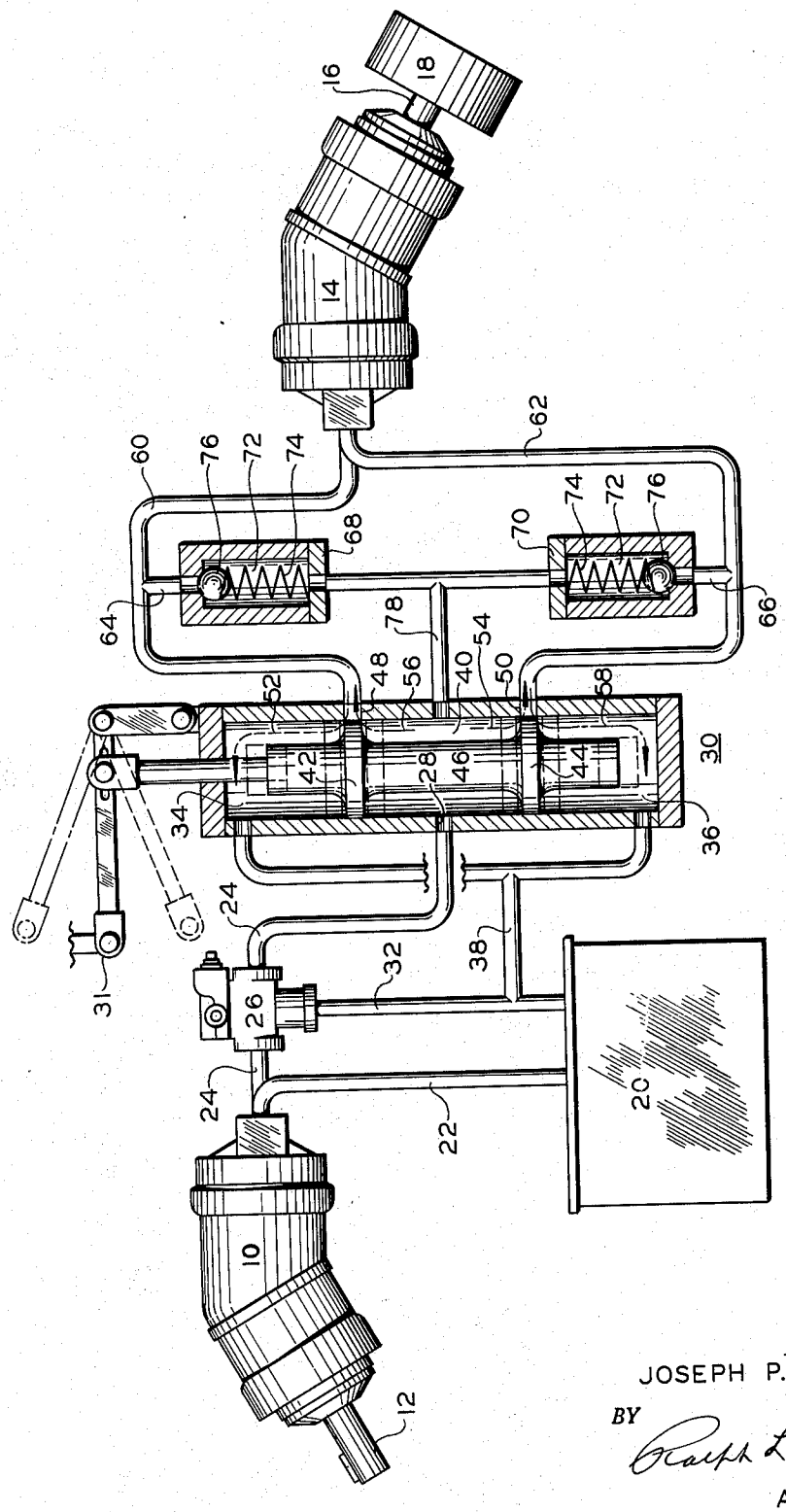
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HYDRAULIC POWER TRANSMISSION FOR OVERRUNNING LOAD

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HYDRAULIC POWER TRANSMISSION FOR OVERRUNNING LOAD

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This invention relates to power transmissions, and is particularly applicable 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.

More particularly the invention relates to such a transmission utilized for driving an overrunning load, that is, one having a substantial moment of inertia. In such systems a fluid motor is customarily provided in a driving relation with the load, and a fluid pump is utilized as a source of pressure to operate the motor. To effect the selective starting and stopping of the load and the motor, and in the case of a double-acting motor to provide for reversing the motor and load, there is ordinarily provided a directional valve to effect the interruption of, or establish, communication between the fluid pump and the motor.

