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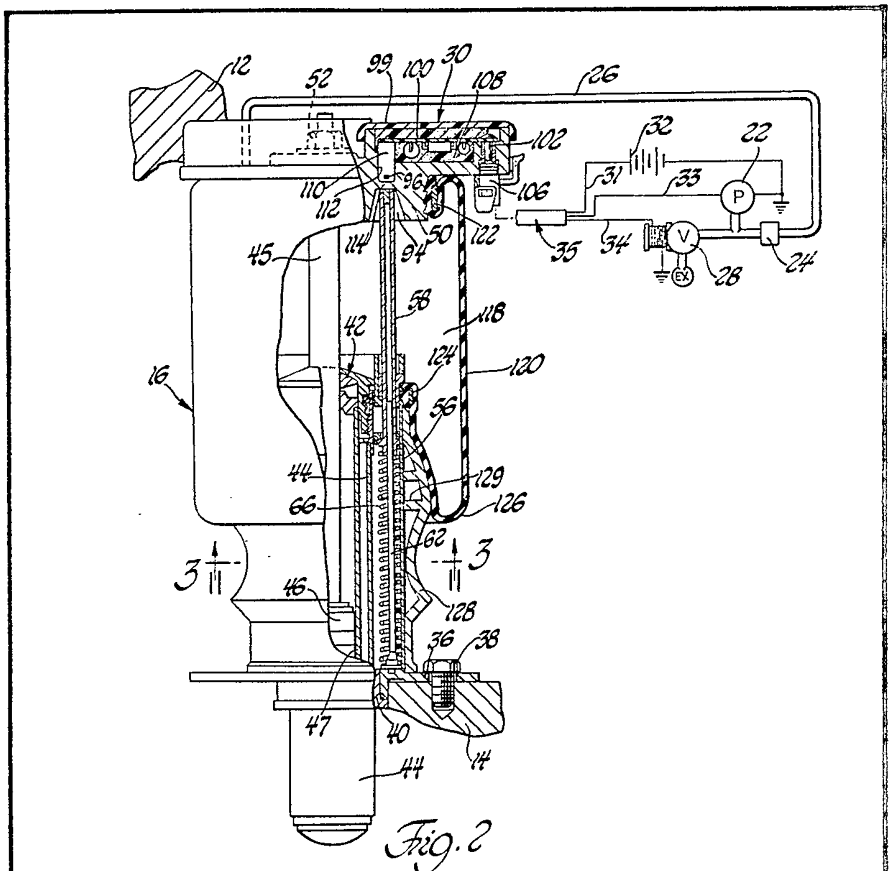
(54) Position Control Systems

(57) A magnetic height sensor 30 is provided in a self-levelling vehicle suspension unit comprising an air spring 16 that includes a pressurized chamber 118 and is connected between sprung and unsprung vehicle masses 12 and 14. In one embodiment, magnets 90 and 92 located on a pair of followers 58 and 60 within the chamber and attached for movement with the unsprung mass produce magnetic fields which pass through the wall of the chamber, and a pair of detectors 96 and 98 outside the chamber and mounted on the sprung mass for movement therewith detect the magnetic fields of the magnets and thereby the position of the followers to determine the relative spacing of the sprung and unsprung masses.

In a second embodiment, the magnetic devices 170, 172 and the detectors 166, 168 are all outside the chamber 162, and a follower 142 inside the chamber selectively interrupts the magnetic field between the magnetic devices and the detectors to determine the relative spacing of the sprung and unsprung masses.

The sensor controls supply and exhaust of air to/from the air spring, but does not respond within a dead band.



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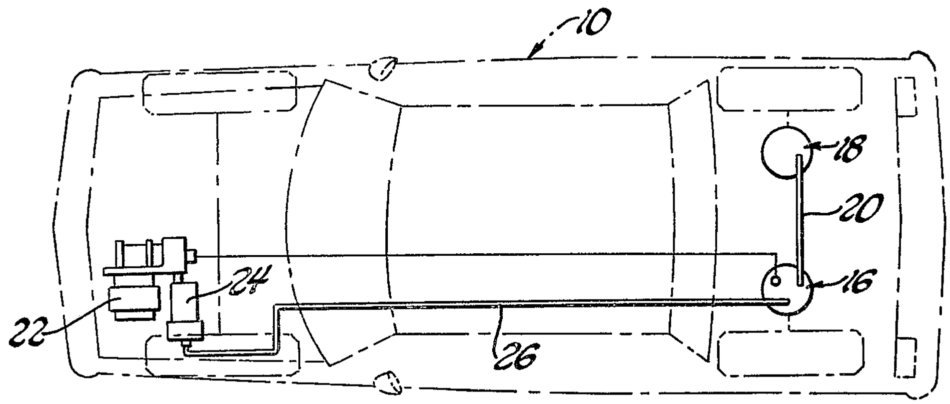

