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PRESSURE RELIEF AND VALVE SPOOL POSITIONING MECHANISM

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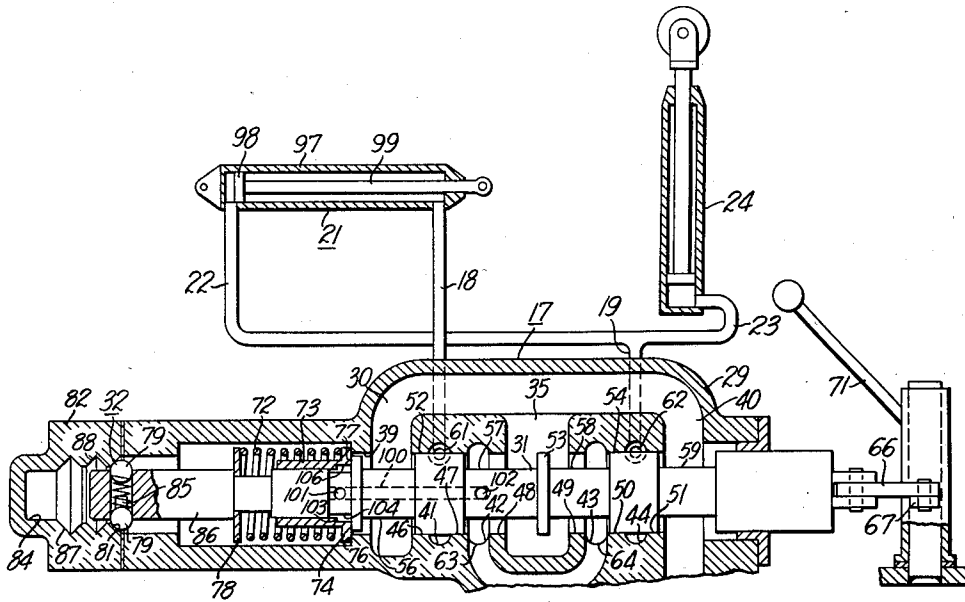


Fig. 3

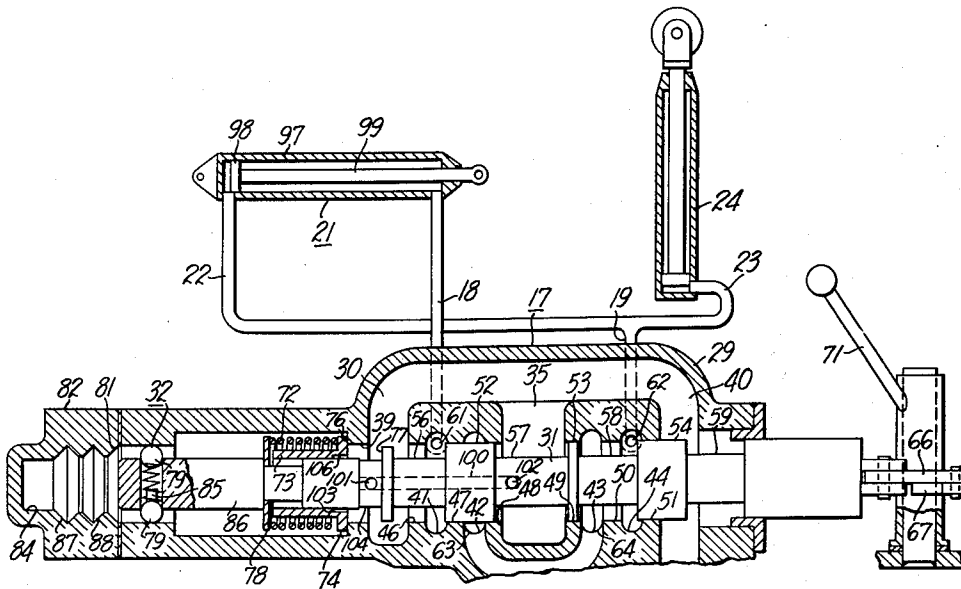


Fig. 4

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PRESSURE RELIEF AND VALVE SPOOL POSITIONING MECHANISM

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This invention relates to hydraulic control systems comprising a means for directing fluid under pressure to hydraulic rams regulating the movement of various operating elements of a machine, and more particularly to a hydraulic control valve wherein are combined centering and relief functions.

