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(54) Title: A METHOD FOR CONTROLLING A WHEEL AXLE LOAD OF A VEHICLE WHEEL AXLE

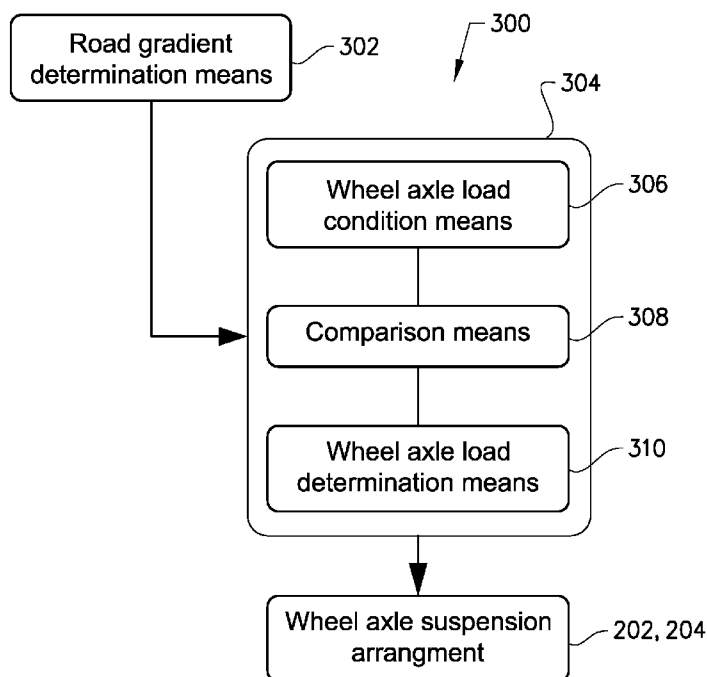


FIG. 3

(57) Abstract: The present invention relates to a method for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle (1), wherein the method comprises the steps of receiving (S1) a signal indicative of a road gradient for said vehicle (1); determining (S2) a wheel axle load condition of at least one of the first and second wheel axles based on the received signal indicative of the road gradient; and determining (S3) whether the determined wheel axle load condition is unfavorable for the vehicle (1). The present invention also relates to a corresponding control unit, a system, and a vehicle.



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A METHOD FOR CONTROLLING A WHEEL AXLE LOAD OF A VEHICLE WHEEL AXLE

TECHNICAL FIELD

5 The present invention relates to a method for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle. The invention is applicable on vehicles, in particularly heavy duty vehicles such as trucks. Although the invention will mainly be described in relation to a truck, it is also applicable for other vehicles such as e.g. working machines or cars.

10

BACKGROUND

In the field of heavy duty vehicles such as trucks, the demands on vehicle performance and the lifetime of vehicle components have been steadily increasing and the vehicles are continuously developed in order to meet the demands from the market. Improved handling of the vehicle, reduced tire wear and increased brake pad
15 life are some of the criteria that become an important aspect for the owner of the vehicle. Furthermore, there are also applicable law directives that have e.g. determined the maximum allowable wheel axle pressure limit on the wheel axles for the vehicle.

20

The vehicles should also be able to fulfil the desired and legal requirements independently of the load condition for the vehicle, i.e. during the entire driving trip when driving from a starting position to a final position. The load on the wheels of the vehicle should not be too high or too low, since this will be unbeneficial for the above
25 defined demands.

There is thus a need to reduce the risk of having load conditions which are unbeneficial for the vehicle.

30 SUMMARY

It is an object of the present invention to provide a method which reduces the risk of having an unfavorable wheel axle load condition of the wheel axles of the vehicle. The object is at least partly achieved by the method for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle according to claim 1.

35

According to a first aspect of the present invention, there is provided a method for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle, wherein the method comprises the steps of receiving a signal indicative of a road gradient for the vehicle; determining a wheel axle load condition
5 of at least one of the first and second wheel axles based on the received signal indicative of the road gradient; and determining whether the determined wheel axle load condition is unfavorable for the vehicle.

The wording "road gradient" should in the following and throughout the entire
10 description be interpreted as an inclination of a road. The road may be the road onto which the vehicle is currently driving or may be the road ahead of the vehicle onto which the vehicle will be driving within a specific time period. Further details regarding the road gradient in front of the vehicle or the road gradient onto which the vehicle is currently driving is given below.

15 Furthermore, the wording "unfavorable load condition" should in the following and throughout the entire description be interpreted as a load condition on at least one of the wheel axles of the vehicle that is unfavorable or unsatisfactory for the wheel axle or the vehicle. An unfavorable load condition may, for example, result in that the
20 handling of the vehicle will be reduced due to a too low pressure on the wheel axle connected to the steering wheel of the vehicle, increased tire wear due to a too large pressure on one of the wheel axles, etc. Detailed example embodiments of unfavorable load conditions are given below.

25 Advantages of the invention are that the wheel axle load condition can be determined based on the road gradient of the vehicle. When driving the vehicle, the load on the wheel axle may change when driving in a downward slope or an upward slope in comparison to driving on a relatively flat, non-inclined, road. An advantage is thus that the present invention determines whether the road gradient will create a
30 wheel axle load condition that is unbeneficial for the vehicle, i.e. if the load on the wheel axle(s) when driving on the road is, or will be, increased/decreased to such an amount that it is unbeneficial for the vehicle.

