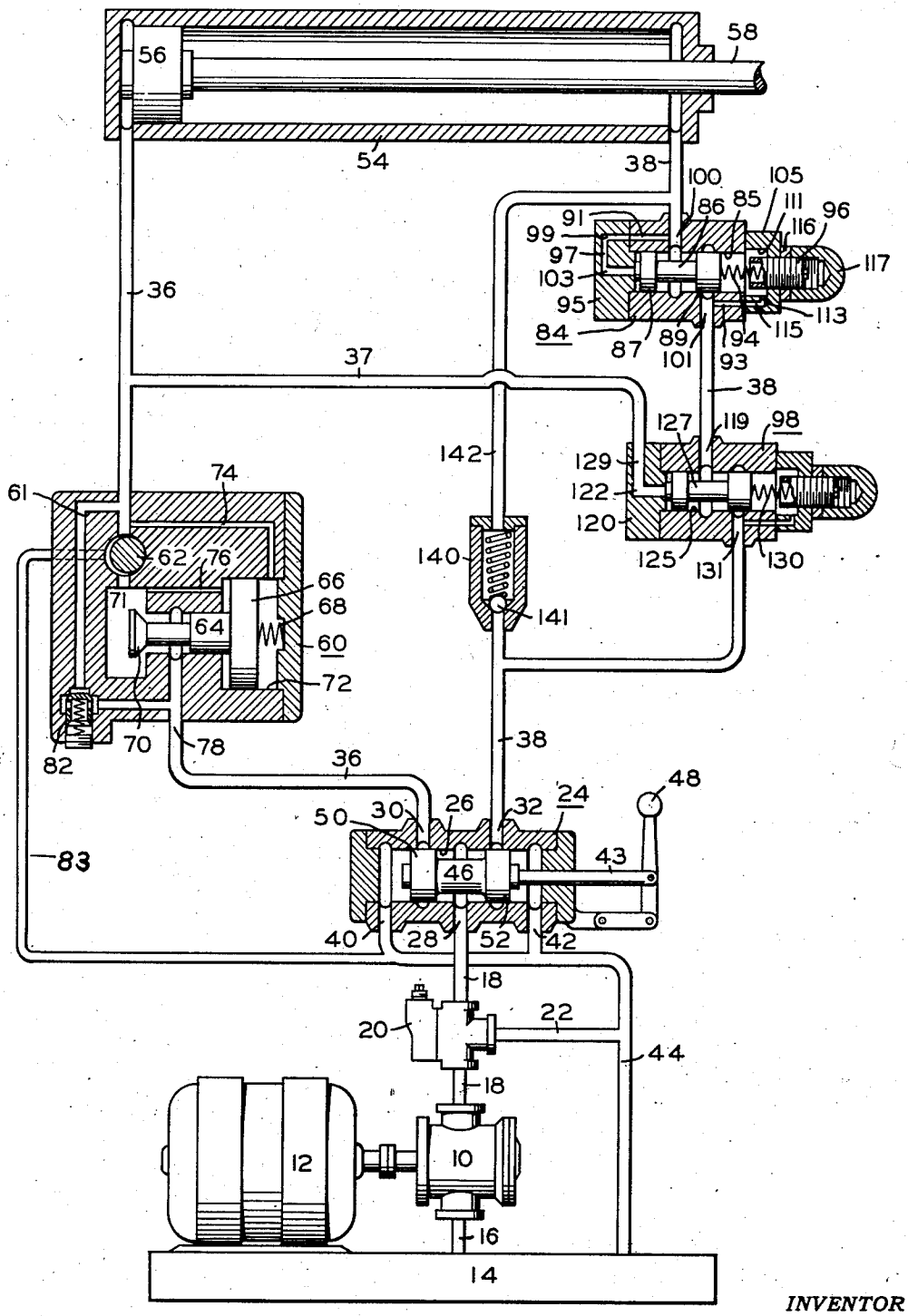
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POWER TRANSMISSION

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INVENTOR

KENNETH R. HERMAN &

BY FERRIS T. HARRINGTON

Ralph L. Tweedale

ATTORNEY

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POWER TRANSMISSION

Kenneth R. Herman, Franklin, and Ferris T. Harrington, Detroit, Mich., assignors to Vickers Incorporated, Detroit, Mich., a corporation of Michigan

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This invention relates to power transmissions, particularly to those of the type comprising two or more fluid pressure energy translating devices, one of which may function as a pump and another as a fluid motor.