The embodiment illustrated in this application is concerned with the hydraulic control system directing the flow of pressure fluid to a single and a double acting hydraulic jack controlling the movement of the apron and ejector of an earth mover. Although the present invention is described in conjunction with the well known hydraulically actuated jacks used to control the apron and ejector of an earth mover it will be apparent in the course of this disclosure that this invention will have other appropriate applications.

In a motor scraper having mechanically interconnected ejector and apron members it is necessary during the ejection cycle, when the load is expelled, to have a small amount of initial motion complete the actuation of the apron member, raising the skirt of the apron substantially before any material motion of the ejector member occurs. When this cycle is then reversed and the apron and ejector members are returned to the loading position the ejector first returns through a substantial portion of its cycle toward the end of which the apron member quickly returns to the loading position.

Due to the nature of the linkage between the apron and the ejector small movements of the ejector during this latter part of the cycle cause relatively large movements of the apron. The apron lift piston is forced to follow the apron thereby compressing the lift jack which forces a relatively large amount of hydraulic fluid out of the apron lift cylinder and into the return to reservoir lines. If the ejector travels at a high rate of speed during this final phase of return travel, the rate of hydraulic fluid flow from the apron lift cylinder may exceed the capacity of these return lines, and an extreme back pressure will be created. The double acting jack for controlling the ejector must also discharge exhaust fluid into these return lines during the return cycle. This results in an excessive pressure being built up on the power fluid side of the ejector piston in order to overcome the return line back pressure. This condition may occur during each motor scraper load cycle and excessive wear and strain to the hydraulic pump, control valve, relief valve and fittings may result if only a normal relief system is provided.

Because of the frequency of occurrence of this high pressure condition, it is desirable to use an auxiliary relief valve, operable during this phase of operation only and having an opening pressure somewhat lower than normal relief pressures. The ejector, ejector cylinder and cylinder support structure are designed to support heavy compressive loads during the ejection cycle. Tensile loads of the same magnitude caused by high pressure, high speed ejector return may damage the structures.

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It is an object of this invention to provide a multi-pressure hydraulic system for an earth mover.

It is a further object to combine the centering and relief functions of a hydraulic valve.

It is a further object to provide a secondary relief valve within a hydraulic fluid directing valve without increasing the number of structural parts composing the valve.

It is a further object to provide a lower operating pressure for the ejector return cycle in a motor scraper.

Fig. 1 is a schematic view of the control system and apron and ejector of a motor scraper, the control valve being shown in an enlarged longitudinal section view illustrating the valve in the "ejector return" setting;

Fig. 2 is a section view of the control valve as indicated by the section line II—II on Fig. 1;

Fig. 3 is a partial longitudinal section view of the control valve illustrating the "hold" setting; and

Fig. 4 is a partial longitudinal section view of the control valve illustrating the "eject" setting.

Referring to Fig. 1, there is shown the hydraulic control system for the apron 11 and ejector 12 of a motor scraper which are mechanically interconnected. The hydraulic system includes a reservoir 13, a gear type pump 14, a relief valve 16 and a hydraulic control valve 17 for directing pressure fluid to and from two cylinder conduits 18 and 19. The cylinder conduit 18 communicates directly with one end of the double acting hydraulic ram 21 which controls the ejector 12. The cylinder conduit 19 has two branches 22 and 23. The branch 22 communicates with the other end of the double acting hydraulic jack 21 while branch 23 communicates with a single acting hydraulic jack 24 controlling the apron 11.

Pressure fluid is supplied to the control valve 17 by the pump 14 through an input conduit 26. The pump is driven by the vehicle's engine, and its output, therefore, varies with the engine's speed. An exhaust conduit 27 connects the control valve 17 with the reservoir 13 and a pump supplying conduit 28 connects the reservoir 13 to the pump 14.

The control valve 17 includes a housing or valve body 29, a valve spool 31, a detent mechanism 32, an inlet chamber 33 and a return chamber 34. Valve 17 is of an open center type. When the valve spool 31 is set at appropriate positions, the centrally disposed inlet branches 36 and 37 are adapted to freely communicate with three laterally spaced channels or exhaust passages 30, 35 and 40 which in turn communicate with the return chamber 34. The bore 39, in which the valve spool 31 is fitted, is interrupted by the annular recesses 41, 42, 43 and 44 so as to form a series of lands 46, 47, 48, 49, 50 and 51. The valve spool 31 is provided with a series of spaced spool lands 52, 53 and 54 formed by the annular grooves or recessed portions 56, 57, 58 and 59, which upon sliding movement of the valve spool, are adapted to cooperate with the spaced recesses 41, 42, 43 and 44 to direct the flow of fluid from the pump discharge through the control valve 17 in a particular manner. The recess 41 is provided with a port 61 which is connected with the cylinder conduit 18. The recess 44 has a port 62 connecting with the cylinder conduit 19. The other two recesses 42 and 43 have ports 63 and 64 freely communicating with the inlet branches 36 and 37 of the inlet chamber 33.