According to an example embodiment, the method may comprise the step of sending
35 a control signal with information for adjusting the wheel axle load of at least one of

the first and the second wheel axles based on the determination of an unfavorable wheel axle load condition of the vehicle.

Hereby, the wheel axle load on the wheel axles may be adjusted if it is determined
5 that the wheel axle load condition is unfavorable. An advantage is thus that the wheel axle load condition can be adjusted based on the specific road gradient such that a beneficial, or at least a non-unbeneficial, load condition for the wheel axles are achieved when driving on the specific road gradient. Adjusting the load condition for the wheel axles will provide for increased vehicle performance such as e.g.
10 increased handling of the vehicle compared to a non-adjusted wheel axle load, reduction of tire wear, increased life time of the brake pad, etc.

According to an example embodiment, the method may comprise the step of sending a control signal with information for adjusting a wheel axle suspension arrangement
15 of at least one of the first wheel axle and the second wheel axle based on the determination of an unfavorable wheel axle load condition of the vehicle.

Hereby, when it is determined that the wheel axle load condition is unfavorable, the wheel axle suspension arrangement is controlled such that the load on the wheel
20 axles are adjusted to be more beneficial. Hence, the pressure on the wheel axle suspension arrangement is adjusted. In an example embodiment, the wheel axle suspension arrangement comprises an electronically controlled air bellow suspension arrangement and in order to adjust the load on the wheel axles, the air pressure of the air bellows is adjusted. For example, if it is determined that the load
25 condition on the first wheel axle is/will be too low due to the road gradient, i.e. the load pressure on the first wheel axle is too low and is in need of being increased in order to be beneficial, the air pressure in the electronically controlled air bellow suspension arrangement of the first wheel axle should be reduced. Likewise, if the load pressure on the first wheel axle needs to be reduced, the air pressure should be
30 increased. Other media than air is of course also conceivable for the wheel axle suspension arrangement, such as e.g. hydraulic fluid, etc.

According to an example embodiment, the method may comprise the steps of comparing the determined wheel axle load condition with a predetermined load
35 threshold range; and determining that the determined wheel axle load condition is

unfavorable if the wheel axle load of at least one of the first and the second wheel axles falls outside the predetermined load threshold range.

The predetermined load threshold range sets the limits for a wheel axle load condition that is beneficial for the vehicle. Hence, a load pressure of the vehicle which is either higher than the maximum load pressure value of the range or lower than the minimum load pressure value is considered to be an unbeneficial load condition for the vehicle. As described above, if the vehicle axle load pressure is too low, i.e. below the minimum load pressure value, the handling of the vehicle may be reduced and the driving wheels of the vehicle may not get enough grip to the ground surface and may therefore slip on the ground surface. If the wheel axle load pressure is too high, i.e. above the maximum load pressure value, the brake pad lifetime may be reduced, or the vehicle may not fulfil the legal requirements of maximum allowable wheel axle load.

Furthermore, it should be readily understood that the predetermined load threshold range may be set differently depending on the specific vehicle, the number of wheel axles arranged on the vehicle or a trailer connected to the vehicle, legal requirements for maximum allowable load pressure for different jurisdictions, etc.

According to an example embodiment, the method may comprise the steps of comparing the wheel axle load of at least one of the first and the second wheel axles with a predetermined maximum allowable wheel axle pressure limit; and determining that the determined wheel axle load condition is unfavorable if the wheel axle load of at least one of the first and the second wheel axles is above the predetermined maximum allowable wheel axle pressure limit.

Hereby, the wheel axle load condition is adjusted when it is determined that the load pressure on one of the first and the second wheel axles will be too high when driving on the road gradient.

According to an example embodiment, the method may comprise the steps of comparing the wheel axle load of a driving wheel axle of the vehicle with a predetermined minimum allowable wheel axle pressure limit; and determining that the determined wheel axle load condition is unfavorable if the wheel axle load of a

driving wheel axle of the vehicle is below the predetermined minimum allowable wheel axle pressure limit.

Hereby, the wheel axle load condition is adjusted when it is determined that the load
5 pressure on a driving wheel axle will be too low when driving on the road gradient.

It should hence be understood that when adjusting the load pressure on e.g. the first wheel axle, the method may determine that the load pressure on the second wheel axle will not be too high or too low as a result of the adjustment. Adjustment of the
10 load pressure of the first wheel axle is thus made such that the load pressure of the second wheel axle will be above the predetermined minimum allowable wheel axle pressure limit and below the predetermined maximum allowable wheel axle pressure limit.

15 According to an example embodiment, the method may comprise the steps of receiving a signal indicative of a load distribution of the vehicle load on at least the first and the second wheel axles of the vehicle; and determining the wheel axle load condition of at least one of the first and the second wheel axles based on the received signal indicative of the load distribution.

20 Hereby, it is determined how much load each of the wheel axles are exposed to. The load pressure on the wheel axles may be received from load sensors arranged in connection to the wheel axles of the vehicle or from calculations relating to the load arranged on the vehicle and its center of gravity. An advantage is that the load
25 distribution between the wheel axles is determined before the vehicle arrives at the road gradient, which can be used as an initial starting point when determining whether the load condition for the road gradient is/will be unbeneficial or not.

