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[54] **HYDRAULIC DIRECTIONAL CONTROL VALVE DEVICE**
14 Claims, 4 Drawing Figs.

[52] U.S. Cl. 137/625.64,
137/596.16, 251/138
[51] Int. Cl. F15b 13/043

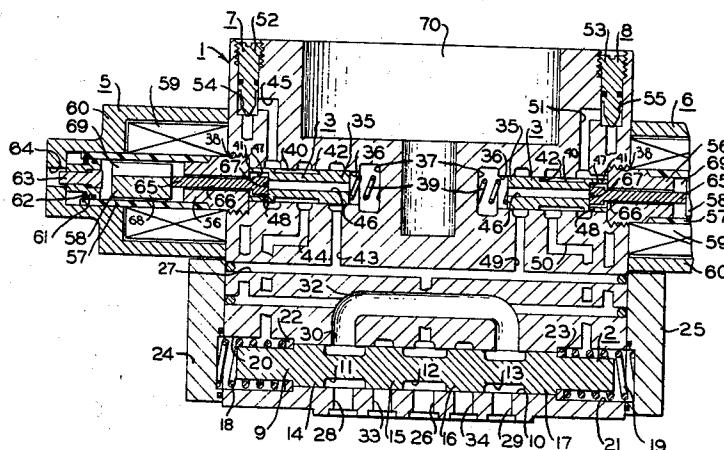
[50] Field of Search 137/625.64,
625.65, 65, 596.16, 625.6; 251/50, 141, 129, 138

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ABSTRACT: A hydraulic directional control valve device in which a pair of pressure balanced solenoid-operated pilot valves are disposed in a single housing with a liquid pressure operated slave spool valve controlled thereby, the solenoid being liquid cooled by communicating the armature chamber with the liquid pressure system by which the slave spool valve is operated, thereby totally immersing the armature in the same liquid utilized to control the slave spool valve member.



