

[54] **PUMP CONTROL SYSTEM**

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417/222

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417/218, 219, 222, 213; 60/52 VS, 450

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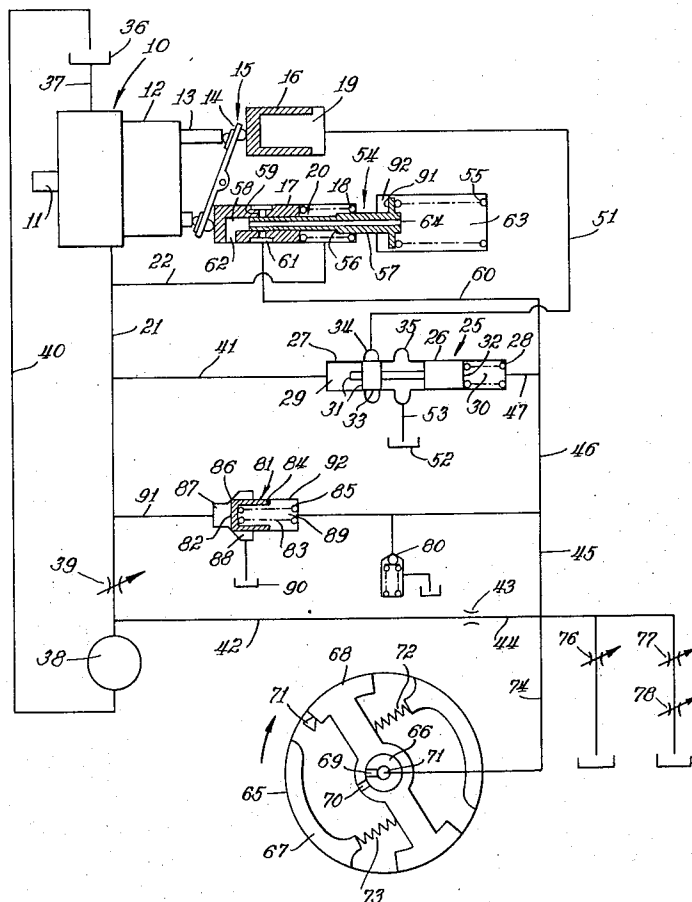
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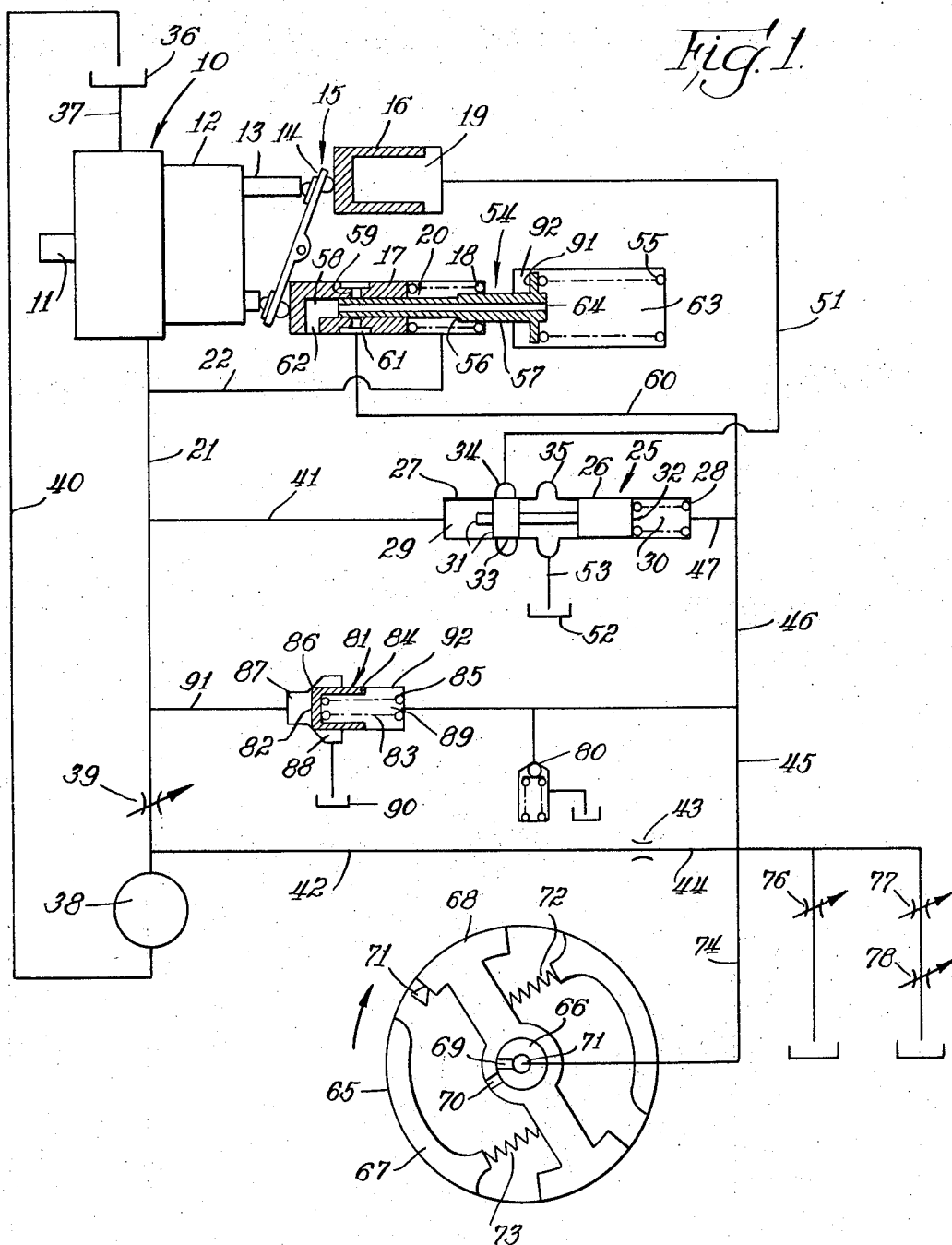
[57] **ABSTRACT**

