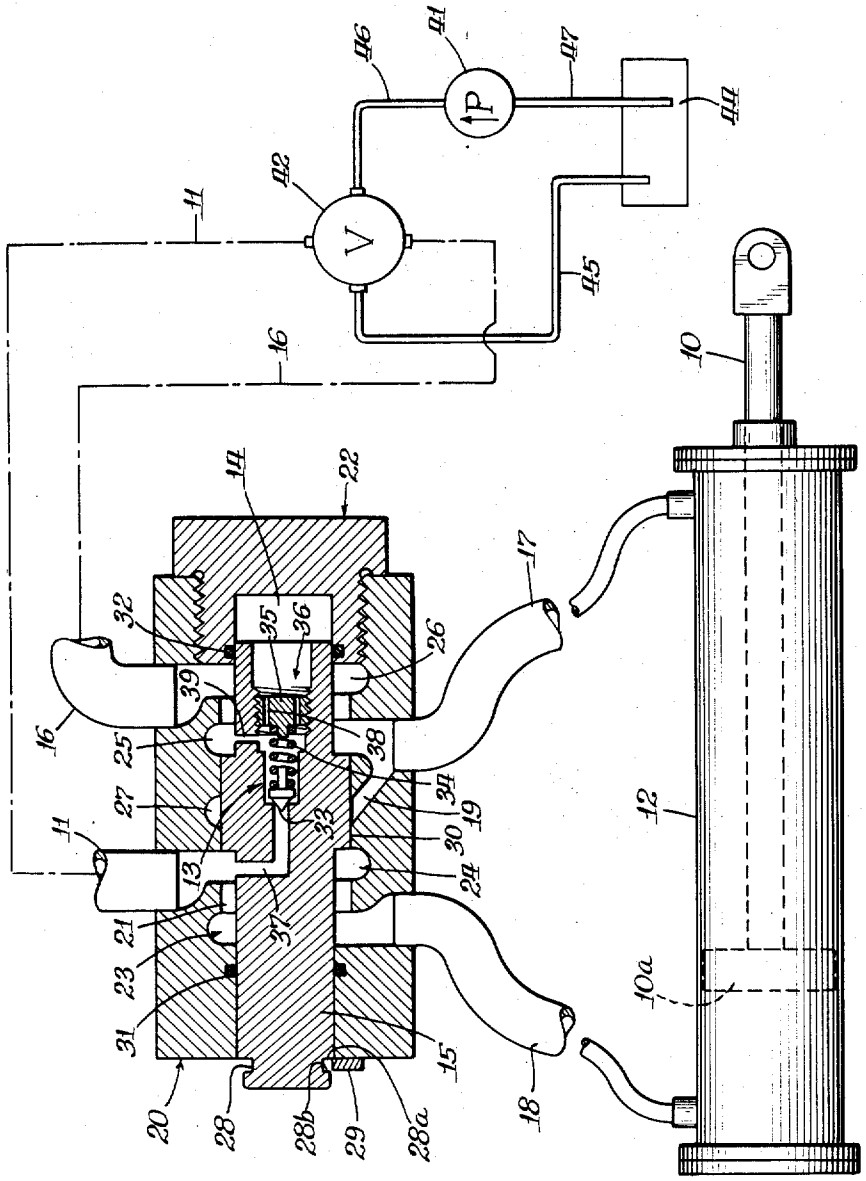
Sept. 22, 1964 D. S. STRADER Re. 25,643

HYDRAULIC CONTROL VALVE OPERATING RESPONSIVE TO HYDRAULIC LOAD PRESSURES

Original Filed Jan. 9, 1959



INVENTOR.

Don S. Strader

BY

Atty.

United States Patent Office

Re. 25,643
Reissued Sept. 22, 1964

25,643

HYDRAULIC CONTROL VALVE OPERATING RESPONSIVE TO HYDRAULIC LOAD PRESSURES

Don S. Strader, Mount Prospect, Ill., assignor to The Frank G. Hough Co., a corporation of Illinois

Original No. 2,994,345, dated Aug. 1, 1961, Ser. No. 785,936, Jan. 9, 1959. Application for reissue June 26, 1962, Ser. No. 207,451

12 Claims. (Cl. 91—415)

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This invention relates generally to hydraulic valve and motor arrangements, and more specifically to an improved hydraulic valve and double acting motor arrangement automatically providing increased speed of the motor in extending when the load upon the motor is relatively light.

