July 22, 1947. W. BECKER 2,424,300

CONTROL SYSTEM FOR HYDRAULIC CIRCUITS

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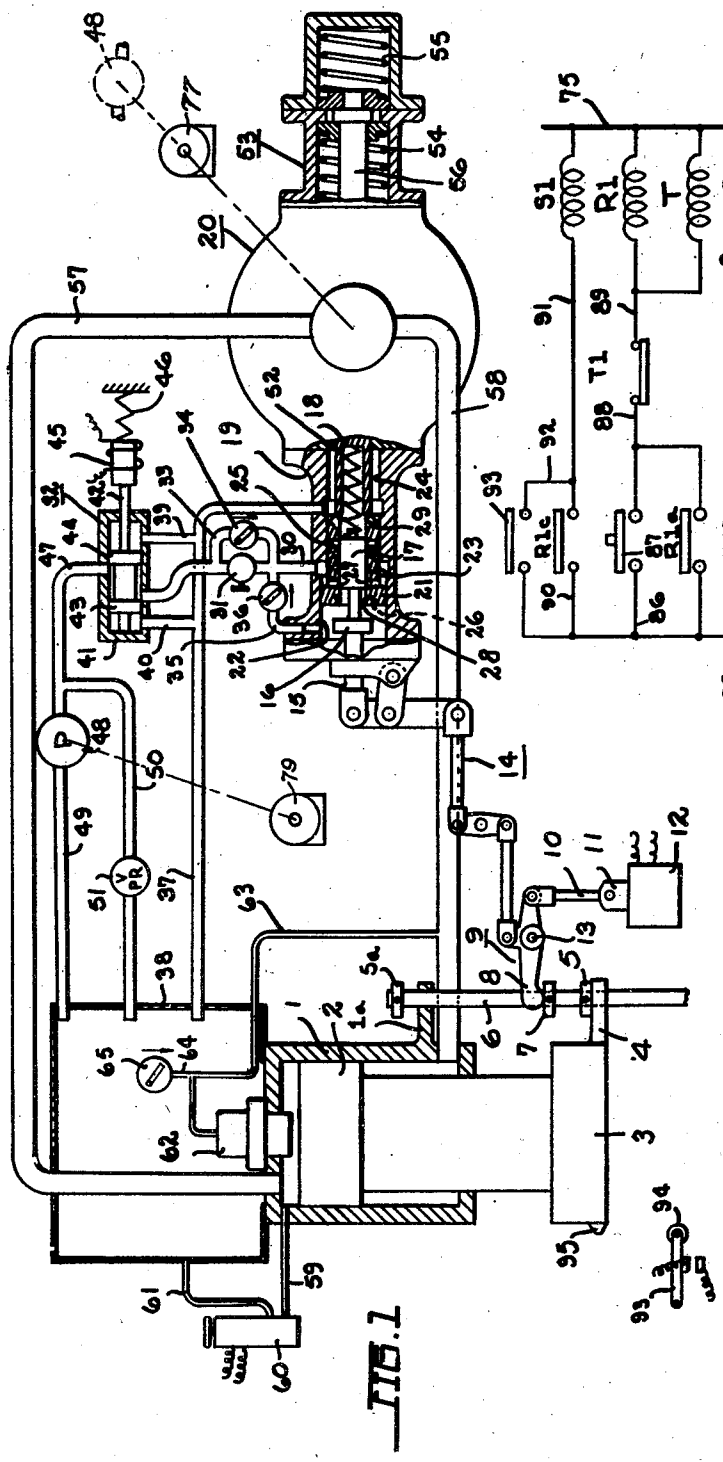

FIG. 1

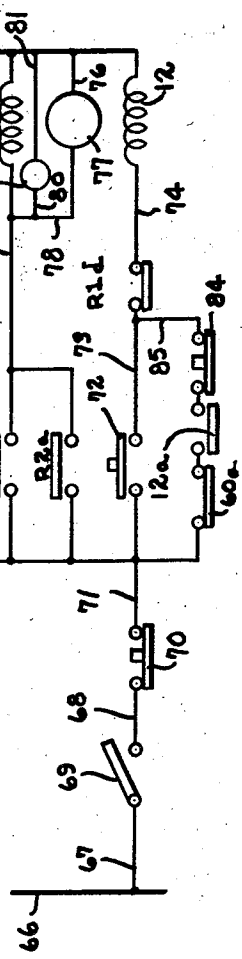

FIG. 2

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CONTROL SYSTEM FOR HYDRAULIC CIRCUITS

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14 Claims. (Cl. 60—52)

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

It is well known that, when a hydraulic press having a vertically reciprocable ram stands idle for a relatively long period of time with the pump units idle, the press ram gradually settles downwardly due to leakage around the driving motor or press piston.

Also, it is customary to interconnect the press platen or ram by means of linkage with a fluid flow varying device, such as the flow control member of a variable delivery pump, whereby the flow of fluid to the retracting means of the hydraulic motor is neutralized at the end of the retraction stroke of the press. In this manner the press ram automatically comes to a halt at the end of the retraction stroke. Therefore, when the press ram settles or slides downwardly, as has been previously explained, the flow controlling means operated by the linkage interconnected with the platen is shifted to direct fluid to the retraction area of the press. If the fluid is supplied by, say, a variable delivery pump, the pump will start under load due to the settling of the ram. In turn, the prime mover for driving the pump will also be started under load and, in the case of an electric motor as the prime mover, expensive and complicated starting devices are required in order not to overload the power lines supplying energy to the driving motor.

