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[54] **PRESSURE RESPONSIVE DIRECTION CONTROL VALVE**
9 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** **91/388,** 91/444, 91/461
[51] **Int. Cl.** **F15b 13/16,** F15b 13/042
[50] **Field of Search** 91/388, 461, 444

[56] **References Cited**

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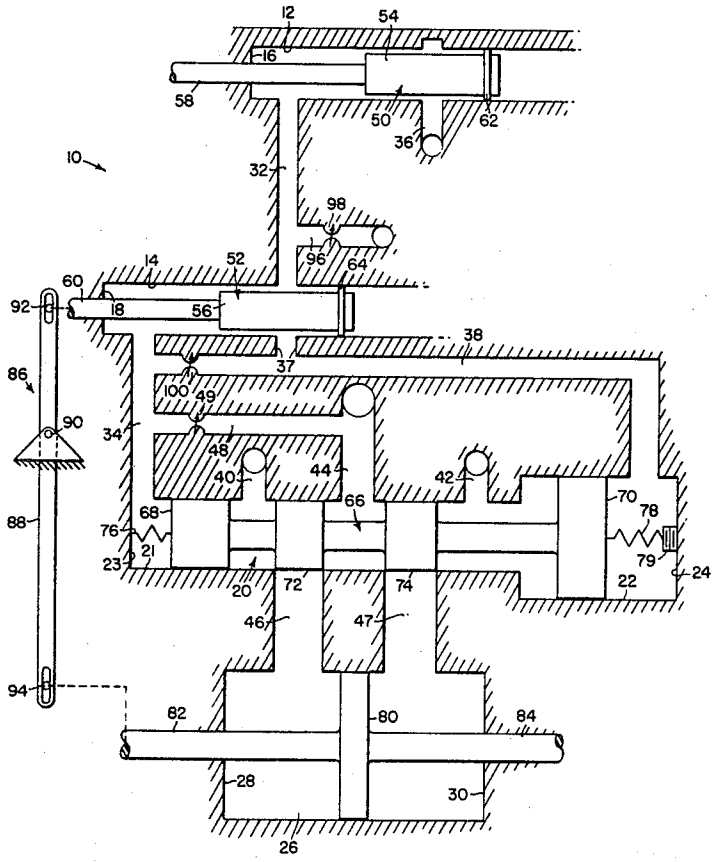
ABSTRACT: A hydraulic control system for a remote, double-acting piston motor in which a normally hydraulically balanced, spring-centered, spool-type direction control valve is shifted from the centered position in which the opposite work ports of the motor are simultaneously pressurized to first and second positions in which fluid under pressure is selectively admitted to one or the other ends of the motor while the opposite end is exhausted. T opposite ends of the direction control valve are connected to the inlet pressures of a respective one of a pair of variable flow resistance valves and the control valve is shifted from the centered position to a selected one of the other positions by changing the resistance, hence the inlet pressure, of one of the flow valves and the control valve is returned to the centered position as a result of a feedback from the motor which shifts the other flow resistance valve until the forces on the opposite ends of the control valve are again equal.



