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FLOW REGULATING DEVICE

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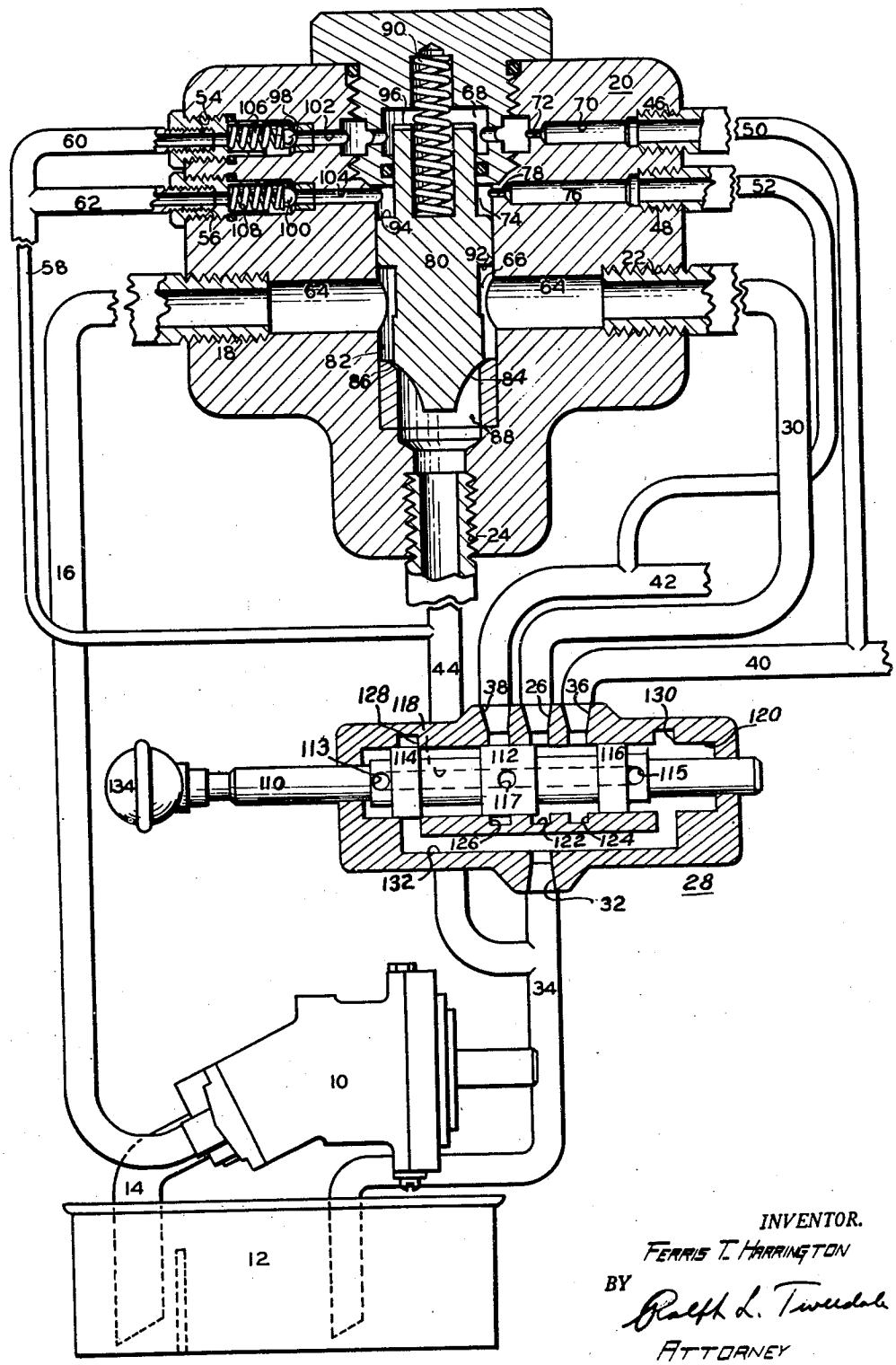


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## FLOW REGULATING DEVICE

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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 is used 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.

In the past where the speed of the motor was to be regulated in both directions and the throttling effect was to be produced by the partial opening of a directional control valve which enables the operator at will to selectively cause rapid transverse movement of the motor in both directions or variable feed movements in both directions at any time, it was deemed necessary to incorporate two compensating by-pass valves in the system, one for each throttle.

