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Weisenbach

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[54] **HYDRAULIC LOAD SENSITIVE SYSTEM**

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[51] **Int. Cl.** **F04b 1/26**

[58] **Field of Search** 60/445, 448, 450, 451, 60/452, 462; 417/212, 213, 217, 222

[56] **References Cited**

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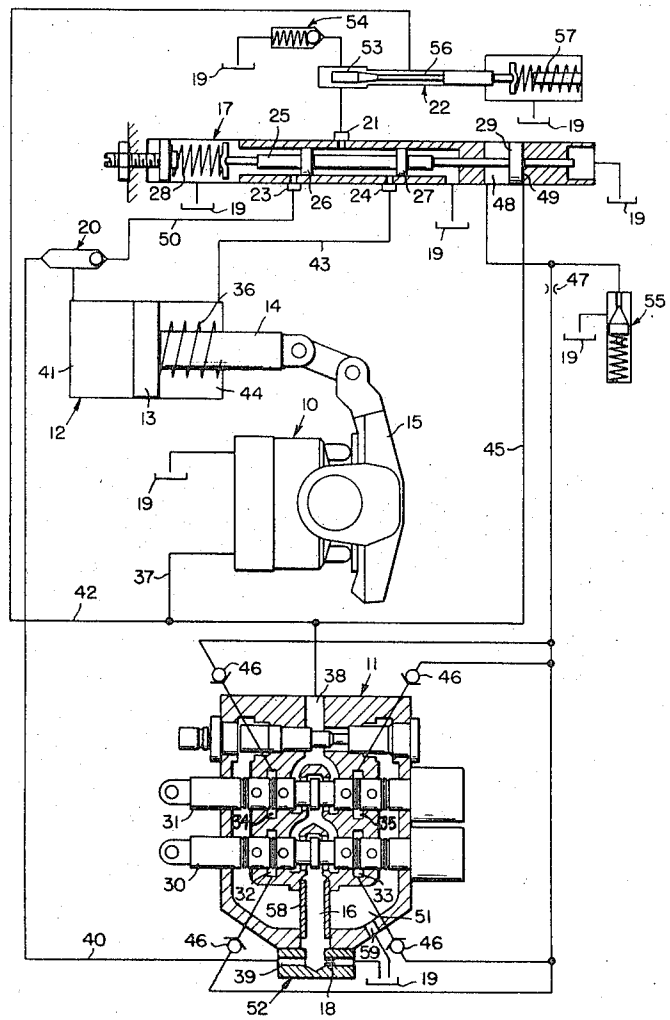
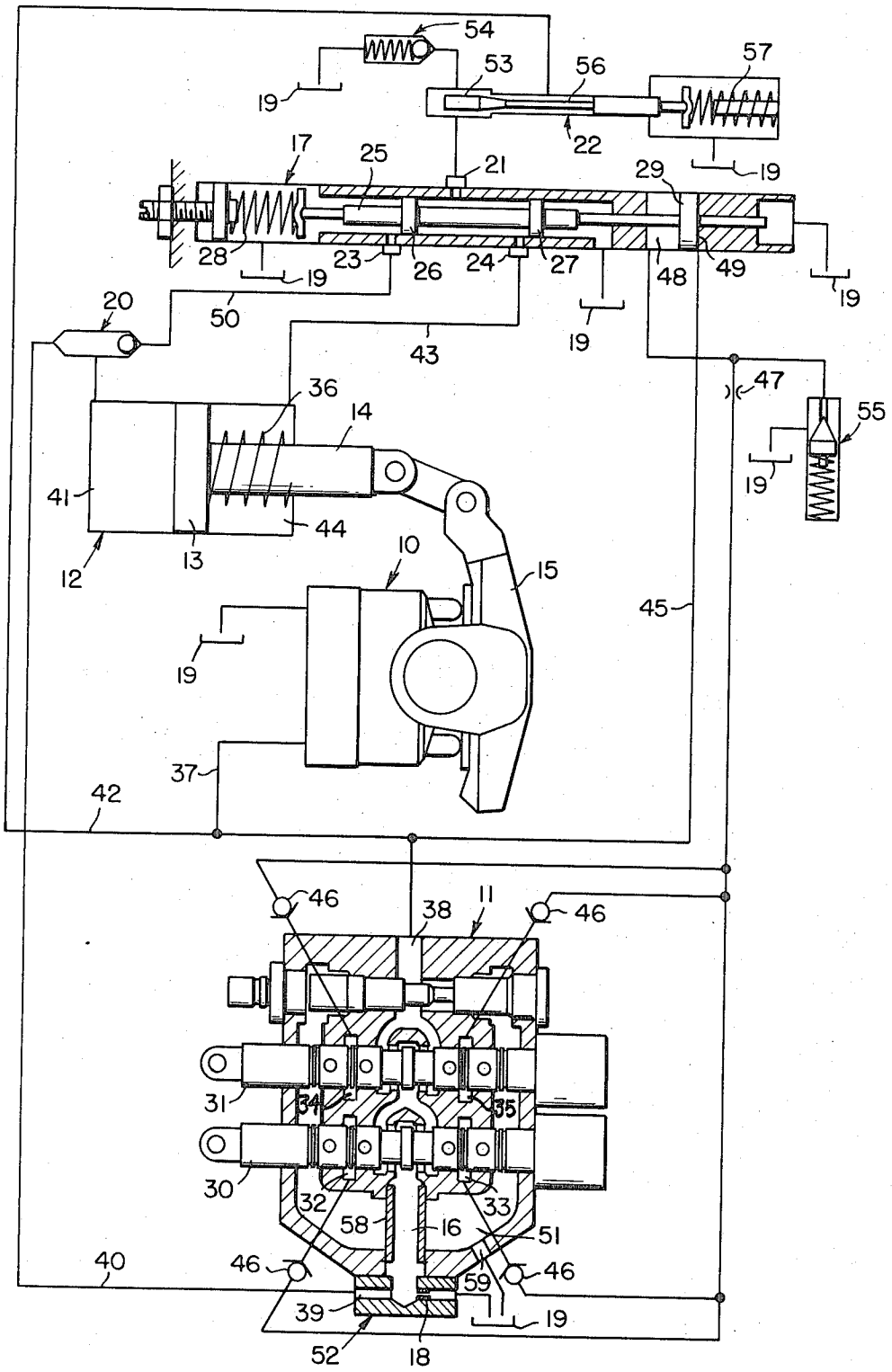
[57] **ABSTRACT**