Double acting hydraulic motors of the piston and cylinder type are commonly used in the tractor loader art to power the members thereof in the various digging operations of the loader. In many material handling operations it oftentimes occurs that the load upon the hydraulic motor in extending is light, and under such conditions it is often desirable that the speed of operation of the motor be increased. This has been difficult to accomplish without increasing the output of the hydraulic pump providing hydraulic fluid for operation of the motor.

It is the object of the present invention to provide a hydraulic valve and double acting motor arrangement wherein a valve will automatically operate responsive to either a relatively light or heavy load upon the motor to provide relatively slow extension of the motor under heavy loads and an increased movement or speed under light loads without any increase in the output of the hydraulic pump supplying hydraulic fluid to the motor.

It is a further object of the present invention to provide a hydraulic valve for use in a hydraulic system of a hydraulic pump and motor, which valve will automatically operate during the extension of the hydraulic motor under a light load to increase the speed of the extension of the motor without an increase in the output of the pump.

It is a further object of the present invention to provide a hydraulic valve for use with a double acting hydraulic motor which will automatically operate irrespective of the initial loading of the motor to provide for increased speed of the motor in extending when the load lightens after the initial operation under a relatively heavy load and to provide for decreased speed of extension of the motor when the loading on the motor becomes relatively heavy after an initial light load without increasing or decreasing the output of the pump.

A feature of the valve of the present invention is the use of a freely sliding spool which is not biased by any coiled springs.

Other objects and features of the present invention will be apparent upon a perusal of the following specification and drawing of which:

FIG. 1 is an enlarged cross-sectional view of a hydraulic valve constructed according to the present invention and a double acting hydraulic motor connected thereto.

The present embodiment is a preferred embodiment but it is to be understood that changes can be made in the present embodiment by one skilled in the art without departing from the spirit and scope of the present invention.

For a general description of the present invention reference is made to the drawing. The subject valve operates to increase or decrease the speed of operation of the hydraulic motor during its extension, the speed of retraction being the same under light or heavy loads.

Assuming the load on the piston rod **10** is heavy, and that hydraulic fluid under pressure is supplied to conduit **11** to extend the piston rod **10** outwardly of the cylinder **12**, the relief valve **13** will open to permit hydraulic fluid to enter closed end **14** of the valve bore. Hydraulic fluid under pressure in the end **14** of the valve bore will maintain the valve spool **15** in the position shown, and the hydraulic fluid entering conduit **11** will pass through the valve and conduit **18** and into the cylinder **12** to cause an outward movement of the piston rod **10**. Hydraulic fluid from the rod end of the cylinder **12** will flow through conduit **17**, the valve and through conduit **16** back to the reservoir.

If the piston rod **10** is under a relatively light load, the hydraulic fluid pressure of the fluid entering the valve from conduit **11** and the pump will not be sufficient to operate relief valve **13**, however, that pressure will be sufficient to move the valve spool **15** to the right as shown in the drawing, blocking conduit **16** from fluid communication with conduit **17** and interconnecting conduit **17** with conduit **18** through the passageway **19**. This hydraulic fluid from the rod end is added to the hydraulic fluid from the pump entering conduit **11** to cause the piston rod **10** to be moved outwardly from the cylinder **12** at an increased speed.

If at any time during the extension of the hydraulic motor the load varies from that initial load against which the hydraulic motor is working, the pressure relief valve **13** will either be operated or restored depending upon the change in load to cause a movement of the spool **15** to provide for either an increase or decrease in the speed of operation of the hydraulic motor.

Turning next to a detailed description of the present invention, continued reference is made to the drawing. The hydraulic valve comprises a valve body **20** having a valve bore **21** formed therethrough. The closed end **14** is defined by a cap member **22** threaded into a tapped portion of the bore **21** at that end of the valve body **20**. The valve body **20** is further provided with four ports to which the conduits **11**, **16**, **17** and **18** are respectively connected. The four ports are respectively connected directly into four annular grooves *24, 26, 25 and 23* **[23, 24, 25 and 26]** which are positioned in a certain spaced apart relationship to each other. The valve bore **21** is provided with another annular groove **27** which is positioned between annular grooves **24** and **25**. Annular groove **27** is connected by passageway **19** into the port connected to conduit **17**.