A hydraulic system including a variable displacement pump with a displacement control mechanism, a sensing valve to control the displacement control, and a logic system providing over-ride control of the sensor valve and the displacement of the pump.

Specific embodiments include the over-riding of load or flow compensated systems, torque over-ride by the use of a pressure and displacement sensitive valve, and a sensor valve that includes a bypass position which cooperates with the displacement control to control the effective output of the pump.

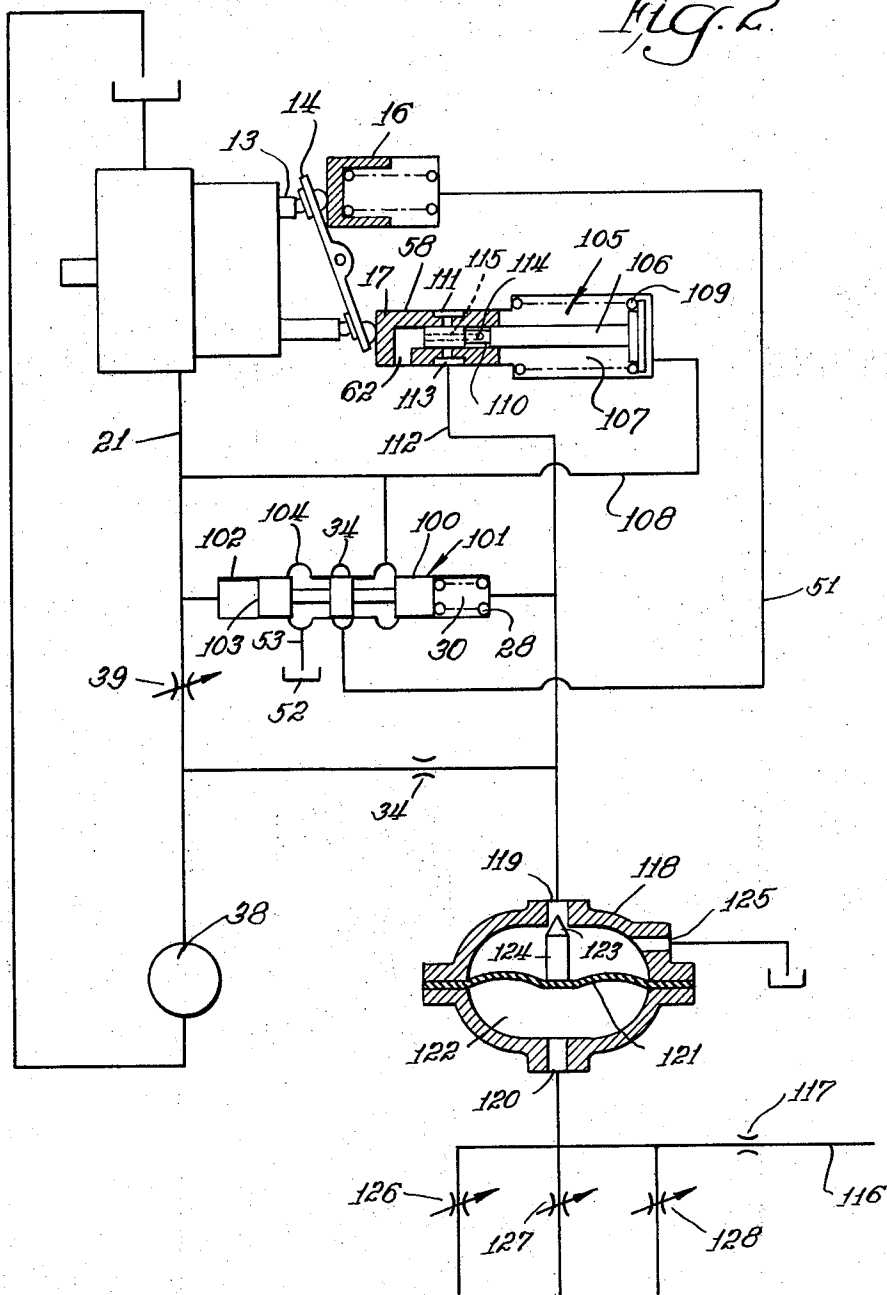
5 Claims, 5 Drawing Figures



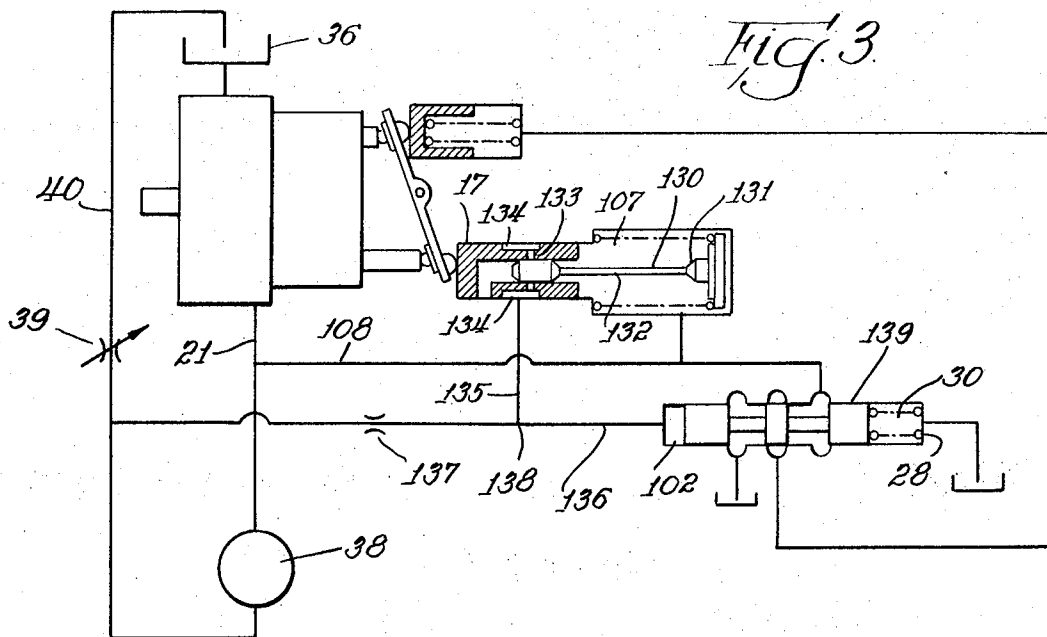
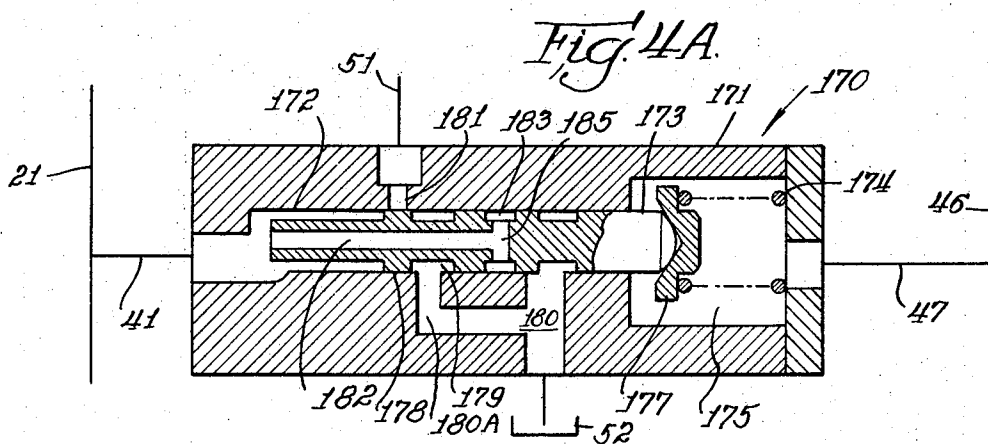
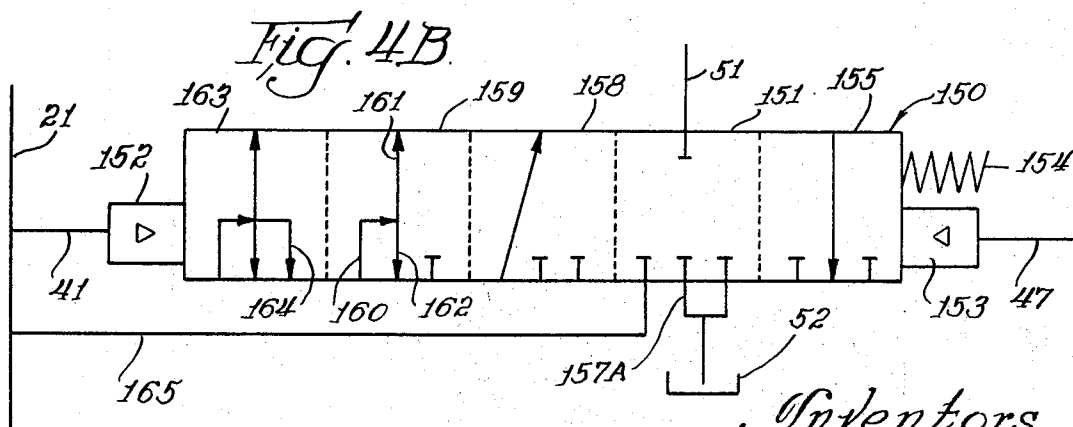