Accordingly, it is an object of this invention to provide means whereby the prime mover driving the pump may be started under no load conditions, regardless of the position occupied by the press ram.

It is an object of this invention to provide a control system including a variable delivery pump having its shaft connected to the driving shaft of a prime mover, in which the pump is automatically held in substantially neutral or no delivery position until the prime mover has been brought up to the desired operating speed.

It is still another object of the invention to provide a control system for use in connection with hydraulic systems, which includes a variable delivery pump drivingly connected with a prime mover, and pilot fluid operated servomotor means for controlling the delivery of said pump, and in which, responsive to the starting of said prime mover, the pilot fluid from said servomotor means is by-passed to an exhaust until said prime mover has reached a predetermined minimum speed.

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It is a still further object to provide a control system for use in connection with a fluid source of variable delivery, which is operable selectively to bring about a temporary reduction in the delivery of said fluid source.

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 the control system according to the invention in connection with a hydraulic press circuit; and

Figure 2 is a wiring diagram for the system of Figure 1.

General arrangement

The control system according to the invention comprises a variable delivery pump including centering springs continuously urging the pump toward neutral, while servomotor means is connected with the pump for selectively shifting the pump into forward or retraction stroke delivery position.

The servomotor means includes a valve member and a reciprocable plunger operable by a pilot fluid source, the connection of which with said plunger is controlled by valve means.

The pump is drivingly connected with a prime mover and the valve is so controlled that it prevents the supply of actuating fluid to the plunger of the servomotor means for a predetermined time following the starting of the prime mover. After the said predetermined time the fluid supply for the plunger is re-established to actuate said plunger for shifting the pump on stroke. The press ram, controlled by the delivery of the pump, is then returned to its initial position. In this way, the prime mover is prevented from starting under load, thereby protecting said prime mover and reducing the power for actuating the same.

The control system according to the invention is also provided with safety means which prevents the operator from accidentally starting a working stroke of the press ram before the prime mover has come up to speed. To this end, the electric circuit for controlling the operation of the ram and the driving motor for the pump, which includes a starter button for starting the motor or prime mover and a forward button for starting the working stroke of the ram, is so arranged that closing of the forward button is not effective until after energization of the motor and the elapse of the above mentioned predetermined time.

According to still another feature of the in-

vention, the valve means controlling the supply of fluid to the servomotor plunger is adapted, at a predetermined point of travel of the press ram, temporarily to interrupt the fluid supply to the plunger to bring about a temporary slow-down of the press ram.

Structural arrangement

Referring now to the drawings in detail, the structure disclosed therein comprises a press cylinder 1 having reciprocably mounted therein a press ram 2, which has connected thereto a press platen 3. The platen 3 is provided with an arm 4 adapted to engage a collar 5 adjustably mounted on a push rod 6, which is reciprocably mounted and guided by any convenient guiding means. Also adjustably mounted on the push rod 6 is a collar 5*a* adapted to engage the arm 1*a* on the press cylinder 1, to thereby limit the downward movement of the push rod 6.

Furthermore adjustably mounted on the push rod 6 is a collar 7 adapted to engage the arm 8 of a three-arm lever, generally designated 9. A second arm of the lever 9 is pivotally connected with a link 10 which, in its turn, is connected to an armature 11 adapted to be actuated by the main solenoid 12 in such a manner as to cause the armature 11 to move downwardly, thereby shifting the three-arm lever 9 in clockwise direction about the pivot 13. The third arm of the lever 9 is connected through a link system, generally designated 14, with a control rod 15, which has connected thereto a flange 16 and a valve member 17.

The valve member 17 is reciprocably mounted in a servomotor plunger 18 which, in its turn, is reciprocably mounted in the servomotor casing 19 connected, in any convenient manner, with the pump 20, constituting a pump of reversible variable delivery. The pump 20 may be of any standard design, for instance of the radial piston type or the radial vane type.

The servomotor plunger 18 has a larger piston portion 21 reciprocable in the bore 22 of the casing 19 and a smaller portion 23 reciprocable in the bore 24 of the casing 19. The smaller portion 23 of the plunger 18 is provided with an annular groove 25 which communicates through longitudinal passageways 26 with the left side of the piston portion 21. The said left side of the piston portion 21 constitutes the larger effective area thereof, while the oppositely located area of the piston portion 21 is smaller and is adapted, through bores 27, to communicate with the bore 28 in which the valve member 17 is reciprocable. The valve member 17 controls the bores 27 and the annular groove 25. The bore 28 is furthermore adapted to communicate with the bore 24 through the passageways 29.

The right hand end of the bore 22 is connected with a conduit 30 comprising an adjustable choke 31 and leading to a control valve, generally designated 32. The choke 31 is adapted to be by-passed by fluid passing from the valve 32 toward the servomotor casing 19 through the conduit 33 and check valve 34 in said conduit. Branching off from the conduit 30 is a conduit 35 comprising a check valve 36 and leading to the left hand end of the bore 22.

The bore 24 in the servomotor casing 19 is furthermore connected through a conduit 37 with a fluid reservoir or tank 38. Branching off from the conduit 37 are conduits 39 and 40 respectively leading to the right hand end and the left hand end of the valve casing 41 of the control valve 32. Reciprocably mounted in the casing 41 is a valve member 42 with piston portions 43 and 44 and an armature 45 adapted to be controlled by the solenoid S1.