Generally, in hydraulic systems having a pump and a reversible fluid motor, a directional control valve for reversing the operation of the motor and a throttle for each end of the motor, a compensating valve for each throttle was incorporated in the system.

It is an object of this invention to provide in such a hydraulic system having a directional control valve for reversing the direction of operation of the motor and having a throttle preferably of the variable type for each end of the motor, a single compensating by-pass valve for maintaining a constantly uniform pressure drop across both throttles.

It is a further object of this invention to provide for a hydraulic system as above stated, a simply constructed and economically manufactured compensating valve of the by-pass type which will be responsive to the pressure drop ahead of and beyond the throttle through which fluid is being directed by the directional control valve to the motor.

It is also an object of this invention to provide in a hydraulic system of the above type in combination with a compensating by-pass valve for the purposes before mentioned, a pressure responsive pilot control valve means causing the compensating valve to also perform the function of a relief valve.

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.

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In the drawing, the single figure is a diagrammatic view of a simple hydraulic system incorporating a sectional view of a preferred form of the present invention.

Referring to the single figure, there is shown a pump 10 which is connected to a tank 12 by means of a suction conduit 14 and which is connected by means of a pump delivery conduit 16 to an inlet port 18 of a flow regulating valve 20 also having a discharge port 22 and a by-pass port 24. The discharge port 22 is connected to a pressure port 26 of a four-way directional valve 28 by means of a conduit 30. The control valve 28 also has a tank port 32 connected to tank 12 by means of a conduit 34 and a pair of motor ports 36 and 38 which are connected to opposite ends of a reversible fluid motor, not shown, by means of conduits 40 and 42. The by-pass port 24 of valve 20 is connected to the tank conduit 34 by means of a conduit 44. The valve 20 also has two control ports 46 and 48, the former of which is connected to motor conduit 40 by means of a conduit 50, and the latter of which is connected to motor conduit 42 by a conduit 52. Two relief ports 54 and 56 are connected to a conduit 58 which is connected to conduit 44 by means of conduits 60 and 62, respectively, which intersects conduit 58.

Pressure port 18 and discharge port 22 of valve 20 are directly connected by means of a passage 64 to an inlet chamber 66. Control port 46 of valve 20 is connected to a first control chamber 68 by means of a passage 70 having a restriction 72 incorporated therein, and control port 48 is connected to a second control chamber 74 by means of a passage 76 also having a restriction 78 incorporated therein. A piston 80 reciprocably mounted in a bore 82 so as to form the inlet and two control chambers previously mentioned within the bore 82 has a valve 84 formed at its lower end for controlling the opening and closing of a seat 86 and by-passing fluid through the seat 86 to an exhaust chamber 88 which is connected to exhaust port 24. A spring 90 of predetermined resistance biases piston 80 so that valve 84 closes seat 86. The piston 80 has a surface indicated by the numeral 92 continuously exposed to pressure in the inlet chamber 66 and a surface indicated by the numeral 94 opposed to the surface 92 which is adapted to be exposed to the pressure existing in motor conduit 42. A third surface at the extreme upper end of the piston 80 and indicated

by the numeral 96 which is also opposed to the surface 92 is adapted to be exposed to pressure existing in motor conduit 40. The surfaces 92, 94 and 96 exposed to pressure within the chambers hereinbefore mentioned are equal in effective area.

It can be seen that if separate throttles were interposed in motor conduits 40 and 42 that the surface area 92 of piston 80 would be continuously exposed to pressure ahead of both throttles whereas the surface area 94 would be exposed to pressure beyond the throttle interposed in motor conduit 42 and the surface area 96 would be exposed to pressure beyond the throttle interposed in motor conduit 40, providing that these throttles were incorporated in the motor conduits 40 and 42 ahead of their intersection with conduits 50 and 52, respectively.

