June 1, 1943. T. F. STACY 2,320,759

FLUID OPERATED MOTOR

Filed Feb. 15, 1939 4 Sheets-Sheet 1

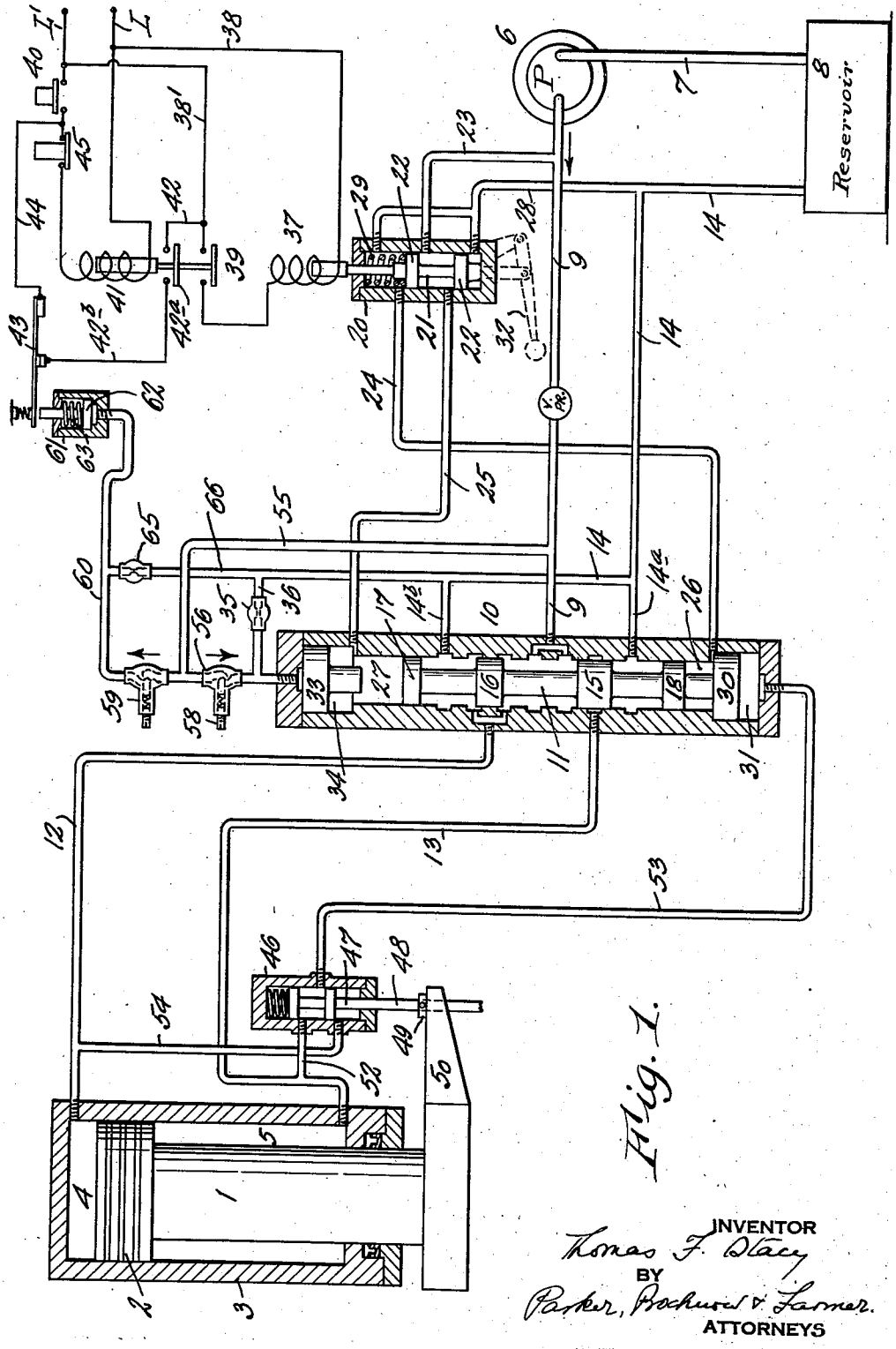


Fig. 1.

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FLUID OPERATED MOTOR

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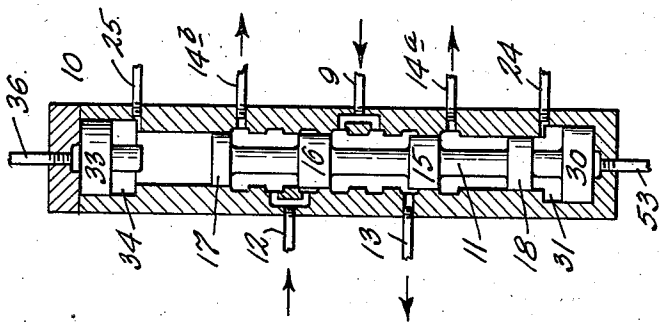


Fig. 4.

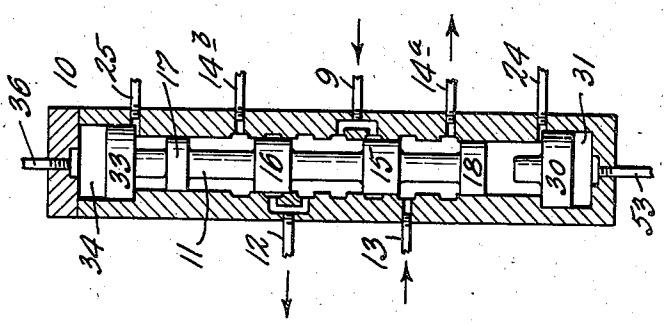


Fig. 3.

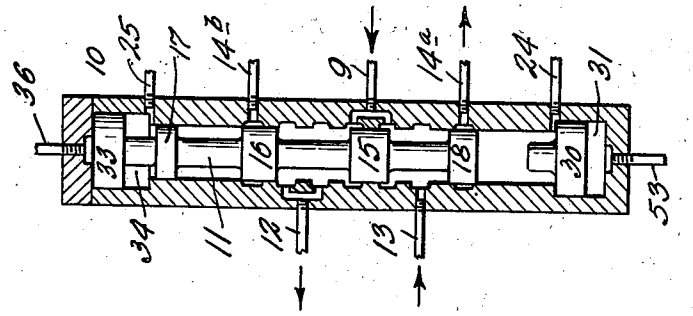


Fig. 2.