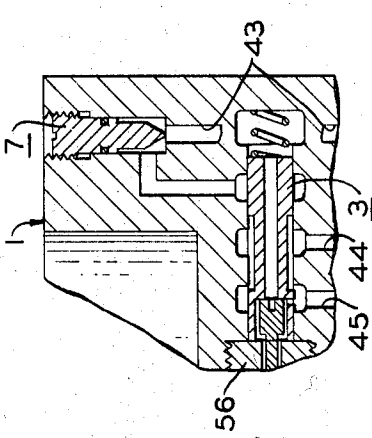


Fig. 4

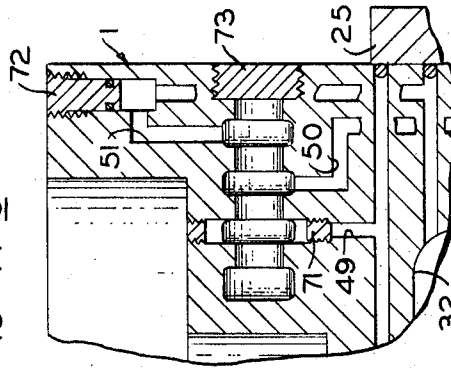


Fig. 3

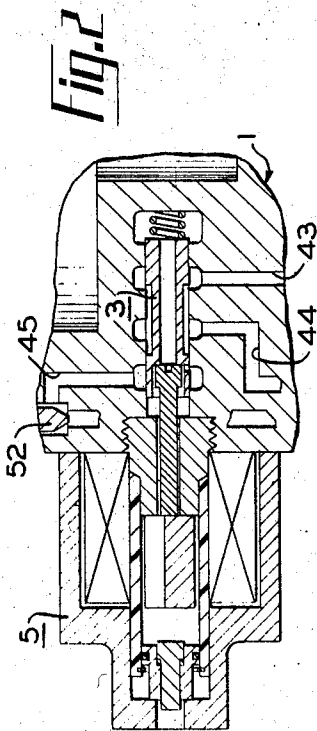


Fig. 2

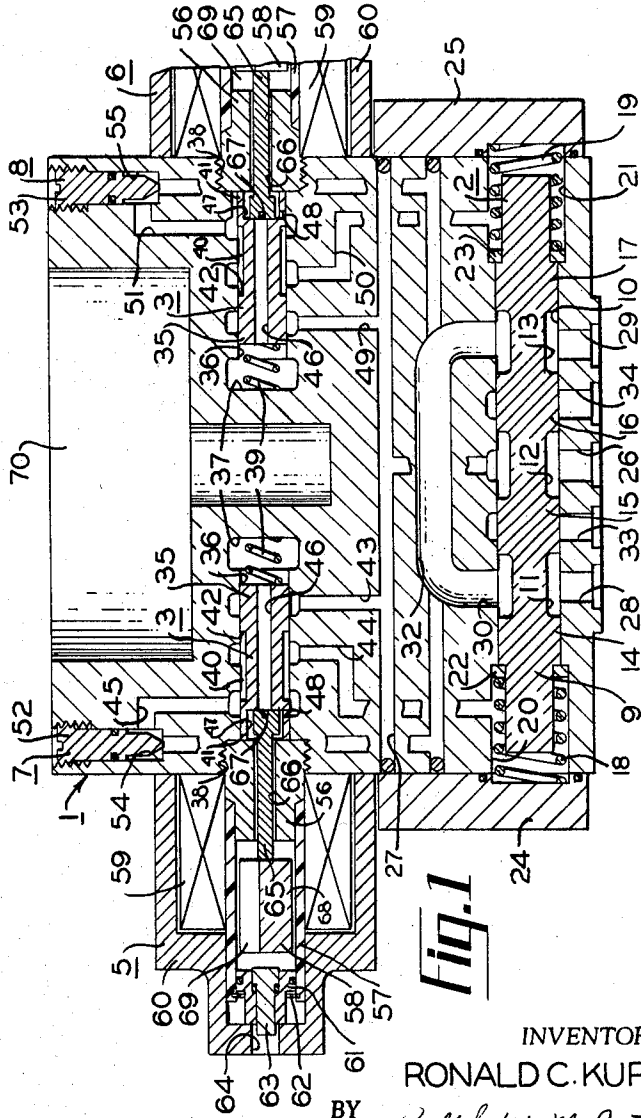


Fig. 1

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HYDRAULIC DIRECTIONAL CONTROL VALVE DEVICE

BACKGROUND OF THE INVENTION

Heretofore, in constructing a hydraulic directional control valve utilizing solenoid-operated pilot valves to control the application of fluid pressure to position the slave spool valve, the pilot valves were disposed in separate housings mounted on the slave spool valve housing and directly operated the pilot valve through a dynamic seal or O-ring isolating the solenoid from the fluid medium utilized to operate the spool valve. If better heat transfer was desirable in heavy duty installation, the solenoids were immersed in oil, as has been done previously in transformer installation, with no communication between the oil in the solenoid and the oil in the pressure system for operating the spool valve. Further, the pilot valve was usually a four-way spool valve operated by one solenoid or a pair of opposing solenoids directly acting against opposite ends of the pilot valve. The use of a pair of opposing solenoids in this manner required an elaborate electrical relay system to prevent simultaneous operation of both solenoids which would otherwise cause burn out of the coil in the unclosed one of the solenoids. Where it was desired to control the speed of operation of the slave spool valve, a filler plate valve body containing two needle valves and two associated check valves were disposed between the slave spool housing and the pilot valve housing to independently control the speed of operation of the spool valve member in both directions of movement.

It is the object of the present invention to provide a hydraulic directional control valve device enclosing in a single housing one or a pair of solenoid operated pilot valves and a fluid pressure operated slave spool valve controlled thereby, and including a simple but effective solenoid liquid cooling system and minimizing the number of parts controlling the speed of operation of the slave spool valve.

