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[54] PUMP DISPLACEMENT CONTROL

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[51] **Int. Cl.**.....**F04b 49/00,** F15b 15/18
[58] **Field of Search**.....60/52 VS; 417/213, 417/273, 217

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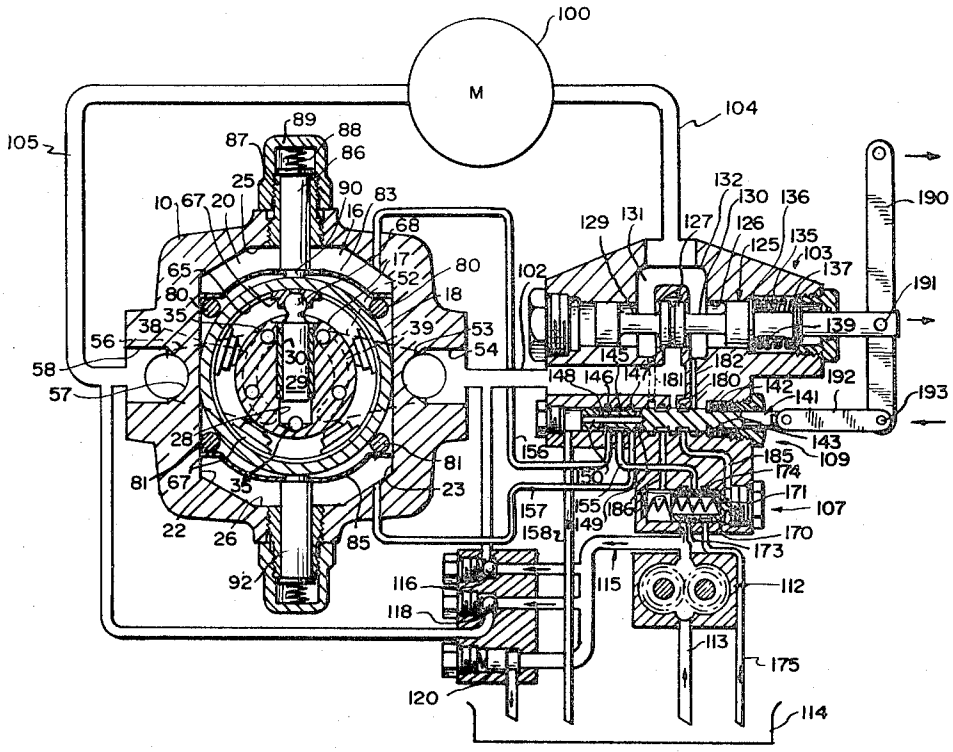
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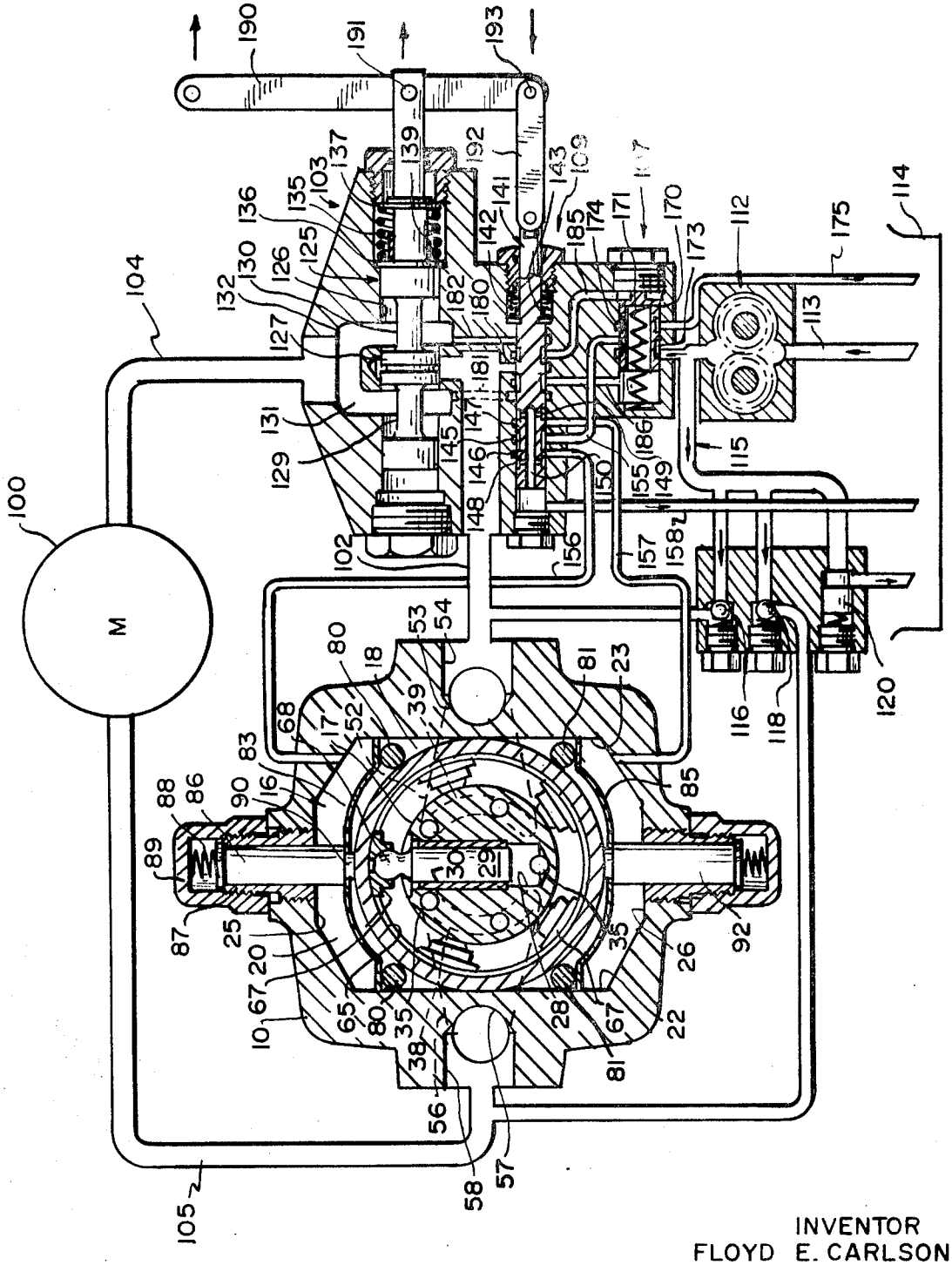
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[57] **ABSTRACT**

