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HYDRAULIC SYSTEM AND REMOTELY OPERATED FLOW CONTROL ARRANGEMENT THEREIN

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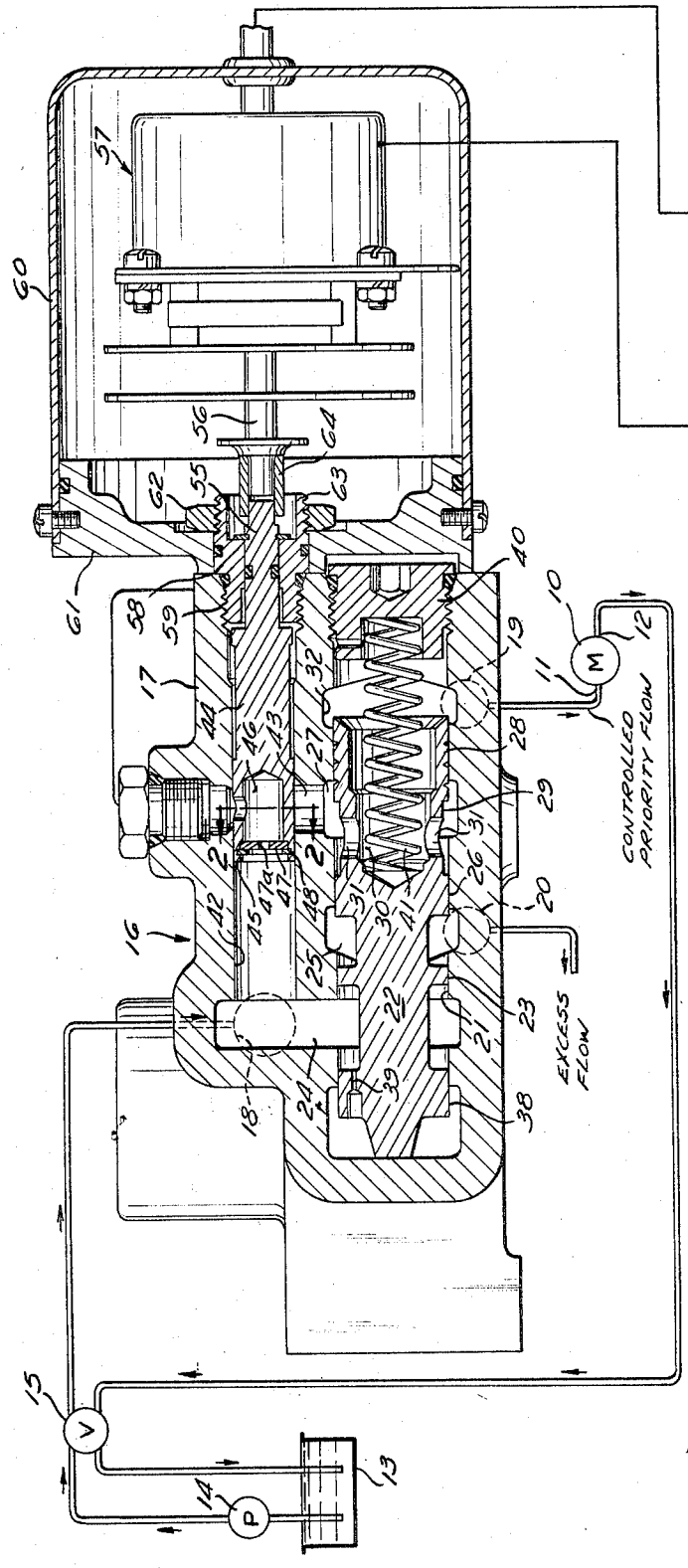

Fig. 1

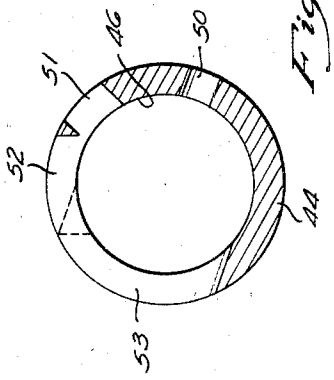

Fig. 2

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HYDRAULIC SYSTEM AND REMOTELY OPERATED FLOW CONTROL ARRANGEMENT THEREIN