For the purpose of relieving excessive pressure fluid in the system, two pilot relief valves 98 and 100, the former of which is connected to chamber 68 by a passage 102 and the latter of which is connected to chamber 74 by a passage 104, will connect either chamber 68 or chamber 74 to the tank 12 whenever a predetermined maximum pressure has arisen in either of the motor conduits 40 or 42. The maximum pressure is determined by the resistance of duplicate springs 106 and 108 biasing valve 100 to a closed position. By connecting either chamber 68 or chamber 74 to tank 12, the pressure forces acting on either of the surfaces 94 and 96 opposing the pressure forces in the chamber 66 acting on surface 92 will become unbalanced and piston 80 will shift upwardly permitting valve 84 to open seat 86 to exhaust chamber 88 and pressure fluid from pump 10 will be by-passed therethrough to tank 12. Although separate throttles could be incorporated in motor conduits 40 and 42, the invention in its preferred form, for reasons of efficiency, economy and simplicity, makes use of the control valve 28 itself for producing a variable throttling effect in the motor conduit 40 and 42. For this purpose, any suitable conventional four-way directional control valve may be used providing that a throttling action may be provided in the motor conduits by the action of the shifting of the valve. Valve 28 contains a spool 110 having a centrally located land 112 and lands 114 and 116 to the left and right, respectively, of land 112. The spool 110 is also provided with a plurality of transverse ports located at the left of land 114, to the right of 116 and in land 112 indicated, respectively, by the numerals 113, 115 and 117, all of which are connected to a centrally located longitudinal passage 118. The spool 110 is reciprocably mounted within a bore 120 which is provided with a groove 122 connected to the pressure port 26, grooves 124 and 126 connected to the motor ports 36 and 38, respectively, and grooves 128 and 130 which are connected to the arms of a passage 132 which is connected to tank port 32. A handle lever 134 is connected to spool 110 for manual operation of the valve 28.

The operator in shifting spool 110 may partially shift the spool to incompletely open the pressure groove 122 to either of the motor ports 36 and 38, and by gradually shifting said spool in either direction, may create a variable opening.

In operation, with the pump 10 running and with spool 110 shifted to the position shown, pressure fluid from pump 10 will be delivered by discharge conduit 16 to the inlet port 18 of valve 20 and by means of passage 64 flow through the inlet chamber 66 to the outlet port 22 from whence



it will be delivered to the pressure port 26 of valve 28 by means of conduit 30. Due to the fact that land 112 has almost completely uncovered pressure groove 122, a rapid traverse movement of the motor will take place. Piston 80, only being responsive to the pressure drop across the throttle, will not in any way interfere with the full flow of fluid from pump 10 to the motor as long as a throttling effect is not produced by a partial shifting of spool 110. Due to the fact that the surface area 96 and the surface area 92 of piston 80 are equal and the pressure forces within chamber 68 and in the chamber 66 are equal, spring 90 will bias piston 80 so that valve 84 thereof will close seat 86. However, if spool 110 is shifted slightly to the right, pressure groove 122 will be partially closed so as to produce a throttle across land 112. In this case, pressure ahead of the throttle will be present in inlet chamber 66 of valve 20 and pressure past the throttle will be present in chamber 68 by means of motor conduit 40, conduit 50, control port 46, passage 70 and restriction 72. The pressure drop across the throttle will unbalance the pressure forces acting on the surfaces 92 and 96, and piston 80 will shift upwardly permitting valve 84 to open seat 86 to exhaust chamber 88 and a quantity of fluid will be by-passed from pump 10 to tank 12, the remainder of which will be delivered by means of motor conduit 40 to the motor, not shown. Whenever the pressure drop across the throttle created by land 112 of valve 28, however, becomes greater or less than the resistance of spring 90, the piston 80 will be shifted to open or close the seat 86 more fully so as to maintain the pressure drop across the throttle constant and thus maintain the flow to the motor from pump 10 constant. Fluid discharging from the motor through conduit 42 is delivered to motor port 38 and by means of groove 126, the plurality of ports 117 in land 112, passage 118, the plurality of ports 115, bore 120, passage 132, tank port 32 and conduit 34 is delivered to tank 12. Due to the fact that motor conduit 42 is directly connected to tank 12, chamber 74 will also be directly connected to tank 12 and, consequently, pressure forces will be lacking in said chamber to react on surface 94 and disturb the opposing pressure forces acting on surface 92 and surface 96. If the spool 110 is shifted completely to the right, pressure port 26 will be completely open to motor port 38 and motor port 36 will be connected to tank port 32. In this position of the spool 110, a rapid traverse movement of the motor in the opposite direction will take place. However, if the operator shifts spool 110 to the left from the complete rightward position, a throttle across the land 112 through the motor port 38 will be created. As in the opposite directional feed movement of the motor, the pressure ahead of the throttle will be present in inlet chamber 66 but, in this case, the pressure beyond the throttle will be present in control chamber 74 so as to expose the surface area 94 of the piston 80 to the pressure beyond the throttle. Pressure fluid from pump 10 will be delivered by means of pump delivery conduit 16 to the inlet port 18 of control valve 20, and by means of passage 64 through the inlet chamber 66, through the outlet port 22 of valve 20 and through the pressure port 26 of valve 28 by means of conduit 30. Fluid will flow through groove 122 and across the throttle created by land 112 into motor port 38 and by means of motor conduit 42 to the opposite end of the motor, not shown, and by means of conduit