A control for a variable displacement pump adapted to supply a reversible load device including fluid operable means for varying the displacement of the pump in opposite directions from neutral to supply fluid in opposite directions to the load, means providing a source of control fluid under pressure, a directional valve for directing control fluid to opposite sides of the displacement varying means to determine the direction of pump delivery, a variable orifice for creating a measurable pressure drop in the pump inlet or the pump outlet, means for sensing the pressure drop across the orifice to control the amount of displacement to provide constant flow, and a single control for first operating the directional valve to establish the direction of pump delivery and then varying the orifice to establish the amount of flow.

15 Claims, 1 Drawing Figure




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PUMP DISPLACEMENT CONTROL

SUMMARY OF THE INVENTION

The present invention relates to a control for varying displacement of a rotary hydraulic pump to control the amount of fluid delivered in opposite directions to a load device. In order to control the rate of fluid flow, the pressure drop across an orifice in the pump inlet or the pump outlet is sensed by a displacement control valve which is adapted to adjust pump displacement in a manner to deliver constant flow regardless of pressure variation caused by the load device. In order to vary the rate of flow, provision is made for varying the size of the orifice opening across which the pressure drop is measured. In order to control the direction of fluid flow from the pump, a directional valve is provided between the displacement control valve and the displacement varying means in a manner to reverse the flow of fluid controlled by the displacement control valve for purposes of reversing the displacement of the pump.