According to an example embodiment, the method may comprise the steps of
30 determining a change in load distribution between at least the first and the second wheel axles based on the received signal indicative of the road gradient; and determining the wheel axle load condition of at least one of the first and the second wheel axles based on the determined change in load distribution.

Hereby, it is determined how the load has been, or will be, redistributed in relation to the road gradient.

According to an example embodiment, the method may comprise the steps of
5 comparing the change in load distribution with a maximum allowable pressure limit; and determining that the determined wheel axle load condition is unfavorable if the change in load distribution is larger than the maximum allowable pressure limit.

If the change in load distribution deviates too much from a maximum allowable limit,
10 the wheel axle load condition is determined to be unbeneficial. Hereby, the load pressure on the wheel axles can be adjusted such that the load distribution is approximately the same as before driving the road gradient.

According to an example embodiment, the signal indicative of the road gradient may
15 relate to an upcoming road gradient for the vehicle.

An advantage is that the vehicle can be prepared to adjust the wheel axle load before entering the road gradient, as described below. This is especially beneficial for systems where the adjustment is not executed immediately on request because
20 of e.g. inertia of the system. The signal indicative of the upcoming road gradient may be received from a GPS or collected from a look-up table in connection to a map or the like.

According to an example embodiment, the method may comprise the step of
25 adjusting the wheel axle load of at least one of the first and the second wheel axles based on the determination of an unfavorable load condition before the vehicle arrives at the upcoming road gradient for the vehicle.

Hence, the adjustment is made before the vehicle arrives at the road gradient and
30 the unbeneficial load condition is thus avoided.

According to an example embodiment, the signal indicative of the road gradient may relate to a present road gradient of the vehicle. Hereby, the adjustment is executed while driving on the road gradient. The signal indicative of the present road gradient
35 may be received from a vehicle inclination sensor. Such a sensor may, for example,

be a gyroscope or the like. The signal relating to the present road gradient may also be received from a GPS or a map.

According to an example embodiment, the method may comprise the steps of
5 determining a road section comprising a portion of the road ahead of a current position of the vehicle; and receiving a signal indicative of the road gradient along the determined road section.

When determining a road section ahead of the vehicle, the method may determine
10 the load condition for the road gradient along the road section. The road section may comprise several various road gradients. The wheel axle load may hence be adjusted in response to the several road gradients well in advance of arriving at the respective road gradient. The wheel axle load may be adjusted by means of a mean value of the inclination of the several road gradients, or it may be adjusted
15 individually for each of the road gradients when arriving at them.

Moreover, the road section may be a section which is positioned directly ahead of the vehicle and extends a predetermined distance ahead of the vehicle. The specific distance of the road section can be set differently depending on e.g. the road
20 topology, etc. For example, if the road ahead of the vehicle is very hilly, the road section can be set shorter than if the road ahead of the vehicle is relatively flat and non-hilly.

According to an example embodiment, the first wheel axle is positioned foremost of
25 the first and the second wheel axles, wherein the method may comprise the step of sending a control signal for reducing the wheel axle load on the first wheel axle if the received signal indicates that the road section along the determined road section is a downhill slope.

According to an example embodiment, the first wheel axle is positioned foremost of
30 the first and the second wheel axles, wherein the method may comprise the step of sending a control signal for increasing the wheel axle load on the first wheel axle if the received signal indicates that the road section along the determined road section is an uphill slope.

35

An advantage is thus that the wheel axle load pressure is adjusted to be reduce/increased based on whether the vehicle is driving in an upward slope or a downward slope.

- 5 According to an example embodiment, the method may comprise the step of adjusting the wheel axle load of at least one of the first and the second wheel axles based on the control signal.

- 10 According to a second aspect of the present invention, there is provided a control unit for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle, wherein the control unit is configured to receive a signal indicative of a road gradient for the vehicle; determine a wheel axle load condition of at least one of the first and second wheel axles based on the received signal indicative of the road gradient; and determine whether the determined wheel
15 axle load condition is unfavorable for the vehicle.

According to an example, the control unit is configured to perform any of the steps described above in relation to the first aspect of the present invention.

- 20 The control unit may be electrically connected to the wheel axle suspension arrangement of the vehicle for sending control signals for adjustment of the wheel axle suspension arrangements, respectively. The control unit must however not be in direct electrical communication with the respective wheel axle suspension arrangement. The control unit may of course be connected to the wheel axle
25 suspension arrangement via another control unit, or the like, of the vehicle, or to an air tank for controlling the supply of compressed air to air bellows of the wheel axle suspension arrangement. The control unit may also be connected to a CAN-bus of the vehicle which in turn distributes control signals to the wheel axle suspension arrangement.

- 30 Furthermore, according to an example embodiment, the control unit may comprise a module comprising receiving means for receiving a signal indicative of a road gradient for the vehicle, determination means for determining a wheel axle load condition of at least one of the first and the second wheel axles based on the signal
35 received by the receiving means; and determination means for determining whether

the wheel axle load condition is unfavorable for the vehicle. The module may be realized by means of software implemented code in the control unit or as hardware which is electrically connected to the control unit.

- 5 Effects and features of this second aspect of the present invention are largely analogous to those described above in relation to the first aspect of the present invention.

According to a third aspect of the present invention, there is provided a system for
10 controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle comprising a control unit according to the above description of the second aspect of the present invention, and adjustment means for adjusting the wheel axle load of at least one of the first and the second wheel axles, wherein the adjustment means is operatively connected to the control unit for receiving a control
15 signal from the control unit.

