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Fletcher

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[54] **VARIABLE DISPLACEMENT PUMP CONTROL SYSTEM**

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[52] **U.S. Cl.** **60/452,** 417/214, 417/270

[51] **Int. Cl.** **F04b 49/00**

[58] **Field of Search** 417/202, 214, 221, 417/222, 253, 270; 60/452; 418/82

[56] **References Cited**

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[57] **ABSTRACT**

A radial piston variable displacement hydraulic pump has a discharge line and an inlet line, which is connected to a fixed displacement charge pump. The pistons are returned by the fluid pressure in the inlet line, and the displacement of the pump is controlled by varying the pressure in the drive chamber of the pump, increasing pressure in the drive chamber resisting the return of the pistons to decrease the piston strokes. The pressure in the chamber is supplied by the charge pump through a pilot-operated stroke control valve, which is biased toward a dump position, wherein it exhausts the pressurized fluid from the chamber, and is shiftable to an alternate position wherein it connects the charge pump to the chamber in response to pressure in a pilot line connected to the pump discharge.

9 Claims, 2 Drawing Figures

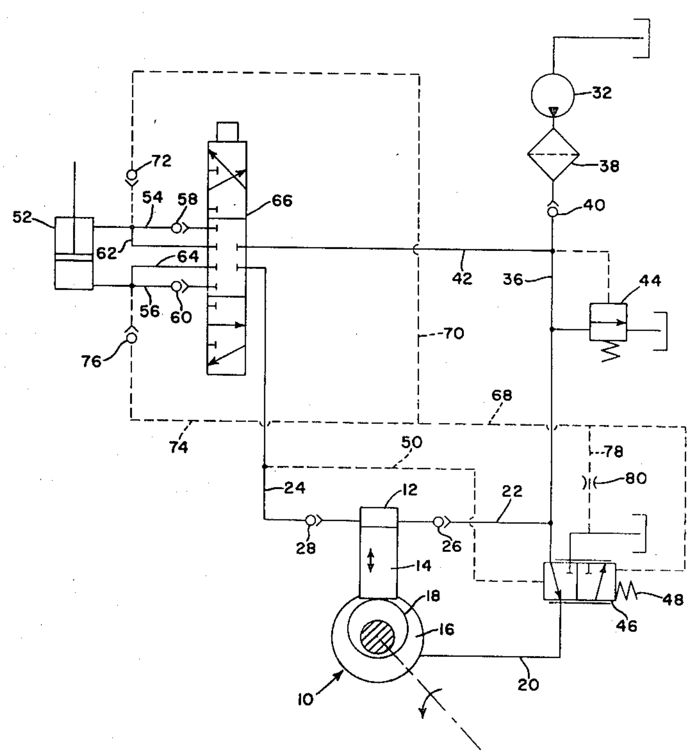

FIG. I

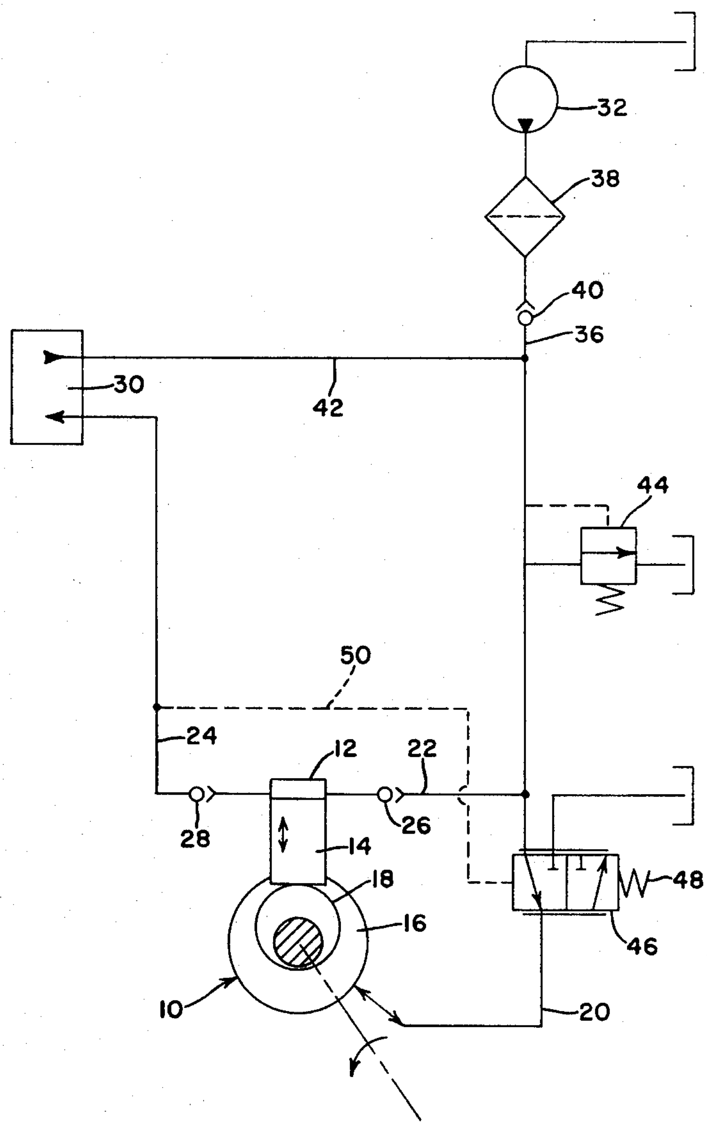

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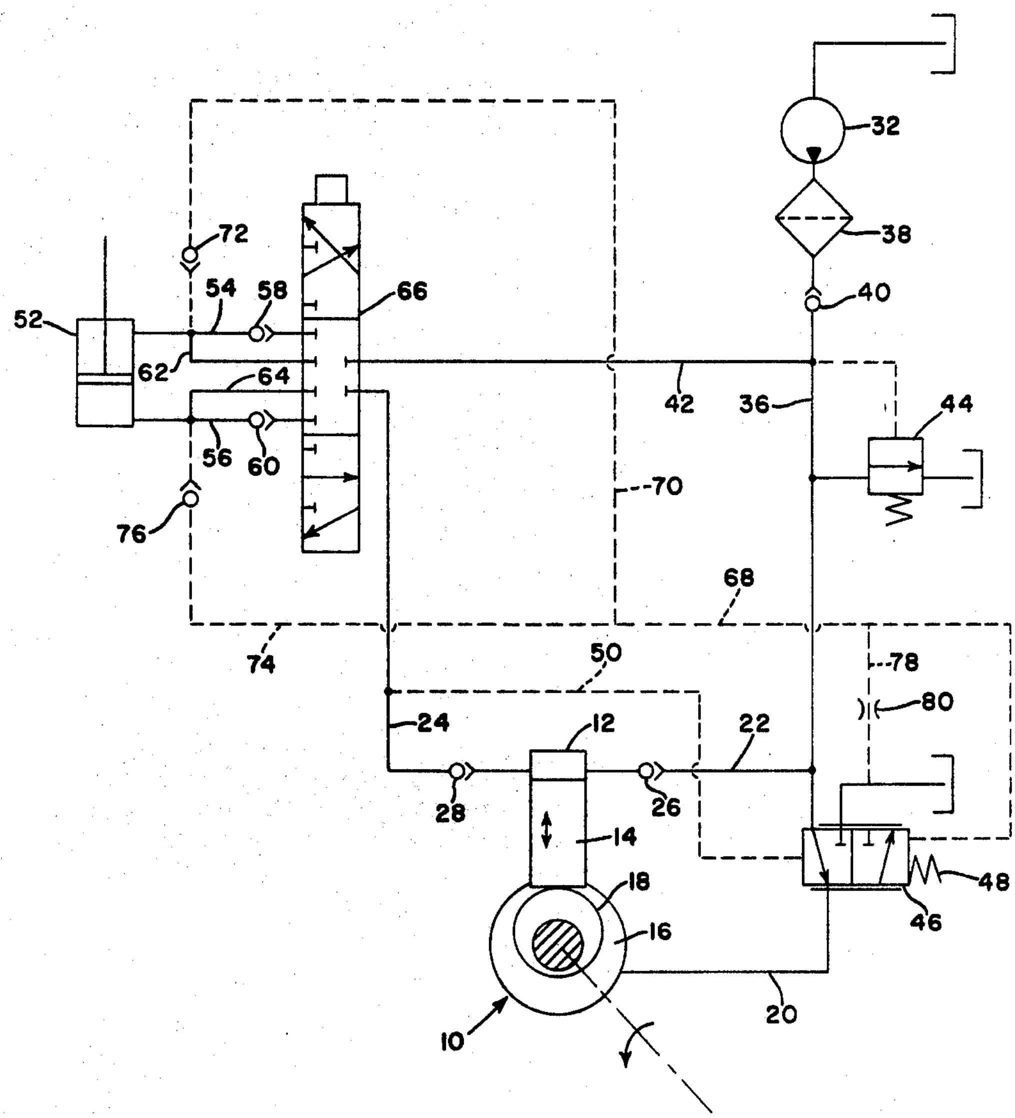
FIG. 2



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VARIABLE DISPLACEMENT PUMP CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a control system for a variable displacement hydraulic pump and more particularly to a control system for a hydraulic pump wherein the displacement is varied by controlling the pressure in the drive chamber of the pump to limit the return or intake stroke of the pump pistons and thereby control the pump displacement.