In the present invention, this object is achieved by disposing in a single valve housing a slave spool valve member spring biased to a neutral position and movable to a first and a second position on opposite sides of the neutral position to effect pressurization of one or the other of two delivery passages, which slave spool valve movement is hydraulically controlled by a pair of separate solenoid-operated three-way pilot spool valves, which, by virtue of their separate construction, may be simultaneously energized without danger of burn out of the solenoid coils. Further, such utilization of two separate three-way pilot valves, rather than a single four-way pilot valve, eliminates the need for check valves associated therewith so that the speed of operation of the slave spool valve may be controlled solely by needle valve means in the hydraulic system disposed to control the rate of flow of hydraulic pressure either to or from the slave spool valve. The pilot spool valves are longitudinally ported to provide pressure balancing thereof in the slave spool valve controlling medium. The interior of the solenoids are also communicated with the same liquid pressure medium thereby eliminating the need for a dynamic seal isolating the solenoid from the slave spool valve pressure medium, and, at the same time, communicating the solenoid with the remainder of the liquid pressure system to provide conduction cooling of the solenoids. The solenoid armatures are also pressure balanced by slot means communicating one end thereof with the other end.

This and other objects will be more readily apparent in the following description, taken in conjunction with the drawing, in which:

FIG. 1 is a diagrammatical view of a hydraulic directional control valve device, showing the invention, and having a pair of solenoid-operated pilot valves shown in the solenoid deenergized position;

FIG. 2 is a diagrammatical view of a portion of the hydraulic directional control valve of FIG. 1, showing one of the solenoid-operated pilot valves in the solenoid energized position;

FIG. 3 is a diagrammatical view of a portion of FIG. 1, showing plug means replacing one of the solenoid-operated pilot valves; and

FIG. 4 is a diagrammatical view of a portion of FIG. 1, showing an alternate portion of the needle valve in the fluid system.

Referring now to FIG. 1 of the drawing, there is shown a housing member 1 having disposed therein a hydraulic pressure operated slave spool valve assembly, generally indicated at 2, and connected via internal passageways for operation by a pressurized hydraulic medium, such as oil, which medium is controlled by a pair of pilot valve assemblies 3 and 4 also disposed within housing 1. A pair of solenoid assemblies 5 and 6 are disposed to control operation of the pilot valve assemblies 3 and 4, respectively. A pair of needle valve assemblies 7 and 8 are mounted in the housing 1 in hydraulic connection with the pilot valves 3 and 4, respectively, to control the speed of operation of the slave spool valve assembly 2.

The slave spool valve assembly 2 comprises a spool valve member 9 axially movable in a mounting bore 10 and having disposed at intervals along its length a plurality of necked portions 11, 12 and 13 forming land portions 14, 15, 16 and 17. The spool valve 9 is biased to the central position, as shown, by way of a pair of opposing spring members 18, 19 disposed in counterbores 20, 21 at the opposite ends of bore 10, the springs being compressed between retainers 22, 23 sleeved on the necked ends of spool valve member 9 and the inside of a pair of end plates 24, 25, respectively, covering the counterbores 20, 21 and attached to the cover by any suitable means, not shown.

A pressure supply port 26 in the bottom of the housing 1 is communicable through the bore 10 with a hydraulic pressure supply passage 27 by way of necked portion 12 when the spool valve 9 is centrally disposed, as shown. Similarly, a pair of tank or sump ports 28, 29 in the bottom of housing 1 are each communicable through bore 10 with the ends 30, 31 respectively, of a tank or sump passage 32 by way of necked portions 11 and 13, respectively, when spool valve 9 is centrally disposed as shown. A pair of delivery passages 33, 34 in the bottom of housing 1 communicate with bore 10 and are sealed by way of lands 15 and 16 when the spool valve is centrally disposed. When the spool valve 9 is moved to the right from the central position, delivery port 33 is communicated with tank port 28 by way of necked portion 11, and delivery port 34 is communicated with pressure supply port 26 by way of necked portion 12. Conversely, when the spool valve 9 is moved to the left from the central position shown, delivery port 33 is communicated with pressure supply port 26 by way of necked portion 12, and delivery port 34 is communicated with tank port 29 by way of necked portion 13.