According to a fourth aspect of the present invention, there is provided a computer program comprising program code means for performing any of the steps described above in relation to the first aspect of the present invention.

20

According to a fifth aspect of the present invention, there is provided a computer readable medium carrying a computer program comprising program code means for performing any of the steps described above in relation to the first aspect of the present invention when the program is run on a computer.

25

Effects and features of the third, fourth and fifth aspects of the present invention are largely analogous to those described above in relation to the first aspect of the present invention.

30 According to a sixth aspect of the present invention, there is provided a vehicle comprising a first wheel axle and a second wheel axle, wherein the vehicle comprises a control unit according to the above described second aspect of the present invention, or a system according to the above described third aspect of the present invention.

35

According to an example embodiment, the first wheel axle and the second wheel axle may be connected to a frame of the vehicle.

5 According to an example embodiment, the first wheel axle and the second wheel axle may be connected to the frame of the vehicle by means of a wheel axle suspension arrangement, respectively.

10 According to an example embodiment, the control unit may be configured to adjust the wheel axle load of at least one of the first and the second wheel axles based on the determination of an unfavorable wheel axle load condition of the vehicle by controlling a bellow pressure of the wheel axle suspension arrangement, respectively.

15 Hereby, the control unit sends a control signal to the wheel axle suspension arrangement, or to a component controlling the wheel axle suspension arrangement, for increasing/decreasing the pressure of the wheel axle suspension arrangement. According to an embodiment, air pressure of an air bellow suspension arrangement may be increased/decreased based on the received control signal from the control unit.

20

According to an example embodiment, the frame may comprise a left and right vehicle frame member extending in a forward direction of the vehicle.

25 According to an example embodiment, the at least one of the first and the second wheel axles may be connected to an axle casing, the axle casing being movable in relation to the frame of the vehicle.

30 Hereby, an alternative method of adjusting the wheel axle load pressure can be achieved. This is thus achieved by moving the axle casing in relation to the frame of the vehicle. This will move the center of gravity of the vehicle load in relation to the wheel axles and hence adjust the load pressure on the wheel axles.

According to an example embodiment, the vehicle may comprise a tractor unit and a trailer unit, wherein the first wheel axle is connected to the tractor unit and the

second wheel axle is connected to the trailer unit. Hence, the control unit is connected to the wheel axles of the trailer unit as well as on the tractor unit.

According to an example embodiment, the first and the second wheel axles may be provided with a load sensor unit, respectively, the load sensor unit being arranged to measure a load pressure from the vehicle. According to an example embodiment, the control unit may be further configured to measure a load pressure level of the respective wheel axle suspension arrangements. The load sensor unit may be connected to the wheel axle suspension system of the vehicle. The load sensor may be arranged to measure an air pressure level on an air bellow suspension arrangement.

Further effects and features of the sixth aspect of the present invention are largely analogous to those described above in relation to the first, second, third, fourth and fifth aspects of the present invention.

Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled person realize that different features of the present invention may be combined to create embodiments other than those described in the following, without departing from the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The above, as well as additional objects, features and advantages of the present invention, will be better understood through the following illustrative and non-limiting detailed description of exemplary embodiments of the present invention, wherein:

Fig. 1 is a side view of a vehicle in the form of a truck according to an example embodiment, suitable for utilizing the present invention;

Fig. 2 is a perspective view illustrating in detail an example embodiment of the frames, suspension arrangements, and wheel axles of the vehicle depicted in Fig. 1;

Fig. 3 is a flow chart illustrating components of a system according to an embodiment for executing the method of the present invention; and

Fig. 4 is a flow chart of a method according to an example embodiment of the present invention.

5 DETAIL DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these
10 embodiments are provided for thoroughness and completeness. Like reference character refer to like elements throughout the description.

With particular reference to Fig. 1, there is provided a vehicle 1 in the form of a truck having a tractor unit 2 and a trailer unit 3. The tractor unit 2 comprises a tractor frame
15 unit 9 and the trailer unit 3 comprises a trailer frame unit 10. The tractor unit 2 comprises two wheel axles, namely a front tractor wheel axle 4 and a rear tractor wheel axle 5. One of the front tractor wheel axle 4 and the rear tractor wheel axle 5 may constitute a first wheel axle of the vehicle. The trailer unit 3 comprises, in the depicted example embodiment, three wheel axles, namely a front trailer wheel axle
20 6, a rear trailer wheel axle 7, and a trailer tag wheel axle 8, which is positioned rearward of the rear trailer axle 7 as seen in the longitudinal direction of the vehicle. One of the front trailer wheel axle 6, the rear trailer wheel axle 7, and the trailer tag wheel axle 8 may constitute a second wheel axle of the vehicle. The load from the vehicle, which includes the vehicle load as well as the load which is loaded on the
25 trailer unit 3 of the vehicle, is distributed over the wheel axles 4, 5, 6, 7 and 8. The load pressure on each of the wheel axles is determined by the total load of the vehicle and its center of gravity. The load pressure on each of the wheel axles is naturally also depending on the number of wheel axles arranged on the vehicle, and the present invention functions equally as well for vehicles having a further number
30 of wheel axles or a lesser number of wheel axles than the vehicle depicted in Fig. 1. Also, the vehicle according to the present invention does not have to carry a trailer unit 3. On the contrary, the vehicle, e.g. a truck, may be provided with a container on the tractor unit. Hence, the frame onto which the container is positioned is arranged on the tractor unit. The vehicle 1 depicted in Fig. 1 is thus beneficially utilizing the

method as will be described in detail below. Hence, the vehicle according to the example embodiment in Fig. 1 comprises the below described various components.

