

April 4, 1944.

R. E. DAVIS

2,345,919

HYDRAULIC DRIVE

Filed March 4, 1940

Fig. 1.

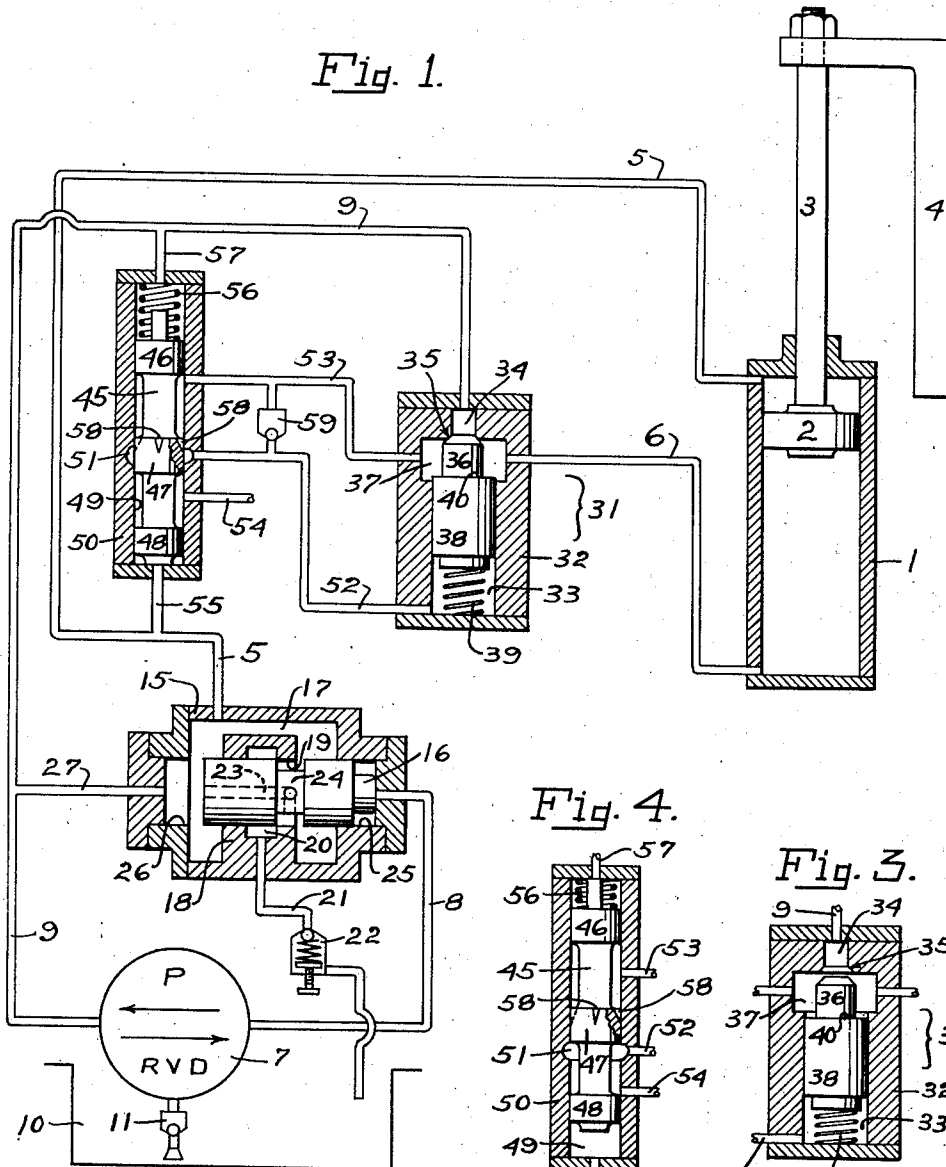


Fig. 4.

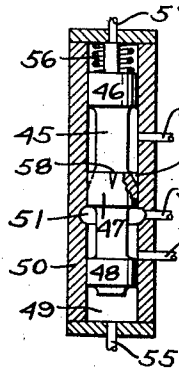


Fig. 3.

