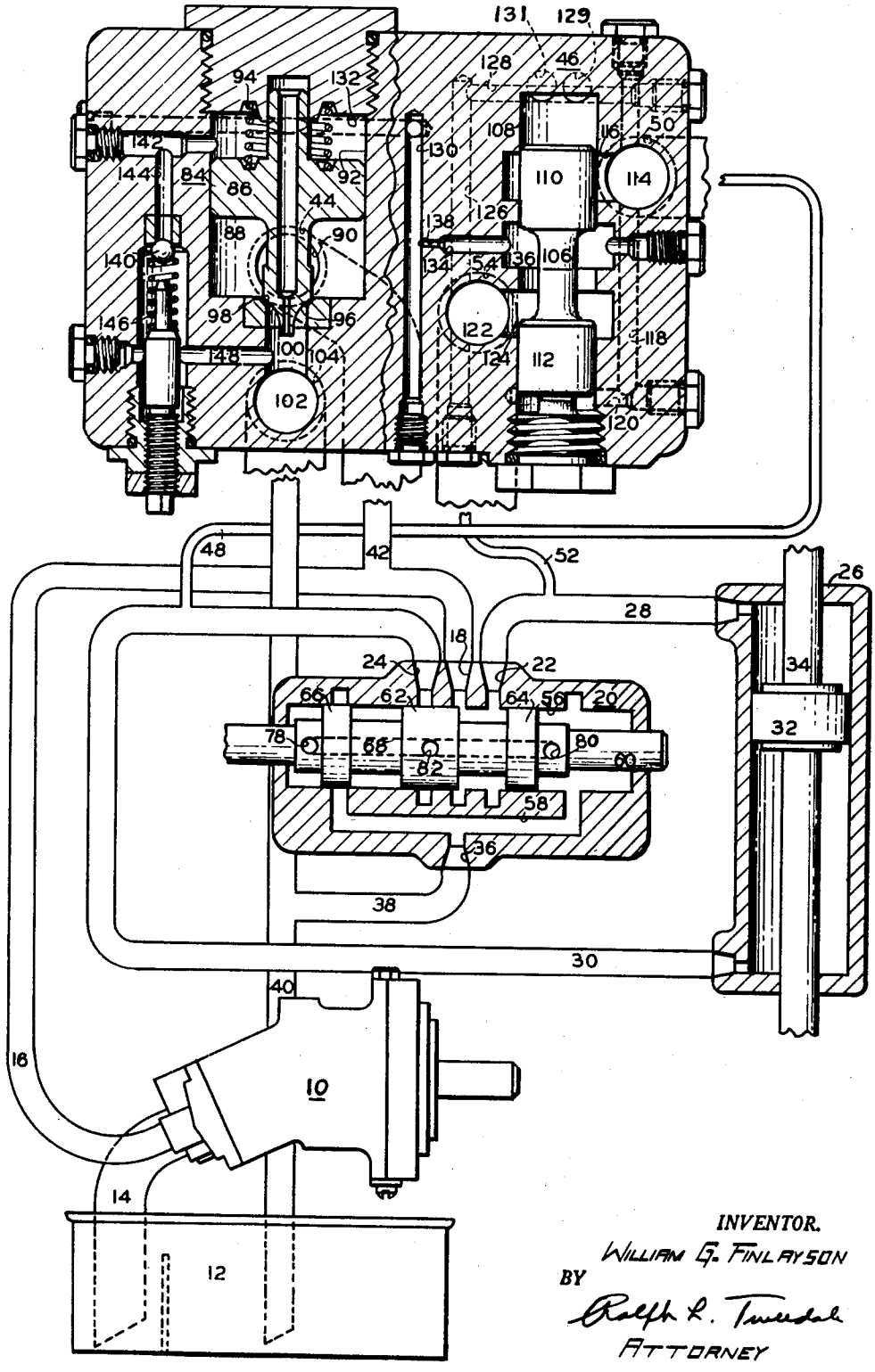
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FLOW REGULATING DEVICE

