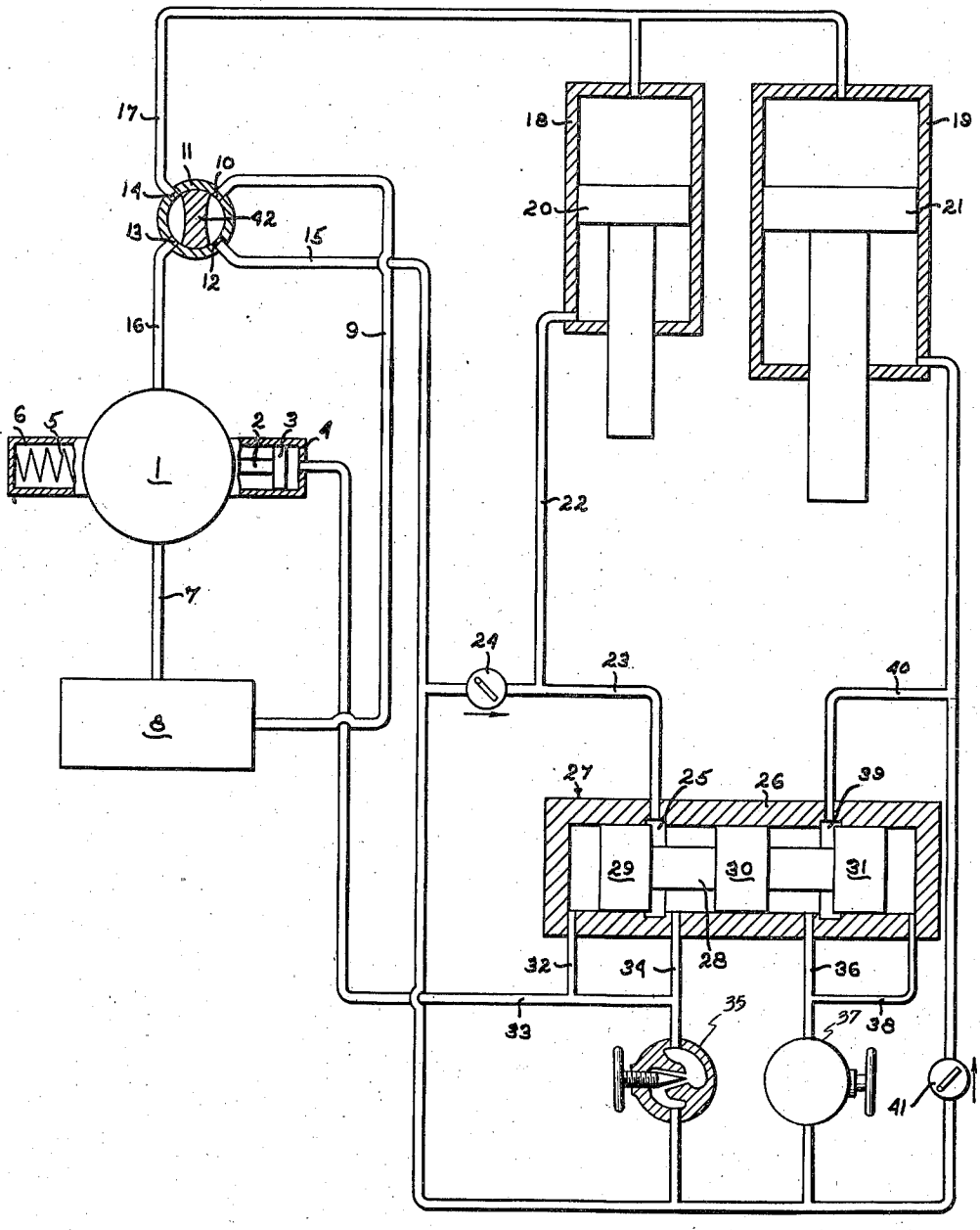
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TWIN-CYLINDER CONSTANT SPEED HYDRAULIC SYSTEM

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TWIN-CYLINDER CONSTANT SPEED HYDRAULIC SYSTEM

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This invention relates to hydraulic machinery and, in particular, to a control system for a plurality of hydraulic motors.

