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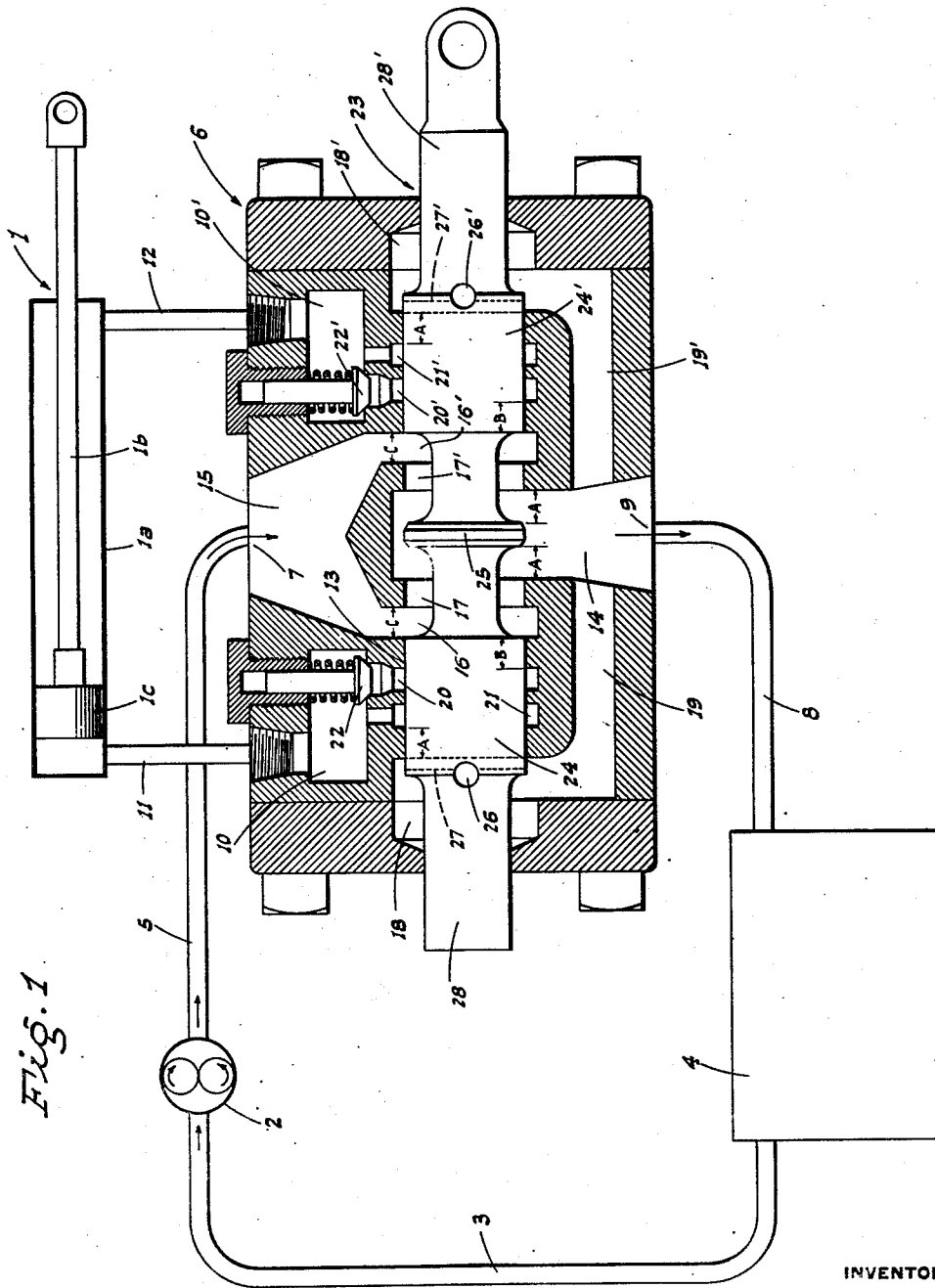
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2,708,909