Fig. 1

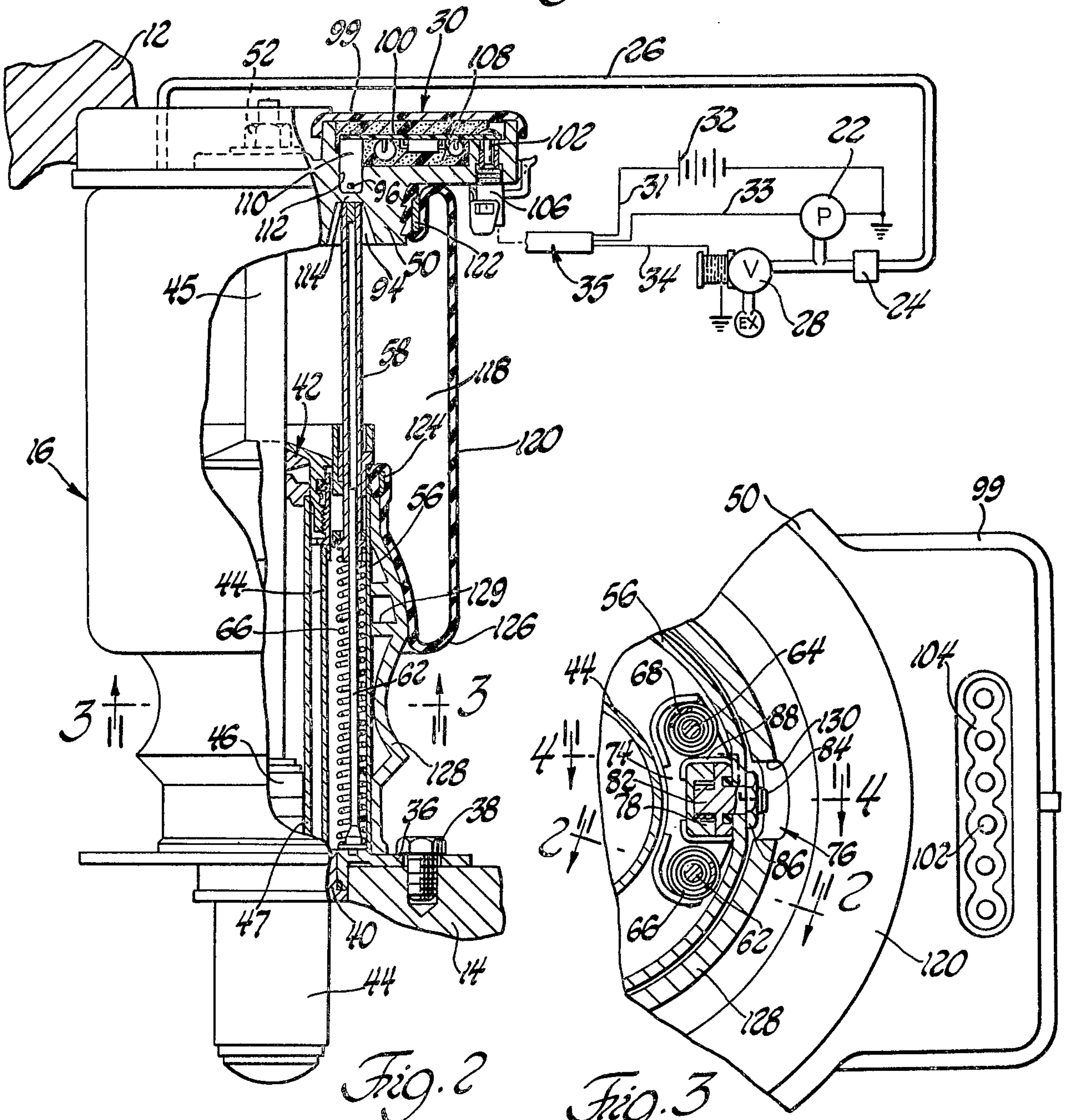

Fig. 2

Fig. 3

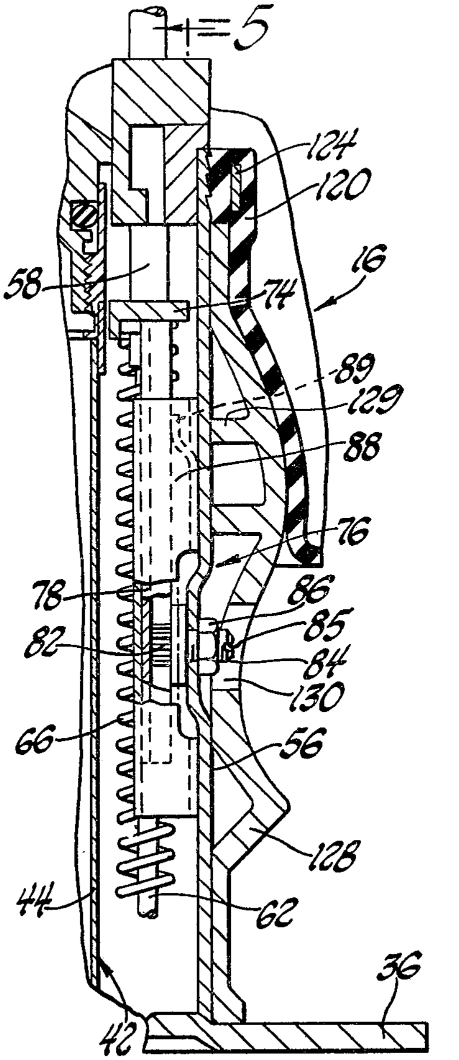

Fig. 4

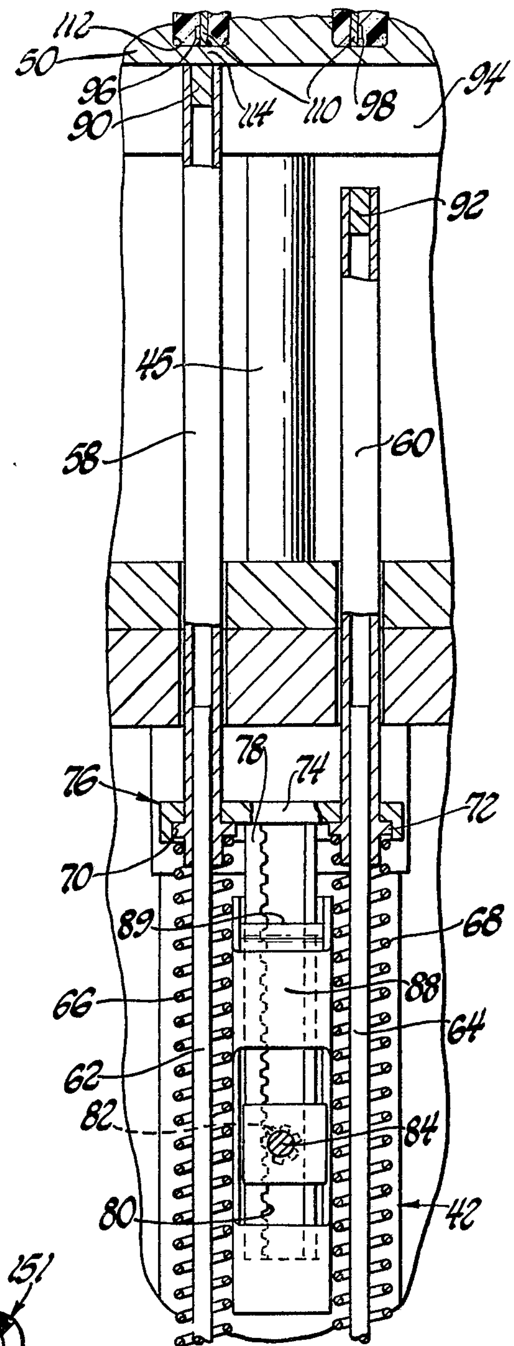

Fig. 5

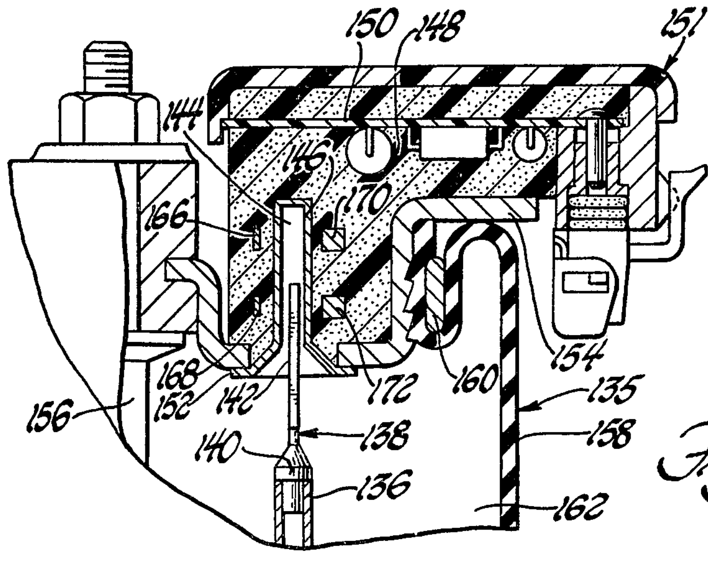

Fig. 6

SPECIFICATION

Position Control Systems

This invention relates to position control systems.

The invention is particularly concerned with such control systems usable in vehicle suspension systems to provide automatic level control for maintaining the vehicle at a design trim height.

Hitherto, many levelling systems have been employed to adjust the trim height of a vehicle by varying the distance between the sprung and unsprung vehicle masses. With such systems, various loads and load distributions can be handled to improve the stability and operating characteristics of a vehicle. In some of these systems air-adjustable shock absorbers have been employed in conjunction with mechanical suspension springs. With appropriate control over the supply and exhaust of air to such air-adjustable shock absorbers, spring rate can be varied to adjust vehicle trim height in accordance with load conditions. However, although these prior systems have been satisfactory and have successfully met prior needs, they often cannot fully meet new automotive standards, in which reduced weight is required for improved fuel efficiency and where an improved suspension is required for smaller vehicles that experience a substantial increase in the proportional difference in the load on the vehicle's suspension system as between its loaded and unloaded condition.

By the present invention there is provided a control system for adjusting the relative position of two members that are relatively movable with respect to one another comprising motor means operatively disposed between and interconnecting the members for movement towards and away from one another, follower means mounted internally of the motor means and operatively connected to one of the members and movable therewith relative to the other of the members, sensor means supported by the other of the members externally of the motor means for sensing the position of the follower means, the sensor means being responsive to the position of the follower means and operatively connected to an electrically energizable control circuit for triggering the circuit to produce predetermined electrical signals, energizable activator means operatively connected to the control circuit and responsive to the predetermined electrical signals for activating the motor means for moving the members away from one another in response to the positioning of the follower means at a first position with respect to the sensor means and to further effect movement of the member towards one another in response to the positioning of the follower means at a second position with respect to the sensor means, the first and second positions being at a predetermined distance from one another to define a zone in which the motor means is free from activation by the circuit and the activator means.

In the context of the present invention, high-pressure pneumatic springs are preferably employed in conjunction with double-acting hydraulic shock absorbers coupled therein to damp oscillations and vibratory action of the pneumatic springs.