The valve member 42 is continuously urged, by means of a spring 46, into its left hand position, shown in the drawing, in which the conduit 30 communicates with the conduit 47 which is connected to the pressure side of a pilot pump 48. The pilot pump 48, which may be of any standard design, and may be a variable delivery or a constant delivery pump, has its suction side connected through the conduit 49 with the tank 38.

Branching off from the conduit 47 is a conduit 50 comprising an adjustable pressure relief valve 51 and leading to the tank 38.

When the solenoid S1 is energized, the valve member 42 moves into its right hand end position, in which the conduit 47 communicates with the conduit 39, while the conduit 30 communicates with the conduit 40.

The servomotor plunger 18 has furthermore arranged therein a spring 52, which continuously urges the valve member 17 to move toward the left with regard to the casing 19. The pump 20 has furthermore connected thereto a casing 53 housing centering springs 54 and 55, which act upon a control rod 56 connected to the flow control member of the pump 20, so as to urge the pump 20 into and tend to hold the same in its neutral or no delivery position.

One side of the pump 20 is connected through a conduit 57 with the upper portion of the press cylinder 1, while the lower portion of the press cylinder 1 is connected through conduit 58 with the other side of the pump 20. Also connected with the upper portion of the press cylinder 1 is a conduit 59 leading to a tonnage control valve 60, which latter is connected, through the conduit 61, with the tank 38. The tonnage control valve 60, which may be of any standard design, for instance of the type disclosed in U. S. Patent No. 2,224,957, comprises a normally closed switch 60*a* (see Figure 2), which opens in response to a predetermined pressure in the conduit 59 and automatically closes again as soon as the pressure in the conduit 59 drops below the value of said predetermined pressure.

Extending into the upper portion of the press cylinder 1 is a surge valve 62, of any conventional design, for instance of the type disclosed in U. S. Patent No. 2,193,248, and adapted, in response to a suction effect in the upper portion of the press cylinder 1, to open so as to effect fluid connection between the tank 38 and the upper portion of the cylinder 1. When a predetermined pressure develops in the upper portion of the cylinder 1, the surge valve 62 closes. The surge valve 62 is connected with a pilot line 63 communicating with the conduit 58. The surge valve 62 is adapted, in response to a predetermined pressure in the pilot line 63, to open for establishing fluid connection between the tank 38 and the upper portion of the press cylinder 1. Branching off from the conduit 63 is a conduit 64 comprising a check valve 65 adapted to allow the flow of fluid from the tank 38 into the conduit 64, while preventing the flow of fluid in the opposite direction.

As shown in Figure 1, the pump 20 is directly driven by a motor 77 while the pilot pump 48 is likewise directly driven by a second motor 78. As will be seen in the description of the wiring diagram of Figure 2 which follows, the motors 78 and 77 are permanently connected in parallel and operate in unison. Both pumps could, therefore, be

operated from a single motor as is indicated by the dotted line portion at the upper right of Figure 1. Hence, it is optional, and in no way affects this invention, whether the pumps are separately driven by individual motors parallelly connected or from a single motor drivingly connected to both.

Referring now to Figure 2, illustrating the wiring diagram for the system of Figure 1, the main supply line 66 has connected thereto the line 67, which is adapted to be electrically connected with the line 68 by closure of the line switch 69. The line 68 is connected through the normally closed stop switch 70 with the line 71, which latter is adapted, by closure of the forward switch 72, to be connected with the line 73. The line 73 is connected through the normally closed switch R1*d* with the line 74, comprising the main solenoid 12 and connected to the main supply line 75. Also connected to the main supply line 75 is the line 76 leading to one terminal of the main motor 77, while the other terminal of the motor 77 is connected to the line 78. The main motor 77 has its driving shaft connected to the shaft of the pump 20 so that rotation of the motor 77 causes rotation of the pump 20. Preferably the driving shaft of motor 77 is connected to the shaft of pump 20 by a flexible coupling.

Arranged parallel to the motor 77 is an auxiliary or pilot pump motor 79, having one terminal connected through line 80 with the line 78, while the other terminal is connected through line 81 with the main supply line 75. The motor 79 has its driving shaft connected with the shaft of the pilot pump 48 so that rotation of the pilot motor 79 causes operation of the pump 48.

The line 78 is connected with a line 82 comprising the contactor solenoid R2, and having one end connected to the main supply line 75, while the other end leads to a terminal of a normally open contactor blade R1*b* which, in closed position, connects the line 82 with the line 83. The line 83 is connected with the line 71 and communicates through the normally closed tonnage control switch 60*a* with the normally open main solenoid switch 12*a*. When the switch 12*a* is closed, the tonnage control switch 60*a* is connected through the normally closed reverse button 84 with the line 85, which latter is connected with the line 73. The line 83 is also adapted to be connected with the line 82 by closure of the contactor switch R2*a*.

Connected to the line 83 is furthermore a line 86 adapted, by closure of the starter button 87, to electrically communicate with the line 88, which latter communicates with the line 89 through the normally closed timer switch T1. The line 89 includes a contactor R1 and is connected with the main supply line 75. Also connected to the main supply line 75 is one terminal of a timer T, the other terminal of which is connected to the line 89. Closure of the contactor switch R1*a* is adapted to effect connection between the line 83 and the line 88. Furthermore connected with the line 83 is a line 90 adapted, by closure of the contactor switch R1*c*, to be connected with the line 91, which latter comprises the solenoid S1, and is connected with the main supply line 75.