FOUR-WAY DIRECTIONAL SPOOL VALVE

Filed March 15, 1954

2 Sheets-Sheet 1



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Fig. 2

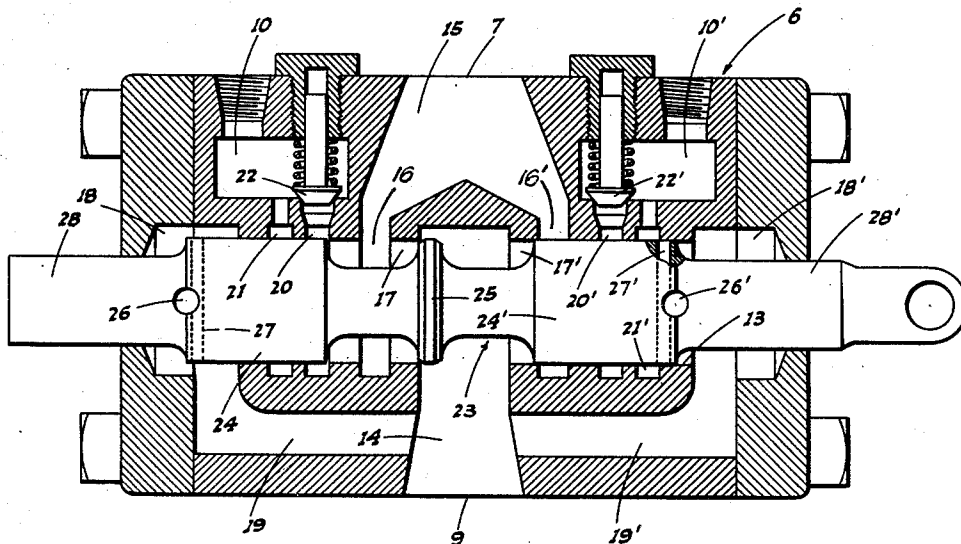
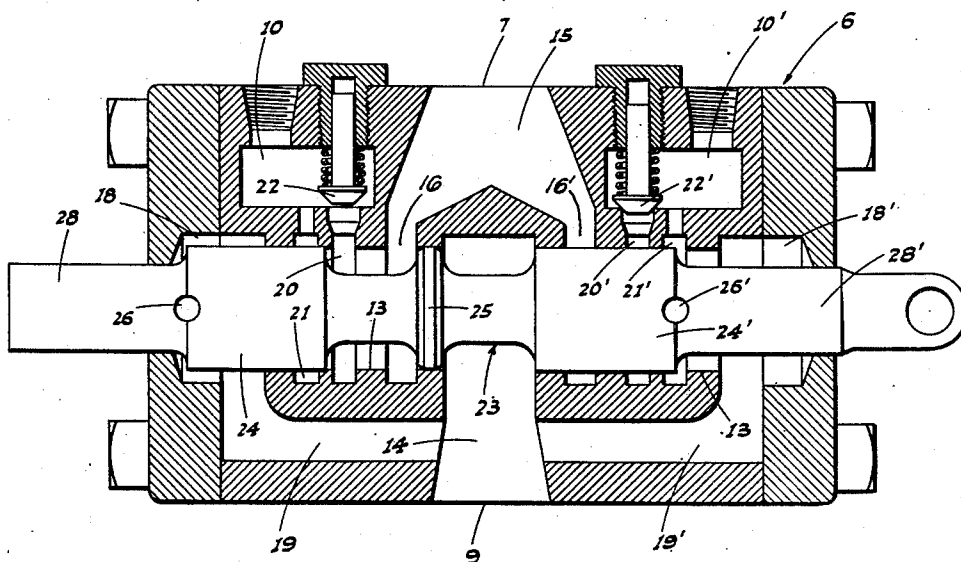


Fig. 3



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FOUR-WAY DIRECTIONAL SPOOL VALVE

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5 Claims. (Cl. 121—46.5)

This invention relates in general to hydraulic power transmission systems and in particular to such systems in which a double acting hydraulic cylinder motor is regulated by a control valve. More specifically, the invention relates to four-way open center directional spool valves for use in such systems.

Valves of this type are known in which each actuator port has but one groove connecting the port to the cylindrical main bore and in which all the lands on the spool are cylindrical in shape to slidably fit the bore. These valves of the prior art have the disadvantage that when the motor is under load and the valve is operated from neutral, a back flow of pressure fluid occurs, causing loss of control of the load. Another disadvantage of these valves is that accurately machined porting is necessary to give close circuit regulation and fine control of the motor.