When a plurality of hydraulic motors is supplied with pressure fluid from a common fluid source, the motor encountering the lowest resistance tends to run ahead of the other motor or motors, which will either move in an erratic manner or may even come to a stop.

It is an object of this invention to provide a hydraulic motor control system which will overcome the above mentioned drawback.

It is another object of this invention to provide a hydraulic system including a plurality of fluid operable motors supplied with pressure fluid from a common fluid source, in which a change in resistance encountered by one motor will have practically no effect on the speed of another motor of said system.

It is another object of this invention to provide a hydraulic system including a plurality of fluid operable motors supplied with pressure fluid from a common fluid source, in which control means is provided adapted automatically to maintain the speed of each individual motor substantially constant.

Another object of this invention consists in the provision of a hydraulic system including two fluid operable motors supplied with pressure fluid from a fluid source common to both motors, in which control means is provided adapted, in response to a decrease or increase in resistance encountered by one motor, to bring about a corresponding change in the supply of pressure fluid to said motor to restore the speed of said one motor, while the speed of the other motor is held substantially constant.

It is a still further object to provide a hydraulic system including two fluid operable motors supplied with pressure fluid from one and the same fluid source, in which means are provided for maintaining a desired back pressure at said motors, and in which, responsive to an increase or a decrease in resistance encountered by one of said motors, the supply of actuating fluid to one motor is increased or decreased respectively, while the speed of the other motor is maintained substantially constant.

Still another object of the invention consists in the provision of a hydraulic system including two fluid operable motors supplied with pressure fluid from one and the same fluid source, in which the speed of one motor may selectively be varied without substantially affecting the speed of the other motor.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing which illustrates, by way of example, an embodiment of the new control system.

The control system shown in the drawing comprises in general two hydraulic motors supplied with pressure fluid from a common variable delivery source, and being hydraulically connected with a balancing valve. The balancing valve, in its turn, is connected with means for creating back pressure in said motors, and is also in fluid communication with a control mechanism associated with the fluid source feeding said motors. The said control mechanism is pressure responsive and adapted to vary the supply of pressure fluid to said motors.

A variation in resistance encountered by one of said motors reacts on said balancing valve so as to cause the latter to create back pressure on the motor encountering the least resistance to such an extent as to exactly balance its load with that of the motor of higher resistance. In addition thereto, the delivery of fluid from said fluid source to said motors is changed. Then a new pressure condition prevails because the pressure created by the fluid source stands on both motors at a value determined by the greater motor load.

Referring now to the drawing in detail, the structure shown therein comprises a pump 1 of the variable delivery type, which may be a radial piston or radial vane pump. The flow control member of the pump 1 has connected thereto a control rod 2 with a piston 3, which latter is reciprocably mounted in a servomotor cylinder 4. The flow control member of the pump 1 is continuously urged, by means of a spring 5 in a casing 6, in a direction to move the pump into increased delivery position. The casing 6 is connected to the pump 1 in any convenient manner.

The suction side of the pump is connected by means of a conduit 7 with a fluid reservoir or tank 8. Also connected with the tank 8 is a conduit 9 leading to the port 10 in the four-way valve 11. The four-way valve 11 is also provided with ports 12, 13 and 14 respectively connected with conduits 15, 16 and 17.

The conduit 16 is connected with the pressure side of the pump 1, while the conduit 17 communicates with the upper portion of the cylinders 18 and 19. Reciprocably mounted in the cylinders 18 and 19 respectively are plungers 20 and 21.