A hydraulic load sensitive system is provided having a variable delivery pump, the output of which is controlled by an open-center control valve. Load sensitive control apparatus is provided including a control cylinder having a piston for operating a control cam of the variable delivery pump. First and second feedback circuits are provided to govern operation of the control cylinder alternately, the first feedback circuit including an open-center position of the control valve and the second feedback circuit including a circuit through a pressure differential valve.

12 Claims, 1 Drawing Figure

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HYDRAULIC LOAD SENSITIVE SYSTEM

BACKGROUND OF INVENTION

This invention relates to hydraulic load sensitive systems for governing delivery and pressure of a variable delivery pump.

Load sensitive hydraulic systems known in the art are generally either of a type employing a closed-center directional control valve such as is disclosed in my prior U.S. Pat. No. 3,191,382, or of the type employing an open-center valve. The variable delivery pump is commonly of the rotating cylinder block type having a cam for adjusting the delivery of the pump. A reason for making the systems load sensitive is to reduce the amount of heat loss during times when maximum delivery and pressure of the pump is not required. Thus, various systems have been developed for improving the efficiency of a hydraulic system by controlling the pump so as to deliver a pressure only slightly higher than the load requires. This conserves horsepower and reduces heat dissipation required. Load sensitive systems such as my above-mentioned prior patent, reduce power loss due to heat dissipation by adjusting the output of the variable delivery pump in accordance with the load, but there are still losses due to fluid circulation when the system is in its quiescent or neutral state, as by the circulation of fluid in my patent from an auxiliary fixed displacement pump through a pilot compensating valve and a differential control valve.