Branching off from the line 91 is a line 92 adapted, by closure of the limit switch 93, to be connected with the line 83. The limit switch 93 is normally held in open position and is closed by engagement of the roller 94 (Fig. 1) with the cam 95 carried by the press platen 3.

Operation

It may be assumed that all parts of the system occupy the position shown in Figure 1, with the exception of the ram 2, which may be assumed to occupy a position intermediate its end positions so that the valve member 17 is moved somewhat to the left with regard to the position in which it is shown in Figure 1. It may furthermore be assumed that the driving motors for the pumps 20 and 48 are at a standstill.

If it is now desired to cause the press ram 2 to perform a working cycle, it is first necessary to retract the ram 2 to its uppermost or retracted position, i. e., the position shown in Figure 1. To this end, the operator closes the line switch 69 and furthermore closes the starter button 87. As a result thereof, the energizing circuit for the contactor R1 and the timer T is closed, which circuit comprises the main supply line 66, switches 69 and 70, line 83, now closed starter button 87, lines 88 and 89, contactor R1 and timer T, and the main supply line 75. Energization of the contactor R1 causes closure of the contactor switches R1*a*, R1*b* and R1*c*, while causing the contactor switch R1*d* to open. Opening of the contactor switch R1*d* has no effect at this time.

Closure of the contactor switch R1*a* establishes a holding circuit for the contactor R1 and the timer T so that the contactor R1 and the timer T will remain energized when the starter button 87 is released and thereby returns to its open position. The said holding circuit comprises the main supply line 66, switches 69 and 70, line 83, contactor switch R1*a*, lines 88 and 89, contactor R1 and timer T and the main supply line 75. The timer T is now operating for a predetermined time for which it has been set. This predetermined time corresponds to a period necessary to bring the main motor 77 up to a desired speed. After this said predetermined time has expired, the timer switch T1 opens temporarily to thereby stop the timer T, and immediately thereafter the timer switch T1 again closes.

Since, as mentioned above, the contactor switch R1*c* closes, the energizing circuit for the solenoid S1 is closed, which energizing circuit comprises the main supply line 66, lines 67, 68, 71, 83 and 90, the now closed contactor switch R1*c*, line 91, solenoid S1 and main supply line 75.

Energization of the solenoid S1 causes the valve member 42 to move toward the right against the thrust of the spring 46, thereby establishing fluid connection between the conduits 39 and 47, while simultaneously connecting the conduit 30 with the conduit 40.

Since, as likewise mentioned above, the contactor switch R1*b* closes, the energizing circuit for the contactor R2 is closed, which energizing circuit comprises the main supply line 66, lines 67, 68, 71 and 83, the now closed contactor switch R1*b*, line 82, contactor R2 and the main supply line 75. Energization of the contactor R2 causes closure of the contactor switch R2*a*, thereby establishing a holding circuit for the contactor R2, which maintains the latter energized when the contactor switch R1*b* opens. Simultaneously with the contactor R2, also the motors 77 and 79 are energized, thereby starting the said motors.

Since the centering springs 55 and 56 hold the flow control member of the pump 20 and, thereby, the pump 20 in no delivery position, operation of the main motor 77 merely rotates the rotor of the pump 20 without, however, causing

the pump 20 to deliver fluid. In other words, at this time no load acts upon the motor 77, and the motor 77 gradually increases its speed until it reaches its normal speed. Since, as mentioned above, the valve member 42 is in its right hand end position, operation of the motor 79 causes the pump 48 merely to run idle, and the fluid delivered by the pump 48 is passed through conduits 47, 39 and 37 into the tank 38. In other words, the fluid delivered by the pump 48 is merely circulated without performing work.

When the motor 77 has reached its desired or normal speed, the timer switch T1, as explained above, opens temporarily, thereby breaking the holding circuit for the contactor R1 and the timer T. This causes deenergization of the timer T and the contactor R1 and, as a result thereof, the contactor switches R1*a*, R1*b* and R1*c* open, whereas the contactor switch R1*d* closes. When the timer switch T1 then again closes, it will not re-establish the energizing circuit for the contactor R1 and the timer T.

Opening of the contactor switch R1*b* has no effect at this time, since the contactor R2 remains energized by the holding circuit established by the contactor switch R2*a*. Consequently, also the motors 77 and 79 remain energized and continue to drive the pumps 20 and 48.

Opening of the contactor switch R1*c* causes deenergization of the solenoid S1, so that the spring 46 returns the valve member 42 to the position shown in Figure 1, in which fluid connection is established between the conduits 47 and 30, while the fluid connection between the conduits 47 and 39 is interrupted. Therefore, the fluid delivered by the pump 48 now passes through the conduit 47, valve 32, conduit 33, check valve 34 and conduit 30 into the bore 22, where it acts upon the smaller or right hand area of the piston portion 21. This causes the plunger 18 to move toward the left, thereby placing the pump 20 on retraction stroke. The fluid expelled during the leftward movement of the plunger 18 from the left hand side of the bore 22 passes through the passageways 26, bore 28, passageways 29 and conduit 37 into the tank 38. The pump 20 now delivers pressure fluid through the conduit 58 into the lower portion of the press cylinder 1 and causes the ram 2 to move upwardly.

The fluid expelled during this upward movement of the ram 2 from the upper portion of the press cylinder 1 passes, in part, through the conduit 57 to the now suction side of the pump 20 and escapes, in part, through the surge valve 62 into the tank 38. It will be appreciated that at this time the surge valve 62 has been opened by the pressure conveyed from the conduit 58 through the pilot line 63 to the surge valve 62.