In order to describe the vehicle 1 in further detail, reference is made to Fig. 2 which depicts the vehicle axles, and how they are connected to the respective frame units of the vehicle. As can be seen, the tractor unit 2 comprises a tractor frame unit 9 as described above. The front tractor wheel axle 4 and the rear tractor wheel axle 5 are each connected to the tractor frame unit 9 by means of a wheel axle suspension arrangement 202, in the following also referred to as a tractor unit wheel axle suspension arrangement. Further, the trailer unit 3 comprises a trailer frame unit 10 as described above. The front trailer wheel axle 6, the rear trailer wheel axle 7 and the trailer tag wheel axle 8 are each connected to the trailer frame unit 10 by means of a respective wheel axle suspension arrangement 204, in the following also referred to as a trailer unit wheel axle suspension arrangement. The wheel axle suspension arrangements are provided on each side of the frame unit in the lateral direction of the vehicle. Hence, a wheel axle suspension arrangement is arranged on each side of the respective wheel axles 4, 5, 6, 7, 8 for connection to the respective frame units of the vehicle.

Furthermore, in the illustrated embodiment depicted in Fig. 2, the tractor unit wheel axle suspension arrangement 202 and the trailer unit wheel axle suspension arrangement 204 comprises a so-called air bellow suspension 206, respectively. The air bellow suspensions 206 are electronically controlled by sending a control signal from a control unit 304 (See Fig. 3) to an air tank (not shown) comprising compressed air for controlling the pressure in the air bellows. The air bellow suspensions 206 are hence pneumatically arranged air bellow suspensions. Although Fig. 2 depicts pneumatically arranged air bellow suspensions, other alternatives are of course also conceivable, such as e.g. hydraulically arranged suspension arrangements.

As described above in relation to Fig. 1, the wheel axles 4, 5, 6, 7, 8 are exposed to a load pressure from the weight of the vehicle 1. The load on the wheel axle should preferably not be too high or too low. If the load pressure is too low on e.g. the front tractor wheel axle 4 the steering handling will be reduced since not enough load pressure is provided between the wheels of the front tractor wheel axle 4 and the

ground. On the other hand, if the load pressure on the front tractor wheel axle 4 is too high, the wheels of the front tractor wheel axle 4 may have a reduced life time, or the load pressure may exceed maximum allowable pressure levels according to legal criteria. Hence, it is important that the load pressure on the wheel axles is within a
5 predetermined load threshold range. Load pressure levels outside this range are considered to be unbeneficial for the vehicle.

When using the above described air bellow suspensions 206, the load pressure on the wheel axles can be controlled by controlling the air pressure in the air bellow
10 suspensions. If, for example, it is desirable to increase the load pressure on the front tractor wheel axle 4, the air pressure in the air bellow suspension arranged between the front tractor wheel axle 4 and the tractor frame unit 9 should be reduced. Likewise, if it is desirable to reduce the load pressure on the front tractor wheel axle 4, the air pressure in the air bellow suspension arranged between the front tractor
15 wheel axle 4 and the tractor frame unit 9 should be increased. It should also be readily understood that if the load pressure of the front tractor wheel axle 4 is adjusted, then the load pressure on at least one of the remaining wheel axles 5, 6, 7, 8 is also adjusted. Hence, the load pressure on the front tractor wheel axle 4 can also be adjusted by means of adjusting the air pressure of at least one of the
20 remaining wheel axles 5, 6, 7, 8 of the vehicle.

When driving on a relatively flat or horizontal road surface, the wheel axle load condition is naturally different in comparison to when driving in an upwardly or downwardly inclined slope. When for example driving in a downwardly inclined slope,
25 the load pressure on the front tractor wheel axle 4 is increase in comparison to when driving on the relatively horizontal road surface. At the same time the load pressure on the rear wheel axles, i.e. the rear trailer wheel axle 7 and the trailer tag axle 8 will be reduced when driving on the downwardly inclined slope. Likewise, when driving on an upwardly inclined slope, the load pressure on the front tractor wheel axle 4 is
30 reduced in comparison to when driving on the relatively horizontal road surface.

During driving on the downwardly inclined slope or the upwardly inclined slope it is important to preserve the driving characteristics of the vehicle. As described above, if the load pressure of the front tractor wheel axle 4 is reduced to a pressure level
35 below a predetermined minimal allowable limit, the steering characteristics of the

vehicle may be insufficient. In this situation, the air pressure of the air bellow suspension connecting the front tractor wheel axle 4 to the tractor frame unit 9 should be reduced such that the load pressure on the front tractor wheel axle 4 is increased to a level where the steering characteristics of the vehicle is improved and
5 functions properly. Likewise, if the load pressure increases to a limit which is higher than what is accepted, the pressure level in the air bellow suspension associated with the wheel axle having a too high pressure should be increased to reduce the load pressure on that wheel axle.

10 In order to describe the function of the invention in further detail, reference is now made to Fig. 3 which is a flow chart illustrating components of a system according to an embodiment for executing the method of the present invention.

