

Aug. 7, 1956

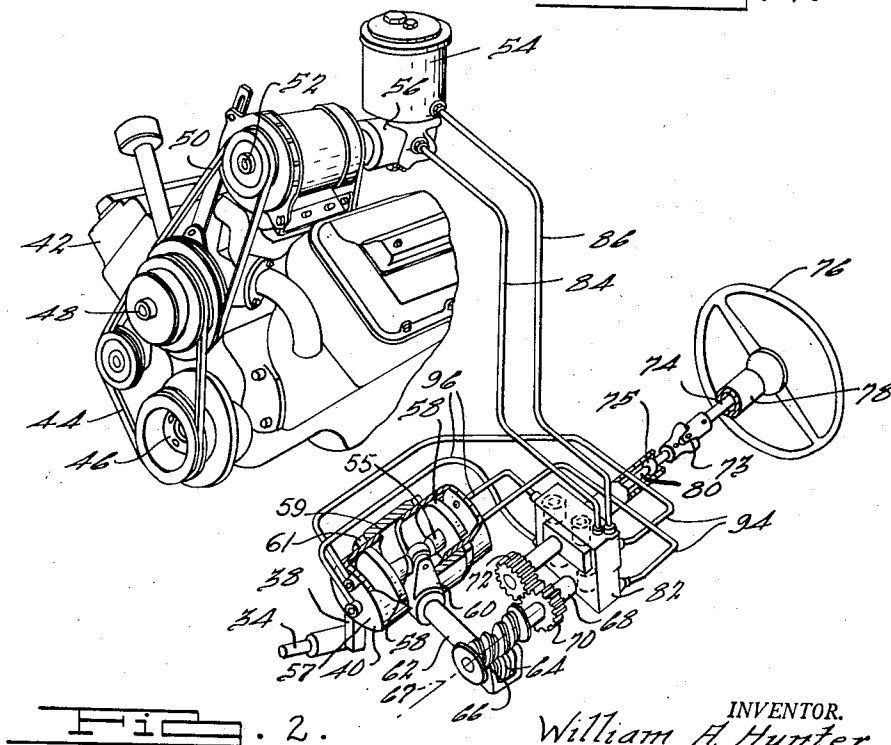
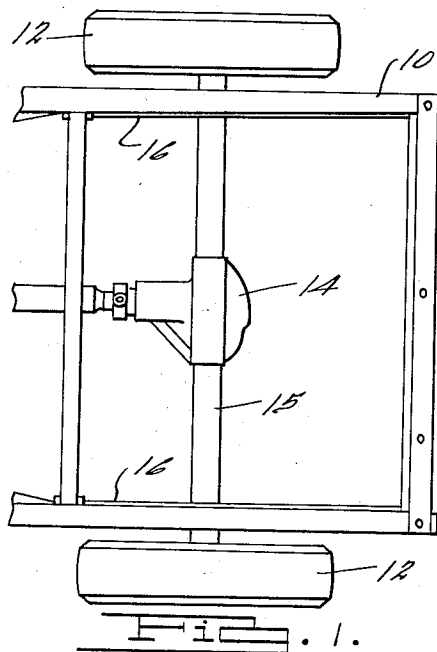
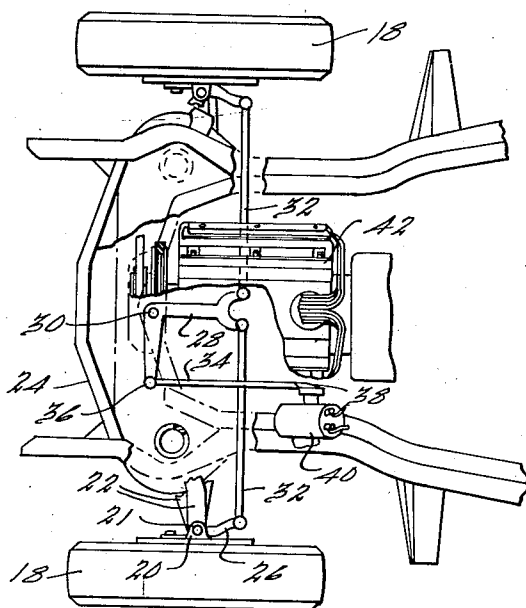
W. A. HUNTER

2,757,643

VALVE MEANS WITH BUILT IN DASHPOT

Filed Aug. 9, 1951

2 Sheets-Sheet 1



INVENTOR.  
William A. Hunter.  
BY  
Harness and Harris  
ATTORNEYS.

