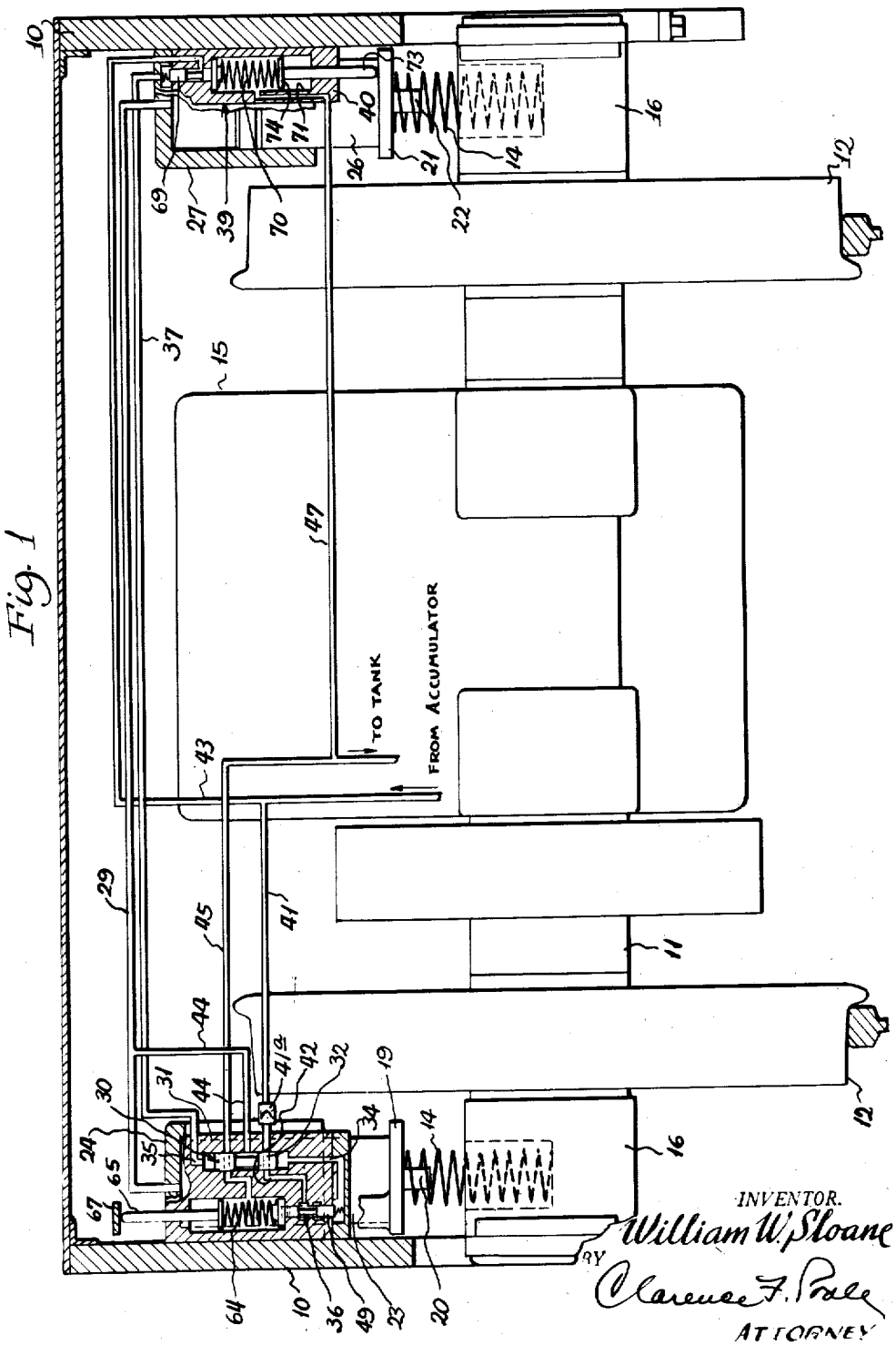
Aug. 12, 1952 W. W. SLOANE 2,606,506

TRANSVERSE EQUALIZING DEVICE

Filed Oct. 31, 1947 4 Sheets-Sheet 1

Fig. 1



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TRANSVERSE EQUALIZING DEVICE

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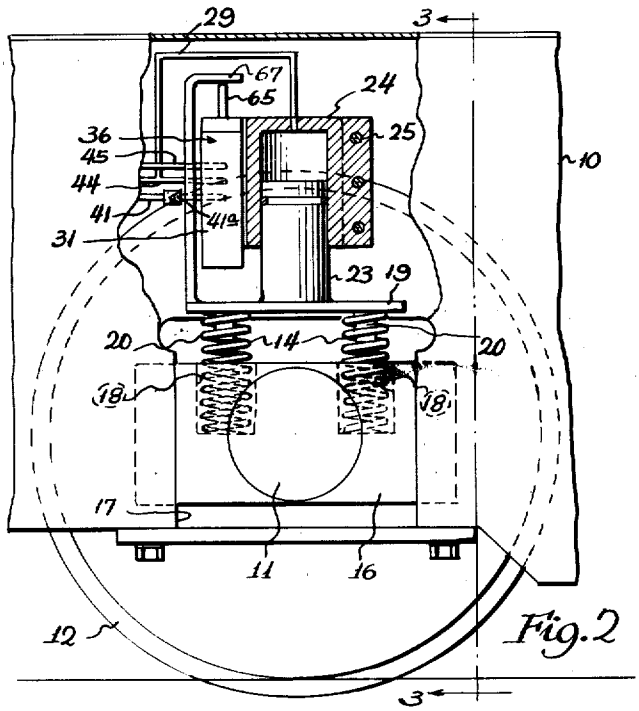