Position-responsive follower rods can be mounted within the pneumatic chambers of the springs, and, without breaching the integrity of the high pressure chamber of the springs, provide information to sensor means disposed externally of the chamber as to the attitude or position of the sprung mass of the vehicle relative to the unsprung mass.

In one preferred embodiment of this invention, a pair of adjustable follower rods unequal in length are located entirely within the confines of the high-pressure pneumatic chamber, without requiring any mechanical penetration of the chamber. These rods extend vertically from a support constituted by a bottom plate secured to the unsprung mass of the vehicle, towards a top plate secured to the sprung mass of the vehicle. The rods are mounted so that they are capable of being telescoped inwardly by an upper cap as the sprung and unsprung masses of the vehicle attain a predetermined distance from one another. The rods are spring-biased outwardly from a fully telescoped position to a predetermined extended distance. Each of the rods has a permanent magnet in the upper end thereof which generates a magnetic field that under certain conditions excites a respective Hall effect device mounted in an integral height sensor externally of the pneumatic spring. This height sensor, operating through a module, signals an electrically driven compressor to supply air to the air springs under certain conditions, or signals an exhaust valve to exhaust air from the spring under certain other conditions. When the vehicle is at trim height, the pressure conditions within the pneumatic chambers are effectively maintained.

The Hall effect is a galvano-magnetic effect. If a magnetic field is applied to a current-carrying conductor, electrons in the conductor are deflected in a direction perpendicular to both the current flow and the magnetic field. Because the electrons must travel within the confines of the conductor, an excess of electrons on one side of the conductor relative to the other causes an electric field to be established which just opposes the force produced by the magnetic field. By applying contacts to the sides of the conductor, it is possible to detect and utilize this Hall voltage to provide a switching action.

In another preferred embodiment of the invention, the Hall effect devices and also the magnets are attached to the sprung portion of vehicle and located in a sensor unit external of the high-pressure pneumatic chamber, being separated by a gap which is adapted to receive a steel vane of a follower attached to the unsprung portion of the vehicle and disposed internally of the pneumatic chamber. In the trim position the vane interrupts the field of a lower one of the magnets, so that, exclusively, an upper one of the

Hall effect devices senses the field of an upper one of the magnets, whereby associated controls ensure that pressure air will not be supplied to, or exhausted from, the pneumatic chamber. When the vehicle sprung mass is low, the vane interrupts the field of both magnets, so that the controls ensure that pressure air will be supplied to the pneumatic chamber until the trim condition is restored. If the vehicle sprung mass is high, the Hall effect devices and their associated magnets are moved away from the vane, so that the controls will ensure that the air pressure is reduced until the trim condition is restored.

The vertical spacing between the Hall effect devices and between their associated magnets provides a null zone so that limited ride motions do not trigger the supply of air to, and exhaust of air from, the pneumatic suspension springs. By the simple replacement of the original sensor unit by a new sensor unit having different spacing between the Hall effect devices and between the associated permanent magnets, a different null zone (dead band) can readily be obtained.

In the accompanying drawings:—

Figure 1 is a diagrammatic plan view of a wheeled motor vehicle with air spring units providing the rear suspension therefor:

Figure 2 is an elevational view partially in section, of one of the air spring units on line 2—2 of Figure 3, in the direction of the arrows, with associated controls shown diagrammatically;

Figure 3 is a fragmentary view on line 3—3 of Figure 2 in the direction of the arrows;

Figure 4 is a fragmentary longitudinal section on the line 4—4 of Figure 3, in the direction of the arrows;

Figure 5 is a fragmentary view on the line 5—5 of Figure 4, in the direction of the arrows; and

Figure 6 is a fragmentary view, with parts broken away and in section, illustrating another embodiment of a control system in accordance with the present invention.

Figures 1 and 2 show an automotive vehicle 10 having sprung and unsprung masses 12 and 14 respectively operatively interconnected by a pair of air spring suspension units 16 and 18. The air spring units 16 and 18 are pneumatically interconnected by an air line 20, and can be supplied with pressurized air from an electrically driven compressor 22 by way of an air drier 24 and an air line 26 to increase the distance between the sprung and unsprung masses of the vehicle and thereby increase vehicle kerb height. Exhaust valve means 28 incorporated with the compressor and air drier is operable to exhaust pressure air from the air sprung units 16 and 18 to decrease the distance between the sprung and unsprung masses of the vehicle, to thereby lower the vehicle kerb height.

A height sensor unit 30, integral with and operatively mounted on top of the air spring unit 16, is connected by an electrical conductor 31 to a battery and is energizable thereby to generate electrical pulses which are transmitted through electrical conductors 33 and 34 of a wiring harness 35 to the compressor 22 and to the solenoid of the exhaust valve 28 to control these components.