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Fig. 2



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PUMP CONTROL SYSTEM

THE INVENTION

The present invention represents an advance in the concept of pump control. In the hydraulic system, a sensing valve is provided to control the displacement control of a variable displacement pump. This sensing valve is actuated to pump displacement increasing and pump displacement decreasing positions by a force balance consisting of a bias force and a hydraulic force. The hydraulic force is controlled by a plurality of manual or automatic valve devices interconnected to form a logic system so that actuation of any one of these valve devices is effective to change the force balance on the sensor valve and to move the sensor valve to a displacement decreasing position. Thus the displacement of the pump can be controlled by a variety of combined signals.

One of the principal uses of the present invention is to achieve over-ride control of flow compensated pump displacement. The over-ride control can then be used to achieve manual or automatic control of the pump displacement from any internal or external source.

THE DRAWINGS

FIG. 1 is a schematic of a hydraulic system of this invention;

FIG. 2 is a schematic of a different embodiment of a hydraulic system of this invention;

FIG. 3 is a schematic of a still further embodiment of a hydraulic system of this invention;

FIG. 4A is a cross sectional view of a sensing valve that includes a bypass position; and

FIG. 4B is a schematic of the sensing valve that includes a bypass position.

DESCRIPTION

Attention is directed to FIG. 1 of the drawings wherein a hydraulic system according to this invention is schematically illustrated. There is shown a variable displacement pump 10 provided with a mechanical power input shaft 11 connected to a source of mechanical power (not shown) which rotates a cylinder barrel 12 causing pistons 13 to reciprocate as they engage a swash plate 14. This general type of variable displacement pump is known in the art.

The swash plate 14 is part of a fluid actuated displacement control mechanism 15 which also includes trunnions (not shown), a large control piston 16, a small control piston 17 and a bias spring 18 biasing the control piston 17 toward the swash plate. A large control cylinder 19 is associated with the piston 16 and a small cylinder 20 is associated with the piston 17.

The inclination of the swash plate 14, the pumping stroke of the pistons 13, and thus the displacement of the pump 10 are dependent upon the pressure fluid in the large control cylinder 19 and in the small control cylinder 20.

Pressurized fluid from a pump output pressure conduit 21 is fed through a conduit 22 to the cylinder 20 where it exerts a force against the small control piston 17, assisting the spring 18 in urging the swash plate 14 toward the maximum displacement position, as shown.

The pressure fluid in the cylinder 19 is the controlling factor in determining the displacement of the pump 10 because the cylinder 20 will accept additional fluid from the conduits 21 and 22 or return excess fluid to

these conduits depending upon whether or not fluid is added to or released from the larger area of the piston 16 and the cylinder 19.

A differential pressure sensitive sensor valve 25 controls the admission of pressure fluid into the cylinder 19 and the release of fluid from the cylinder 19. The sensor valve 25 includes a valve spool 26 in a bore 27, biased by a spring 28 toward a first position toward the left from its neutral position shown.

The sensor valve 25 includes fluid receiving chambers 29 and 30, which serve to apply fluid pressure against fluid responsive areas 31 and 32, respectively, provided on the projected ends of the valve spool 26.

The chamber 29 also serves as a pressure inlet port for the sensor valve 25 and cooperates in this manner with a spool land 33 and with ports 34 and 35 to control fluid to and from the cylinder 19 and the large control piston 16.

The fluid responsive areas 31 and 32 of the valve spool 26 are made responsive to pressures that vary in magnitude as a function of flow across a variable orifice 39 by a connection with the chamber 29 through conduits 21 and 41 and a connection with the chamber 30 through conduits 21, 42, a restrictor 43, and conduits 44, 45, 46 and 47.

In operation, a fluid from a reservoir 36 enters the pump 10 through a conduit 37 and is delivered to a fluid motor 38 through the conduit 21 and the variable orifice 39. Fluid exhausted from the motor 38 is returned to the reservoir 36 by a return conduit 40. The variable orifice 39 controls fluid flow to motor 38.

Flow through the variable orifice 39 produces a differential pressure signal to the chambers 29 and 30 in proportion to, or indicative of the value of the variable orifice and the instantaneous flow rate in the conduit 21.

The difference in the pressures applied to the fluid responsive means consisting of fluid responsive areas 31 and 32 is effective to oppose the bias force means or spring 28 of the sensor valve 25. Differential pressures above a certain level are effective to overcome the bias force of the spring 28 and to move the spool 26 toward the right as viewed in the drawing to a second or displacement decreasing position whereas when lower differential pressures exist the spring 28 moves the spool 26 to the left toward a first or displacement increasing position.