Fig. 2

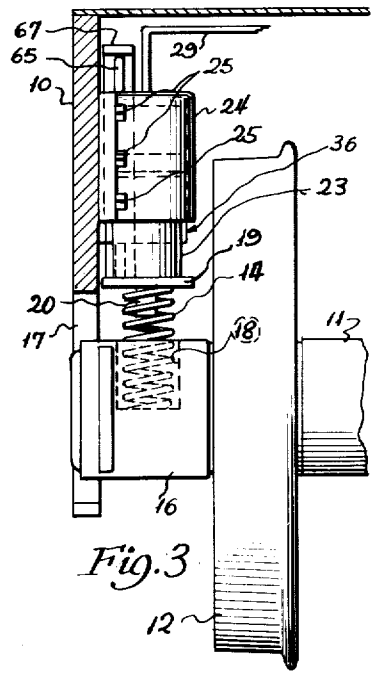


Fig. 3

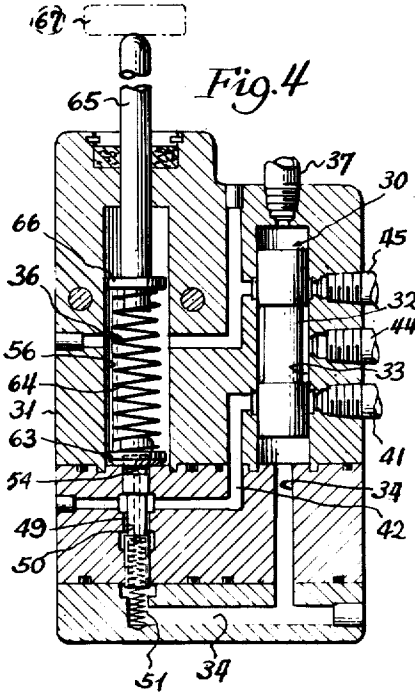


Fig. 4

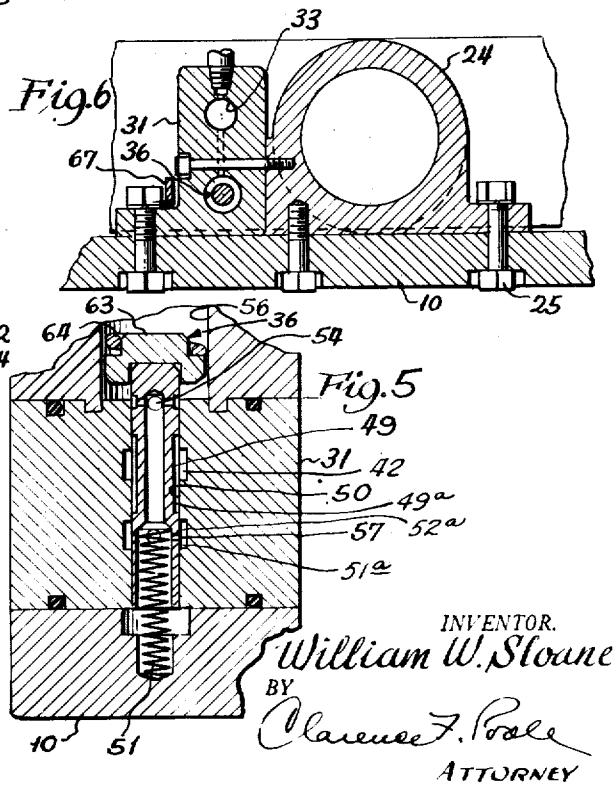


Fig. 5

Fig. 6

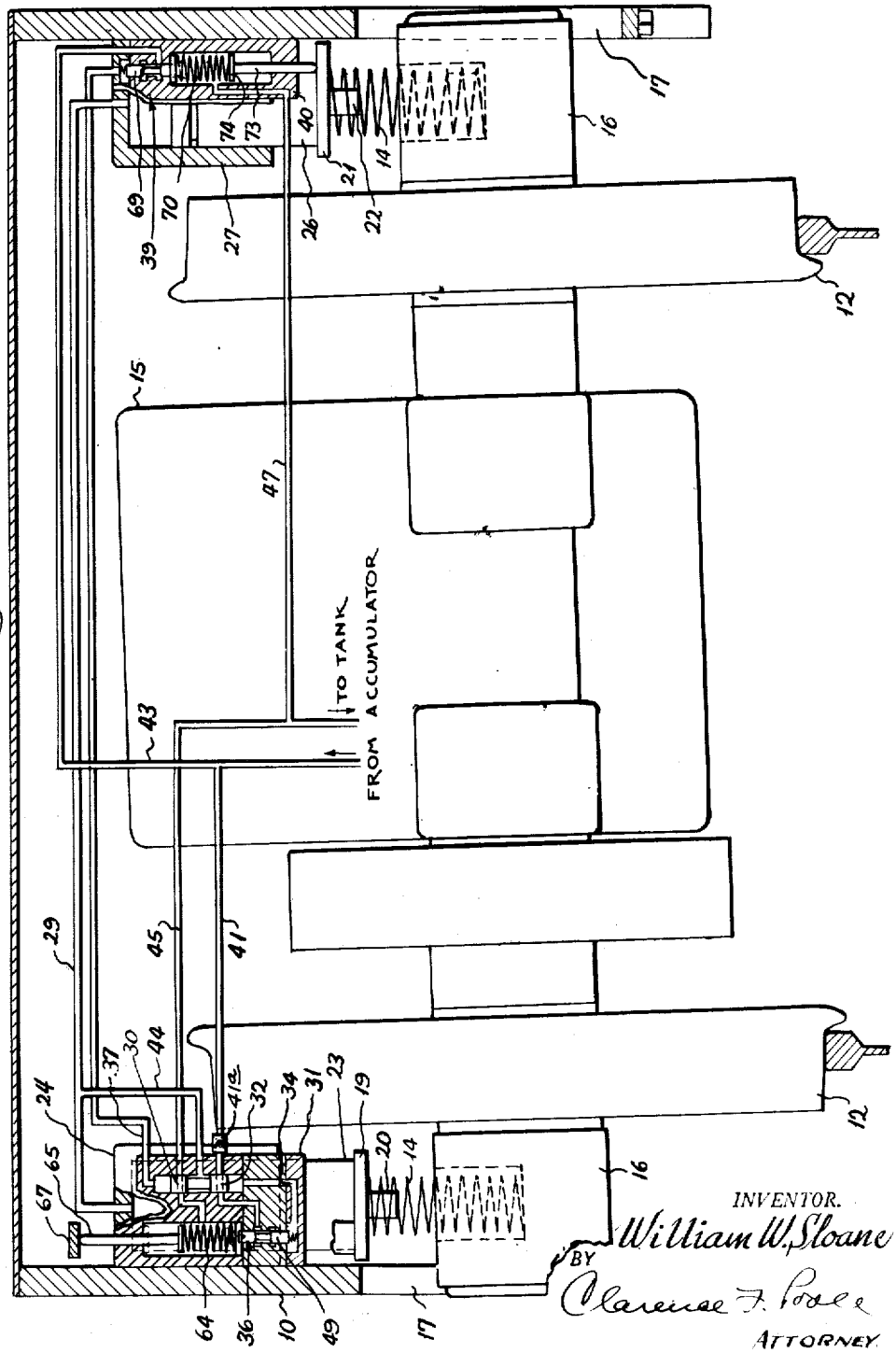
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TRANSVERSE EQUALIZING DEVICE