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ABSTRACT OF THE DISCLOSURE

A flow control arrangement for selectively determining the speed of a hydraulic motor comprises a pressure-compensated flow regulator close to the motor, a rotary solenoid next to the flow regulator, and a multi-position selector switch remote from the flow regulator and connected electrically to the rotary solenoid so that the rotational position of the output shaft of the rotary solenoid will correspond to the setting of the selector switch. This output shaft is coupled to a rotatable valve in the flow regulator which provides a variable orifice controlling the hydraulic flow to the motor.

This invention relates to a hydraulic system and to a remotely operated hydraulic flow control arrangement therein for regulating the flow to a hydraulic motor which is to be operated at a constant speed selectively determined by the user.

Prior to the present invention, in systems of this general type it was necessary to provide a relatively complex and expensive hydraulic feedback circuit connected to the hydraulic motor to maintain its speed constant despite pressure changes in the supply fluid or changes in the load on the hydraulic motor. In addition to their complexity and expense, such systems were not well-suited for remote control operation, such as on highway maintenance trucks where the hydraulic motor drives a salt spreader and the driver of the truck should be able to selectively set the speed of the spreader from his normal driving position in the cab.

The present invention is directed to a novel and improved hydraulic system which is adapted to be remotely controlled and to a novel and improved hydraulic flow control arrangement for use in such a system.

It is an object of this invention to provide a novel and improved flow control arrangement for selectively regulating the speed of a hydraulic motor from a remote point.

It is also an object of this invention to provide a novel and improved hydraulic system embodying such a flow control arrangement.

Another object of this invention is to provide such a system which does not require a hydraulic feedback circuit associated with the hydraulic motor.

Another object of this invention is to provide such a system which does not require long hose connections from the remote control point to the hydraulic motor.

Another object of this invention is to provide such a novel and improved remotely operated flow control arrangement which minimizes the fluid pressure losses in the supply system for the hydraulic motor whose speed it controls.

Further objects and advantages of this invention will be apparent from the following detailed description of a presently-preferred embodiment thereof, which is illustrated in the accompanying drawing.

In the drawing:

FIGURE 1 shows schematically a hydraulic system in accordance with the present invention, including the present flow control arrangement connected for remote operation to control selectively the speed of the hydraulic motor in the system; and

FIGURE 2 is a fragmentary cross-section, taken along the line 2—2 in FIG. 1, through a portion of the flow divider in the present flow control arrangement.

Referring to the drawing, the system shown therein comprises a hydraulic motor 10, which may be of any suitable type, having an inlet 11 for hydraulic fluid under pressure and an outlet 12 for returning the hydraulic fluid to a reservoir 13. Hydraulic fluid under pressure is supplied to the inlet 11 of motor 10 by a pump 14, which pumps fluid from the reservoir 13, through a control valve 15 and thence through a flow regulator in the form of a pressure-compensated, priority-type flow divider 16, to be described in detail hereinafter. The control valve 15 controls both the supply flow from the pump 14 to the flow divider 16 and the return flow from the outlet 12 of the fluid motor 10 to the reservoir 13.

In the particular embodiment illustrated, the flow divider 16 comprises a cast housing or body 17 having an inlet port 18, a controlled priority flow outlet port 19 connected to the inlet 11 of fluid motor 10, an excess flow outlet port 20.

The flow divider body 17 has a first longitudinal bore 21 which slidably receives a first valve member 22. Valve member 22 has a first cylindrical land 23 which normally sealingly engages the bore 21 between an inlet passage 24, connected to the inlet port 18, and a first outlet passage 25, connected to the excess flow outlet port 20.

Valve member 22 has a second cylindrical land 26 which sealingly engages the first bore 21 between the first outlet passage 25 and an intermediate annular groove 27 surrounding bore 21.

Valve mamber 22 has an additional, generally cylindrical, third land 28 which sealingly engages the first bore 21 to the right of groove 27 in FIG. 1. Between its lands 26 and 28 valve member 22 has a reduced diameter portion 29 which is spaced inwardly from the wall of bore 21.