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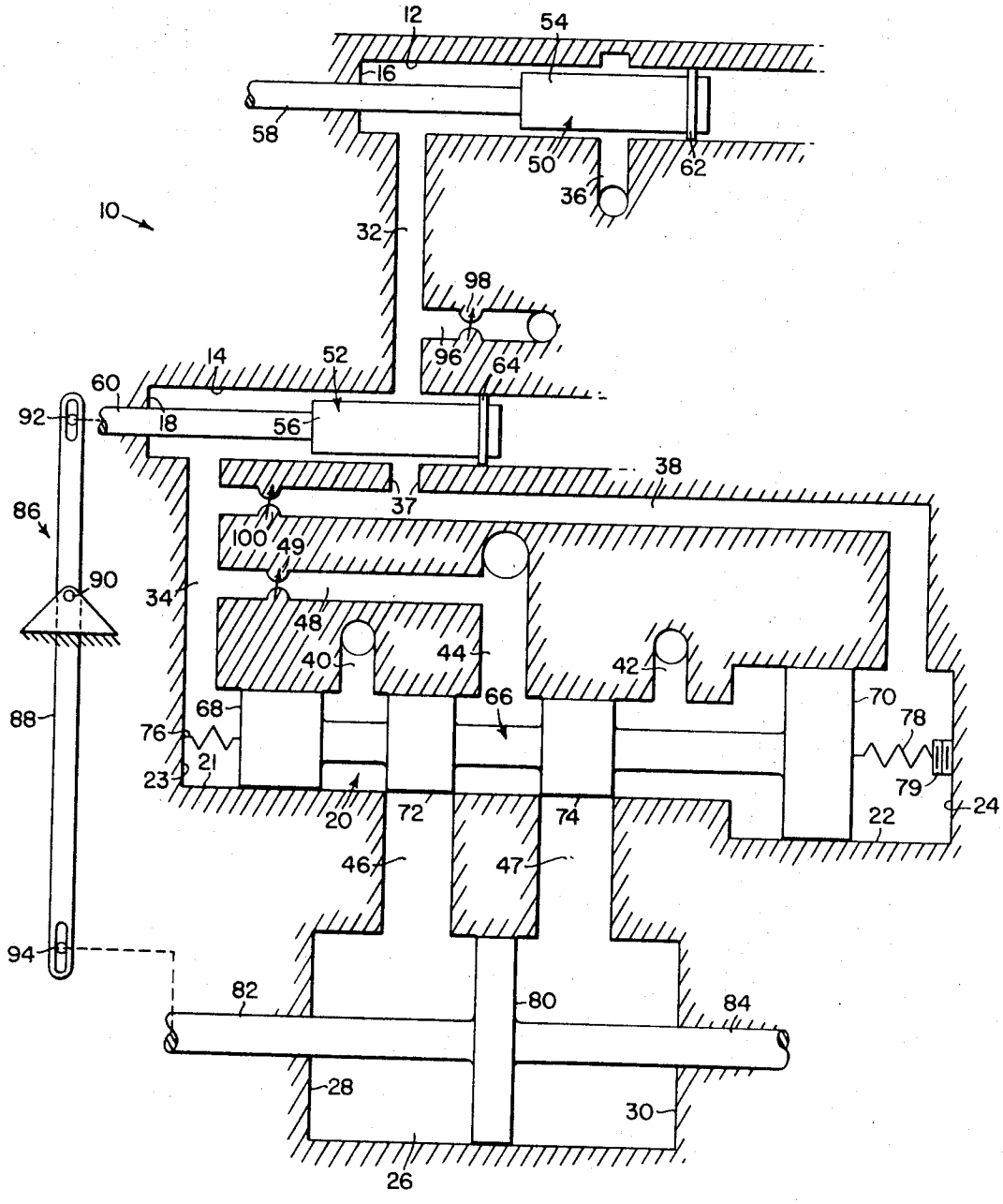

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PRESSURE RESPONSIVE DIRECTION CONTROL VALVE

BACKGROUND OF THE INVENTION

This invention relates to a hydraulic system for controlling a remote, double-acting motor, such as used in steering and manipulation of implement parts, and more specifically relates to a system wherein a normally hydraulically balanced, spring-centered, spool-type direction control valve is provided for simultaneously pressurizing both ports of the motor and for selectively admitting fluid to one or the other of the ports while exhausting the opposite port and wherein an input force operates on a variable flow resistance valve in the system for changing the pressure on one end of the control valve to shift the control valve, and a feedback from the motor operates on another variable flow resistance valve in the system for changing the pressure on the other end of the control valve so as to again hydraulically balance the control valve.

Hydraulic systems similar to that of the invention are known, for example in U.S. Pat. No. 2,974,639 to O'Conner et al. issued 14 Mar. 1961. Such systems are, however, somewhat complicated and, therefore, lack hydraulic stability. Also in the known systems, no provision is made to compensate for variances between manufactured and design dimensions.

SUMMARY OF THE INVENTION

According to the present invention there is provided a hydraulic system for controlling a remote, reversible hydraulic motor which includes a spring-centered spool-type direction control valve wherein the inlet to a first variable flow resistance valve is connected to a fluid chamber at one end of the control valve and a second variable flow resistance valve is connected in series with the first flow resistance valve and has its inlet connected to a fluid chamber at the other end of the control valve.

An object is to adapt one of the variable flow resistance valves for connection to an input signal while interconnecting the output of the hydraulic motor with the other variable flow resistance valve by means of a feedback signal.

An object of the invention is to provide a system in which the flow resistance valves may be placed remotely from each other.

Another object is to provide normally closed adjustable flow restriction valves for bypassing fluid from the inlets of the flow resistance valves for compensating for differences in manufactured dimensions from design dimensions.

