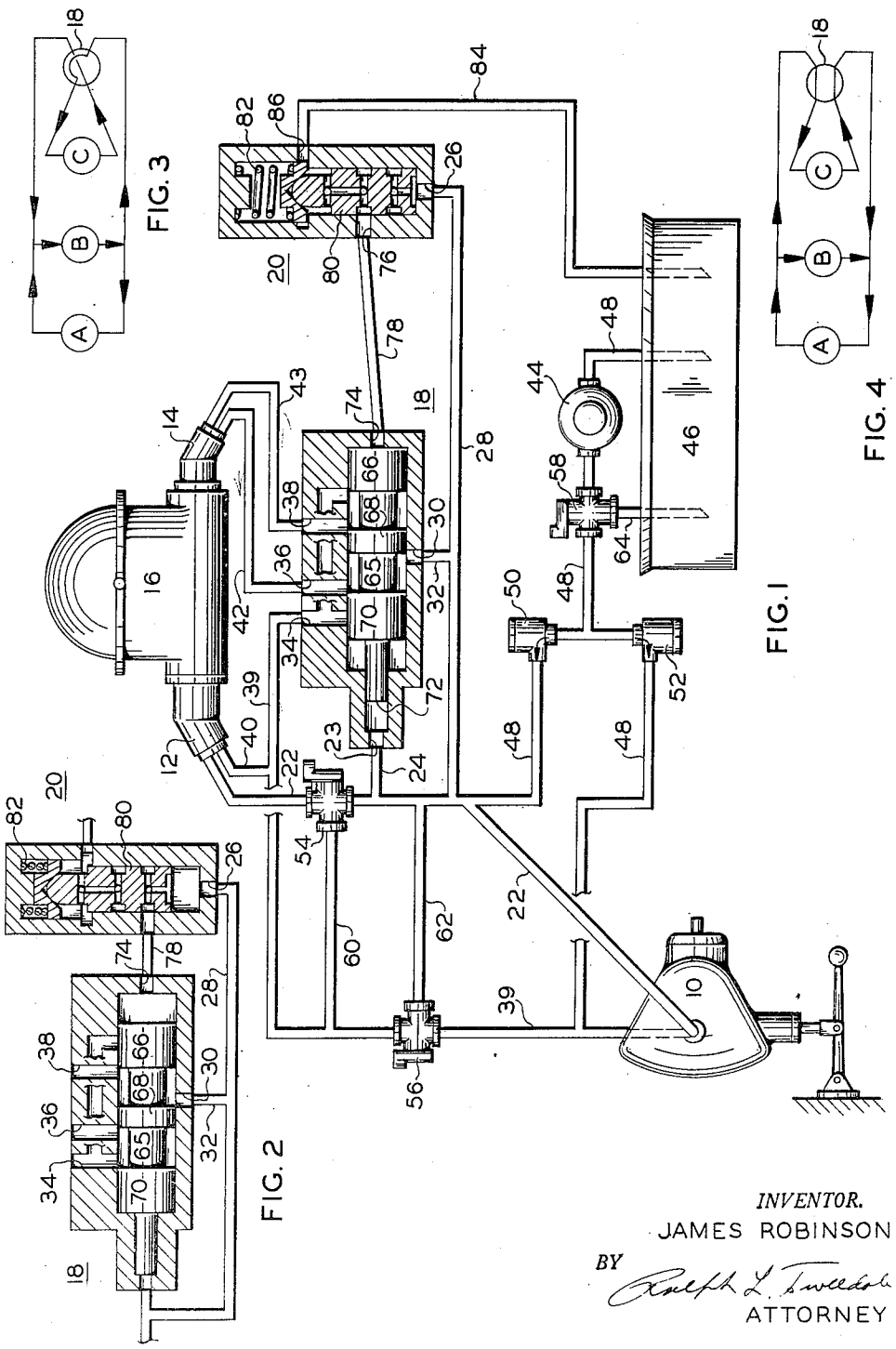
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PUMP-MOTOR HYDRAULIC SYSTEM, INCLUDING MULTIPLE MOTORS AND THEIR CONTROLS

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INVENTOR.
JAMES ROBINSON
BY Ralph L. Tweedale
ATTORNEY

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PUMP-MOTOR HYDRAULIC SYSTEM, INCLUDING MULTIPLE MOTORS AND THEIR CONTROLS

James Robinson, Huntington Woods, Mich., assignor 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.

The invention is generally concerned with a system of this character for driving a load device requiring low torque at high speeds and high torque at low speeds.

In particular, the invention is concerned with a system of this type at which a very high torque is demanded at low speed and a very high speed at low torque, and wherein the intermediate torque and speed between these extreme conditions are relatively unimportant.