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FLOW REGULATING DEVICE

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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 particularly concerned with flow regulating valves of the compensating by-pass type for use in hydraulic transmissions containing a fluid pump, a reversible fluid motor and throttling means for regulating the speed of the motor. This type of valve has been used in the past to maintain a constantly regulated flow of fluid through the throttle, doing this by being responsive to the pressure ahead of and beyond the throttle for maintaining a uniformly constant pressure drop across the throttle. However, where the speed of the motor was to be regulated in both directions and a throttling effect was to be produced by the partial opening in both directions of a directional control valve, the problem of maintaining a constant pressure drop across both throttles was solved by using a separate compensating valve for each throttle.

It is an object of this invention to provide in a hydraulic system having a fluid pump, a reversible fluid motor, and a directional control valve which may be opened partially to provide a throttling means for each end of the motor, means combined with a single compensating by-pass valve for causing the compensating valve to maintain a uniformly constant pressure drop across both throttles.

It is a further object to provide for a hydraulic system, as above mentioned, a single compensating valve of the by-pass type responsive to pressure ahead of both throttles and a pressure-actuated shuttle valve in combination therewith to cause the compensating valve to be responsive to the pressure drop beyond the throttle through which fluid is being directed to the motor.

It is also an object of this invention to provide in combination with a compensating valve of the by-pass type a simply constructed, economically manufactured shuttle valve for the purpose above stated and, in addition, a pressure responsive, pilot-control valve for causing the compensating valve to relieve the pump of excessive pressure fluid.

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 shown is a diagrammatic view of a simple hydraulic system incorporating a sectional view of a preferred form of the present invention.

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Referring now to the single figure, there is shown a pump 10 which may be driven by a prime mover, not shown, which is connected to a tank 12 by means of a suction conduit 14 and which is connected by means of a pump discharge conduit 16 to the pressure port 18 of a four-way directional control valve 20. A pair of motor ports 22 and 24 of directional control valve 20 are connected to opposite ends of a balanced-type cylinder motor 26 by means of fluid conduits 28 and 30, respectively, the motor 26 having a piston 32 reciprocably mounted therein to which is connected a piston rod 34 extending from each end of the motor. A tank port 36 of valve 20 is connected to tank 12 by means of a conduit 38 and a conduit 40.

A branch conduit 42 connected to pump delivery conduit 16 connects the pump 10 to a pressure port 44 of a flow control valve 46. A branch conduit 48 connected to motor conduit 30 connects the latter conduit to a cylinder port 50 of the valve 46, and a branch conduit 52 connected to motor conduit 28 connects the latter conduit to another cylinder port 54 of valve 46.

The valve 20 is provided with a centrally-located longitudinal bore 56 which is directly connected to the pressure port 18 and the motor ports 22 and 24 and which is connected to the tank port 36 by means of a passage 58 having two arms connecting the passage 58 to opposite ends of the bore 56. Reciprocably mounted in the bore 56 is a spool 60 provided with a centrally-located land 62 and lands 64 and 66 spaced apart to the right and left, respectively, of central land 62. Spool 60 is provided with a centrally-located longitudinal passage 68 which is directly connected to a plurality of ports 78 to the left of land 66, a plurality of ports 80 to the right of land 64, and a plurality of ports 82 in central land 62. The lands 62 and 64 cooperate to control the admission of fluid from the pressure port 18 to either of the motor ports 22 or 24, and the plurality of ports 82 in cooperation with the passage 68 and the plurality of ports 78 and 80 control the return flow of fluid from motor 26 flowing in motor conduits 28 or 30 so as to properly direct said return flow to tank port 36 through the medium of passage 58. The spool 60 may be shifted completely in either direction so as to open the pressure port 18 completely to motor port 22 or 24, or it may be variably partially shifted in either direction so as to partially open motor port 22 or 24 to pressure port 18 for providing a throt-

tling effect for the flow of fluid to motor 26 through motor conduit 28 or 30. Thus, the effect of the partial opening of the pressure port and the motor port produces an effect exactly identical to that of having a variable throttle in each of the motor conduits 28 and 30.

