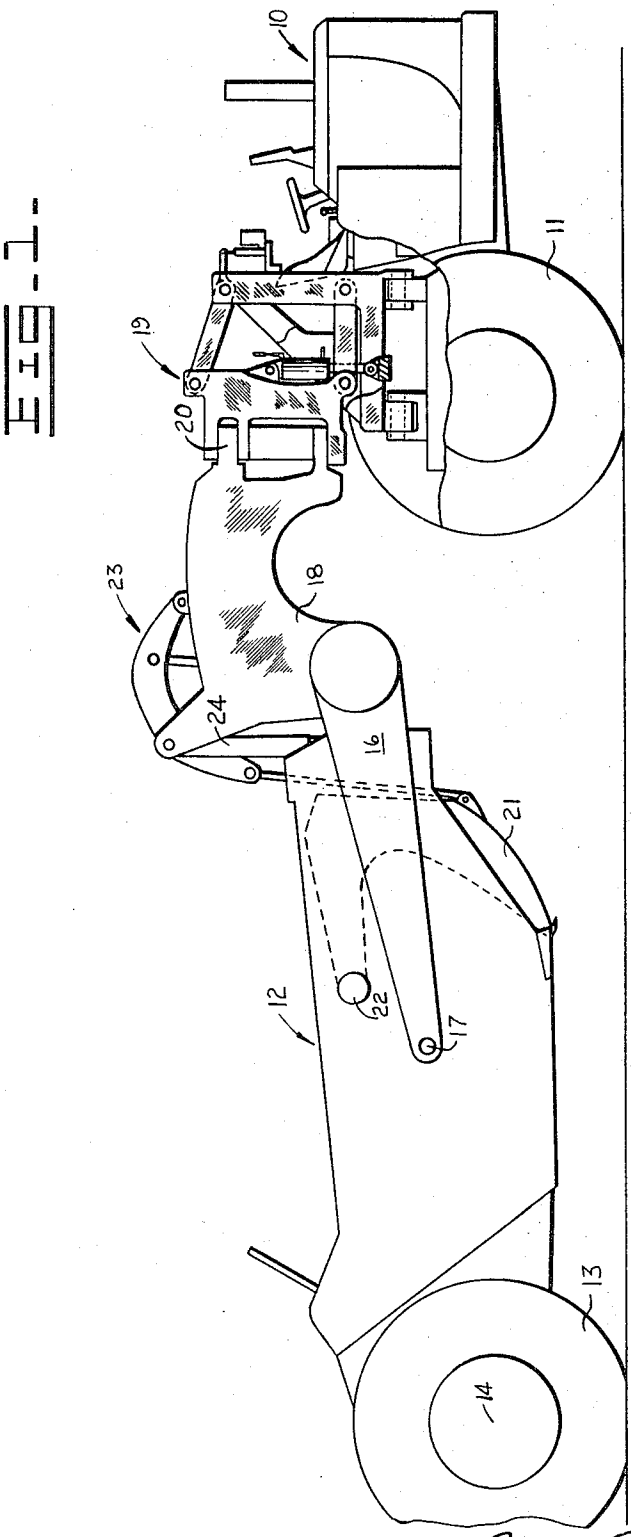
March 28, 1967 J. C. BARTON ET AL 3,311,389