The valve spool **15** is inserted in the valve bore **21** through the end into which the cap **22** is threaded. One end of the valve spool **15** is movable outwardly of the valve body **20** and that end is provided with an annular slot **28**. A locking member **29** is movably secured to the valve body **20**, and when in the position shown in the drawing, engages one side *28a* of the slot **28** of the valve spool **15** to limit the outward movement of the valve spool **15** from the valve body **20** **[**to selectively prevent operation of the valve**]**. If the locking member **29** is moved into the slot **28**, it will engage the other side *28b* of the slot **28** to lock the valve spool **15** in the position shown in the drawing. The valve spool **15** is further provided with a single land **30** which is formed thereon somewhat longitudinally centrally of the valve spool **15**. Fluid sealing rings **31** and **32** are also provided and are positioned in suitable annular grooves in the valve body **20** and engage the valve spool **15** to prevent the leakage of hydraulic fluid along the valve spool **15**.

The relief valve **13** is carried in the valve spool **15** and comprises a valve head **33**, a coiled spring **34**, and an

adjusting screw **35**. The valve head **33** cooperates with a valve seat disposed at the inward end of a valve chamber **36**. The other end of the valve chamber **36** opens into the closed end **14** of the valve bore **21**. The valve seat is connected by passageway **37** to the outer surface of the valve spool **15** at a point longitudinally thereon which is on the side of the land **30** of the valve spool **15** opposite from the side toward the cap **22**. The adjusting screw **35** is threaded into a tapped section within the valve chamber **36** and is provided with a plurality of holes **38** therethrough for the free flow of fluid between opposite sides of the adjusting screw **35**. The coiled spring **34** is positioned between the valve head **33** and the adjusting screw **35** and serves to bias the valve head **33** against the valve seat sealing passageway **37** from valve chamber **36**. The *adjusting* [set] screw **35** may be threaded inwardly or outwardly of the valve chamber **36** to vary the seating force of the valve head **33** against its valve seat. A further small passageway **39** is provided between the valve chamber **36** and the outer surface of the valve spool **15** on the side of the land **30** toward the cap **22**. The passageway **39** serves as a vent to prevent hydraulic locking of the valve spool **15** and to control the time of movement of the valve spool **15**.

As noted previously, the outward limit of the valve spool **15** is determined by the locking member **29**, and the inward limit of movement of the valve spool **15** is determined by the closed end **14**. The annular grooves **23**, **24**, **27**, **25** and **26** and the land **30** are so relatively positioned that when the valve spool **15** is in its outwardmost position as shown in the drawing, annular groove **27** is blocked by the land **30**, annular grooves **23** and **24** are interconnected in free fluid communication, and annular grooves **25** and **26** are interconnected in free fluid communication. When the valve spool **15** is moved to its inwardmost position, annular grooves **23**, **24** and **27** are interconnected in free fluid communication, and annular grooves **25** is blocked by land **30**.

The hydraulic motor which comprises cylinder **12** and piston rod **10** is of the double-acting type with the head end of the cylinder **12** connected to conduit **18** and with the rod end of the cylinder **12** connected to conduit **17**. *A conventional double-acting hydraulic motor is constructed so that the inner end of the piston rod 10 terminates in a piston lead 10a having a diameter sufficiently large so that that the piston head 10a engages the inner wall of the cylinder 12 to form an operative double-acting hydraulic motor. It is obvious from the drawing that the diameter of the piston head 10a is substantially greater than the diameter of the piston rod 10.* [It is intended that some hydraulic pump reservoir and valve means (not shown) be provided and connected to conduits **11** and **16** to provide for the selective application of hydraulic fluid under pressure to either of conduits **11** or **16** with the venting of hydraulic fluid from the other conduit.] *A supply portion of the hydraulic circuit in FIGURE 1 of a conventional construction comprises a pump 41, a control valve 42, and a reservoir 44. The control valve 42 is connected to the pump 41 and reservoir 44 through conduits 45, 46 and 47. The control valve 42 is further connected to conduits 11 and 16 which are connected to the valve 20. The control valve 42 is selectively operable in a conventional manner to direct hydraulic fluid to valve 20 through either of conduits 11 and 16 and from valve 20 through the other of these conduits.*

Turning next to a detailed description of the operation of the present invention, continued reference is made to the drawing. Considering first the operation of the instant invention when high pressure hydraulic fluid is delivered to the valve through conduit **16** *from the control valve 42* with the conduit **11** being vented to the reservoir *44*, the high pressure hydraulic fluid will flow into annular groove **26**, valve bore **21**, annular groove **25**, conduit **17** to the rod end of the hydraulic motor. From the head

end of the hydraulic motor, hydraulic fluid will flow through conduit **18**, annular groove **23**, valve bore **21**, annular groove **24**, and conduit **11** to the reservoir. The relief valve **13** will not be operated at this time due to the relatively low pressure in passageway **37**. The hydraulic fluid pressure in annular groove **25** acting on the side of the land **30** will maintain the valve spool **15** in its outwardmost position as shown in the drawing and the hydraulic motor will be retracted.