Customarily, such valves are of the type wherein the relation of the valve lands and the motor ports controlled thereby is such that as the land crosses the port the port is momentarily blocked by the land. Such an arrangement provides a valve position in which the motor ports are blocked to permit locking the motor in a desired position. Further, the slight overlap of the land prevents the motor port from acting as a fluid path to short circuit the pump across the valve lands.

The use of such a valve in a system utilized for driving a load with a heavy inertia moment has an inherent disadvantage in that surge or transient pressures of magnitudes far exceeding the pump outlet pressure may be generated. For example, assume that a double acting fluid motor is driving an inertia load at a substantial rate of speed with the valve connecting the pump outlet to one of the motor ports and connecting the other motor port to tank. If the valve is suddenly shifted to a position wherein the motor port serving to return fluid to the reservoir is blocked, the pressure generated in the blocked motor line by the motor being driven as a pump by the inertia load may be extremely high. For example, in a particular transmission of this type, where the pump operating pressure was 3000 p. s. i., pressures generated by the overrunning of the inertia load were measured to be of the order of 15,000 p. s. i. Pressures of such magnitude are destructive of system components and might run even higher, dependent on the kinetic energy stored in the moving load, and the rate of deceleration.

In the past, systems have been guarded against damage due to such transient pressures by the provision of a relief valve in the line between the directional valve and the motor. The relief valves provided in the past have been of the conventional type wherein the fluid discharged to relieve excess pressure is discharged directly to the reservoir. Such an arrangement has several serious disadvantages. One of these disadvantages is that, since the valves must not open under normal system pressures, which may be of the order of 3000 p. s. i., extremely heavy biasing means must be utilized to maintain the valve in a closed position. Utilization of such a valve

results in inaccurate operation and the necessity of heavy general construction of the valve.

It has also been proposed to use a relief valve of the hydracone type wherein a small pilot valve effects operation of a large main valve. This arrangement of course permits use of a relatively light control spring due to the small area of the pilot valve, but has the disadvantage of introducing to the system a relatively large body of oil which adversely affects the response characteristics of servo systems in which positional and speed control are critical.

It is an object of this invention to provide a power transmission for driving an inertia load in which the system components are adequately protected against excessive pressures caused by overrunning of the load.

Further, it is an object of this invention to provide, in such a system, valves for relieving the inertia produced pressures, which valves are operative only at very high pressures and yet which may utilize extremely light mechanical biasing means.

Still another object is to provide such a system in which inertia induced pressures are properly relieved, and in which the mass of oil in the system between the directional valve and the motor is kept to a minimum.

A still further object is to provide such a system in which simple, low cost components are used in which piping connections are simple and few in number.

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 schematic view of a power transmission employing a preferred form of the present invention.

There is illustrated in the drawing a pump **10** of the axial piston type having a drive shaft **12** for connection to a prime mover, not shown. Connected to the pump **10** by fluid conduits hereinafter described is a fluid motor **14**, also being illustrated as of the axial piston type. The motor **14** is connected by a drive shaft **16** to a load having a large moment of inertia and indicated at **18**.

The system includes a reservoir **20** which provides a supply of fluid to replenish leakage and also provides a point of relative quiesence in the system where the operating fluid is cooled, deaerated, and cleaned. A suction conduit **22** leads from the reservoir **20** to the inlet port of the pump **10**. Fluid pumped by pump **10** is discharged therefrom through the delivery conduit **24** which leads to the inlet of a relief valve **26**. The delivery conduit **24** extends from the other side of relief valve **26** to the inlet port **28** of a directional valve generally designated **30**. Valve **30** includes operating mechanism **31** which may be connected to any suitable source of a control input.

An exhaust conduit **32** extends from the relief valve **26** to the reservoir **20**, and operation of the valve **26** is such that fluid is diverted from the conduit **24** to the discharge conduit **32** and hence to tank **20** in such quantities as are required to maintain the maximum delivery pressure of the pump **10** at the pressure setting of the valve **26**.

The end chambers **34** and **36** of valve **30** are vented to the reservoir **20** through a branched passage **38** which leads from those end chambers to the discharge conduit **32**. Thus while the pump **10** is in operation the central chamber **40** of valve **30** will be continuously under pump operating pressure conducted thereto by a delivery conduit **24**, and each of the end chambers **34** and **36** will be maintained at reservoir pressure. The end chambers **34** and **36** are separated from the central chamber **40** by the lands **42** and **44** on the spool **46** of the valve **30**. The

lands 42 and 44 cooperate respectively with a pair of motor ports 48 and 50 in the body of valve 30. The axial length of lands 42 and 44 preferably equals or slightly exceeds the axial extent of the ports 48 and 50 and the lands are spaced apart the same distance as are the ports.

