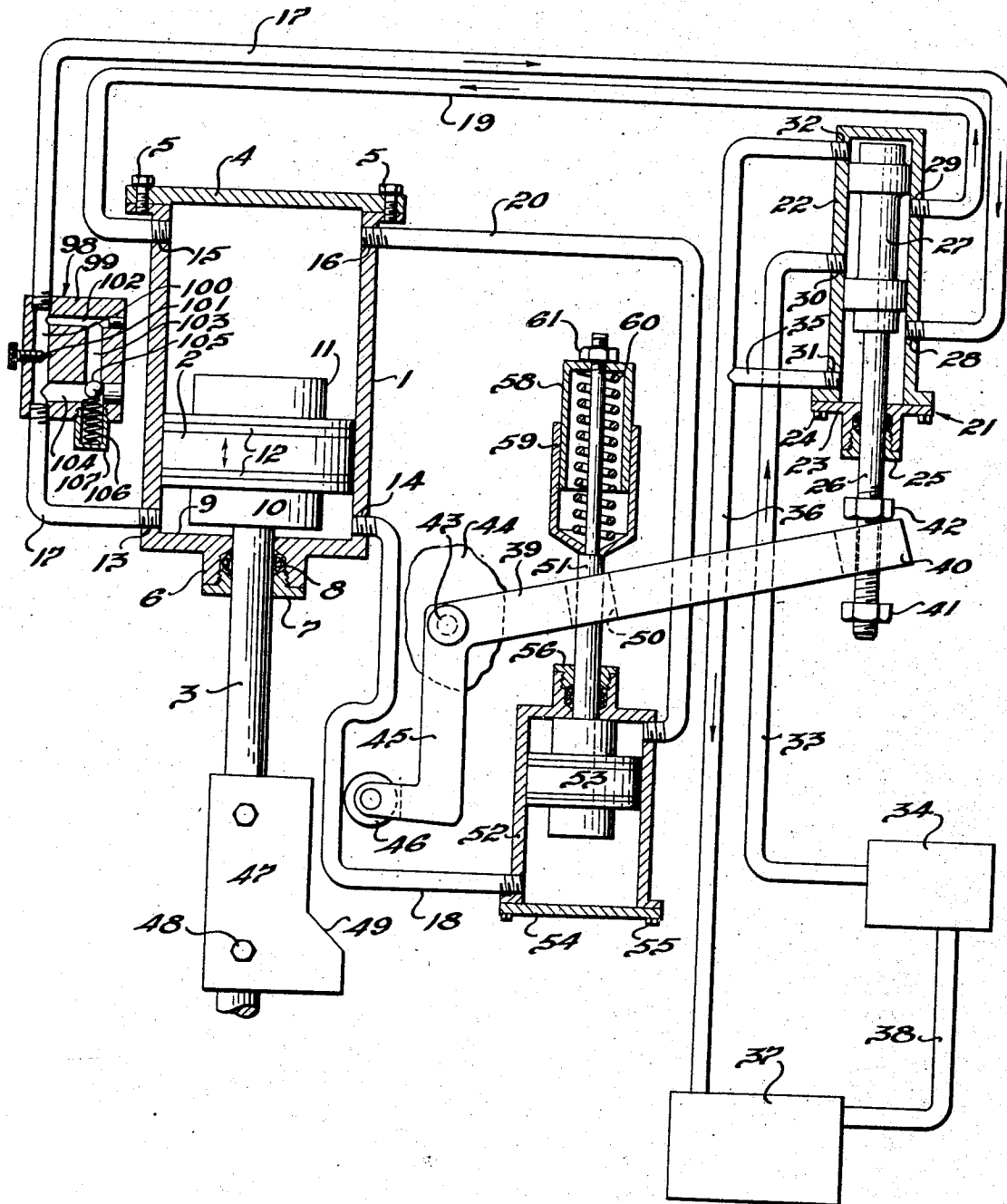


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HYDRAULIC CYCLE CONTROL

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HYDRAULIC CYCLE CONTROL

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This invention relates to reciprocating fluid pressure motors, and is of particular value in connection with such motors as are used on hydraulically operated machine tools, and the like.

Machine tools have been provided with double acting fluid pressure cylinders and pistons for actuating reciprocating work or tool holders during the operation of the machine. In prior installations means are provided for shifting the intake and exhaust valves, to reverse the piston, and such means usually comprise some sort of mechanical trip mechanism which is actuated by means associated with the piston, as the latter approaches the end of its stroke. It has been found that for some classes of work such a mechanism does not give a sufficiently positive and accurate stop for the piston in its operative movement. Accordingly, it is one of the objects of this invention to provide a reversing means for a fluid pressure motor which will provide a positive and fixed point of reversal in the motor's cycle of movement.