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FLUID OPERATED MOTOR

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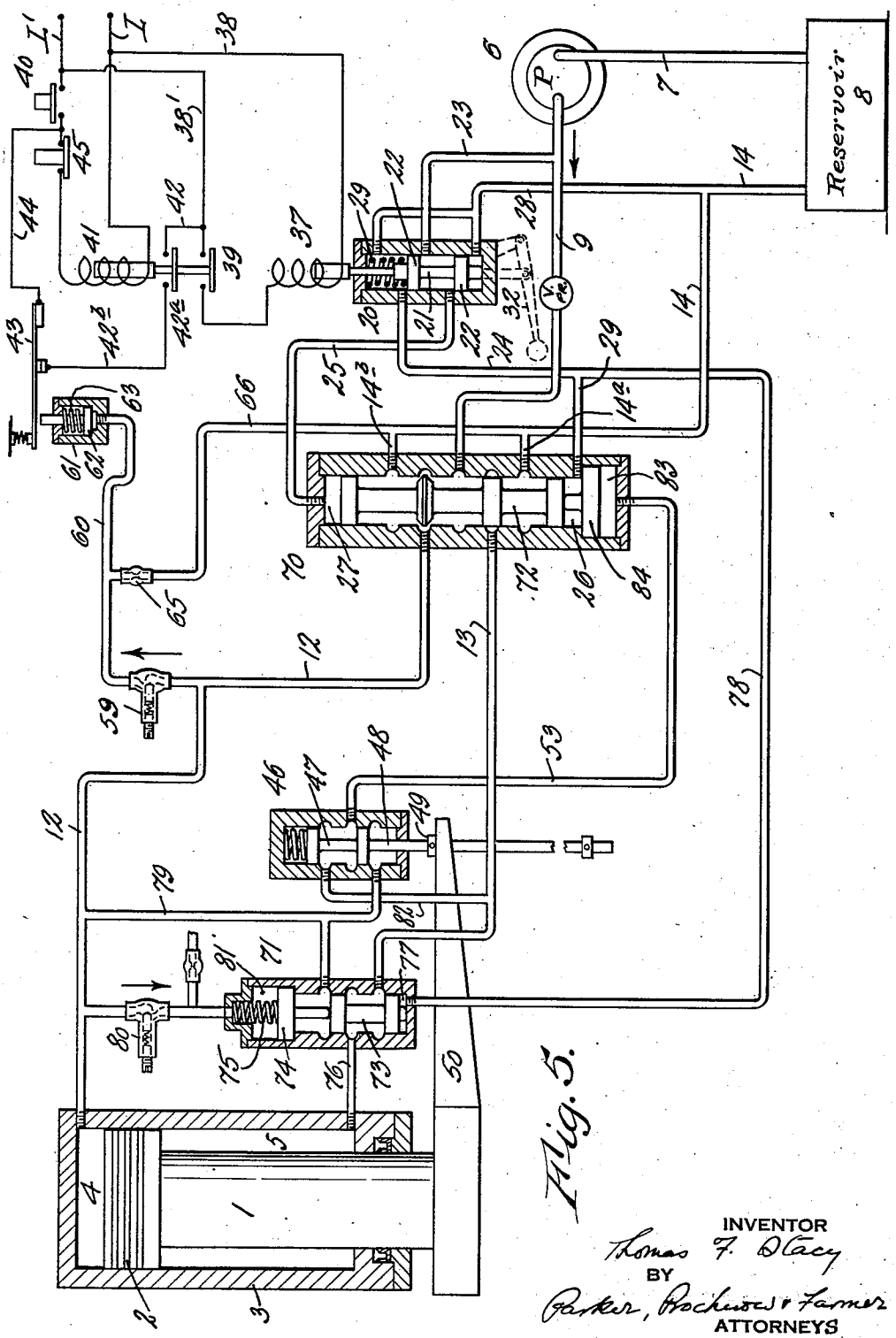


Fig. 5.

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FLUID OPERATED MOTOR

Filed Feb. 15, 1939 4 Sheets-Sheet 4

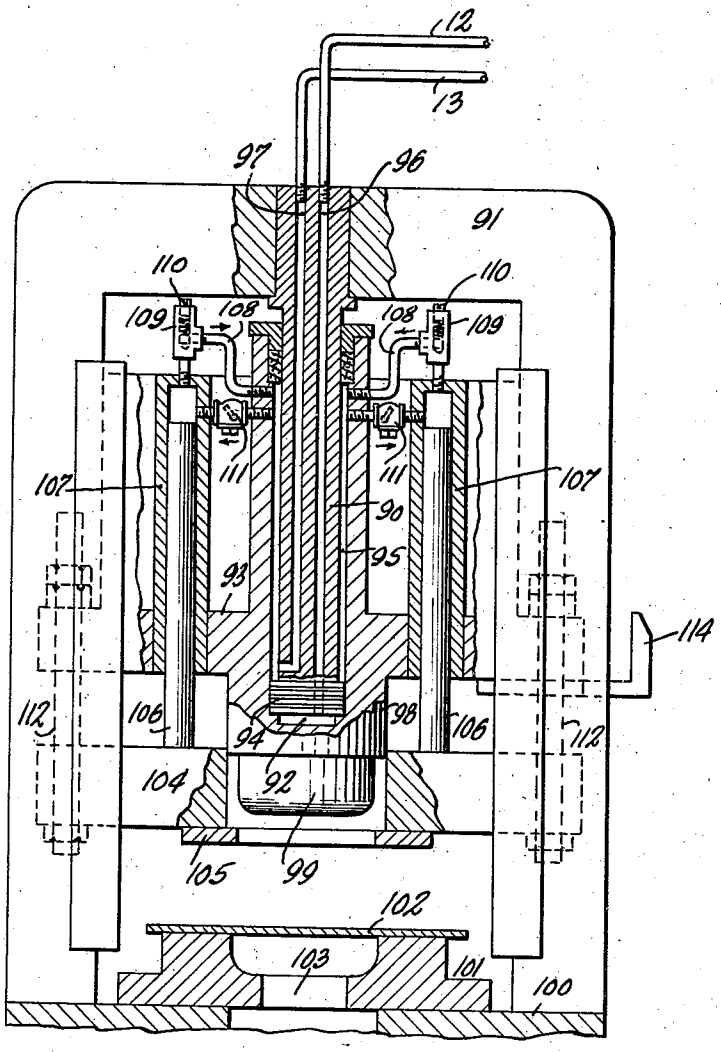


Fig. 6.

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2,320,759

UNITED STATES PATENT OFFICE

2,320,759

FLUID OPERATED MOTOR

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Application February 15, 1939, Serial No. 256,561

11 Claims. (Cl. 60—52)

This invention relates to fluid pressure actuated motors and the control thereof, and more particularly to hydraulic presses and a method and mechanisms for controlling the operation of the ram elements thereof.

One object of the invention is to provide an improved method of operation, and control or operating means for fluid actuated motors, which will insure efficient, smooth and rapid operation of the motor, and which, while being relatively simple and easy to operate, will be dependable in operation.