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Fig. 7



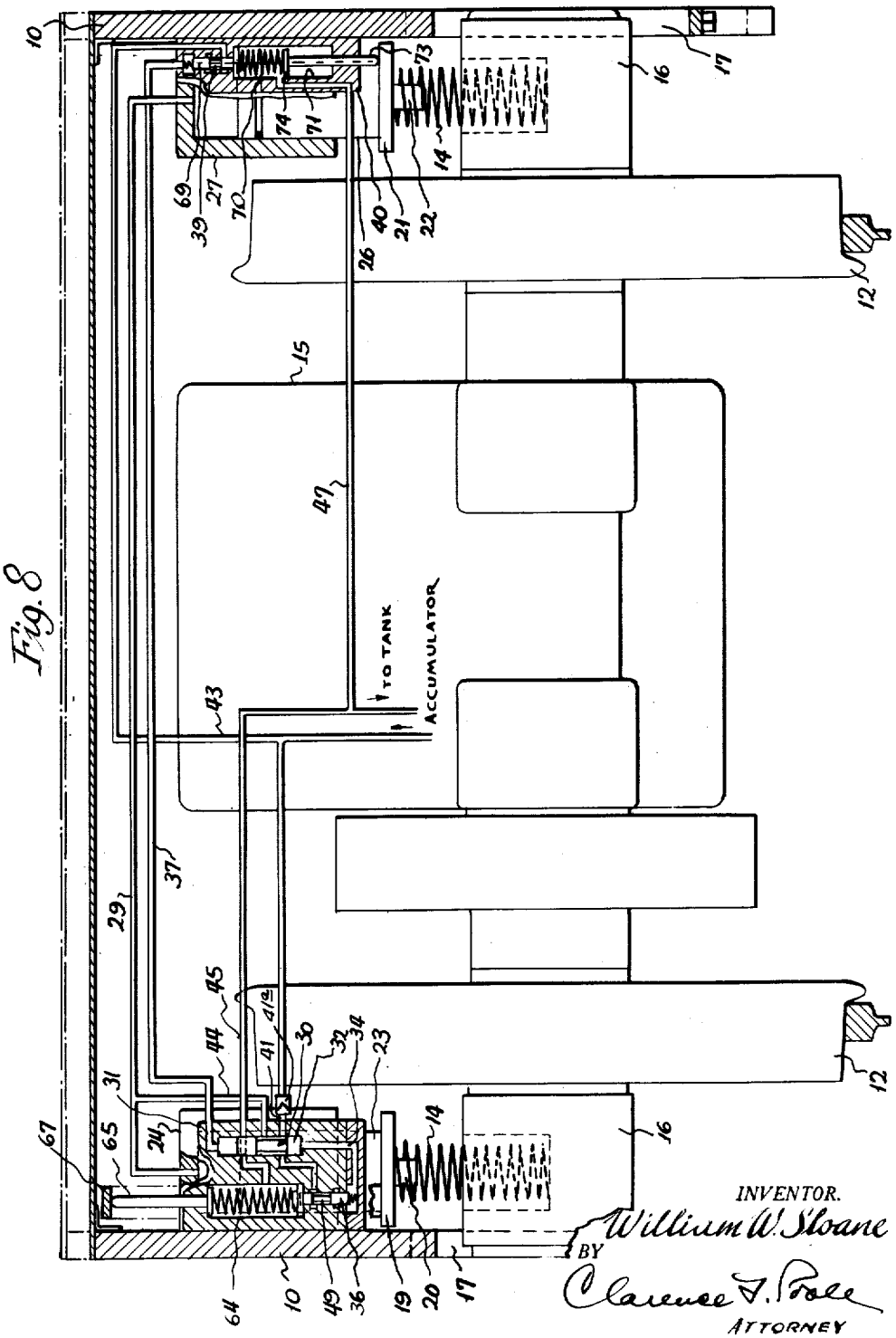
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TRANSVERSE EQUALIZING DEVICE

Filed Oct. 31, 1947 4 Sheets-Sheet 4

Fig. 8



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Patented Aug. 12, 1952 2,606,506

UNITED STATES PATENT OFFICE

2,606,506

TRANSVERSE EQUALIZING DEVICE

William W. Sloane, Chicago, Ill., assignor to Goodman Manufacturing Company, Chicago, Ill., a corporation of Illinois

Application October 31, 1947, Serial No. 783,271

17 Claims. (Cl. 105—164)

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This invention relates to improvements in transverse equalizing devices for locomotives or vehicles and more particularly relates to fluid operated equalizing devices adapted for use on locomotives in mines.

The principal objects of my invention are to provide an improved form of fluid operated transverse equalizing device affording flexibility of the supporting wheels and axles so as to readily follow uneven track.

Another object of my invention is to provide a fluid operated system having a novel form and arrangement of valve means operable during operation of the system, for automatically replenishing fluid lost from the system by leakage and for releasing excess fluid from the system.

A further object of my invention is to provide a fluid operated transverse equalizing device for a locomotive or other type of vehicle, including a novel form and arrangement of valves automatically operable while the vehicle is in operation or is standing still, by relative movement between the vehicle frame and wheels, for replenishing fluid lost from the system by leakage and for releasing excess fluid from the system.