In the past, it has been old to sense the pressure drop across an orifice and vary displacement to maintain the pressure drop, and therefore the flow, constant. Insofar as is known to applicant, it is believed novel to utilize such a control in connection with a directional valve for reversing pump displacement in an arrangement for varying the orifice in both directions of flow and sensing the pressure drop in both directions of flow for varying displacement.

It is a general object of the present invention to provide a new and improved control for a variable displacement pump including a directional valve for reversing flow of control fluid relative to displacement varying means together with means responsive to pressure drop across an orifice in both directions of flow for controlling the amount of displacement.

In a preferred embodiment illustrated, the directional valve is provided with valving for directing flow from the upstream side of the orifice to decrease displacement and valving for directing flow from the downstream side of the orifice to increase displacement on flow in either direction through the orifice.

As illustrated, the directional valve is movable in opposite directions from neutral to a stop position, the orifice valve is variable in opposite directions from neutral, and a single manual control is provided for operating both valves.

Preferably, the directional valve is biased to neutral by a relatively weak spring, and the orifice valve is biased to neutral by a relatively strong spring, so that operation of the manual control will first operate the directional valve to establish the direction of pump delivery, and then operate the orifice to establish the amount of fluid flow.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE is a hydraulic circuit diagram including cross sectional illustrations through a variable displacement pump and controls therefor embodying the principles of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawing in detail, a pump includes a housing **10** which is somewhat rectangular in cross section and defines a chamber **16** for housing a rotary cylinder block **17** and a generally cylindrical cam ring **18** surrounding the cylinder block. The chamber **16** includes end walls as at **20**, side walls **22** and **23**, and top and bottom walls **25** and **26**.

The cylinder block **17** includes a generally cylindrical main body with a plurality of radially disposed fluid cylinders as at **28**, each of which contains a reciprocable piston **29** slidable in a suitable liner **30** in the cylinder. The fluid chambers **28** are radially disposed and each extends from the periphery of the cylinder block radially inwardly past the axis of rotation of the cylinder block, nearly to the diametrically opposite periphery of the cylinder block. The cylinders are axially spaced in the cylinder block and they are angularly spaced relative to each other. In the construction illustrated, five pistons are utilized at about 72° apart so as to be equally spaced about the periphery of the cylinder block.

In order to port fluid to and from the chambers **28**, the cylinder block includes a plurality of axially disposed passages or ports **35**, each of which intersects one of the fluid chambers **28**. Each of the axial passages **35** extends to the end of the cylinder block for communication with appropriate valving. As illustrated, a valve plate is provided at the end of the cylinder block with a pair of symmetrically disposed arcuately shaped inlet and outlet ports **38** and **39** adapted for successive communication with axial passages **35** as the cylinder block rotates.

In order to mount the cylinder block for rotation, it may be formed at opposite ends with shaft extensions (not visible) appropriately mounted in suitable bearings such as bushings in the ends of the housing. At least one of such shaft extensions may be formed with a terminal portion adapted for connection with a driving member when the unit is used as a pump.

The arcuate port **39** in the valve plate communicates with a laterally extending passage **52** in the housing which intersects with a longitudinal passage **53** in turn communicating with a housing port **54**. The arcuate port **38** in the valve plate communicates with a laterally extending passage **56** in turn communicating with a longitudinal passage **57** which communicates with a housing port **58**.

For purposes of controlling reciprocation of the pistons, the cam ring **18** is formed with a plurality of axially adjacent cam tracks as at **65** of generally similar configuration, each adapted for cooperation with a complementary bearing slipper **67** on the end of each piston. As illustrated, each piston is formed with a spherical end **68** and each bearing slipper **67** is formed with a shank portion crimped on the spherical end **68** for purposes of mounting the bearing slipper on the piston for universal movement relative thereto.