It can be seen that with the valve spool 46 in the position indicated by the solid outline, the motor ports 48 and 50 will be blocked by the lands 42 and 44, and hence isolated from communication with both the central chamber 40 and the end chambers 34 and 36. Shifting the valve spool 46 to the position indicated by the dotted outlines will effect fluid communication as indicated by the dotted arrows 52 and 54. Similarly, movement of the spool 46 to the position indicated by the alternate dot and dash outline will effect communication as indicated by the alternate dot and dash arrows 56 and 58.

Extending from the motor ports 48 and 50, respectively, are a pair of motor conduits 60 and 62 which lead to the motor 14. Motor 14 is of the reversible type and capable of operation in either direction dependent on which of the conduits 60 or 62 is under pressure.

The conduits 60 and 62 have extending therefrom conduits 64 and 66, respectively. Conduit 64 leads to a spring biased ball type valve designated 68. Similarly, the conduit 66 leads to a valve of the same type, designated 70. Each of the valves, 68 and 70, comprises a housing having a central chamber 72 therein which contains a spring 74 and a ball 76. The spring 74 in each of the valves 68 and 70 biases the ball 76 therein to a position such that the central chamber 72 of the valve is isolated from its associated conduit 64 or 66. A branched passage 78 extends from the central chamber 40 of the valve 30 to communicate with the chamber 72 in each of the valves 68 and 70. As heretofore noted, chamber 40 is maintained at the outlet pressure of pump 10 by a fluid conducted through the delivery conduit 24, and hence delivery pressure of pump 10 will be conducted to the chamber 72 of each of the valves 68 and 70. Each of the balls in the valves 68 and 70 is thus subjected on one side to pressure in the chamber 72 and on the other side to the pressure existing in the motor conduit 60 or 62 associated with that valve. Each of the balls 76 has exerted thereon a force due to its spring 74, a force due to the operating pressure of the pump acting upon the effective area of the ball exposed to pressure in chamber 72 and a force due to pressure in the motor line 60 or 62 associated with that valve and acting on the effective area exposed thereto. Since the effective areas of balls 76, which are exposed to operating pressure of the pump, and pressure in the associated motor line are substantially equal, the pressure in the motor line must at least equal the pump operating pressure before the valve can be opened. Further, to open the valve the pressure in the motor line must exceed the operating pressure of the pump by an amount necessary to induce deflection of the spring 74. Any fluid passing through the valve 68 or 70 to relieve excessive pressure in the motor conduit 60 or 62 will result in increased discharge through the relief valve 26 which maintains the outlet pressure of the pump at the desired maximum.

In operation, the system relief valve 26 might be set to bypass fluid from delivery conduit 24 so as to prevent the operating pressure of the pump 10 from exceeding, say, 3000 p. s. i. Assuming that the valve spool 46 of the valve 30 has been moved to the position indicated by the dotted outline of the spool, fluid will flow through the conduit 24, through the central chamber 40 of valve 30, and through the valve port 50 into the motor conduit 62 leading the fluid motor 14. Rotation of motor 14 and inertia load 18 is thus induced. Fluid from the discharge side of motor 14 passes through the motor conduit 60 to motor port 48, and from there passes through the end chamber 34 and the conduit 38 to the reservoir 20. It should be noted that at this time full operating pressure of the pump 10 is imposed on both the effective area of

the ball 76 in valve 70, which is thus maintained in closed position by the force of spring 74. The ball 76 of the valve 68 is subjected to pump operating pressure on one side and on the other to tank pressure. Valve 68 is thus retained in the closed position. On shifting of spool 46 of the valve 30 to the position shown in the solid lines, the motor port 48 is blocked by the land 42 thus blocking flow from the conduit 60 to the reservoir. As heretofore noted, the load 18 has a high moment of inertia and the blocking of motor port 48 tends to rapidly decelerate the motor 14, resulting in the creation of high pressure in conduit 60 which, if not relieved, would result in rupture of some of the system components.