A more limited object is to provide a reversing means for a fluid pressure motor of the type described which is effective only after the movable element of the motor contacts a fixed abutment which prevents further movement thereof in one direction.

Another object is to provide a means for reversing a reciprocating fluid pressure motor at a fixed point in its path of movement, which means is controlled by the fluid pressure within the motor itself.

Another object is to provide means to actuate the reversing valve of a fluid pressure motor upon a drop in the exhaust pressure at one side of said motor incident to the completion of its exhaust stroke.

Other objects and advantages of the invention will become apparent from the attached specification, the accompanying drawing and the appended claims.

The drawing illustrates, partly diagrammatically, a preferred form of the invention, the essential elements thereof being illustrated in section.

In the drawing there is shown at 1 the cylinder of a hydraulic motor, which includes a piston 2 and piston rod 3. The piston rod 3 may be adjustably connected to a reciprocating work or tool holder, not shown, of a machine tool. Such a machine may, for example, be a drill press having a reciprocating drill head which is adjustably connected to the piston rod.

The cylinder 1 has a removable head 4 secured in place by suitable studs 5. The opposite end of the cylinder is formed at 6 to receive a conventional packing gland 7 having a packing 8 for preventing leakage around the piston rod. The interior end wall 9 is flat and is adapted to engage

abutment 10 on the piston when the latter reaches the limit of its movement in the working direction. A similar abutment 11 is provided at the opposite face of the piston, and piston rings 12 are fitted into conventional ring grooves about the periphery of the piston. The walls of the cylinder adjacent its forward end are provided with a pair of ports 13 and 14, while similar ports 15 and 16 are provided adjacent the opposite end of the cylinder. These ports are threaded or otherwise adapted to receive suitable fluid conduits 17, 18, 19 and 20, respectively.

Each of the conduits 17 and 19 is adapted to operate either as a pressure or exhaust conduit for the end of the cylinder to which it is connected. These functions are controlled by a reversing valve, indicated generally at 21, which is interposed in lines 17 and 19. The reversing valve 21 comprises a casing 22 closed at one end and having at the opposite end thereof a removable closure plate 23 secured in place by studs 24. Plate 23 is provided with an opening for the reception of a packing gland 25 and a valve rod 26 extends through the opening and has a valve head 27 on its inner end. The valve housing 22 is provided with five ports 28, 29, 30, 31 and 32, spaced respectively along the axis of the housing and the conduits 17 and 19 are threaded into the ports 28 and 29, respectively. Port 30 communicates with a conduit 33 which is connected to the discharge side of a pump 34, while ports 31 and 32 communicate through conduits 35 and 36 with an atmospheric pressure storage reservoir 37. The intake of pump 34 is connected to reservoir 37 by a conduit 38.

A valve operating lever 39 is slotted at its end 40 to receive the end of valve rod 26 and the end of the rod is threaded to receive a pair of nuts 41 and 42 which are adapted to engage opposite sides of the end of the lever. The lever 39 is pivoted at 43 to a fixed portion of the machine 44 and carries an extension 45 to which is secured a roller 46. A cam 47 adjustably secured to the piston rod 3 of the hydraulic motor by any suitable means, such as by set screws 48, has a bevel 49 adapted to cooperate with the roller. It will be apparent that as piston 2 approaches the upper end of cylinder 1, as viewed in the drawing, the beveled portion 49 of cam 47 can engage roller 46 and will shift lever 39 to the position it assumes in the drawing. However, upon return movement of the piston downward as viewed in the drawing, cam 47 will pass beyond roller 46 without changing the position of lever 39.

The lever 39 is apertured at 50 to receive a piston rod 51 of an actuating motor comprising a cylinder 52 and a piston 53 having abutments similar to those on the piston 2. This cylinder has a removable closure plate 54 at one end thereof, held in place by studs 55, and at the

opposite end is provided with a packing gland 56 for the reception of piston rod 51. The upper end of cylinder 52 is in constant communication with the upper end of the operating cylinder 1 through conduit 20. Secured to an extension 57 of rod 51 is a compressible abutment member comprising a pair of telescopic housings 58 and 59, within which is a coiled compression spring 60. A nut 61 threaded on the end of rod 57 is provided for retaining this assembly in place. It will be observed that when piston 53 moves downwardly, as shown in the drawing, housing member 59 will engage one side of lever 39 and will resiliently force it in a clockwise direction about pivot 43.

The opposite or lower end of cylinder 52 is in communication with the lower end of cylinder 1 through a conduit 18.