In carrying out my invention I provide an equalizing device in which one end of the locomotive frame is mounted on springs at opposite ends of one axle, through cylinders and pistons connected together by a fluid connection, to allow the axle to swing in a vertical plane independently of the resiliency of its supporting springs, so the locomotive may readily follow an uneven track. I also connect the cylinders to a source of hydraulic power through valve means operated by relative movement between the locomotive frame and axle, either while the locomotive is in operation or is standing still, to normally maintain a closed circuit between said cylinders and to automatically supply fluid from the source of hydraulic power, to replenish fluid lost by leakage and to release excess fluid from the system.

These and other objects of my invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings wherein:

Figure 1 is a transverse sectional view taken through a mine locomotive, showing the locomotive traveling on a level track and diagrammatically showing the equalizing cylinders and valve means for replenishing fluid lost by leakage and for releasing excess fluid from the system;

Figure 2 is a fragmentary view in side elevation of a portion of a locomotive with parts broken away and in section in order to show the connection between one set of springs and its equalizing cylinder;

Figure 3 is a fragmentary transverse sectional view taken substantially along line 3—3 of Figure 2;

Figure 4 is an enlarged detail fragmentary sectional view taken through one of the control valves for replenishing fluid leaking from the system or for releasing excess fluid therefrom;

Figure 5 is an enlarged fragmentary sectional view showing certain details of the valve piston of the control valve shown in Figure 4;

Figure 6 is a fragmentary horizontal sectional view showing the mounting of one of the cylinders and its associated valve on the locomotive frame;

Figure 7 is a transverse sectional view somewhat similar to Figure 1 but showing the locomotive traveling over an irregular track; and

Figure 8 is a fragmentary transverse sectional view somewhat similar to Figures 1 and 7, but showing the locomotive frame in a lowered position with respect to its axle due to leakage of fluid from the system, and showing the control valves in position to replenish fluid in the system.

In the drawings the embodiment of my invention illustrated is shown as being applied to a locomotive of a type used underground in mines although it may be applied to any other type of locomotive, or to a truck or car, or road vehicle movable along the ground. A portion of this locomotive is shown in Figures 1, 2 and 3, in which appear two side plates 10, 10 connected together by end cabs and bumpers (not shown) at their forward and rear ends and constituting the frame of the locomotive. An axle 11 having a pair of supporting wheels 12, 12 thereon is provided for supporting said frame for movement along a track. It should here be understood that the usual locomotive used in mines is provided with two axles with wheels thereon and that the frame is supported on these wheels and axles through springs 14, 14. In applying my invention to a locomotive of this type, one supporting axle is preferably mounted in the usual manner, that is to say, without an equalizing device, so as to provide the desired stability to the frame, while the other supporting axle is mounted with the equalizing device so as to include a wide range of flexibility with respect to the frame and the one stabilizing axle, and cause the wheels of the locomotive to readily follow an uneven track.

A motor 15 is supported on the axle 11 to pro-

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vide power therefor. Said motor is journaled at one end on the axle 11 and may be flexibly connected near its other end to the locomotive frame in any manner suitable to locomotives of the type illustrated. Each end of the axle 11 is journaled in a journal box 16. Said journal boxes may be of any well known construction, arranged to move vertically in pedestals or guides 17, 17 formed in the side plates 10 of the locomotive frame.

The springs 14, 14 are mounted in cylindrical sockets 18, 18 formed in the journal boxes 16, 16 and opening to the tops of said boxes. Said springs at one side of the locomotive form a support for a longitudinally extending plate 19 and encircle pins 20, 20 depending from said plate (se Figure 2). Said springs at the opposite side of the locomotive form a support for a longitudinally extending plate 21 and encircle pins 22, 22 depending from said plate.

A piston 23 is secured at its lower end to the top of the plate 19 and extends upwardly from said plate within an equalizing cylinder 24. Said cylinder abuts the inside of the side plate 10 and is secured thereto as by nuts and bolts 25, 25. In a similar manner a piston 26 is secured to and projects upwardly from the plate 21 and extends within an equalizing cylinder 27 secured to the inside of the opposite side plate 10 from the cylinder 24.

The cylinders 24 and 27 are partially filled with fluid such as oil and a pipe 29, extending across the locomotive frame, connects the head ends of said cylinders together, so that as the locomotive travels over an irregular track and one end of the axle 11 and its associated wheel 12 is raised, one piston will move upwardly within its cylinder and the fluid displaced thereby will move the opposite piston downwardly along its cylinder, to positively depress the opposite end of the axle and hold the two wheels on the track, and permit a greater flexibility of vertical movement of said wheels and their supporting axle than could be obtained through the springs 14, 14.

Referring now to the automatic valve means for replenishing fluid which may leak from the equalizing system and for releasing surplus fluid therefrom, a shuttle valve 30 is mounted in a valve block 31, secured to one side plate 10 of the locomotive adjacent the equalizing cylinder 24. Said shuttle valve, as herein shown, includes a valve piston 32 slidably movable in a valve chamber 33 formed in said valve block, and is moved along said chamber to the required position, by fluid under pressure engaging either of its ends. A passageway 34 leads from the pressure side of a variable pressure valve 36 in the valve block 31 to the lower end of the valve piston 32 for supplying fluid under pressure to the lower end of said valve piston. A pipe 37 leads from the upper end of the valve chamber 33 and extends transversely of the locomotive and is connected with the pressure end of a variable pressure valve 39, for supplying fluid under pressure to the upper end of a valve piston 69 movable therein. Said last named variable pressure valve is mounted in a valve block 40, mounted adjacent the cylinder 27 on the inside of a side plate 10 of the locomotive.