Referring now to flow regulating valve 46, there is shown a compensating by-pass valve 84 reciprocably mounted therein which is comprised of a piston 86 having its under-surface area exposed to pressure within an inlet chamber 88 which is connected to the pressure port 44 of valve 46 by means of a passage 90 and its upper surface exposed to pressure within a control chamber 92. A spring 94 of predetermined resistance biases piston 86 so that a valve 96 formed at the lower end thereof closes a seat 98 which is connected to an exhaust chamber 100. Exhaust chamber 100 is connected to tank 12 by means of a passage 102 which is directly connected to an exhaust port 104, the latter being connected to tank 12 by means of conduit 40.

A shuttle valve 106 is adapted to connect either the motor conduit 28 or the motor conduit 30 to the control chamber 92 of valve 84. Shuttle valve 106 is reciprocably mounted in a bore 108 and is provided with end lands 110 and 112. Cylinder port 50 is connected to bore 108 by means of a passage 114 which intersects a groove 116 of bore 108 controlled by land 110. Cylinder port 50 is also connected to the end surface of land 112 by means of a passage 118 and a passage 120 which although on a slightly different plane that of bore 108 intersects bore 108, passage 114 not only intersecting groove 116 but also intersecting passage 118. Cylinder port 54 is connected to bore 108 by means of a passage 122 which intersects a groove 124 of bore 108. Cylinder port 54 is connected to the end surface of land 110 by means of a passage 126 which intersects a passage 128, the latter passage being connected to the extreme end of bore 108 by means of two passages 129 and 131. Passages 118 and 120 lie in a different plane from that of passages 126 and 128 so that the two sets of passages do not connect with each other.

The shuttle valve 106 is adapted to be actuated upwardly when the control valve 20 directs pressure fluid to the motor 26 through motor conduit 30 and downwardly when pressure fluid is directed to the motor through motor conduit 28. The shuttle valve 106 will block communication between the control chamber 92 and the end of the motor from which fluid is flowing to tank 12 while at the same time expose the upper surface of piston 86 within chamber 92 to the pressure in the motor conduit through which pressure fluid is flowing to the motor. Bore 108 is connected to a vertical passage 130, the latter of which is connected to control chamber 92 of compensating valve 84 by a passage 132, by means of a passage 134 which connects a groove 136 of bore 108 with vertical passage 130. A restriction 138 is formed in passage 134 for a purpose hereinafter mentioned.

Control chamber 92 of valve 84 is connected to a small poppet relief valve 140 by means of a passage 142 and a passage 144 intersecting passage 142. When a predetermined pressure has arisen in control chamber 92 as determined by the resistance of a spring 146, relief valve 140 will open passage 144 to exhaust chamber 100 of compensating valve 84 by means of a passage 148.

In operation, with the pump 10 running and spool 60 of control valve 20 shifted, as shown, so

as to partially open pressure port 18 to conduit 28, pressure fluid will be discharged from pump 10 through conduit 16 and enter the pressure port 18 of valve 20. Pressure fluid will also flow by means of conduit 42 connected to pump discharge conduit 16 to the pressure port 44 of flow-regulating valve 46 where, by means of passage 90, it flows into the inlet chamber 88 of compensating valve 84, exposing the under-surface of piston 86 to the pressure within said chamber. Pressure fluid entering pressure port 18 is directed by control valve 20 to conduit 28 and thence flows to the upper end of motor 26, shifting piston 32 downwardly. Due to the fact that pressure port 18 and motor port 22 have only been opened partially by land 62, a drop in pressure takes place across port 18. This drop in pressure across pressure port 18 is present in control chamber 92 to act upon the upper surface of piston 86 by means of conduit 52, cylinder port 54, passage 122, groove 124, bore 108, groove 136, passage 134, passage 130 and passage 132. The drop in pressure across port 18 present in conduit 28 is present in control chamber 92 because shuttle valve 106 has been actuated by pressure fluid in conduit 28 to open cylinder port 54 of valve 46 to the control chamber 92 of valve 84. Pressure fluid in conduit 28, being delivered to the upper end of motor 26, is also delivered to cylinder port 54 by means of conduit 52 and by means of passage 122 to vertical passage 126 where it flows to the upper end of bore 108 to act on the extreme surface of land 110 by means of passage 128 and passages 129 and 131. The pressure force necessary to shift shuttle valve 106 being much less than that needed to shift piston 32 of motor 26 shuttle valve 106 will be actuated completely before the motor may operate. Fluid displaced from the lower end of bore 108 by the land 112 is conducted to the motor port 24 of directional control valve 20 by means of passages 120, 118, and 114 and port 50 of shuttle valve 46, and conduits 48 and 30, and thence to the tank 12 by means of the transverse ports 82, passage 68, and transverse ports 80 of valve spools 60, valve bore 56, passage 58, port 36, and conduits 38 and 40.