Between the cylinder 1 and the reversing valve 21 a one-way throttle valve 98 is positioned in conduit 17 and comprises a block 99 having a longitudinal bore 100 passing entirely therethrough. The opposite ends of bore 100 are connected respectively to the adjacent ends of conduit 17 and an adjusting screw 101 is provided for restricting the flow through this bore. In order to permit a free flow of fluid to the cylinder 1 through conduit 17, a one-way by-pass is provided around the throttle screw 101 and this by-pass comprises connected conduits 102, 103 and 104, and a one-way ball check valve comprising a ball 105 and a spring 106, the latter being mounted in a housing 107 secured to block 99. The outer end of bores 102 and 104 may be closed by any suitable means, such as plugs.

The drawing shows the parts in the position they occupy during downward movement of the operating piston towards its lowermost position and before the completion of such movement. Under this condition, the reversing valve 21 will connect the pump 24 to the upper end of cylinder 1 through conduit 23, the housing of the reversing valve, and conduit 19, thus supplying pressure to effect movement of the piston. At the same time, the lower end of cylinder 1 will be exhausting through conduit 17, the throttle valve 98, the lower end of housing 22 of the reversing valve, conduit 35 and conduit 36 to the reservoir 37. The throttle screw 101 will be adjusted to provide an appreciable back pressure at the exhaust side of piston 2 for a purpose to be described.

The high pressure at the upper side of piston 2 will be communicated through conduit 20 to the upper end of cylinder 42 of the reversing valve actuator. At the same time the exhaust pressure at the lower side of piston 2 will be communicated through conduit 18 to the lower end of cylinder 52. It is thus apparent that high or operating pressure is effective upon the upper end of the valve actuating piston 53 while the exhaust pressure is effective upon the opposite end thereof. The proportions of the parts and the operating and exhaust pressures are so selected, however, that the exhaust pressure at the lower end of piston 53 overcomes the high pressure at the opposite end and maintains the piston at the upper end of the cylinder as shown in the drawing. This overbalancing of a higher by a lower pressure is effected by reason of the fact that the piston rod 51 reduces the effective area of the upper end of piston 53 sufficiently to compensate for the excess pressure at that end. The relative diameters of the piston and the piston rod of the actuator are so proportioned as to insure

that the piston 53 will remain at its uppermost position until the resistance to movement of piston 2 exceeds the maximum resistance that will be offered by the tool during normal use.

The above described condition will continue to exist so long as piston 2 continues its movement toward the lower end of cylinder 1. However, when piston 2 reaches and abuts the end of its cylinder, or any other positive stop that may be provided, no further movement is possible regardless of the pressure at the upper end of the cylinder. Therefore, the fluid at the exhaust side will be relieved of the normal exhaust pressure caused by discharge of fluid past the metering screw 100. As soon as the pressure at the lower end of cylinder 1 drops below the normal exhaust pressure, however, this reduction in pressure is communicated in the manner previously indicated to the lower end of the actuator cylinder 52, unbalancing the piston 53 which immediately moves downwardly under the influence of full operating pressure from the upper end of cylinder 1 through conduit 20.

During the downward movement of piston 53, the fluid in the lower end of cylinder 52 will exhaust through conduit 18, the lower end of cylinder 1, conduit 17, ports 28 and 31 of the reversing valve 21 and conduits 35 and 36 to the storage reservoir 37. This movement of piston brings the abutment member 59 into engagement with lever 39 and shifts valve rod 26 downwardly, placing port 28 in communication with port 32 and placing port 29 in communication with port 30.

Shifting of the reversing valve from the position illustrated, places conduit 17 in communication with the pump through conduit 33 and the valve housing, and it places conduit 19 in communication with the discharge reservoir 37 through conduit 36 and the valve housing. The pressure in conduit 17 passes through the by-pass passages and one-way valve of the throttle mechanism 98 to the lower end of cylinder 1, thus initiating the effecting movement of the operating piston 2 in a reverse direction or upwardly, as viewed in the drawing. During such movement the fluid at the upper end of piston 2 discharges freely through conduit 19.

During the reverse movement of piston 2 the high pressure at the upper end of cylinder 1 is communicated through port 14 and conduit 18 to the lower end of the actuator piston 53. Since atmospheric pressure is effective upon the upper end of piston 53, this piston will move upwardly rapidly until it assumes the position shown in the drawing. Such motion, however, will not affect the position of lever 39, which will remain in the position to which it was previously moved by the reverse movement of the actuator piston 53 until roller 46 is engaged by the beveled surface 49 of cam 47 on piston rod 3.

Near the end of the upward movement of piston 2 the beveled surface 49 of cam 47 engages roller 46 on lever 39 and thereafter shifts the lever and reversing valve to the position shown in the drawing. This admits fluid under pressure to the upper end of cylinder 1 through line 19 and connects line 17 to exhaust through the bleed valve 101. All of the fluid passages are filled with incompressible fluid with the result that there will be no lag in the response of the motor to the shift of the reversing valve. The moment the operating pressure is applied to the fluid in the upper end of the cylinder 1 there will of necessity arise a corresponding exhaust

back pressure at the lower end of cylinder 1 and these operating and exhaust pressures will maintain piston 53 in its upper position until piston 2 completes its downward movement. From this point, the above described cycle of movement will be repeated.