The pneumatic air spring unit 16 has a mounting plate 36 adjacent the lower end thereof which is secured by fastener means 38 to the unsprung mass 14 of the vehicle 10. The mounting plate 36 has a central cylindrical opening therein in which a cylindrical collar 40 is secured. A double-acting hydraulic shock absorber (damper) 42, such as that disclosed in our United States Patent 3,203,511 (Long, Jr.), is secured to the collar 40. This shock absorber has an elongated cylindrical reservoir tube 44 which extends axially into the air spring unit 16. A cylindrical piston rod 45 having a piston 46 fixed to its lower end is mounted for reciprocatory movement in an oil-filled cylinder tube 47 concentrically mounted within the reservoir tube. The piston rod 45 extends through a cover 50 formed as a disc-like upper cap, in this embodiment an aluminium casting, of the air spring unit. The upper end of the piston rod is secured to the cap 50 by fastener means including a nut 52 threaded on to the end of the piston rod. With this construction, relative movements of the sprung and unsprung masses of the vehicle towards and away from one another result in reciprocatory movement of the piston and piston rod in the cylinder tube for appropriate damping of the action of the vehicle suspension spring units.

As is best seen in Figure 2, the pneumatic air spring suspension unit 16 has a cylindrical lower support 56 which is spaced radially outwardly of the shock absorber 42. The lower end of this support is secured to the mounting plate 36, and from this end the support extends upwardly and concentrically with respect to the shock absorber reservoir tube 44.

The cylindrical lower support 56 has a pair of vertical openings in a ring portion in the upper end thereof, for slidably receiving a pair of unequal-length follower tubes 58 and 60. These follower tubes 58 and 60 are mounted for telescopic vertical movement on respective vertically extending support rods 62 and 64 located between the reservoir tube and the cylindrical lower support 56. The bases of these rods are secured to the mounting plate 36. Disposed around the support rods 62 and 64 are respective helical springs 66 and 68 that have their lower ends seated on the mounting plate 36: these springs 66 and 68 spiral upwardly into engagement with respective annular shoulders 70 and 72 formed on the lower ends of the follower tubes 58 and 60 respectively. With this arrangement the follower tubes move with the unsprung mass of the vehicle relative to the sprung mass until the lower surface of the cap 50 is contacted by the ends of the respective tubes.

With the springs 66 and 68 biasing the follower tubes 58 and 60 upwardly, shoulders 70 and 72 (Fig. 5) of the respective tubes contact a portion of a cross-member 74 of an adjustable stop assembly 76 which determines the maximum outward (that is, uppermost) position of the tubes relative to the unsprung mass 14. The stop assembly further includes a rack 78 extending downwardly from the cross-member 74. The rack is formed with teeth 80 which mesh with the teeth of a spur gear 82 secured to the inner end of a rotatable adjustment shaft 84 that extends radially from the spur gear through an opening in the wall of the cylindrical lower support 56, so providing access from externally of the unit 16. The adjustment shaft 84 has a threaded outer end for receiving a nut 86 which, when advanced on the shaft into engagement with the lower support 56, locks the shaft and the spur gear against rotation, to thereby set the position of the stop assembly in an adjusted position. With the cross-member 74 thus fixed, the extent of outward movement of the follower tubes 58 and 60 is established. Seals are provided for the cylindrical lower support 56 and the adjustment shaft 84 to ensure an air-tight seal when the nut 86 is tightened on the adjustment shaft 84. The outer end of the shaft 84 is slotted at 85 for receiving the bit of a screwdriver, to allow the stop assembly 76, including its cross-member 74, to be easily adjusted upwardly or downwardly for setting the trim height of the vehicle. The rack 78 of the stop assembly 76 is slidably supported by a thin-walled cage 88 attached to the inner wall of the cylindrical lower support 56. This cage 88 embraces the rack 78, as shown in Figures 2 and 4, and has a tang 89 lanced inwardly into resilient spring engagement with the axially movable rack, to take up any play which might otherwise occur between these components.

The upper ends of the follower tubes 58 and 60 carry respective permanent magnets 90 and 92 which are fixed into the tubes and are adapted to be positioned by the tubes under certain conditions into a recess 94 formed in the underside of the cover 50. These magnets and their fields are movable relative to a pair of Hall effect devices 96 and 98, as will be hereinafter described.

To accommodate the height sensor unit 30, the aluminum cap 50 has formed in the outer side thereof a rectangular recess fitted with a removable plastics cover 99. A circuit board 100 containing an electronic circuit for height control is secured within a box so formed. The circuit board includes terminals 102 at one edge thereof, and a port 104 in the aluminum cap accommodates an electrical connector 106 from the wiring harness 35, which plugs into the terminals. Except for the terminals, the component side of the circuit board is embedded in a conventional potting compound 108. The hall effect devices 96 and 98 are mounted on posts 110 that depend from the circuit board 100 into a recess 112 formed in the top surface of the cap 50. The recess 94 for the magnets 90 and 92 is separated from the recess 112 for the Hall effect devices 96 and 98 by a thin wall 114 of the aluminum casting constituting the ap 50.

When the compressor 22 is energized by the battery 32, pressurized air will be supplied by the compressor through the line 26 into an expansible and contractible pressure chamber 118 formed by a sleeve 120 of a fabric-reinforced elastomeric material which is disposed around the piston rod 45 and the upper portion of the shock absorber. The upper end of the sleeve 120 is secured in an air-tight manner by a steel band 122 to an annular and downwardly extending neck portion of the cap 50. The lower end of the sleeve is reversely curved inwardly, and is attached to the upper end of the cylindrical lower support 56 by a band 124. The sleeve forms a rolling lobe 126, which contacts and rolls over the profiled outer periphery of a fixed piston 128 that is disposed around the cylindrical lower support 56 and has internal ribs 129 contacting the support to provide a firm base for the lobe as it rolls on the profile provided by the varying diameters of the fixed piston. An opening 130 in the piston 128 provides an access opening to the height adjustment shaft 84. As the load on the sprung mass is increased, the distance between the sprung and unsprung masses of the vehicle decreases, as the lobe rolls downwardly on the fixed piston 128. Conversely, as the load on the sprung mass decreases, the sprung and unsprung masses of the vehicle are moved away from one another by the air spring, with the lobe rolling upwardly on the fixed piston 128.