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W. A. HUNTER

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VALVE MEANS WITH BUILT IN DASHPOT

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2 Sheets-Sheet 2

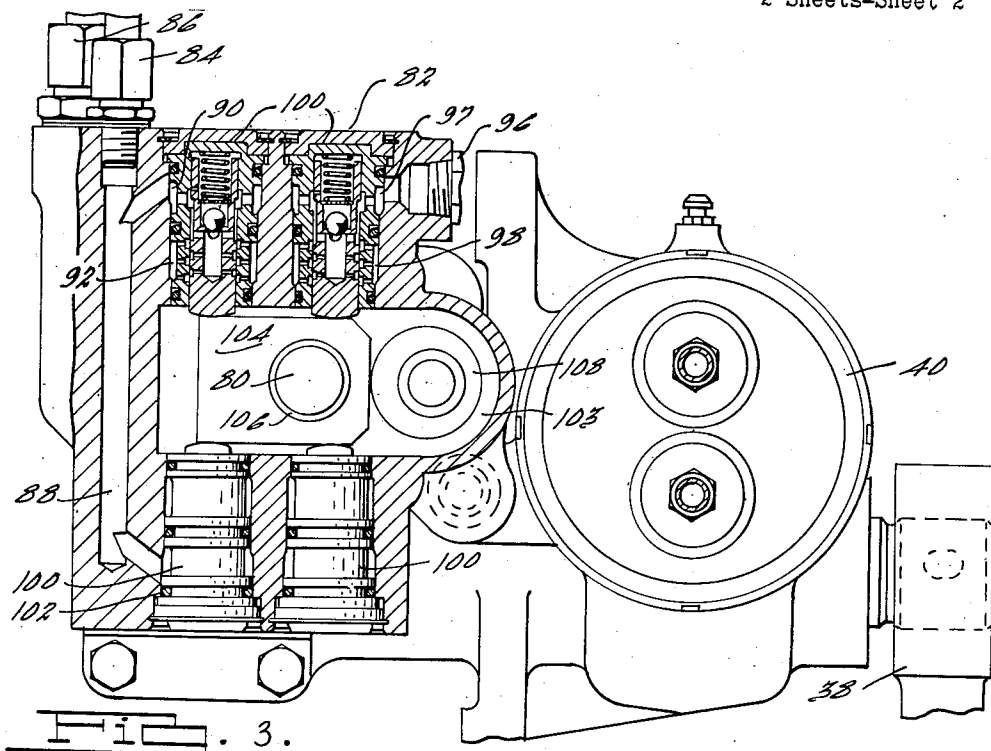


FIG. 3.

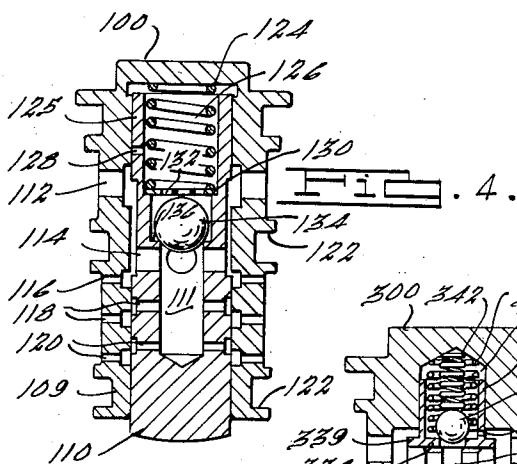


FIG. 4.

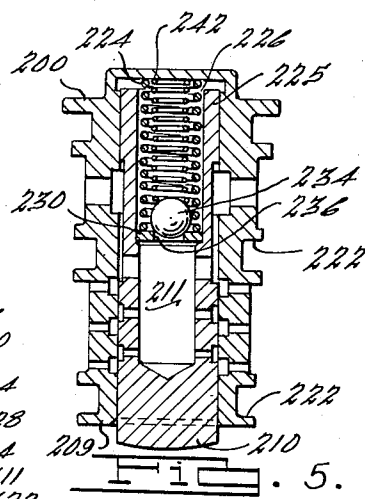


FIG. 5.

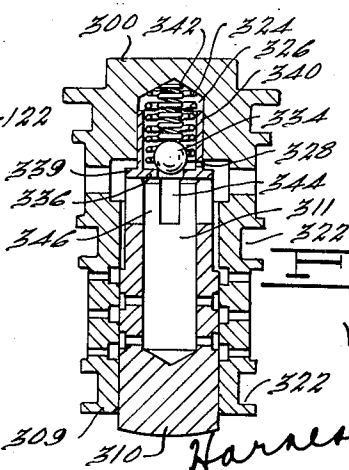


FIG. 6.

INVENTOR.  
William A. Hunter.  
BY  
Harness and Harris  
ATTORNEYS.