Other objects of the invention are to provide an efficient metal drawing press and operating mechanism therefor of improved and desirable construction; also to provide improved control mechanism for presses and analogous fluid operated motors by which the ram element is moved rapidly in its working stroke until a substantial resistance is encountered, then moved at reduced speed under increased pressure until a predetermined maximum pressure is attained, or the ram element reaches a predetermined position, and the ram element is then retracted to initial open position.

Other objects of the invention are to provide a novel and improved control or operating valve for fluid motors or presses; also to provide a novel operating mechanism for the work clamping or holding element of metal drawing presses.

Other objects and advantages will be apparent from the following description of some embodiments or examples of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

The accompanying drawings illustrate the improved control mechanism as applied to press motors of different types and also illustrate somewhat different control or operating mechanisms embodying the invention.

In said drawings:

Fig. 1 is a schematic diagram of an ordinary fluid actuated press or ram motor with control or operating mechanism embodying the invention, and showing the position of the main control valve when the press is open and idle.

Figs. 2, 3 and 4 are sectional views of the main control valve and showing respectively the positions of the movable valve element for high speed forward movement, reduced speed full pressure forward movement and return movement of the movable press element.

Fig. 5 is a schematic view similar to Fig. 1, but showing a somewhat modified embodiment of the control or operating mechanism.

Fig. 6 is a view, partly in sectional elevation and partly schematic, showing a hydraulic metal drawing press with control or operating mechanism embodying my invention.

Referring first to Figs. 1–4 of the drawings, the fluid actuated motor comprises a ram element 1 with a piston 2 arranged to reciprocate in a cylinder 3 having a main cylinder cavity 4 at one side of the piston to which fluid under pressure is admitted to force the ram outwardly in a working stroke, and a pull back cylinder cavity 5 at the opposite side of the piston to which pressure fluid is admitted for retracting the ram 1. These parts are typical of hydraulic press motors in some of which the main and pull back pistons operate in separately housed cylinders but are connected for retracting the ram element, and it will be understood that this invention relates to the operation of the ram element in one direction by pressure in a main cylinder and in the opposite direction by pressure in a pull back cylinder, whether the main and pull back cylinder pressures operate on the same or different pistons or movable elements connected to the ram element.

6 indicates a pump arranged to draw fluid through a pipe 7 from a reservoir or supply tank 8 and deliver it under pressure through a main discharge or supply pipe 9 for actuating the motor. The pump may be, as represented, a constant displacement pump, or it can be of the variable delivery type, and other sources of operating fluid under pressure may be employed in place of the pump and reservoir shown.

10 represents a main motor-operating or control valve comprising, as shown, a movable valve element or piston 11 arranged to reciprocate in a casing. The valve casing is connected to the supply pipe 9 and is connected by a pipe 12, to the main cylinder 4 and by a pipe 13 to the pull back cylinder 5. A pipe 14 having branches 14*a* and 14*b* leading to spaced points of the valve casing 11, connects the valve directly with the reservoir 8. These pipes communicate with the piston cavity of the valve 10 through ports in the casing walls, each of the pipes 9 and 12 preferably communicating with the cavity by two branch ports. The movable valve element 11 is provided with lands 15, 16, 17 and 18 arranged to open and close these ports to control the flow of the fluid through said pipes.

Fig. 1 shows the position of the press ram and of the valve element 11 when the press is open

and idle. In this position of the parts, the land 15 closes the port to the pipe 13, and the land 16 is disposed between the branch ports of pipe 12 while the lands 17 and 18 are located respectively above and below the ports to pipes 14b and 14a. The pressure fluid can then pass from supply pipe 9 through the valve and pipe 12 to the main cylinder 4, while land 15 shuts off pipe 13 and prevents discharge of fluid from the pull back cylinder 5. Also, the fluid can pass from supply pipe 9 through the valve cavity and around land 16 through the branch ports of pipe 12 and through branch 14b and pipe 14 to the reservoir. Thus, the fluid can circulate from the pump freely back to the reservoir without creating operating pressure in the main cylinder 4, and therefore, the press ram 1 is held in its uppermost or open position by the confined fluid in the pull back cylinder 5.

The outward or working stroke of the ram 1 from the open, idle position shown is caused by shifting the valve element 11 to its uppermost position, shown in Fig. 2. Then the land 15 is disposed between the branch ports of supply pipe 9 while lands 16 and 18 respectively close the ports to branch pipes 14b and 14a. The fluid will then pass from the supply pipe 9 around the land 15 and through pipe 12 to the main cylinder 4 and the fluid will discharge from the pull back cylinder 5 through pipe 13 into the valve and around the land 15 through the branch ports of supply pipe 9 and through the pipe 12 into the main press cylinder 4. Thus, since the fluid is delivered at pump pressure to the main cylinder and fluid is also bypassed freely from the pull back cylinder into the main cylinder, the maximum supply of fluid will be delivered to act on the larger area of the ram piston in the main cylinder, and the ram 1 will be moved outwardly at its highest speed until the press closes against the work and pressure builds up in the main cylinder 4. At such time the valve element 11 is shifted, preferably automatically, as later explained, to its next lower position, shown in Fig. 3, which is the low speed full pressure position of the valve 10.

Then, fluid can exhaust from the pull back cylinder 5 through pipe 13, valve 10 between lands 15 and 18 and through pipes 14a and 14 to the reservoir. Also, fluid will be delivered from supply pipe 9 through the valve between lands 15 and 16 and pipe 12 into the main cylinder cavity 4. The working stroke of the ram 1 will therefore be continued at full pressure but at a reduced speed, since the pull back cylinder is opened to exhaust and the fluid is supplied to the main cylinder at full pump pressure, but is not supplemented by the volume of liquid bypassed from the pull back cylinder, as during the initial high speed movement of the ram.

When the ram 1 reaches the limit of its working stroke, or is subjected to a predetermined maximum pressure, the valve element 11 is shifted, preferably automatically, as later explained, and through its intermediate idle press position shown in Fig. 1, by which pressure on the ram in the main cylinder is relieved, to the ram return position shown in Fig. 4. In this fourth position of valve element 11, the fluid can discharge from the main cylinder cavity 4 through pipe 12, valve 10 between the lands 16 and 17 and pipes 14b and 14 to the reservoir, and fluid will be delivered under pressure from the supply pipe 9 through the valve between the lands 15 and 16 and pipe 13 to the pull back cylinder, thus returning or retracting the ram to the idle, open position shown.