Excessive flow rates, in relation to those preselected by the variable orifice 39 and indicated by the pressure drop across the orifice 39, will result in the valve spool 26 being moved to the right to the second position. The valve spool 26 then establishes a fluid communication path between the outlet conduit 21 and the large control piston 16 via the conduit 41, the chamber 29, the port 34 and the conduit 51. With such connection, the same value of fluid pressure is applied to the piston 16 as is applied to the piston 17 because both cylinder 19 and cylinder 20 are connected to the pump outlet pressure conduit 21. The larger area of the piston 16 is effective to overcome the force exerted by the small control piston 17, and the displacement of pump 10 is reduced until the flow through the variable orifice 39 equals the desired value as determined by the present restriction of the variable orifice 39.

When flow rates are smaller than selected by the variable orifice 39, the spring 28 will move the valve spool 26 to the left, to a first position, establishing fluid com-

munication between the cylinder 19 and a sump 52 via the conduit 51, the port 34, the port 35 and the conduit 53.

The system as described in the preceding paragraphs is a demand type of system. The system is controlled by the flow caused pressure drop across variable orifice 39 so that the pump displacement is controlled to provide the flow necessary to satisfy the system demand as expressed by the flow area established through variable orifice 39.

This demand system can also be thought of as being load sensitive in that the displacement of the pump is controlled to provide a flow that causes a pressure equal to the load pressure plus a small pressure increment for flow across variable orifice 39.

The over-ride system of the present invention can be visualized as performing a function that is opposite to a demand type of system. Whereas the demand system can be adapted to provide an increase in pump displacement from the signalling of one or a plurality of fluid restrictions such as variable orifice 39; the logic system of the present invention provides means whereby a number of manual or automatic safety or control devices can be provided to over-ride the demand system; and any one of the over-ride devices is effective to decrease the pump displacement.

This over-ride concept can also be thought of as providing a negative signal in that it negates the signal produced by the demand system. As illustrated in FIG. 1, opening of variable orifice 39 increases the fluid pressure applied to area 32 through conduits 42, 44, 45, 46 and 47. Conversely, opening of valve means 76 is effective to negate the pressure applied to area 32 by conducting pressure fluid from area 32 to a fluid sump via conduits 47, 46, 45 and valve means 76. Restrictor 43 is effective to prevent an excessive rate of flow from conduit 21 to area 32 via conduits 42, 44, etc., thereby cooperating with the flow through valve means 76 to negate the fluid pressure applied to area 32.

This negative signal concept is utilized in several different ways in the embodiment shown in FIG. 1. In each case, a pressure drop is caused in the conduits 44, 45, 46 and 47 and in the chamber 30 by exhausting fluid to sump; and (A) the restrictor 43 between the conduits 42 and 44 limits the flow into the chamber 30, so that a relatively small exhaust flow is effective to lower the pressure in the chamber 30.

A first application of this negative signal concept is illustrated by the pressure and displacement sensitive valve 54 (hereinafter referred to as "pd" valve). The pump outlet pressure in the cylinder 20 exerts a force against a spring 55 by acting against a shoulder 56 of a valve plunger 57, making the plunger 57 and the spring 55 a pressure-to-position mechanism.

The projected area of the valve plunger 57 in a bore 58 is in communication with a sump (not shown) via a cross-hole 62 and the pump housing (not shown). The projected end of the plunger 57 in a spring chamber 63 is likewise in fluid communication to the sump via a longitudinal hole 64. Thus only the area of the shoulder 56 in the cylinder 20 is subjected to fluid pressure.

The small end of the plunger 57 cooperates with the bore 58 and a cross-hole 59 of the small control piston 17 to form a two-way valve. If the piston 17 is considered to be stationary, the pressure-to-position transforming action of the shoulder 56 and the spring 55 combines with the valving action of the cooperating

portions of the piston 17 and the plunger 57 to form a pressure sensitive valve. However, the piston 17 is not stationary, but moves with the swash plate 14. Thus the valve is made to be swash plate angle or displacement sensitive and so the valve is both pressure and displacement sensitive.

The pd valve 54 opens when the combination of pump pressure and displacement exceed design or pre-set combinations. That is, pressure moves the plunger 57 to the right and an increase in displacement moves the piston 17 and the cross-hole 59 to the left.

When the plunger 57 uncovers the cross-hole 59, the pressure in the chamber 30 is reduced by fluid exhausting through a conduit 60, an annular groove 61, the cross-hole 59, the bore 58 and a cross-hole 62 to the pump housing and to a sump. This reduction of pressure in chamber 30 causes a reduction in the displacement of pump 10.

Since input torque is directly related to output pressure and displacement, the pd valve formed by the plunger 57 and the piston 17 functions as a torque compensator to limit the input torque that is required to drive the pump.

The pd valve may be combined with a remote transducer such as an acceleration transducer 65. The transducer 65 includes a shaft 66 and a body 67 mounted on the output shaft of the pump driving means to receive support and rotation therefrom. A sensor mass 68 is mounted on the shaft 66 for relative rotation with the shaft; and the cooperating surfaces of the shaft 66 and the mass 68 combine with cross-holes 69 and 70 to form a two-way valve.

The mass 68 is held against a stop 71 by springs 72 and 73 when the velocity of the shaft 66 is constant or increasing. However, upon deceleration of the shaft 66, the mass 68 rotates clockwise with respect to the shaft 66, compressing the springs 72 and 73 and opening communication from the chamber 30 to a sump via the conduits 47, 46, 45 and 74 to a longitudinal hole 75, the cross-hole 69 and the cross-hole 70.