Transmissions of this character are widely used on machine tools for actuating reciprocating slides, rotary spindles, etc. It is frequently necessary in applications of this character to make provision for sudden and wide fluctuations in motor load, as, for example, when a cutting tool breaks through a work piece, and to so arrange the circuit that the motor is positively prevented from ever jumping ahead under a sudden relief in load.

There are in use several methods which accomplish this result, one method comprising the use of a back-pressure valve in the motor outlet line which acts to maintain a predetermined back pressure therein. Systems of this character present one drawback particularly troublesome in large size machines, namely, that the back-pressure valve is an energy dissipator, and, if the back pressure which must be maintained is very high and the volume of fluid passed therethrough is also high, a considerable heating of the oil occurs which adversely affects the system as a whole. In addition, the waste of power at the back-pressure valve requires a larger power input to the machine and thus gives the circuit as a whole a low efficiency.

It is an object of the present invention to provide an improved power transmission system wherein the above difficulties are avoided, at least to a substantial extent, and at the same time to positively prevent any jumping ahead of the fluid motor under a sudden relief in load.

A further object is to provide a system of this character wherein a relatively low value of back pressure is normally maintained in the motor outlet when the motor load is sufficiently high to, of itself, prevent jumping ahead. At the same time, additional means are provided for increasing the back pressure to a higher value whenever the motor load falls below a certain value. In this way it is assured that the high back pressure necessary to prevent jumping ahead is applied only during intervals when jumping ahead is otherwise likely to occur.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing wherein a preferred form of the present invention is clearly shown.

In the drawing:

The single figure is a diagrammatic view of a power transmission system embodying a preferred form of the present invention.

There is indicated at 10 a pump adapted to be driven by a suitable prime mover, such as an electric motor 12. The pump 10 withdraws fluid from a tank 14 through a suction conduit 16 and delivers the same to a delivery conduit 18. The latter has a relief valve 20 of conventional construction for bypassing oil to the tank 14 through a conduit 22 whenever a predetermined pressure is exceeded in the delivery conduit 18.

The conduit 18 extends to a directional four-way valve 24 which directs the flow of liquid from pump 10 to and from either end of the cylinder 54. The directional valve 24 comprises a main body member having a longitudinal bore 26 within which is mounted a slidable spool 46. The bore 26 is provided with a plurality of annular ports arranged along its length, of which 28 is the pressure port, 30 and 32 the cylinder ports, and 40 and 42 the tank ports. The pressure port communicates with the delivery conduit 18, while the tank ports 40 and 42 communicate with tank 14 through a conduit 44. The cylinder ports 30 and 32 communicate with motor conduits 36 and 38, respectively, which lead to the opposite ends of a fluid motor 54. The latter comprises a cylinder within which is mounted a movable piston 56 to move rod 58 and cause it to do work.

The spool 46 of valve 24 is provided with solid lands 50 and 52 which close the cylinder ports 30 and 32 when the spool is in central position, illustrated. The righthand end of the spool 46 has secured thereto an operating stem 43 which is attached to a manually-operated lever 48.

Conduit 36 extends from port 30 of valve 24 to the head end of cylinder 54 through a hydrostatic flow control valve 60 which controls the rate of liquid flow thereto. Valve 60 includes an adjustable throttle valve 62 which limits the rate of fluid flow and a pressure compensator 64 which maintains the rate of controlled flow independent of the variations in the operating pressure or fluctuations in cutting tool resistance. The pressure compensator 64 consists of a piston 66, piston spring 68 and a valve 70 controlling the flow from port 78 into a chamber 71. Piston 66 is mounted in a cylinder 72 from which two passages 74 and 76 extend, one from each side of the piston 66 to the opposite sides of the throttle 62. A light spring 68 tends to keep open valve 64 by urging it to the left. The hydrostatic pressure compensator 64 regulates the fluid flow to

the throttle 62 in accordance with the pressure drop across the throttle 62, that is, as pressure in chamber 71 rises slightly, the piston 66 will move to the right, pressure on its left side being greater than that on its right, and continue to close valve 70 until the rate of liquid flowing into chamber 71 is the same as that of the liquid being discharged through the throttle 62. Since the rate of discharge through the throttle 62 will remain constant, the rate of movement of the working tool will also be relatively constant. The flow control valve 60 contains an integral check valve 82 to provide for the reverse flow. A drain conduit 83 connects the end of throttle valve 62, at a point below the plane of the drawing, with the exhaust conduit 44 for the purpose of draining seepage along the stem of the throttle valve.