The integral relief valve and centering mechanism of this invention is formed by a passage 100 which is drilled through the spool 31 with associated cross drilled connecting passages 101 and 102, a pressure surface 103 is machined in the spacer 73, a recess 104 in the valve spool 31 and the spring 72 which acts to hold the flange 74 on one end of spacer 73 against the shoulder 77 which

is presented by land portion 80 of spool 31. This valve is operative when the spool has been displaced to the "ejector return" position as shown in Fig. 1. With the valve in this position, pressure fluid is being delivered from inlet passage 36 through inlet port 63, recess 57, and motor port 61 to the conduit 18 which communicates with the rod end of the double acting hydraulic jack 21. Pressure fluid supplied to the rod end of the cylinder 97 acts to return the ejector 12 from the "eject" position to the loading position. The pressure fluid which is supplied to the cylinder or motor port 61 also is in communication with the spool recess or groove 104 between lands 80 and 105. This communication is established through the cross drilled passage 102 through recess 57 of the spool 31, the internal passage 100 and the cross drilled passage 101 which connects with the spool recess 104. The recess 106 in the spacer 73 provides a pressure chamber, one wall portion of which is defined by a radially extending pressure surface 103 against which the pressure fluid from passage 100 acts to displace spacer 73 to the left in order to separate flange 74 from engagement with the mating shoulder 77 on the valve spool 31. Flange 74 and shoulder 77 are normally held together in fluid sealing relationship by action of the compression spring 72 which reacts between spool 31 and spacer 73 but if excessive pressure develops in the ejector return hydraulic system they will be forced apart and some of the pressure fluid will be allowed to escape from between spacer 73 and land 80, and thence through bore 39 into the exhaust passage 30.

The axial movement of the valve spool 31 is accomplished by manually actuating the control handle 71 which is connected to the spool by the lever arm 67 and the link 66.

The detent mechanism 32 includes a housing 82 which is attached to the valve housing 29. The housing has a central bore 84, for reception of an end portion 86 of the valve spool 31 and is formed with two annular indentations or grooves 87 and 88, to provide two detent positions for the valve spool 31. To prevent the valve spool 31 from being moved to the left beyond the detent position fixed by the annular groove 87, a stop 85 is provided between the two detent balls. The stop 85 limits the minimum radial displacement from the detent balls so as to prevent any movement of the detent balls to the left of the groove 87. The diameter of the bore to the right of the detent housing 82 is enlarged sufficiently to permit the passage of the detent balls 79. The stop 85 does not restrict movement of the spool 31 to the right.

The relief valve 16 is disposed in the valve body 29 to unload the inlet chamber 33 into the return chamber 34 when the discharge pressure reaches a predetermined limit. The relief valve is composed of a tapered valve plunger 91 which is biased against the valve seat 90 by the compression spring 92.

The double acting hydraulic jack 21 serves to retract and extend the ejector 12 and to assist in raising the apron 11. The single acting hydraulic jack 24 is provided to lift the apron 11 during one portion of its travel. The double acting hydraulic ram 21 has a cylinder 97 within which is reciprocably disposed a piston 98 connected to the piston rod 99. The piston 98 is exposed to hydraulic fluid pressure admitted by the cylinder conduit 18 on one side and by the branch 22 of the cylinder conduit 19 on the other side.

Referring to Fig. 2, a cross section is provided which more clearly illustrates the relationship between the valve housing 29, the spacer flange 74, the pressure surface 103 formed on spacer 73 by the annular recess 106, the valve spool 31, the internal passage 100 within the valve spool 31, and the cross drilled passage 101 communicating between the internal passage 100 and the pressure chamber formed by annular recess 106.