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2,757,643

## VALVE MEANS WITH BUILT IN DASHPOT

William A. Hunter, Highland Park, Mich., assignor to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Application August 9, 1951, Serial No. 241,025

7 Claims. (Cl. 121—46.5)

This application relates to a valve system which is characteristically quiet in operation in the presence of the usual outside disturbances, and particularly to such a valve system for use in an hydraulic steering mechanism for vehicles.

Hydraulic steering mechanisms for vehicles conventionally include such elements as a power cylinder or fluid motor by means of which the vehicle running gear linkage is operated to steer the vehicle, a source for pressure fluid which is delivered to the power cylinder or motor, a valve unit serving the power cylinder or motor and controlling flow of the pressure fluid so delivered, and a control valve operating member commonly connected to the vehicle steering wheel and directly or indirectly mechanically connected to the running gear steering linkage. One common expedient is to have the latter control valve operating member interposed as a reaction member in the mechanical train between steering wheel and running gear steering linkage.

It has been noticeable in certain hydraulic systems, especially systems such as the above hydraulic power steering type, that the road reaction due to vehicle motion has a tendency to be fed into the vehicle running gear and that by following along a direct or indirect mechanical path to the valve operating member the impacts of road reaction tend to be reflected in valve clatter in the power cylinder control valve unit. Disturbances which have a tendency to produce valve clatter are not only objectionable because of their effects primary in nature, but also are further objectionable because of their secondary feed back effects of the character in which the disturbed control valves cause the power cylinder to be set spasmodically in motion and to produce accumulative dynamic disturbances which may feed back into the already disturbed mechanical path just noted.

An object of the present invention is to provide a valve-member-operated valve unit having a damping device incorporated therewith to oppose the sudden motions of the valve operating member which give rise to valve clatter.

A further object is to provide the combination of a pair of opposed valves having an intervening reciprocal valve operating member, in which combination both valves readily move when the operating member is set in slow motion in either direction of reciprocation but in which more rapid motion of the valve operating member in one direction of reciprocation is forcefully opposed by one valve and in the opposite direction of reciprocation is forcefully opposed by the other valve.

Another object of the invention is the provision of a reciprocating-member-operated type of valve formed of fixed and movable sleeve-like parts one within the other, the valve being operated at one end due to thrust of the reciprocating member on the movable sleeve-like part and having a dashpot at the other end self-contained between the sleeves to react against and oppose thrust from the reciprocating member.

Other features, objects, and advantages will either be specifically pointed out or become apparent when for a

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better understanding of the invention reference is made to the following detailed description taken in conjunction with the accompanying drawings in which:

Figure 1 is a plan view of a road vehicle to which the present invention is applied;

Figure 2 is a perspective view showing the prime power and steering machinery of the vehicle of Figure 1;

Figure 3 is a plan view partly in section showing the steering valves and steering motor incorporated in the steering machinery of Figure 2;

Figure 4 is an enlarged sectional view of one of the individual valves of Figure 3; and

Figures 5 and 6 are sections through modified forms of the valve of Figure 4.

In Figure 1 of the drawings, a steerable vehicle is shown having a body frame or chassis 10 characterized by suitable running gear providing spring suspension for the vehicle, front and rear. A pair of rear wheels 12 having an interposed drive differential 14 is carried on either side of the chassis 10 by the outer ends of an axle housing 15 which is attached to intermediate portions of longitudinal rear load springs 16. The ends of springs 16 are connected to the chassis 10 for springing the rear of the vehicle.

A pair of front wheels 18 is disposed on either side of the front end of the vehicle chassis 10 at the outer ends of the respective similar steering knuckles shown, only one of which at 20 will be described in the environment of its front suspension unit for the reason of brevity.

Knuckle 20 is pivoted about a vertically extending knuckle support 21 which is mounted at the laterally outer ends of a pair of vertically spaced control arms 22. The control arms 22 are pivotally connected at their inner ends to locations on a cross member 24 of the chassis 10. The steering knuckle 20 has a steering arm 26 affixed thereto and extending rearwardly. A steering intermediate arm 28 is pivoted at 30 to the cross member 24 and has a forked end to which is attached a pair of tie rods 32 which extend in opposite directions and one of which is connected to the rear end of the knuckle arm 26. The other tie rod 32 is similarly connected to another knuckle arm symmetrically arranged to the vehicle chassis with respect to knuckle arm 26. The intermediate arm 28 has another end which is pivoted at 36 to a longitudinally extending drag link 34. The drag link 34 is pivoted at its rear end to a downwardly hanging pitman 38 carried on a steering shaft laterally projecting from a power cylinder unit 40. A vehicle engine 42 is supported at its forward end by motor mountings to the chassis cross member 24.