The mechanism for automatically shifting the movable element of control valve 10 to effect the above stated operation of the press ram, as illustrated in Fig. 1, is constructed and operates as follows:

20 represents a pilot valve comprising, as shown, a valve element or piston 21 arranged to move in a cylinder casing and provided with two spaced lands 22. The casing of this valve 20 is connected by a pipe 23 to supply pipe 9 and by pipes 24 and 25 respectively to cylinder cavities 26 and 27 in the main valve 10 below and above the main valve element 11. The pilot valve casing is also connected with the reservoir 8, as by a pipe 28 connecting with pipe 14, said pipe 28 having branches connecting with the cavity of the pilot valve above and below the ends of element 21. In the open position of the press, element 21 is held down in the position shown in Fig. 1, as by a spring 29 in the valve casing above element 21, and fluid is delivered from supply pipe 9 through the pipe 23, the pilot valve and pipe 25 to cylinder area 27 of the main valve above element 11, while the cylinder area 26 of the main valve below element 11 is connected through pipe 24, pilot valve and upper branch of pipe 28 to the reservoir. The main valve element 11 is thus held down in its intermediate idle position shown in Fig. 1.

Downward movement of the main valve element 11 beyond the intermediate position shown in Fig. 1, by the fluid pressure on its upper end, is preferably prevented by engagement of the element with the stem of a stop piston 30 which is arranged to move in a cylinder cavity 31 in the lower end of the main valve casing, and at the time is held in its upper stopping position under the control of the press ram, as hereinafter explained.

The main valve element 11 is shifted to its uppermost, Fig. 2 position for initiating the working stroke of the press ram 1, by moving pilot valve element 21 upwardly, which can be done manually, as by an operating lever 32, shown by dotted lines, connected to a projecting stem of element 21, or by means, preferably electrically operated, illustrated in Fig. 1 and presently described.

When the element 21 is thus raised against the action of its spring 29, it connects the lower cylinder area 26 of the main valve 10 through pipe 24, pilot valve and pipe 23 to the supply pipe 9, and relieves the pressure in the upper cylinder area 27 of the main valve through pipe 25, pilot valve 20 and pipe 28, which leads to the reservoir. Fluid pressure above a pilot piston 33 in a cylinder 34 at the upper end of main valve 10 is relieved at this time through a bleeder element 35 in a pipe 36 connecting cylinder 34 with pipe 14 so that piston 30 can move up and not oppose the ascent of main valve element 11 to the uppermost position.

The electrical operating means for the pilot valve 20, as shown, comprises a solenoid 37, the core of which is connected to a projecting stem of pilot valve element 21, and the winding of which is connected across main line conductors L, L' by conductors 38 and 38', and a relay switch 39 controlling the solenoid. A starting push button switch 40 in the main line is adapted, when closed to connect the magnet winding 41 of relay switch 39 across the line and close the relay switch, thus completing the circuit through the

solenoid 37, and thereby lifting the pilot valve element 21 and starting the work stroke of the ram, as before stated. When the relay switch 39 is closed to start the press, it also closes a holding circuit, comprising a conductor 42 extending from the conductor 38', contact piece 42a of the relay switch, conductor 42b, the movable member of a pressure operated reversing switch 43, conductor 44, and line conductor L' and a second push button switch 45 in line conductor L' through the winding 41 of relay 39 back to line conductor L. The pressure operated switch 43 and second push button switch 45 are normally closed, and when the starting push button switch 40 is closed to start the press and then released, the holding circuit will remain closed and hold the relay switch closed and the solenoid operated pilot valve in its starting position until the holding circuit is broken. This may be done automatically by the opening of the pressure operated switch 43, as later explained, or by operation of the second push button switch 45, manually at any time. This electrical operating means, including the actuating solenoid for the pilot valve 20, the relay switch and holding circuit, are of usual construction and operation and are described simply to explain the operation thereof. Any other suitable electric means controlling the operation of the pilot valve and including a switch, as 43, adapted to be automatically operated under the control of the press ram for returning the ram and pilot valve element to normal position, could be employed.

46 indicates a ram-operated reversing valve which, as shown, comprises an element or piston 47 movable in a cylinder and adapted to be shifted under control of the press ram or platen, as for example, by an arm 50 connected to the press ram and adapted to engage a collar or projection 49 on the projecting stem 48 of valve 46. Just before the press ram, in its return movement, reaches the open, idle position shown, the arm 50 will lift the valve element 47 to the upper position shown, against the action of a return spring, which may be a coil spring in the valve casing above the movable element 47. In this position the valve 46 applies fluid pressure from the pull back cylinder 5 through pipe 13 and a branch pipe 52 thereof, the valve 46 and a pipe 53 to the bottom cylinder chamber 31 of main valve 10, and the pressure holds the stop piston 30 up, as shown in Fig. 1, against a stop shoulder in the valve casing and thus prevents descent of the element 11 of the main valve beyond its intermediate idle position, shown.

When, however, the press ram is started on its working stroke, the platen arm 50 will move out of contact with the stem collar of reversing valve element 47, which will then be moved down by its spring and cut off communication between pipe 53 and the pull back cylinder and establish communication from the pipe 53 through the valve 46, a pipe 54, and pipe 12 to the main press cylinder 4. At this time main valve element 11 is in its uppermost starting position shown in Fig. 2, to deliver fluid under pressure to the cylinder 4, and this pressure is thus communicated to the cylinder chamber 31 to retain stop piston 30 in its upper position shown during the working stroke of the press ram.

When the ram encounters a predetermined resistance to its working stroke, the increased pressure in the fluid pipes 12 and 9, which then communicate, will be transmitted through a pipe 55 from the supply pipe 9 and through a pressure-operated relief valve 56 of ordinary type into the cylinder chamber 34 at the upper end of the main valve 10 above the pilot piston 33. The movable element of the pressure relief valve 56 is held seated or closed by the usual spring, the pressure of which is adapted to be regulated, as by a screw, 58, so that a predetermined low pressure in the pipe 55 will open this valve and admit the pressure to the pilot valve cylinder 34. When the required low pressure is reached, due to the closing of the press ram against the work, the pilot piston 33 is forced down by the pressure on it and moves the main valve element 11 down to the low speed full pressure position shown in Fig. 3. As at this time, the movable element of the pilot valve 20 is in its upper position, pressure will be delivered from the supply pipe 9 through pipes 23 and 24 into the lower cylinder area 26 of main valve 10 below the element 11, and this pressure, opposing the predominating pressure on the larger pilot piston 33, will prevent over-movement of the element 11 beyond its low speed, full pressure position shown in Fig. 3.

Thus, the working stroke of the press ram will be continued under full pressure. At the end of the working stroke of the ram and when a predetermined maximum pressure has been reached, a pressure relief valve 59, which may be similar to the relief valve 56, but which is set to open at this maximum pressure, is opened, and thus fluid pressure is communicated from the pipe 55 through said relief valve 59 and a pipe 60 to the actuating device 61 of the pressure-operated reversing switch 43. This actuating device, as shown, comprises a cylinder in which a piston 62 is movable and having a stem projecting into position to move the movable element of the reversing switch 43 to open said switch. The piston 62 is held in its normal retracted position by a spring 63, which may be arranged in the cylinder above the piston, but when pressure is admitted to the cylinder by the opening of the relief valve 59, the piston will be moved upwardly to open the reversing switch, and this breaks the solenoid holding circuit so that the pilot control valve 20 is then returned by its spring to its normal position shown, as before explained.