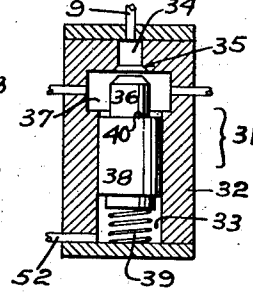
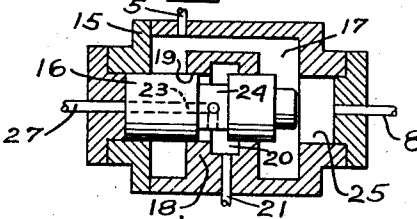


Fig. 2.



INVENTOR.
RICHARD E. DAVIS
BY *Wesley Merrill*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,345,919

HYDRAULIC DRIVE

Richard E. Davis, Wauwatosa, Wis., assignor to
The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application March 4, 1940, Serial No. 322,099

12 Claims. (Cl. 60—52)

This invention relates to hydraulic drives of the type employed for operating a machine having an element which is to be operated in opposite directions by the motor of the drive and which is constantly urged in one direction by an independent force, such as the platen of a vertical press or the tool slide of a vertical broaching machine each of which is constantly urged downward by gravity.

A drive employed for this purpose ordinarily includes a resistance valve which resists the discharge of liquid from the motor during movement of the element in the direction in which it is urged by the independent force, and the resistance valve is so adjusted or proportioned that the pressure required to open it is higher than the pressure created in the motor by the element being urged in that direction by the independent force, thereby enabling the motor to hold the element stationary when the machine is idle.

However, when the motor is operating the element in that direction to perform useful work, the energy expended in forcing the motor discharge liquid through the resistance valve not only causes the liquid to become heated but also reduces the force available for performing useful work.

If the machine is operated continuously or if the cycles of operation of the machine follow each other at closely spaced intervals, heat will be generated much faster than it can be dissipated and the temperature of the liquid will rise until the liquid becomes so hot that the pump could not function properly and would probably be damaged if operated at such a temperature.

The present invention has as an object to provide such a machine with a hydraulic drive having means which will hold the platen, slide or other element of the machine stationary when the machine is idle but which will not materially reduce the force available for performing useful work or cause the liquid to become overheated.

Other objects and advantages will appear from the following description of an embodiment of the invention shown schematically in the accompanying drawing in which the views are as follows:

Fig. 1 is a circuit diagram of a hydraulic drive in which the invention is embodied.

Figs. 2, 3 and 4 are views showing the valves in positions other than those shown in Fig. 1.

For the purpose of illustration, the drive has been shown provided with a reciprocating hy-

draulic motor consisting of a stationary vertical cylinder 1 and a piston 2 which is fitted in cylinder 1 and connected by a rod 3 to a carriage or slide 4 which may be the tool slide of a vertical broaching machine.

Motor 1—2 is adapted to be energized by liquid supplied to the upper and lower ends of cylinder 1 through two channels 5 and 6 respectively. The liquid may be supplied from a unidirectional pump to opposite ends of cylinder 1 alternately through an ordinary reversing valve but, since the displacement of the pump must be varied in order to vary the speed at which slide 4 moves the tools carried thereby across the work, a reversible pump is ordinarily employed as a reversing valve would only add to the cost of the machine.

As shown, motor 1—2 is energized by liquid supplied by a reversible pump 7 which delivers liquid into one or the other of two channels 8 and 9 to cause the motor to operate in one direction or the other and which draws its supply of liquid from a reservoir 10 through a check valve 11 during movement of piston 2 in one direction and is supplied with liquid from cylinder 1 during movement of piston 2 in the opposite direction as will presently be explained.

Since the volume of liquid discharged from cylinder 1 will vary from the volume delivered thereto by an amount equal to the displacement of piston rod 3, and since it is desirable to move slide 4 upward at a speed considerably higher than the speed at which it is moved downward, the drive has been shown as being provided with a differential valve consisting primarily of a valve casing 15 and a valve member 16 arranged therein.

Valve casing 15 encloses a chamber 17 with which channel 5 communicates through a side wall thereof. Chamber 17 contains a boss 18 which is ordinarily formed integral with another side wall of casing 15 and has formed therein a bore 19 in which valve member 16 is slidably fitted. Boss 18 has an annular groove 20 formed therein around bore 19 and connected by channel 21 to a relief valve 22 which discharges into reservoir 10, and valve member 16 has a duct 23 extending inward from one end thereof and then radially outward into communication with an annular groove 24 which is formed in valve member 16 intermediate the ends thereof and adapted to register with groove 20 in boss 18.