In Figure 2, the engine 42 may be seen to have a crankshaft 46 which by a V-belt provided at 44 drives a water circulating pump 48 for the engine. The water pump 48 in turn drives a V-belt 50 for a generator 52. A reservoir 54 and oil pump assembly 56 is mounted at the rear of the generator 52. A replaceable cartridge type full flow filter element, not shown, is located in the reservoir 54. Oil being returned to reservoir 54 from the hydraulic system later to be described, passes through the full flow oil filter and into the reservoir chamber. A small spring loaded vent valve provided in the reservoir cover is forced open to provide a passage to the atmosphere when excessive pressure occurs within the reservoir 54. With cold oil, insufficient oil passes through the filter to the reservoir 54 and oil pressure builds up in the return line from the system to the reservoir. Therefore, a spring loaded relief valve, not shown, may properly be provided in the top of the filter. The valve is calibrated to open when the oil pressure in the filter builds up and in the illustrated embodiment was set to unseat at about 5 to 7 pounds pressure to permit oil to

pass by the filter and directly into the chamber of reservoir 54.

Oil pump 56 is a rotor type pump driven from the rear end of the generator shaft 52 by means of a flexible coupling, not shown. Rotor means provided in the pump 56 draws oil from reservoir 54 and discharges it through certain flow control means to supply the above noted hydraulic system. Oil pressure in the hydraulic system is determined by the resistance to turning of the front road wheels 18. A rapid build-up of oil pressure tends to occur when the road wheels 18 are turned against a curb or when the steering wheel is turned all the way in one direction such that the power steering mechanism reaches the end of the stroke. To prevent excessive oil pressure, a pressure relief in pump 56 is provided to limit the oil pressure to between 600 to 650 pounds per square inch. During a normal parking operation of the vehicle shown, the oil pressure averaged about 500 pounds per square inch.

The pump 56 supplies pressure fluid for the power cylinder unit 40 having an axially aligned pair of opposed pistons 58 reciprocable therein and each carrying an inner protruding stud 55 at their relatively adjacent ends. Other main elements of the compact power steering unit disclosed in Figure 2 in conjunction with the engine 42 comprise a steering gear shaft 62, a worm and roller drive 64, 66, a lower section or piece 80 of a two-piece steering column incorporating a universal joint 73 at an in-between location and an upper piece 74, a valve body assembly 82, and a pair of jointly meshing spur gears 70, 72. The power cylinder unit 40 is formed of a pair of drawn steel cylinders 57 which are screwed into a steering gear housing 59 and locked into place each with an appropriate spanner nut 61. The inner protruding studs 55 carried by pistons 58 are in actuality hardened steel pins which bear against a hardened steel roller shown carried on a power arm 60. To insure accurate movement of the power arm 60 the hardened steel roller may be mounted on needle bearings. The power arm 60 is mounted to steering gear shaft 62 and may be held in position by a set screw and lock nut. A series of broached splines, not shown, on the side opposite the set screw positively locks the power arm 60 to the steering gear shaft 62. The worm 66 is mounted for rotation by means of a worm shaft 68 having a longitudinal axis 67. The worm 66 meshes with roller 64 which is carried by the steering gear shaft 62 and by means of which a rocking movement may be imparted to the shaft 62.

The spur gear 72 meshing with the worm shaft spur 70 is carried by the lower piece 80 of the noted two-piece steering column. Lower piece 80, which through universal joint 73 actually forms an extension of the steering column, is rotatably supported in a case-mounted spherical bearing 75, which permits the steering column spur gear 72 to orbit slightly about the work shaft spur 70 and thus climb up or down with respect to work shaft axis 67. The lower piece 80 of the steering column extends through the valve body assembly 82. Valve body assembly 82 is served with pressure fluid by a flexible supply line 84 from the pump 56 and by a flexible return line 86 leading to the reservoir 54. The upper piece or steering shaft 74 of the two-piece steering column is rotatably mounted within a column jacket 78 and is rotatable by a conventional steering wheel 76. The power cylinders 40 have respective inlet lines 94 coming from the valve body assembly 82 and outlet lines 96 leading back to the valve body assembly.

In Figure 3 the system supply line 84 from pump 56 is connected to the valve body assembly 82 and supplies an oil gallery 88 communicating with upper and lower annular chambers, one of which is shown at 90. The valve body assembly includes four valves, two jointly opposed valves on the left acting as distribution valves, and two jointly opposed valves on the right acting as

reaction valves, all of which may be made alike. For convenience of manufacture, the respective distribution and reaction valves 100 are disposed somewhat differently in the hydraulic system with respect to one another and have different purposes in their operation. Of the opposed distribution valves to the left, the upper one controls the annular chamber 90 and provides an appropriate restrictive connection therewith to a chamber 92 in communication with one or the other of the power cylinders 40, and the lower opposed distributing valve is connected similarly to the remaining power cylinder 40. These connections to the respective ends of the power cylinders 40 are provided by the power cylinder inlet lines 94 shown in Figure 2. The power cylinder outlet lines 96 in turn connect the same respective ends of the power cylinders to annular chambers, one of which is shown at 97, for the opposed reaction valves to the right in Figure 2. The fluid passing through the upper reaction valve, for instance, is controlled by the valve and thence delivered to an annular chamber 98 whereupon it is discharged into a valve block assembly internal chamber 103 which is connected with the system return line 86 draining back to reservoir 54.