A conventional open-center valve control system delivers full flow at low pressure providing wear on the pump, and the full flow of fluid through filters and heat exchangers, causing considerable loss of energy.

An object of the present invention is to provide a system which substantially obviates one or more of the limitations and disadvantages of the described prior systems.

Other objects purposes and characteristic features will be in part obvious from the accompanying drawing, and in part pointed out as the description of the invention progresses.

SUMMARY OF INVENTION

A hydraulic load sensitive system is provided having a variable delivery hydraulic pump used in connection with an open-center directional control valve and load sensitive control apparatus comprising a control cylinder having a piston and a rod for actuating a control cam of the variable delivery pump. A first feedback circuit is provided for governing output of the variable delivery pump under quiescent conditions by providing fluid to the control cylinder through the open-center valve. A second feedback circuit for the variable delivery pump delivers fluid through a differential valve to the control cylinder.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, while its scope will be pointed out in the appending claims.

The accompanying drawing is a schematic diagram of a hydraulic load sensitive system according to a preferred embodiment of the present invention.

With reference to the drawing, a hydraulic load sensitive system is illustrated comprising a variable delivery hydraulic pump **10**, an open-center control valve **11**,

and load sensitive control means including a control cylinder **12** containing a piston **13** having a rod **14** for actuating a control cam **15** of the variable delivery pump **10**. A first feedback circuit is provided for control of the variable delivery pump extending from output of the pump **10** to the control cylinder **12** through an open-center circuit including chamber **16** of the control valve **11** for limiting pressure output of the pump **10** during quiescent conditions. A pressure differential valve **17** is provided for comparing pump delivery pressure with load pressure and selectively delivering fluid to the control cylinder **12** in a second feedback circuit extending from output of the pump **10**.

The flow of fluid through the open-center chamber **16** of the open-center valve **11** has two paths, one being through a restricted opening **18** to a reservoir **19**, and the other being to the pump control cylinder **12** as has been described.

Input to the pump control cylinder **12** is through a pressure sensitive shuttle valve which selectively delivers pressure from the first or second feedback circuits to the control cylinder **12** in accordance with which pressure is the greater.

The pressure differential valve **17** has a supply port **21** receiving output from the pump **10** through a pressure reducer valve **22**. The pressure differential valve **17** has a port **23** connected through shuttle valve **20** to chamber **41** at the headend of piston **13** in control cylinder **12**, and port **24** of the pressure differential valve **17** is connected to chamber **44** of the control cylinder **12** at the rod end of the piston **13**. A spool **25** in the valve **17** has spaced lands **26** and **27** for cooperating with ports **23** and **24** respectively to provide selectively, supply, exhaust, and lap controls. Axial movement of the spool **25** to the right is in part by bias of a compression spring **28**, and hydraulic operation of the spool **25** is provided by a balanced piston **29** secured to the spool **25** near its righthand end.

The open-center valve **11** is modified from the type disclosed in the prior U.S. Pat. No. 3,162,095, granted Dec. 22, 1964 which is herein incorporated by reference. The open-center position of the valve of U.S. Pat. No. 3,162,095 is modified according to the present invention by addition of a sleeve **58** separating exhaust of fluid through open-center chamber **16** from an exhaust manifold **51**. The present invention also adds a divider **52** at output from open-center chamber **16** applying such output in part through port **39** and in part through restricted orifice **18** to reservoir **19**. A further port **59** is provided for connecting exhaust chamber **51** to the reservoir **19**. The present invention can also be used in connection with an open-center parallel valve similar to the type disclosed in U.S. Pat. No. 2,945,351.