Valve member 22 has an axial recess or passage 30 which is open at its right end and which communicates with bore 21 through radial passages 31 in its reduced diameter portion 29.

To the right of the land portion 28 on valve member 22 in FIG. 1, the flow divider housing has an annular groove 32 surrounding bore 21 and communicating with the controlled priority flow outlet port 19.

A plug 40 is threadedly mounted in the right end of bore 21 in FIG. 1. A coil spring 41 is engaged under compression between the inner end of this plug and the closed end of the axial recess 30 in valve member 22 to bias the latter to the position shown in FIG. 1, where the valve 1 and 23 blocks the inlet port 18 from the excess flow outlet port 20.

At its left end in FIG. 1, valve member 22 has a cylindrical pilot or guide oprtion 38, which slidably engages the first bore 21 to the left of the inlet passage 24. This pilot or guide portion 38 is formed with an orifice 39 for equalizing the fluid pressure on its opposite sides.

The flow divider body 17 has a second longitudinal bore 42 extending parallel to the first bore 21. At its left end in FIG. 1 this second bore 42 is open to the inlet passage 24. A cross passage 43 connects the second bore 42 to the first bore 21 at the intermediate annular groove 27 in the latter.

A control valve 44 is rotatably mounted in the second bore 42 to control the priority flow therethrough from inlet port 18 to outlet port 19. This control valve has a cylindrical front end 45 which sealingly engages bore 42 just ahead of the cross passage 43. At this end the control valve has an axial passage 46 whose front end receives an orifice plate 47 with an orifice 47*a* therein. The orifice plate is held in place by a snap ring 48.

Communicating with the passage 46 behind the orifice plate 47 are a plurality of transverse passages 50, 51, 52 and 53 (FIG. 2) in the cylindrical front end 45 of the control valve 44 which together provide a variable orifice adapted to register selectively with the cross passage 43, depending upon the rotational position of the control valve 44. As the control valve 44 is turned progressively in one direction the flow through its variable orifice 50–53 to the cross passage 43 increases from zero progressively to a maximum flow rate, and then back to zero when the original rotational position of the control valve is again reached.

In the operation of this flow divider, there is a controlled priority flow from inlet port 18 through the second bore 42, orifice 47*a*, passage 46 in control valve 44, through the variable orifice 50–53 in the latter, through the cross passage 43 in the flow divider housing 17 into the annular intermediate groove 27 therein, through the radial openings 31 in valve member 22 into the axial recess 30 therein, and from the right end of that recess in FIG. 1 to the controlled priority flow outlet port 19.

The volume per minute of this fluid flow to the controlled priority flow outlet port 19 remains substantially constant despite fluctuations in the fluid pressure at the inlet port 18 or varying loads on either the hydraulic motor 10 in the controlled priority flow circuit or in the excess flow circuit. The controlled flow rate may be selectively adjusted by turning the control valve 44 to determine the registration of the latter's variable orifice 50–53 with the cross passage 43 between the bores 42 and 21 in the flow divider body.

In the operation of this flow divider, fluid delivered to the inlet passage 18 flows through the passage 42, orifice 47*a*, the variable orifice 50–53 in valve member 44, passage 43, openings 31 in the valve 22, bore 30 in valve 22 to controlled flow outlet 19. When the input flow exceeds the controlled flow set by the variable orifice in valve member 44, valve 22 moves to the right in FIG. 1 against the biasing force exerted by spring 41, first opening to bypass fluid from the inlet port 18 to the excess flow outlet port 20. Should there be a tendency for continued increase in controlled flow after the valve 22 has opened the passage to bypass fluid from the inlet port 18 to the excess flow outlet port 20, the valve 22 will move further against spring 41 to restrict flow to the controlled flow outlet port 19 by restricting the passage between recess 30 and the controlled flow outlet port 19. Valve 22 thus operates to maintain a fixed pressure drop across control orifices 47*a* and 50–53 by either bypassing inlet flow to the excess flow outlet port or by restricting the passage for inlet flow to the controlled flow outlet port to maintain a substantially fixed flow to the controlled flow outlet port regardless of variations of pressure at either the controlled flow outlet port 19 or the excess flow outlet port 20.