Opening of this communication from the chamber 30 to a sump as a function of pump drive engine deceleration affects a reduction of pump displacement whenever the total load on the engine exceeds the available torque. Thus the deceleration sensing system considers not only pump drive torque, but all engine loads, and the engine's ability to handle the loads.

The variable restrictors or over-ride valves 76, 77 and 78 schematically represent a logic system of transducer or manually actuated devices.

An additional pressure control for the chamber 30 is a pilot relief valve 80 which cooperates with the restrictor 43 to limit the pressure in chamber 30. Pressure values in the conduit 21 and the chamber 29 which exceed the limited value, will move the valve spool 26 to the right, compress the spring 28, exhausting fluid through the valve 80 to a sump, and effect a reduction in the displacement of the pump 10 by communicating the large control piston 16 with the conduit 21.

It should be noticed that the over-ride portion of the system will control the displacement of the pump without the necessity of the inclusion of the variable orifice 39 and the flow compensation feature. With the variable orifice 39 eliminated, fluid pressures in the chamber 29 and 30 will equal each other and the fluid pressure in the conduit 21 just as if the variable orifice 39 were included but opened to its minimum restriction.

Thus the spring 28 urges valve spool 26 to the left to a displacement increasing position; and the over-ride system is effective to reduce the displacement of the pump 10 to the desired value by the bleeding off of fluid pressure from the chamber 30 to a sump.

A bypass valve 81 is provided in the system and is adapted to cooperate with the displacement control mechanism 15 in the control of the effective output of pump 10 by bypassing excess flow to sump in response to the same control signal pressures that actuate the sensor valve 25.

The bypass valve 81 includes a plunger 84 slidably fitted in a bore 92 of a body or housing (not shown). The plunger 84 cooperates with the bore 92 and with a seat 86 to provide the chambers 87 and 89; and plunger 84 provides substantially equal fluid pressure responsive areas 82 and 83 in the chambers 87 and 89.

The area 82 in the chamber 87 is thus responsive to the fluid pressures in the conduit 21 as is the area 31 of the sensor valve 25; since the chamber 29 and the area 31 are connected to the conduit 21 by the conduit 41; and the chamber 87 and the area 82 are connected to the conduit 21 by the conduit 91.

In like manner, the area 32 of the sensor valve 25 and the area 82 of the bypass valve 81 are subjected to the fluid pressures in the conduits 44, 45, 46 and 47.

Therefore the bypass valve 81 responds to excessive flows and the resultant excessive pressure differentials across the variable orifice 39 to bypass excess flow to sump; and the bypass valve 81 also responds to any of the negative or over-ride signals connected to the conduits 44, 45, 46 and 47 to bypass excess pump flow to sump. The result is that the bypass valve 81 cooperates with the displacement control mechanism 15 to control the effective output of the pump 10, the required response of the displacement control 15 is reduced, so that the stability of the system is enhanced.

Another embodiment of the invention is illustrated schematically in FIG. 2 to which attention is now directed. In this embodiment, the swash plate 14 inclines in the opposite direction from that in FIG. 1. This requires a slightly different sensor valve construction, so that a reduction in pressure in the chamber 30 will result in the large control piston 16 and the cylinder 19 being placed in communication with the sump 52 rather than with the pump pressure conduit 21.

In the FIG. 2 embodiment the valve spool 100 of the sensor valve 101 moves to the right when the pressure in the chamber 30 is below that in the chamber 102 and the force on the fluid responsive area 103 is sufficient to overcome the spring 28 and the force generated on the spool 100 by the fluid pressure in the chamber 30. The valve spool 100 by moving to the right establishes fluid communication between the large control piston 16 and the sump 52 via the conduit 51, the port 34, the port 104 and the conduit 53.

The pd valve 105 of FIG. 2 is somewhat different from that shown in FIG. 1. The partition between the spring chamber 63 and the small control piston cylinder 20 of the FIG. 1 embodiment has been eliminated along with various manufacturing problems. Thus, the valve plunger 106 is greatly simplified.

Fluid pressure supplied to the chamber 107 via the conduits 21 and 108 acts against the projected end of the plunger 106 to compress the spring 109, moving the annular groove 110 of the plunger 106 closer to regis-

tering with the cross-hole 111 of the small control piston 17.

An increase in displacement is effective to reduce the distance between the annular groove 110 and the cross-hole 111 making the pd valve 105 both pressure and displacement sensitive.

When the groove 110 registers with the cross-hole 111 fluid from the chamber 30 is bled to the sump via the conduit 112, the annular groove 113 and the cross-hole 114 and the longitudinal hole 115 in the valve plunger 106, the bore 58 and the cross-hole 62 to the pump housing and sump.

A power amplifier 118 replaces the acceleration transducer 65 of FIG. 1. The power amplifier 118 includes a high pressure port 119, an exhaust port 125, and a control port 120. A flexible diaphragm 121 presents a large working area to a pressure signal in a chamber 122 whereas a high pressure seat 123 presents a small pressure responsive area. Thus, the control of small pressures in chamber 122 is effective to control the seating of a plunger 124 against the seat 123.