The pilot valve assembly 3 comprises a spool valve member 35 disposed for axial movement in a bottom bore 36 laterally disposed in housing 1, the bottom end 37 of the bore comprising a pressure balancing chamber. The outer end of the bore communicates with a threaded counterbore 38 into which is threaded the core of a solenoid, as hereinafter described in detail, to substantially close bore 36 and provide an outer limit of movement for the spool valve 35. A spring 39 disposed between the inner end of the spool valve and the bottom of bore 36 biases the spool valve to the outer limit, as shown, which outer limit position corresponds to the deenergized condition of the solenoid assembly 5, as hereinafter described in detail.

A necked portion 40 on the surface of spool valve member 35 separates two land portions 41, 42 so that when the spool valve 35 is biased to the position shown, branch passage 43 of aforementioned fluid pressure passages 27 is sealed by land 42. At the same time, pressure passage 44, communicating pressure chamber 20 of slave spool valve assembly 2 with bore 36, is communicated by way of necked portion 40 of spool valve 35 with branch passage 45 of the aforementioned tank or sump passage 32. When spool valve 35 is moved inwardly to the position illustrated in FIG. 2, sump branch passage 45 is sealed relative to pressure passage 44 by way of land 41, and pressure passage 44 is communicated with pressure supply branch passage 43 by way of necked portion 40.

In order to provide pressure balancing of pilot spool valve member 35, there is provided therein an axial throughbore 46 communicating at one end with aforementioned pressure chamber 37, and communicating at the other end with a counterbore 47. Land 41 is ported at 48 to communicate the counterbore 47, bore 46, and pressure chamber 37 with pilot spool valve bore 36 so that when the pilot spool valve is disposed in either position, as shown in FIG. 1 and FIG. 2, the port 48 communicates pressure cavity 37, bore 46 and counterbore 47 with the sump or tank passage 45, thereby providing a breather port.

The pilot valve assembly 4 is identical to the above-described spool valve assembly 30, therefore, the components thereof corresponding to pilot valve assembly 3 have been given the same reference numerals. It is to be noted that branch passages 49, pressure passage 50, and branch passage 51 correspond to the previously described pressure supply branch passage 43, pressure passage 44 and sump branch passage 45, respectively.

In order to provide for adjusting the speed of movement of slave spool valve 9, a pair of needle valves 52 and 53 of needle valve assemblies 7 and 8, respectively, are threadedly inserted in a pair of bores 54, 55, respectively, which bores intersect tank branch passage 45, 51, respectively, so that axial adjustment of the needle valve correspondingly adjusts the rate of flow from pressure passage 44 to tank branch passage 45, tank passage 32 and tank ports 28 and 29.

The solenoid assembly 5 includes an elongated member 56 of magnetizable material threadedly received in previously described threaded counterbore 38 in housing 1 and serves as the solenoid pole piece and also as the mounting means by which the solenoid assembly is attached to the housing 1. A tubular member 57 of nonmagnetic material is attached at one end to the pole piece by any suitable means, such as welding, and axially extends relative to the pole piece to serve as a chamber for a plunger member 58 disposed for reciprocable movement therein. A spool wound coil 59 is sleeved on tubular member 57 and core 56, and is enclosed within a housing 60 which may be attached to the tubular member 57 or the housing 1, in any suitable manner, not shown.

A manual override mechanism comprising a mounting member 61 retained in the end of tubular member 57 by way of a snapping 62, includes an axially movable member 63 accessible through an aperture 64 in housing 60 for inward movement to move plunger 58 to its inward position, as shown in FIG. 2, in the event a solenoid energizing circuit, not shown, is inoperable.

A plunger extension 65 extends through a throughbore 66 in pole piece 56 into the previously described counterbore 47 in pilot valve member 35 to axially engage the radial shoulder formed between bore 46 and counterbore 47 to thereby move pilot spool valve member 35 to the inner position, shown in FIG. 2, when the solenoid is energized. In order to communicate the plunger chamber with bore 36, radial clearance is provided between plunger extension 65 and throughbore 66 in any suitable manner, as by axially extending flats, not shown, on plunger extension 65.

In order to provide accessibility of the fluid medium to the plunger chamber to provide for liquid conduction cooling of the solenoid, the inner end of the solenoid extension 65 is radially spaced from the wall of counterbore 47, providing a path from port 48 in land 41 of pilot spool valve 35 to the counterbore 47, bore 66 and the plunger chamber in tubular member 57.