SYSTEM FOR CONTROL OF PITCH AND BOUNCE
IN TRACTOR-TRAILER COMBINATIONS

Filed June 7, 1965 4 Sheets-Sheet 1

FIG. 1



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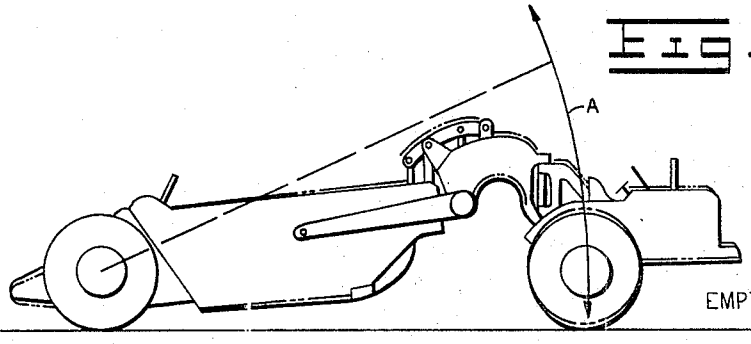
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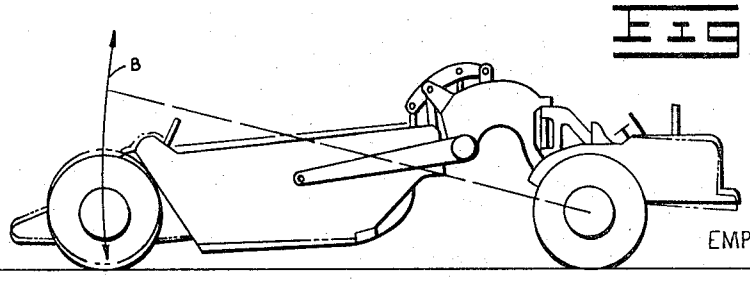
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Fig. 2.



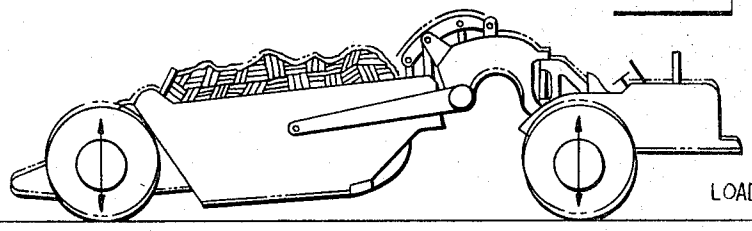
EMPTY BOUNCE

Fig. 3.



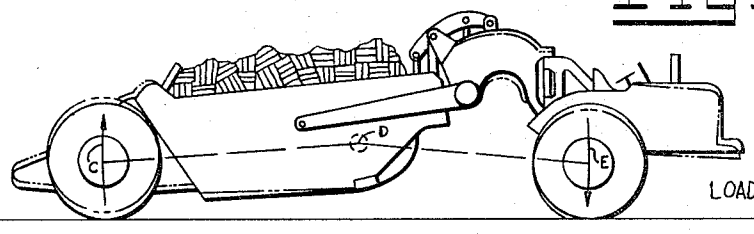
EMPTY PITCH

Fig. 4.



LOADED BOUNCE

Fig. 5.



LOADED PITCH

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SYSTEM FOR CONTROL OF PITCH AND BOUNCE IN TRACTOR-TRAILER COMBINATIONS