A pressure line 41 leads from a source of hydraulic pressure such as a pump and accumulator (not shown) which may be used to supply fluid under pressure to operate the brakes, sanders, controller and other devices on the locomotive. Said pressure line communicates with the lower portion of the valve chamber 33, for supplying fluid under pressure to said valve chamber when

the valve piston 32 is in a lowermost position in said chamber. A passageway 42 connects said pressure line with the valve chamber of the variable pressure valve 36, for supplying fluid under pressure thereto, to be supplied by said variable pressure valve to the lower end of said valve piston. A check valve 41*a* is provided in said pressure line 41 to prevent fluid from passing from said chamber back into said pressure line. A pressure line 43 also connects said pressure line 41 with the valve chamber of the variable pressure valve 39, for supplying fluid under pressure thereto. A pressure line 44 is connected from the valve chamber 33, intermediate its ends, to the pipe 29, to supply fluid under pressure to said pipe and replenish fluid leaking from either of the equalizing cylinders 24 or 27.

A return line 45 leads from said valve chamber 33 on the opposite side of the pressure line 44 from the pressure line 41, to return surplus fluid which may leak from the pressure line 41 past the valve piston 32 into the equalizing cylinders, and to return fluid leaking past the valve piston 32 or leaking past or discharged from the variable pressure valve 36, to the fluid storage tank for the hydraulic system (not shown). Similarly, a return line 47 is connected from the valve block 40 of the variable pressure valve 39, to the return line 45, to return fluid leaking by or discharged from said variable pressure valve.

The variable pressure valve 36 may be of a well known form of brake valve commonly used to operate the hydraulic brakes of mine locomotives, and includes a valve piston 49 movable in a valve chamber 50 formed in the valve block 31. A spring 51 extends within a hollow inside portion of said valve piston, to tend to move said valve piston upwardly into a closed position. Said valve piston is drilled from its lower end and the drilled portion thereof communicates with a cross drill 54 adjacent the upper end of said piston, for releasing fluid into a chamber 56, in alignment with and communicating with the valve chamber 50. Said valve piston is also cross drilled at 52*a* adjacent its lower end and the cross drilled portion thereof intersects the upper portion of a land 57 at the lower end of said piston, to permit fluid to pass from the pressure passageway 42 around the reduced diameter portion 49*a* of piston 49, past the cross drill at the land 57 and through the hollow inside of said valve piston to the passageway 34, upon downward movement of the valve piston a distance sufficient for the upper end of the land 57 to clear the upper edge of an annular port 51*a* formed in the valve body. When the valve piston is in the position just mentioned the lower end of the valve piston 32 will be subjected to fluid pressure from the passageway 34 passing through the cross drill 51*a*. This will tend to move said valve piston upwardly into the position shown in Figure 4. It will be noted that so long as the reduced diameter portion 49*a* of the valve piston 49 is in registry with the annular ports 42*a* and 51*a* and provides a passageway therebetween that the flow of fluid to the lower end of the valve piston 32 will take place, provided that the cross drill 52*a* of the land 57 is also in registry with the annular port 51*a*. A spring seat 63 is mounted on the upper end of the valve piston 49 and forms a seat for an operating spring 64, mounted in the chamber 56. The end of said compression spring opposite from said seat extends along the lower end of a valve rod 65 for a short part of its length and abuts a collar or flange 66 secured to said rod. Said valve rod is

slidably mounted in the upper end of the valve block 31 and extends upwardly therefrom. The upper end of said valve rod is adapted to be engaged by the underside of a longitudinally turned end of an operating member 67. Said operating member is mounted adjacent one end of the plate 19 and extends upwardly therefrom and its upper end is turned horizontally to extend longitudinally of the locomotive, to engage and form an operating means for said valve rod 65, upon relative movement between said plate 19 and the locomotive frame.

As the piston 23 moves downward with respect to the cylinder 24, as may be occasioned by a low spot in the track rail, the horizontally turned end of the operating member will approach the valve 36. This will displace the spring 64 downwardly along the chamber 56 and move the valve piston 49 in a direction to permit fluid to pass from the pressure passageway 42 past the reduced diameter portion 49a and the cross control 52a to the pressure passageway 34, and exert pressure against the lower end of the valve piston 32 with a force substantially equal to the force exerted by the spring 64. As said spring is displaced a further distance the pressure in the pressure line 34 will be correspondingly increased. Similarly, when the piston 23 moves upward with respect to the cylinder 24 as may be occasioned by high places in the track rail, the horizontally turned end of said operating member will be moved away from said valve block 36 and permit said spring 64 to extend itself, and reduce the pressure against the lower end of the valve piston 32.

The variable pressure valve 39 is similar to the variable pressure valve 36, so need not herein be shown or described in detail. Said variable pressure valve includes a valve piston 69 like the valve piston 49 of the valve 36. An operating spring 70 is mounted in a chamber 71 formed in the valve block 40 and is operatively connected with the lower end of the valve piston 69, to tend to move said valve piston upwardly in said valve block upon displacement of said spring upwardly along said valve block. The end of said spring opposite from said piston extends along a valve rod 73 and abuts a collar 74 on said valve rod. Said valve rod is slidably mounted in the lower end of said valve block and extends downwardly therefrom, and its lower end engages the top of the plate 21. As the piston 26 moves upwardly with respect to the cylinder 27 the spring 70 will be displaced upwardly to move the valve piston 69 to an open position and supply fluid to the pressure pipe 37 at varying pressures dependent upon the displacement of said spring, and exert a pressure on the upper end of the valve piston 32 and tend to move said valve piston downwardly along the valve chamber 33, when pressure on the upper end of said piston is greater than pressure exerted on the lower end thereof through the variable pressure valve 36 and pressure passageway 34.

It should here be noted that the valve 39 operates oppositely from the valve 36, so that when the entire frame moves downwardly with respect to the axle 11, the high pressure side of the valve 39 will open while the high pressure side of the valve 36 will close and cause a differential in pressure on opposite ends of the piston 32. When, however, the axle 11 moves vertically about an axis extending longitudinally of the locomotive, both valves will open or close together and maintain substantially the same pressures on opposite ends of said piston 32.

During normal operation of the locomotive, the pistons 23 and 26 will be extended from their cylinders the same distances and the locomotive frame will be level and parallel to the axis of the axles 11, 11, as in Figure 1. The operating spring 64 of the valve 36 will be displaced downwardly within its chamber, while the operating spring 70 will be displaced upwardly the same distance within its chamber. Fluid, therefore, will be supplied to both ends of the valve piston 32 at substantially the same pressures, to hold said valve piston in the neutral position shown in Figures 1 and 4 and block the passage of fluid to the pressure line 29, and to hold fluid in said pressure line.