In order to provide conduction cooling of the solenoid by way of the hydraulic medium, the plunger chamber is in constant communication with the fluid medium in bore 46 of the spool valve 35 and pressure balancing chamber 37 by way of an axial step 67 in the end of plunger extension 65, thereby providing an uninterrupted column of fluid extending from the plunger chamber at one end to the pressure balancing chamber 37 at the other end. The previously described breather port 48 provides for exhaust of fluid expanded by heat.

In order to provide pressure balancing of the plunger member 58, the fluid medium passes from one end of the plunger member to the other by way of flats 68 on the plunger 58 and through an axial slot 69 in the plunger 58, which slot is usually present in conventional plungers to reduce eddy currents.

The solenoid assembly 6 is identical to the above-described solenoid assembly 5 and accordingly corresponding parts have been assigned the same reference numbers.

Cavity 70 in the upper portion of housing member 1 contains a terminal block, not shown, providing electrical connection of the solenoid assemblies 5 and 6 with a source of electrical power, not shown.

Referring now to FIG. 3 of the drawing, it is seen that to convert the double solenoid-operated valve device of FIG. 1 to a single solenoid-operated device, the solenoid assembly 6 and the needle valve assembly 8 may be replaced by appropriate plug members 71, 72 and 73, thereby closing off pressure supply to the pressure chamber 21 at the right end of the slave spool valve assembly 2 while maintaining communication between pressure chamber 21 and the sump branch passage 51.

In now describing the operation of the device as shown in FIG. 1, it will be assumed that hydraulic pressure is supplied at pressure inlet port 26 and that both solenoid assemblies 5 and 6 are in the deenergized position, as shown. Under these conditions, springs 39 bias both the pilot spool valve devices 35 and the plungers 58 to the positions shown, thus closing branch passages 43 and 49 of the pressure supply passage 26, and communicating the pressure chambers 20, 21 with supply branch passages 45 and 51, respectively.

Assuming now that it is desired to move spool valve 9 to the right, thus communicating pressure supply port 26 with delivery port 34 and simultaneously connecting delivery port 12 to tank port 28, the solenoid assembly 5 is energized to move plunger 58, plunger extension 65 and pilot spool valve 35 to the right to the position shown in FIG. 2. During movement of the plunger 58 to the right, the fluid medium disposed in the plunger chamber between the right end of the plunger 58 and the pole piece 56 is displaced to the other end of the plunger chamber by way of slot 67 and flats 66. Similarly, any fluid medium disposed in pressure chamber 37 passes through bore 46, step 67 and counterbore 47 to the left end of bore 36 so that the movement of neither the plunger 58 nor the pilot valve 35 is resisted by the fluid pressure medium.

During the latter portion of movement of the solenoid plunger 58 and pilot valve 35 to the position shown in FIG. 2, branch passage 43 of fluid pressure passage 27 is communicated with pressure passage 44, thus pressurizing pressure chamber 20 to move slave spool valve to the right to effect the aforementioned communications. Since the pressure chamber 21 is already communicated with tank port 29 by way of pressure passages 50, needle valve 53, and branch passage 51 of tank passage 32, the slave spool valve moves to the right at a speed controlled by the adjusted setting of needle valve assembly 8.

When solenoid assembly 5 is deenergized, the plunger 58, plunger extension 65 and pilot spool valve member 35 are moved leftwardly to the original positions shown in FIG. 1 under the urging of biasing spring 39, during which movement the supply branch passage 43 is sealed and pressure passage 44 is recommunicated with tank branch passage 45 to depressurize pressure chamber 20 in slave spool valve assembly 2, thereby permitting springs 19 and 18 to recenter the slave spool valve 9.

During the aforementioned leftward movement of solenoid plunger 58 and pilot valve 35, fluid in the left end of each of the plunger cavity and the pilot valve bore 36 is transferred to the corresponding right hand thereof by way of the slot 69 and bore 36, respectively. If the plunger chamber and bore 36 are not already supplied with hydraulic fluid, the fluid in tank branch passage 45 or pressure passage 44 enters by way of port 48.