82 to control port 48 of valve 20, from whence by means of passage 76 and restriction 78, the pressure forces existent in motor conduit 42 past the throttle will also be present in the chamber 74. Piston 80, because of the unbalancing of the pressure forces, will be shifted slightly so as to open the seat 84 slightly and a quantity of fluid will be by-passed through the tank 12, through exhaust chamber 88, tank port 24, conduit 44 and conduit 34, the remainder of said fluid flowing to the motor. If at any time the pressure drop across the land 112 becomes any greater or less than the resistance of spring 90, as in the former case, the pressure forces existing in inlet chamber 66 and chamber 74, acting on the opposing surfaces 92 and 94, will tend to shift the piston 80 so as to more fully open or close seat 86 in order to by-pass a sufficient quantity of fluid to the tank 12 in order to maintain the pressure drop across the land 112 uniformly constant. If at any time the pressure in conduit 42 exceeds the resistance of spring 108 maintaining valve 100 in a closed position, the valve 100 will shift and open the chamber 74 to tank 12. Due to the fact that the fluid in chamber 74 may bleed through the opening created by valve 100 faster than pressure fluid could enter chamber 74 through the restriction 78, the pressure forces in inlet chamber 66 and chamber 74 suddenly become unbalanced and the piston 80 is shifted upwardly so that the valve 84 completely opens seat 86 to the exhaust chamber 88 and the full flow of fluid from pump 10 will be by-passed through the tank 12. Likewise, if at any time the pressure in motor conduit 40 should exceed a predetermined pressure as determined by the resistance of spring 106, valve 98 will shift and open chamber 68 to tank 12. The pressure forces then existing in chambers 68 and chamber 66 suddenly become unbalanced, and piston 80 will shift upwardly carrying valve 84 with it and opening seat 86 fully to exhaust chamber 88 thereby by-passing the flow of pressure fluid from pump 10 to the tank 12. Thus the pilot control valves 98 and 100 cause the piston 80 with the valve 84 connected thereto to perform the function of a relief valve.

It should be noted that the flow regulating valve containing the piston having a surface area continuously exposed to pressure before the throttles and having two other surface areas which are opposed and equal thereto which may be alternatively exposed to pressure past the throttles is a simple, economical and efficient manner of utilizing one flow regulating valve to maintain a constant pressure drop across both throttles.

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 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 forming a pair of throttles, one for each end of the motor, during a predetermined range of shifting the control valve in each direction, and a single compensating by-pass valve for maintaining a constant pressure drop across either throttle selectively.

2. In a hydraulic power transmission containing a fluid pump forming a source of pressure



fluid 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 forming a pair of throttles, one for each end of the motor, during a predetermined range of shifting the control valve in each direction, a single compensating by-pass valve for maintaining a constant pressure drop across either throttle selectively, and means responsive to a predetermined pressure for causing the compensating valve to perform the function of a relief valve.

3. A flow regulating valve of the by-pass type for use in a hydraulic system containing a fluid pump forming a source of pressure fluid, a reversible fluid motor, a directional control valve for reversing the directional operation of the motor and a pair of throttles, one for each end of the motor, said flow regulating valve containing a piston having a surface area adapted to be continuously exposed to pressure ahead of the throttles, a second surface area associated with the piston and opposed to the first surface area adapted to be exposed to pressure beyond one of the throttles, a third surface area associated with the piston also opposed to the first area adapted to be exposed to pressure beyond the other throttle and valve means associated with the piston for regulating the flow of fluid to the motor, whereby the piston valve maintains a constant pressure drop across the throttle through which fluid is adapted to flow to the motor.

4. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor, a directional control valve for reversing the direction of operation of the motor and a pair of throttles, one connected to each end of the motor, a flow regulating valve of the by-pass type containing a compensating valve for controlling the by-pass having first, second and third equal piston surface areas, the first of which is continuously exposed to pressure ahead of the throttles, and the second and third areas being opposed to the first surface area and selectively exposed to pressure past the throttles, whereby the single compensating valve selectively mantains a constant pressure drop across both throttles.