The pilot valve 20 then, as before stated, connects cylinder area 26 of main valve 10 to the reservoir and applies pressure in the cylinder area 27 of main valve and thus shifts main valve element 11 downwardly until it is arrested in the intermediate idle position shown in Fig. 1, by the stop piston 30 of main valve 10. At this time, this stop piston is held up by the pressure beneath it in its cylinder 31 from the main press cylinder 4 through pipe 54, valve 46 and pipe 53, and prevents movement of main valve element 11 down beyond the Fig. 1 position. Main valve 10 now connects the main press cylinder 4 through pipes 12, 14b and 14 to the reservoir until the pressure in main cylinder drops to zero and relieves the pressure beneath the stop piston 30 and permits this to recede and allow the main valve element 11 to be shifted to its lowermost or ram return position by the pressure on the upper end of element 11.

Thus, the main valve cannot be shifted to return position and admit the pressure fluid to the pull back cylinder 5 until the pressure on the ram 1 in the main cylinder 4 has been relieved, and this prevents shock, due to sudden application of opposing pressures, which would otherwise occur in the operating system.

The main valve element 11 now being in the

ram return position shown in Fig. 4, the main press cylinder 4 is connected through pipes 12, 14b and 14 to the reservoir, and pressure is applied through supply pipes 9 and 13 to the pull back cylinder, and the ram is returned to its own position shown in Fig. 1. Just before the ram reaches this open position, the ram arm 50 will shift element 47 of the valve 46 to the position shown in Fig. 1. This connects the stop piston cylinder 31 to the pull back cylinder 5 through pipes 53, 52 and 13, and the pressure will lift piston 30 and return main valve element 11 to the intermediate idle position shown in Fig. 1, when as before explained, discharge of fluid from the pull back cylinder will be shut off by land 15 of main valve 10, and main cylinder 4 will be connected through pipes 12, 14b and 14 to the reservoir. Also, as before explained, the main valve 10 connects the supply pipe 9 to pipes 14b and 14, so that the pressure fluid is by-passed from the pump back to the reservoir and the press will remain open and idle until the working stroke of the ram is again initiated by the operation of the pilot valve 20, either manually or through the operating means described.

After the working stroke of the ram has been arrested by opening the reversing switch 43 by means of its pressure actuating device 61, the pressure in the cylinder of this device is relieved through an ordinary bleeder element 65 in a pipe 66 connected to the reservoir, as by pipe 14. This permits the movable element of device 61 to be returned by its spring, thus allowing the switch 43 to close to reestablish the electrical connections for again starting the press by operation of the starting push button 40.

In the operation as above described, the return of the ram is effected at the end of the working stroke through the medium of the predetermined pressure operating the pressure-actuated reversing switch 43 of the holding circuit, but manifestly the return could be effected by shifting the main valve when the press ram reaches a predetermined outward position by the operation of valve shifting means actuated by the ram when it reaches a predetermined position in its outward or working stroke.

The working stroke of the press ram can be stopped at any desired point and its return effected by operating the second push button switch 45 to open the holding circuit and thus cause the return of the solenoid actuated pilot valve 20 to its normal position.

The above described 5-way valve construction is particularly advantageous in a high speed injection molding machine where speed is of prime importance, but where most of the forward stroke requires little or no pressure, although some work is being done; also, on small arbor and general toolroom presses in which it is an advantage to use a high forward speed with positive operation from the pump rather than depend on a prefill system, since in the small presses there is not enough weight of the ram to insure a high forward speed.

Instead of the 5-way main control valve 10 in the system, as shown in Fig. 1, a 4-way valve and a 3-way valve could be used, as shown in the modified control system illustrated in Fig. 5. The 4-way valve 70 can be operated in any suitable manner, for example, by means of the pilot valve 20 and its electrical operating mechanism, as shown in Fig. 1. The 4-way valve is used to connect the main press cylinder 4 and also the pull back cylinder 5 alternately to fluid supply and exhaust, and the 3-way valve 71 is used to connect the pull back cylinder either to the main press cylinder or to exhaust through the 4-way valve.

With the exception of the 4-way and 3-way valves 70 and 71 arranged and connected as now to be explained, the system may be the same as illustrated in Fig. 1 and the parts thereof corresponding with those shown in Fig. 1 are designated by the same reference characters.

The main valve 70 may be an ordinary 4-way valve with a piston element moved in opposite directions in the valve cylinder by admitting pressure fluid from the supply pipe 9, as under control of the pilot valve 20 through pipe 24 or pipe 25 to the pilot cylinder cavities 26 or 27 in the valve casing above or below element 72. The pilot valve 20 may be operated to start the press by pushing the starting push button 40 to energize the solenoid 37, and the pilot valve may be returned to its normal or open press position under control of the reversing switch 43 operated by the pressure-actuated device 61, as explained in connection with Fig. 1. The main valve 70 applies pressure either from supply pipe 9 through pipe 12 to the main cylinder 4 or from supply pipe 9 through pipe 13 to the pull back cylinder 5. However, the 3-way valve 71 is interposed in the line 13 between main valve and the pull back cylinder. The movable piston or element 73 of 3-way valve 71, which is preferably operated by a pilot piston 74 of larger area than element 73 and having a stem engaging element 73, is normally held down as shown, by a spring 75 which may be arranged in the cylinder above the pilot piston 74. In this position, valve 71 connects the pipe 13 to the pull back cylinder through a pipe 76 so that main valve 70 is connected to the pull back cylinder, as in the Fig. 1 arrangement, without functioning of the 3-way valve 71.

Beneath the element 73, the 3-way valve has a cylinder cavity 77 connected by a pipe 78 and the pipe 24 to the lower cylinder cavity 26 of main valve 70, and also to the pilot valve 20. When the pilot valve 20 is raised, as by operating the push button switch 40, pressure is applied through pipe 24 to cylinder cavity 26 of main valve 70 to shift the element 72 upwardly to apply pressure from supply pipe 9 through pipe 12 to main cylinder 4. At this same time, pressure is applied through pipe 78 to cylinder cavity 77 of 3-way valve 71, thereby lifting element 73 and connecting pipe 76 from the pull back cylinder, through a pipe 79, and the pipe 12 to the main cylinder. The pressure fluid can therefore bypass from pull back cylinder to the main cylinder and the press ram will be moved in its working stroke at its highest speed, as in the Fig. 1 embodiment.