Still a further object is to provide a simplified, inexpensive control for a two-way hydraulic cylinder which is hydraulically stable and reliable.

These and other objects will be apparent from the following detailed description and accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE shows a hydraulic system embodying the invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

The system includes a valve body **10** which defines a pair of similar bores **12** and **14** respectively having closed ends **16** and **18**, and a bore **20** having first and second cylindrical portions **21** and **22** of different diameters and opposite closed ends **23** and **24**. The valve body **10** also defines a bore **26** which has opposite closed ends **28** and **30**.

The bores **12** and **14** are intersected adjacent their respective closed ends by inlet passages **32** and **34** respectively. The bore **12** is connected to an outlet passage **36** spaced axially from the inlet passage **32** and leading to a sump (not shown). The inlet **32** of the bore **12** serves as an outlet for the bore **14** and is spaced axially from the inlet passage **34**. The inlet passage **34** intersects the portion **21** of the bore **20** adjacent the closed end **23**, and diametrically opposite from the intersection of the passage **32** with the bore **14** is a passage **37** which joins a passage **38** which interconnects the inlet passage **34** and the right end of the portion **22** of the bore **20**.

Also intersecting the portion **21** of the bore **20** are axially spaced sump-connected passages **40** and **42**, a passage **44** midway between the passages **40** and **42** connected to a source of fluid under pressure (not shown) and work passages **46** and **47** between the passages **40** and **44** and **42** and **44** and respectively leading to the cylinder bore **26** adjacent its respective closed ends **28** and **30**. A passage **48** interconnects the passage **44** and the inlet passage **32** and contains a manually preset restriction **49** which may be an adjustable needle valve.

The bores **12** and **14** respectively carry variable flow resistance valves **50** and **52**. The flow resistance valves **50** and **52** respectively have reduced piston portions **54** and **56**, which bridge the respective outlet passages **36** and **32** of the bores **12** and **14**, and piston rods **58** and **60** extending respectively through the bore ends **16** and **18**. O-ring seals **62** and **64** respectively encircle the other ends of the pistons **54** and **56**.

A pressure responsive control valve **66** is axially movable in the bore **20** and includes left- and right-hand pistons **68** and **70** respectively slidably fitting bore portions **21** and **22**. The purpose of the enlarged bore portion **22** and piston **70** will be explained below. The control valve **66** further includes a pair of axially spaced lands **72** and **74** respectively at the left- and right-hand sides of the passage **44**. Springs **76** and **78** are respectively positioned between the opposite ends **23** and **24** of the bore **20** and the oppositely directed faces of the pistons **68** and **70** and normally center the control valve **66** at the position illustrated wherein the lands **72** and **74** respectively block the passages **42** and **44**. A screw element **79** combines with the spring **78** for adjusting the centered position of the valve **26**.

The cylinder bore **26** carries a piston **80** having oppositely extending piston rods **82** and **84** which respectively extend through the bore ends **28** and **30**. A feedback **86**, here shown as mechanical, moves the flow resistance valve **52** in response to movement of the piston **80** and includes a lever **88** fulcrumed at **90** intermediate its ends and having lost motion connections **92** and **94** at opposite ends connected respectively to the piston rods **60** and **82**. While the input- and feedback-connected valves **50** and **52** respectively are shown in a common valve block, it is significant that they may be mounted remotely from each other.

In order to compensate for any difference in the dimensions of the manufactured device from the design dimensions, which would cause undesired flow to the flow resistance valves **50** and **52**, a bypass **96** to the sump is provided in the inlet passage **32** and contains a manually adjustable restriction **98** and a similarly manually adjustable restriction **100** is located in the passage **38** adjacent to the inlet passage **34** for bypassing fluid from the passage **34** to the passage **38**.

The operation of the system is described here as applied to power steering. In such application, the piston rod **58** of the flow resistance valve **50** would be connected to receive steering wheel movement for moving the flow resistance valve in the bore **12**. The restriction **49** is adjusted to insure the provision of enough fluid to operate the hydraulic motor and to adequately supply flow to the flow resistance valves **52** and **54**. Although the preferred embodiment shows connections to a single source of fluid pressure, it should be understood that separate sources may be used for the flow resistance valves and hydraulic motor and the fluid for valve operation need not be hydraulic fluid.