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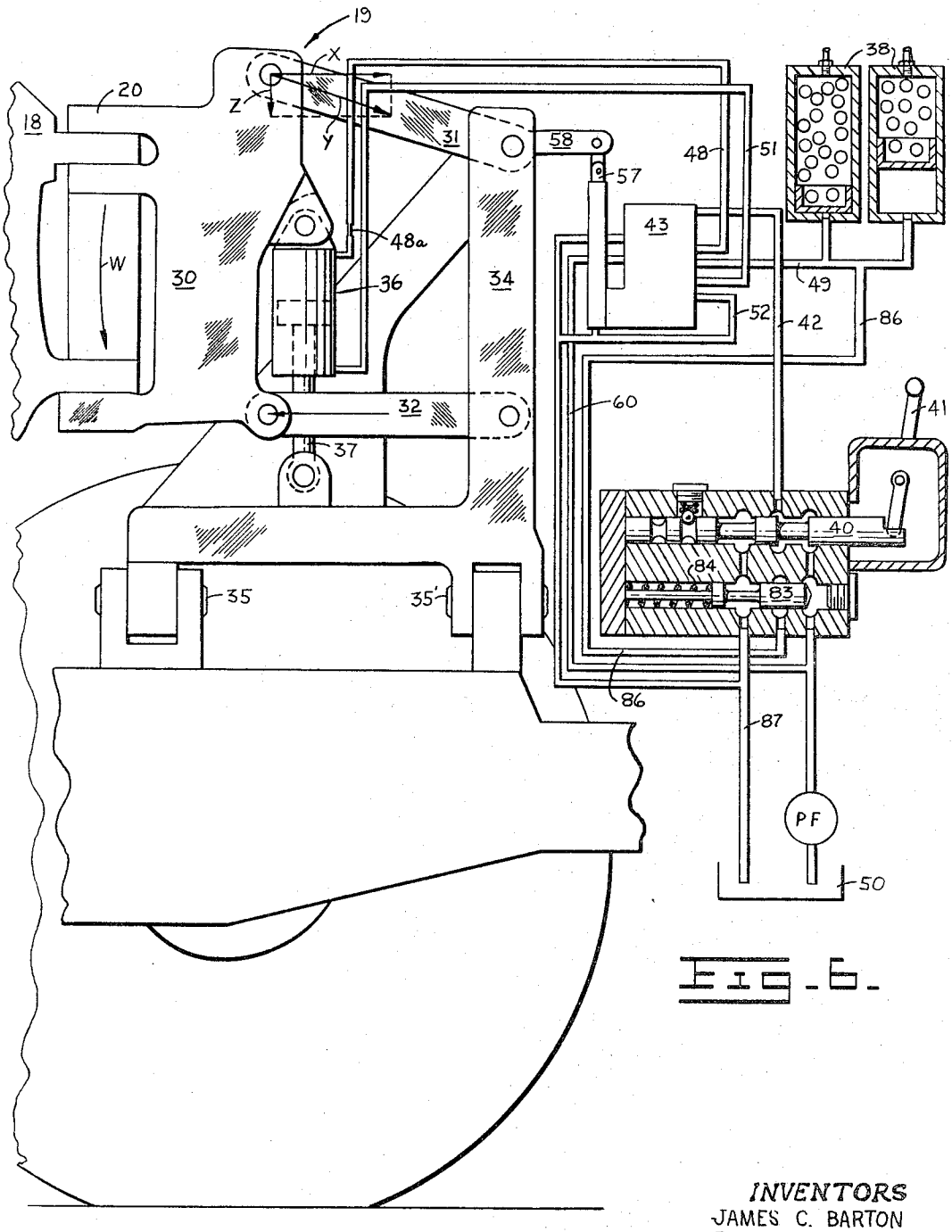


Fig. 6.