Bore 19 is arranged in axial alignment with two bores 25 and 26 which are arranged in the opposite ends of casing 15 and have the same

diameter as bore 19 so that valve member 16 may be fitted in bore 19 and either of bores 25 and 26 simultaneously. Bore 25 has channel 8 connected thereto and bore 26 is connected by a channel 27 to channel 8 intermediate the ends thereof so that, when valve member 16 is in the position shown in Fig. 1, channel 5 communicates through chamber 17 and channel 27 with channel 8 and communication between channels 5 and 8 is blocked and, when valve member 16 is in the position shown in Fig. 2, channel 5 is connected to channel 8 through chamber 17 and channel 9 is connected through channel 27, duct 23, grooves 24 and 29 and channel 21 to relief valve 22.

The weight of slide 4 and associated parts tends to move piston 2 downward and cause it to eject liquid from the lower end of cylinder 1 so that, if channel 6 were connected directly to channel 9, the pressure created in the lower part of cylinder 1 due to the weight supported by piston 2 would cause liquid to leak through the pump and thereby permit piston 2 and slide 4 to move downward slowly when the machine was idle, it being understood that a small amount of internal leakage is an inherent characteristic of all pumps.

If when the machine is idle downward movement of slide 4 were prevented by connecting a free return resistance valve between the lower end of cylinder 1 and the intake of pump 7 according to the usual practice, the entire volume of liquid expelled from the lower part of cylinder 1 would have to be forced through the resistance valve which would cause a waste of power and a large amount of heat to be generated in the liquid.

In order to overcome the above objectionable features, a hydraulically operated resistance valve 31 is connected between channels 6 and 9 to prevent downward movement of piston 2 when the machine is idle and to permit substantially free flow of liquid when the machine is in operation.

Resistance valve 31 has been shown as including a valve casing 32 having an axial bore 33 formed therein and communicating at its upper end with an axial port 34 having an annular valve seat 35 formed around the inner end thereof. Valve seat 35 normally has a valve member 36 in engagement therewith to control communication between port 34 and an annular port 37 which is formed in the wall of the bore 33 at the upper end thereof. Ports 34 and 37 have channels 8 and 9 connected thereto, respectively, so that valve member 36 controls communication between channels 8 and 9.

Valve member 36 is connected to or formed integral with a plunger 38 which is fitted in bore 33 and urged upward by a light spring 39 so that valve member 36 is normally held in contact with valve seat 35 to block communication between channels 8 and 9. Valve member 36 is smaller in diameter than plunger 38 to provide therebetween a shoulder 40 upon which liquid may act to move plunger 38 downward and thereby move valve member 36 away from valve seat 35 to open communication between channels 8 and 9.

The area of shoulder 40 and the tension of spring 39 are so proportioned that a very low pressure, for instance 25# per square inch, will exert sufficient force upon shoulder 40 to move plunger 38 downward and thereby move valve member 36 out of contact with valve seat 35.

Since when the machine is idle piston 2 will be urged downward by the weight of slide 4 and associated parts and since resistance valve 31 prevents piston 2 from ejecting liquid from the lower end of cylinder 1, pressure will be created in the lower part of cylinder 1 and this pressure will act upon shoulder 40 and tend to move plunger 38 and valve member 36 downward to open resistance valve 31.

However, the same pressure is applied to the lower end of plunger 38 and, since the effective pressure area on the lower end of plunger 38 is greater than the effective pressure area at the upper end thereof due to the area of valve member 36 which is open to port 34, the upward force exerted by the liquid exceeds the downward force exerted thereby so that valve member 36 is firmly held in contact with valve seat 35 when the machine is idle.

The application of pressure to the lower end of plunger 38 is under the control of a pilot valve 45 having three spaced apart heads or pistons 46, 47 and 48 formed thereon and closely fitted in the bore 49 of a valve casing 50. Piston 47 controls an annular groove or port 51 which is formed in the wall of bore 49 and connected by a channel 52 to the lower end of bore 33 in valve casing 32. That part of bore 49 between pistons 46 and 47 is open at all times to the lower end of cylinder 1 as by being connected by a channel 53 to port 37 in valve casing 32, and that part of bore 49 between pistons 47 and 48 is connected to a drain channel 54.