When the ram 2 approaches its upper or retracted position, the platen arm 4 engages the collar 5 and thereby shifts the push rod 6 into the position shown in the drawing, so that the three-arm lever 9, through its linkage 14, causes the valve member 17 to move toward the right, with regard to the position it last occupied, into the position shown in Figure 1.

Since, as previously mentioned, the plunger 18 was shifted toward its left hand position, the rightward movement of the valve member 17 brings about fluid connection between the right side or smaller effective area of the piston portion 21 and the left side or larger effective area of the said piston portion. Consequently, pressure fluid passes from the conduit 30 through the bores 27 and 28 into the left hand end of the bore 22 where it acts upon the larger effective area of the piston portion 21 and shifts the plunger 18 toward the right until it occupies the position shown in Figure 1. The pump 20 is then in its neutral or no delivery position and, since now fluid is neither delivered to nor withdrawn from the press cylinder 1, the ram 2 comes to a stop. The ram 2 is now in its position for starting a pressing cycle. The fluid delivered by the pilot pump 48 is now by-passed through the pressure relief valve 51 into the tank 38.

To start a working cycle of the ram 2, the operator closes the forward switch 72, thereby closing the energizing circuit for the main solenoid 12. Energization of the solenoid 12 causes the armature 11 to move downwardly so that the three-arm lever 9 moves in clockwise direction and, by means of the linkage 14, moves the valve member 17 toward the right against the thrust of the spring 52. The valve member 17 thereby releases the bores 27 so that pressure fluid delivered by the pump 48 now passes through conduits 47, 33 and 30 and the bores 27 and 28 and causes the plunger 18 to move toward the right against the thrust of the centering springs 54 and 55. As a result thereof, the pump 20 is placed on forward stroke, and now delivers fluid through the conduit 57 into the upper portion of the press cylinder 1, while withdrawing fluid through the conduit 58 from the lower portion of the press cylinder 1.

The press ram 2 now moves downwardly by gravity as fast as fluid is withdrawn from the lower portion of the cylinder 1. The suction effect created in the upper portion of the cylinder 1 maintains the surge valve 62 open, so that the fluid delivered by the pump 20 into the upper portion of the cylinder 1 is supplemented by fluid passing from the tank 38 through the surge valve 62 into the cylinder 1. When the ram 2, during its downward movement, approaches the position at which the platen 3 or a die connected thereto engages the work piece to be shaped, the cam 95 engages the roller 94 and closes the switch 93.

Closure of the switch 93 establishes a by-pass circuit for the now open contactor switch R1*c*, thereby closing the energizing circuit for the solenoid S1. Energization of the solenoid S1 causes the valve member 42 to move toward the right, thereby again effecting fluid connection between the conduits 47 and 39, while connecting the conduits 30 and 40 with each other. Since now fluid may escape from the left hand portion of the bore 22 through the conduit 35, check valve 36, conduit 30, choke 31 and conduits 40 and 37 into the tank 38, the centering springs 54 and 55 move the plunger 18 toward the left, thereby decreasing the delivery of the pump 20. The rate of decrease of this delivery is determined by the setting of the choke 31 through which the fluid expelled during the leftward movement of the plunger 18 must escape. The decrease in the delivery of the pump 20 also causes a reduction in the quantity of fluid withdrawn from the lower portion of the cylinder 1, so that the ram 2, in its downward movement, is slowed down.

As soon as the cam 95 has passed the roller 94, at which time the platen or a die connected thereto, has engaged a work piece, the switch 93 again opens. As a result thereof, the energizing circuit for the solenoid S1 is again interrupted and the spring 46 moves the valve member 42 again to the left, thereby restoring the position shown in Figure 1 of the valve 32.

Pressure fluid delivered by the pump 48 now

again shifts the plunger 18 toward the right in the manner described previously, thereby returning the pump 20 to its full delivery forward stroke position. The ram 2 now performs its actual pressing stroke.

When, at the end of the pressing stroke, a predetermined pressure has built up in the upper portion of the press cylinder 1, this pressure is conveyed through the pilot line 59 to the tonnage control valve 60 and causes the tonnage control switch 60a to open. This breaks the holding circuit for the main solenoid 12 so that the latter becomes deenergized. As a result thereof, the spring 52, which was previously loaded, shifts the valve member 17 toward its extreme left hand position, thereby causing the valve member 17 to release the annular groove 25, while preventing fluid connection between the larger and the smaller effective areas of the piston portion 21. As a result thereof, the fluid delivered by the pump 48 into the conduit 30 now acts upon the smaller effective area of the piston portion 21 and causes the plunger 18 to move toward the left, while the fluid expelled during this leftward movement of the plunger 18 from the left hand portion of the bore 22 passes through the passageways 26, annular groove 25, passageways 29 and conduit 37 into the tank 38.

The pump 20 is now in its retraction stroke position, in which it delivers pressure fluid through conduit 58 into the lower portion of the press cylinder 1, and causes the ram 2 to move upwardly, while the fluid expelled from the upper portion of the cylinder 1 passes, in part, through the conduit 57 to the now suction side of the pump 20 and, in part, into the tank 38 through the surge valve 62 which, as previously explained, has been opened by pressure fluid conveyed from the conduit 58 through the pilot line 63 to the surge valve 62. The ram 2 now performs its upward movement or retraction stroke in the manner set forth above in connection with the description of the conditioning of the press for a working cycle after a period of idleness.