Attached to the exhaust end of the cylinder 54 by a conduit 38 are two bypass valves 84 and 98 connected in series for providing back pressure therein to firmly hold the piston 56 as it moves through its work stroke. Valve 84 comprises a main body having a central longitudinal bore 85 which is provided with ports 100 and 101, communication between which is controlled by a movable spool 86. The latter has two lands 87 and 89 which are freely slidable with a liquid tight fit in bore 85.

The body 84 includes a pair of auxiliary passages 91 and 93 extending from ports 100 and 101, respectively, to the end face of the body 84.

Mounted on the left end face of the body 84 is an end cap member 95 which is provided with a chamber 103 through which fluid pressure enters the left end of bore 85 to act on spool 86. Chamber 103 connects with a passage 97, having an auxiliary branch passage 99 extending to the end of cap 95 and in direct communication with passage 91 of body 84.

On the righthand end of the main body is secured an end cap 105 through which is threaded an adjusting screw 96. A spring 94 extends from within the screw 96 to the valve spool 86 holding it in a closed position to the left, disconnecting ports 100 and 101. The spring 94 is adjusted by the screw 96 to whatever back pressure in cylinder 54 is desired. A chamber 111 in the end cap 105 is in communication with the end of the bore 85 for exhausting oil therefrom as spool 86 reciprocates in bore 85. Leading from chamber 111 is a passage 113 having an auxiliary branch passage 115 which extends to the end of cap 105 and in communication with passage 93 of body 84. The end cap 105 also carries a lock nut 116 and a closure cap 117, both secured on the screw 96.

Port 101 of valve 84 communicates with port 119 of valve 98 through a conduit 38. Valve 98 is of similar construction to valve 84, the only difference being in the left end cap 120. The latter is provided with a chamber 122 through which fluid pressure enters the left end of bore 125 to act on the spool 127. Chamber 122 connects with passage 129 which extends to the side of the end cap 120 and is in communication with inlet line 36 through a conduit 37. The setting of spring 130 is much higher than that of spring 94 of valve 84.

To provide for rapid return a check valve 140 is mounted onto conduit 38 which extends from the directional valve 24. The check valve 140 has a conduit 142 extending to the rod end of cylinder 54, circumventing valves 84 and 98.

In operation, while the pump 10 is being driven by the electric motor 12, oil is withdrawn from the tank 14 through a suction conduit 16 and delivered through conduit 18 to the directional valve 24. With the spool 46 in neutral position, illustrated, the full pump delivery is bypassed to the tank 14 through a relief valve 20 via conduits 22 and 44.

To advance the piston 56, lever 48 of valve 24 is pushed inward. This action allows the pump delivery to be directed from the pressure port 28 to the motor port 30 where it is delivered by conduit 36 to the flow control valve 60. The liquid will enter chamber 71 through the opening formed by valve 70 to the throttle 62 where it is metered into the inlet line 36 of cylinder 54 and forces back piston 56 at a certain rate of speed as determined by the adjustment of the throttle valve 62. The metered liquid also enters conduit 37 leading to the valve 98.

The discharging liquid from the back of piston 56 will, as it flows through valves 84 and 98 to tank, be restricted to build up a back pressure on the discharge end of the cylinder 54 to prevent surging of the piston 56 after the work is completed and also to maintain back pressure proportional to the load fluctuations, thus preventing jerky action on the feed stroke.

Valve 84 restricts the flow of the discharged liquid by causing it to encounter a resistance at port 100 before flowing through it to port 101, and to valve 98 via conduit 38. This resistance is overcome whenever pressure in port 100 rises above the value for which the spring 94 is set. This pressure is transmitted through passages 91, 99, and 97 to the valve actuating chamber 103 where it acts on valve spool 86, opening it and permitting the liquid to pass to port 101.

Valve 98 will open to allow the discharge liquid to flow to tank when a certain fluid pressure is admitted to the chamber 122 through passage 129 which communicates with the inlet conduit 36 through conduit 37. This pressure controls the amount of liquid that will be bypassed to the tank 14 through port 131, changing with load variations.

During the feeding operation with a zero load to overcome, before the piston 56 can be forced back, pressure in conduit 37 must be built up to exceed the value of the setting of the spring 130 of valve 98. Before the opening of valve 98, the discharge liquid will be admitted into port 119 because of the lower setting of valve 84. At this phase, valve 98 determines the back pressure in cylinder 54.

