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US 6431557 B1

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(54) Abstract Title
A vehicle air suspension system including trailer load measurement means

(57) A vehicle air suspension system comprises a control unit 24 which controls the flow of air to and from the air springs 16, 18 via a valve block 22. Pressure sensors 28 and ride height sensors 30 enable the control unit 24 to measure the air pressure in the air springs 16, 18 and the ride height at each of the wheels. A remote control unit 34 controls the suspension system to raise the vehicle to bring the vehicle's tow ball 42 into contact with a tow bar 44 of a trailer 46. A step change in the air pressure at the point of contact is used to measure the trailer nose load which is transmitted to the remote control unit 34 which displays it to the driver.

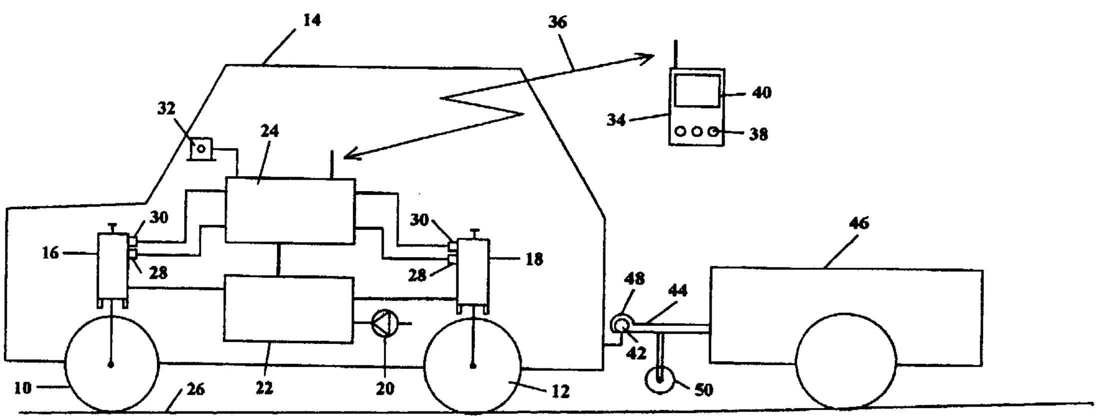

Fig. 1

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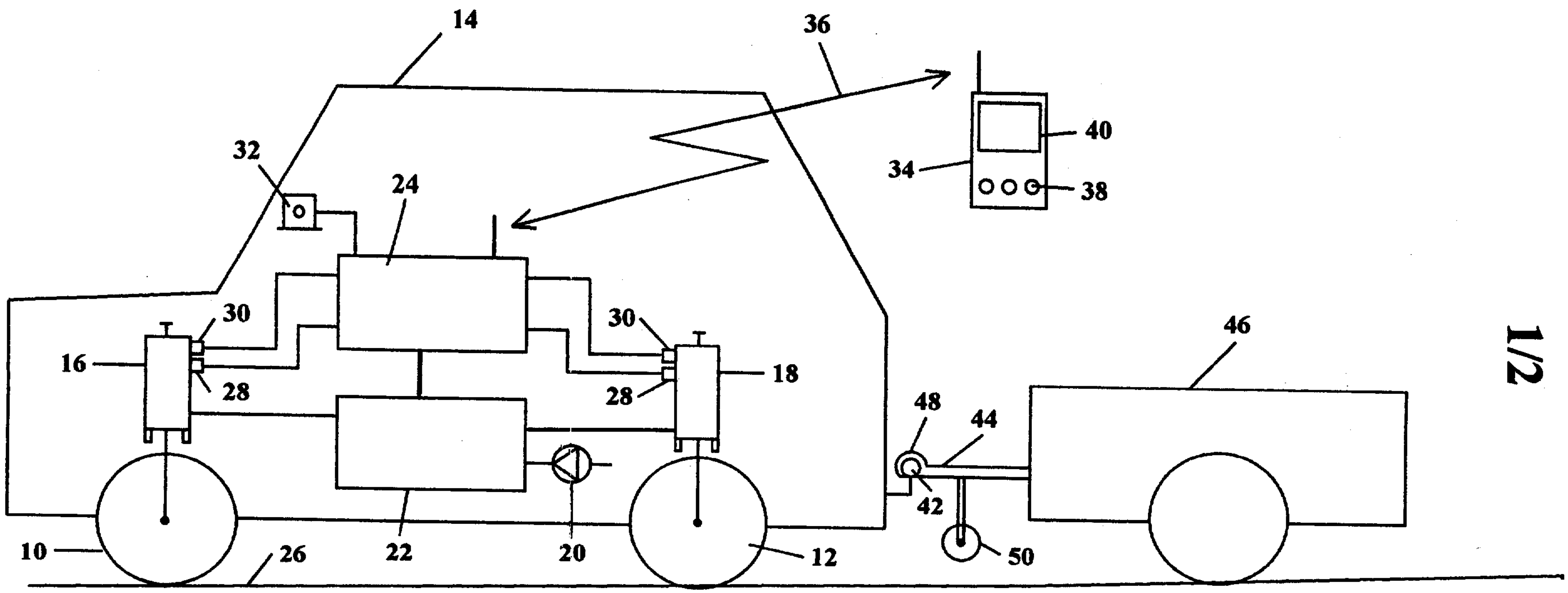