It has been discovered that these disadvantages are overcome by providing, in a valve of the type mentioned, a pair of grooves connecting each actuator port to the main bore, a check valve in one of the grooves of each pair, and a spool having a tapered center land and a pair of cylindrical end lands, the end lands each having a pair of intersecting passages therethrough.

It is therefore an object of this invention to provide a new and improved four way open center directional spool valve having means for obtaining a more effective and regulated control of a double acting hydraulic cylinder motor than heretofore obtained.

Another object of this invention is to provide a four way open center directional spool valve having means for obtaining an unrestricted flow of fluid through its actuator ports when the spool is thrown to its full open position.

It is a further object of this invention to provide a four way open center directional spool valve having means for preventing a back flow of pressure fluid from the motor when the valve is moved out of neutral.

Still another object of this invention is to provide a four way open center spool valve having means for metering the flow of fluid from the valve to the motor and from the motor to the valve to obtain close circuit regulation and fine motor control without having accurately machined porting.

Objects and advantages other than those above set forth will be apparent from a consideration of the following description when read in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a simple hydraulic transmission system incorporating a sectional view of a valve embodying the invention and showing the valve spool in neutral position.

Fig. 2 is a sectional view of the valve with the valve spool shown in a different position.

Fig. 3 is a sectional view of the valve with the valve spool shown in a still different position.

Referring more particularly to the drawings by characters of reference, the hydraulic transmission system

illustrated in Fig. 1 comprises a double acting hydraulic cylinder motor 1 having a cylinder 1a with a piston rod 1b and head 1c reciprocally operable therein. A pump of the constant delivery type such as gear pump 2 is connected through a suction conduit 3 to a source of fluid such as tank 4 and is also connected through a discharge conduit 5 to a four way open center directional spool valve 6 at inlet port 7 of the valve 6. The pump discharges fluid through the valve in the arrow direction. The tank 4 is connected through return conduit 8 to outlet port 9 of the valve. Actuator port 10 of the valve is connected to one end of the motor 1 through conduit 11 and actuator port 10' of the valve is connected through conduit 12 to the other end of the motor.

The body of valve 6 defines therein a main longitudinal cylindrical bore 13. A vertical outlet chamber 14 intersects the bore at the center portion thereof. This outlet chamber communicates with outlet port 9. An inlet chamber 15 disposed centrally of the length of the valve body communicates with inlet port 7. Inlet chamber 15 also communicates with a pair of inlet branch grooves 16, 16' which intersect the bore 13 on opposite sides of the outlet chamber 14 to thus connect inlet chamber 15 to outlet chamber 14 through bypass bore portions 17, 17' of the bore 13. Each of the bore portions 17, 17' is adjacent outlet chamber 14. Communicating with the ends of bore 13 are return chambers 18, 18' which connect the bore to outlet chamber 14 through return passageways 19, 19'.

Surrounding the bore and intersecting therewith are pressure grooves 20, 20' and return grooves 21, 21'. Grooves 20, 21 are connected to actuator port 10 and grooves 20', 21' are connected to actuator port 10'.

A check valve 22 is disposed between actuator port 10 and pressure groove 20 and another check valve 22' is disposed between actuator port 10' and pressure groove 20'.

A valve piston or spool 23 has thereon a pair of cylindrical end lands 24, 24' slidably engageable with the bore upon movement of the spool axially in the bore. The spool is movable in either direction through the valve. The spool 23 also has thereon a tapered center land 25 disposed centrally intermediate the end lands 24, 24'. End land 24 has therethrough near its endmost extremity a pair of intersecting passages 26, 27. Passage 27 is completely within land 24 while passage 26 overlaps the spool shaft portion 28 adjacent the land 24. End land 24' likewise has therethrough near its endmost extremity a pair of intersecting passages 26', 27'. Passage 27' is completely within land 24' while passage 26' overlaps the spool shaft portion 28' adjacent land 24'.