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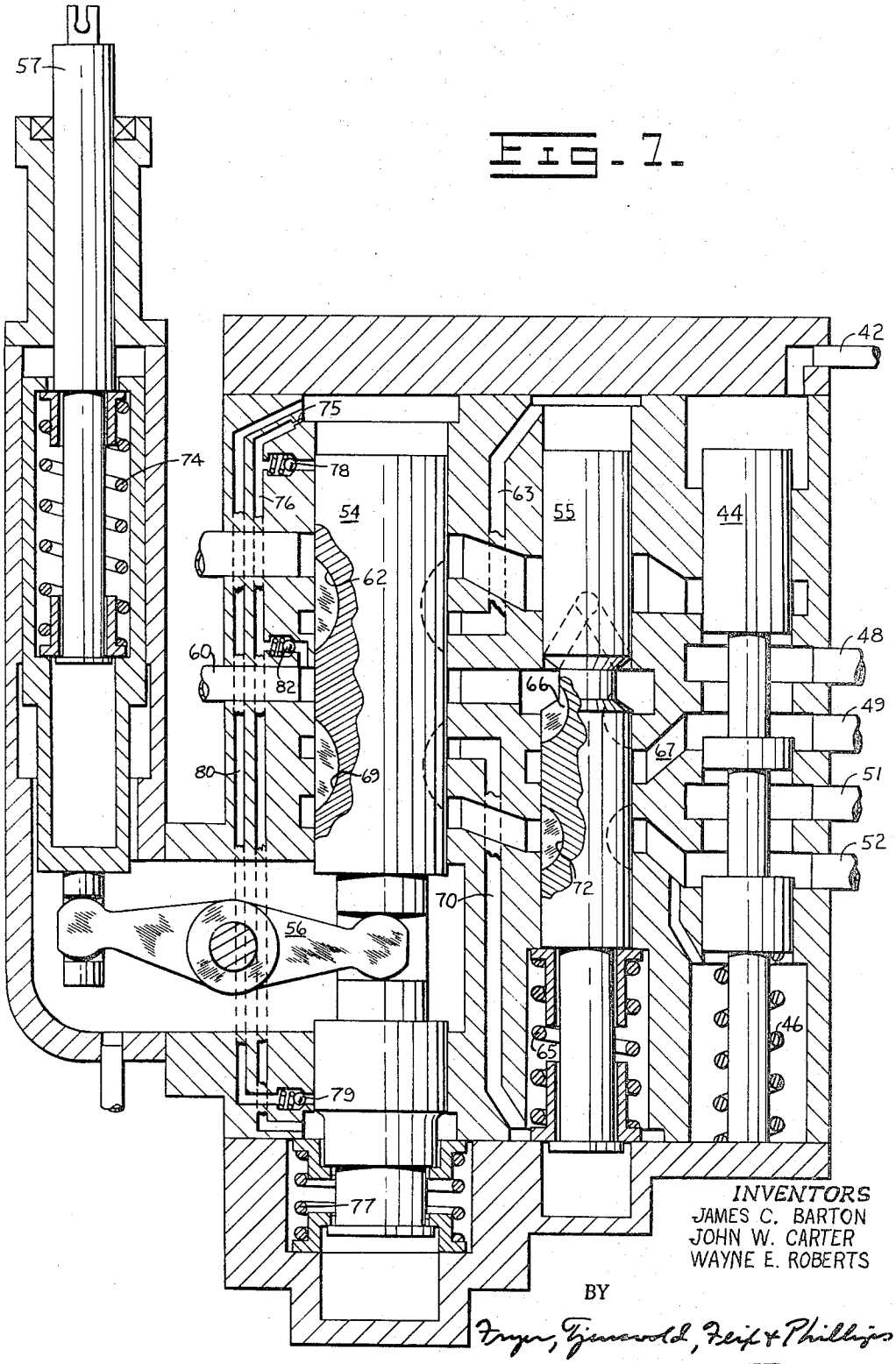
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Fig. 7.



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3,311,389

SYSTEM FOR CONTROL OF PITCH AND BOUNCE IN TRACTOR-TRAILER COMBINATIONS

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Filed June 7, 1965, Ser. No. 461,887
5 Claims. (Cl. 280—489)

This invention relates to improving the riding qualities and reducing stresses in the structural components of tractor-trailer combinations and particularly to such combinations wherein the tractor is of the two-wheel type.

In some two-wheel tractor applications, and particularly in a two-wheel tractor and two-wheel earth-moving scraper combination, the resiliency of the tires and the weight of the scraper suspended between the front and rear wheels of the combination during the haul at relatively high speeds create an intolerable vertical or bouncing movement. In addition to bouncing of the tractor, there are operating conditions which cause it to pitch or rock about the axis of its two wheels. The predominating types of bouncing and pitching under different operating conditions are illustrated and will be more fully discussed in the ensuing description.

Former attempts at improving the riding qualities of two-wheel tractor-scraper combinations have resulted in noticeable suppression of bounce but have failed to produce acceptable corrections of pitch. It is the object of the present invention to provide a system capable of suppressing both bounce and pitch with a single cushioning or spring device.

A further object is to combine with such a system an automatic levelling or control device to compensate deflection of the spring mechanism caused by loading and unloading of the scraper.

A still further object is to provide means for locking out the system effectively to prevent resilient action when the scraper is in the loading part of a cycle.

Still further objects and advantages of the invention and the manner in which the objects are attained is made apparent in the following specification by reference to the accompanying drawings.

In the drawings:

FIG. 1 is a schematic view in side elevation of a two-wheel tractor and trailer combination, the trailer being in the form of an earthmoving scraper of conventional design and showing the present invention applied;

FIGS. 2, 3, 4 and 5 are schematic views illustrating different types of vibration to which the tractor-trailer combination is commonly subjected;

FIG. 6 is an enlarged view in side elevation of the controlling mechanism of the present invention illustrating the hydraulic circuit therefor schematically; and,

FIG. 7 is an enlarged view in section of one of the valve mechanisms illustrated in FIG. 6.