Fig. 1

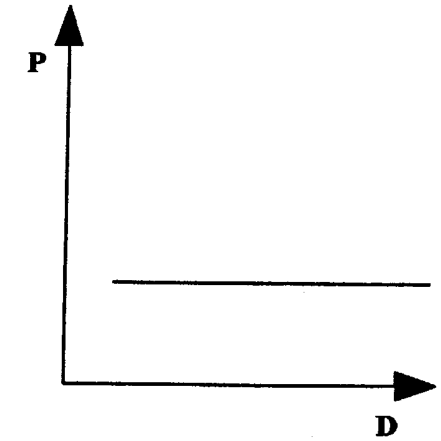

Fig. 2

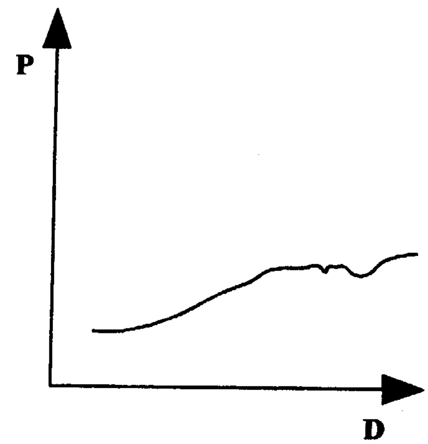

Fig. 3

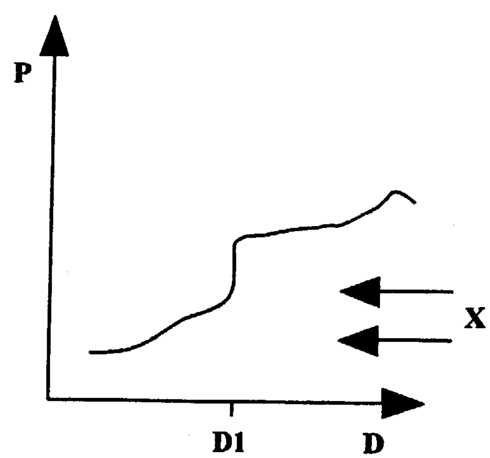

Fig. 4

TRAILER LOAD MEASUREMENT

The present invention relates to the measurement of the loads exerted by a trailer on a towing vehicle.

The stability of a trailer when being towed by a towing vehicle is affected by a number of factors, one of which is the vertical load exerted on the tow ball or other towing attachment by the front end of the trailer. This load is referred to as the trailer nose weight. It is therefore desirable that the driver of a towing vehicle can determine the nose weight of a trailer that the vehicle is towing.

The present invention comprises apparatus for measuring a load exerted by a trailer on a towing vehicle fitted with air springs, the apparatus including;

means for monitoring air pressure in at least one of said air springs,

means for varying a ride height of the towing vehicle,

means for monitoring the ride height of the towing vehicle,

and means for detecting a step change in the relationship between monitored air pressure and monitored ride height as the ride height is varied, thereby to measure said load.

In one embodiment, the means for monitoring air pressure is adapted to monitor air pressure only in an air spring fitted at the rear of the towing vehicle.

Optionally, the apparatus may be configured to apply a correction to the measured load dependent upon rotation of the towing vehicle about a trailer attachment point.

The ride height monitoring means may comprise one or more ride height sensors arranged to measure vertical travel of the vehicle body relative to the vehicle wheels. However any suitable means of measuring vertical movement of the towing attachment could be used.

Preferably the apparatus further comprises display means arranged to indicate said load to a user.

A user operable activation unit may be provided in order to communicate with the means for varying the ride height..