Due to the fact that the under-surface of piston 86 is equal to the upper surface of said surface and that the pressure ahead of the throttle is acting on the under-surface of the piston and the pressure beyond the throttle is acting on the upper surface of the piston, the resistance of spring 94 will determine the pressure drop across the throttle 18. If this pressure drop tends to become greater or less than the resistance of the spring 94, this increase and decrease of pressure drop will also be present in inlet chamber 88 and control chamber 92 to shift piston 86 upwardly or downwardly thereby shifting the valve 96 to more fully open or close the seat 98 to exhaust chamber 100. Only an amount of fluid will be bypassed sufficient to maintain the flow across the throttle 18 constant.

If a rapid-traverse movement of the motor 26 is desired, the spool 60 of control valve 20 may be shifted completely to the left from the position indicated on the drawing so as to open fully the pressure port 18 to the motor port 22. In such a case, due to the fact that piston 86 is only responsive to a pressure drop across an existing throttle which no longer exists because spool 60 has been shifted completely, the compensating valve 84 will be closed and permit the rapid movement of piston 32 of motor 26.

If the motor 26 is to be operated in the opposite direction and a regulated feed movement is desired, spool 60 is shifted rightwardly but not completely so as to partially open pressure port 18 to motor port 24. Pressure fluid from pump 10 will now be delivered by pump discharge conduit 16 to the pressure port 18 of control valve 20 and also by means of branch conduit 42 to the pressure port 44 of flow-regulating valve 46. Due to the fact that the pressure port 18 has been only opened partially to motor port 24, a throttle is created at port 18, and the pressure ahead of said throttle will be present in inlet chamber 88 to act on the under-surface of piston 86. Pressure fluid flowing across the throttle created by land 62 at port 18 will be delivered by means of conduit 30 to the lower end of motor 26, shifting piston 32 upwardly and at the same time by means of branch conduit 48 connected to motor conduit 30 to the motor port 50 of valve 46 from whence by means of passage 114 it is delivered to passage 118 and by means of passage 120 to bore 108 where it may act upon the extreme end surface of land 112, shifting shuttle valve 106 upwardly. Due to the fact that the pressure force needed to shift shuttle valve 106 is much less than that needed to shift piston 32 of motor 26, shuttle valve 106 will move and shift completely to the extreme position before motor 26 begins to operate in the opposite direction. Fluid displaced from the upper end of bore 108 by the land 110 is conducted to the motor port 22 of directional control valve 20 by means of passages 129 and 131, passages 128, 126, and 122 and port 54 of shuttle valve 46, and conduits 52 and 28, and thence to the tank 12 by means of transverse ports 82, passage 68, and transverse ports 78 of valve spool 60, valve bore 56, passage 58, port 36, and conduits 38 and 40.