Each valve 100 of the four-valve body assembly is suitably sealed by O-ring seals as at 102. The difference between the pairs of opposed valves described is one of function, the so-called distribution valves on the left serving to direct oil to the proper cylinder whereas the reaction valves to the right do two things: control the oil flow from and back pressure in the power cylinders and also regulate the ratio between manual and hydraulic steering torque in an inherent manner which may become apparent with close study of the hydraulics of the system. In the valve body assembly chamber 103, there is located a valve operating block 104 through which the steering shaft 80 extends journaled therein by needle bearings 106. An eccentric cam 108 provides for adjustment of the valve operating block 104 according to a predetermined path.

In Figure 4 one of the identical four valves 100, shown in Figure 3, is illustrated in enlarged cross section. Valve 100 has an outer part comprising a sleeve 109 open at one end and closed at the other. The inner part of the valve includes a valve proper 110, a seat 130 for a spring, a spring 124, and a ball 134 all of which are assembled in a combination movable as a unit with respect to the outer part 109. From either the chamber 90 of Figure 3 or the chamber 97 of Figure 3, depending on whether the valve is connected to act as a distribution or a reaction valve, oil enters an internal passage 111 in valve 100 of Figure 4 through one or more holes 112, preferably four in number, around the circumference of the sleeve and four holes 114 in the sleeve 110 constituting the valve proper. When the valve is open, the oil flows in a direct fashion from the valve sleeve inlet holes 112 through a set of eight discharge holes 116 in the sleeve 109 and also in a more circuitous path from the inside 111 of the valve through two sets 118, 120 of eight holes each in the valve proper and in the valve sleeve 109. Sleeve 109 is provided with suitable annular grooves 122 in which the O-rings of Figure 3 are received.

A spring 124 occupies a dashpot chamber 126 formed by the dashpot portion 125 of valve proper 110 and the closed end of sleeve 109. Dashpot portion 125 has an opening 128 formed therein to provide controlled leakage between dashpot chamber 126 and the hydraulic circuit at 112. The seat 130 for spring 124 is provided with one or more apertures 132 and serves as the upper part of a cage for the ball check valve 134. Ball check valve 134 seats in an opening 136 forming the mouth of passage 111 and thereby restricts the opening 136. Ball 134 unseats to permit unrestrained downward movement of valve proper 110 but seats, however, in its full capacity as a check valve upon upward movement of valve proper

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110 and effectually traps fluid in the dashpot chamber 126. The controlled leakage permitted by bleed 128 from chamber 126 permits only slow movement of the valve proper 110 in an upward direction as shown in Figure 4. The fit between dashpot portion 125 and sleeve 109 in the vicinity of bleed 128 is loose enough for bleed 128 to be calibrated and to function as intended. Spring 124 urges the valve proper 110 in a downward direction at all times.

The operation of the dashpot construction just set forth is best understood from a brief description of the hydraulic system operation. When the engine 42 is running and the steering wheel is not turned, oil from pump 56 flows through flexible hose 84 to the gallery 88 in the valve body assembly and from there to the respective ones of the distributing valve annular chambers including chamber 90. The oil then passes from the distributing valves and in the case of the upper distributing valve, for instance, through a discharge passage 92 in the valve body and through rigid inlet tubing 94 to one of the respective power cylinders 40. From the power cylinders 40 the oil passes through rigid outlet tubing 96 and re-enters the valve body housing and flows to the respective annular chambers including the upper annular chamber 97, for the reaction valves on the respective opposite sides of the valve operating block 104. Passages in the valve and valve body provide for the transfer of oil from each reaction valve to an annular chamber similar to annular chamber 98 for the upper reaction valve and thence to the valve operating block cavity 103. From block cavity 103 oil flows through flexible hose 86 to the reservoir 54. When the steering wheel 76 is turned, the valve operating block 104 closes the set of valves toward which the block moves and permits the opposite set fully to open.