The cam ring **18** is normally urged to a central position in the chamber **16**, as shown, where the ring is concentric with the cylinder block so that there will be no reciprocation of the pistons on rotation of the cylinder block and therefore no displacement of fluid. The cam ring is movable in opposite radial directions from the neutral concentric position by supply of fluid under pressure to either the top of the chamber **16** or the bottom of the chamber **16**. In order to provide separate sealed chambers at the top of the cam ring and the bot-

tom of the cam ring in the chamber **16**, opposite ends of the ring have sealing engagement with opposite end walls of the chamber **16**. Diametrically opposite peripheral sides of the cam ring **18** fit closely adjacent opposite side walls **22** and **23** of the chamber **16**.

In order to provide a seal between the outer side of the cam ring and the adjacent side wall of the chamber **16**, sealing rods are utilized as at **80** in the top of the chamber **16** and as at **81** in the bottom of the chamber. In order to hold the rods **80** in position and bias the rods and cam ring in one direction toward a central concentric position, an arched leaf spring **83** includes opposite ends resting on the sealing rods **80**. In the bottom of the chamber a similar arched leaf spring **85** has opposite ends engaging sealing rods **81**. Centrally of the arch, the leaf spring **83** is engaged by a spring-biased plunger **86** reciprocable in an adjustable threaded bushing **87** in the housing. The plunger **86** is biased by a spring **88** seated against a cap **89** on the bushing **87**. The plunger **86** has a reduced end portion **90** seated in a complementary aperture in the leaf spring **83**. The leaf spring **85** biases the cam ring and sealing rods **81** in an opposite direction toward the neutral concentric position as a result of a spring-biased plunger **92** similar to that described at **86**.

In the absence of supply of fluid under pressure to either the top of the chamber **16** or the bottom of the chamber **16**, both plungers **86** and **92** engage the cam ring **18** and the spring mechanisms illustrated are effective to maintain the cam ring in a central position concentric about the cylinder block to produce zero displacement. Fluid under pressure may be supplied to the top of the chamber **16** to move the cam ring to infinitely vary displacement in one direction from neutral, ultimately to one extreme eccentric position where the spring-biased plunger **92** functions as a stop at the end of its movement.

If fluid is exhausted from the upper part of the chamber and pressure is supplied to the lower part of the chamber, displacement may be varied in the opposite direction from neutral.

The pump illustrated is shown and described more completely in my copending application Ser. No. 147,443, filed concurrently herewith (Attorney's Docket No. 6531).

As shown herein, the variable displacement pump is connected in closed hydraulic circuit with a load device **100** which may be a reversible rotary hydraulic motor suitable for the intended purposes. For example, the motor **100** may be utilized for propulsion of a vehicle. Specifically, the pump housing port **54** is connected to a conduit **102** leading through a variable orifice valve **103** to a conduit **104** connected to one side of the motor **100**. Pump housing port **58** is connected with a conduit **105** in turn connected with the opposite side of the motor **100**. The orifice valve **103** is constructed to provide a variable restriction in the path of fluid flow between the pump port **54** and the motor **100**. Displacement of the pump is controlled by a displacement control valve **107** which senses the pressure drop across the orifice in valve **103** and controls displacement to provide constant flow. The direction of pump delivery through port **54** or port **58** is controlled by a directional valve **109**.

In order to provide charge fluid to replace leakage in the closed hydraulic circuit, a charge pump **112** may be utilized to draw fluid through a conduit **113** from a reservoir **114**. The charge pump may be conveniently driven by the shaft of the main pump, and delivers charge fluid through a conduit **115** to a pair of check valves **116** and **118** adapted to provide communication respectively with the main conduits **102** and **105**. When fluid is supplied by the main pump from the port **54**, the check valve **116** is held closed by the relatively high pressure and fluid is replenished through the check valve **118** which is opened by the pressure of charge fluid against the pressure of return fluid in the conduit **105**. Conversely, when the main pump delivers pressure fluid through the port **58** to the conduit **105**, the check valve **118** is held closed, and charge fluid is supplied through the check valve **116**. Pressure of charge fluid developed by the charge pump **112** is limited by relief valve **120** adapted to relieve excess pressure and flow to the reservoir **114**.