In accordance with the present invention the controlled priority flow to the fluid motor 10 is set selectively from a location remote from the flow divider itself. (In order to minimize hydraulic losses, the flow divider 16, the pump 14 and the hydraulic motor 10 preferably are as close as possible physically to one another, so as to minimize the length of the hose connections between them.) The rotatable control valve 44 in the flow divider, whose rotational position determines the controlled priority flow rate, has an integral stem 55 which is coupled to the output shaft 56 of a rotary solenoid 57. The control valve stem 55 extends rotatably through a coupling plug 58, which has a screw-threaded inner end 59 threadedly mounted in the right end of the second bore 42 in the flow divider housing. A cover 60 for the rotary solenoid 57 carries an end plate 61 which snugly receives the coupling plug 58. A jam nut 62 is threadedly mounted on the screw-threaded outer end 63 of the coupling plug just inside the end plate 61.

The output shaft 56 of the rotary solenoid 57 is coupled to the stem 55 of the control valve 44 through a coupling 64, which imparts the rotational or turning movement of the solenoid output shaft 56 to the control valve 44, but permits a certain amount of axial movement of the solenoid output shaft 56 with respect to control valve 44.

The rotary solenoid 57 may be of known construction and mode of operation, the details of which are not part of the present invention. For example, it may correspond substantially to a rotary solenoid as disclosed in U.S. Patent 2,496,880 or 2,501,950. The rotary solenoid has an armature which is rotatable in step-by-step fashion in response to the closing of an external switch, this armature being coupled to the output shaft 56 so that the latter turns the same amount as the armature and is displaced a slight distance axially in response to the movement of the armature.

The rotary solenoid 57 is under the control of a remotely located, rotatable, selector switch 70 having a manually rotatable contact 71 which may be turned to engage any one of several circumferentially spaced fixed contacts 72, here shown as twelve in number. The several contacts of this selector switch are interconnected with the rotary solenoid 57 in a known manner such that the output shaft 56 of the latter will have a rotational position corresponding to that of the manually rotatable contact 71 of the remote selector switch 70. For example, if the switch contact 71 is turned from the "zero" to the "2" position, the rotary solenoid will be energized to turn its output shaft 56 to the same rotational position. Consequently, the control valve 44 in the flow divider 16 will also be turned to the rotational or angular position which corresponds to the rotational position of the manually rotatable contact 71 of the remote switch 70. Thus, by turning this switch contact to the desired position, the flow divider can be adjusted to provide any one of several flow rates to the fluid motor 10, the number of such different flow rates (including zero flow rate) corresponding to the number of fixed contacts 72 in the selector switch.

With this arrangement, the rotary selector switch 70 may be mounted close to the operator of the system, such as in the cab of a truck, while the flow divider 16 and the rotary solenoid 57 are as close as desired to the fluid motor 10, so as to minimize the hydraulic losses in the system. For any particular rotational setting of the control valve 44 in the flow divider, the controlled priority flow to the fluid motor 10 will remain constant despite changes in the load on this motor, or in the load at the excess flow circuit, or in the inlet pressure to the flow divider. Accordingly, the speed of the motor 10 can be set selectively from a remote location and yet there is no necessity for complicated and expensive hydraulic feedback circuits for regulating the motor speed.

While a hydraulic system including a particular presently-preferred embodiment of the present flow control arrangement has been shown and described, it is to be understood that the invention is susceptible of other physical embodiments differing from the particular arrangement disclosed and that various modifications, omissions and refinements which depart from the disclosed embodiment may be adopted without departing from the spirit and scope of this invention. For example, the flow divider 16 may be replaced by another type of flow regulator, such as by plugging the excess flow outlet port 20 in housing 17, in which case this valve arrangement will still function to regulate the flow to the controlled flow outlet port 19 in accordance with the rotational position of control valve 44 independent of the fluid pressure at either port 18 or port 19. In such case, member 22 would function as a pressure-compensating piston which is adapted to restrict the flow to outlet port 19 and thereby maintain a fixed pressure differential between ports 18 and 19 as determined by the setting of control valve 44. Also, if desired, the step-by-step rotary sole-

noid 57 may be replaced by any other type of rotary actuator having an output shaft whose rotational position will be determined by a remotely located variable electrical control device, preferably manually operated.