Figures 2 and 5 illustrate the air spring units suspending the vehicle body at a predetermined trim height with respect to the unsprung vehicle mass and the roadway. In this condition, the magnetic field of the permanent magnet 90 is sensed by the Hall effect device 96, but the Hall effect device 98 is not close enough to the field of its associated magnet 92 for the associated circuitry to be affected. Under such conditions the circuit pulses in response to the output of only the Hall effect device 96, to close the exhaust valve and shut off the compressor 22, so that air is not supplied to or exhausted from the air springs of the suspension units 16 and 18.

If the load on the vehicle is increased to cause the sprung mass to move towards the unsprung mass, the cap 50 causes the follower tube 58 to move downwardly, with the elastomeric sleeve 120 rolling downwardly on the contoured piston 128. When the cap 50 in its downward movement exceeds a predetermined 15 mm downward dead band movement, the cap will come into close proximity to the permanent magnet 92 disposed on the follower tube 60. When the flux field of this magnet 90 is sensed by the Hall effect device 98, the circuit responds by energizing the compressor, to supply pressure air to the air spring units 16 and 18 by way of the line 26. The Hall effect device 96 continues to provide an output, and the exhaust valve remains closed. Pressurized air supplied by the compressor increases the pressure in the chamber 118, so causing the air spring to increase in length and the rolling lobe 126 to roll upwardly on the fixed piston 128. This continues until the point is reached at which the vehicle has been returned to the trim, and the magnetic field of the permanent magnet 92 is no longer sensed by the Hall effect device 98, whereby the compressor is de-energized.

If the load on the vehicle is reduced to cause the cap 50 and the Hall effect devices 96 and 98 to move upwardly from the Figure 5 position by air spring elongation, and thus away from close proximity to the field of the magnet 90, the Hall effect device 96 is no longer able to respond to the field of the magnet 90, and the Hall effect device 98 remains in an "off" state. Under these conditions the pulsing circuit effects energization of the solenoid of the exhaust valve 28 to release air pressure from the pressure chamber 118 of the unit 16 and the corresponding chamber of the unit 18. The compressor remains denergized, and as a result of the pressure reduction in the chamber 118 the air spring contracts and the sprung portion of the vehicle moves towards the unsprung portion 14 until the trim height position of Figure 2 is re-established.

In the event that trim adjustment is needed, the nut 86 is loosened and the adjustment shaft 84 is turned to raise or lower the cross-member 74 of the adjustable stop assembly 76, and hence vary the uppermost positions of the follower tubes 58 and 60. If the trim height needs to be reduced, the adjustable stop assembly 76 is moved downwardly so that the sprung mass of the vehicle will move downwardly to establish a new, lower trim condition of the suspension. If the trim height needs to be increased, the adjustable stop assembly 76 is moved upwardly, whereby the magnets 90 and 92 can move upwardly to a higher predetermined position. The trim operation will be as previously described.

In this embodiment of the invention, static and dynamic seals have been eliminated, since the Hall effect devices can sense the presence of the moving magnetic fields through the aluminum cap 50.

Another embodiment of a control system in accordance with the invention is illustrated in Figure 6, which shows a pneumatic air spring suspension unit 135 similar to the unit 16 of the illustrated first embodiment. Explanation of the Figure 6 embodiment will thus be necessary only in respect of the differences where major constructional and operational changes are involved these differences mainly involving the Hall effect devices and their control by the internal follower attached to the unsprung mass of the vehicle. In the Figure 6 embodiment, the air spring unit 135 has a rolling-lobe air spring and shock absorber construction corresponding to that of the unit 16 shown in Figure 2, but only a single follower tube 136 is employed instead of the pair of follower tubes 58 and 60 in the Figure 2 embodiment. This tube 136 is spring-biased upwardly and is telescopically mounted on a rod, in the same way as are the tubes 58 and 60 in the Figure 2 embodiment. A steel insert 138 carried by the tip of the follower tube 136 has a shouldered base 140 received in the end of the tube, and a flattened vane 142 that extends upwardly from the base. The vane 142 is adapted to be received in an elongated recess 144 formed by a thin-walled stainless steel insert 146 embedded in potting compound 148 mounting the component side of a circuit board 150 of an integral height sensor unit 151, which is the same as unit 30 of the Figure 2 embodiment. The insert 146 has a flared mouth portion 152 which is laser-welded or otherwise secured in an air-tight manner to a metallic upper cap formed by a cover plate 154 of the pneumatic suspension spring unit.

The cover plate 154 is secured to the sprung mass of the vehicle and to a piston rod 156 of a shock absorber employed therewith and corresponding to the shock absorber 42 of the first embodiment. Also, a cylindrical sleeve 158 of fabric-reinforced rubber is attached to an annular shoulder portion of the cap 154 in an air-tight manner by a band 160. The sleeve 158 forms an expandible and contractible pneumatic chamber 162, with pressurized air being supplied to and exhausted from this chamber as in the Figure 2 embodiment of this invention.