The fluid coming to the inlet of one of the opposed pistons 58 is shut off and the fluid leaving through the outlet of the opposite piston 58 is shut off; oil flow then occurs only through the open set of distribution and reaction valves and the pistons 58 are caused to move in the power cylinders 40. Only about .007-.013 inch movement at valve block 104 is required in the physical embodiment of the structure shown in order to start application of the hydraulic power. The spring 124 insures positive contact between the valve proper 110 and the valve operating block 104. When the ball 134 seals the small dashpot chamber 126 in the rear of the valve, a dashpot action is provided because the only oil exit from this chamber is the small hole 128 and therefore, the valve operating mechanism tends to be prevented from clattering when road shocks are encountered.

It has been previously noted that the lower end 80 of the two-piece steering column is connected to the upper piece 74 by a universal joint 73 and is mounted in a spherical bearing 75, such mounting permitting the steering column spur gear 72 to move several thousandths of an inch with respect to the spur gear 70 and the worm shaft axis 67. The eccentric cam 108 adjustment is used to control center spacing of the spur gears 70, 72 and to prevent lateral movement of the steering column spur gear 72. Therefore, when the steering wheel is turned counterclockwise or clockwise, the steering column spur gear 72 climbs up or down with respect to worm shaft axis 67. The resulting movement of the valve operating block 104, while of very small magnitude, is sufficient to open and close the distribution and reaction valves 100 in the desired combination. A difference in pressure occurs between the power cylinders when the valves are operated and the pistons 58 move the power arm 60 in the same direction as do the worm and roller 64, 66 in driving the steering gear shaft 62.

During neutral operation when the steering wheel 76 is not turned, all four valves 100 are in a partially open position which at least for the upper set of valves is brought out in the sectioned showing of Figure 3. Oil

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from the pump 56 flows through each distribution valve through lines 94 to a respective power cylinder 40 and from there through one of the lines 96 to the corresponding reaction valve to the right in Figure 3. Oil is returned from each reaction valve through a flexible line 86 to the oil reservoir and filter 54. Inasmuch as the same oil pressure is supplied to both cylinders 40, the pistons remain in a stationary position and there is no amount of steering movement of the front road wheels 18. When the steering wheel 76 is turned for a left turn, for instance, the steering column spur gear 72 climbs up the worm shaft spur gear 70 in an orbital fashion and the valve operating block 104 moves up to cause the top valves 100 to move toward fully closed position and the bottom valves 100 to move toward fully open position. The sectioned set of valves of Figure 3 happen to be the valves selected which for purposes of the present example are to be visualized in the fully closed position and but very slight movement is required to change the valves from the neutral position shown (i. e., partially open) to a closed position. Oil from pump 56 will then flow at an increased rate through the resultingly fully open lower distribution valve to one power cylinder 40. Due to the fact that the open reaction valve is in the outlet line 96 from the opposite power cylinder 40, a difference in pressure occurs between the two cylinders, and the piston assemblies 58 are moved in the direction of the low pressure end of the cylinder assembly.

Piston movement is transmitted to the steering gear shaft 62 through power arm 60 and thus adds to the manual effort supplied to the steering gear shaft 62 through worm and roller 64, 66. The resultant rotation of the steering gear shaft 62 tends to turn the worm shaft spur gear 70 to an additional degree than does the rotation alone provided by the steering wheel movement. As a result, the steering column spur gear 72 and valve operating block 104 are forced back into the neutral position and the road wheels are maintained in the position indicated by the steering wheel location. The hydraulic system disclosed also reacts to oppose any tendency of the road wheels to turn due to chuck holes, ruts, or a tire blow-out. When the wheels tend to turn as a result of road obstruction or blow-out, the movement is transmitted through the running gear steering linkage 26, 32, 28, 34, 38, 62 to the worm and roller 64, 66. Because the driver is holding the steering wheel 76 the resultant rotation of the worm shaft spur gear 70 forces the steering column spur gear 72 to move up or down. This movement causes one set of distribution and reaction valves to open, and the other set on the opposite side of block 104 to close such that the oil pressure in the power cylinders 40 opposes the movement of the car wheels. Because the action of the hydraulic system is essentially instantaneous, very little wheel fight is felt by the driver.

The movement of the steering column spur gear 72 up and down, as just described, is not attended by any objectionable valve clatter by reason first, of the fact that there is no valve lost motion to take up owing to presence of spring 124, and second, due to the fact that the dashpot chambers 126 of two of the valves 100 are always effective to oppose the block 104 being suddenly set in motion from the neutral position of rest and causing an attendant clatter. When the vehicle is turning a corner, the car wheels automatically seek to return to a straight ahead position and center themselves as soon as the driver releases the steering wheel. This self-centering action of the wheels occurs in the same fashion as with conventional mechanical steering because the driver is not applying the small amount of effort required to hold the wheels in a turn position.

