switch 91, line 80, switch blade 78, line 79 and main supply line 68. This causes energization of the solenoid 94 which, in its turn, causes the switch blade 103 to establish a new circuit comprising the main supply line 69, line 104, line 102 with solenoid 59 and main supply line 68. Energization of the solenoid 59 causes valve 47 to interrupt communication between the conduits 66 and 43 and, thereby, prevents any pressure fluid from being conveyed from line 55 through valve 49, lines 48, 43 and 66 to the lower part of the press cylinder 1, and thereby from by-passing the four-way valve 19.

If, due to leakage, the press ram 3 should drop somewhat, the cam 92 will release the arm 133 so that the switch 91 moves to its upper position in which it breaks electric connection between lines 80 and 93, while establishing electric connection between lines 88 and 90. While the re-establishment of electric connection between lines 88 and 90 has no energizing effect on the solenoid 89, because solenoid 117 is in deenergized condition, the interruption of electric connection between lines 80 and 93 causes deenergization of the solenoid 94. As a result thereof, the switch blade 103 moves to open position, and the solenoid 59 becomes deenergized.

Deenergization of the solenoid 59 causes the valve 47 to reestablish fluid connection between the conduits 43 and 66, so that pressure fluid is conveyed from pressure supply line 17 through conduits 55, 57, 48, 43 and 66 to conduit 33 and from there into the lower portion of the press cylinder 1. The ram 3, therefore, again moves upwardly until it has reached its full retraction position in which the cam 92 causes the switch 91 again to establish connection between lines 80 and 93, as previously described, so that the solenoids 94 and 59 are again energized and the valve 47 again interrupts fluid connection between the conduits 43 and 66. The ram 3 is then again halted.

It should be noted that the automatic filling of the press cylinder 1 or the automatic returning of the ram 3 to its full retracted position when the ram 3 drops, due to leakage occurring in the press cylinder 1, is effected without shifting the four-way valve 19.

As will be clear from the above, the press ram 3 may selectively be stopped practically instantaneously at any desired point of travel during the advancing as well as during the retraction stroke by the mere temporary opening of the stop button 131. It will furthermore be obvious that when the press ram 3 has been thus stopped, it can be caused selectively either to return to its full retracted position, or to continue its respective stroke during which it was halted. To return the ram from any halted position to its full retracted position, it is merely necessary to actuate the reverse switch button 122 so as to close the same temporarily, as has been previously explained. When the press ram 3 has been stopped during the fast traverse stroke, it can be made to continue its advancing stroke by merely closing the starter switch 73 again.

When the press ram has been stopped during the actual pressing stroke and it is desired to continue the pressing stroke of the ram, the operator first closes the starter switch 73 and then manually closes the limit switch 115 by actuating the switch arm 115a.

As will be clear from the foregoing description, the shifting speed of the valve 19 may be controlled by setting the choke valves 42, 53 and 56 accordingly. Similarly, the setting of the choke valve 67 will control the speed of the return movement of the ram 3 to its full retracted position when the ram 3 had dropped, due to leakage in the press cylinder 1.

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

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

1. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger for reciprocating the same, a fluid source for selectively supplying pressure fluid to said advancing or said retracting means, a valve member movable selectively into a first or second end position, or into a neutral or intermediate position for controlling the supply of fluid from said fluid source to said advancing and retracting means and also controlling the release of fluid therefrom, said valve member being operable selectively to release fluid from said retracting means, while simultaneously perventing the supply of pressure fluid from said fluid source to said advancing means, other valve means operable to supply fluid to said advancing means when said valve member is in its last mentioned position, means operable in response to a predetermined travel of said plunger for varying the position of said valve means to admit pressure fluid to said advancing means, while allowing escape of fluid from said retracting means, and means operable selectively, irrespective of the position of said plunger, for moving said valve member into said intermediate or neutral position to cause said valve member to prevent both supply of pressure fluid to and escape of fluid from both said advancing and retracting means to halt said plunger.

2. In a hydraulic system, a substantially vertically reciprocable plunger, fluid operable advancing and retracting means associated with said plunger for reciprocating the same, a fluid source for selectively supplying pressure fluid to said advancing or retracting means, valve means for controlling the supply of fluid to or withdrawal of fluid from said advancing and retracting means, means for shifting said valve means into position for releasing fluid from said retracting means, while preventing the supply of pressure fluid to said advancing means to effect advancing movement of said plunger by gravity, a surge valve connected to supply fluid to said advancing means during its descent by gravity, means responsive to a predetermined advancing movement of said plunger for shifting said valve means into position for admitting pressure fluid from said fluid source to said advancing means, while simultaneously releasing fluid from said retracting means, means for shifting said valve means into position for admitting pressure fluid from said fluid source to said retracting means, while releasing fluid from said advancing means, and means operable irrespective of the position of said plunger for shifting said valve means into an intermediate or neutral position to simultaneously prevent supply of pressure fluid to and release of fluid from either of said advancing and retracting means to halt said plunger.

3. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger for reciprocating the same, a check valve connected to supply fluid to said advancing means in response to a predetermined reduction in pressure therein, a fluid source for selectively supplying pressure fluid to said advancing or said retracting means, valve means operable by pressure fluid from said fluid source for controlling the supply of pressure fluid to and the release of fluid from said advancing and retracting means, said valve means being movable selectively into position for releasing fluid from said retracting means, while simultaneously preventing the supply of pressure fluid from said fluid source to said advancing means, said valve means also being operable to admit pressure fluid from said fluid source to said advancing means, while simultaneously allowing release of fluid from said retracting means, and vice versa, emergency means, and means responsive to the actuation of said emergency means for causing pressure fluid from said fluid source to move said valve means into position for interrupting fluid connection between said fluid source and either of said advancing and retracting means, while simultaneously preventing release of fluid from either of said advancing and retracting means.

4. In a hydraulic system, a plunger, fluid operable advancing and retracting means associated with said plunger, a fluid source for supplying pressure fluid selectively to said advancing or retracting means, a valve member movable selectively into any one of four predetermined positions for controlling the supply of pressure fluid to and the release of fluid from said advancing and retracting means, fluid operable actuating means operable by fluid from said fluid source for first moving said valve member to release fluid from said retracting means, while simultaneously preventing the supply of pressure fluid to said advancing means, a surge valve connected to supply said advancing means when said valve member is in its first mentioned position, and secondly to move said valve member to admit pressure fluid to said advancing means while continuing to release fluid from said retracting means and, thirdly, to move said valve member to admit fluid pressure to said retracting means while releasing fluid from said advancing means, and fourthly to move said valve member to prevent release of fluid from or supply of pressure fluid to either of said advancing or retracting means, auxiliary valve means for controlling the supply of fluid to and the exhaust of fluid from said actuating means, means operable selectively for moving said valve member to said fourth position for halting said plunger at any desired point of travel and for any desired time, and means operable selectively to cause said halted plunger to continue its cycle or to return to its retracted position.

5. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger, a fluid source for supplying actuating fluid to said advancing or said retracting means, a valve including a movable valve member for controlling the supply of fluid from said source to said advancing and retracting means and also controlling the release of fluid therefrom, said valve member being movable selectively into position to establish restricted fluid communication between said retracting means and exhaust while simultaneously preventing communication between said source and said advancing means, a surge valve connected to supply said advancing means in response to a predetermined suction therein, and means operable in response to a predetermined advancing movement of said plunger for moving said valve member into position to admit pressure fluid from said source to said advancing means while simultaneously establishing unrestricted fluid communication between said retracting means and exhaust.

6. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger, a fluid source for supplying actuating fluid to said plunger, valve means including a reciprocable valve member for controlling the supply of fluid from said source to said plunger and also for controlling the release of fluid therefrom, said valve member having associated therewith fluid operable actuating means adapted to be actuated by pressure fluid from said fluid source, means for controlling the supply of fluid from said fluid source to said valve member actuating means so as selectively to move said valve member into a first position for establishing restricted fluid communication between said retracting means and exhaust while simultaneously preventing the supply of fluid from said source to said advancing means, means operable to supply fluid at substantially no pressure to said advancing means when said valve member is in its first position, and means responsive to a predetermined advancing movement of said plunger for varying the supply of actuating fluid to said valve member and shifting the latter into a second position for establishing communication between said source and said advancing means while simultaneously reducing the restriction between said retracting means and exhaust.

7. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger, a fluid source for supplying pressure fluid to said advancing or to said retracting means, valve means for controlling the supply of fluid from said source to said advancing and retracting means and also controlling the release of fluid therefrom, means independent of said valve means and responsive to a predetermined advancing movement of said plunger away from its fully retracted position for bypassing said valve means whereby hydraulically to interconnect said fluid source with said retracting means for returning said plunger to its fully retracted position, and means responsive to the initiation of the forward stroke of said plunger for interrupting said bypass connection.

8. In a hydraulic system, a plunger having associated therewith fluid operable advancing and retracting means, a fluid source for supplying pressure fluid to said advancing or to said retracting means, a valve member for controlling the supply of fluid from said source to said advancing and retracting means, said valve member being movable into position for preventing the supply of fluid from said source to said advancing or said retracting means and for preventing the exhaust of fluid from said advancing and retracting means, means responsive to a predetermined advancing movement of said plunger away from its retracted position and when said valve member is in said position for bypassing said valve member thereby interconnecting said fluid source with said retracting means so as to return said plunger to its fully retracted position, and means selectively operable simultaneously to actuate said valve member to permit the exhaust of fluid from said retracting means

to bring about the advancing movement of said plunger and to interrupt said bypass connection.

9. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger, a fluid source for supplying pressure fluid to said advancing or retracting means for reciprocating said plunger, a main control valve means including a movable valve member for controlling the supply of pressure fluid from said fluid source to said advancing and retracting means and also controlling the release of fluid therefrom, fluid operable means for actuating said valve member, auxiliary valve means operable to control the supply of fluid to said valve member for moving the latter into position to interrupt the supply of fluid to and the exhaust of fluid from said advancing and retracting means at the end of the retraction stroke of said plunger, means independent of said main control valve means and responsive to a predetermined advancing movement of said plunger away from its retracted position when said valve member is in its last mentioned position for establishing a bypass connection between said fluid source and said retracting means around said main control valve means for returning said plunger to its fully retracted position, means selectively operable for actuating said auxiliary valve means for moving said valve member into position to bring about an advancing stroke of said plunger, and means operable simultaneously with said last mentioned means for interrupting said bypass connection.



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