In this Figure 5 embodiment, upper and lower Hall effect devices 166 and 168 connected by conductors (not shown) to the circuit board 150 are embedded in the potting material adjacent the elongated recess 144. These Hall effect devices are operative to sense the magnitude of magnetic fields produced by respective upper and lower permanent magnets 170 and 172, and provide outputs correspondingly. The circuit of the integral height sensor unit 151 responds by producing electrical signals triggering operation of the compressor and exhaust valve, generally as described in connection with the first embodiment of the invention. However, in this Figure 6 embodiment the different combinations of outputs from the Hall effect devices are obtained by interrupting the flux patterns of the magnetic fields of the magnets 170 and 172 in accordance with the position of the flattened vane 142.

Specifically, in the Figure 6 position the vehicle is at trim height, and only the Hall effect device 166 is activated, whereby the logic in the sensor unit causes both the compressor and the exhaust valve to be de-activated.

If the load on the vehicle is increased, the pneumatic spring will deflect and the sleeve 158 will roll on the fixed piston 128 as the sprung mass moves downwardly with respect to the unsprung mass. When the field between the magnet 170 and the Hall effect device 166 is thereby interrupted by the vane 142, the control circuitry effects operation of the compressor to supply pressure air to the chamber 162, with the exhaust valve remaining inactivated. The cap 154 and the sprung mass of the vehicle will thereupon be caused to move upwardly to the trim height condition shown in Figure 6, at which point the compressor will be de-activated.

If an excess amount of pressurized air is supplied to the chamber 162, or if the vehicle is unloaded, the air spring unit 135 will move the sprung mass of the vehicle upwardly with respect to the unsprung mass, whereby the fields of both the magnets 170 and 172 will be sensed by the associated Hall effect devices. Under such conditions the circuitry triggers energization of the coil of the exhaust valve, so that pressure air is removed from the chamber 162, with the compressor remaining de-activated. The sprung mass of the vehicle thereby moves downwardly until trim height is re-established, whereupon the exhaust valve is once again closed.

In this second embodiment of the invention the Hall effect devices 166 and 168 and the magnets 170 and 172 are external of the pneumatic chamber 162, so that no special sealing is needed for these components.

In the Figure 6 embodiment of the invention, the height sensor unit 151 can be replaced by a similar type of sensor unit with a larger or a smaller vertical spacing between the magnets and between their associated Hall effect devices, to correspondingly increase or decrease the width of the trim (null) zone. In the Figure 2 embodiment this result can readily be achieved by variation of the relative lengths of the two follower tubes 58 and 60, inasmuch as by having a small differential between the lengths of the follower tubes 58 and 60 a narrow trim zone is established, and conversely by having a larger differential between the lengths of the follower tubes 58 and 60 a correspondingly wider trim zone is established. After the height differential has been set, the uppermost positions of the follower tubes can, as stated above, be varied upwardly or downwardly to accordingly adjust the trim zone upwardly or downwardly with respect to the unsprung mass.

The aforedescribed embodiments of a control system in accordance with the invention permit improved fuel efficiency with a new and improved lightweight ride control system that effectively maintains high ride quality and further meets consumer needs for passenger and luggage capacity. The improved attitude control and levelling system effectively replaces the prior type of mechanical suspension spring and air-adjustable shock absorber system. The present lightweight and automatic level control system as described is more responsive to load conditions and quickly adjusts to the prevailing load conditions to keep the vehicle in trim. The prior mechanical suspension elements, notably torsion bars, coil springs and leaf springs, are not necessary in the context of the new and improved air spring units. In addition to the use of air springs replacing the mechanical springs, further imrovements are made within the scope of this invention by providing automatic adjustment of the spring rate of the air spring to provide for improved attitude control over the suspension system, which control is responsive to a wide range of load conditions from a full maximum load to an unloaded operating condition.

Claims

1. A control system for adjusting the relative position of two members that are relatively movable with respect to one another comprising motor means operatively disposed between and interconnecting the members for movement towards and away from one another, follower means mounted internally of the motor means and operatively connected to one of the members and movable therewith relative to the other of the members, sensor means supported by the other of the members externally of the motor means for sensing the position of the follower means, the sensor means being responsive to the position of the follower means and operatively connected to an electrically energizable control circuit for triggering the circuit to produce predetermined electrical signals, energizable activator means operatively connected to the control circuit and responsive to the predetermined electrical signals for activating the motor means for moving the members away from one another in response to the positioning of the follower means at a first position with respect to the sensor means and to further effect movement of the members towards one another in response to the positioning of the follower means at a second position with respect to the sensor means, the first and second positions being at a predetermined distance from one another to define a zone in which the motor means is free from activation by the circuit and the activator means.

2. A control system according to claim 1, in which the motor means comprises a pneumatic spring, the energizable activator means comprises an electrically energizable compressor responsive to the electrical signals from the control circuit for supplying pressurized gas to the pneumatic spring for linearly elongating the said spring for moving the members away from one another in response to positioning of the follower means at the said first position, and electrically controlled exhaust valve means responsive to the predetermined electrical signals for exhausting air from the pneumatic spring to permit the members to move relatively towards one another in response to positioning of the follower means at the said second position, and the predetermined distance between the first and second positions defines a deflection zone for the pneumatic spring in which the compressor is inactive and the exhaust valve means is closed.

3. A control system according to claim 1 or 2, constituting an automotive suspension and level control system for adjusting the relative position of sprung and unsprung vehicle members relatively movable with respect to one another.