The lower portion of the cylinder 18 communi-

cates through a conduit 22 with a conduit 23, which latter comprises a check valve 24 and has one end connected to the conduit 15, while the other end leads to an annular recess 25 in the valve casing 26 of a balancing valve, generally designated 27.

Reciprocably mounted in the valve casing 26 is a valve member 28 having three spaced and interconnected piston portions 29, 30 and 31. The left end of the valve casing 26 is connected through the conduit 32 with a conduit 33, which latter leads to the servomotor cylinder 4. The space intermediate the piston portions 29 and 30 communicates with a conduit 34 comprising a choke valve 35 and leading to the conduit 15. The space between the piston portions 30 and 31 is connected with a conduit 36 comprising a throttle valve 37 and also communicating with the conduit 15.

Branching off from the conduit 36 is a conduit 38 leading to the right hand end of the valve casing 26. The valve casing 26 also comprises an annular recess 39 communicating through a conduit 40 with the conduit 15, which latter comprises a check valve 41 and is in fluid connection with the lower portion of the cylinder 19.

Operation

It may be assumed that the pump 1 has been started and that the valve cock 42 has been moved into the position shown in the drawing, in which is establishes fluid connection between the conduits 16 and 17. Pressure fluid delivered by the pump 1 will then pass through the conduits 16 and 17 into the cylinders 18 and 19, where it will act upon the plungers 20 and 21 respectively so as to move the same downwardly.

Fluid expelled from the lower portion of the cylinder 18 passes through conduits 22 and 23 into the recess 25 in the valve casing 26, and from there will flow through the conduit 34, choke valve 35 and conduits 15 and 9 into the tank 8.

Due to the choke valve 35, a back pressure will be established in the conduit 34 between the choke valve 35 and the valve casing 26. This pressure will be conveyed through the conduit 32 into the left hand portion of the valve casing 26 and will be conveyed also through the conduit 43 into the servomotor cylinder 4.

The fluid expelled from the lower portion of the cylinder 19 passes through the conduits 15 and 40 into the recess 39 of the valve casing 26, and from there through the conduit 36, chock valve 37 and the conduits 15 and 9 into the tank 8.

Due to the valve 37, a back pressure will be established in the conduit 36 between the valve 37 and the valve casing 26, which pressure will be conveyed into the right hand portion of the valve casing 26 through the conduit 38.

The differential pressures respectively acting upon the piston portions 29 and 31 move the valve member 28 into a position in which these pressures balance each other. It may be assumed that when the said pressures balance each other, the valve member 28 occupies the position shown in the drawing.

The pressure conveyed through conduit 33 into the servomotor cylinder 4 acts on the control piston 2 and shifts the pump 1 into a delivery position, corresponding to the pressure determining the balancing position of the valve member 28.

Unbalanced motor loads

It may now be assumed that, for some reason, the loads acting on the plungers 20 and 21 become unbalanced and that the load on the plunger 20 increases. As a result thereof, the plunger 20 will slow down and the pressure in conduits 22 and 23 will drop somewhat. Therefore, also the pressure on the right side of the piston portion 29 and in conduits 34 and 32, as well as the pressure acting on the left side of the piston portion 29, will drop. Consequently, the valve member 28 will move toward the left, increasing the free communication between the conduit 23 and the recess 25, while decreasing the free communication between the conduit 40 and the recess 39. Due to the increase in the free communication between the conduit 23 and the recess 25, the back pressure in the conduit 22 and thereby the resistance encountered by the plunger 20 will decrease so that the pressure load on the plunger 20 is substantially restored.

The decrease of the free communication between the conduit 40 and the recess 39 results in a higher back pressure in the conduits 40 and 15 and, therefore, in a greater load acting on the plunger 21. Without further control mechanism, the plunger 21 would slow down. However, since the decrease in pressure in the conduit 34 was also conveyed through the conduit 43 into the servomotor cylinder 4, the spring 5 has shifted the flow control member of the pump 1 into a new position in which the delivery of the pump 1 is increased. The increase in delivery of the pump goes to the cylinder 19 and makes up for the increased resistance encountered by the plunger 21, so that the speed of the plunger 21 remains substantially the same, in spite of the new balancing position occupied by the valve member 28. In other words, the speed of both plungers 20 and 21 is substantially maintained, in spite of variations in the load encountered by these plungers.