When the locomotive is traveling over rough track as shown in Figure 7, one end of the axle 11 will be raised while the other end will be lowered. The piston 26 will be moved upwardly within the equalizing cylinder 27 and will displace fluid through the pressure line 29, to tend to extend the piston 23 from its equalizing cylinder 24 and exert a positive downward force on the low end of the axle. An equal force will thus be exerted on each wheel, to hold both wheels in engagement with the track rails. The operating springs 64 and 70 will be displaced substantially the same distances and cause substantially the same pressure to be exerted against the lower end of the valve piston 32 as against the upper end of said valve piston, and hold said valve piston in a neutral position and hold the circuit between said equalizing cylinders closed.

When, however, fluid leaks from the equalizing system, and the entire locomotive frame moves downwardly with respect to the axle 11 as shown in Figure 8, the valve block 40 will approach the plate 21, while the operating member 67 will move away from the valve block 31. Pressure against the upper end of the valve piston 32 will thus increase, while pressure against the lower end of said valve piston will decrease. This will cause said valve piston to move into position to supply fluid under pressure from the pressure line 41, through the valve chamber 33 and pressure line 44 to the pipe 29, connecting the head ends of the cylinders 24 and 27 together, to supply fluid under pressure thereto until the locomotive frame has been elevated along the pistons 23 and 26 to the normal position shown by broken lines in Figure 8. When this occurs the operating springs of the valves 36 and 39 will both be displaced the same amount and said valve piston 32 will be moved to a neutral position, to hold fluid in said pressure line 44.

When fluid leaks past the valve piston 32 from the pressure line 41 to the pressure line 44 and causes an excess amount of fluid to be supplied to the cylinders 24 and 27, raising one end of the locomotive frame above a normal position, the operating member 67 will approach the valve 36 and depress the valve rod 65, while the valve 39 will move away from the plate 21, and permit the spring 70 to extend the valve rod 73 from the valve block 40. This will open the pressure side of the valve 36 and close the pressure side of the valve 39. Pressure against the lower end of the valve piston 32 will thus increase while pressure against the upper end of said valve piston will decrease. Said valve piston will then move upwardly into position to release fluid from the pressure line 44 and cylinders 24 and 27 until the pressures on opposite ends of said valve piston are again equalized, at which time said valve piston will again move to a neutral position, and

the locomotive frame will be in the normal position shown in Figure 1.

It may be seen from the foregoing that a simplified form of hydraulic transverse equalizer has been provided which may be used on track or road vehicles, and includes a simplified construction and arrangement of valves operable while the vehicle is in operation or is standing still, which give substantially the same pressure when the axle is pivotally moving in a plane perpendicular to an axis extending longitudinally of the vehicle, and which establish a differential in pressure when the vehicle frame moves vertically with respect to its normal position into planes extending substantially parallel to the axle, for automatically replenishing fluid leaking from the equalizer and for releasing excess fluid from the equalizer. It may further be seen that these valves consist of two oppositely operable variable pressure valves at opposite sides of the vehicle, and a shuttle valve operated by the differential in pressure thereon supplied by said variable pressure valves, to supply fluid to or to release fluid from the equalizing cylinders when the pressure supplied by one variable pressure valve is greater than the other, and to hold pressure in said equalizing cylinders when the pressure supplied by both of these valves is the same.

While I have herein shown and described one form in which my invention may be embodied, it will be understood that the construction thereof and the arrangement of the various parts may be altered without departing from the spirit and scope thereof. Furthermore, I do not wish to be construed as limiting my invention to the specific embodiment illustrated, excepting as it may be limited in the appended claims.

I claim as my invention:

1. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of equalizing cylinders and pistons, each being mounted on opposite sides of said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to effect downward movement of one end of said axle upon upward movement of the opposite end of said axle and cause the pressures on the wheels on opposite ends of said axle to be substantially the same, and a plurality of cooperating valves connected with a source of supply of fluid under pressure and with said cylinders and operated by vertical movement of the vehicle frame relative to said axle in planes generally parallel to the longitudinal axis of said axle, to automatically replenish fluid leaking from said cylinders.

2. In a vehicle, a frame, an axle having supporting wheels, and an equalizing device for said axle comprising a pair of equalizing cylinders and pistons, each being mounted on opposite sides of said frame and affording vertically moving supports for opposite ends of said axle, and a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to effect downward movement of one end of said axle upon upward movement of the opposite end of said axle and cause the pressure on the wheels on opposite ends of said axle to be substantially the same, a valve at each side of said frame, fluid connections to said valves for supplying fluid under pressure thereto, means for operating said valves by bodily vertical movement of said frame with respect to said axle into planes extending substantially parallel to the longitudinal axis of said axle, to establish a differential in pressure by opening one valve and closing the other as said frames moves towards or away from said axle due to leakage from said cylinders or to excess fluid leaking therein, and a third valve operated by the differential in pressure created by said pair of valves in such movement, so as to automatically replenish fluid leaking from said cylinders or to release excess fluid therefrom.

3. In a vehicle, a frame, an axle having supporting wheels, and an equalizing device for said axle comprising a pair of equalizing cylinders and pistons, each being mounted on opposite sides of said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to effect downward movement of one end of said axle upon upward movement of the opposite end of said axle and cause the pressures on the wheels on opposite ends of said axle to be substantially the same, a variable pressure supply valve at each side of said frame, fluid connections to said supply valves for supplying fluid under pressure thereto, operative connections to said supply valves for operating said valves by bodily vertical movement of said frame with respect to said axle into planes extending substantially parallel to the longitudinal axis of said axle, to increase the pressure of fluid supplied by one valve and decrease the pressure of fluid supplied by the other valve, a third valve connected from a source of pressure to said cylinders, fluid connections from said two valves to said third valve providing a path for differential fluid pressure for operating said third valve, to open said third valve and replenish fluid leaking from said cylinders or to release excess fluid therefrom when the pressure of fluid supplied by one of said variable pressure valves is different from that supplied by the other.