As the load on the rod 58 increases, pressure will also increase in the inlet conduit 36 which will be transmitted to chamber 122 causing the spool 127 to be moved more to the right, allowing the liquid to be discharged with less resistance, thus lessening the back pressure. Thus, when the spool 127 is in the extreme right position, the back pressure will equal merely the pressure needed to keep valve 84 open.

Upon the lessening of the load to a point below the setting of valve 98, pressure in the inlet conduit 36 will also lessen and accordingly will lessen in chamber 122. This will tend to close the valve spool 127 of valve 98, thus creating a greater back pressure in motor outlet line 38 which replaces, so to speak, the load resistance which was reduced.

To reverse the operation, returning the piston 56 to its former position, lever 48 is pulled outward. This connects the pressure port 28 with the motor port 32 providing for rapid return. The full pump delivery is now directed through

conduit 38, unseating ball check 141, valve 98 being closed, and entering conduit 142 where it is delivered to the rod end of the cylinder 54. Liquor discharging from the front of piston 56 will be bypassed around flow control valve 60, through conduit 61, unseating check valve 82, to port 78 where it is delivered to valve 24 by conduit 36. The valve spool 46, being in the extreme right position, will direct the liquid to the tank conduit 44 leading to the tank 14.

It will be seen that the present invention maintains back pressure while "feeding-in" and at the same time keeps the oil in the circuit much cooler than heretofore because during normal load conditions the motor exhaust fluid flow passes to the tank through a low-pressure, back-pressure valve.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, a flow controller in the supply line for regulating the rate of flow to the motor, a back pressure valve in the return conduit and responsive to motor outlet pressure for maintaining a predetermined low back pressure in the motor outlet, and a second back pressure valve also in the return line and having an operative connection to the supply conduit whereby the second back pressure valve is responsive to the sum of the pressures produced in the supply conduit by the back pressure and by the motor load and is effective to impose additional back pressure only when the motor load is below a predetermined minimum.

2. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, a flow controller in the supply line for regulating the rate of flow to the motor, a back pressure valve in the return conduit and responsive to motor outlet pressure for maintaining a predetermined low back pressure in the motor outlet, and a second back pressure valve also in the return line in series with the other valve and having an operative connection to the supply conduit whereby the second back pressure valve is responsive to the sum of the pressures produced in the supply conduit by the back pressure and by the motor load and is effective to impose additional back pressure only when the motor load is below a predetermined minimum.

3. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, means for regulating the rate of flow to the motor, a back pressure valve in the return conduit and responsive to motor outlet pressure for maintaining a predetermined low back pressure in the motor outlet, and a second back pressure valve also in the return line and having an operative connection to the supply conduit whereby the second back pressure valve is responsive to the sum of the pressures produced in the supply conduit by the back pressure and by the motor load and is effective to impose additional back pressure only when the motor load is below a predetermined minimum.

4. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, means for maintaining a predetermined minimum back pressure in the outlet from the motor under all conditions, and means for imposing additional back pressure only when the motor load falls below a predetermined minimum.

5. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, means for regulating the rate of flow to the motor, directional control means for selectively directing fluid to the motor in one direction or the other, a back pressure valve in the return conduit and responsive to motor outlet pressure for maintaining a predetermined low back pressure in the motor outlet, a second back pressure valve also in the return line and having an operative connection to the supply conduit whereby the second back pressure valve is responsive to the sum of the pressures produced in the supply conduit by the back pressure and by the motor load and is effective to impose additional back pressure only when the motor load is below a predetermined minimum, and a single check valve arranged to bypass both back pressure valves during flow to the motor in one direction.

6. In a hydraulic power transmission system the combination with a source of pressure fluid, a fluid motor operable by fluid supplied from said source, supply and return conduits connecting the source with the motor, a flow controller in the supply line for regulating the rate of flow to the motor, and including a throttle and a compensating valve responsive to the pressure drop through the throttle for maintaining such pressure drop substantially constant, a back pressure valve in the return conduit and responsive to motor outlet pressure for maintaining a predetermined low back pressure in the motor outlet, and a second back pressure valve also in the return line and having an operative connection to the supply conduit whereby the second back pressure valve is responsive to the sum of the pressures produced in the supply conduit by the back pressure and by the motor load and is effective to impose additional back pressure only when the motor load is below a predetermined minimum.

KENNETH R. HERMAN.
FERRIS T. HARRINGTON.