When the press closes against the work, pressure will be built up in the main press cylinder 4 and line 12 and will operate through a pressure relief valve 80, corresponding with the relief valve 58 in Fig. 1, to apply pressure in the cylinder cavity 81 above pilot piston 74 of the 3-way valve. This moves the pilot piston 74 and shifts element 73 downwardly against the pressure in the cylinder cavity 77 below said element, since the pilot piston is of larger area than the element 73. The pull back cylinder 5 will then be connected through pipes 76 and 13 to the main 4-way valve 70 and through this and pipes 14a and 14 to the reservoir, and the pressure applied in the main press cylinder 4

will then cause the ram to continue its working stroke at low speed under full or maximum pressure, since the pull back cylinder is then open to exhaust.

During all parts of the cycle, except when the pilot valve 20 is operated to apply pressure in cylinder cavity 77 below element 73 of the 3-way valve, this element will remain down under the action of its spring 75, and when in this position, the pull back cylinder is connected through the pipes 76 and 13 to the main 4-way valve 70 and the valve 70 functions as a 4-way valve.

In this Fig. 5 modification, a ram actuated reversing valve 46, like the valve 46 in Fig. 1, and also a stop piston in the main valve 70 beneath element 72 are employed. This valve 46, in its normal, open press position shown, applies pressure from the pull back cylinder 5 through pipe 76, 3-way valve 71, pipe 13, a pipe 82, valve 46 and pipe 53 into the cylinder cavity 83 beneath the stop piston 84 in the main 4-way valve 70, in order to shift the element 72 of the 4-way valve to the neutral position shown when the press reaches the full, open position; or the ram actuated valve 46, when its movable element is lowered, by starting the press ram on its working stroke, will apply pressure from the main press cylinder 4 through pipes 12, 79, valve 46 and pipe 53 into cylinder cavity 83 of the 4-way valve beneath the stop piston 84, in order to prevent full reversal of the element 72 of the main 4-way valve at the end of the pressure stroke, until the pressure in the main press cylinder 4 has dropped appreciably. This prevents reversal of the press ram until pressure in the main cylinder is lowered and avoids shock to the system, as explained in connection with the Fig. 1 embodiment. Except as explained, the Fig. 5 embodiment is arranged and operates like the Fig. 1 embodiment.

In the foregoing description, reference has been made to vertical movements for various parts, but this has been done for convenience of reference and to indicate directions of movement, but it will be understood that the parts will perform these relative functions just the same whether arranged in the position shown or disposed in horizontal or other positions, and such positions or movements as are described as either horizontal or vertical, are to be understood as not limiting details of the invention.

In the metal drawing press disclosed in Fig. 6, the ram 90 is stationary and fastened in the head 91 of the press frame and works in a cylinder cavity 92 in a moving platen 93. The ram has a piston head 94 furnished, as usual, with piston rings, and the portion of the cylinder cavity above the piston head forms the pull back cylinder 95.

Two passages 96 and 97 extend longitudinally through the ram 90 from its outer end portion for connection with the pipe lines for the supply and discharge of operating liquid to and from the cylinders without the necessity for using flexible hose or connections. The passage 96 passes through the piston head and communicates with the main cylinder cavity 92 and the other passage 97 communicates with the pull back cylinder 95 above the piston head.

When the liquid is admitted into the passage 96, the platen 93 will be moved towards the work and when the liquid is admitted to the other passage 97, the platen will be retracted. For larger presses with larger rams, the standard press construction, in which the cylinder is formed in the stationary head casting and the ram moves with the platen, could be used.

Operating or control means as disclosed either in Fig. 1 or Fig. 5 can be employed for operating the press, the pipe lines 12 and 13 of the operating system being connected respectively by the ram passages 96 and 97 to the main and pull back cylinders; and it being understood that the lines 12 and 13 are associated and connected in the control system like the correspondingly numbered lines 12 and 13 of either Fig. 1 or Fig. 5, so that the operation of the press can be controlled in the same manner described in connection with Fig. 1 or Fig. 5.

The platen 93 has an extension 98 which may be part of the platen casting, and to which is fastened a draw punch 99. Suitably mounted on the press bed 100 is a draw die 101, and the metal blank 102 to be drawn is placed on the draw die, as usual. A cavity 103 is shown in the press bed for mounting the kickout cylinder and piston, not shown.

104 represents a blank holder platen to the under side of which is fastened a blank clamping ring 105. Two or more rams or pistons 106, secured to the blank holder platen 104, are arranged to reciprocate in cylinders 107 machined in or fixed to move with the main platen 93.

Hydraulic connections to each cylinder 107 are made through a relief valve. As shown, the upper end of each cylinder communicates with a pipe 108 provided with a pressure opened relief valve 109 of ordinary construction, for permitting discharge of the operating liquid at a predetermined pressure from the cylinder. The relief valve may be closed by the usual spring, the pressure of which may be regulated by an adjustable screw 110. The valve prevents flow of liquid into the cylinder 107 but allows discharge of the liquid therefrom, as indicated by the arrow, when the pressure in the cylinder becomes sufficient to open the relief valve. The two cylinders could be connected by branches with a pipe equipped with a single relief valve 109, but preferably, as shown, each cylinder has its separate pipe 108 and valve 109. Preferably, though not necessarily, the pipes 108 connect with the pull back cylinder 95, which is connected in the control mechanism as explained in connection with Figs. 1 and 5, thus enabling the discharge of liquid from the pull back cylinder and the cylinders 107. Also associated in parallel with each relief valve 109 is a check valve 111 which opens to allow free flow of liquid into the cylinder 107, but is closed by the liquid pressure to prevent discharge from the cylinder. For the sake of making the construction clearer, this check valve is shown in a separate pipe leading from each cylinder 107 to the pull back cylinder, but if desired, the check valve could be associated with the relief valve in a single casing or unit in the pipe 108.

It will be noted that the combined relief and check valves 109, 111 are so constructed that free flow of the liquid into the cylinders 107 is permitted, but the fluid can only discharge from these cylinders through the relief valves under the pressure necessary to open these valves.

The blank holder platen 104 and main platen are connected so as to permit relative movement between them, as by two or more rods 112 slidably mounted in holes in the platens and equipped with nuts arranged to engage portions of the platens so as to allow the platen 104 to

approach the main platen but limiting its movement away therefrom.

In the operation of such a press, the blank 102 is placed on the die 101 and the press started in operation. Both the platens 93 and 104 will move together toward the die, and even though the holder platen 104 should stick, it will be forced ahead because the fluid in the cylinders 107 cannot escape except at a predetermined pressure through the relief valve 109. When the clamping ring contacts with the blank, the holder platen will stop, but the main platen 93 with the draw punch will continue its travel under the pressure of the liquid supplied to the main cylinder 92. As soon as there is any relative motion between the platens 93 and 104, the fluid must be forced from cylinders 107 through the relief valve or valves 109, and pressure is therefore developed in these cylinders on the rams 106. Continued motion of the main ram causes displacement of the fluid from cylinders 107 and continued application of pressure through the rams 106 and platen 104 on the blank to prevent it from wrinkling.