The apparatus may further comprise warning means arranged to provide a warning if the load exceeds a predetermined value.

Preferred embodiments of the present invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a schematic view of a vehicle including a suspension system according to the invention;

Figure 2 is a graph showing the relationship between air spring pressure and ride height in an ideal suspension system; and

Figures 3 and 4 are graphs showing variations in air spring pressure and ride height in the system of Figure 1.

Referring to Figure 1 a vehicle comprises two front wheels 10 and two rear wheels 12 and a body 14. The wheels 10, 12 and the hubs on which they are mounted, which comprise unsprung parts of the vehicle, are connected to the body by means of a suspension system which includes front air springs 16 for the front wheels and rear air springs 18 for the rear wheels. The body 14 and any parts of the vehicle that moves with it therefore form the sprung parts of the vehicle.

The suspension system further comprises a compressor 20 and a valve block 22 which includes valves which control the flow of air from the compressor to the air springs 16, 18 and from the air springs to atmosphere. An electronic control unit 24 controls the operation of the valve block 22 so as to control the volume and pressure of the air in each of the air springs 16, 18, thereby controlling the height of the body 14 relative to the wheels 10, 12 and the surface 26 on which the vehicle is standing or travelling.

An air pressure sensor 28 and a ride height sensor 30 on each of the air springs 16, 18 provide signals to the control unit 24 enabling it to measure the air pressure in each of the air springs and the ride height of the body 14 relative to each of the wheels 10, 12.

The control unit 24 controls a number of functions of the air suspension system, including the vehicle ride height, which can be considered as an average of the ride heights at each of the four wheels 10, 12. A driver input 32 is provided within the vehicle and connected to the control unit 24 to enable the driver to select one of a plurality of ride heights for the vehicle, depending on the conditions in which he expects to be driving. A remote control unit 34 is also provided which can communicate remotely with the control unit 24 by means of a communications link 36 which in this embodiment is a two way radio link. The remote control unit 34 has a user input in the form of a number of buttons 38 enabling a user to input commands which can then be transmitted to the control unit 24, and a display 40 which can display information relating to the operation of the air suspension system to the user.

A towing attachment, in the form of a tow ball 42 is attached to the rear of the vehicle body 14 and is arranged for attachment to the tow bar 44 of a trailer 46, the tow bar 44 having a socket 48 which is arranged to fit over the top of the tow ball 42. The trailer also comprises a jockey wheel 50 on the tow bar 44 which can support the front end of the trailer 46 when it is not supported on the tow ball 42.

In order to aid in hitching up the trailer 46 to the vehicle, the remote control unit 34 is arranged to allow a user to input commands to increase and decrease the vehicle ride height to raise and lower the vehicle body 14, and hence the tow ball 42. This enables the user to lower the ride height to its lowest level, move the trailer 46 so that the socket 48 is positioned above the tow ball 42 with the front of the trailer supported on the jockey wheel 50, and then raise the vehicle body and tow ball 42 so that the tow ball comes into contact with the socket and then lifts the front end of the trailer 46, lifting the jockey wheel 50 off the ground 26. During this operation the control unit 24 is arranged to measure the change in the vertical load, or nose weight, exerted by the front end of the trailer 46 on the tow ball 42 as will be described below.

Referring to Figure 2, in an ideal air suspension system in which the air springs support the entire weight of the vehicle, the air pressure P in the air springs will remain constant if air is pumped into them or released from them. Only the volume of the air in the springs will change as the vertical displacement D of the body, i.e. the ride height, changes. Changes in ride height can therefore be represented as a flat line characteristic as shown in Figure 2.

In a typical air suspension system, as the volume of air in the springs is changed to change the ride height D, the pressure also changes. This is as a result of the suspension geometry which may vary the air pressure required to support the vehicle as the ride height changes, and also due to dynamically generated changes in load, and stiction effects which will be particularly pronounced if the suspension geometry is such that a change in ride height results in a change in track width, as is the case with most independent suspensions. The result of these effects is that the pressure P changes with ride height D in an irregular manner as shown in Figure 3.

When the suspension is used to lift the front end of the trailer 46 as described above, there will be a certain ride height D_1 at which the tow ball 42 comes into contact with the tow bar socket 48. At this point the ride height will remain substantially constant while the air pressure increases to a level sufficient to support the additional load, which is the nose weight of the trailer 46, applied to the tow ball 42. Then when the air pressure has increased sufficiently the ride height will again start to increase as the front end of the trailer 46 is lifted so that the jockey wheel 50 is lifted clear of the ground 26. The result of this is that the air pressure will vary with ride height as shown in Figure 4. As can be seen from Figure 4 the pressure varies with ride height in an irregular manner similar to that of Figure 3, but, at the ride height D_1 where the tow ball comes into contact with the trailer socket 48, there is a step change x in the air pressure P with substantially no change in ride height.