When shuttle valve 106 has shifted completely upwardly, land 110 will have opened groove 116 to passage 114, and pressure fluid in said passage may enter bore 108 from whence it may flow to the control chamber 92 of valve 84 by means of passage 134, restriction 138, passage 130 and passage 132. Pressure fluid in bore 108 is prevented from flowing into passage 122 by means of land 112 of valve 106 blocking communication therefrom. When shuttle valve 106 has moved completely upwardly, piston 32 of motor 26 will begin to shift, and compensating valve 84 will maintain the flow across the throttle created at port 18 constant. Pressure ahead of pressure port 18 will be present in inlet chamber 88, and pressure past the throttle at port 18 will be present in control chamber 92. If the pressure drop across the throttle tends to be greater or less than the resistance of spring 94, piston 88 will shift, opening or closing seat 98 more fully to exhaust chamber 100, and a sufficient amount of fluid will be by-passed to tank 12 to maintain the flow across throttle 18 constant.

If a rapid traverse movement of motor 26 is desired in the upper direction, spool 60 is shifted completely rightwardly so as to open fully pressure port 18 to motor port 24, and the full flow of pressure fluid from pump 10 will be delivered to the lower end of motor 26 while compensating valve 84 remains closed.

The block 46 is so constructed that all its connection ports come out at the bottom surface thus lending it to use with a gasket mounted valve block. Thus it may be bolted against any flat surface which has mating conduit openings formed to register with the ports of the valve

block. Preferably the mounting surface may be formed on the four-way valve 20 in which case the branch passages 48 and 52 are unnecessary.

It should be noted that any conventional type of four-way directional control valve may be used providing that the directional control valve may be opened partially in both directions so as to produce a throttling effect in the motor conduits 28 and 30. In addition, variable throttles could be incorporated in motor conduits 28 and 30, the directional control valve shifted completely in both directions, and the throttles in such motor conduits could be operated manually or by pressure responsive means. In its preferred form, however, the invention is used with the type of four-way directional control valve shown for the reason that the operator may at any time determine the degree of opening in order to have a variable feed movement of the motor and the operator may at any time produce a rapid-traverse of the motor 26 in either direction.

It should also be noted that the shuttle valve 106 is simply designed and economically manufactured and that, when used in combination with the compensating by-pass valve 84, it is a simple and an efficient means of producing feed movement in both directions of a reversible fluid motor with the use of only one compensating valve.

Whenever the pressure in motor conduit 28 or motor conduit 30 reaches a predetermined maximum, this pressure is also present in control chamber 92 and, by means of passage 142 and passage 144, may act upon pilot control valve 140 to shift the same against the resistance offered by spring 146 and opening control chamber 92 to exhaust chamber 100 by means of passage 148. Due to the fact that pressure fluid in control chamber 92 may bleed through the opening created by the shifting of pilot control valve 140 faster than pressure fluid may enter the control chamber 92 through the restriction 138, a sudden unbalancing of pressure forces takes place within inlet chamber 88 and control chamber 92, causing the increase of pressure in inlet chamber 88 to shift the piston 86 upwardly and resulting in the valve 96 opening seat 98 completely to exhaust chamber 100. All excessive pressure fluid from pump 10 is then completely by-passed by means of compensating valve 84 to the tank 12.

Whenever the pressure in motor conduit 28 or 30 drops below the resistance offered by spring 146, the spring 146 will shift the valve 140 to close communication between the control chamber 92 and exhaust chamber 100, thus again balancing the pressure forces in inlet chamber 88, control chamber 92 and permitting spring 94 to shift the piston 86, and the valve 96 will close seat 98. Compensating valve 84 is thus in a position to again be responsive to the pressure drop created across port 18 for either direction of operation and will be responsive to the pressure drop across said port so as to maintain a constant regulated flow of fluid to the motor 26. Thus, the pilot control valve 140 used in combination with the compensating valve 84 enables the compensating valve 84 to perform the double function of maintaining a constant pressure drop across the throttle created at port 18 by the right or left hand peripheral surface of land 62 and also enables the compensating valve 84 to perform the function of a relief 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 containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve and a pressure actuated shuttle valve for maintaining a uniformly constant pressure drop across the throttle through which fluid is being directed by the control valve to the motor.

2. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve containing a compensating valve having opposed piston areas one area of which is continuously exposed to pressure ahead of the throttles and a pressure actuated shuttle valve for exposing the remaining compensating valve piston area to pressure beyond a throttle through which pressure fluid is being directed to the motor thereby maintaining a uniformly constant pressure drop across said throttle.

3. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve having a bypass and a compensating valve for controlling the by-pass, said compensating valve having opposed piston areas one area of which is continuously exposed to pressure ahead of the throttles, and a pressure actuated shuttle valve for exposing the remaining piston area to pressure beyond a throttle through which pressure fluid is being directed to the motor thereby maintaining a uniformly constant pressure drop across said throttle.

4. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve having a bypass and a compensating valve for controlling the by-pass, said compensating valve having opposed piston areas one area of which is continuously exposed to pressure ahead of the throttles, and a shuttle valve connected to both ends of the motor beyond the throttles and to the remaining piston area of the compensating valve, said shuttle valve being responsive to pressure fluid flowing to the motor to expose the remaining piston area to pressure beyond a throttle through which pressure fluid is flowing to the motor whereby the compensating valve maintains a uniformly constant pressure drop across said throttle.

5. In a hydraulic power transmission containing a fluid pump, a reversible fluid motor, a directional control valve and separate fluid conduits connecting the control valve to the pump, to both ends of the motor and to an exhaust source, said control valve being of the type for selectively directing fluid to and from the motor for either direction of operation thereof and having a range of travel in each direction for providing a variable throttle for each motor conduit, the combination of a flow regulating valve containing a by-pass, a compensating valve for controlling the by-pass and means resiliently biasing the compensating valve to close the by-pass, said compensating valve having opposed piston areas one area of which is continuously exposed to pressure ahead of the throttles, and a shuttle valve connected beyond the throttles to the motor conduits and to the remaining piston area of the compensating valve, said shuttle valve being responsive to pressure fluid in a motor conduit through which fluid is flowing to the motor for connecting said conduit to the remaining piston area of the compensating valve whereby the compensating valve maintains a uniformly constant pressure drop across the throttle through which pressure fluid is flowing to the motor.

6. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a compensating by-pass valve and a pressure actuated shuttle valve for maintaining a uniformly constant pressure drop across the throttle through which fluid is being directed by the control valve to the motor and means responsive to predetermined increases in pressure for causing the compensating by-pass valve to perform the function of a relief valve.

7. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a compensating by-pass valve and a pressure actuated shuttle valve for maintaining a uniformly constant pressure drop across the throttle through which fluid is being directed by the control valve to the motor and a pilot control valve responsive to predetermined increases in pressure for causing the compensating by-pass valve to perform the function of a relief valve.

8. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve and a pressure actuated shuttle valve for maintaining a uniformly constant pressure drop across the throttle through which fluid is being directed by the control valve to the motor, said flow regulating valve containing a by-pass, a compensat-

ing valve for controlling the by-pass having opposed piston areas one of which is connected to the pump ahead of the throttles, and resilient means of predetermined resistance biasing the compensating valve to close the by-pass, and the shuttle valve being connected to the remaining piston area of the compensating valve and to the directional control valve beyond the throttles, said shuttle valve being responsive to pressure past the throttle through which pressure fluid is flowing to the motor for exposing the remaining piston area of the compensating valve to pressure beyond said throttle.

9. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor and a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof, said control valve having a range of travel in each direction for providing a variable throttle for each end of the motor, the combination of a flow regulating valve and a pressure actuated shuttle valve for maintaining a uniformly constant pressure drop across the throttle through which fluid is being directed by the control valve to the motor, said flow regulating valve containing a by-pass, a compensating valve for controlling the by-pass having opposed piston areas one of which is connected to the pump ahead of the throttles, and resilient means of predetermined resistance biasing the compensating valve to close the by-pass, and the shuttle valve being connected to the remaining piston area of the compensating valve and to the directional control valve beyond the throttles, said shuttle valve being responsive to pressure past the throttle through which pressure fluid is flowing to the motor for exposing the remaining piston area of the compensating valve to pressure beyond said throttle, and means responsive to predetermined increases in pressure for causing the compensating by-pass valve to perform the function of a relief valve.