The valve spool 31 is normally urged to the "hold"

setting as illustrated in Fig. 3 by the coil spring 72 embracing a spacer 73 slidably mounted at one end of the valve spool. The inner radial portion of flange 74 abuts against a shoulder 77 of the valve spool and an outer radial portion of flange 74 is in engagement with an annular shoulder 76, the latter being formed on the valve housing within bore 39. The compression spring 72 in this position effectively reacts between shoulder 76 at one end and spring lock 78 at the opposite end, spring lock 78 being held against axial movement by end portion 86 of valve spool 31. When the valve 17 is assembled the spring 72 is under sufficient compression to urge spool 31 in the leftward axial direction thereby urging the pair of detent balls 79 against an annular ridge 81 and the valve spool is thus releasably maintained in the "hold" position.

Movement of the valve spool 31 to the right from the "hold" position as shown in Fig. 3 is resisted by the coil spring 72. During this movement to the right the valve spool 31 slides in the spacer 73 and the shoulder 77 separates from its contact with the shoulder or flanged portion 74 of the spacer. Movement of the valve spool 31 to the left of the "hold" setting is not opposed by the spring 72. During this movement of the valve spool the flanged portion 74 of the spacer loses its contact with the shoulder 76 in the valve housing 29 and the spring is carried by the valve spool. Thus, when the valve is moved to the left of the "hold" position, the only resistance to movement is that presented by the detent mechanism 32.

When the valve spool 31 is adjusted to the position wherein the detent balls 79 are in the detent groove 88 the valve is disposed in the "float" position. In this position both the inlet chamber 33 and the hydraulic conduits 18 and 19 are in communication with the return chamber 34.

In operation when the valve spool 31 is adjusted to the "return" position, which is shown in Fig. 1, motor port 61 is open to communication with inlet port 63 and motor port 62 is opened to exhaust passage 40. The secondary relief valve mechanism including spacer 73, recess 106, pressure surface 103, land 80 and spring 72, and which is the subject of this invention, is in communication with the pressure fluid in inlet port 63 which is at that time being supplied to motor port 61 and thence to the rod end of the hydraulic cylinder 97. It will be noted that only in the "return" position is this secondary relief valve mechanism effective to provide a reduced maximum operating pressure in the portion of the high pressure side of the hydraulic system between the control valve and the hydraulic jacks.

The centering action of this secondary valve structure is utilized when the valve spool 31 is adjusted to the "hold" position illustrated by Fig. 3. With the spool so disposed the compression spring 72 urges the spacer shoulder 74 against the valve housing land 76 causing the detent balls 79 to be held against the ridge 81. It should be noted that the valve spool 31 must be manually held in the "eject" position as shown in Fig. 4 against the action of the compression spring 72. When the operator removes his hand from the operating lever 71, the valve spool 31 automatically biased to the "hold" setting illustrated in Fig. 3 and is releasably maintained in this setting by the spring force exerted by spring 72.

Thus, the spring 72 serves both the function as a biasing means for spacer 73 of the secondary relief valve mechanism and as a biasing means for the valve spool wherein the latter is maintained in the "hold" position and is automatically returned from the "eject" position to the "hold" position when the operator of the vehicle ceases to manually actuate the control handle 71.

It should be understood that it is not intended to limit the invention to the particular forms and details described hereinabove and that the invention includes such other forms and modifications as are embraced by the scope of the appended claims.

What is claimed is:

1. In a pressure control valve of the type including an exhaust passage and an axially slidable valve spool having a series of lands and grooves and being adapted to connect an inlet port with a fluid motor port, a pressure relief mechanism comprising: a spacer member having an interior surface circumscribing and axially slidable on said valve spool; a shoulder on said valve spool in axially confronting relationship to one end of said spacer; biasing means for urging said one end of the spacer into fluid sealing contact with said shoulder; a pressure chamber formed between said one end of the spacer and said shoulder, one wall portion of said chamber being defined by a pressure surface on said spacer; and passage means for interconnecting said pressure chamber with one of the grooves in said spool whereby a predetermined pressure in said inlet port may be directed against said pressure surface overcoming said biasing means and displacing said spacer member in an axial direction away from said shoulder thereby opening said pressure chamber for communication with said exhaust passage.

2. The combination set forth in claim 1 wherein the passage means for interconnecting said pressure chamber with one of said grooves in the valve spool is formed within said valve spool.