5. In a hydraulic power transmission containing a fluid pump forming a source of pressure fluid, a reversible fluid motor, a directional control valve for reversing the direction of operation of the motor and a pair of throttles, one connected to each end of the motor, a flow regulating valve of the by-pass type containing a compensating valve for controlling the by-pass having first, second and third equal piston surface areas, the first of which is continuously exposed to pressure ahead of the throttles, and the second and third areas being opposed to the first surface area and selectively exposed to pressure past the throttles, whereby the single compensating valve selectively maintains a constant pressure drop across both throttles, and duplicate means connected to the second and third surface areas responsive to predetermined pressure increases for causing the compensating valve to perform the function of a relief valve.

6. A flow regulating valve for use in a hydraulic power transmission containing a fluid pump, a reversible fluid motor, a directional control valve for reversing the direction of operation thereof hydraulically connected to the pump, to both ends of the motor and to a return source and throttle means for each end of the motor, said flow regu-

lating valve comprising in combination a by-pass, a compensating valve for opening and closing the by-pass and resilient means of predetermined resistance biasing the compensating valve to close the by-pass, said compensating valve having a first piston surface area adapted to be continuously exposed to pressure ahead of the throttles, a second surface area on said piston equal to the first area and opposed thereto adapted to be exposed to pressure beyond one of the throttles and a third surface area on said piston also equal to the first area and opposed thereto adapted to be exposed to pressure beyond the remaining throttle, whereby the compensating valve is responsive to pressure ahead of and beyond the throttle through which fluid is directed to the motor for maintaining a constant pressure drop across said throttle.

7. In a hydraulic power transmission containing a fluid pump, a reversible fluid motor, a directional control valve for selectively directing fluid to and from the motor for either direction of operation thereof and conduits connecting the control valve to the pump, to both ends of the motor and to an exhaust source, said control valve having a range of travel in each direction providing a variable throttle for each end of the motor, a flow regulating valve comprising in combination a by-pass, a compensating valve for opening and closing the by-pass, and resilient means of predetermined resistance biasing the compensating valve to close the bypass, said compensating valve having a first piston surface area continuously exposed to pressure ahead of the throttles, a second surface area on said piston equal to the first area and opposed thereto exposed to pressure beyond one of the throttles and a third surface area on said piston also equal and opposed to the first area exposed to pressure beyond the remaining throttle, whereby the compensating valve is responsive to the pressure ahead of and beyond the throttle through which pressure fluid is directed to the motor for maintaining a constant pressure drop across said throttle.

8. A flow regulating valve for use in a hydraulic power transmission containing a fluid pump, a reversible fluid motor, a directional control valve for reversing the direction of operation of the motor hydraulically connected to the pump, to both ends of the motor and to a return source and variable throttle means for each end of the motor, said flow regulating valve comprising in combination a valve body having an inlet chamber adapted to be connected to the pump ahead



of the throttles, means forming a by-pass connected to the inlet chamber, a piston reciprocably mounted in the body having a valve formed therein for opening and closing the by-pass, resilient means of predetermined resistance biasing the valve to close the by-pass, a first surface area on the piston located within the inlet chamber and responsive to pressure therein, a second chamber adapted to be connected to a motor conduit beyond the throttling means therein, a second surface area on the piston equal in area and opposed to the first surface area located within the second chamber and responsive to pressure therein, a third chamber adapted to be connected to the other motor conduit beyond the throttling means therein, and a third surface area on the piston also equal in area and opposed to the first surface area located within the third chamber and responsive to pressure therein.

9. A flow regulating valve of the by-pass type for use in a hydraulic transmission containing a fluid pump, a reversible fluid motor and throttling means connected to each end of the motor comprising in combination means forming a by-pass, a compensating valve for opening and closing the by-pass, resilient means biasing the compensating valve to close the by-pass, a first surface area on the compensating valve responsive to pressure ahead of the throttles, a second surface area opposed to the first area and equal thereto responsive to pressure past one of the throttling means in opposition to the first mentioned pressure and a third surface area also opposed to the first area and equal thereto responsive to pressure beyond the remaining throttling means in opposition to the first mentioned pressure whereby the compensating valve is responsive to the pressure drop across the throttle through which fluid is adapted to flow to the motor for maintaining a uniformly constant flow through said throttle.

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