The lower end of bore 49 is connected by a channel 55 to channel 5 so that, when pump 7 is adjusted to deliver liquid to the upper end of cylinder 1 to move piston 2 downward, liquid will enter the lower end of bore 49 and move valve 45 upward to the position shown in Fig. 4. Valve 45 is urged downward by a spring 56 arranged in the upper end of bore 49 but, in order that a light spring may be employed and to assure that valve 45 will be positively moved downward at the proper point in a cycle of operation, the upper end of bore 49 is ordinarily connected to channel 9 by a channel 57 so that, when pump 7 is adjusted to deliver liquid to the lower end of cylinder 1 to move piston 2 upward, liquid will enter the upper end of bore 49 and move valve 45 downward to the position shown in Fig. 1.

When pilot valve 45 is in the position shown in Fig. 1, piston 47 overlaps port 51 and communication between port 51 and channel 52 is provided by a plurality of small tapered grooves 58 which are formed in piston 47 to throttle the flow of liquid to the lower end of bore 33 and thereby prevent plunger 38 from advancing valve member 36 into contact with valve seat 35 with such force that damage might result. In order that resistance valve 31 may be quickly opened, a check valve 59 is connected between channels 52 and 53 to permit liquid to escape freely from channel 52 into channel 53 but to prevent the flow of liquid in the opposite direction except through the grooves 58.

Operation

When the several parts are in the positions shown in Fig. 1 and pump 7 is idle or at zero stroke, the weight of slide 4 and associated parts will tend to move piston 2 downward and cause it to eject liquid from the lower part of cylinder 1 but spring 39 will hold valve member 36 against valve seat 35 and prevent the escape of liquid so

that the force exerted by piston 2 will create pressure in the lower part of cylinder 1.

This pressure will extend through channel 6 to port 37 in valve casing 32 and tend to move plunger 38 downward by acting upon shoulder 40 but it cannot do so for the reason that the same pressure will extend from port 37 through channel 53, bore 49 in valve casing 50, grooves 58 in piston 47, port 51 and channel 52 to the lower end of bore 33 in valve casing 32 and act upon the lower end of plunger 38 so that valve member 36 is held firmly in contact with valve seat 35, thereby positively preventing piston 2 and slide 4 from descending when the machine is idle.

To start the machine on a working stroke, pump 7 is adjusted to cause it to deliver liquid into channel 8. The liquid will shift differential valve member 16 to the position shown in Fig. 2 and then flow through chamber 17 and channel 5 to the upper end of cylinder 1 but the liquid in the lower part of cylinder 1 initially prevents piston 2 from moving downward and thereby causes pump pressure to rise.

Liquid will then flow from channel 5 through channel 55 to the lower end of bore 49 in pilot valve casing 50 and move pilot valve 45 upward to the position shown in Fig. 4, pilot valve 45 expelling liquid from the upper end of bore 49 through channel 57 into channel 9 which is connected to the intake side of pump 7.

Raising pilot valve 45 connects port 51 to drain channel 54 so that the pressure in the lower end of bore 33 is destroyed. The pressure acting upon shoulder 40 will then move plunger 38 and valve member 36 downward and plunger 38 will expel liquid from the lower part of bore 33 through channel 52 and bore 49 into drain channel 54. Downward movement of valve member 36 opens communication between channels 6 and 9 so that piston 2 may expel liquid from the lower end of cylinder 1.

The liquid discharged by pump 7 will then flow through channel 8, chamber 17 in differential valve casing 18 and channel 5 to the upper end of cylinder 1 and move piston 2 downward on a working stroke, and piston 2 will expel liquid from the lower part of cylinder 1 through channel 6 and resistance valve 31 into channel 9.

Since the volume of liquid discharged from cylinder 1 is greater than the volume of liquid supplied to cylinder 1 by pump 7, a part of the discharge liquid will flow through channel 9 to the intake of pump 7 and the remainder will flow from channel 9 through channel 27, duct 23, grooves 24 and 20, channel 21 and relief valve 22 into reservoir 10. Relief valve 22 will resist the discharge of liquid therethrough and thereby cause pressure to be created in channel 9 so that pump 7 is supercharged at a pressure equal to the pressure required to open relief valve 22.

