HYDRAULIC LOAD SENSITIVE SYSTEM

Inventor: Charles O. Weisenbach, Watertown, N.Y.

Assignee: General Signal Corporation, Rochester, N.Y.

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Primary Examiner—William L. Freeh
Assistant Examiner—G. P. LaPointe
Attorney, Agent, or Firm—Harold S. Wynn

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
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 powerloss 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 to 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 55 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.
3,809,501

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 restricted circuit is also established through the open-center position of valve 11 out of port 39 and along line 40 through the valve 11 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.