In the past, conventional hydraulic transmissions of this type required a large hydraulic motor for delivering high torque which in turn necessitated the use of a large pump for driving the motor at extremely high speeds.

It is an object of this invention to provide a hydraulic power transmission system which enables the use of smaller units for the extreme conditions mentioned, thereby reducing the overall cost and weight.

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:

Figure 1 is a diagrammatic view of a hydraulic power transmission system embodying a preferred form of the present invention.

Figure 2 is a diagrammatic view of two of the control elements shown in Figure 1, but showing the same in a different operating position.

Figure 3 is a simplified schematic view of the hydraulic system shown in Figure 1 and tracing the course of fluid therein when the control parts are in the position as shown in Figure 1.

Figure 4 is a view corresponding to that of Figure 3, but showing the course of fluid flow when the control parts are in the position shown in Figure 2.

Referring now to Figure 1, there is shown a reversible pump 10, the displacement of which may be manually varied and which may be driven by an electric motor or other prime mover (not shown). The pump 10 is adapted to supply pressure fluid to a pair of fixed displacement rotary fluid motors 12 and 14 which are mechanically coupled to each other and which are also connected to a drum or hoist 16 for the purpose of driving the same. The motor 12 has a greater

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displacement per unit of time than that of motor 14.

A circuit is provided connecting the pump 10 and motors 12 and 14 continuously in parallel. This circuit is controlled by a directional control valve 18 which remains in the position shown in Figure 1 when the pressure in the circuit is low. When the pressure in the circuit increases to a value determined by the setting of a pressure responsive pilot relief valve 20, the control valve 18 is operated to a position shown in Figure 2. A delivery conduit 22 connects the outlet of the pump 10 to the inlet of the motor 12. The delivery conduit 22 is also connected to a control port 23 at the left end of valve 18 by means of a branch conduit 24, to a control port 26 of the pilot valve 20 by means of a branch conduit 28, and to a pressure port 30 of the control valve 18 by means of a branch conduit 32 of the conduit 28. The control valve 18 is also provided with operating ports 34, 36 and 38, the former of which is connected by a return conduit 39 to the pump 10 and to the outlet of the motor 12 by a branch conduit 40. The port 36 is connected to the outlet of the motor 14 by a conduit 42 and the port 38 is connected to the inlet of the motor 14 by a conduit 43. Due to the fact that the pump 10 and the motors 12 and 14 are connected to each other in a closed system, a replenishing pump 44, which is connected to a tank 46 by a conduit 48, supplies fluid to either the delivery or return conduit 22 or 39 by means of a branched conduit 48. Duplicate check valves 50 and 52 are incorporated in the branches of the conduit 48.

Suitable relief valves 54, 56 and 58 are incorporated respectively in the conduits 22, 39 and 48. The relief valves 54, 56 and 58 exhaust excessive pressure fluid, respectively, to the conduits 39, 22, and to the tank 46, respectively, by conduits 60, 62 and 64.

A fluid operated valve spool 65 of the control valve 18 is provided with an extreme right end land 66, a center land 68, and a land 70 to the left of land 68. The left end of the spool 65, indicated generally by the numeral 72, is adapted to be in continual communication with conduit 22 by means of the branch conduit 24 and port 23. The land 66 which has a greater surface area than the left end portion 72 of the spool 65 is only in communication with conduit 22 when the valve 20 is operated in response to predetermined increases in pressure in conduit 22. For this purpose, the right end of the valve 18 is provided with a port 74 in communication with

land 66 which is connected to an outlet port 76 of the valve 20 by a conduit 78.

The valve 20 is provided with a spool 80 biased to the position shown by means of a spring 82 of predetermined resistance. In the position shown, the spool 80 blocks communication between the port 26 and the port 76, but upon pressure increases in conduit 22, as determined by the resistance of spring 82, the spool 80 shifts upwardly to connect the conduits 22 and 28 and the port 26 to the port 76 and the conduit 78. The valve 20 is vented by means of a conduit 84 connected to a venting port 86 of the valve 20 and to the tank 46.

It should be noted that the delivery and return conduits 22 and 39, respectively, of the pump 10 which are connected to the inlet and outlet of the motor 12, and likewise the inlet and outlet conduits 42 and 43, respectively, of motor 14 alternate as delivery and return and as inlet and outlet conduits depending upon the direction of rotation of the pump 10.