The principal parts of a two-wheel tractor and scraper combination are schematically illustrated in FIG. 1 of the drawings where a tractor **10** is shown as having a pair of supporting wheels, one of which is illustrated at **11**. The scraper comprises a bowl **12** pivotally supported by wheels, one of which is shown at **13**, so that it may be raised and lowered about an axis **14** common to the axis of the wheels and between the carrying position shown or a lower position where a cutting edge **15** engages and cuts earth to fill the bowl as the scraper moves forwardly. A draft assembly comprises spaced arms, one of which is illustrated at **16**, pivoted as at **17** to opposite sides of the bowl and rigidly connected with a forwardly extending gooseneck **18** secured to the tractor through a hitch assembly generally indicated at **19** to which the draft assembly is pivotally connected as at **20**.

A conventional apron **21** is pivoted to the sides of the bowl as at **22** and may be moved to and from a position closing the front of the bowl by means of linkage **23** and suitable power means (not shown). The forward end of the bowl is raised and lowered by power means herein shown as a hydraulic jack **24** extending between a bracket on the gooseneck **18** and the forward portion of the bowl. A pair of jacks is often used for this purpose. Extension of the jack or jacks positioned as shown lowers the bowl to its scraping position while retraction thereof raises it to the carrying position shown and the bowl swings about the axis **14**. Consequently, the entire bowl structure, including the draft connection, may be considered as a weight capable of oscillating about the axis **14** and prevented from doing so only by the connection of the forward end with the tractor.

The present invention takes advantage of this pendulum-like weight and provides the means to permit limited cushioned swinging or oscillation of the scraper about its supporting axis and means for tuning this vibratory movement to a frequency so regulated with respect to the natural frequency of the bouncing motion caused by the large rubber-tired wheels **11** and **13** as to modify or cancel out the bouncing motion.

The predominant types of bounce and pitch which impose high stresses on the machine components and cause operator discomfort are schematically shown in FIGS. 2–5, inclusive. FIG. 2 illustrates what is known as empty bounce when the scraper is unloaded and the tractor is bouncing in a substantially vertical direction which is actually on an arc struck from the axis of the scraper wheels as represented by the arrow A. Since the empty scraper is not sufficiently heavy to create dangerous stresses in machine components, this type of vibration is objectionable principally because of discomfort suffered by the operator.

FIG. 3 shows a type of vibration which has been classified as empty pitch in which the wheels of the scraper are in effect bouncing vertically or on the arc represented by the arrow B and causing the tractor to pitch forwardly about the axis of its wheels. This pitching of the empty machine is a transient vibration, less damaging to vehicle components and less annoying to the operator than other types of vibration.

FIG. 4 illustrates what is known as loaded bounce type of vibration wherein the tractor and scraper are undergoing a vertical motion simultaneously. This creates excessive stresses in the machine components due to the very heavy loads supported between the widely-spaced forward wheels of the tractor and rear wheels of the scraper. It does not, however, subject the operator to severe discomfort.

FIG. 5 is an illustration of a vibration known as loaded pitch wherein the scraper with a load is tending to bounce upwardly as on an arc represented by an arrow C struck from a center which may be, for example, at D. At the same time the wheels of the tractor are moving downwardly on an arc represented by an arrow E struck from the same center D. This type of vibration also introduces severe stresses to the components though they may not be as severe as those produced by the loaded bounce type of FIG. 4. The loaded pitch of FIG. 5 also creates an uncomfortable situation for the operator because of the tendency of his seat to throw him forwardly.

The hitch assembly is more clearly shown in FIG. 6 wherein the vertical pivot **20** is illustrated as connecting the gooseneck **18** with a bracket **30** which is in turn pivotally connected by links **31** and **32** with an A-frame **34**. This A-frame comprises a conventional part of hitches of this type and is itself pivoted as by pins **35** and **35'** on a horizontal axis with the tractor frame.