The directional valve **109** directs the flow of fluid from the charge pump **112** to either the top of the chamber **16** or the bottom of the chamber **16** to define the direction of pump displacement. The directional valve also functions to direct pressure from the upstream side of the orifice valve **103** and the downstream side of the valve **103** to appropriate sides of the displacement control valve **107**.

The variable orifice valve **103** includes a valve stem **125** slidable in a valve bore **126** having a central enlarged land or piston portion **127** normally blocking the passage **102** when the stem **125** is positioned as illustrated. At opposite sides of the land **127**, the stem includes reduced portions **129** and **130** adapted on movement of the valve stem in opposite directions to communicate the passage **102** respectively with channels **131** or **132** leading to the conduit **104**.

The orifice valve stem **125** is normally biased to the central position illustrated by a centering spring **135** which bears at opposite ends against rings **136** and **137** slidable on the valve stem toward each other but biased away from each other by the spring toward abutments on the valve stem and in the spring chamber. Thus, the valve stem may be moved in either direction from neutral against the centering force of the spring **135**. In order to limit the amount of movement of the valve stem, a sleeve **139** is positioned on the valve stem between the spring seat rings **136** and **137** to stop movement when opposite ends of the sleeve contact the rings **136** and **137**.

The directional valve **109** includes a valve stem **141** which is controlled by a spring centering and stop mechanism like that associated with the orifice valve stem **125** including a centering spring **142** and a stop sleeve **143**.

In order to control the direction of flow of control fluid to the displacement varying means, the directional valve stem **141** includes a reduced portion **145** between a pair of lands **146** and **147**. Outwardly from the lands **146** and **147** a pair of grooves **148** and **149** communicate with an axial passage **150** in the stem. When the valve stem is positioned as illustrated, the lands **146** and **147** block the flow of control fluid from passage **155** to passages **156** and **157** leading respectively to the top and bottom of the displacement varying chamber

116. At the same time, both of the passages 156 and 157 communicate through ports 148 and 149 with the drain passage 150 which in turn communicates with conduit 158 leading to the reservoir 114. On movement of the valve stem 141 to the left, the stem groove 145 supplies control fluid from the passage 155 to the passage 156 leading to the upper portion of chamber 16 while the port 149 communicates the lower portion of the chamber 16 with drain. Conversely, if the valve stem is moved to the right, control fluid is supplied from the passage 155 to the lower part of the chamber 16, while the upper part of the chamber is connected to drain.

The displacement control valve 107 includes a valve member 170 urged toward the right by a spring 171 where a groove 173 communicates the charge pump with the charge passage 155. If the valve member 170 is moved to the left by pressure fluid, a groove 174 communicates the passage 155 with a drain conduit 175 leading to reservoir 114. In operation, fluid from the upstream side of the orifice valve is communicated to the right end of the valve member 170 and fluid from the down stream side of the orifice is communicated to the left of the valve member 170. Thus, in the event of an increase in pressure drop across the orifice, displacement is reduced.

The directional valve 141 is constructed to port pressure from the upstream side of the orifice to the right of the valve member 170 and to port fluid from the downstream side of the orifice to the left side of the valve 170, regardless of the direction of flow through the orifice. For such purposes, the valve stem 141 includes a land normally blocking a port 180 for sensing pressure in the passage 102 between the pump and the orifice. Lands on the valve stem 141 also normally block passages 181 and 182 communicating respectively with channels 131 and 132 for sensing pressure in the passage 104 between the orifice and the motor 100.

In operation, on movement of the valve stem 141 toward the left, charge fluid is ported through the passage 155 to the top of the chamber 116 to put the pump into stroke to deliver fluid under pressure through the port 54 and to the motor 100 from which it is returned to the pump through the conduit 105. Movement of the valve stem to the left also communicates the port 180 at the upstream side of the orifice with passage 185 leading to the right end of control valve 170. At the same time, the passage 181 at the down stream side of the orifice is communicated with the left end of the valve member 170 through a stem groove and passage 186. Thus, when the orifice is open, and the pressure drop across the orifice increases, the valve member 170 is moved toward the left to port the passage 155 to drain and reduce displacement. If the pressure drop then reduces, the valve member 170 moves back toward the right and control fluid is again ported to the top of the chamber 16.