Assuming next that high pressure hydraulic fluid is delivered to conduit **11** *from the control valve 42* and that conduit **16** is *vented* [vented] to the reservoir *44*, and that a relatively heavy load is applied to the piston rod **10**, the high pressure hydraulic fluid will flow from conduit **11** into annular groove **24** and from annular groove **24** into passageway **37** and valve bore **21**. From valve bore **21** the fluid will flow into annular groove **23**, and conduit **18** to the head end of the hydraulic motor. The high pressure hydraulic fluid in passageway **37** will exert a force against the valve head **33** sufficient to unseat the valve head **33** and the hydraulic fluid will then flow through the valve chamber **36** and passageways **38** of the adjusting screw **35** to the closed end **14** of the valve bore **21**. Since spool **15** is designed to have a larger area exposed on the end cooperating with closed end **14** than the area on the end of the land **30**, this hydraulic fluid in the closed end **14** will exert a sufficient force on the end of the valve spool **15** to maintain the valve spool **15** in the position shown in the drawing. As the hydraulic motor is extended under the relatively heavy load, hydraulic fluid will flow from the rod end through conduit **17**, annular groove **25**, valve bore **21**, annular groove **26** and conduit **16** to the reservoir *44*.

Assuming next the condition wherein high pressure hydraulic fluid is delivered through conduit **11** *from the control valve 42* and conduit **16** is connected to the reservoir *44*, and that the loading upon the piston rod **10** is relatively light, the hydraulic fluid in passageway **37** will not be of a pressure sufficient to unseat valve head **33** from its valve seat. However, the hydraulic fluid in annular groove **24** will act upon the side of the land **30**, and since the other side of the land **30** is connected to the reservoir through conduit **16**, it will move the valve spool **15** to its inwardmost position. The hydraulic fluid under pressure in annular groove **24** will then flow through valve bore **21**, annular groove **23**, conduit **18** to the head end of the hydraulic motor. As the hydraulic motor is extended under the relatively light load, the hydraulic fluid in the rod end thereof will flow through conduit **17**, passageway **19**, annular groove **27**, and valve bore **21** to annular groove **24**, thus adding the fluid flow from the rod end to that being supplied to the head end of the hydraulic motor thereby increasing the speed of movement of the hydraulic motor in extending. Since at this point the annular groove **26** is blocked from any fluid communication with annular groove **25**, no hydraulic fluid will flow to the reservoir through conduit **16**.

Assuming next the immediately above described condition of extension of the hydraulic motor under light load, and assuming further that during the extension of the hydraulic motor the load thereon is suddenly increased to a relatively heavy load, since passageway **37** is still connected to annular groove **24** through the valve bore **21**, the increased pressure in annular groove **24** caused by the application of a relatively heavy load will in acting through passageway **37**, unseat valve head **33** permitting hydraulic fluid to flow to the closed end **14**. The pressure of the hydraulic fluid in closed end **14** will cause the valve spool **15** to be moved to its outward-most position as shown in the drawing thereby blocking annular groove **27** and interconnecting conduit **17** with conduit **16**. The operation will cause a reduction in the speed of extension of the hydraulic motor. The converse will occur if the hydraulic motor is being extended under a heavy load and the load lightens considerably

during the operation of the motor. In such a situation the lower pressure in passageway **37** will permit valve head **33** to seat itself and the hydraulic fluid pressure in annular groove **24** will move the valve spool **15** to its inwardmost position. As the valve spool **15** is moved toward the inwardmost position, hydraulic fluid in the closed end **14** and the valve chamber **36** will flow through the vent passageway **39** into the valve bore **21**.

It is evident from the foregoing description and the drawing of the invention that because of the construction of valve bore 21 with the two spaced apart annular grooves 23 and 24, relative to the construction and range of movement of valve spool 15, that conduits 11 and 18 are in communication at all times regardless of the position of valve spool 15.