3. In a pressure control valve of the type including a main valve body; an exhaust passage in said valve body, a ported bore in said body intersecting the exhaust passage, and a valve spool axially slidably carried in said bore and having a series of lands and grooves adapted to connect an inlet port with a fluid motor port, a pressure relief mechanism comprising: a spacer member having an interior cylindrical wall circumscribing and axially slidable on said valve spool; a shoulder on said valve spool in axially confronting relationship to one end of said spacer; biasing means for urging said one end of the spacer in one axial direction into fluid sealing contact with said shoulder; a pressure chamber formed between said one end of the spacer and said shoulder, one wall portion of said pressure chamber being defined by a pressure surface on said spacer; passage means for interconnecting said pressure chamber with one of the grooves in said spool whereby a predetermined pressure in said inlet port may be directed against said pressure surface overcoming said biasing means and displacing said spacer member in an axial direction away from said shoulder thereby opening said pressure chamber for communication with said exhaust passage; and a stop means formed within the valve bore in confronting relation to and engageable with said spacer member for limiting travel of the latter in said one axial direction.

4. The combination set forth in claim 3 wherein said pressure chamber is formed by means of an annular recess in the interior cylindrical wall of said spacer member.

5. In a pressure control valve of the type including a main valve body; an exhaust passage in said body; a ported valve spool bore formed in said body intersecting said exhaust passage; and a valve spool axially slidably received in said bore for controlling interport flow therein, said valve spool being adapted to connect an inlet port and a fluid motor port in one position; and a pressure relief mechanism comprising a spacer member having an interior cylindrical wall circumscribing and axially slidable on said valve spool, biasing means including a compression spring reacting between said valve spool and said spacer member for urging one end of the latter in one axial direction into fluid sealing engagement with said one of the lands of said valve spool, a pressure chamber formed between said one land and said spacer member with one wall of the chamber being defined by a pressure surface on said spacer, a passage means formed within said valve spool for connecting said inlet port and said

pressure chamber in fluid communication when the spool valve is adjusted to said one position and wherein a predetermined pressure in said inlet port is directed against the pressure surface of said spacer member displacing the latter in an axial direction opposite said one axial direction moving the spacer away from said one land thereby opening said pressure chamber to communication with the exhaust passage.

6. The combination set forth in claim 5 wherein an annular shoulder is formed in said valve bore in axially confronting relation to said one end of the spacer, the latter being engageable with said shoulder upon shifting said valve spool in said one axial direction, after said engagement further shifting of said valve spool in said one axial direction compresses said compression spring.

7. In a pressure control valve of the type including a main valve body having an exhaust and an inlet passage formed therein; a ported valve spool bore formed in said body having an inlet port connected to a fluid pressure inlet passage, a first motor port connected to one end of a double acting jack, and a second motor port connected to the other end of said jack and to a single acting hydraulic jack; and a valve spool axially slidably received in said bore for controlling interport flow therein, said valve spool having a first position wherein said inlet port is connected with said first motor port while said second motor is connected with said exhaust passage, a second position wherein said second motor port is connected with said inlet port while said first motor port is connected with said exhaust passage, and an intermediate position wherein said first and second motor ports are closed; a pressure relief mechanism comprising a spacer member having an interior cylindrical wall circumscribing and axially slidable on said valve spool, biasing means including a compression spring reacting between said valve spool and said spacer member for urging one end of the latter in one axial direction into fluid sealing engagement with said one of the lands of said valve spool, a pressure chamber formed between said one land and said spacer member with one wall of the chamber being defined by a pressure surface on said one end of the spacer, a passage means formed within said valve spool for connecting said inlet port and said pressure chamber in fluid communication when the spool valve is adjusted to said first position whereby a predetermined pressure in said inlet port being directed against the pressure surface of said spacer member displaces the latter in an axial direction opposite said one axial direction moving the spacer away from said one land to open said pressure chamber for communication with the exhaust passage, and a shoulder formed within said valve bore in axially confronting relation to said one end of the spacer, the latter being engageable with said shoulder upon shifting said valve spool in said one axial direction out of said intermediate position into said second position whereby said spring will be compressed between said shoulder and said valve spool biasing the latter from said second to said intermediate position.

8. The combination set forth in claim 7 wherein a primary relief valve mechanism is operatively interposed between said inlet and exhaust passages and is responsive to a first predetermined pressure within said inlet passage for opening the latter to communication with said exhaust passage, and wherein the predetermined pressure within the inlet port sufficient to displace said spacer away from said one land is lower than said first predetermined pressure.

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