If the piece to be drawn is of irregular shape, it may be desirable to hold decidedly different clamping pressures on different portions of the blank, and this is possible in the described construction, since the separate relief valves 109 can be independently adjusted to give the different pressures desired on the different portions of the blank.

Since during the drawing movement of the main platen, the main control valve (10 in Fig. 1) connects the pull back cylinder 95 to the reservoir for discharge of the liquid from said cylinder, and the cylinders 107 are connected to the pull back cylinder, the liquid is also discharged from cylinders 107 through the main valve 10. Thus, while for convenience and simplicity of construction, the relief valves 109 are piped to the pull back cylinder, manifestly, they could be otherwise suitably connected for delivery and discharge of the liquid to and from the cylinders 107 under the control of the main valve.

When a predetermined pressure has been built up in the main ram cylinder 92, or when the draw platen reaches a predetermined position, the main valve 10 is reversed to return the main platen to open position in the manner explained in describing the Fig. 1 control system. The liquid is then discharged through the ram passage 96 and is supplied to the pull back cylinder through the ram passage 97, and the fluid will also be delivered through check valves 111 into the operating cylinders 107 for the blank holder platen. This will hold the blank holder platen 104 and maintain pressure on the blank during the return movement of the main platen, until the blank holder platen is picked up and returned with the main platen by the rods 112. Thus, the blank is stripped from the draw punch by the blank holder platen during the initial return movement of the punch.

The main control valve 10 can be operated to retract the ram, as above described in connection with Fig. 1, through the medium of a reversing valve actuated by an arm or part 114 connected to or moving with the main platen 93. It should be manifest that the metal drawing press described can also be operated by the modified control means illustrated in Fig. 5.

Obviously, the connections from the relief valves 109 to the pull back cylinder can be easily effected in a reversal of the described press construction, in which the main cylinder 92 is stationarily mounted in the head of the press and the ram moves and carries or operates the main platen 93. In such reversed construction, the relief and check valves 109, 111 could be piped to a passage extending longitudinally through the main ram and communicating with the pull back cylinder at a point just below the piston head of the ram, like the passage 97 in Fig. 6, in which the ram is stationary.

Presses of this type may be employed for the operation of the ram of an injection molding press. The injecting ram is operated by fluid pressure first at a relatively rapid rate of movement and low pressure, and then later in the same stroke at a relatively low rate of movement and high molding pressure sufficient to set the molding material in the mold, and this change in rate of movement and pressure is obtained automatically in accordance with this invention at the desired point, as hereinbefore explained, which point is selected as that when the mold is approximately filled with the molding material at which time rapidity of movement is less important and the high pressure must be applied to set the molding material in the mold. Such a change is accomplished quickly and automatically by the press and control system therefor which has been hereinbefore explained and illustrated.

It will be understood that various changes in the details which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention, as expressed in the appended claims.

I claim as my invention:

1. The combination with a hydraulic press comprising a main cylinder, a pull back cylinder, and a ram element operated in opposite directions by liquid pressures in said cylinders, of a valve and connections to supply liquid under pressure to each cylinder and release liquid from the other cylinder alternately, said valve having a movable element, a pilot member actuated responsive to pressure in the main cylinder for moving said valve element to apply increased pressure in the main cylinder after an initial movement of the ram element in one direction, and a supplemental pilot member actuated responsive to pressure in the main cylinder for preventing movement of said valve element to the position to deliver liquid to the pull back cylinder for returning the ram element until after the pressure in the main cylinder is relieved.

2. The combination with a hydraulic press comprising a main cylinder, a pull back cylinder, and a ram element operated in opposite directions by liquid pressures in said cylinders, of a valve and connections to supply liquid under pressure to each cylinder and release liquid from the other cylinder alternately and for supplementing the supply of liquid to the main cylinder by liquid by-passed from the pull back cylinder to cause an initial rapid movement in one direction of the ram element, said valve having a movable element, a pilot member actuated responsive to pressure in the main cylinder for moving said valve element to apply increased pressure in the main cylinder after an initial movement of the ram element in one direction, and a supplemental pilot member actuated responsive to pressure in the main cylinder for preventing movement of said valve element to the position to deliver liquid to the pull back cylinder for returning the

ram element until after the pressure in the main cylinder is relieved.

3. The combination with a hydraulic press comprising a main cylinder, a pull back cylinder, and a ram element operated by liquid pressures in said cylinders, of a valve and connections for supplying operating liquid under pressure to each cylinder and releasing fluid from the other cylinder alternately for moving said ram element in opposite directions, liquid pressure actuated means for operating said valve to supply pressure liquid to the main cylinder and by-pass liquid from the pull back cylinder to the main cylinder to produce movement of the ram element in one direction, means operating said valve responsive to pressure in the main cylinder to shut off the by-passed liquid and release liquid from the pull back cylinder after an initial movement of the ram element in said one direction, means for operating said valve to supply liquid to the pull back cylinder and release liquid from the main cylinder for returning said ram element, and means acting responsive to pressure in the main cylinder for preventing operation of the valve to deliver liquid to the pull back cylinder until after a predetermined reduction of pressure in the main cylinder.

4. The combination with a hydraulic press comprising a main cylinder, a pull back cylinder, and a ram element operated in opposite directions by liquid pressures in said cylinders, of a valve and connections for supplying operating liquid under pressure to each cylinder and releasing liquid from the other cylinder alternately, by-pass connections from the pull back cylinder to the main cylinder, said valve comprising a valve element movable in opposite directions in a casing by pressure liquid delivered to the casing at opposite ends of said valve element, a pilot piston of larger area than said valve element and acting responsive to pressure in the main cylinder for shifting said valve element in one direction to shut off said by-pass connections and deliver pressure liquid to the main cylinder and release the liquid from the pull back cylinder, and an auxiliary pilot piston of larger area than said valve element and operating responsive to pressure in the pull back cylinder and main cylinder for preventing the movement of said valve element to deliver liquid to the pull back cylinder until after a predetermined reduction of pressure in said main cylinder.