Having described the subject invention, what is new and desired to be protected by Letters Patent is:

[1. In a hydraulic system having means selectively operable to supply hydraulic fluid under pressure to either of two conduits and to receive hydraulic fluid from the other of said two conduits, a valve connected to said two conduits, a double-acting hydraulic ram connected to said valve, said valve comprising means operating responsive to the hydraulic fluid pressures in said two conduits for passing hydraulic fluid above a certain predetermined pressure from said conduits to said hydraulic ram and for passing hydraulic fluid received from said hydraulic ram to said conduits, and means operating responsive to a reduction in hydraulic fluid pressure at the one of said conduits supplying hydraulic fluid to extend said ram below said certain predetermined pressure for diverting the return of hydraulic fluid from the rod end of said hydraulic motor to the head end thereof.]

2. In a hydraulic system having means selectively operable to supply hydraulic fluid under pressure to either of two conduits and to receive hydraulic fluid from the other of said two conduits, a valve having four valve ports, one of said two conduits connected to the first of said ports, the other of said two conduits connected to the fourth of said ports, a double-acting piston and cylinder hydraulic motor, conduit means connecting the head end of said hydraulic motor to the second and the rod end of said hydraulic motor to the third of said four valve ports, said valve comprising a valve spool freely slidably carried in a valve bore, said valve spool having a land formed thereon and positioned so that one side of said land is in free fluid communication with said first port and the other side of said land is in free fluid communication with said fourth port, said four valve ports being connected into said valve bore at positions so that high pressure hydraulic fluid at the other of said conduits and low pressure hydraulic fluid at said one of said two conduits moves said valve spool to interconnect said one of said conduits and the head end of said hydraulic motor in free fluid communication and connects the other of said conduits and the rod end of said hydraulic motor in free fluid communication, said four valve ports further positioned so that a hydraulic fluid pressure at said one of said two conduits of a pressure higher than the pressure at the other of said two conduits but lower than a certain predetermined pressure will move said valve spool to interconnect the head and rod ends of said hydraulic motor with said one of said two conduits, and will block said fourth port, said spool including hydraulically operated valve means operating responsive to a hydraulic fluid pressure at said one of said two conduits higher than said certain predetermined pressure for moving said spool to interconnect said one of said two conduits and the head end of said hydraulic motor in free fluid communication and to interconnect said other of said two conduits and the rod end of said hydraulic motor in free fluid communication.

3. In a hydraulic system having means selectively operable to supply hydraulic fluid under pressure to either of two conduits and to receive hydraulic fluid from the other of said two conduits, a valve having four valve ports, the first and fourth of said valve ports connected to said two conduits, a hydraulic ram having a port at each end thereof for extension and retraction of the piston rod thereof, the head end of said hydraulic ram connected to the second of said ports, the rod end of said hydraulic ram connected to the third of said ports, said valve comprising spool means carried in said valve in cooperation with said four valve ports and operating responsive to a greater hydraulic fluid pressure at said fourth port than said first port to interconnect the first and second of said ports in free fluid communication and the third and fourth of said ports in free fluid communication, and operating responsive to a certain hydraulic fluid pressure at said first of said ports and greater than any pressure at said fourth of said ports to interconnect the first and second of said ports in free fluid communication and the third and fourth of said ports in free fluid communication, said spool means further operating responsive to a substantial decrease in said certain hydraulic fluid pressure at the first of said ports to interconnect said first, second and third ports in free fluid communication and to block said fourth port.

4. In a hydraulic system having means selectively operable to supply hydraulic fluid under pressure to either of two conduits and to receive hydraulic fluid from the other of said two conduits, a valve having four valve ports, the first and fourth of said valve ports respectively connected to said two conduits, a hydraulic ram having a port at each end thereof for extension and retraction of the piston rod thereof, the head end of said hydraulic ram connected to the second of said ports, the rod end of said hydraulic ram connected to the third of said ports, said valve comprising spool means carried in said valve in cooperation with said four valve ports and operating responsive to a greater hydraulic fluid pressure at said fourth port than said first port to interconnect the first and second of said ports in free fluid communication and the third and fourth of said ports in free fluid communication, and operating responsive to a certain hydraulic fluid pressure at said first port and greater than any pressure at said fourth port to interconnect said first, second and third ports in free fluid communication and to block said fourth port, a hydraulic fluid chamber formed in said valve at one end of said spool means, a second hydraulic valve formed in said spool means and connected between the end of said spool means at said chamber and the surface of said spool means, said second valve operating responsive to an increase in hydraulic fluid pressure at the first of said ports above said certain hydraulic fluid pressure to admit hydraulic fluid to said chamber to operate said spool means to interconnect said first and second ports in free fluid communication and to interconnect said third and fourth ports in free fluid communication.