If the load on the plunger 20 had decreased instead of increased, as described above, a similar series of operations would have been effected, but these operations would have been exactly reverse to those set forth above.

If, for some reason, it should now happen that the load on the plunger 21 increases, the control operation is effected in a somewhat different manner, due to the fact that the control pressures in the conduit 36 do not act directly upon the servomotor 3, 4. An increase in load on the plunger 21 will first slow down the latter. This in turn will bring about a decrease in pressure in the conduits 15 and 40 and, thereby, also in the recess 39 and the conduits 36 and 38. In this way, the balance on the valve member 28 is disturbed and the valve member 28 moves toward the right. Thus, the free communication between the conduit 23 and the recess 25 is decreased, while the free communication between the conduit 40 and the recess 39 is increased. The decrease in the free communication between the conduit 23 and the recess 25 results in a slight pressure drop in the conduits 34 and 33 and, therefore, also results in a pressure drop in the right hand end of the servomotor cylinder 4. Therefore, the spring 5 moves the pump 1 into an increased delivery position. A greater quantity of fluid is, therefore, delivered by the pump 1 through the conduit 17 into the cylinder 18, which makes up for the increased load on the plunger 20 created by the decrease in free communication between the conduit 23 and the recess 25. Another part of the increased delivery of fluid by the pump 1 enters the cylinder 19 and makes up for the increased load acting on the plunger 21. In this way, the speed of the plungers

20 and 21 is substantially maintained in spite of the change in load acting thereupon.

Again the same sequence of actions would occur with opposite effects if a decrease rather than an increase of load were effected upon the plunger 21.

Change in the throttle setting

It may now be assumed that the operator desires to change the speed of one plunger, for instance, wants to increase the speed of the plunger 20. To this end, the operator opens the choke valve 35 and sets the same in correspondence to the desired speed. As a result of the new setting of the valve 35, the pressure in conduits 34 and 33 falls off slightly. This in turn results in a pressure drop in the right hand portion of the cylinder 4 so that the spring 5 moves the pump 1 into an increased delivery position.

The pressure drop in the conduits 34 and 32 and, thereby, also in the left hand end of the valve casing 26 causes the valve member 28 to move toward the left. Consequently, the free communication between the conduit 23 and the recess 25 is increased; while the free communication between the conduit 40 and the recess 39 is decreased. Due to this increase in free communication between the conduit 23 and the recess 25, the pressure in the conduits 22 and 23 drops and the plunger 20 moves faster. The restriction of the free communication between the conduit 40 and the recess 39 results in an increased pressure in the conduit 15, and, thereby in an increased load acting on the plunger 21. Under normal circumstances, this would result in a slow down of the plunger 21. However, since the pump 1 has been shifted into an increased delivery position as mentioned above, an increased quantity of fluid is delivered by the pump into the cylinder 19, making up for the increase in load on the plunger 21 so that the plunger 21 substantially maintains its speed while the plunger 20 now moves at increased speed, as desired.

It will be obvious that a corresponding control operation will be effected if the operator adjusts the choke valve 35 to bring about a reduction in speed of the plunger 20.