I claim:

1. A flow control arrangement comprising:
a variable electrical control having a plurality of different stable operating positions to which it may be set selectively;
an electrically operated rotary actuator having a rotatable output shaft and connected electrically to said control to have the rotational position of said output shaft determined by the setting of said control in each of said operating positions of said control;
and a flow regulator having an inlet port and a controlled flow outlet port, a rotatable control valve between said inlet port and said controlled flow outlet port and coupled to said output shaft of the rotary actuator to be turned by the latter and operative to control the flow between said inlet port and said controlled flow outlet port in accordance with its rotational setting, and means operable to hold substantially constant the flow to said controlled flow outlet port, for a given rotational setting of said control valve, independent of the fluid pressure at said inlet port or at said outlet port.

2. A flow control arrangement comprising:
a variable electrical control having a plurality, greater than three, of different stable operating positions to which it may be set selectively;
an electrically operated rotary actuator positioned remote from said control and having a rotatable output shaft, said rotary actuator being connected electrically to said control such that the rotational position of said output shaft corresponds to the setting of said control in each of said operating positions of said control;
and a flow regulator positioned close to said rotary actuator and having an inlet port and a controlled flow outlet port, a rotatable control valve disposed between said inlet port and said controlled flow outlet port to control the fluid flow between them, said control valve being coupled to said output shaft of the rotary actuator to be turned by the latter, said control valve having variable orifice means thereon which controls the flow rate between said inlet port and said controlled flow outlet port in accordance with its rotational setting, and pressure-compensating means connected between said inlet port and said outlet port and operable to maintain substantially constant the fluid pressure differential between said inlet and outlet ports so as to hold substantially constant the flow to said controlled flow outlet port, for a given rotational setting of said control valve.

3. A flow control arrangement according to claim 2, wherein said rotatable control valve has means thereon defining a fixed flow restriction orifice between said inlet port and said variable orifice means.

4. In a hydraulic system, the combination of:
a source of hydraulic liquid under pressure;
a hydraulic motor;
and a flow control arrangement for selectively regulating the speed of said motor comprising
a variable electrical control positioned remote from said motor and having a plurality of different stable operating positions to which it may be set selectively;
an electrically operated rotary actuator having a rotatable output shaft and connected electrically to said control and operative to position said output shaft at a rotational position which corresponds to the setting of said control in each of said operating positions of said control;
and a flow regulator positioned close to said motor and having an inlet port connected to receive hydraulic liquid from said source and a controlled flow outlet port connected to the inlet of said motor, a rotatable control valve between said inlet port and said controlled flow outlet port and coupled to said output shaft of the rotary actuator to be turned by the latter and operative to control the flow between said inlet port and said controlled flow outlet port in accordance with its rotational setting, and pressure compensating means connected between said inlet and outlet ports for regulating the flow through said control valve to said controlled flow outlet port so as to maintain said flow substantially constant for a given rotational setting of said control valve.

5. A hydraulic system comprising:
a hydraulic motor;
a pump for operating said motor;
and a flow control arrangement for selectively regulating the speed of said motor comprising
a variable electrical control positioned remote from said motor and having a plurality of operating positions to which it may be set selectively;
a rotary actuator having a rotatable output shaft and connected electrically to said control to have the rotational position of said output shaft determined by the setting of said control in each of said operating positions of said control;
and a flow regulator positioned close to said motor and having an inlet port connected to receive hydraulic liquid from said pump and a controlled flow outlet port connected to the inlet of said motor, a rotatable control valve disposed between said inlet port and said controlled flow outlet port to control the fluid flow between them, said control valve being coupled to said output shaft of the rotary actuator to be turned by the latter, said control valve having variable orifice means thereon which controls the flow between said inlet port and said controlled flow outlet port in accordance with its rotational setting, and a pressure-compensating member connected between said inlet and outlet ports and slidable in response to the fluid pressure differential between said ports to variably restrict the flow to said outlet port so as to hold substantially constant the flow through said control valve to said controlled flow outlet port, for a given rotational setting of said control valve, independent of the fluid pressure at said inlet port or said outlet port.