From the foregoing, it will be apparent that energization of the solenoid assembly 6 will, in an identical manner, effect

movement of the spool valve member 9 to the left at a speed controlled by the setting of needle valve assembly 7, communicating pressure supply port 26 with delivery port 33 and communicating delivery port 34 with sump port 29.

From the foregoing, it will also be readily apparent that upon simultaneous energization of both solenoid assemblies 5 and 6, both pilot valve members will be moved to the corresponding position shown in FIG. 2 to simultaneously pressurize both pressure chambers 21 and 20 at the opposite ends of the slave spool valve 9, so that the slave spool valve 9 remains in the center position, as shown in FIG. 1.

In now describing the operation of the device with solenoid assembly 6 and pilot spool valve assembly 5 removed, in the manner illustrated in FIG. 3, it will be readily seen by analysis with the foregoing description of the double solenoid operated device of FIG. 1, that upon energization of the solenoid assembly 5 to move the slave spool valve 9 to the right, liquid under pressure is exhausted from the pressure chamber 21 by way of pressure passages 50, bore 36 and tank branch passage 51 to tank passage 32 and bore 10 to tank port 29. The needle valve assembly 8 is omitted from FIG. 3 since, in a single solenoid operated device, speed control of the slave spool valve 9 is usually not required.

Referring now to FIG. 4 of the drawing showing an alternate position of the needle valve in the fluid system, there is shown a hydraulic control device of the type shown in FIGS. 1, 2 and 3 of the drawing and having the same component parts bearing the same reference numerals, in which the needle valve assembly 7 is disposed in the pressure supply branch passage 43, rather than in the tank branch passage 45.

In now describing the operation of the device of FIG. 4, it will be seen by analysis with the foregoing description of FIGS. 1 and 2, when the solenoid assembly 5 is deenergized, land member 42 of pilot spool valve member 35 closes branch supply passage 43 relative to bore 36 and pressure passage 44 in the same manner as previously described with respect to FIG. 1. However, when the solenoid assembly 5 is energized moving spool valve member 35 inwardly to communicate branch supply passage 43 with pressure passage 44 in the same manner as in FIGS. 1, 2 and 3, the needle valve assembly 7 controls the speed of movement of slave spool valve 9 to the right in accordance with the axial adjustment of needle valve member 52, which accordingly meters the fluid flow into pressure chamber 20.

When the solenoid assembly 5 is deenergized, fluid flows directly from pressure passage 44 to tank passage 45.

I claim:

1. A solenoid-operated hydraulic control valve device, comprising:
 - a. a housing;
 - b. a cylindrical cavity in said housing;
 - c. a plurality of hydraulic passage means in said housing each communicating with said cavity;
 - d. a spool valve disposed for axial movement in said cavity to intercommunicate said plurality of passage means in different combinations in accordance with the axial position of said spool valve;
 - e. a solenoid assembly mounted on said housing and including a plunger means disposed for axial movement in a plunger chamber, one end of said plunger means axially engageable with said spool valve to axially position said spool valve in accordance with energization of said solenoid assembly;
 - f. means biasing said spool valve and said plunger means to a normal axial position when said solenoid assembly is deenergized;
 - g. passage means communicating said plunger chamber with at least one of said plurality of hydraulic passage means;
 - h. said solenoid assembly further including a pole piece having one end comprising one end of said plunger chamber and the other end comprising one end of said cavity;
 - i. an axial throughbore in said pole piece communicating said plunger chamber with one end of said cavity; and

j. said plunger means comprises a plunger member in said plunger chamber and a plunger extension extending with radial clearance through said throughbore into said cavity.

2. A solenoid-operated hydraulic control valve device, as recited in claim 1, in which, passage means intercommunicates both ends of said cavity.

3. A solenoid-operated hydraulic control valve device, as recited in claim 2, in which, said passage means which intercommunicates both ends of said cavity comprises axial throughbore means in said spool valve.