Vertical movement between the tractor and the bracket **30** made possible by links **31** and **32** is cushioned by a hydraulic cylinder **36** pivotally connected to the bracket **30** and having its rod **37** pivotally connected to the A-frame. A pair of accumulators **38** are in circuit with the cylinder **36** to provide the cushioning effect when cushioning is desired and may be disassociated therewith when cushioning is undesirable as, for example, when the scraper is engaged with the ground. The vibrations of the scraper or secondary mass may be tuned to the desired spring rate and frequency relative to the vibrations of the tractor or primary mass by proper selection of the areas of the pistons in accumulators **38**, the volume of the upper chamber of the accumulators and the initial precharge pressure thereof. In this manner the system is made to function as a tuned and damped absorber to cancel or oppose the vibrations of the tractor. It is apparent that the cushioning of vertical movement between the tractor and scraper would normally be cushioned by the vertically disposed hydraulic cylinder **36** and this has been accomplished by using parallel links in place of the links **31** and **32** which, in the present construction, are not parallel but form a trapezoid. Because of the inclination of the upper link **31** with respect to the link **32**, and when torsional forces represented by an arrow W are being transmitted through the linkage due to pitching vibrations, a force diagram is produced which, as distinguished from the unidirectional arrow existing on the link **32**, comprises two angularly related components represented by arrows X and Y which produce a resultant force represented by arrow Z. Since this force is vertical, it induces relative vertical motion between the forward end of the scraper and the tractor which is also cushioned by the vertically disposed cylinder **36** so that the pitch type vibrations which create this force diagram are cushioned by the same mechanism which serves to cushion the bounce-type vibrations. While the links **31** and **32** are illustrated as forming a trapezoid, other nonparallel arrangements are operable such, for example, as a trapezium.

This means for locking out the bounce suppression circuit includes a manual valve with a spool **40** controlled as by a lever **41** to direct fluid in the position shown from the pump through a line **42** and to one end of a lockout valve in a housing **43** which lockout valve has a spool **44** shown in FIG. 7. With spool **44** held in the position shown against the pressure of a spring **46**, the head end of the jack communicates with the accumulators by communication between lines **48** and **49** with line **48** having a restriction **48***a* to dampen the velocity of relative motion of piston **37** and cylinder **36**. At the same time the rod end of the jack is vented or connected with the tank **50** through lines **51** and **52** and communicating conduits shown in FIG. 6. When it is desired to operate without the cushioning effect of the jack and accumulator valve, lever **41** is shifted to the left as viewed in FIG. 6 blocking pressure from the pump and establishing communication between line **42** and the tank **50** to permit spool **44** of FIG. 7 to move upwardly under the influence of its spring, thus closing communication between the head end of the cylinder **36** and the accumulators and establishing communication between lines **49** and **51** so that the accumulator pressure is directed to the rod end of the jack. This pressure moves the rod upwardly with respect to the cylinder which in effect lowers the bracket **30** until it is solidly supported with respect to the tractor.

To be most effective in cushioning, the piston of cylinder **36** should normally assume an intermediate position with respect to the ends of the cylinder. Since this position would vary greatly when the scraper is loaded or unloaded, levelling means are provided to vary the effective volume of oil in the cylinder and accumulators as the position of the parts tend to vary with variation in load. This is accomplished with a pilot valve having a spool **54** shown in FIG. 7 and a levelling valve with a

spool **55**. The pilot valve spool is adjusted by a lever **56** controlled by a link **57** connected as shown in FIG. 6 with an extension **58** of the upper link **31** of the trapezium connection. When the scraper is being loaded and the increasing weight tends to move the cylinder **36** downwardly with respect to its piston, fluid is added to the head end of the cylinder. This occurs when extension **58** through link **57** swings lever **56** clockwise and adjusts pilot valve spool **54** downwardly until pump pressure is communicated through a line **60** and through slots **62** in spool **54** to a passage **63** leading to one end of the spool **55** of the levelling valve. This spool is thus moved downwardly against the force of a centering spring **65** until pressure is communicated through slots **66** and passage **67** to the head end of the jack and to the accumulators via lines **48** and **49**, respectively. Thus, the volume of oil in the head end of the jack is augmented until the forward end of the scraper is raised sufficiently to again neutralize the pilot valve spool **54**.