Assuming that the steering gear of the vehicle is positioned for straight ahead travel, the hydraulic system will be in the equilibrium condition illustrated wherein the flow restriction valves **50** and **52** occupy positions with respect to the respective outlet passages **36** and **32** which establish a preselected ratio of pressure drops corresponding to a preselected ratio of the distance the piston portion **54** extends upstream from the outlet **36** as compared to the distance the piston portion **56** extends upstream from the outlet **32**, and the control fluid pressures existing in the passages **34** and **38** respectively will, in conjunction with the pressure existing in the sump-connected passages **40** and **42**, exert equal and opposite forces on the smaller diameter piston **68** and the larger diameter piston **70**.

The pressure-responsive control valve **66** is thus hydraulically balanced and is centered by the springs **76** and **78**. In this position the lands **72** and **74** block the respective passages **46** and **47**.

If it is desired to steer the vehicle to one side or the other, the steering wheel is merely turned so as to shift the flow resistance valve **50** either to the left or right from the position illustrated. Assuming that the valve **50** is shifted to the right, the left end of the piston **54** will move closer to the outlet passage **36**, and the resistance to fluid flow from the passage **32** to the sump passage **36** will be decreased. With a decrease in resistance to flow, the pressure of the fluid in the passage **32** will correspondingly decrease and this decrease in fluid pressure will occur in the passage **38** and result in a lesser force being applied to the larger piston **70** of the control valve **66**. Since the forces on the opposite end of the control valve are no longer equal, the control valve will shift to the right and connect the passages **46** and **47** respectively to the sump passage **40** and to the pressure passage **44**. Since the right end of the hydraulic motor cylinder **26** is now pressurized, the piston **80** will shift to the left to turn the wheel being steered and simultaneously cause the feedback lever **88** to pivot clockwise and shift the restriction valve **52** to the right until the pressure in the inlet passage **34** decreases enough to again balance the force exerted by fluid pressure on the opposite ends of the control valve **66**, allowing the compression springs to again center the control valve whereby the hydraulic motor will be held in its shifted position. The design of the system is such that the position that the left end of the piston **56** of the flow resistance valve **52** now occupies with respect to the outlet **32** as compared to the position occupied by the piston **54** of the flow resistance valve **50** with respect to the outlet passage **36** will be the ratio preselected. Also, the preselected ratio of pressure drops will again be established.

An operation similar to that described above when shifting the flow resistance valve **50** to the right will occur if the flow resistance valve is shifted to the left from the position illustrated, but the directions of movement will of course be reversed. That is to say, pressure will increase in the passage **38** and the control valve **66** will shift to the right. In this position of the control valve, fluid under pressure is connected to the left end of the cylinder **26** and the right end is connected to sump; thus the piston **80** will shift to the right and pivot the lever **88** counterclockwise to shift the flow resistance valve **52** to the left until fluid forces on the opposite ends of the control valve **66** are again equalized and the control valve is moved by the compression springs to the centered position.

In the event that the manufactured dimensions of the various bores and passages differ from the designed values for a preselected flow, the flow into the bores and passages, and, hence the pressures, may be adjusted by opening the normally closed restriction valves **98** and **100** to bypass such fluid as is necessary to achieve pressures at the opposite ends of the control valve **66** to apply equal forces to its opposite ends for a preselected position of the flow resistance valves **50** and **52**.

It should be understood that the hydraulic system may be used for applications other than power steering, for example, for adjusting and holding an agricultural implement at a selected working position. In such an application, the piston rod **58** of the flow resistance valve **50** would be attached to a means which would follow the contour of the ground's surface while the piston rod **78** of the hydraulic actuator would extend between the implement and the support frame to hold the implement a preselected distance relative to the surface of the ground and would be automatically actuated to raise and lower the implement to compensate for variations in ground contour.

I claim:

1. A hydraulic system comprising: a control conduit means including variable flow resistance means for establishing control pressures at first and second series connected locations, a valve bore means, conduit means for connecting a source of fluid under pressure to said control conduit means upstream from said first location and to said valve bore means, return fluid passage means intersecting said valve bore means, a reversible hydraulic motor having a pair of work passages connected to said valve bore means, a control valve means axially shiftable in said valve bore means between a neutral position wherein fluid is blocked to the work passages of the hydraulic motor and active positions wherein one or the other of the work passages is connected to fluid pressure while the opposite work passage is connected to the return passage means, bias means normally holding said control valve means in said neutral position, said control valve means including means for sensing the control pressures at said first and second locations and for directing forces represented by the pressures in opposite axial directions, means for adjusting said variable flow resistance means to a preselected position for causing a ratio of control pressures which will result in equal and opposite forces being applied to said control valve whereby said bias means will hold said control valve in said neutral position, said flow resistance means being adapted for connection to an input signal for disturbing the preselected ratio of control pressures so that the control valve means will shift to one of said active positions to cause actuation of said hydraulic motor, and feedback means interconnecting the output of said motor with said flow resistance means for adjusting the latter for reestablishing the preselected control pressure ratio whereby the bias means will again return the control valve means to its neutral position.