The valve is so dimensioned that: the distance B between either pressure groove 20, 20' and its associated branch groove 16, 16' is less than the width C of the branch grooves 16, 16'; the width C is less than the distance A between either return groove 21, 21' and its associated return chamber 18, 18'; and the distance A is also the distance from the tapered land 25 to either of the bore portions 17, 17' when the spool is in its neutral position. Fig. 1 shows the spool in its neutral position with the tapered center land 25 thereby positioned in the center of the valve.

Referring to Fig. 1, showing the spool in its neutral position, land 24 completely closes off grooves 20, 21, from bore 13 and land 24' completely closes off grooves 20', 21' from bore 13. Thus the actuator ports 10, 10' and the motor 1 are also completely closed off from the pump and the pump discharges fluid only through the open center "double branch" path including inlet chamber 15, branch grooves 16, 16', bypass bore portions 17, 17' and outlet chamber 14. The motor is thus closed off from the pump and the motor piston is held motionless

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to so hold any load connected thereto. To move the piston and thus the load, the valve spool must be moved from its neutral position. For example, if it is desired to move the motor piston to the right, the valve spool 23 is moved to the left and the operation is as follows:

Movement of the spool to the left from its neutral position through the distance B causes land 24 to open that part of bore 13 which is between groove 16 and groove 20 and permits fluid to flow into that part. Land 24 has not yet opened groove 20 to the bore. When the spool has further moved to the left through the distance C, land 24' completely closes off branch groove 16' from the bore and thus disconnects bypass bore portion 17' from inlet chamber 15 so that the pump now discharges fluid through the open center "single branch" path including inlet chamber 15, groove 16, bypass bore portion 17 and outlet chamber 14. Land 24 has now slightly opened pressure groove 20 to the bore and the check valve 22 prevents a flow of fluid from the motor back through conduit 11 and port 10 to groove 20 and thus holds the motor piston motionless preventing an unintentional loss of control of the load.

Fig. 2 shows the valve spool further moved to the left through the distance A. The tapered center land 25 is starting to enter bypass bore portion 17 to initiate a metering or throttling action between that bore portion and outlet chamber 14 to meter the fluid flowing through the "single branch" path. Pressure now builds up in pressure groove 20 and overcomes any load back pressure in actuator port 10 thus opening check valve 22 and allowing fluid to flow through port 10 and conduit 11 to the motor. The end land 24' is now positioned such that passage 27' will communicate with return groove 21', thus allowing fluid to flow from the motor through conduit 12, port 10', then meteringly through return groove 21' and passages 27', 26', into return chamber 18' and on through passageway 19' to outlet chamber 14. There now thus coexists with the "single branch" path heretofore described a "motor path" through which fluid flows to move the motor piston to the right. This motor path includes inlet chamber 15, groove 16, bore 13, groove 20, port 10, conduit 11, the motor, conduit 12, port 10', groove 21', passages 27', 26', bore 13, chamber 18', passageway 19', and outlet chamber 14. Further movement of the spool 23 to the left moves tapered land 25 more snugly into bore portion 17 to throttlingly increase the resistance of the "single branch" path and moves passage 27' into fuller communication with return groove 21' to more fully open the "motor" path. Thus a greater share of the pump's discharge is through the motor path and a lesser share is through the "single branch" path and the motor piston therefore moves more rapidly to the right. The controlled metering or throttling action gives close circuit regulation and fine motor control without the need of accurately machined ports.

Fig. 3 shows the spool further moved to the left to its limit or full open position. The tapered land 25 is now centered in bore portion 17 to completely close the "single branch" path. The land 24 now has completely opened pressure groove 20 and land 24' has opened return groove 21' to its maximum thus fully opening the "motor" path. The "single branch" path is completely closed and therefore the pump now discharges fluid only through the "motor" path obtaining therethrough an unrestricted flow to move the motor piston to the right at full speed.

To operate the valve to move the motor piston and its load in the opposite direction, the valve spool 23 is moved in the opposite direction (to the right from the neutral position).