The control unit 24 is arranged, in response to a command from the remote control unit 34 to raise the vehicle, to control the flow if air into the air springs 16, 18 to increase the ride height and, as the air is being pumped into the air springs, to monitor the changes in air pressure P and ride height D. The control unit 24 then analyses the signals from the sensors 28, 30 to detect the occurrence of a step change in pressure, and, if such a step change is detected, to measure its height. From this measurement the nose weight of the trailer can be determined. The control unit 24 then transmits a signal to the remote control unit 34 indicating the measured nose weight, which is displayed to the user on the display 40.

It will be appreciated that when the tow ball contacts the tow bar socket it will be possible for the ride height at the wheels to change slightly without any change in height of the tow ball 42, as the vehicle rotates about the tow ball 42 with the front rising more rapidly than the rear. Therefore the algorithm for detecting the step change in air pressure will need to take this into account.

In some cases, rather than using the air pressure in all of the air springs to measure the nose weight, it is preferable to use only the rear springs 18. In particular if the suspension includes a levelling system it may be arranged to increase the air pressure in the rear springs more than in the front springs to counteract the effect of the trailer which will tend to hold down the rear of the vehicle more than the front. Therefore in a modification to the system described above the changes in air pressure in the rear air springs 18 only is measured and used to determine the trailer nose weight. Similarly because the ride height of the front wheels 10 can vary with very little effect on the height of the tow ball 42, in a further modification the ride height of only the rear wheels 12 is monitored as the ride height increases and used to determine the point at which the tow ball has come into contact with the trailer socket 48.

In a further embodiment, rather than indicating to the user the trailer nose weight, the control unit is arranged to detect a nose weight greater than a predetermined value, which might for example be the maximum nose weight which the vehicle can safely tow. If this limiting nose weight is exceeded then the driver is warned, either via the remote control unit or via some form of alarm or indicator on the vehicle.

CLAIMS

1. Apparatus for measuring a load exerted by a trailer on a towing vehicle fitted with air springs, the apparatus including;

means for monitoring air pressure in at least one of said air springs,

means for varying a ride height of the towing vehicle, means for monitoring the ride height of the towing vehicle,

and means for detecting a step change in the relationship between monitored air pressure and monitored ride height as the ride height is varied, thereby to measure said load.

2. Apparatus according to claim 1 in which the means for monitoring air pressure is adapted to monitor air pressure only in an air spring fitted at the rear of the towing vehicle.

3. Apparatus according to either foregoing claim in which the device is configured to apply a correction to the measured load dependent upon rotation of the towing vehicle about a trailer attachment point.

4. Apparatus according to any foregoing claim further comprising display means arranged to indicate said load to a user.

5. Apparatus according to any foregoing claim further comprising a user-operable activation unit arranged to communicate with the means for varying the ride height.

6. Apparatus according to claim 5 wherein the activation unit is operable from positions remote from the vehicle.

7. Apparatus according to claim 5 or claim 6 when dependent on claim 4 wherein the display means forms part of the activation unit.

8. Apparatus according to any foregoing claim further comprising warning means arranged to provide a warning if the load exceeds a predetermined value.

9. Apparatus for measuring a load substantially as hereinbefore described with reference to Figures 1, 3 and 4 of the accompanying drawings.

10. A vehicle including the apparatus according to any foregoing claim.

11. A method for measuring a load exerted by a trailer on a towing vehicle fitted with air springs, the method including the steps of;

monitoring air pressure in at least one of said air springs,

varying a ride height of the towing vehicle,

monitoring the ride height of the towing vehicle,

and detecting a step change in the relationship between monitored air pressure and monitored ride height as the ride height is varied, thereby to measure said load.

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Application No:	GB 0307287.3	**Examiner:**	Kevin Hewitt
Claims searched:	1 to 11	**Date of search:**	15 August 2003

Patents Act 1977 : Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	US 6431557 B1 (TERBORN et al.) See whole document.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{V}:

B7D; G1W

Worldwide search of patent documents classified in the following areas of the IPC^{7}:

B60D; B60G; G01G

The following online and other databases have been used in the preparation of this search report:

WPI; EPODOC; JAPIO