Such a pump is shown in U.S. Pat. No. 3,002,462 issued to T. E. Raymond. As described in said patent, the inner ends of the pistons extend into the drive chamber or crankcase of the pump and are biased inwardly by springs in the closed end of the pump cylinders. The crankcase or drive chamber of the pump is connected to the pump discharge line, so that when the discharge pressure reaches a predetermined value, the pressure in the crankcase prevents the return of the pistons, whereby the pump goes out of stroke. The bias of the springs is supplemented by the inlet pressure of the pump, so that the crankcase pressure must overcome both the inlet pressure and the spring bias force before it moves the pistons out of stroke.

On certain agricultural and industrial vehicles which utilize this type of pump, a relatively small flow is drained from the crankcase, so that, in order to maintain the crankcase pressure, the pump remains slightly in stroke. Also, to get the pump into stroke rapidly, a quick dump valve is required to rapidly drain the crankcase. Also, in currently utilized pumps of this type, the flow of pressurized fluid to and from the crankcase is controlled by relatively complicated stroke control valving, with a relatively large pressure drop across the valving.

SUMMARY OF THE INVENTION

According to the present invention, there is provided an improved stroke control system for the above described variable displacement hydraulic pump.

More specifically, the stroke control system utilizes a charge pump, which supplies pressurized fluid to the pump inlet at a relatively high pressure, without interruptions for other hydraulic functions, thereby eliminating the need for the return springs in the pump.

An important feature of the invention resides in the utilization of the charge pump pressure to pressurize the pump crankcase or drive chamber, the flow of pressurized fluid to and from the crankcase being controlled by a stroke control valve responsive to the pump output pressure.

Another feature of the invention is the provision of means for making the system responsive to the load pressure at a hydraulic function in addition to the pump output pressure, providing a demand compensated system.

An important advantage of this invention resides in the fact that it eliminates the need for a quick dump valve to get the pump in the stroke rapidly and further eliminates the loss due to the constant drainage from the high pressure outlet while the pump is operating at less than full stroke.

Still another feature of the invention resides in the fact that there is a relatively small pressure drop across the stroke control valve, allowing the use of a spool-type valve.

Still another feature of the invention resides in the fact that the oil flow in the crankcase is directly related to the pump output, rather than the inverse relationship, so that there is maximum oil flow in the crankcase at maximum pump displacement, reducing the operating temperature of the pump.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic illustration of one embodiment of the invention, wherein the stroke control valve is responsive to the pump output pressure.

FIG. 2 is a schematic illustration of a second embodiment of the invention wherein the system is modified so that the stroke control valve is also responsive to the load pressure.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The hydraulic system includes a variable displacement radial piston hydraulic pump **10** having a plurality of radially arranged cylinders **12** with pistons **14** mounted for reciprocation therein, only a single cylinder and piston being schematically illustrated in the drawings since pumps of this type are well known. The inner end of each cylinder opens into a central, closed drive chamber or crankcase **16,** in which an eccentric type drive mechanism **18** rotates, the drive mechanism engaging the inner ends of the piston **14** to reciprocate the pistons in response to the rotation of the drive mechanism. The fluid pressure is supplied to and exhausted from the crankcase **16** by means of a regulating line **20.** The outer or closed end of each cylinder **12** is connected to an inlet line **22** and an outlet line **24** respectively having check valves **26** and **28,** which permit the flow of fluid only from the inlet line to the cylinder and from the cylinder to the discharge line **24.** As is well known, each cylinder is connected to the inlet and discharge lines through appropriate manifolding and includes its own pair of check valves. The discharge line **24** supplies pressurized fluid to one or more hydraulic functions, indicated by the functional box **30** in FIG. **1.**

A fixed displacement charge pump **32** draws fluid from a reservoir and discharges it into an outlet line **36,** which is conventionally provided with a filter **38** and a check valve **40** which permits flow of fluid only from the charge pump. The hydraulic function **30** is connected to the outlet line **36** via a return line **42.** A pressure regulating valve **44** is disposed in the outlet line **36** to maintain the pressure therein at a predetermined level, the pressure regulating valve **44** dumping the fluid in the outlet line to a reservoir when the predetermined pressure is reached, so that flow from the charge pump in excess of that required by the main pump is returned to the reservoir, preferably through a cooler (not shown). The charge pump outlet line **36** is connected to the main pump inlet line **22,** so that the charge pressure tends to return the piston **14** during the intake stroke of the pistons.