With such an amplifier, compressed air can be used as a control medium for use with remote transducers or manually actuated over-ride valves as schematically represented by variable restrictors 126, 127 and 128. The use of air permits the transducer or other over-ride valve means to exhaust directly to the atmosphere. An air supply (not shown) is connected to the air conduit 116; and the restrictor 117 serves to limit the supply of air to the parallel connected over-ride valve or variable restrictors 126, 127, and 128 thereby assuring the effectiveness of any of the variable restrictors 126, 127, and 128 in the lowering of the pressure in the chamber 122 and the opening of the seat 123.

Another embodiment of the invention is illustrated in FIG. 3. Here the variable orifice 39 has been inserted in the return conduit 40 between the fluid motor 38 and the sump 36; and the upstream side of the orifice 39 and the chamber 102 of the sensor valve 139 have been interconnected. The portion of the conduit 40 between the orifice 39 and the reservoir 36 is assumed to have a negligible pressure; so it is not necessary to connect the chamber 30 of the sensor valve 139 to the downstream side of the orifice 39. Instead, the chamber 30 communicates with a sump.

The pd sensitive valve 130 of FIG. 3 operates in a manner similar to the valve 105 of FIG. 1. Movement of the small control piston 17 to the right and/or movement of the valve plunger 131 to the left establishes communication from the pump outlet port to the chamber 102 of the sensor valve 139 via the conduit 21, the conduit 108, the chamber 107, reduced stem portion 132 of the plunger 131, the cross-hole 133, an annular groove 134, a conduit 135 and a conduit 136. A reduction in pump displacement by the pd valve 130 is thus achieved by increasing the pressure in the chamber 102 rather than by reducing the pressure in the chamber 30, as was done in the FIGS. 1 and 2 embodiments.

A restrictor 137 prevents an excessively large flow from the conduit 136 to the return conduit 40 during torque compensation by pd valve 130 without preventing the actuation of the sensor valve 139 by the pressure signal generated by the orifice 39.

Any of the parallel connected transducers or valve means of FIGS. 1 and 2 can be adapted to the FIG. 3 configuration by adapting these valve means to apply

fluid pressure from the conduit 21 to the chamber 102 as does pd valve 130.

FIGS. 4A and 4B show a variation of the sensor valve of FIG. 1 in which a third operating position has been added to bypass excess fluid.

FIG. 4A shows a preferred configuration of the bypass type sensor valve whereas FIG. 4B illustrates the principles of operation schematically.

In FIG. 4B, the bypass type sensor valve 150 is shown in a neutral position, as represented by the box 151, in which fluid communication is blocked between the conduit 51 and the pressure conduit 165 and between the conduit 51 and the sump 52. Thus fluid is blocked in the conduit 51 and in the cylinder 19 of FIG. 1.

The sensor valve 150 is actuated to its operating positions by the operators 152 and 153 and the bias spring 154. The operators 152 and 153 correspond respectively to the areas 31 and 32 and to the chambers 29 and 30 of FIG. 1.

The sensor valve 152 is moved to the left to its first or displacement decreasing position by the bias spring 154 when the fluid pressures in the operators 152 and 153 approach equality. This first operating position is shown by the box 155. Pressure fluid trapped in the cylinder 19 (FIG. 1) then is released via the conduit 51, the valve communication path 156 and the exhaust port 157A to sump 52. The releasing of fluid from the cylinder 19 allows an increase in pump displacement (FIG. 1) which results in an increase in flow and an increase in pressure drop across the orifice 39 thereby moving the sensor valve 150 back to its neutral position.

In like manner, the sensor valve 150 is actuated to the second or pump displacement decreasing position 158 by a fluid pressure in the operator 152 that is able to overcome the combined force produced by the operator 153 and the spring 154.

A third operating position, not previously described, is shown by the box 159. An excess of pressure differential between conduits 41 and 47 (FIG. 1), beyond that necessary to force the sensor valve 150 to its second operating position, will be effective to move the sensor valve 150 to third operating position 159.

In the third operating position, pressure from the conduit 165 is applied to the valve passage 160 and is then applied to the cylinder 19 (of FIG. 1) via the passage 161 to decrease the displacement of the pump and to the passage 162 and the exhaust port 157A to bypass excess fluid.

A fourth operating position may be utilized to obtain a more nearly idealized combination of large flow area and short actuating stroke. The box 163 shows this fourth operating position as having an additional bypass passage 164. The value of this fourth operating position will be more apparent from a study of the configuration shown in FIG. 4A.

FIG. 4A shows bypass type sensor valve 170 comprising a body 171 having a bore 172 and a valve spool 173. The valve spool 173 is spring pressed to the left by a spring 174 and a spring adapter 177 in the cavity 175. The cover 176 is attached to body 171 by any suitable method to form an end of cavity 175 and to retain the spring 174.

The valve spool 173 of the sensor valve 170 is shown with the valve spool 173 in the neutral position so that fluid in the conduit 51 and in the cylinder 19 (FIG. 1) is blocked by the land 178 of spool 173.