When the ram 2 reaches its retracted position, it causes the pump 20 to move into neutral or no delivery position and, thereby, comes to a stop, as was also previously explained.

If it is desired, during the advancing stroke of the press ram, to return the ram to its retracted position before the ram has reached the end of its forward stroke, it is merely necessary to open the reverse switch 84, thereby breaking the energizing circuit for the main solenoid 12, so that the spring 52 in the servomotor plunger 18 causes the pump to move into retraction stroke position. The ram then performs a retraction stroke in the manner described above.

If it is desired, in case of an emergency, or for some other reason, to stop the press ram at its respective position, the operator opens the stop switch 70, thereby deenergizing all parts of the electric circuit including the pump motor 77.

Particular attention is directed to the fact that if the press ram, due to leakage during a period of idleness of the press, has moved to a position intermediate its end positions, and if now the operator, in order to return the ram from this intermediate position to its retracted position, accidentally closes the forward switch 72 instead of the starter button 87, this will not result in an accidental downward movement of the ram 2. All that will happen is that the main solenoid 12 will be energized, thereby shifting the valve member 17 toward the left. However, since this will

not close the energizing circuits for the main motor 77 and the auxiliary or pilot pump motor 79, the pumps 20 and 48 will not be started, and no movement of the ram will be brought about.

If the operator now, noticing that the motors 77 and 79 remain at a standstill, closes the starter button 87 simultaneously with the forward button 72, this will likewise not bring about an accidental downward movement of the ram 2.

It will be appreciated that, as soon as the starter button 87 is closed, the contactor R1 is energized, thereby opening the contactor switch R1d, so that the main solenoid 12 is deenergized and the spring 52 moves the valve member 17 to its left hand end position. However, since the energization of the contactor R1 also causes energization of the solenoid S1, as previously explained, with the result that the valve member 42 is moved to its right hand end position, the fluid delivered by the pump 48, when the motor 79 is energized, is by-passed to the tank 38 and, therefore, does not bring about a movement of the plunger 18. On the other hand, the springs 54 and 55 maintain the pump 20 in its neutral position, so that the energization of the main motor 77 merely rotates the rotor of the pump 20 without load. In other words, the condition of the system is the same as if only the starter button 87 had been closed.

The particular electric circuit shown in Figure 2, therefore, comprises a safety feature, which is a safeguard against accidental downward movement of the ram 2 when it is intended to return the ram 2 from an intermediate position, into which it has moved due to leakage during a period of idleness, to its retracted position.

While the control system of the invention has been described with the pumps 20 and 48 driven by two separate motors, it will be appreciated that, if desired, the motor 79 may be omitted and the pump 48 drivingly connected with the motor 77, without in any way affecting the operation of the control system described above.

If desired, the pilot pump 48 may be replaced by an accumulator, in which instance the conduit 39 and the motor 79 with the lines 80 and 81 will be omitted. It will then be appreciated that when the solenoid S1 is energized, the escape of fluid from the accumulator is prevented, whereas when the solenoid S1 is deenergized and the valve member 42 occupies the position shown in Figure 1, fluid connection is established between the accumulator and the conduit 30.

While the system according to the invention has been described in connection with automatic means for effecting fluid connection between the pilot pump 48 and the servomotor means 17, 18 and 19, after the pump motor 77 has reached a predetermined speed, it is, of course, understood that, if desired, the automatic means for effecting said connection may be omitted, and that the valve solenoid S1 may be deenergized manually when the pump motor 77 has reached its desired speed.

It will also be appreciated that, if the above described slow-down arrangement for slowing down the ram 2 at a predetermined point of travel thereof should not be required or be replaced by other means, the conduits 33 and 35 together with the valves 34 and 36 and also the choke 31 and switch 93 may be omitted. In this instance, the bore shown in Figure 1 at the left side of the larger piston portion 21 and directly communicating with the conduit 35 will either be omitted or plugged without affecting the con-

trol system of the present invention for preventing the starting of the pump motor 77 under load.

It will be understood that I do not wish to be limited by the specific structure shown in the drawings and described in the specification, except as required by the appended 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 double-acting plunger, a fluid source of reversible delivery for supplying actuating fluid to said plunger, a prime mover drivingly connected to said source, yielding means normally urging said source toward neutral, a fluid operable servomotor normally positioning said source to deliver to said plunger in one direction, control means energizable to move said servomotor to position said source to deliver to said plunger in the other direction, means operated by said plunger in a predetermined position of movement thereof in said one direction for actuating said servomotor for moving said fluid source into no delivery position, and means operable automatically in response to the starting of said prime mover for exhausting said servomotor whereby said yielding means moves said source to neutral and for interrupting the energizing circuit to said control means to prevent movement of said servomotor into position to move said source to deliver to said plunger in the said other direction upon the restoration of the supply of pressure fluid to said servomotor, said automatically operable means being effective for a predetermined length of time.

2. In a hydraulic system, a vertically reciprocable plunger, a pump of reversible delivery connected to supply said plunger, means continuously urging said pump toward neutral, a prime mover directly connected with said pump, a fluid operable servomotor associated with said pump normally urging the same to deliver to said plunger to move the same upwardly and adapted for actuation by said plunger in a predetermined upper position thereof for moving said pump to neutral, control means energizable to actuate said servomotor to move said pump to deliver to said plunger to move the same downwardly, a source of fluid for supplying said servomotor, means operable automatically in response to the starting of said prime mover for interrupting the supply of fluid to said servomotor while simultaneously exhausting said servomotor and for interrupting the energizing circuit for said control means, said automatically operable means being effective for a predetermined length of time during which said prime mover comes up to speed, and other means operated by said plunger during its downward movement for momentarily at least partially exhausting said servomotor for momentarily slowing down the downward movement of said plunger.