Upward movement of the forward end of the scraper tends to occur when its load is discharged because of the high pressure in the head end of the jack. This tendency to move upwardly is transmitted through the link **57** to move the lever **56** counterclockwise, thus adjusting spool **54** of the pilot valve upwardly and communicating pressure from line **60** through slots **69** and passage **70** to the lower end of levelling valve spool **55**, thus moving spool **55** upwardly and forming communication through slots **72** between passage **67** and line **52** and consequently venting the head of the piston and the accumulators to tank.

Link **57** includes telescoping elements which are separated by a spring **74** in a conventional manner to permit partial collapsing or extension of the link in the event of retarded action of other parts. Such retarded action, for example, is purposely designed to prevent operation of the levelling mechanism upon sudden, temporary loading as occurs when the wheels encounter an obstruction and the machine is jolted. In this case, action of the pilot valve is delayed by a restriction shown at **75** in a passage **76** which communicates between opposite ends of the spool, thus action of the spool is slow though sufficiently fast to accommodate the gradual increase in load as the scraper is loaded. Return of the spool by its centering spring which is shown at **77** is, however, more rapid since when the spool has left center in either direction, a passage to a pair of check valves **78** and **79** is uncovered and these check valves permit unrestricted flow through lines **76** and **80**, respectively, to the opposite ends of the valve spool. A third check valve shown at **82** permits pump pressure from line **60** to make up oil at either end of the spool **54** in the event of leakage.

When the levelling system has, in effect, been disabled by actuation of spool **40** to discontinue pressure to the accumulators and the head end of the cylinder, it is desirable that pressure be communicated to the rod end of the cylinder to forcibly hold the forward end of the scraper in its lowermost position. This takes place automatically because as the forward end of the scraper moves downwardly by gravity, it raises link **57** upwardly, moving lever **56** clockwise and lowering spool **54** of the pilot valve. This communicates pump pressure from line **60** through slots **62** and passage **63** to the upper end of levelling valve spool **55**. This spool is then moved downwardly against the bias of its centering spring and pump pressure from line **60** is communicated through slots **66** to passage **67** and, thus, to accumulator line **49** and cylinder rod end line **51** since the lockout valve spool **44** is now urged upwardly by its spring **46**.

Since the existence of pressure in a system including accumulators and cylinders and the like is dangerous in an unattended machine, a valve is provided to vent the system automatically when the tractor engine and, therefore, the hydraulic pump is shut down. This venting system, as shown in FIG. 6, includes a spool **83** normally held by pump pressure in the position shown and against

the bias of a spring 84. Upon failure of the pump from any cause, the spring 84 moves the spool 83 toward the right, providing communication between a line 86 and the accumulators and a line 87 to the tank. In this manner all pressure fluid is vented from the system to permit the forward end of the scraper to move downwardly by gravity so that it is solidly supported on the tractor. This effectively prevents unpredictable collapsing of the spring system over a period of time due to leakage through the valves and past the piston of cylinder 36.

We claim:

1. A system for controlling both bounce and pitch-type vibrations at the articulated connection between vehicle components comprising at least two links pivotally connected with each of said components, spring means forming a connection between said components for lineal deflection in response to relative vertical motion between the components caused by bounce-type vibration, said links being nonparallel whereby pitch-type vibrations between the components will induce relative vertical motion and lineal deflection of the spring means, said spring means being a hydraulic pneumatic cylinder capable of being tuned and damped.

2. The combination of claim 1 for use in earthmoving equipment with means to render the spring ineffective during selected portions of an earthmoving cycle.

3. The combination of claim 1 with levelling means comprising means effective upon increasing and decreasing weight supported by the cylinder to add or subtract hydraulic fluid therefrom.

4. The combination of claim 3 including means to retard the flow of levelling fluid, and resilient link means in the levelling control to absorb shocks and prevent levelling in response thereto.

5. The combination of claim 1 in which hydraulic fluid supporting one component in a raised position relative to the other is supplied by a pump, and means for venting such fluid from the cylinder automatically upon shutdown of the pump.

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