Referring now to Figure 1, for a hoisting operation, with the pump 10 being operated in a direction making conduit 22 the delivery conduit and conduit 39 the return conduit, pressure fluid is delivered by conduit 22 to the inlet of motor 12, to the pressure port 30 of valve 18 by conduits 28 and 32 and to the control port 26 of valve 20 by conduit 28. Pressure fluid is also delivered to the port 23 of valve 18 by means of the conduit 22 and branch conduit 24. Pressure fluid entering the port 23 of the valve 18 contacts the portion 72 of the spool 65 and shifts the latter to the position shown. As long as the pressure in conduit 22 remains below the setting of the valve 20, the spool 65 is maintained in the position shown. Although conduit 22 is in communication with the outlet of the motor 14, as the motor 12 is capable of delivering a greater torque than motor 14, the former motor will drive the latter as a pump. The displacement from motor 12 is delivered to the inlet of the motor 14 by the conduit 40 connected to the outlet of motor 12, conduit 39, ports 34 and 38 of the control valve 18, and the inlet conduit 43 of the motor 14. The displacement from motor 14 is delivered by means of the ports 36 and 30 of the valve 18 and the conduits 32 and 28 to the delivery conduit 22 of pump 10 and thence to the inlet of the motor 12. As motor 12 has a greater displacement than motor 14, the discharge from motor 12 in excess of the consumption of motor 14 is returned to the pump 10 by means of the return conduit 39. Consequently, the drum 16 will be driven solely by the motor 12. The speed at which the drum is driven by the motor 12 will be commensurate with the total displacement of pump 10 being delivered to the motor 12 plus the total displacement of motor 14 added to the pump delivery, pump 10 and motor 14 thus acting in parallel to supply the motor 12. The torque delivered is low, being that of motor 12 less that required to operate motor 14 as a pump. The driving speed will be high because the displacement of motor 14 is added to the supply of fluid flowing to the inlet of the motor 12 from pump 10.

When the torque demand reaches the opposite extreme, the pressure in conduit 22 will also increase. When it reaches a value determined by the setting of spring 82 of valve 20, the spool 80 will shift upwardly to connect the conduits 22 and 28 and the ports 26 and 76 of the valve 20 to the conduit 78 and the port 74 of the valve

18. The positions of the control valve 18 and the pilot valve 20 will now be as shown in Figure 2. With an equal pressure existent at both ends of the valve spool 65, the latter will shift leftwardly due to the greater surface area of land 66. With the valve spool 65 shifted leftwardly, the port 30 of the valve 18 will be connected to port 38 thereof and the port 36 will be connected to the port 34. Pressure fluid from the pump 10 in addition to being delivered to the inlet of the motor 12 is now delivered by conduits 22, 28 and 32, the valve ports 30 and 38, and the conduit 43 to the inlet of the motor 14. Fluid displaced from the motor 12 through conduit 40 flows back to the pump 10 through the return conduit 39 while the displacement from the motor 14 also flows to the return conduit 39 of pump 10 by means of conduit 42, and the ports 36 and 34 of valve 18. As the total displacement of the pump 10 is now divided between both of the motors, the speed of the drum 16 will be proportionately decreased. However, the motor 14 will now deliver torque to the drum 16 in addition to the torque delivered by the motor 12. Consequently, although the speed of the drum is proportionately decreased by the subtracting of the consumption of motor 14 from the fluid displacement of the pump 10, the torque delivered is increased to the combined delivered torque of both motors.

If the rotation of pump 10 is reversed for a lowering operation, the supply conduit 39 becomes the delivery conduit and the delivery conduit 22 becomes the return conduit. Likewise, the inlets and the outlets of the motors 12 and 14 are reversed as to the operation of said motors. Fluid is now delivered by the pump 10 through the delivery conduits 39 and 40 to the inlet of motor 12 to reverse the driving direction of motor 12. Although conduit 39 is open to the outlet of the motor 14, the motor 12 will drive the motor 14. The inlet of the motor 14 is supplied with fluid being displaced from motor 12 by means of the conduits 22, 28 and 32, the ports 30 and 36 of valve 18, and the conduit 42. Fluid displaced from the motor 14 is added to the supply of fluid from the pump 10 and directed to the inlet of motor 12 by means of the conduit 43, the ports 38 and 34 of the valve 18, and conduit 39. There will be a continual pressure in the conduit 22 and a negligible pressure in conduit 39 regardless of whether a hoisting or lowering operation is taking place. The pressure exists in the direction of the load and due to the fact that the load on both motors 12 and 14 is in the same direction and continually biases the motors in that direction, regardless of a hoisting or lowering operation, there will be a continual pressure in the conduit 22. The amount of the pressure is dependent upon the load. The setting of the valve 20 is accordingly determined by the pressure which a high load will create in order to connect both motors to the load and thus utilize their combined torque output.