If it is now desired to increase the speed of the plunger 21, the control operation differs somewhat from that described above in connection with the setting of the choke valve 35 because the momentary change in the control pressure in conduit 36 must act through the valve 27 to affect the setting of the pump 1. To increase the speed of the plunger 21, the operator opens the valve 37 to the desired extent. After the valve 37 is open, the pressure in the conduit 36 drops slightly and, consequently, also a pressure drop occurs in the recess 38 and the conduits 36 and 38 as well as in the right hand end of the valve casing 26. Therefore, the balance acting on the valve member 28 is disturbed and the valve member 28 moves toward the right. This movement reduces the free communication between the conduit 23 and the recess 25, while increasing the free communication between the conduit 40 and the recess 39. The decrease in free communication between the conduit 23 and the recess 25 brings about a drop in pressure in the conduits 34, 32 and 33 and, therefore, also in the right hand end portion of the servomotor cylinder 4. Consequently, the spring 5 moves the pump 1 into increased delivery position until the thrust exerted by the spring 5 is balanced by the pressure acting on the larger area of the piston 3.

The decrease in free communication between the conduit 23 and the recess 25 results in an increased load on the plunger 20 and would normally slow down the speed of the plunger 20. However, this increase in load on the plunger 20 is made up by the increased delivery of the pump 1 into the cylinder 18 so that the speed of the plunger 20 remains substantially constant. Since, on the other hand, the free communication between the conduit 40 and the recess 39 has been increased, a pressure drop occurs in the conduit 15 so that the load on the plunger 21 is decreased and the speed of the plunger 21 is increased as desired.

If it is desired to decrease the speed of the plunger 21 instead of increasing the speed, it is obvious that the valve 37, instead of being opened, will be further closed, whereupon the control operations will then occur in an order reverse to that just described for increasing the speed of the plunger 21.

When it is desired to reverse the movement of the plungers 20 and 21, the operator reverses the valve cock 42 so as to establish fluid connection between the conduit 17 and the conduit 9, while simultaneously connecting the conduits 15 and 16 with each other. It will then be clear that pressure fluid delivered by the pump 1 into the conduit 16 will pass through the conduit 15, check valve 24 and conduit 22 into the lower portion of the cylinder 18, and will also flow through the check valve 41 into the lower portion of the cylinder 19. The plungers 20 and 21 will then move upwardly, and the fluid expelled thereby will flow through the conduits 17 and 9 into the tank 8.

In the control system shown in the drawing, the return speed of the plungers 20 and 21 is not controlled by the valve 27 so that the full delivery of the pump 1 is conveyed to the lower portion of the cylinders 18 and 19.

While the invention has been described in connection with reciprocable plungers 20 and 21, it will be obvious that the control system would work equally well with rotary motors without requiring any change in the system.

It will be understood that the invention is not limited to the particular structure shown in the drawing, but also embraces such modifications as come within the scope of the claims.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. In a hydraulic system, a plurality of fluid operable motors, each motor having a fluid inlet and a restricted fluid outlet, a fluid source common to said motors for supplying pressure fluid to said inlets to actuate said motors, means for establishing fluid connection between said fluid source and said inlets, pressure responsive control means associated with said outlets for controlling the flow of fluid from said outlets to an exhaust, said control means being operable to simultaneously vary the restrictions in said outlets in response and according to changes in loads on said motors, and means operatively connected with said control means and with said fluid source for varying the delivery of pressure fluid to said motors in accordance with the actuation of said control means, said control means and said last mentioned means being adapted to maintain the speeds of said motors substantially constant.

2. In a hydraulic system, a plurality of hydraulic motors with fluid inlets and outlets, the inlets of said motors being hydraulically interconnected during the movement of said motors in one direction, a fluid source of variable delivery

for supplying pressure fluid to said motors to actuate the same, means for selectively conveying pressure fluid from said fluid source to said motors, and control means operatively connected with said motors and said fluid source for automatically varying the supply of pressure fluid from said fluid source to said motors and the rate of fluid flow through each of said motors in response to variations in load of said motors to thereby maintain the speed of said motors substantially constant irrespective of changes in load of each individual motor.