4. A control system according to claim 1, consituting a suspension and levelling system for maintaining at a set trim height a vehicle having sprung and unsprung masses, in which the motor means comprises an air spring adjustable in

length and including a polymeric rolling-lobe sleeve interconnecting the sprung and unsprung masses and confining a column of gas which is subject to compression and expansion and has an elasticity providing resilient mounting of the sprung mass over the unsprung mass, control means constituting the said energizable actuator means is effective in operation to supply gas to the sleeve to increase the gas pressure therein to elongate the air spring and thereby increase the distance between the sprung and unsprung masses, the control means further incorporating gas pressure exhaust means for exhausting pressurized gas from the interior of the sleeve to decrease the length of the air spring and thereby decrease the distance between the sprung and unsprung masses, first and second magnetic means within the interior of the sleeve provide separate magnetic fields which extend externally of the sleeve, a pair of follower means as aforesaid are of unequal length and separately mount the magnetic means for movement in a predetermined path within the limits of the sleeve, connector means operatively connect the follower means to one of the masses so that the follower means and the magnetic means move in the said path by distances corresponding to the relative movement of the masses, and sensor means external of the sleeve are effective in operation to sense movement of the magnetic means and trigger the controls to provide a supply of pressurized gas to the interior of the sleeve when the masses are disposed at a predetermined minimum distance from another, and to exhaust pressurized gas from the interior of the sleeve when the masses are disposed at a predetermined maximum distance from one another, the sensor having a null zone permitting limited movement of the sprung mass relative to the unsprung mass between the said minimum and maximum distances without gas being supplied to or exhausted from the sleeve.

5. A control system according to claim 4, including means extending externally of the air spring for adjusting the follower means with respect to one of the masses, to thereby adjust the trim height of the vehicle.

6. A control system according to claim 1, consituting an automatic levelling system for a vehicle having sprung and unsprung masses, in which the motor means comprises an air spring having a column of gas confined within a cylindrical sleeve of resilient polymeric material interconnecting the sprung and unsprung masses, a double-acting shock absorber is operatively disposed within the sleeve and is connected between the sprung and unsprung masses for damping the oscillatory action of the air spring, the energizable actuator means comprises an electrically driven compressor operable to supply gas to the sleeve to increase the height of the column of gas confined therein to thereby increase the suspension spring spacing between the sprung and unsprung masses, and an electrically controlled exhaust valve means operable to exhaust pressurized gas from the interior of the sleeve to decrease the height of the column of gas and thereby decrease the suspension spring spacing between the sprung and unsprung masses, magnetic means within the gas column provides a magnetic field which extends externally of the air spring, follower means as aforesaid provides a mounting for the magnetic means for movement in a predetermined path within the limits of the gas column, connector means operatively connects the follower means to one of the masses so that the follower means and the magnetic means move in the said path through distances corresponding to the relative movement of the masses, and Hall effect device means is disposed externally of the air spring for sensing movement of the magnetic means and is effective to trigger the compressor and the exhaust valve means to effect supply of pressurized gas to the interior of the sleeve when the masses are disposed at a predetermined minimum distance from one another and to exhaust pressurized gas from the interior of the sleeve when the masses are disposed at a predetermined maximum distance from one another, the Hall effect device means having a null zone permitting limited relative movement between the said minimum and maximum istances without triggering of operation of the compressor and the exhaust valve means.

7. A control system according to claim 1, constituting an automatic levelling system for a vehicle having sprung and unsprung masses, in which the motor means comprises an air spring having a column of gas confined within a rolling-lobe cylindrical sleeve of resilient polymeric material interconnecting the sprung and unsprung masses, a double-acting shock absorber is operatively disposed within the sleeve and is connected between the sprung and unsprung masses for damping the oscillatory action of the air spring, the energizable actuator means comprises an electrically driven compressor operable to supply gas to the sleeve to increase the height of the column of gas confined therein to thereby increase the suspension spring spacing between the sprung and unsprung masses, and an electrically controlled exhaust valve means operable to exhaust pressurized gas from the interior of the sleeve to decrease the height of the column of gas and thereby decrease the suspension spring spacing between the sprung and unsprung masses, cap means operatively connects one end of the sleeve to the sprung mass of the vehicle, a sensor unit is supported by the cap means, an insert extends into the sensor unit through the underside of the cap means to form an elongated recess pneumatically connected to the column of gas, the magnetic means comprises first and second magnets vertically spaced from one another and supported in the sensor unit adjacent a first side of the recess, the Hall effect device means comprises first and second Hall effect devices vertically spaced from one another and supported in the

sensor unit for sensing the magnetic field of the first and second magnets respectively, the follower means is attached to the unsprung mass of the vehicle and has a vane portion adapted to interrupt the fields of one or both of the magnets when inserted respective predetermined distances into the recess, and electrically energizable circuit means is operatively connected to the Hall effect devices for triggering the compressor and the exhaust valve means in response to the position of the vane portion with respect to the recess to effect the said supply of pressurized gas to the interior of the sleeve when the masses are disposed at a predetermined minimum distance from another, and to effect the said exhaust of pressurized gas from the interior of the sleeve when the masses are disposed at a predetermined maximum distance from one another.

8. A control system substantially as hereinbefore particularly described and as shown in Figures 1 to 5 of the accompanying drawings.

9. A control system substantially as hereinbefore particularly described and as shown in Figure 6 of the accompanying drawings.

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