With the valve spool 46 of the valve 30 in the position indicated by the solid outlines, the discharge of pump 10 is not being utilized and hence will be discharged over the relief valve 26 at its pressure setting of 3000 lbs. p. s. i. This 3000 lb. pressure also exists in chamber 72 of valve 68, and hence is exerted on ball 76 keeping valve 68 closed. A pressure in excess of 3000 lbs. p. s. i. will thus be required in the conduit 60 before the valve 68 will open. As heretofore noted, the amount by which pressure in the conduit 60 must exceed 3000 p. s. i. will be determined by the load of the spring 74. Assuming that the spring 74 is a 500 p. s. i. spring, that is, an unbalanced pressure of 500 p. s. i. is required on the area of ball 76 exposed to pressure in conduit 60 in order to open the valve; the valve 68 will relieve any pressure in conduit 60 in excess of 3500 lbs. p. s. i.

When the motor 14 is operated in the reverse direction, analogous considerations are applicable to the operation of valve 70 when the spool 46 of valve 30 is moved to the center position.

Thus by utilization of a relatively light spring of the order of 500 p. s. i., the valves 68 and 70 will withstand 3500 p. s. i. before opening. Further, a very slight volume of oil has been added to that in the conduits between the motor and valve to preserve satisfactory response characteristics of the system. Another important advantage derived from an arrangement such as that herein described, is that a minimum of piping connections is needed. For example, the fluid which passes over the valves 68 and 70, in relieving surge pressures in the motor lines 60 and 62, is conducted to the reservoir through conduit 24 and conduit 32, which conduits are also utilized in the normal functioning of the circuit.

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 power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; means for preventing excessive pump operating pressure; and pressure responsive valve means having a pair of opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve being normally closed but operative in response to pressure in said return conduit means to vent fluid from said return conduit means, whereby excessive pressures due to overrunning of the load are prevented.

2. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; means for preventing excessive pump operating pressure; and pressure responsive valve means having a pair of substantially

equal opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve being normally closed but operative in response to pressure in said return conduit means to vent fluid from said return conduit means, whereby generation of pressures substantially in excess of pump operating pressure due to overrunning of the load is prevented.

3. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; means for preventing excessive pump operating pressure; and pressure responsive valve means having a pair of opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve means being spring biased to a normally closed position but operative in response to pressure in said return conduit means to vent fluid from said return conduit means, whereby excessive pressures due to overrunning of the load are prevented.

4. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; means for preventing excessive pump operating pressure; and pressure responsive valve means having a pair of substantially equal opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve means being spring biased to a normally closed position but operative in response to pressure in said return conduit means to vent fluid from said return conduit means, whereby pressure due to overrunning of the load is limited to an amount in excess of pump operating pressure determined by the load of said spring.

5. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; means for preventing excessive pump operating pressure; and pressure repsonsive valve means having a pair of opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve means being normally closed but operative in response to pressure in said return conduit to open fluid communication between that part of the conduit means between the first named valve means and the motor and the pump outlet, whereby excessive pressures due to overrunning of the load are prevented.

6. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; relief valve means in communication with the outlet of the pump; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; and pressure responsive valve means having a pair of opposed effective areas, one of said areas exposed to pump operating pressure, the other to pressure in said return conduit means between the first named valve means and the motor, said pressure responsive valve means being normally closed but operative in response to pressure in said return conduit to open fluid communication between that part of the conduit means between the first named valve means and the motor, and the pump outlet, whereby excessive pressures due to overrunning of the load are prevented.

7. In a power transmission for driving a load having substantial inertia, the combination of: a fluid reservoir; a fluid pump; a double acting fluid motor in a driving relation with said load; a pair of motor conduits for conducting fluid to and from said motor; a pump delivery conduit; valve means for selectively connecting one of said motor conduits to the pump delivery conduit and the other to the reservoir; relief valve means communicating with the pump delivery conduit; and a pair of pressure responsive valve means each having an effective area exposed to pressure in one of said motor conduits and an opposed effective area exposed to pressure in said pump delivery conduit, said pressure responsive valve means being normally closed but operative in response to pressure in said motor conduit means to vent fluid therefrom to said pump delivery conduit, whereby excessive pressures due to overrunning of the load are prevented.

8. In a power transmission for driving a load having substantial inertia, the combination of: a fluid pump; a fluid motor in a driving relation with said load; relief valve means in communication with the pump outlet; fluid supply and return conduit means interconnecting the pump and the motor; valve means in the supply and return conduit means to control fluid flow therein; secondary conduit means connecting the pump outlet to said fluid return conduit means between the valve and the motor; and check valve means in said secondary conduit, said check valve means being so oriented as to block flow from the pump, whereby excessive pressures due to overrunning of the load are prevented.

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