4. In a vehicle, a frame, an axle having supporting wheels, and an equalizing device for said axle comprising a pair of equalizing cylinders and pistons, each being mounted on opposite sides of said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to effect downward movement of one end of said axle upon upward movement of the opposite end of said axle, a variable pressure supply valve at each side of said frame, fluid connections to said supply valves for supplying fluid under pressure thereto, operative connections to said valves for operating said supply valves by bodily vertical movement of said frame with respect to said axle into planes extending substantially parallel to the longitudinal axis of said axle, to increase the pressure of fluid supplied by one valve and decrease the pressure of fluid supplied by the other valve, a shuttle valve including a valve chamber having a valve piston movable therein, a fluid connection for supplying fluid under pressure to said chamber intermediate its ends, a fluid connection from said chamber for supplying fluid under pressure to said equalizing cylinders, and fluid connections from said two variable pressure valves to opposite ends of said chamber, for supplying fluid under pressure to opposite ends of said valve piston for moving said valve piston into position to permit fluid to pass from said chamber to said equalizing cylinders, to replenish fluid leaking therefrom when said frame has moved to a position where the pressure sup-

plied by one of said variable pressure valves will be greater than the pressure supplied by the other of said valves.

5. In a vehicle, a frame, an axle having supporting wheels, and an equalizing device for said axle comprising a pair of equalizing cylinders and pistons, each being mounted on opposite sides of said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to effect downward movement of one end of said axle upon upward movement of the opposite end of said axle, a variable pressure control valve at each side of said frame, fluid connections to said control valves for supplying fluid under pressure thereto, oppositely operating operative connections to said control valves for operating said control valves by bodily vertical movement of said frame with respect to said axle into planes extending substantially parallel to the longitudinal axis of said axle, to cause one of said control valves to move into a position to deliver an increased pressure and the other of said control valves to move into position to deliver a reduced pressure, and to cause said control valves to establish substantially the same pressure when said axle twists about an axis extending longitudinally of the vehicle, a shuttle valve including a valve chamber having a valve piston movable therein, a fluid connection for supplying fluid under pressure to said chamber intermediate its ends, a fluid connection from said chamber for supplying fluid under pressure to said equalizing cylinders, a return fluid connection from said chamber for releasing excess fluid from said equalizing cylinders, and fluid connections from said two variable pressure valves to opposite ends of said chamber, for supplying fluid under pressure to opposite ends of said valve piston, to move said valve piston into positions to supply fluid to or to release fluid from said equalizing cylinders, when said frame has moved vertically with respect to said axle into planes extending substantially parallel to the longitudinal axis thereof, and to hold fluid in said cylinders when said axle twists about an axis extending longitudinally of the vehicle.

6. In a fluid pressure system, two cylinders having pistons movable therein, a fluid connection between said cylinders so that movement of one piston within one cylinder in one direction will displace fluid and cause movement of the other piston within the other cylinder in an opposite direction, and valve means for replenishing fluid lost from said system by leakage or for relieving excess fluid therefrom including two valves so constructed and arranged that they will provide substantially the same pressures when said pistons move with respect to their cylinders in opposite directions with respect to each other, and will provide a differential in pressure when said pistons move with respect to their cylinders in the same directions with respect to each other, said valve means including a valve having a member movable in response to said differential pressure to pass fluid into or away from said pressure system.

7. In a fluid pressure system, two cylinders having pistons movable therein, a fluid connection between said cylinders so that movement of one piston within one cylinder in one direction will displace fluid and cause movement of the other piston within the other cylinder in an opposite direction, and valve means for replenishing fluid lost from said system by leakage or for releasing excess fluid therefrom including two valves so constructed and arranged that they will give substantially the same pressures when said pistons move with respect to their cylinders in opposite directions with respect to each other and will establish a differential in pressure when said pistons move with respect to their cylinders in the same directions, and a third valve connected with a source of fluid supply and a return, and also connected with said cylinders for supplying fluid to or for releasing fluid therefrom, and for holding fluid under pressure therein, said third valve being connected with and operated by the differential in pressure established by said two valves and being operable to hold fluid in the system when the pressure established by said two valves is the same.

8. In a fluid pressure system, two cylinders having pistons movable therein, a fluid connection between said cylinders forming a closed circuit therebetween, whereby movement of one piston within one cylinder will displace fluid and cause movement of the other piston within the other cylinder, and means for replenishing fluid lost from said cylinders by leakage or for releasing excess fluid therefrom, including two oppositely operating valves, each being associated with one of said cylinders and being operable by movement of said pistons with respect to said cylinders, and adapted to establish a differential in pressure upon movement of said two pistons with respect to their cylinders in the same direction, and a third valve connected with a source of hydraulic fluid under pressure and with said cylinders and to a return, and operated by the differential in pressure established by said valves for supplying fluid under pressure to said cylinders or to connect said cylinders to the return and release excess fluid therefrom.

9. In a fluid pressure system, two cylinders having pistons movable therein, a fluid connection between said cylinders forming a closed circuit therebetween, whereby movement of one piston within one cylinder will displace fluid and cause movement of the other piston within the other cylinder, and means for replenishing fluid lost from said cylinders by leakage or for releasing excess fluid therefrom, including two oppositely operating variable pressures valves, each being associated with one of said cylinders and being operable by movement of said pistons with respect to said cylinders, and adapted to establish a differential in pressure upon simultaneous movement of said two pistons with respect to their cylinders in the same direction, and a third valve connected with a source of hydraulic fluid under pressure and with said cylinders. and operated by the differential in pressure established by said variable pressure valves for supplying fluid under pressure to said cylinders or for releasing excess fluid therefrom.