The charge pump outlet line **36** is also connected to the inlet of a pilot-operated stroke control valve **46,** which is preferably a two-position spool-type valve of known construction. In the position shown in FIG. **1,** the stroke control valve **46** connects the charge pump outlet line **36** to the regulating line **20,** while in the alternate or exhaust position, the outlet line **36** is blocked and the regulating line **20** is connected to the reservoir.

The valve **46** is biased toward its exhaust position by a spring **48**, which acts on one end of the valve, while the opposite end of the valve is connected to the discharge line **24** by a pilot line **50**, which applies the discharge pressure to the end of the valve in opposition to the spring **48**. When the force exerted by the pressure in the pilot line **50** exceeds the spring force, the stroke control valve **46** shifts to its open condition as illustrated in FIG. **1**.

In operation, when the stroke control valve **46** remains in its open condition, the pressure in the drive chamber or crankcase **16**, which acts on the inner ends of the pistons **14**, is equal to the pressure in the inlet line **22**, which acts on the outer end of the pistons **14**, so that the pistons are balanced and there is nothing to force their return after their pumping stroke. Thus, the pump goes out of stroke.

When the hydraulic function **30** is actuated, there is an immediate pressure drop in the discharge line **24** and the pilot line **50**, so that the stroke control valve spring **48** shifts the stroke control valve to the left to connect the regulating line **20** to the reservoir, thereby exhausting fluid pressure from the crankcase **16**. This, of course, unbalances the pressure on the pistons **14** during their intake stroke, so tht the pressure on the outer ends of the pistons forces the pistons inwardly during their intake stroke, to place the pump into stroke again. As is apparent, the pump will remain in stroke as long as the pressure in the discharge line **24** is below the predetermined pressure at which the pressure in the pilot line **50** overcomes the force of the spring **48** to again direct the charge pump output pressure to the crankcase and place the pump out of stroke. As is also apparent, the stroke control valve quickly dumps the fluid pressure in the crankcase to quickly place the pump in stroke upon actuation of the hydraulic function **30**.

The embodiment shown in FIG. **2** is the same as the embodiment shown in FIG. **1** except that the stroke control valve **46** is responsive to load pressure in addition to the pressure in the discharge line **24**. In the second embodiment, the hydraulic system includes a hydraulic function or load represented by a two-way hydraulic cylinder **52** having its opposite ends connected to hydraulic lines **54** and **56**, respectively provided with check valves **58** and **60**, which permit flow of fluid only to the hydraulic cylinder. Bypass lines **62** and **64** are respectively connected to the hydraulic lines **54** and **56** to bypass the check valves **58** and **60** to permit exhaust of the fluid from the cylinder. A three-position control valve **66** is connected to the main pump discharge line **24**, the return line **42**, and the hydraulic lines **54**, **56**, **62**, and **64**. The control valve **66** is illustrated in its neutral position, wherein all of the hydraulic lines are blocked, and is shiftable downwardly therefrom to connect the bypass line **64** to the return line **42** and the line **54** to the pump discharge line **24**, so that the upper end of the cylinder **52** is pressurized and the lower end is connected to the return line. As is apparent, the valve is shiftable in the opposite direction from the neutral position to pressurize the line **56** and exhaust the upper end of the cylinder via the line **62**.

A pilot line **68** communicates with the end of the pilot-operated stroke control valve **46** on the opposite end from the pilot line **50** and is connected to the upper hydraulic cylinder line **54** through a hydraulic line **70** having a check valve **72** and to the lower cylinder line

56 by a line **74** having a check valve **76**, the check valves **72** and **76** permitting the flow of fluid only from the line **54** or **56** to the pilot line **68**, depending on which line is pressurized. The pilot line **68** is connected to the reservoir via a drain line **78** having a flow-restricting orifice **80**.