If the valve stem 141 is moved to the right, control fluid is supplied through the passage 155 and the stem groove 145 to the lower end of chamber 16 so that the pump delivers fluid under pressure through the conduit 105 and the motor 100 returns fluid to the pump through the conduit 104. Now, the upstream side of the orifice is adjacent the motor rather than the pump, but the upstream pressure is again delivered to the right end of the valve 170 through the passage 182, a stem groove and passage 185. At this time, the left end of the valve 170 again communicates with the downstream side of the orifice through the port 180, a stem groove and the passage 186.

The directional valve stem 141 and the orifice valve stem 125 are controlled by a common manually operable control lever 190 which is pivotally connected to valve stem 125 at 191. The lever is connected to control the valve stem 141 through a link 192 pivotally connected to the valve stem 141 and pivotally connected to the lever 190 at 193.

In order to properly program the movement of the valve stems 141 and 125, the centering spring 142 in the directional valve is relatively weak and the centering spring 135 in the orifice valve is relatively strong. Thus, if the manual control lever 190 is pivoted in a clockwise direction, the pivot 191 will be relatively fixed and the directional valve spring 142 will yield so that the directional valve stem 141 moves to the left before the orifice valve stem 125 moves. When the movement of the directional valve stem 141 is limited by the stop sleeve 143, further pivotal movement of the lever 190 in a clockwise direction will move the orifice valve stem 125 to the right until limited by the stop sleeve 139, but it should be understood that the size of the orifice may be infinitely varied from the fully closed position to the fully open position to vary the rate of flow of fluid delivered by the pump. For any given orifice setting, the valve 107 senses the pressure drop and undertakes to vary the displacement to maintain the pressure drop constant. In this manner, the control functions to maintain a constant rate of flow for a given orifice setting and therefore to operate the motor at a constant speed regardless of the load.

I claim:

1. A control for a variable displacement pump adapted to supply a reversible load device, comprising,

a. a fluid operable means for varying the displacement of the pump in opposite directions from neutral,

b. a first conduit connected to function as a pump outlet on displacement of the pump in one direction and as a pump inlet on displacement of the pump in the opposite direction,

c. a second conduit connected to function as a pump inlet on displacement of the pump in said one direction and as a pump outlet on displacement in said opposite direction,

d. means providing a source of control fluid under pressure,

e. directional valve means for directing control fluid to opposite sides of the displacement varying means,

f. means defining an adjustable orifice creating a pressure drop in one of said conduits during flow in either direction through the conduit,

g. means for sensing the pressure drop across the orifice during flow in either direction through the orifice defining means to control the displacement varying means to provide a constant flow rate for each orifice setting, and

h. means for adjusting the orifice defining means to vary the size of the orifice to vary the rate of flow delivered by the pump.

2. A control as defined in claim 1, including a single manual control for operating the directional valve and the orifice defining means.

3. A control for a variable displacement pump adapted to supply a reversible load device, comprising,

a. a fluid operable means for varying the displacement of the pump in opposite directions from neutral,

b. a conduit connected to function as a pump outlet on displacement of the pump in one direction and as a pump inlet on displacement of the pump in the opposite direction,

c. a conduit connected to function as a pump inlet on displacement of the pump in said one direction and as a pump outlet on displacement in said opposite direction,

d. means providing a source of control fluid under pressure,

e. directional valve means for directing control fluid to opposite sides of the displacement varying means,

f. an orifice creating a pressure drop in one of said conduits,

g. means for sensing the pressure drop across the orifice to control the displacement varying means during flow in either direction through the orifice,

h. a single manual control for operating the directional valve means and the orifice varying means, and

i. means responsive to the control to first operate the directional valve means to put the pump in stroke and then operate the orifice varying means to select the rate of flow.