5. In a hydraulic system as claimed in claim 4, wherein said second valve comprises a spring loaded check valve disposed in said spool means and includes means for adjusting the spring loading thereof, and a vent passageway formed in said spool means between said chamber and said fourth port to permit hydraulic fluid to bleed from said chamber at a rate substantially lower than the flow of any hydraulic fluid through said check valve.

6. A hydraulic valve and motor arrangement comprising a hydraulic cylinder having a hydraulic conduit at each end thereof and a reciprocating piston slidably carried therein, a valve body having four ports, the first of said ports connected to the conduit at one end of said cylinder, the fourth of said ports connected to the conduit at the other end of said cylinder, valve spool means slidably carried in said valve body for operation to two different positions and for cooperation with said four valve ports so that in one operated position of said valve spool means said first *port* and *the* second *of said* ports are in-

erconnected in free fluid communication and *the third f said ports and said fourth port* [said third and fourth orts] are interconnected in free fluid communication, and o that in the other operated position of said valve spool neans said first and second ports are interconnected in ree fluid communication and said third and fourth ports re interconnected in free fluid communication when any oad upon said motor is of a relatively high value and so hat said first, second and fourth ports are connected in ree fluid communication and said third port is blocked vhen any load upon said motor is of a value substantially ess than said relatively heavy load.

7. In a hydraulic fluid control valve, four valve ports, 'alve means carried in said valve in cooperation with said our valve ports and operating responsive to a certain ıydraulic fluid pressure at the first of said ports to inter- :onnect the first and second of said ports in free fluid :ommunication and the third and fourth of said ports in ree fluid communication, said valve means further op- rating responsive to a substantial decrease in said cer- ain hydraulic fluid pressure at the first of said ports to nterconnect said first, second and third ports in free fluid :ommunication and to block said fourth port.

8. A control valve comprising a valve bore having one nd thereof closed, a valve spool having a land formed hereon and slidably carried in said valve bore, five annu- ar grooves formed in said valve bore in a certain spaced ıpart relationship, four valve ports, the first of said valve orts connected into the first of said annular grooves, the econd of said valve [bores] *ports* connected into the sec- ınd of said annular grooves, the third of said valve *orts* [bores] connected into the third of said annular rooves, and the fourth of said valve ports connected into he fourth and fifth of said annular grooves, an adjustable elief valve carried in said valve spool and connected be- ween the outer surface of said valve spool and the end hereof adjacent said closed end of said bore, said five ınnular grooves, said land, and the opening of said relief 'alve in the outer surface of said valve spool relatively ositioned so that said first and second annular grooves are nterconnected in free fluid communication, said third ınd fourth annular grooves are connected in free fluid :ommunication, said fifth annular groove is blocked by aid land and said opening of said relief valve in the outer urface of said spool is interconnected with said second ınnular groove in free fluid communication when said 'alve spool is positioned in one operated position, and o that said first, second and fifth annular grooves and aid opening of said relief valve in said spool are connect- d in free fluid communication and said fourth annular roove is blocked by said land when said valve spool is ositioned in another operated position.

9. In a hydraulic fluid control valve, a valve bore hav- ng one end thereof closed, a valve spool slidably carried n said valve bore, the inner end of said spool being ormed to define a chamber with the closed end of said ore and engageable therewith to provide one operated osition thereof, means for limiting the outward move- nent of said spool to provide another operated position hereof, four ports connected into said bore in a certain paced-apart relationship, said spool having a land ormed and positioned thereon so that the first, second nd third of said ports are interconnected in free fluid ommunication and the fourth port is blocked when said pool is moved to said one operated position by a hy- raulic force on the side of said land cooperating with aid first port, and so that said first and second ports are onnected in free fluid communication and said third and ourth ports are connected in free fluid communication vhen said spool is moved to said another operated po- ition by a hydraulic force on the other side of said and and cooperating with said fourth port, and means or admitting hydraulic fluid under pressure to said hamber to move said spool from said one operated po- ition to said another operated position responsive to a

hydraulic pressure at said first port which is above a certain predetermined hydraulic fluid pressure.