The second embodiment of the invention operates in the same manner as the embodiment described in FIG. **1**, except that the stroke control valve **46** is responsive to both the pressure in the discharge line **24** and the pressure in either of the hydraulic lines **54** or **56** to the load, depending upon which line is pressurized. Thus, if the hydraulic cylinder **52** is acting against a relatively light load, the pressure in the hydraulic line to the cylinder will be relatively small, and the pump will go out of stroke when the discharge pressure equals the pressure in the load line plus the amount necessary to compensate for the force of the spring **48**. Of course, if there is a relatively large load, so that the pressure in the line to the hydraulic cylinder is relatively high, the stroke control valve **46** will not shift to place the pump out of stroke until the discharge pressure exceeds the load pressure by the amount necessary to overcome the spring force. Thus, the system is demand compensated, wherein the pump output pressure depends upon the pressure required to move the load.

I claim:

1. A hydraulic system comprising: a main variable displacement hydraulic pump having an inlet line and a discharge line; a pump regulating means responsive to pressure in a pump regulating line to respectively decrease or increase pump displacement in response to an increase or decrease in the pump regulating line pressure; a charge pump means having an inlet line connected to a reservoir and an outlet line connected to the main pump inlet line for supplying fluid thereto; a pilot-operated stroke control valve means connected to the reservoir, the charge pump outlet line and the regulating lines; means biasing the valve toward a first position wherein it connects the pump regulating line to the reservoir to decrease the pressure therein and increase the pump displacement; and a first pilot line operatively connected to the stroke control valve and the main pump discharge line for shifting the valve against said biasing means when the force exerted by fluid pressure in the pilot line exceeds the force exerted by the biasing means into a second position wherein it connects the charge pump outlet line to the pressure regulating line to increase the pressure therein and reduce the pump displacement.

2. The invention defined in claim **1** and including at least one hydraulic function and the biasing means includes a second pilot line operatively connected to the hydraulic function and the stroke control valve for applying the fluid pressure in the hydraulic function to the stroke control valve in opposition to the first pilot line, so that the valve shifts to its second position when the pressure in the discharge line exceeds the pressure in the hydraulic function by a predetermined amount.

3. The invention defined in claim **2** and including a bleed line having a flow restricting orifice connecting the second pilot line to the reservoir.

4. The invention defined in claim **1** and including a pressure regulating valve operatively associated with the charge pump outlet line for maintaining a predetermined pressure in the outlet line.

5. A hydraulic system comprising: a main variable displacement hydraulic pump having a plurality of cylinders with inner ends opening into a closed drive chamber and closed outer ends connected to an inlet line and a discharge line, a piston mounted in each cylinder and drive means within the chamber engageable with the inner ends of the pistons to reciprocate the pistons, the pressure in the inlet line returning the pistons into driving engagement with the drive means and the pressure in the chamber opposing said engagement, so that the piston strokes are dependent upon the relative pressures in the inlet line and the drive chamber; a pump regulating line connected to the drive chamber; a charge pump having an outlet line connected to the main pump inlet line for supplying pressurized fluid to the outer ends of the cylinders; a pilot-operated stroke control valve shiftable between a first position, wherein it connects the pump regulating line to the reservoir to decrease the pressure in the drive chamber and increase the piston strokes, and a second position, wherein it connects the pump regulating line to the charge pump discharge line to increase the pressure in the drive chamber and decrease the piston strokes; means biasing the stroke control valve toward its first position; and a pilot line between the main pump discharge line and the sroke control valve for applying the

discharge line pressure to the valve opposite the biasing means to shift the valve into its second position when the force exerted by the pilot line pressure exceeds the force exerted by the biasing means.

6. The invention defined in claim 5 and including at least one hydrualic function, the biasing means including a second pilot line operatively connected to the hydraulic function and the stroke control valve for applying the fluid pressure in the hydraulic function to the stroke control valve in opposition to the first pilot line, so that the valve shifts to its second position when the pressure in the discharge line exceeds the pressure in the hydraulic function by a predetermined amount.

7. The invention defined in claim 6 and including a bleed line having a flow restricting orifice connecting the second pilot line to the reservoir.

8. The invention defined in claim 5 and including a pressure regulating valve operatively associated with the charge pump outlet line for maintaining a predetermined pressure in the outlet line.

9. The invention defined in claim 5 wherein the piston and cylinder extend radially from the pump axis and the drive means comprises a cylindrical member eccentrically disposed relative to the pump axis.

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