4. A control for a variable displacement pump adapted to supply a reversible load device, comprising,

a. reversible fluid operable means for varying the displacement of the pump in opposite directions from neutral,

b. means yieldably biasing the displacement varying means toward neutral,

c. a first conduit connnected to function as a pump outlet to the load on displacement of the pump in one direction from neutral and as a pump inlet from the load on displacement of the pump in the opposite direction from neutral,

d. a second conduit connected to function as a pump inlet from the load on displacement of the pump in said one direction from neutral and as a pump outlet to the load on displacement of the pump in said opposite direction from neutral,

e. means providing a source of control fluid under pressure,

f. a directional valve for directing control fluid to opposite sides of the displacement varying means,

g. means defining an adjustable orifice creating a pressure drop in one of said conduits during flow in either direction through the conduit,

h. a displacement control valve responsive to the pressure drop across the orifice during flow in either direction through the orifice defining means to increase displacement of the pump on decrease of the pressure drop and decrease displacement on increase of the pressure drop thereby to maintain a constant flow rate for a given orifice setting, and

i. manually operable means for adjusting the orifice defining means to vary the orifice to vary the flow rate.

5. A control as defined in claim 4 wherein the adjustable orifice includes a movable valve member in a valve bore, means biasing the valve member to a position closing the orifice, and a manual control for moving the valve member selectively in varying amounts to vary the size of the orifice to vary the rate of flow.

6. A control as defined in claim 4 wherein the directional valve includes a valve member movable in a valve bore, means biasing the valve member to a neutral central position blocking flow of control fluid to the displacement varying means, and a manually operable control for moving the valve member in opposite directions from neutral to selectively direct control fluid to one side or the other of the displacement varying means.

7. A control for a variable displacement pump adapted to supply a reversible load device, comprising,

a. reversible fluid operable means for varying the displacement of the pump in opposite directions from neutral,

b. means yieldably biasing the displacement varying means toward neutral,

c. a conduit connected to function as a pump outlet to the load on displacement of the pump in one direction from neutral and as a pump inlet from the load on displacement of the pump in the opposite direction from neutral,

d. a conduit connected to function as a pump inlet from the load on displacement of the pump in said one direction from neutral and as a pump outlet to the load on displacement of the pump in said opposite direction from neutral,

e. means providing a source of control fluid under pressure,

f. a directional valve for directing control fluid to opposite sides of the displacement varying means,

g. a variable orifice creating a pressure drop in one of said conduits,

h. a displacement control valve responsive to the pressure drop across the orifice during flow in either direction through the orifice to increase displacement of the pump on decrease of the pressure drop and decrease displacement on increase of the pressure drop thereby to maintain a constant flow rate for a given orifice setting,

i. means for directing fluid from the downstream side of the orifice to the displacement control valve to increase displacement, and

j. means for directing fluid from the upstream side of the orifice to the displacement control valve to decrease displacement.

8. A control for a variable displacement pump adapted to supply a reversible load device, comprising,

a. reversible fluid operable means for varying the displacement of the pump in opposite directions from neutral,

b. means yieldably biasing the displacement varying means toward neutral,

c. a conduit connected to function as a pump outlet to the load on displacement of the pump in one direction from neutral and as a pump inlet from the load on displacement of the pump in the opposite direction from neutral,

d. a conduit connected to function as a pump inlet from the load on displacement of the pump in said one direction from neutral and as a pump outlet to the load on displacement of the pump in said opposite direction from neutral,
e. means providing a source of control fluid under pressure,
f. a directional valve member for directing control fluid to opposite sides of the displacement varying means,
g. a variable orifice creating a pressure drop in one of said conduits,
h. a displacement control valve responsive to the pressure drop across the orifice during flow in either direction through the orifice to increase displacement of the pump on decrease of the pressure drop and decrease displacement on increase of the pressure drop thereby to maintain a constant flow rate for a given orifice setting,
i. manually operable means for moving the valve member in opposite directions from neutral to selectively direct control fluid to one side or the other of the displacement varying means,
j. valving on the directional valve member for directing fluid from the downstream side of the orifice to the displacement control valve to increase displacement regardless of the direction of valve member movement, and
k. valving on the directional valve member for directing fluid from the upstream side of the orifice to the displacement control valve to decrease displacement regardless of the direction of valve member movement.