The system 300 is configured to be implemented on a vehicle 1 as depicted in Fig. 1
15 and comprises a road gradient determination means 302 for determining the road gradient for the vehicle, and a control unit 304. The control unit 304 is in turn connected to the each of the wheel axle suspension arrangements 202, 204 described above. The control unit 304 may however be connected to an air tank or a hydraulic fluid tank which supplies air/fluid to the wheel axle suspension
20 arrangements. In such a case, the control unit sends control signals to the air tank or hydraulic tank which in turn supplies air/fluid to the wheel axle suspension arrangement 202, 204.

Furthermore, the control unit 304 comprises a wheel axle load condition means 306,
25 a comparison means 308 and a wheel axle load determination means 310. Although the wheel axle load condition means 306, the comparison means 308 and the wheel axle load determination means 310 are described as being a respective part of the control unit 304, they may equally as well constitute a separate means from the control unit 304. In such a case, the control unit is in connection to each of the
30 means to receive information/data therefrom, or to provide information/data thereto.

The road gradient determination means 302 is, as stated above, arranged to determine the road gradient for the vehicle 1. The road gradient may relate to the road gradient of which the vehicle is presently driving, or to an upcoming road
35 gradient for the vehicle. The road gradient determination means 302 can also

determine the road gradient for a road section of predefined length in front of the vehicle during driving. The road gradient determination means 302 may comprise e.g. a GPS, a gyroscope, a map, or other suitable means for detecting and determining the inclination of the road. Hence the road gradient determination means
5 thus receives information regarding either the present road inclination or an upcoming road inclination of the road onto which the vehicle is driving. The signal indicative of the road gradient is thereafter provided to the control unit 304.

The control unit 304 thus receives the signal from the road gradient determination
10 means 302, and the wheel axle load condition means 306 of the control unit 304 determines a wheel axle load condition of at least one of the wheel axles 4, 5, 6, 7, 8 of the vehicle based on the received signal from the road gradient determination means 302. Hereby, the wheel axle load condition means 306 determines the load pressure on at least one of the wheel axles, preferably all the wheel axles, based on
15 the road gradient. The wheel axle load condition means 306 may determine the load pressure on the wheel axles by means of calculating the load on the respective wheel axles as a function of the load distribution of the vehicle and the inclination of the road gradient.

20 The determined/calculated load condition for the wheel axles 4, 5, 6, 7, 8 of the vehicle is thereafter compared to a predetermined set of rules. The comparison is executed by means of a comparison means 308 which thus compares the wheel axle load condition of the at least one wheel axle with e.g. the above described predetermined load threshold range.

25 The wheel axle load determination means 310 of the control unit 304 determines whether the wheel axle load condition for the wheel axle is unfavorable for the vehicle 1. More specifically, the wheel axle load determination means 310 receives information from the comparison means for determining if the load condition of the
30 wheel axles is such that the load pressure is either too high or too low in relation to the predetermined load threshold range.

If it is determined by the control unit that the load condition is, or will be when arriving at the road gradient, unfavorable for the vehicle, the control unit sends a signal to at
35 least one of the wheel axle suspension arrangements to adjust its suspension such

that the wheel axle load is adjusted. The wheel axle load is hence increased or decreased depending on whether it is desirable to increase or decrease the load pressure on the wheel axles as described above.

- 5 In order to sum up, reference is made to Fig. 4 which illustrates a flow chart of the method according to an example embodiment of the present invention. Firstly, a signal is received S1, which signal is indicative of a road gradient for the vehicle. The road gradient may, as described above, relate to the present/current road gradient of the vehicle, or to an upcoming road gradient for the vehicle. Thereafter, the wheel
- 10 axle load condition for at least one of the wheel axles of the vehicle is determined S2 based on the received signal indicative of the road gradient. Hence, it is determined/calculated how much load the wheel axles will be exposed to when driving on the road gradient. It is thereafter determined S3 if the wheel axle load condition is unfavorable for the vehicle 1. It may hence be determined if e.g. the
- 15 wheel axle load of the respective wheel axles are too high or too low. If the wheel axle load condition is determined to be unfavorable for the vehicle, the wheel axle load is adjusted. This can be made by adjusting the wheel axle suspension arrangement for at least one of the wheel axles 4, 5, 6, 7, 8 of the vehicle.
- 20 It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims. The wheel axle load condition means, the comparison means, the road gradient determination means and the wheel axle load determination means
- 25 may also be constituted by modules arranged to execute the above described functionalities, i.e. a wheel axle load condition module, a comparison module, a road gradient determination module and a wheel axle load determination module. Also, one or more of the means/modules may be excluded from the system. Its functionality/functionality may instead be included in one of the other modules.