Because of the valve **11** of this embodiment of the present invention being of the series-parallel type, both plungers **30** and **31** can be operated independently to control respective devices such as double acting pistons as is disclosed in the above mentioned U.S. Pat. No. 3,162,095. Both plungers **30** and **31** must be in their center positions in order to deliver an open-center output.

Having thus considered the general structure of the load sensitive system according to one embodiment of the present invention, the organization will be further considered relative to typical operating conditions.

OPERATION

To consider typical operating conditions of the load sensitive hydraulic system, it will be assumed that the system is applied to the control of one or more double acting hydraulic actuators, plungers **30** and **31** being provided in control valve **11** for governing operation of such actuators (not shown) respectively. An actuator controlled by plunger **30** would be connected across ports **32** and **33**, and an actuator controlled by plunger **31** would be connected across ports **34** and **35**.

To consider first the quiescent conditions of the system, it will be assumed that the open-center valve **11** is in its center position as illustrated, and that a prime mover (not shown), provided for driving the pump **10**, is started. The pump control piston **13** is spring biased to the left by a light spring **36** so that the pump **10** is in stroke when the rotation of the cylinder block of the pump **10** is started. The pump **10** thus delivers an output over line **37** to the supply port **38** of the valve **11**. A limited amount of fluid passes from the pump **10** through the open-center position of valve **11** and through the restricted orifice **18** to reservoir **19**.

A parallel less restricted circuit is also established through the open-center position of valve **11** out of port **39** and along line **40** through shuttle valve **20** to the chamber **41** at the head-end of piston **13**. Thus as pressure quickly builds up in pump **10**, because of restriction **18** fluid is delivered rapidly to chamber **41** to actuate the piston **13** to the right for reducing the stroke of the pump **10**. Fluid is also delivered at this time for pump **10** over line **42** and through the left-hand end of pressure reducer **22** to the supply port **21** of differential valve **17**.

With valve **17** in the position shown, fluid is applied over line **43** to chamber **44** at the rod end of piston **13** at a relatively low pressure of about 100 p.s.i. Pressure from the pump **10** is also applied over line **45** to the right-hand side of the balanced piston **29** of valve **17**. This actuates the spool **25** to the left against the bias of spring **28** to a position that will lap the ports of the valve **17** at substantially **100** p.s.i. differential between pump and load pressure, which under quiescent conditions would be approximately 100 p.s.i. pump pressure.

When a valve plunger **30** or **31** of the valve **11** is actuated, the free flow of oil through the valve **11** is shut off, and the pressure acting on the head-end of the piston **13** of control cylinder **12** immediately drops to near zero. As a result, the pump **10** increases in flow and pressure, and the opening of a metering land of the actuated plunger **30** or **31** discharges pressure to an associated actuator (not shown). This pressure is also applied through a check valve **46** and a restricting orifice **47** to a chamber **48** at the left of balanced piston **29** in the differential valve **17**. With load pressure applied to chamber **48** and pump pressure applied to chamber **49**, in view of the bias of spring **28**, the spool **25** laps the ports **23** and **24** when a fixed differential, which can be approximately 100 p.s.i., is reached between the pump pressure and the load pressure. Therefore, pump pressure is maintained approximately 100 p.s.i. higher than load pressure.

If this differential decreases because of a change in the load, spool **25** is actuated to the right to provide delivery from port **24** to chamber **44** of the control cylinder **12** to increase the delivery of the pump **10** by actuation of the piston **13** to the left. The fluid in chamber **41** can be exhausted either over line **40** through orifice **18** to the reservoir **19** or over line **50** through port **23** to the reservoir **19** through the left-hand portion of valve **17**.

If, on the other hand, the pressure differential increases because of changes in load conditions, the spool **25** becomes actuated further to the left so as to connect supply port **21** through port **23** and over line **50** with chamber **41** of control cylinder **12** to reduce the delivery of pump **10**. At this time, fluid in chamber **44** can be exhausted over line **43** to the reservoir **19**.