5. The combination with a hydraulic press having a main cylinder, a pull back cylinder and a ram operated in opposite directions by fluid pressure in said cylinders, of a source of fluid under pressure, a valve having a chamber with ports arranged in succession along a wall thereof and into an intermediate one of which said source delivers fluid as an inlet port and a valve element in and movable along said chamber, said valve element having spaced lands passing said ports to open and close them as said valve element moves in said chamber and occupies four operative positions, one of said ports at one side of said one intermediate port opening into the chamber on opposite sides of a land of said valve element then in front of it, means connecting that port to said main cylinder, means connecting another of said ports at the other side of said one intermediate port to the pull back cylinder, said valve element having a second land closing said another port when the first land is in front of said one port connected to the main cylinder, with said inlet port between said lands that are at the same time in front of said ports connected to said cylinders, means connecting to exhaust those ports further from said inlet port than the ports connected to said cylinders, means connected to the ends of said chamber beyond said lands for shifting said valve element by fluid pressure selectively into two end positions, and pressure responsive pistons in the ends of said chamber for limiting movement of said element to two intermediate positions, one of which intermediate positions is an inactive position in which a land closes said port connected to said pull back cylinder, and a land is in front of said port connected to said main cylinder, whereby fluid from said source circulates through said main cylinder port to exhaust, and said main cylinder is connected to exhaust, another of which positions is an extreme end position and a preliminary advancing position in which said lands connect said source to both of said cylinders and cut off both of those cylinders from exhaust, to cause a rapid advance of said ram element, another of which positions is the other intermediate position and a secondary advance position in which said lands connect said pull back cylinder to exhaust and keep said main cylinder connected to said source and cut off from exhaust, another of which positions is the other extreme position and a reverse position in which said lands connect said main cylinder to exhaust, disconnect it from said source and also connect said pull back cylinder to said source and disconnect it from exhaust.

6. An improved system for controlling a hydraulic motor of the type comprising an advancing cylinder, a returning cylinder, a motor member operated in opposite directions by fluid pressures in said cylinders, a continuously running pump for supplying actuating fluid, a reservoir, a main valve for controlling the delivery of fluid to said cylinders and having a casing with a chamber therein, a valve element mounted in said casing for back and forth movement therein through four positions, and having at least four lands spaced apart thereon, said chamber having a plurality of intermediate and end ports spaced apart in the direction of movement of said element, said chamber terminating at each end in an enlarged compartment, a separate piston in each of said compartments and limiting movement of said element, but operable to push, to a limited extent, said element when fluid under pressure is admitted to the outer ends of said compartments, one intermediate port being connected to the advancing cylinder, another intermediate port being connected to the returning cylinder, still another intermediate port between said other intermediate ports being connected to said pump, the other intermediate ports disposed endwise of the chamber, beyond said first-mentioned intermediate ports being connected to said reservoir, means selectively operable for delivering fluid under pressure to said end ports alternately, means for connecting one end compartment at the rear of the piston in that compartment to said pump, a pressure relief valve in said last connecting means and opening under selected pressure to pass fluid to that compartment, a conduit leading from the other end compartment from behind the piston in that compartment to both of said cylinders, an auxiliary valve in said conduit for selectively and alternately connecting said conduit from said end compartment to said cylinders, a bleeder port connected to said last connecting means at a point between the pressure relief valve and that end compartment

to which it leads, said lands and ports being of such relative sizes and so arranged that when said valve element is held in neutral, intermediate position by pressure from said conduit to its connected end compartment at one end of said chamber and pressure in said chamber at the opposite end thereof, fluid from said pump will be delivered to said advancing cylinder and also to reservoir, and escape of fluid from said returning cylinder through said main valve is prevented, that when said valve element is held at one end of said chamber nearest the compartment having the bleeder connection, by fluid pressure in said chamber at the opposite end thereof, said main valve will connect said pump to both cylinders, both cylinders together through said chamber, and close the intermediate ports leading to said reservoir, that when said valve element is moved into an intermediate position from the last-mentioned position by pressure added to said compartment to which said pressure relief valve is connected, with continued pressure to the other end of said chamber, said main valve will connect said pump to said advancing cylinder and connect said returning cylinder to said reservoir, that when said valve element is held in its other end position by pressure in that end of said chamber nearest said compartment having the bleeder connection, said main valve will connect said returning cylinder to said pump and said advancing cylinder to said reservoir.

7. A system substantially as set forth in claim 6 and means responsive to the pressure of fluid delivered by said pump for causing an operation of said selectively operable means that causes delivery of fluid under pressure to said end ports alternately and a reversal in such delivery automatically when the pressure delivered by the pump exceeds a predetermined pressure.

8. A system substantially as set forth in claim 6 in which said means selectively operable for delivering fluid under pressure to said end ports alternately, includes a control valve, the operation of which causes such alternate delivery, means yieldingly urging said control valve into one position, means for operating said control valve against said urging means into another position and releasably holding it in said another position, and means responsive to the pressure of fluid delivered by said pump for causing a release of said control valve when the pressure of fluid delivered by the pump exceeds a predetermined pressure.

9. A system substantially as set forth in claim 6 in which said means selectively operable for delivering fluid under pressure to said end ports alternately, includes a control valve, the operation of which causes such alternate delivery, means yieldingly urging said control valve into one position, means for operating said control valve against said urging means into another position and releasably holding it in said another position, and means responsive to the pressure of fluid delivered by said pump for causing a release of said control valve when the pressure of fluid delivered by the pump exceeds a predetermined pressure, said last-named pressure responsive means including a pressure responsive switch and a pressure relief valve through which fluid passes from said pump to operate said switch only after the pressure of fluid delivered by the pump exceeds a predetermined pressure, and a bleeder connection from said pressure responsive switch to said reservoir.

10. A system substantially as set forth in claim 6, and means operable by said motor member for operating said auxiliary valve in a manner to connect said conduit to said returning cylinder whenever said motor member reaches a selected position in its return movement, and means for yieldingly urging said auxiliary valve in a direction to connect said conduit to said advancing cylinder automatically when said auxiliary valve is released by said motor member.

11. An improved valve for controlling the activity of a hydraulic motor which comprises a valve casing having an elongated chamber therein terminating at each end in an enlarged compartment, a piston in each of said compartments, a valve element in said chamber operable endwise therein and having a length less than the distance between said pistons when said pistons are at their limits of movement toward one another, so as to be movable between two operative positions as limited by said pistons at their said limits, said valve element having at least four lands thereon spaced apart in a direction lengthwise of the chamber, said chamber between said compartments having at least seven ports opening therefrom and spaced apart in a direction endwise of said chamber, with said lands operable upon endwise movement of said valve element to connect selected ones of said ports in different combinations, one of said ports being adjacent each end of said chamber but in the zone between said compartments, and a conduit opening outwardly from the outward end of each compartment, one of the ports intermediate the length of said chamber opening into the chamber on opposite sides of the adjacent land when said element is in one of said two operative positions, one of the next adjacent ports opening into said chamber on opposite sides of the adjacent land, which is next to said other adjacent land, when said valve element is moved endwise beyond the other of said operative positions, one of said intermediate ports being closed by one of said adjacent lands when said element is in said one of said two operative positions, but connected to said next adjacent port when said element moves from said one operative position in a direction against the adjacent limiting piston.

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