In a lowering operation, the load actually drives the motors and the motors tend to drive the pump and overhaul the same. When the load is increased, the tendency to overhaul the pump is increased. The pump continually opposes this tendency to overhaul and consequently any increase in load increases the pressure in the conduit 22.

Thus, in a lowering operation, if the load is increased to an extent creating a pressure in conduit 22 sufficient to overcome the resistance of valve 20, the valve 20 will be operated to con-

nect the conduits 22, 28, and 26 to conduit 78 and shift the valve spool 65 of the valve 18 to the position shown in Figure 2. Conduit 39 is now connected to the inlet of motor 12 and to the inlet of motor 14 by means of ports 34 and 36 of valve 18 and conduit 42. The outlet of the motor 14 is connected to conduit 22 by conduit 43, ports 38 and 30 of valve 18 and conduits 32 and 28. The outlet of motor 12 is connected to conduit 22. The speed of the drum is decreased because the conduit 39, connected to the outlet of the pump 10, is connected to the inlet of both motors, thus dividing its displacement.

It should thus be noted that the transmission provided is an economical and efficient means of driving a load device at high speed with low torque and with high torque at low speed. The speed of the larger motor at low torque is increased by adding to the pump delivery the displacement from the smaller motor. The torque delivered is low because only the one motor drives the load device at high speed and the torque is further decreased by that one motor having to drive the smaller motor as a pump.

The torque delivered to the load device is increased by adding the torque delivery of the smaller motor for driving the load device at low speed. The speed is low because the pump flow is proportionately divided between the two motors.

It should also be noted that the extreme low and high speeds of the load device and the extreme low and high torque delivered thereto may be varied over a wide range by careful preselection of the displacement and torque delivery of the motors.

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 of a pump unit A, a motor unit B and a combination motor-pump unit C, unit B having a greater displacement than unit C and units B and C being mechanically coupled to each other and to a load device, a circuit connecting the units and means for selectively establishing two circuit connections, one with units A and C in parallel with each other to operate unit B as a motor and unit C as a pump and the other with unit A operating B and C in parallel as motors.

2. In a hydraulic power transmission system the combination of a pump unit A, a motor unit B, and a combination motor-pump unit C, unit B having a greater displacement than unit C and units B and C being mechanically coupled to each other and to a load device, a circuit establishing a parallel connection of the units and means for selectively reversing the connections of one of the units B and C to cause the unit C to either assist or oppose the unit B in driving the load device.

3. In a hydraulic power transmission system the combination of a pump unit A, a motor unit B, and a combination motor-pump unit C, unit B having a greater displacement than unit C and units B and C being mechanically coupled to each other and to a load device, a circuit connecting the units, and pressure responsive control valve means for selectively establishing two circuit connections, one with units A and C in parallel with each other to operate unit B as a motor and unit C as a pump and the other with unit A operating B and C in parallel as motors.

4. In a hydraulic power transmission system the combination of a pump unit A, a motor unit B and a combination motor-pump unit C, unit B having a greater displacement than unit C and units B and C being mechanically coupled to each other and to a load device, a circuit establishing a parallel connection of the units and pressure responsive control valve means for selectively reversing the connections of one of the units B and C to cause the unit C to either assist or oppose the unit B in driving the load device.

5. In a hydraulic power transmission system the combination of a pump unit A, a motor unit B and a combination motor-pump unit C, unit B having a greater displacement than unit C and units B and C being mechanically coupled to each other and to a load device, a circuit connecting the units and means for selectively establishing at predetermined low pressures one circuit connection and at a predetermined increase in pressure another circuit connection, the one at low pressures establishing units A and C in parallel with each other to operate B as a motor and C as a pump and the one at high pressure establishing units B and C in parallel with unit A operating both unit B and unit C as motors.

6. In a hydraulic power transmission system the combination of a variable displacement pump unit A, a motor unit B and a motor-pump unit C, units B and C both being of the fixed displacement type and unit B having a greater displacement per unit of time than unit C, the units B and C being mechanically coupled to each other and to a load device, a circuit including connections continuously establishing the units in parallel relationship, and means for controlling the connections for causing A and C to operate B and for causing A to operate B and C.

7. In a hydraulic power transmission system the combination of a variable displacement pump unit A, a motor unit B and a motor-pump unit C, units B and C both being of the fixed displacement type and unit B having a greater displacement per unit of time than unit C, the units B and C being mechanically coupled to each other and to a load device, a circuit including connections continuously establishing the units in parallel relationship, and pressure responsive means for controlling the connections, said means at low pressures causing A and C to operate B for driving the load device at high speed and low torque and said means at predetermined higher pressures causing A to operate B and C for driving the load device at low speed and high torque.

JAMES ROBINSON.

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