The pressure required to open relief valve 22 is ordinarily substantially higher than the pressure required to compress spring 39 so that the force exerted by the liquid on shoulder 40 and valve member 36 will move valve member 36 far enough from valve seat 35 to provide free flow of liquid from channel 6 into channel 9. Consequently, the resistance to the discharge of liquid from the lower end of cylinder 1 is provided solely by relief valve 22 which is adjusted to provide in cylinder 1 a back pressure of the magnitude ordinarily employed for this purpose, for example, 300# per square inch.

While the pressure in the upper end of cylinder 1

der 1 must exceed the pressure required to perform useful work by an amount equal to the back pressure, pump 7 need create only the pressure required to perform the useful work for the reason that it is supercharged by the back pressure.

For example, if a pressure of 1000# should be required to perform the useful work and the back pressure should be 300#, a pressure of 1300# would be required in the upper end of cylinder 1 to move piston 2 on a working stroke but, since pump 7 is supercharged by the back pressure, it would only have to raise the pressure from 300# to 1300# or a difference of 1000# and, since the volume of liquid exhausted through relief valve 22 is relatively small for the reason that the ratio of the area of cylinder 1 to the area of piston rod 3 is ordinarily five or six to one, the power loss at relief valve 22 is relatively small and the amount of heat created in the liquid is so small that it is readily dissipated.

If piston 2 had connected thereto a second rod which had the same diameter as rod 3 and extended through the lower end of cylinder 1 or if the invention were applied to a downward acting hydraulic press in which the ram or piston rod extended through the lower end of the cylinder, differential valve 15-16 and relief valve 22 would be omitted in which case the apparatus would function in the above described manner to positively hold the piston stationary when the machine was idle but would cause no power loss whatever during a working stroke of the piston.

After piston 2 has completed its working stroke, pump 7 is adjusted to deliver liquid into channel 9, thereby causing pressure to be created therein and the pressure in channels 5 and 6 to drop substantially to zero so that differential valve member 16 is moved to the position shown in Fig. 1 by pressure extending from channel 9 through channel 27, and pilot valve 45 is moved downward to the position shown in Fig. 1 by spring 56 or by pressure extending from channel 9 through channel 57 to the upper end of bore 49.

The liquid delivered by pump 7 into channel 9 will move resistance valve member 36 downward and then flow through ports 34 and 37 and channel 6 to the lower end of cylinder 1, downward movement of valve member 36 being resisted only by spring 39 for the reason that plunger 38 can expel liquid from the lower part of bore 33 through channel 52, check valve 59 and channel 53 into port 37.

The liquid delivered by pump 7 to the lower end of cylinder 1 will move piston 2 upward and cause it to expel liquid from the upper end of cylinder 1 through channel 5, chamber 17 in differential valve casing 15 and channel 27 into channel 9 where it augments the volume of liquid discharged by pump 7 which at this time draws its supply of liquid through check valve 11 from its reservoir 10. Pump 7 thus need only to supply a volume of liquid equal to the displacement of piston rod 3 so that piston 2 is moved upward at high speed.

When piston 2 reaches its upper limit, pump 7 is stopped or the displacement thereof is reduced to zero, piston 2 will come to rest, spring 39 will move valve member 36 into contact with valve seat 35, and the pressure in the lower end of cylinder 1 will extend through the previously described channels to the lower end of bore 33 and cause plunger 38 to hold valve member 36 firmly against seat 35 to thereby prevent piston 2 from descending as previously explained.

The invention herein set forth is susceptible

of various modifications and adaptations without departing from the scope thereof as hereafter claimed.

The invention is hereby claimed as follows:

1. In a machine having an element constantly urged in one direction, the combination of a hydraulic motor connected to said element and having a first port and a second port interchangeable for the admission and discharge of liquid to and from said motor, said element exerting upon said motor a force tending to operate it in one direction and cause it to discharge liquid through said second port, a pump connected to both of said ports, means for directing liquid from said pump to said ports selectively to cause said motor to move said element in opposite directions selectively, a valve for preventing the discharge of liquid through said second port and thereby causing the force exerted by said element to create pressure in said motor, a piston operable by the pressure created by said element for holding said valve closed to prevent said motor from discharging liquid through said second port and thereby enabling said motor to hold said element stationary when said pump is ineffective to energize said motor, and means operable in response to said pump delivering liquid to said first port for exhausting the pressure from said piston.