4. A solenoid-operated hydraulic control valve device, as recited in claim 10, in which:

- a. said axial throughbore means in said spool valve comprises an axial throughbore having a counterbore at the end adjacent said one end of said cavity forming a radial shoulder between said throughbore and said counterbore;
- b. one end of said plunger extension is axially disposed in said counterbore with radial clearance and axially seated on said shoulder; and
- c. means on said one end of said plunger extension communicated said bore with said counterbore around said one end of said plunger extension.

5. A solenoid-operated hydraulic control valve device, as recited in claim 1, in which:

- a. said cavity comprises a bottom bore in said housing and having a threaded counterbore opening at the surface of said housing; and
- b. said pole piece is threadedly received in said counterbore to removably mount the solenoid assembly on said housing.

6. A solenoid-operated hydraulic control valve device, as recited in claim 5, in which:

- a. a tubular member having one closed end is attached at the other end to said one end of said pole piece; and
- b. said plunger chamber being defined by the interior wall of said tubular member, said closed end and said one end of said pole piece.

7. A directional control valve device, comprising:

- a. a housing;
- b. a slide valve in said housing and having three axial positions;
- c. means biasing said slide valve to the central one of said three positions;
- d. a pair of pressure chambers in said housing each receiving one of the opposing ends of said slide valve and each operable when pressurized to move said slide valve to a different one of the two end positions of said three axial positions;
- e. a pair of individually energizable solenoid-actuated pilot valves, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to exhaust, and each having an energized position in which the corresponding one of said pressure chambers is communicated with a source of supply; and
- f. a pair of needle valves, each associated with a corresponding one of said pair of pressure chambers to control the rate of exhaust therefrom.

8. A directional control valve device, comprising:

- a. a housing;
- b. a slide valve in said housing and having three axial positions;
- c. means biasing said slide valve to the central one of said three positions;
- d. a pair of pressure chambers in said housing each receiving one of the opposing ends of said slide valve and each operable when pressurized to move said slide valve to a different one of the two end positions of said three axial positions;
- e. a pair of individually energizable solenoid-actuated pilot valves, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to exhaust, and each having an energized posi-

- tion in which the corresponding one of said pressure chambers is communicated with a source of supply; and
- f. a pair of needle valves, each associated with a corresponding one of said pair of pressure chambers to control the rate of supply thereto.
 9. A hydraulic directional control valve device, comprising:
 - a. a housing;
 - b. a three-position pressure-operated slide valve in said housing;
 - c. means biasing said slide valve to the central one of said three positions;
 - d. a pair of pressure chambers in said housing disposed to act on the opposite ends of the slide valve and each operable when pressurized while the other is depressurized to move the slide valve to a different one of the two end positions of said three positions;
 - e. supply passage means in said housing;
 - f. tank passage means in said housing;
 - g. a pair of pressure passage means in said housing, each communicating with a corresponding one of said pair of pressure chambers;
 - h. a pair of solenoid-actuated pilot valves in said housing, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to said tank passage in bypass of the other one of said pair of chambers, and having an energized position in which the corresponding one of said pair of chambers is communicated with said supply passage means in bypass of the other one of said pair of chamber; and
 - i. a pair of adjustable needle valves disposed in said tank passage, each operable to control the fluid flow only from a corresponding one of said pressure chambers.
 10. A hydraulic directional control valve device, comprising:
 - a. a housing;
 - b. a three-position pressure-operated slide valve in said housing;
 - c. means biasing said slide valve to the central one of said three positions;
 - d. a pair of pressure chambers in said housing disposed to act on the opposite ends of the slide valve and each operable when pressurized while the other is depressurized to move the slide valve to a different one of the two end positions of said three positions;
 - e. supply passage means in said housing;
 - f. tank passage means in said housing;
 - g. a pair of pressure passage means in said housing, each communicating with a corresponding one of said pair of pressure chambers;
 - h. a pair of solenoid-actuated pilot valves in said housing, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to said tank passage in bypass of the other one of said pair of chambers, and having an energized position in which the corresponding one of said pair of chambers is communicated with said supply passage means in bypass of the other one of said pair of chambers;
 - i. said supply passage means comprises a pair of supply passage means for connection to a common source of supply;
 - j. said tank passage means comprises a pair of tank passages for connection to a common tank; and
 - k. each of said solenoid-actuated pilot valves communicates a different one of said pair of supply passages to the corresponding one of said pair of pressure chambers when energized, and communicates a different one of said pair of tank passages to the corresponding one of said pressure chambers when deenergized; and
 - l. an adjustable needle valve is disposed in each of said pair of tank passages.
 11. A hydraulic directional control valve device, comprising:
 - a. a housing;