3. In a hydraulic system, a vertically reciprocable double-acting plunger, a variable delivery pump for supplying fluid to said plunger, yielding means normally urging said pump toward neutral, a fluid operable servomotor associated with said pump normally urging the same to deliver to the underneath side of said plunger and adapted for actuation by said plunger in a predetermined upper position thereof for moving said pump to neutral, first electrical means energizable to move said servomotor to position said pump to deliver to the upper side of said plunger, an auxiliary fluid source for supplying actuating fluid to said servomotor, a prime mover directly connected to drive said pump, an electric starter for initiating movement of said prime mover, valve means normally connecting said auxiliary source with said servomotor, second electrical means energizable to move said valve means to exhaust said servomotor whereby it loses effect on said pump, a control circuit interlocking said electrical means and said starter means and operable upon energization of the latter to open the energizing circuit for said first electrical means and to energize said second electrical means, and after a predetermined length of time to re-establish the energizing circuit for said first electrical means and to de-energize said second electrical means.

4. In a hydraulic system, a reciprocable plunger, fluid operable advancing and retracting means associated with said plunger for reciprocating the same, a pump of reversible variable delivery for supplying pressure fluid selectively to said advancing or said retracting means, fluid operable servomotor means associated with said pump for reversing the delivery thereof to selectively supply pressure fluid to said advancing and retracting means, an auxiliary fluid source for supplying actuating fluid to said servomotor means to move said pump into delivery position in either of two directions to control the direction of flow therefrom, centering means continuously urging said pump into and tending to hold the same in substantially neutral or no delivery position, means operated by said plunger at least in one position thereof to actuate said servomotor for moving and holding said pump in neutral position as long as said plunger is in said one position, electric motor means drivingly connected with said pump, starter means for initiating operation of said motor means, control means for actuating said servomotor means to move said pump into delivery position to supply pressure fluid to said advancing means, and electrically actuated means operatively connected with said starter means and said control means and responsive to the actuation of said starter means and operable for a predetermined length of time to prevent operative operation of said control means and for preventing delivery of fluid from said auxiliary fluid source to said servomotor means.

5. In a hydraulic system, a reciprocable plunger having fluid operable advancing and retracting means, a pump of reversible delivery for supplying actuating fluid to said means, fluid operable servomotor means for positioning said pump to deliver in either direction, means for supplying actuating fluid to said servomotor including valve means movable to exhaust said servomotor, centering means continuously urging said pump toward neutral position, means operated by said plunger at least in one position thereof to actuate said servomotor for moving and holding said pump in neutral position as long as said plunger is in said one position, a prime mover drivingly connected with said pump, means responsive to the initiation of starting of said prime mover for actuating said valve means to exhaust said servomotor for a predetermined length of time thereby to prevent said servomotor from placing the pump in delivery position upon loss of effect of said plunger to hold said servomotor in neutral position until said prime mover reaches a predetermined minimum speed, and other means operable by said plunger during the movement thereof for momentarily actuating said valve means to exhaust said servomotor.

6. In a hydraulic system, a reciprocable plunger having fluid operable advancing and retracting means, a pump of reversible delivery for supplying actuating fluid to said means, fluid operable servomotor means associated with said pump for determining the direction of delivery thereof, means for supplying actuating fluid to said servomotor including valve means actuatable to exhaust said servomotor, centering means continuously urging said pump toward neutral position, control means selectively operable to actuate said servomotor to move said pump to deliver to said advancing area, means operated by said plunger in its retracting direction of movement to actuate said servomotor for moving said pump toward neutral position, a prime mover drivingly connected with said pump, starter means for energizing said prime mover, and means interlocking said starter means and said control means and operable for a predetermined time after the actuation of said starter means to initiate movement of said prime mover to prevent actuation of said control means, during which time said prime mover reaches a predetermined minimum speed, said means also being operable during the same period to actuate said valve means to exhaust said servomotor.

7. In a hydraulic system, a reciprocable plunger having fluid operable advancing and retracting means, a pump of reversible variable delivery for supplying pressure fluid selectively to said advancing or said retracting means, fluid operable servomotor means associated with said pump for reversing the delivery thereof to selectively supply pressure fluid to said advancing and retracting means, an auxiliary fluid source for supplying actuating fluid to said servomotor, centering means continuously urging said pump into and tending to hold the same in substantially neutral or no delivery position, means operated by said plunger at least in one position thereof to actuate said servomotor for moving and holding said pump in neutral position as long as said plunger is in said one position, an electric motor drivingly connected to the drive shaft of said pump for positively driving the same, starter means for starting operation of said electric motor, electrically operable control means operable in response to the operation of the said starter means and effective for a predetermined length of time for preventing delivery of fluid to said servomotor means to thereby prevent movement of said pump thereby into delivery position upon loss of effect of said plunger to hold said servomotor in neutral position, a second starter means for causing said servomotor means to place said pump into position for delivering pressure fluid to said advancing means, and means actuated in response to the actuation of said first starter means to render such second starter means ineffective for a predetermined time to permit said prime mover to reach a predetermined minimum speed.