2. In a machine having an element constantly urged in one direction, the combination of a hydraulic motor connected to said element and having a first port and a second port interchangeable for the admission and discharge of liquid to and from said motor, said element exerting upon said motor a force tending to operate it in one direction and cause it to discharge liquid through said second port, a pump connected to both of said ports, means for directing liquid from said pump to said ports selectively to cause said motor to move said element in opposite directions selectively, a low pressure resistance valve connected to said second port to resist the discharge of liquid therefrom and thereby cause the force exerted by said element to create pressure at said second port, a servo-motor for applying to said valve a closing force proportional to said pressure to hold said valve closed and thereby enable said motor to hold said element stationary when said pump is ineffective to energize said motor, and means responsive to said pump delivering liquid to said first port for rendering said servo-motor ineffective to hold said valve closed.

3. In a machine having an element constantly urged in one direction, the combination of a hydraulic motor connected to said element and having a first port and a second port interchangeable for the admission and discharge of liquid to and from said motor, said element exerting upon said motor a force tending to operate it in one direction and cause it to discharge liquid through said second port, a pump connected to both of said ports, means for directing liquid from said pump to said ports selectively to cause said motor to move said element in opposite directions selectively, a spring loaded low pressure resistance valve connected to said second port to resist the discharge of liquid therefrom and thereby cause the force exerted by said element to create pressure at said second port, means including a pilot valve for causing said pressure to apply sufficient additional loading to said resistance valve to positively hold it closed against said pressure and thereby enable said motor to hold said element

stationary when said liquid directing means is inoperative, and means responsive to said pump delivering liquid to said first port for shifting said pilot valve to remove said additional loading from said resistance valve.

4. In a machine having an element constantly urged in one direction, the combination of a hydraulic motor connected to said element and having a first port and a second port interchangeable for the admission and discharge of liquid to and from said motor, said element exerting upon said motor a force tending to operate it in one direction and cause it to discharge liquid through said second port, a pump connected to both of said ports, means for directing liquid from said pump to said ports selectively to cause said motor to move said element in opposite directions selectively, a valve casing having a bore and an annular valve seat communicating with said bore at one end thereof, a valve member arranged within said bore and fitted to said valve seat, a plunger fitted in said bore and having its adjacent end connected to said valve member, fluid channels connecting said valve seat and the part of said bore adjacent said valve seat in series between said pump and said second port, a light spring constantly urging said valve member against said seat to cause it to resist the discharge of liquid through said seat and thereby cause the force exerted by said element to create pressure at said second port, said valve member being smaller in diameter than said plunger to provide a shoulder therebetween so that said valve member is urged away from said seat by pressure created by said pump or by said element and acting upon said valve member or upon said shoulder, means including a valve for connecting the opposite end of said bore to said second port so that the opposite end of said plunger is subjected to the pressure created by said element and said plunger is caused to hold said valve member firmly against said seat to prevent liquid from being ejected through said second port and thereby enabling said motor to hold said element stationary when said liquid directing means is inoperative, said valve being adapted when shifted to connect said opposite bore end to drain to thereby prevent said plunger from urging said valve member against said seat, and means responsive to said pump delivering liquid to said first port for shifting said valve to thereby permit the liquid discharged by said pump to energize said motor.

5. In a machine having a vertically movable element, the combination of a vertical cylinder, a piston fitted in said cylinder and connected to said element, the weight of said element tending to move said piston downward and cause it to eject liquid from the lower end of said cylinder, a pump, means for directing liquid from said pump to opposite ends of said cylinder selectively to cause said piston to reciprocate said element, a valve for preventing said piston from ejecting liquid from the lower end of said cylinder and thereby causing the weight of said element to create pressure in the lower part of said cylinder, a piston operable by said pressure for holding said valve closed to prevent liquid from being ejected from the lower part of said cylinder and thereby enabling said piston to support said element in a stationary position when said liquid directing means is inoperative, and means operable in response to said pump deliv-

ering liquid to the upper end of said cylinder for exhausting the pressure from said piston.