Although only one embodiment of the invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

It is claimed and desired to secure by Letters Patent:

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1. A four way open center directional spool valve, said valve defining a pair of actuator ports, a main bore, a pressure groove and a return groove each connected to each of said actuator ports and intersecting said bore, a check valve disposed between each of said actuator ports and said pressure grooves, and a spool operable in said bore, said spool having thereon a centrally disposed tapered land for throttlingly cooperating with said bore, said spool also having thereon a pair of end lands for connecting and disconnecting said grooves and said bore, each of said end lands having therethrough a pair of intersecting passages for connecting and disconnecting said return grooves and said bore.

2. A four way open center hydraulic directional spool valve comprising a body defining therein a main bore, an outlet chamber intersecting said bore, and an inlet chamber, said body also defining therein a first branch groove connecting said inlet chamber to said bore, a first bypass portion of said bore connecting said first branch groove to said outlet chamber, a second branch groove connecting said inlet chamber to said bore, a second bypass portion of said bore connecting said second branch groove to said outlet chamber, a first return chamber communicating with one end of said bore, a second return chamber communicating with the other end of said bore, a first passageway connecting said first return chamber to said outlet chamber, a second passageway connecting said second return chamber to said outlet chamber, said body further defining a first actuator port, a first pressure groove intersecting said bore and connected to said first actuator port, a first return groove intersecting said bore and connected to said first actuator port, a second actuator port, a second pressure groove intersecting said bore and connected to said second actuator port, and a second return groove intersecting said bore and connected to said second actuator port, a first check valve disposed between said first actuator port and said first pressure groove, a second check valve disposed between said second actuator port and said second pressure groove, a spool movable axially in said bore in either direction from a neutral position therein, a first end land on said spool cooperable with said first grooves, a second end land on said spool cooperable with said second grooves, and a tapered land on said spool intermediate said first and second lands, said tapered land throttlingly cooperable with said bore at said bypass portions for metering the flow of fluid from said inlet chamber to said actuator ports, said first and second lands each having therein a pair of intersecting passages cooperable with said return grooves for directing said flow of fluid from said actuator ports to said outlet chamber.

3. A valve as defined in claim 2 in which the distance between either of said pressure grooves and its associated branch groove is less than the width of the branch grooves, and that said width is less than the distance between either of said return grooves and its associated return chamber, and that the last said distance is equal to the distance from said tapered land to either of said bypass bore portions when said spool is in said neutral position.

4. A four way open center directional spool valve comprising a body defining therein a main bore, an outlet chamber intersecting said bore at the central region thereof, an inlet chamber disposed centrally of the length of said valve, a first branch groove connected to said inlet chamber and intersecting said bore on one side of said outlet chamber forming a first bypass portion of said bore between said first branch groove and said outlet chamber, a second branch groove connected to said inlet chamber and intersecting said bore on the opposite side of said outlet chamber forming a second bypass portion of said bore between said second branch groove and said outlet chamber, a first return chamber communicating with one end of said bore, a first passageway connecting said first return chamber and said outlet chamber, a first actuator port, a first return groove connected to

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said first actuator port and intersecting said bore between said first return chamber and said first branch groove, a first pressure groove connected to said first actuator port and intersecting said bore between said first return groove and said first branch groove, a second return chamber communicating with the opposite end of said bore, a second passageway connecting said second return chamber and said outlet chamber, a second actuator port, a second return groove connected to said second actuator port and intersecting said bore between said second return chamber and said second branch groove, a second pressure groove connected to said actuator port and intersecting said bore between said second return groove and said second branch groove, a first check valve disposed between said first actuator port and said first pressure groove, a second check valve disposed between said second actuator port and said second pressure groove, a spool movable axially in said bore in either direction from a neutral position therein, a first end land on said spool cooperable with said first grooves, a second end land on said spool cooperable with said second grooves, and a tapered land on said spool intermediate said first and second lands, said tapered land throttlingly cooperable with said bore at said bypass portions for metering the flow of fluid from said inlet chamber to said actuator ports, said first and second lands each having

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therein a pair of intersecting passages cooperable with said return grooves for directing said flow of fluid from said actuator ports to said outlet chamber.

5 A valve as defined in claim 4 in which the distance between either of said pressure grooves and its associated branch groove is less than the width of the branch grooves, and that said width is less than the distance between either of said return grooves and its associated return chamber, and that the last said distance is equal to the distance from said tapered land to either of said bypass bore portions when said spool is in said neutral position.

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