10. In a hydraulic power transmission containing a fluid pump and a reversible fluid motor the combination of a directional control valve for reversing the direction of operation of the motor, means in the control valve for creating a throttle for each end of the motor upon shifting the control valve a predetermined range in each direction, a flow regulating valve containing a by-pass, a compensating valve for controlling the by-pass, and resilient means of predetermined resistance biasing the valve to close the by-pass, said compensating valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of both throttles, and a hydraulically actuated shuttle valve connected to both ends of the motor beyond the throttles and to the remaining piston surface of the compensating valve for exposing the latter surface to pressure beyond the throttle through which pressure fluid is flowing to the motor whereby the compensating valve is responsive to the pressure drop across the throttle through which fluid is flowing to the motor.

11. In a hydraulic power transmission containing a fluid pump and a reversible fluid motor the combination of a directional control valve for reversing the direction of operation of the motor, a pair of throttles one each connected to each end of the motor, a flow regulating valve containing a by-pass, a compensating valve for controlling the by-pass, and resilient means of predetermined resistance biasing the valve to close the by-pass, said compensating valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of both throttles, and a hydraulically actuated shuttle valve connected to both ends of the motor beyond the throttles and to the remaining piston surface of the compensating valve for exposing the latter surface to pressure beyond the throttle through which pressure fluid is flowing to the motor whereby the compensating valve is responsive to the pressure drop across the throttle through which fluid is flowing to the motor.

12. In a hydraulic power transmission having a fluid pump forming a source of pressure fluid, a reversible fluid motor, and means forming a pair of throttles one for each end of the motor the combination of a compensating by-pass valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of the throttles and a hydraulically actuated shuttle valve responsive to the direction of flow through said throttles for exposing the opposite piston surface area to pressure beyond a throttle through which fluid is being directed to the motor.

13. In a hydraulic power transmission having a fluid pump forming a source of pressure fluid, a reversible fluid motor, and means forming a pair of throttles one for each end of the motor the combination of a compensating by-pass valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of the throttles, a hydraulically actuated shuttle valve responsive to the direction of flow through said throttles for exposing the opposite piston surface area to pressure beyond a throttle through which fluid is being directed to the motor whereby the compensating valve maintains a uniformly constant pressure drop across both throttles and means responsive to a predetermined pressure for also causing the compensating valve to perform the function of a relief valve.

14. In a hydraulic power transmission having a fluid pump forming a source of pressure fluid and a reversible fluid motor the combination of a directional control valve for reversing the directional operation of the motor, means in said control valve for forming a pair of throttles, one for each end of the motor, during a predetermined range of shifting the control in each direction, a compensating by-pass valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of the throttles and a hydraulically actuated shuttle valve connected to the remaining piston surface area responsive to the position of the control valve for exposing the remaining surface area to pressure beyond a throttle through which fluid is being directed to the motor.

15. In a hydraulic power transmission having a fluid pump forming a source of pressure fluid and a reversible fluid motor the combination of a directional control valve for reversing the directional operation of the motor, means in said control valve for forming a pair of throttles, one for each end of the motor, during a predetermined range of shifting the control in each direction, a compensating by-pass valve having opposed piston surface areas one of which is continuously exposed to pressure ahead of the throttles, a hydraulically actuated shuttle valve connected to the remaining piston surface area responsive to the position of the control valve for exposing the remaining surface area to pressure beyond a

throttle through which fluid is being directed to the motor whereby the compensating valve maintains a uniformly constant pressure drop across the latter throttle and means responsive to a predetermined pressure for causing the compensating valve to perform the function of a relief valve.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,102,865	Vickers	Dec. 21, 1937
2,157,707	Keel	May 9, 1939