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CLAIMS

1. A method for controlling a wheel axle load on at least one of a first wheel axle (4, 5) and a second wheel axle (6, 7, 8) of a vehicle (1), **characterized by** the steps of:
- receiving (S1) a signal indicative of a road gradient for said vehicle;
- 5 - determining (S2) a wheel axle load condition of at least one of the first and second wheel axles (4, 5, 6, 7, 8) based on the received signal indicative of the road gradient; and
- determining (S3) whether the determined wheel axle load condition is unfavorable for the vehicle (1).
- 10 2. The method according to claim 1, comprising the step of:
- sending a control signal with information for adjusting the wheel axle load of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) based on the determination of an unfavorable wheel axle load condition of the vehicle (1).
- 15 3. The method according to any one of claims 1 – 2, comprising the step of:
- sending a control signal with information for adjusting a wheel axle suspension arrangement (202, 204) of at least one of said first wheel axle (4, 5) and the second wheel axle (6, 7, 8) based on the determination of an unfavorable wheel axle load
- 20 condition of the vehicle.
4. The method according to any one of the preceding claims, comprising the steps of:
- comparing the determined wheel axle load condition with a predetermined load
- 25 threshold range; and
- determining that the determined wheel axle load condition is unfavorable if the wheel axle load of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) falls outside the predetermined load threshold range.
- 30 5. The method according to any one of the preceding claims, comprising the steps of:
- comparing the wheel axle load of at least one of the first and the second wheel axles with a predetermined maximum allowable wheel axle pressure limit; and

- determining that the determined wheel axle load condition is unfavorable if the wheel axle load of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) is above the predetermined maximum allowable wheel axle pressure limit.

5 6. The method according to any one of the preceding claims, comprising the steps of:

- comparing the wheel axle load of a driving wheel axle of the vehicle with a predetermined minimum allowable wheel axle pressure limit; and
- determining (S3) that the determined wheel axle load condition is unfavorable if the
10 wheel axle load of a driving wheel axle of the vehicle is below the predetermined minimum allowable wheel axle pressure limit.

7. The method according to any one of the preceding claims, comprising the steps of:

15 - receiving a signal indicative of a load distribution of the vehicle load on at least the first and the second wheel axles of the vehicle; and
- determining (S2) the wheel axle load condition of at least one of the first and the second wheel axles based on the received signal indicative of the load distribution.

20 8. The method according to claim 7, comprising the steps of:

- determining a change in load distribution between at least the first and the second wheel axles based on the received signal indicative of the road gradient; and
- determining (S2) the wheel axle load condition of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) based on the determined change in load
25 distribution.

9. The method according to claim 8, comprising the steps of:

- comparing the change in load distribution with a maximum allowable pressure limit; and
30 - determining (S3) that the determined wheel axle load condition is unfavorable if the change in load distribution is larger than the maximum allowable pressure limit.

10. The method according to any one of the preceding claims, wherein the signal indicative of the road gradient relates to an upcoming road gradient for said vehicle.

11. The method according to claim 10, comprising the step of:

- adjusting the wheel axle load of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) based on the determination of an unfavorable load condition before the vehicle arrives at the upcoming road gradient for the vehicle.

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12. The method according to any one of claims 1 – 9, wherein the signal indicative of the road gradient relates to a present road gradient of the vehicle.

13. The method according to any one of the preceding claims, comprising the steps of:

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- determining a road section comprising a portion of the road ahead of a current position of the vehicle; and
- receiving (S1) a signal indicative of the road gradient along the determined road section.

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14. The method according to claim 13, wherein the first wheel axle (4) is positioned foremost of the first and the second wheel axles, the method comprising the step of:

- sending a control signal for reducing the wheel axle load on the first wheel axle (4) if the received signal indicates that the road section along the determined road

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section is a downhill slope.

15. The method according to claim 13, wherein the first wheel axle (4) is positioned foremost of the first and the second wheel axles, the method comprising the step of:

- sending a control signal for increasing the wheel axle load on the first wheel axle (4) if the received signal indicates that the road section along the determined road section is an uphill slope.

25

16. The method according to claim 2 or any one of claims 3 – 14, comprising the step of:

30

- adjusting the wheel axle load of at least one of the first and the second wheel axles based on the control signal.

17. A control unit (304) for controlling a wheel axle load on at least one of a first wheel axle (4, 5) and a second wheel axle (6, 7, 8) of a vehicle (1), **characterized in that** the control unit (304) is configured to:

35

- receive (S1) a signal indicative of a road gradient for said vehicle;
- determine (S2) a wheel axle load condition of at least one of the first and second wheel axles (4, 5, 6, 7, 8) based on the received signal indicative of the road gradient; and
- 5 - determine (S3) whether the determined wheel axle load condition is unfavorable for the vehicle.

18. The control unit according to claim 17, further configured to perform the steps of any one of claims 1 – 16.

10

19. A system (300) for controlling a wheel axle load on at least one of a first wheel axle and a second wheel axle of a vehicle comprising a control unit (304) according to any one of claims 17 or 18 and adjustment means for adjusting the wheel axle load of at least one of the first and the second wheel axles, wherein the adjustment
- 15 means is operatively connected to the control unit for receiving a control signal from the control unit.

20. A computer program comprising program code means for performing the steps of claims 1 – 16 when said program is run on a computer.

20

21. A computer readable medium carrying a computer program comprising program code means for performing the steps of claims 1 – 16 when said program is run on a computer.

- 25 22. A vehicle (1) comprising a first wheel axle (4, 5) and a second wheel axle (6, 7, 8), wherein the vehicle comprises a control unit (304) according to any one of claims 17 – 18 or a system (300) according to claim 19.

23. The vehicle (1) according to claim 22, wherein the first wheel axle (4, 5) and the

30 second wheel axle (6, 7, 8) is connected to a frame (9, 10) of said vehicle (1).