It will be apparent from the above description and the accompanying drawing that a means for reversing a reciprocating fluid pressure motor at a fixed point in its stroke has been provided and only after its movable element has engaged and been stopped by a fixed abutment. This positively insures that the movable carriage or other device operated by the motor will always change its direction of motion at exactly the same point in each cycle. This feature is of great value where very accurate cuts must be made by machine tools.

In addition, it will be noted that since the reversal of the operating piston 2 is effected upon an abnormal increase in the resistance to downward motion of that piston, the device will automatically reverse when the operating tool offers an abnormal resistance to motion. Thus if the piston 2 is used to drive a drill, the drill will be automatically withdrawn when the drill pressure becomes too great.

While there is illustrated and described only one form of the invention, it is apparent that considerable variation may be made in the details and arrangement of parts without departing from the spirit thereof, or the scope of the appended claims.

We claim:

1. In combination, a double acting expansible chamber fluid pressure motor having a reversing valve for reversing the pressure and exhaust connections at the opposite ends of the movable element thereof, a cylinder having closed ends, a piston in said cylinder, one of said piston and cylinder members being stationary and the other movable and connected to said reversing valve for operating the latter, an open conduit connecting one chamber of the motor with one end of said cylinder, a second conduit connecting the other chamber of said motor with the opposite end of said cylinder, whereby the application of excess pressure to one chamber of said motor effects movement of the movable element thereof and also said piston in one direction respectively, means associated with the piston and cylinder for preventing movement of said piston in the opposite direction when an excess pressure is applied to the other chamber of said motor until the movable element of said motor has completed its movement in the opposite direction, a lost motion connection between said piston and cylinder units and said reversing valve for preventing operation of said valve thereby in said first direction of movement, and means associated with said motor for operating said valve near the end of the movement of said motor element in said one direction.

2. In combination with a double acting fluid pressure motor including a piston, a cylinder, a second fluid pressure motor having a piston and cylinder, a piston rod projecting from one end of said second cylinder, an open conduit connecting one end of said first cylinder with the piston rod end of said second cylinder, a second open conduit connecting the opposite ends of said cylinders, the cross sectional areas of the second piston and its rod being so proportioned

that the normal operative pressure at said piston rod end of the second cylinder is insufficient to overcome the normal exhaust pressure at the opposite end of said second cylinder, a reversing valve for said first motor adapted to reverse the pressure and exhaust connections at opposite ends of said first cylinder, and means associated with the projecting end of said piston rod of the second motor for operating said reversing valve.

3. In combination with a double acting fluid pressure motor including a piston, a cylinder and a reversing valve for reversing the pressure and exhaust connections at opposite ends of said cylinder, means operatively connected to said reversing valve including a second fluid pressure motor having a piston and cylinder, a piston rod in said second cylinder, an open conduit connecting one end of said first cylinder with the piston rod end of said second cylinder, a second open conduit connecting the opposite ends of said cylinders, the cross sectional areas of the second piston and its rod being so proportioned that the normal operative pressure at said piston rod end of the second cylinder is insufficient to overcome the normal exhaust pressure at the opposite end of said second cylinder, a lost motion device in the connection between said second motor and said reversing valve for preventing operation of the valve by said second motor when said second piston moves toward its piston rod, but permitting operating in the opposite direction, and means associated with the first motor for shifting the reversing valve in the direction in which it cannot be moved by said second motor when the piston of said first motor approaches the end of its travel in the direction toward said open conduit.

4. In combination with a double acting fluid pressure motor including a cylinder, a piston in the cylinder and a reversing valve for reversing the pressure and exhaust connections at opposite ends of said cylinder, a second closed ended cylinder, a piston in said second cylinder having a piston rod projecting through one end thereof, a constantly open fluid pressure communication between one end of the first cylinder and one end of the second cylinder, a constantly open fluid pressure communication between the opposite ends of said cylinders, a restricted exhaust outlet for said opposite end of the first cylinder, a positive stop for said first piston in its movement toward said opposite end of the first cylinder, the effective areas of said pistons being such that the pressure differential normally required to drive the first piston toward said opposite end of the first cylinder will be insufficient to shift said second piston from said one end of said second cylinder until the exhaust pressure at said opposite end of the first cylinder drops incident to engagement of said positive stop for the first piston, a lost motion mechanical connection between the projecting end of the piston rod of said second piston and the reversing valve effective to shift said reversing valve when the second piston moves from said one end of the second cylinder but ineffective to shift said reversing valve when said second piston moves in the opposite direction, and means for shifting said reversing valve in the opposite direction upon movement of said first piston to said one end of the first cylinder.

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