8. A control system for a hydraulic pump which is drivingly connected to a prime mover to prevent the pump from being placed on a delivery stroke before the prime mover has reached a predetermined minimum speed that includes in combination, servomotor means operably connected to the pump to place the same on a delivery stroke in either direction or in neutral, yielding means normally urging said pump into neutral position, control means operably connected to said servomotor having on position for placing said servomotor in position to place said pump on delivery stroke in one direction and a second position to place said servomotor in position to place said pump on delivery stroke in the other direction, means for supplying fluid to said servomotor for actuating the same in response to movements of said control means, and other means operable automatically upon initiation of movement of said prime mover for preventing the supply of fluid to said servomotor thereby to permit said yielding means to position said pump in neutral and to render said control means ineffective to change the position of said servomotor, said other means being operable for a predetermined length of time to permit said prime mover to attain a predetermined minimum speed.

9. A control system for a hydraulic pump that is directly connected to a prime mover to prevent the pump from being placed on a delivery stroke before the prime mover has reached a predetermined minimum speed, that includes in combination, a pump of variable delivery, a prime mover directly connected to the pump for driving the same, servomotor means operably connected to the pump to place the same on a delivery stroke or on neutral, means normally urging said pump into neutral position, control means operably connected to said servomotor having one position for placing said servomotor in position to place said pump on a delivery stroke and a second position to place said servomotor in position to place said pump on neutral stroke, electrically operated means for preventing delivery of actuating fluid to said servomotor, means for energizing said prime mover to start said pump and including means to operate said electrically actuated means to prevent delivery of actuating fluid to said servomotor whereby to prevent said servomotor from changing the position of said pump from neutral position as retained therein by the said aforesaid means irrespective of the position of said control means, means operable after a period of time during which said motor has attained a predetermined minimum speed for rendering said electrically actuated means ineffective to permit flow of actuating fluid to said servomotor for actuation in response to said control means, means for rendering said control means active to position said servomotor in a position to place said pump on a delivery stroke, and means actuated in response to said means for energizing said motor for rendering said last-mentioned means ineffective.

10. In a hydraulic system, a fluid operable motor, a pump of variable delivery for supplying fluid to said motor, means continuously urging said pump toward neutral, fluid operable servomotor means for moving said pump to delivery position, a prime mover directly connected with said pump, an auxiliary source of pressure fluid for supplying said servomotor, valve means connecting said auxiliary source with said servomotor, means responsive to the starting of said prime mover for actuating said valve to prevent the supply of fluid from said auxiliary source of said servomotor, said means being effective during a predetermined period of time to allow said prime mover to come up to speed under no load, means operable in response to a predetermined movement of said motor for actuating said valve means to interrupt the supply of fluid to said servomotor while exhausting the same, and flow restricting means connected to control the rate of exhaust from said servomotor.

11. In a hydraulic system, a fluid operable motor, a pump of variable delivery for supplying fluid to said motor, means continuously urging

said pump toward neutral, fluid operable servomotor means for moving said pump to delivery position, a prime mover directly connected with said pump, an auxiliary source of pressure fluid for supplying said servomotor, valve means connecting said auxiliary source with said servomotor, means responsive to the starting of said prime mover for actuating said valve to prevent the supply of fluid from said auxiliary source to said servomotor, said means being effective during a predetermined period of time to allow said prime mover to come up to speed under no load, means operable in response to a predetermined movement of said motor for actuating said valve means to interrupt the supply of fluid to said servomotor while exhausting the same, flow restricting means connected to control the rate of exhaust from said servomotor; and means responsive to a predetermined further movement of said motor for again bringing about the supply of actuating fluid from said auxiliary source to said servomotor.

12. In a hydraulic system, the combination with a pump having pressure operated delivery control means, yielding means continuously urging said pump toward neutral and effective to so position said pump in the absence of pressure in said control means, power means directly connected to drive said pump, a source of pressure fluid, a valve connecting said source of pressure fluid with said control means, valve actuating means operable automatically in response to the starting of said power means for actuating said valve to prevent the supply of fluid from said source to said control means whereby said pump is retained in neutral by said yielding means, and means automatically responsive to the elapse of a predetermined period of time following the starting of said power means for rendering said valve actuating means ineffective whereby the supply of fluid to said control means is re-established.

13. In a hydraulic system, in combination with a pump normally yieldingly urged toward neutral and having pressure operated delivery control means, power means directly connected with said pump for driving the same, a source of pressure fluid, valve means connecting said source with said control means and having an exhaust connection, valve actuating means operated by and

for a predetermined time after the starting of the power means to actuate said valve means for disconnecting said control means from said source and for connecting it instead with exhaust, means permitting free supply of fluid from said valve to said control means and a restricted exhaust of fluid from said control means, and other means selectively operable for energizing said valve actuating means irrespective of whether or not said prime mover is being started.

14. In combination with a vertically reciprocable fluid actuated plunger, a fluid source for supplying actuating fluid to said plunger, means normally urging said source into neutral position for preventing the delivery of fluid to or the removal of fluid from said plunger, control means for controlling the delivery of said pump; linkage operated by said plunger in its uppermost position for moving said pump to neutral, fluid operable means connecting said linkage and said control means with said pump, means operable in response to the starting of said pump for exhausting said fluid operable means thus making ineffective said linkage and said control means, said means being effective for a predetermined time, and other means selectively operable for partially exhausting said fluid operable means during the operation of said pump for controlling the delivery thereof.

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