10. In a hydraulic fluid control valve, a valve bore heaving one end thereof closed, a valve spool slidably carried in said valve bore, the inner end of said spool being formed to define a chamber with the closed end of said bore and engageable therewith to provide one operated position thereof, means for limiting the outward movement of said spool to provide another operated position thereof, four ports connected into said bore in a certain spaced-apart relationship, said spool having a land formed and positioned thereon so that the first, second and third of said ports are interconnected in free fluid communication and the fourth port is blocked when said spool is moved to said one operated position by a hydraulic force on the side of said land in free fluid communication with said first port, and so that said first and second ports are connected in free fluid communication and said third and fourth ports are connected in free fluid communication when said spool is moved to said another operated position by a hydraulic force on the other side of said land in free fluid communication with said fourth port, a valve formed in said spool and connected between said chamber and the surface of said spool on the side of the land in free fluid communication with said first port, said valve including means operating responsive to a hydraulic fluid pressure at said first port above a certain predetermined pressure to open and deliver hydraulic fluid to said chamber to move said spool from said one operated position to said another operated position.

11. In a hydraulic fluid control valve, a valve bore having one end thereof closed, a valve spool slidably carried in said valve bore, the inner end of said spool having a passageway therein opening into a chamber defined by the closed end of said bore and the end of said spool, the end of said spool being engageable with the closed end of said bore to provide one operated position of said spool, means at the other end of said spool and said valve for limiting the outward movement of said spool to provide another operated position thereof, four ports connected into said bore in a certain spaced-apart relationship longitudinally thereof, said spool having a land formed and positioned thereon between said first and fourth ports so that the first, second and third of said ports are connected in free fluid communication and the fourth port is blocked when said spool is moved to said one operated position by a hydraulic force on the side of said land which is in fluid communication with said first port, and so that said first and second ports are connected in free fluid communication and said third and fourth ports are connected in free fluid communication when said spool is moved to said another operated position by a hydraulic force on the other side of said land which is in free fluid communication with said fourth port, a check valve carried in said passageway in said spool and connected to the outer surface of said spool on the side of said land which is in free fluid communication with said first port, said check valve being formed to operate responsive to a hydraulic fluid pressure at said first port which is above a certain predetermined hydraulic fluid pressure to open to permit hydraulic fluid to flow through said passageway to said chamber to move said spool from said one operated position to said another operated position.

12. In a hydraulic fluid control valve as claimed in claim 11, wherein said check valve comprises a set screw threaded into said passageway, a valve head, and a coiled spring disposed between said set screw and said valve head to bias said check valve to the closed position, said set screw having openings therethrough to permit free hydraulic fluid flow into said chamber.

13. In a hydraulic fluid control valve, four valve ports, valve spool means carried in said valve in cooperation with said four valve ports and freely slidable therein to one position to interconnect the first and second of said

four valve ports in free fluid communication and said third and fourth ports of said four valve ports in free communication, and freely slidable to another position to interconnect said first, second and third valve ports in free fluid communication and to block said fourth port, a land formed on said valve spool means at a position so that hydraulic fluid of a certain relatively low pressure at said first port and a lower pressure hydraulic fluid at said fourth port slides said valve spool means to said another position and so that high pressure hydraulic fluid at said fourth port and low pressure hydraulic fluid at said first port causes said valve spool means to slide to said first position, valve means formed in said valve spool means and operating responsive to a hydraulic fluid pressure at said first valve port higher than said certain relatively low pressure to open and permit hydraulic fluid under pressure to act upon one end of said valve spool means to slide said valve spool means to said first position.

References Cited in the file of this patent or the original patent

UNITED STATES PATENTS

523,419	Thorpe	July 24, 1894
1,775,856	Hauser	Sept. 16, 1930
2,267,284	Livers	Dec. 23, 1941
2,367,682	Kehle	Jan. 23, 1945
2,376,519	Stacy	May 22, 1945
2,502,800	Renick	Apr. 4, 1950
2,590,454	Pilch	Mar. 25, 1952
2,615,432	Meddock	Oct. 28, 1952
2,665,554	Rockwell	Jan. 12, 1954
2,814,309	Koenig	Nov. 26, 1957
2,916,049	Ruhl et al.	Dec. 8, 1959
2,916,050	Ruhl	Dec. 8, 1959