In the modification of Figure 5 a valve 200 is shown which is either very similar or the same in operation as the valve of Figure 4 but which differs slightly there-

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from in regard to structure. The outer part of the valve 200 is constituted by a sleeve 209 closed at one end and open at the other end. The inner part of the valve is constituted by a valve proper 210, a seat 230 for a spring and a ball check, a ball check 234, and springs 224, 242 all of which are assembled in combination to move as a unit with respect to the outer valve part 209. Outer part 209 and valve proper 210 are provided with sets of four and eight passages similar to the valve of Figure 4 and have annular grooves 222 suitable for O-ring seals. Valve proper 210 has an internal passage 211 and a dashpot portion 225. Dashpot portion 225 slides in the closed end of sleeve 209 and is slightly undersized with respect to the inside diameter of sleeve 209 such as to provide controlled leakage between the sliding surface. The ball check seat 230 has an opening 236 to the internal passage 211 and in the opening is received the ball check 234 so as to restrict it. A light spring 242 located in a dashpot chamber 226, acts to hold ball check 234 on its seat and a surrounding heavier spring 224 located in dashpot chamber 226 acts on seat 230 to urge the valve proper 210 in a downward direction at all times. Upon upward movement of valve proper 210 within sleeve 209, ball check 234 seats and restricts flow out of dashpot chamber 226 permitting the valve to move only slowly as fluid escapes between the sliding dashpot portion 225 and the adjacent inner surfaces of closed end of sleeve 209.

In Figure 6 another modified form of valve is shown at 300 similar to the valve of Figure 4. A sleeve 309 constitutes the outer part of valve 300 and is closed at one end and open at the other. The inner part of valve 300 is constituted by a valve proper 310, a ball check 334, springs 324, 342, and a seat 339 for a spring and ball check and providing at the same time a dashpot portion, all assembled together in combination to move as a unit with respect to the outer valve part 309. Valve part 309 is provided with sets of four and eight passages similar to the valve of Figure 4 and with suitable annular O-ring grooves 322 which are similarly shown. Valve proper 310 is slotted with longitudinal slots 344 at one end which define one or more protruding fingers 346, preferably four in number. Fingers 346 engage an end of seat 339 in which an opening 336 is provided which leads into an internal passage 311 in valve proper 310. The ball check 334 seats in the opening 336 to close it and restrict flow from a dashpot chamber 326 formed between dashpot portion 340 and the closed end of sleeve 309. The ball check 334 is urged toward seating position by a light spring 342. A relatively heavier spring 324 thrusts against seat 339. The seat 339 is provided with a restricted opening 328 which is open at both ends in the position shown for the valve in Figure 6. As valve 310 is moved upwardly, the outer end of opening 328 is covered by the adjacent inner surface of the closed end of sleeve 309 and provides by virtue of the sliding fit between surfaces an even greater restricted bleed for the dashpot chamber 326. When ball check 324 is seated it restricts the central opening 336 into passage 311.

Valve 100 of Figure 4 and the modifications thereof at 200 and 300 in Figures 5 and 6 are each of a type adapted to use in the valve body assembly 82 of Figure 3.

Variations within the spirit and scope of the described invention are equally comprehended by the foregoing description.

What is claimed is:

1. For use with a mechanically operated member subject to shock and having two sides and an hydraulic circuit system; a valve forming a part of said circuit system and incorporating a self-contained dashpot therein for damping movements of the mechanically operated member, said valve being formed of parts mounted one within the other and one projecting axially outwardly of the other for establishing engagement with one side of

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the mechanically operated member, means for biasing said projecting part into continuously engaged relation with the said one side of the mechanically operated member and opposing all relatively inward movement of the projecting part due to urgings of the said one side of the mechanically operated member, the parts being relatively reciprocative and the outer part thereof having a plurality of first ports and a second port, said plurality of first ports being in line of the inner part reciprocation with respect to the outer part so as to be effectively controlled by the inner part, said parts forming a fluid-trapping dashpot container as aforesaid at an end thereof decreasing in volume with the movement aforesaid due to the urgings of the mechanically operated member and having an opening incorporated in the inner part and connected with the hydraulic circuit, a spring biased valve element covering the opening to prevent rapid escape of hydraulic fluid trapped in the container upon decrease in volume of the same and thereby to effect resistance to the urgings of the mechanically operated member and damp the inward movements of the said one side thereof, and a similar valve engageable with the other side of the mechanically operated member.

2. A control-member-actuated valve having slow response to displacing forces transmitted thereto by such control member, said valve being formed of sleeve-like parts mounted one within another with an annular space between and being relatively disposed such that one part projects beyond the other for engagement with the control member and is reciprocable with respect to the said other part, said parts forming a fluid-trapping damping container at one end changing in volume with relative reciprocal movement of the parts, the inner of the sleeve-like parts having an opening between the interior thereof and the annular space and between the interior thereof and the container, said valve parts having ported valving surfaces formed thereon communicating with the annular space and interior of the inner part and registerable upon reciprocation of the parts to permit discharge of hydraulic liquid therefrom, and a spring-biased valve element inside the sleeve-like inner valve part and covering the container opening to prevent rapid escape of hydraulic liquid trapped in the container thereby causing the inner valve part to respond slowly to displacing forces transmitted thereto by the control member and to resist all sudden displacement by the control member.