3. In a hydraulic system, a plurality of hydraulic motors with fluid inlets and outlets, the inlets of said motors being hydraulically interconnected during the movement of said motors in one direction, a fluid source for supplying pressure fluid to said motors, means for selectively conveying pressure fluid from said fluid source to said inlets, choke means for maintaining pressure at the outlets of said motors, valve means interposed between said outlets and said choke means for controlling the flow of fluid from said outlets to said choke means, said valve means being operable in response to a variation in pressure between said valve means and one of said choke means for varying the flow of fluid from the outlet of one motor to the choke means pertaining thereto in an inverse order to the variation in the flow of fluid from the outlet of another motor to the choke means pertaining thereto, and means associated with said fluid source for varying the supply of fluid from said fluid source to said motors in accordance with the operation of said valve means to thereby maintain the speed of each individual motor substantially constant.

4. In a hydraulic system, a pair of fluid operable motors having their inlets continuously interconnected during the movement of said motors in one direction, means for supplying pressure fluid to said inlets for actuating said motors, a plurality of choke means respectively associated with said fluid operable motors, valve means interposed between the outlets of said motors and said choke means and adapted in response to variations in pressure at the outlet of one motor to vary the pressure at the outlet of the other motor, and control means associated with said fluid source and responsive to the actuation of said valve means for bringing about a change in the quantity of fluid delivered from said fluid source to said motors to thereby maintain the speed of said motors substantially constant.

5. In a hydraulic system, a pair of hydraulic motors with a fluid inlet and outlet for each motor, a fluid source common to each of said motors for supplying pressure fluid thereto to actuate said motors, a plurality of choke means respectively associated with the outlets of said motors for maintaining pressure at said outlets, a reciprocable valve member for controlling the flow of fluid from said outlets to said choke means, piston means associated with said valve member and operable in response to variations in pressure at each of said outlets to thereby actuate said valve member for restricting the flow of fluid of one of said motors, while simultaneously bringing about an increase in the flow of fluid at the exhaust of another motor to the choke means pertaining thereto, and control means operatively connected with said valve member and said fluid source for varying the supply of fluid from said fluid source to said motors to maintain the speed of said motors substantially constant.

6. In a hydraulic system, a plurality of hydraulic motors with an inlet and an outlet for each motor, a fluid source of variable delivery for supplying pressure fluid to said motors, control means for controlling the delivery of said fluid source, means for simultaneously connecting said fluid source with each of said inlets, a plurality of choke means respectively associated with said outlets for maintaining pressure at said outlets, and pressure responsive means interposed between said outlets and said choke means and adapted in response to variations in pressure at one of said choke means to bring about a corresponding change in pressure at another choke means and also to actuate said control means for a variation in the delivery of said fluid source so as to maintain the speed of said motors substantially constant.

7. In a hydraulic system for simultaneously operating a pair of hydraulic motors at substantially constant and mutually independent speeds, the combination with said motors of a variable delivery source of fluid pressure for supplying pressure fluid thereto, valve means for selectively establishing fluid connection between said fluid source and the inlets of said motors, flow responsive means in the outlets of each of said motors for creating control pressures therein, means associated with said fluid source for varying the delivery thereof in response to one of said control pressures, and flow restricting means adapted in response to both of said control pressures to control the rate of fluid flow through each of said motors.

8. In a fluid operable system for simultaneously operating a pair of fluid operable motors at substantially constant and mutually independent speeds, the combination with said motors of a source of fluid pressure for supplying actuating fluid thereto, flow responsive means in the outlets of each of said motors for creating control pressures therein, means for controlling the supply of fluid from said fluid source to said motors in response to at least one of said control pressures, and flow restricting means adapted in response to both of said control pressures to control the rate of fluid flow through each of said motors.

9. In a fluid operable system for simultaneously operating a pair of fluid operable motors at substantially constant and mutually independent speeds, the combination with said motors of a source of fluid pressure for supplying actuating fluid thereto, flow control means operable to vary the supply of fluid from said source to said motors, other flow control means operable to control the rate of fluid flow from said motor outlets, and means responsive to the speeds of said motors for actuating both of said flow control means.

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