6. In a machine having a vertically movable element, the combination of a vertical cylinder, a piston fitted in said cylinder and connected to said element, the weight of said element tending to move said piston downward and cause it to eject liquid from the lower end of said cylinder, a pump, means for directing liquid from said pump to opposite ends of said cylinder selectively to cause said piston to reciprocate said element, a low pressure resistance valve connected to the lower end of said cylinder to resist the discharge of liquid therefrom and thereby cause the weight of said element to create pressure in lower end of said cylinder, a servo-motor for applying to said valve a closing force proportional to said pressure to hold said valve closed and thereby enable said piston to support said element in a stationary position when said pump is inoperative, and means responsive to said pump delivering liquid to the upper end of said cylinder for rendering said servo-motor ineffective to hold said valve closed.

7. In a machine having a vertically movable element, the combination of a vertical cylinder, a piston fitted in said cylinder and connected to said element, the weight of said element tending to move said piston downward and cause it to eject liquid from the lower end of said cylinder, a pump, means for directing liquid from said pump to opposite ends of said cylinder selectively to cause said piston to reciprocate said element, a spring loaded low pressure resistance valve connected to the lower end of said cylinder to resist the discharge of liquid therefrom and thereby cause the weight of said element to create pressure in lower end of said cylinder, means including a pilot valve for causing said pressure to apply sufficient additional loading to said resistance valve to positively hold it closed against said pressure and thereby enable said piston to support said element in a stationary position when said liquid directing means is inoperative, and means responsive to said pump delivering liquid to the upper end of said cylinder for shifting said pilot valve to remove said additional loading from said resistance valve.

8. In a hydraulic circuit including a motor, a pump for supplying liquid to said motor to energize the same, fluid channels connecting said pump to said motor and forming therewith a hydraulic circuit having a first side and a second side, and means for reversing the flow in said circuit, the combination of a resistance valve connected into said first side of said circuit, a cylinder, a piston arranged in said cylinder for urging said valve to its closed position, means including a pilot valve for connecting said cylinder to said first side of said circuit to thereby subject said piston to the pressure therein and cause it to hold said resistance valve closed, and means responsive to an increase in the pressure in the second side of said circuit for shifting said pilot valve to exhaust the pressure from said piston.

9. In a machine having an element constantly urged in one direction, a hydraulic motor connected to said element to operate the same in opposite directions and having a first port and a second port, said element exerting upon said

motor a force tending to cause it to discharge liquid through said second port, a pump, fluid channels connecting said pump to said ports to form with said motor a hydraulic circuit, and means for reversing the flow in said circuit, the combination of a resistance valve connected between said second port and said pump to resist the discharge of liquid from said motor and thereby cause the force exerted by said element to create pressure at said second port, hydraulic means for holding said valve closed, means including a pilot valve for connecting said hydraulic means to said second port, and means for operating said pilot valve in response to reversal of pressure in the opposite sides of said circuit.

10. In a hydraulic system for driving in opposite directions a load which is constantly urged in one of said directions, the combination of a hydraulic motor connected to said load and having a first port and a second port interchangeable for the admission and discharge of liquid to and from said motor, said load exerting upon said motor a force tending to operate it in a direction to cause it to discharge liquid through said second port, a pump, means for directing liquid from said pump to said ports selectively to cause said motor to drive said load in opposite directions selectively, a valve connected to said second port and adapted when closed to prevent the discharge of liquid therefrom and thereby cause said load to create pressure at said second port, a piston operable by said pressure to hold said valve closed to thereby prevent said load from operating said motor, and means operable in response to said pump delivering liquid to said first port for causing said piston to fully open said valve.

11. In a hydraulic system including a motor having a first port and a second port and being constantly urged in a direction to cause it to discharge liquid through said second port, the combination of a valve connected to said second port and adapted when closed to prevent the discharge of liquid therefrom and thereby cause pressure to be created at said second port, a piston connected to said valve and urged by said pressure in a direction to hold said valve closed, means for directing liquid under pressure to said first port, and means operable by the pressure at said first port for causing the pressure at said second port to move said piston in a direction to open said valve.

12. In a machine having an element urged in one direction by a substantially constant force, the combination of a hydraulic motor connected to said element and provided with interchangeable inlet and discharge ports, a pump, means for directing liquid from said pump to said ports alternately to cause said motor to move said element in opposite directions alternately, a valve adapted when effective to prevent the discharge of liquid from one of said ports to thereby prevent said element from being moved by said force, and means responsive to the pressure at the other port reaching a given value for enabling the pressure at said one port to render said valve ineffective to prevent the discharge of liquid from said motor.

RICHARD E. DAVIS.