10. In a fluid pressure system, two cylinders having pistons movable therein, a fluid connection between said cylinders so that movement of one piston within one cylinder in one direction will displace fluid and cause movement of the other piston within the other cylinder in an opposite direction, and valve means for replenishing fluid lost from said system by leakage or for releasing excess fluid therefrom including two variable pressure valves, each being associated with one of said cylinders and operated by movement of said pistons with respect to said cylinders and being so constructed

and arranged that they will give substantially the same pressures when said pistons move with respect to their cylinder in opposite directions and will establish a differential in pressure when said pistons move with respect to their cylinders in the same directions with respect to each other, and a third piston valve connected with a source of fluid supply and a return, and also connected with said cylinders for supplying fluid thereto and for releasing fluid therefrom, and for holding fluid under pressure therein, and fluid pressure connections from said variable pressure valves to opposite ends of said third piston valve, for supplying fluid under pressure for holding said piston valve in a position to hold fluid in said cylinders when the pressures delivered by said variable pressure valves are the same, and for moving said piston valve into positions to release fluid from or to supply fluid to said cylinders when a differential in pressure is established by said two variable pressure valves.

11. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of equalizing cylinders and pistons mounted on said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to equalize the pressures on the wheels on opposite ends of said axle, a pressure operated supply valve connected with a source of supply of fluid under pressure and with said cylinders, a pair of control valves associated one each with one of said cylinders and having fluid connection with said pressure operated supply valve to supply fluid under pressure thereto, to operate said supply valve to move into its several operative positions by the difference in pressure supplied thereto by said control valves and by the balancing of the pressure supplied thereto, said control valves being operable by relative movement between said vehicle frame and its supporting axle and one moving in a diection to increase pressure supplied to said supply valve and the other moving in a direction to decrease pressure supplied to said supply valve upon movement of said vehicle frame into planes parallel to the axis of its supporting axle, and actuating said supply valve to move into a position to replenish fluid to said cylinders by the differential in pressure supplied thereto by said valves.

12. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of equalizing cylinders and pistons affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to maintain the pressures on the wheels on opposite ends of said axle equal, a shuttle valve connected between a source of fluid supply and said cylinders to supply fluid under pressure thereto, and control valves connected with opposite ends of said shuttle valve and with said source of fluid supply to supply fluid under pressure to said shuttle valve to hold said shuttle valve in position to block the supply of fluid to said cylinders, when the pressures thereon are balanced and to operate said valve by unbalancing the pressures thereon, said control valves being operated by relative movement between said frame and axle and establishing a difference in pressure on opposite ends of said shuttle valve upon bodily movement of said frame toward said axle in generally parallel planes, to operate said shuttle valve to automatically replenish fluid leaking from said cylinders.

13. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of equalizing cylinders and pistons mounted on said frame and affording vertically moving supports for opposite ends of said axle, a fluid connection between said cylinders arranged to transfer fluid from one cylinder to the other, to maintain the pressures on said wheels substantially equal under all operating conditions, a variable pressure control valve at each side of said frame, fluid pressure connections to said control valves, supplying fluid under pressure thereto, operative connections to said control valves, operating said control valves by relative movement between said frame and axle, each control valve having an outlet pressure port, and a supply valve connected to supply fluid to said cylinders and connected to said outlet pressure ports and operated by pressure delivered therefrom, one of said control valves being operable to increase the pressure at its outlet pressure port and the other of said control valves being operable to decrease the pressure at its outlet pressure port upon bodily movement of said frame toward said axle in a plurality of generally parallel planes, and said supply valve being operable by a difference in pressure delivered by said control valves into position to replenish fluid to said equalizing cylinders.

14. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of equalizing cylinders affording vertically moving supports for opposite ends of said axle and valve means for replenishing fluid lost from said equalizing device through leakage and for releasing excess fluid therefrom including two valves each connected with a source of fluid supply and operated by relative movement between said frame and axle and each delivering the same pressures when said axle twists vertically about an axis extending longitudinally of the vehicle, and delivering different pressures when said frame moves vertically in planes generally parallel to said axle, a third valve connected with said cylinders to supply fluid to and to release fluid from said cylinders, said third valve also being connected with said two valves and operated by the difference in pressures delivered thereto to replenish fluid in said cylinders upon bodily movement of said frame with respect to said axle in one direction, and to release fluid from said cylinders upon bodily movement of said frame with respect to said axle in an opposite direction.

15. In a vehicle, a frame, an axle having supporting wheels, an equalizing device for said axle comprising a pair of connected equalizing cylinders affording vertically moving supports for opposite ends of said axle, valve means for replenishing fluid lost from said equalizing device through leakage and for relieving excess fluid therefrom including two control valves connected with a source of fluid supply, a third supply valve connected with a source of fluid supply and with said cylinders and also having said two valves connected thereto to deliver fluid under pressure thereto to operate said supply valve when the pressures delivered by said two valves are unequal, to supply fluid to and to release fluid from said cylinders, said control valves being operable by movement of the locomotive frame relative to the axle and each giving substantially the

same pressure when said axle twists about an axis extending longitudinally of the vehicle and delivering different pressures when said frame moves bodily in a vertical direction with respect to said axle in a plurality of generally parallel planes, and said supply valve holding fluid in said equalizing device when the pressures delivered by said control valves are the same.

16. A fluid pressure equalizing device for vehicles having a frame and a supporting wheel and axle comprising a cylinder and piston affording a vertically moving support for said axle, valve means connected with a source of supply of fluid under pressure and operable by relative vertical movement of said frame with respect to said axle, a fluid operated supply valve connected between a source of supply of fluid under pressure and said cylinder for supplying fluid under pressure thereto, said valve means having fluid connection with said supply valve and supplying fluid at different pressures, on opposite sides thereof, upon bodily movement of said frame toward said axle, effected by leakage of fluid from said cylinder for operating said supply valve to replenish fluid leaking from said cylinder.

17. In a vehicle, a frame, a pair of spaced axles having supporting wheels thereon, an equalizing

device for one of said axles comprising a pair of cylinders and pistons affording vertically moving supports for opposite ends of said one axle, a fluid connection between said cylinders transferring fluid from one cylinder to the other, valve means connected with a source of supply of fluid under pressure and operated by relative movement between said frame and said one axle, a fluid operated supply valve connected between a source of supply of fluid under pressure and said cylinders, for supplying fluid under pressure thereto, and fluid connections from said valve means to said supply valve operating said supply valve to replenish fluid leaking from said cylinders upon bodily movement of said frame toward said one axle about said other axle, effected by leakage of fluid from said cylinders.

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The following references are of record in the file of this patent:

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