If the open-center control valve **11** is quickly actuated to its open-center position when power has been applied to a load, the feedback circuit through the open-center position to the control cylinder **12** takes precedence over the circuit through the pressure differential valve **17** to quickly restore the pump **10** to its normal position with approximately 100 p.s.i. pressure, irrespective of trapped pressure in the load that maintains a high pressure in the chamber **48** at the left of the balanced piston **29**. Fluid in chamber **44** can be exhausted over line **43**, through port **21** of valve **17**, chamber **53** of pressure reducer **22**, and check valve **54** to reservoir **19**.

In case of an overload condition, pressure regulator valve **55** becomes actuated and in conjunction with orifice **47** limits the pressure in chamber **48**. Orifice **47** restricts flow through the relief valve **55**, and thus reduces heat loss.

Pressure reducer **22** is supplied with fluid over line **42**. The pressure of this fluid drives a metering plunger **56** to the right against bias of spring **57**. Movement of plunger **56** to the right restricts flow of fluid to supply port **21** of valve **17**, thus reducing supply pressure to valve **17** to a selected pressure, such as to 100 p.s.i.

Having thus described a particular hydraulic load sensitive system as a preferred embodiment of the present invention, it is to be understood that various modifications and alterations may be made to the specific embodiment shown without departing from the spirit or scope of the invention.

What is claimed is:

1. A hydraulic load sensitive system comprising a variable delivery hydraulic pump, an open-center control valve, and load sensitive control means wherein improved load sensitive control means comprises:

a. a control cylinder containing a piston having a shaft for actuating a control cam of the variable delivery pump,

b. a first feedback circuit from output of the pump to the control cylinder through an open-center circuit of the control valve for limiting pressure output of the pump,

c. a pressure differential valve for comparing pump delivery pressure with load pressure,

d. a second feedback circuit from output of the pump to the control cylinder through the pressure differential valve for limiting pressure output of the pump and

e. means for rendering the first and second feedback circuits effective alternately for limiting output pressure of the pump.

2. A hydraulic load sensitive system according to claim **1** wherein another open-center circuit through the control valve provides a restrictive circulation of

fluid through the pump when the valve is in an open-center position.

3. A hydraulic load sensitive system according to claim 1 wherein inputs to the control cylinder in the first and second feedback circuits include a pressure sensitive shuttle valve which selects input from the first or second feedback circuit having the highest pressure.

4. A hydraulic load sensitive system according to claim 1 wherein the pressure differential valve has pressure supply, lap, and exhaust positions for governing respective connections to the control cylinder.

5. A hydraulic load sensitive system according to claim 4 wherein connections from ports of the differential valve are applied to the control cylinder at opposite sides of the piston for governing output pressure of the pump.

6. A hydraulic load sensitive system according to claim 4 wherein a pressure reducer valve is included in the second feedback circuit.

7. A hydraulic load sensitive system according to claim 6 wherein the pressure reducer valve is connected between output of the pump and input to the differential valve.

8. A hydraulic load sensitive system according to claim 4 wherein the differential valve comprises;

1. a differential cylinder containing an axially reciprocating spool,

2. a spring for biasing the spool in one direction, and

3. means including a balanced piston for operating the spool selectively in opposite directions in accordance with different relative pump and load pressures.

9. A hydraulic load sensitive system according to claim 8 wherein load pressure is applied to the differential valve through a restricting orifice.

10. A hydraulic load sensitive system according to claim 9 wherein load pressure applied to the differential valve is also applied to a pressure regulator valve.

11. A hydraulic load sensitive system according to claim 1 wherein the open-center valve has an open-center exhaust chamber separate from an exhaust manifold used when the open-center valve has one of its plungers in an actuated position.

12. A hydraulic load sensitive system according to claim 11 wherein the open-center valve has two exhaust ports when in its open-center position, one of which is restricted.

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