6. A system according to claim 5, wherein said rotatable control valve carries means defining a fixed flow restriction orifice between said inlet port and said variable orifice means.

7. A flow control arrangement comprising:
a multi-position selector switch having a plurality of different stable operating positions to which it may be set selectively;
a rotary solenoid having a rotatable output shaft, said rotary solenoid being connected electrically to said selector switch and operative to position said output shaft at a rotational position corresponding to the setting of said selector switch in each of said operating positions of said switch;
and a flow divider positioned close to said rotary solenoid having an inlet port, a controlled priority flow outlet port, an excess flow outlet port, a rotatable control valve disposed between said inlet port and said controlled priority flow outlet port to control the fluid flow between them, said control valve being coupled to said output shaft of the rotary solenoid to be turned by the latter, said control valve having variable orifice means thereon which controls the flow between said inlet port and said controlled priority flow outlet port in accordance with its rotational setting, and pressure-compensating valve means connected between said inlet port and both said outlet ports and operable to regulate the

flow through said rotatable control valve to said controlled priority flow outlet port, for a given rotational setting of said control valve, by controlling the connection of said inlet port to said excess flow outlet port and variably restricting the flow from said variable orifice means to said controlled priority flow outlet port.

8. In a hydraulic system, the combination of:
a source of hydraulic liquid under pressure;
a hydraulic motor;
and a flow control arrangement for selectively regulating the speed of said motor comprising
a multi-position selector switch positioned remote from said motor and having a plurality of operating positions to which it may be set selectively;
an electrically operated rotary actuator having a rotatable output shaft and connected electrically to said selector switch such that the rotational position of said output shaft corresponds to the setting of said selector switch;
and a flow divider positioned close to said motor and having an inlet port connected to receive hydraulic liquid from said source, a controlled priority flow outlet port connected to the inlet of said motor, an excess flow outlet port, a rotatable control valve between said inlet port and said controlled priority flow outlet port and coupled to said output shaft of the rotary actuator to be turned by the latter and operative to control the flow between said inlet port and said controlled priority flow outlet port in accordance with its rotational setting, and pressure-compensating valve means subjected to the pressure differential between said inlet port and said controlled priority flow outlet port and controlling the flow between said inlet port and said excess flow outlet port to hold substantially constant the flow through said rotatable control valve to said controlled priority flow outlet port for a given rotational setting of said control valve.

9. A hydraulic system comprising:
a hydraulic motor;
a pump for operating said motor;
and a flow control arrangement for selectively regulating the speed of said motor comprising
a multi-position selector switch positioned remote from said motor and having a plurality of operating positions to which it may be set selectively;
a rotary solenoid having a rotatable output shaft and connected electrically to said selector switch to have

the rotational position of said output shaft correspond to the setting of said selector switch in each of said operating positions of said switch;
and a flow divider positioned close to said motor and having an inlet port connected to receive hydraulic liquid from said pump, a controlled priority flow outlet port connected to said inlet of said motor, an excess flow outlet port, a rotatable control valve disposed between said inlet port and said controlled priority flow outlet port to control the fluid flow between them, said control valve being coupled to said output shaft of the rotary solenoid to be turned by the latter, said control valve having variable orifice means thereon which controls the flow between said inlet port and said controlled priority flow outlet port in accordance with its rotational setting, and pressure-compensating valve means having a first valving portion thereon which controls the fluid flow from said inlet port to said excess flow outlet port and having an additional valving portion thereon which variably restricts the flow between said variable orifice means on the control valve and said controlled priority flow outlet port, said pressure-compensating valve means being subjected to the fluid pressure differential between said inlet port and said controlled priority flow outlet port to have its position determined by said pressure differential whereby to hold substantially constant the flow to said controlled priority flow outlet port, for a given rotational setting of said control valve, by controlling the fluid connections between said inlet port and said excess flow outlet port and between said inlet port and said controlled priority flow outlet port.

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