9. A control for a variable displacement pump adapted to supply a reversible load device, comprising,
a. reversible fluid operable means for varying the displacement of the pump in opposite directions from neutral,
b. means yieldably biasing the displacement varying means toward neutral,
c. a conduit connected to function as a pump outlet to the load on displacement of the pump in one direction from neutral and as a pump inlet from the load on displacement of the pump in the opposite direction from neutral,
d. a conduit connected to function as a pump inlet from the load on displacement of the pump in said one direction from neutral and as a pump outlet to the load on displacement of the pump in said opposite direction from neutral,
e. means providing a source of control fluid under pressure,
f. a directional valve for directing control fluid to opposite sides of the displacement varying means,
g. a variable orifice creating a pressure drop in one of said conduits,
h. a displacement control valve responsive to the pressure drop across the orifice during flow in either direction through the orifice to increase displacement of the pump on decrease of the pressure drop and decrease displacement on increase of the pressure drop thereby to maintain a constant flow rate for a given orifice setting, and
i. said variable orifice comprising a valve stem movable in a valve bore, means biasing the valve stem to a neutral central position closing the orifice, and means for moving the valve stem selectively in opposite directions from neutral in varying amounts to vary the size of the orifice to vary the rate of flow.

10. A control as defined in claim **9**, wherein the directional valve comprises a valve stem movable in a valve bore, means biasing the valve member to a neutral central position blocking flow of control fluid to the displacement varying means, means for moving the valve stem in opposite directions from neutral to selectively direct control fluid to one side or the other of the displacement varying means, and stop means limiting movement of the valve stem in opposite directions.

11. A control as defined in claim **10** including valving on the directional valve stem for directing fluid from the downstream side of the orifice to the displacement control valve to increase displacement regardless of the direction of displacement and the direction of flow through the orifice, and valving on the directional valve stem for directing fluid from the upstream side of the orifice to the displacement control valve to decrease displacement regardless of the direction of displacement and the direction of flow through the orifice.

12. A control as defined in claim **10** including a single manually operable control lever connected for operating the directional valve and the variable orifice.

13. A control as defined in claim **12** including means pivotally connecting the lever to the directional valve stem, means pivotally connecting the lever to the orifice valve stem, relatively weak spring means centering the directional valve stem, and relatively strong spring means centering the orifice valve stem, so that operation of the lever first effects movement of the directional valve stem to put the pump in stroke, and after the directional valve stem stop is encountered, then effects movement of the orifice valve stem to vary the rate of flow.

14. A control for a variable displacement pump adapted to supply a reversible load device, comprising,
a. reversible fluid operable means for varying the displacement of the pump in opposite directions from neutral,
b. means yieldably biasing the displacement varying means toward neutral,
c. a conduit connected to function as a pump outlet to the load on displacement of the pump in one direction from neutral and as a pump inlet from the load on displacement of the pump in the opposite direction from neutral,
d. a conduit connected to function as a pump inlet from the load on displacement of the pump in said one direction from neutral and as a pump outlet to the load on displacement of the pump in said opposite direction from neutral,
e. means providing a source of control fluid under pressure,
f. a directional valve for directing control fluid to opposite sides of the displacement varying means,
g. a variable orifice creating a pressure drop in one of said conduits,
h. a displacement control valve responsive to the pressure drop across the orifice during flow in either direction through the orifice to increase displacement of the pump on decrease of the pressure

drop and decrease displacement on increase of the pressure drop thereby to maintain a constant flow rate for a given orifice setting, and

i. a single manually operable control lever for operating the directional valve and the variable orifice.

15. A control as defined in claim 14 including means pivotally connecting the lever to the directional valve, means pivotally connecting the lever to the variable orifice, relatively weak means resiliently resisting movement of the directional valve, relatively strong means resiliently resisting variation of the orifice, whereby operation of the control lever first operates the directional valve and then operates the variable orifice.

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