3. In a hydraulic system including a fluid circuit and a valve operating member, opposed control valves disposed in said fluid circuit on either side of said valve operating member, said valves being formed with an inner valve part adapted to be reciprocated by said valve operating member, an outer valve part surrounding the inner valve part, said outer valve part having at least one port forming a portion of said fluid circuit, said port being situated along the line of reciprocation of the inner valve part and variably restricted thereby, said inner and outer valve parts forming a damping chamber, said chamber changing in volume upon relative movement of said valve parts, an opening formed in one of said valve parts interconnecting said chamber with the fluid circuit, yieldable means disposed between the valve parts for biasing the latter in opposition to the valve actuating forces exerted by said valve operating member, and valve means in said opening for retarding the rate of change in volume within the chamber thereby preventing sudden movement of the valve assembly and the valve operating member in one direction due to the application of external forces.

4. In a hydraulic system including a fluid circuit and a valve operating member, opposed control valves disposed in said fluid circuit on either side of said valve operating member, said valves being formed with an inner part adapted to be reciprocated by said valve operating member, an outer valve part surrounding the inner valve part, said outer valve part having at least one port forming a portion of said fluid circuit, said port being situated

along the line of reciprocation of the inner valve part and variably restricted thereby, said inner and outer valve parts forming a damping chamber, said chamber changing in volume upon relative movement of said valve parts, an opening formed in one of said valve parts interconnecting said chamber with the fluid circuit, yieldable means disposed between the valve parts for biasing the latter in opposition to the valve actuating forces exerted by said valve operating member, and a check valve in said opening for retarding the rate of change in volume of said chamber and for preventing sudden movement of the valve members and the valve operating member in one direction due to the sudden application of external forces.

5. In a hydraulic system including a fluid circuit and a valve operating member, opposed control valves disposed in said fluid circuit on either side of said valve operating member, said valves being formed with one part thereof adapted to be reciprocated by said valve operating member, another valve part telescopically associated with said one valve part, a first of said valve parts having at least one port forming a portion of said fluid circuit, said port being situated along the line of reciprocation of the second valve part and variably restricted thereby, said inner and outer valve parts forming a damping chamber, said chamber changing in volume upon relative movement of said valve parts, an opening providing communication between said chamber and said fluid circuit, yieldable means disposed between said valve parts for biasing the latter in opposition to the valve actuating forces exerted by said valve operating member, said opening being restricted upon relative movement between said valve parts thereby retarding the rate of change in volume of the chamber and preventing sudden movement of the valve parts and the valve operating member upon a sudden application of external forces.

6. In a hydraulic system including a fluid circuit and a valve operating member, opposed control valves disposed in said fluid circuit on either side of said valve operating member, said valves being formed with an inner part adapted to be reciprocated by said valve operating member, an outer valve part surrounding the inner valve part, one of said valve parts having at least one port forming a portion of said fluid circuit, said port being situated along the line of reciprocation of the other valve part and variably restricted thereby, said inner and outer valve parts forming a damping chamber, said chamber changing in volume upon relative movement of said valve parts, an opening formed in one of said valve parts inter-

connecting said chamber with the fluid circuit, a valve cooperating with said opening so as to be seated thereacross, and means forming a passage between said chamber and said fluid circuit with provision for progressively restricting the same during relative movement of said valve ports throughout a range of operating positions, said passage being substantially fully open during initial relative movement of said valve ports from a neutral position, said passage restrictively passing hydraulic fluid therethrough and retarding the rate of change in volume of the chamber thereby preventing sudden movement of the valve parts and the valve operating member upon sudden application of external forces.

7. In a hydraulic system including a fluid circuit and a valve operating member, opposed control valves disposed in said fluid circuit on either side of said valve operating member, said valves being formed with one part thereof adapted to be reciprocated by said valve operating member, another valve part telescopically associated with said one valve part, said valve parts having at least one port, a first of said valve parts having at least one port forming a portion of said fluid circuit, said port being situated along the line of reciprocation of the second valve part and variably restricted thereby, said inner and outer valve parts forming a damping chamber, said chamber changing in volume upon relative movement of said valve parts, an opening providing communication between said chamber and said fluid circuit, a check valve means for controlling the degree of restriction of said opening, and means forming a variably restricted passage for providing a predetermined degree of communication between said chamber and said fluid circuit independently of the operation of said check valve means.

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