2. The invention defined in claim **1** wherein the variable flow resistance means comprises first and second valve bores respectively at said first and second series connected locations, each of said valve bores having an inlet and an outlet, the series connection between the locations being between the outlet of the first bore and the inlet of the second bore, first and second pistons being of lesser diameters than said first and second bores, respectively, and being positioned for axial movement in at least the portions of the bores between the respective inlets and outlets for causing a variable pressure drop between the respective inlets and outlets, and one of said pistons being adapted for connection to said input signal and the other of said pistons being connected to said feedback means.

3. The invention defined in claim **1**, said control conduit means further including adjustable means for bypassing selected amounts of fluid around said first and second locations for aiding in establishing said preselected ratio of pressure drops.

4. The invention defined in claim **2**, said control conduit means further including adjustable means for bypassing selected amounts of fluid around said first and second pistons for aiding in establishing said preselected ratio of pressure drops.

5. The invention defined in claim **1** wherein the means for sensing the pressure drops includes piston means.

6. The invention defined in claim **5** wherein the valve bore means includes first and second portions, the first portion being of a smaller diameter than the second, said piston means comprising first and second pistons positioned respectively in and being of diameter sufficient to span said first and second bore portions, said control conduit means connecting the inlet of said first bore to one side of the smaller piston for exerting a force in one axial direction and connecting the inlet of said second bore to one side of the larger piston for exerting a force in the other axial direction.

7. A hydraulic system comprising: a valve bore, supply and return conduit means intersecting said valve bore, a reversible hydraulic motor having a pair of work passages, a pressure responsive control valve means positioned in said valve bore for axial shifting movement from a normally maintained neutral position wherein said work passages of the motor are blocked to either of two active positions wherein said supply conduit means is connected with one or the other of said work passages of said motor while simultaneously interconnecting the opposite work passage with said return conduit means,

bias means tending to maintain said control valve means in said neutral position, control conduit means being adapted for connection to a source of fluid under pressure and including first and second series connected flow resistance valve means, each having an inlet connected to said control valve means so as to normally apply equal and opposite acting forces on the control valve whereby said bias means maintains said control valve means in said first position, one of said flow resistance valve means being adapted for connection to and being responsive to an input signal for selectively causing changes in pressure at its inlet for causing an unbalance of said oppositely acting forces on said control valve thereby causing the control valve to shift axially to one of said active positions for operating said hydraulic motor and a feedback means interconnecting the output of said hydraulic motor and the other of said flow resistance valve means for causing adjustment of said other flow resistance valve means for creating a pressure at its inlet for again producing an equal and opposite force on said control valve means whereby the bias means will again restore said control valve means to said neutral position.

8. The invention defined in claim 7 wherein said flow resistance valve means includes first and second bores each being intersected by an inlet and an outlet port, conduit means interconnecting the outlet port of said first bore with the inlet

port of said second bore, said control valve means including pistons at its opposite ends, said control conduit means further including first and second conduits respectively interconnecting the inlet ports of said first and second bores with one of the opposed faces of said pistons, said pair of flow resistance valve means each being positioned in a respective one of said bores and including an axially shiftable piston portion of lesser diameter than the bore bridging the outlet port and having one end positioned between the inlet and outlet ports and a fluid-tight seal annularly disposed about the other end and means for connecting the piston portion of one of said flow resistance valves to said input signal means and said feedback means being connected to the piston portion of the other of said flow resistance valves.

9. The invention defined in claim 8 and further including a normally closed adjustable restrictor valve interconnecting said first and second conduits, and said conduit means connecting the outlet port of said first bore with the inlet port of said second bore also including an adjustable normally closed restrictor valve joining the conduit means with the sump, whereby said restrictor valves may be opened to bypass fluid for adjusting the pressure in the first and second conduits.