Movement of the valve spool 173 to the left, to a first operating position, is effective to connect the conduit 51 to the sump 52 via the port 181, the reduced diameter portion 179, and the passage 180A.

In a second operating position, the land 178 is moved to the right allowing communication between the conduit 41 and the conduit 51 via the port 181. Pressure fluid is thus added to the large cylinder of the displacement control mechanism to decrease the displacement of the pump.

Additional movement of the spool 173 to the right is effective to bypass excess pump flow by communicating the conduit 41 with the sump 52 via the longitudinal hole 182, the cross-hole 185, the reduced diameter 183, and the passage 180. Only a limited flow can be bypassed via longitudinal hole 182. However, this construction has the advantage of requiring a very small distance between the second and third operating positions.

A fourth operating position may be added in which an additional and greatly increased bypass flow path may be achieved. In the fourth operating position, flow from the conduit 41 is communicated directly to the passage 180A by the land 178 moving to the right, and opening the bore 172 to the passage 180A.

It is apparent that the bypass type sensor valve provides the same function as does bypass valve 81 of FIG. 1; and that it is responsive to the same signals; that is, flow generated pressure drops across the variable orifice 39 or negative signals from the over-ride logic circuit.

Although the pump has been shown to include a displacement control mechanism having two control pistons, it is to be understood that other types of pumps having a variable discharge and other types of discharge or displacement control mechanisms can be used without departing from the spirit of the invention. For example, it is not unusual to build pump displacement control having only a single control piston, and a bias spring or an offset trunnion to bias the swash plate in one direction.

What is claimed is:

1. In a hydraulic system including a variable displacement pump as a source of fluid pressure, a sump, fluid conduits, and a fluid motor all operatively connected;
- a fluid actuated displacement control mechanism connected to said pump and adapted to control the displacement of said pump in response to fluid pressures applied to said displacement control mechanism;
- a sensor valve operatively connected to said displacement control mechanism and to said hydraulic system and being adapted for being moved by a force balance to displacement increasing and displacement decreasing positions wherein connections are made between said system and said displacement control mechanism to control the fluid pressures applied to said displacement control mechanism and to increase and to decrease the displacement of said pump;
- force balance means consisting of bias force means and fluid responsive means and adapted to move said sensor valve to said displacement increasing and displacement decreasing positions in response to a control signal pressure;

control signal pressure supply means interconnecting said fluid responsive means with a source of fluid pressure in said system whereby said sensor valve is moved to said displacement increasing position by said control signal pressure;

over-ride valve means consisting of a power amplifier means having one port in fluid communication with said fluid responsive means and having another port in fluid communication with said sump; and

fluid restrictor means interposed into said control signal pressure supply means and being adapted to reduce the fluid flow that is required through said over-ride valve means to reduce said control signal pressure applied to said fluid responsive means, to change said force balance; and to move said sensor to said displacement decreasing position; whereby actuation of any one of said over-ride valves is effective to reduce the displacement of said pump.

2. The system as claimed in claim 1 in which said over-ride valve means includes a pilot relief valve operatively connected to said fluid responsive means and to said pump and being adapted to control the force balance of said sensor valve in response to the pressure produced by said pump; the displacement of said pump being reduced when pump pressure exceeds a predetermined value.

3. The system as claimed in claim 1 in which said sensor valve includes a position in which fluid is bypassed from said pump to said sump, and said control signal pressure is effective to move said sensor valve to said position, whereby position of said sensor valve comprises a bypass valve means.

4. In a hydraulic system including a variable displacement pump as a source of fluid pressure,

a sump, fluid conduits, and a fluid motor all operatively connected;

a fluid actuated displacement control mechanism connected to said pump and adapted to control the displacement of said pump in response to fluid pressures applied to said displacement control mechanism;

a sensor valve operatively connected to said displacement

control mechanism and to said hydraulic system and being adapted for being moved by a force balance to displacement increasing and displacement decreasing positions wherein connections are made between said system and said displacement control mechanism to control the fluid pressures applied to said displacement control mechanism and to increase and to decrease the displacement of said pump;

force balance means consisting of bias force means and fluid responsive means and adapted to move said sensor valve to said displacement increasing and displacement decreasing positions in response to a control signal pressure;

control signal pressure supply means interconnecting said fluid responsive means with a source of fluid pressure in said system whereby said sensor valve is moved to said displacement increasing position by said control signal pressure;

over-ride valve means consisting of a transducer which is pressure and displacement sensitive and comprises; a pressure-to-position transducer; a mechanical displacement reference mechanism; and a variable fluid resistance means;

fluid restrictor means interposed into said control signal pressure supply means and being adapted to reduce the fluid flow that is required through said over-ride valve means to reduce said control signal pressure applied to said fluid responsive means, to change said force balance; and to move said sensor to said displacement decreasing position; whereby actuation of any one of said over-ride valves is effective to reduce the displacement of said pump.

5. The system as claimed in claim 4 in which said displacement control mechanism includes a control piston; and said variable fluid resistance means comprises two relatively movable elements, one of said elements being connected to and coaxial with said control piston in said displacement control mechanism whereby said control piston provides said mechanical displacement reference.

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