- b. a three-position pressure-operated slide valve in said housing;
 - c. means biasing said slide valve to the central one of said three positions;
 - d. a pair of pressure chambers in said housing disposed to act on the opposite ends of the slide valve and each operable when pressurized while the other is depressurized to move the slide valve to a different one of the two end positions of said three positions;
 - e. supply passage means in said housing;
 - f. tank passage means in said housing;
 - g. a pair of pressure passage means in said housing, each communicating with a corresponding one of said pair of pressure chambers;
 - h. a pair of solenoid-actuated pilot valves in said housing, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to said tank passage in bypass of the other one of said pair of chambers, and having an energized position in which the corresponding one of said pair of chambers is communicated with said supply passage means in bypass of the other one of said pair of chambers;
 - i. said supply passage means comprises a pair of supply passage means for connection to a common source of supply;
 - j. said tank passage means comprises a pair of tank passages for connection to a common tank;
 - k. each of said solenoid-actuated pilot valves communicates a different one of said pair of supply passages to the corresponding one of said pair of pressure chambers when energized, and communicates a different one of said pair of tank passages to the corresponding one of said pressure chambers when deenergized; and
 - l. a needle valve device is disposed in each of said pair of supply passages.
12. A directional control valve device, comprising:
- a. a housing;
 - b. a slide valve in said housing and having three axial positions;
 - c. means biasing said slide valve to the central one of said three positions;
 - d. a pair of pressure chambers in said housing each receiving one of the opposing ends of said slide valve and each operable when pressurized to move said slide valve to a different one of the two end positions of said three axial positions;
 - e. a pair of individually energizable solenoid-actuated pilot valves, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to exhaust, and each having an energized position in which the corresponding one of said pressure chambers is communicated with a source of supply; and
 - f. said pair of solenoid-operated pilot valves each comprise:
 1. a slide valve member;
 2. a coil member having a chamber therein; and
 3. a plunger member in said chamber for operating said slide valve member.
13. A hydraulic directional control valve, comprising:
- a. a housing;
 - b. a three-position pressure-operated slide valve in said housing;
 - c. means biasing said slide valve to the central one of said three positions;
 - d. a pair of pressure chambers in said housing disposed to act on the opposite ends of the slide valve and each operable when pressurized while the other is depressurized to move the slide valve to a different one of the two end positions of said three positions;
 - e. supply passage means in said housing;
 - f. tank passage means in said housing;
 - g. a pair of pressure passage means in said housing, each communicating with a corresponding one of said pair of pressure chambers;

- h. a pair of solenoid-actuated pilot valves in said housing, each having a deenergized position in which a corresponding one of said pair of pressure chambers is communicated to said tank passage in bypass of the other one of said pair of chambers, and having an energized position in which the corresponding one of said pair of chambers is communicated with said supply passage means in;
- i. said pair of solenoid-operated pilot valves each comprise:
1. a slide valve member;
 2. a coil member having a chamber therein;

3. a plunger member in said chamber for operating said slide valve member; and
 - j. additional passage means communicating said chamber with one of said supply passage means, tank passage means or one of said pair of pressure passage means.
14. A hydraulic directional control valve device, as recited in claim 13, in which: said slide valve member of each of said pilot valves includes an axial throughbore communicating with said additional passage means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,554,234 Dated January 12, 1971

Inventor(s) Ronald C. Kurtz

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 6, line 13, numeral "10" should be --3--; lines 22, "communicated" should be --communicate--

Column 7, line 29, "chamber" should be --chambers--

Column 9, line 7, after "in" insert --bypass of the other one of said pair of chambers--

Signed and sealed this 8th day of June 1971.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

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