24. The vehicle according to claim 23, wherein the first wheel axle (4, 5) and the second wheel axle (6, 7, 8) is connected to the frame (9, 10) of said vehicle by means of a wheel axle suspension arrangement (202, 204), respectively.

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25. The vehicle according to claim 24, wherein the control unit (304) is configured to adjust the wheel axle load of at least one of the first and the second wheel axles (4, 5, 6, 7, 8) based on the determination of an unfavorable wheel axle load condition of the vehicle (1) by controlling a bellow pressure of the wheel axle suspension arrangement, respectively.

26. The vehicle according to any one of claims 23 - 25, wherein the frame comprises a left and right vehicle frame member extending in a forward direction of the vehicle.

27. The vehicle according to any one of claims 23 – 26, wherein at least one of the first and the second wheel axles are connected to an axle casing, said axle casing being movable in relation to the frame of the vehicle.

28. The vehicle according to any one of claims 22 – 27, comprising a tractor unit (2) and a trailer unit (3), wherein said first wheel axle (4, 5) is connected to the tractor unit (2) and the second wheel axle (6, 7, 8) is connected to the trailer unit (3).

29. The vehicle according to any one of claims 22 – 28, wherein the first and the second wheel axles are provided with a load sensor unit, respectively, said load sensor unit being arranged to measure a load pressure from the vehicle.

30. The vehicle according to any one of claim 21 – 28, wherein the control unit is further configured to measure a load pressure level of the respective wheel axle suspension arrangements.

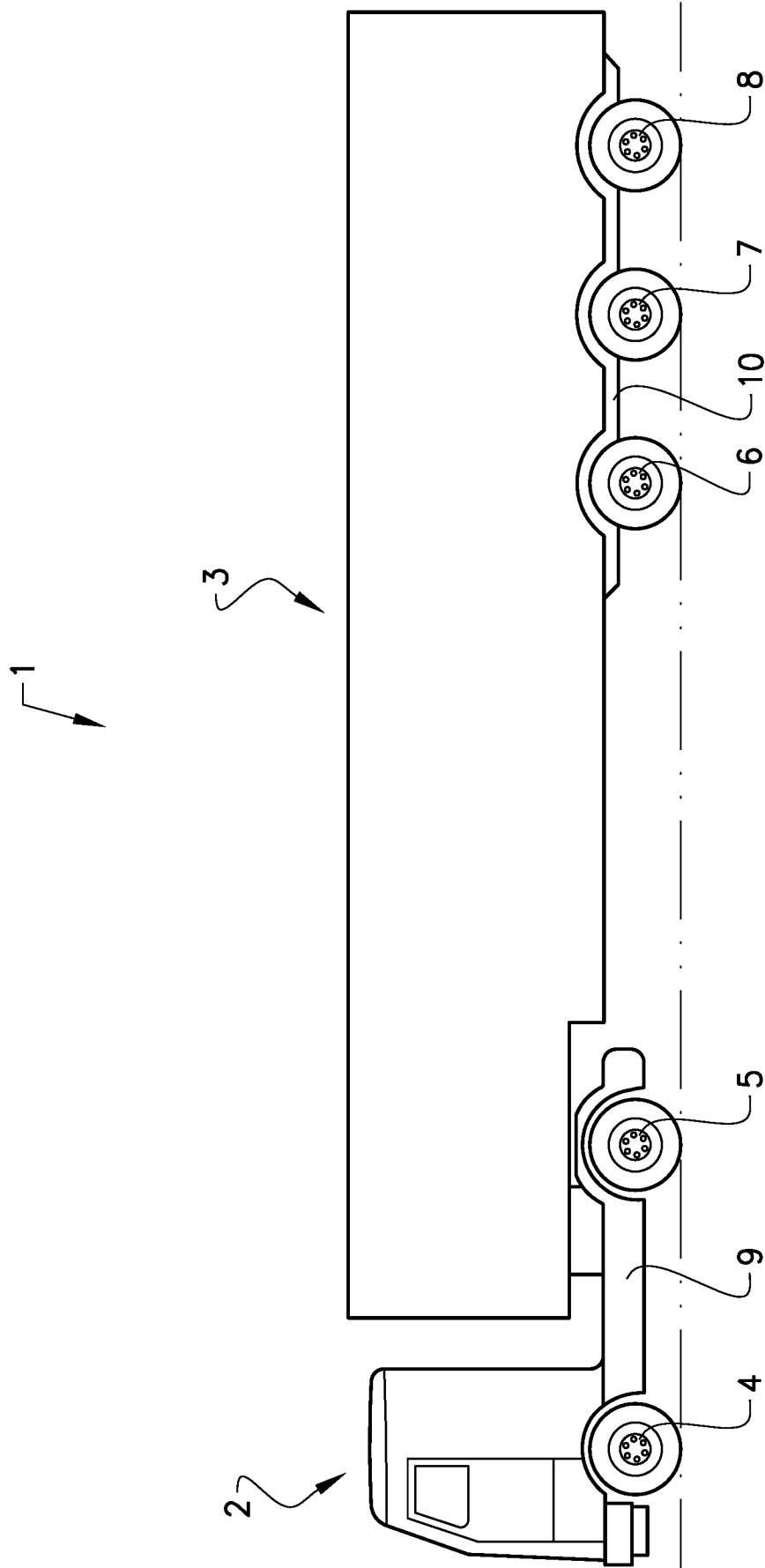


FIG. 1

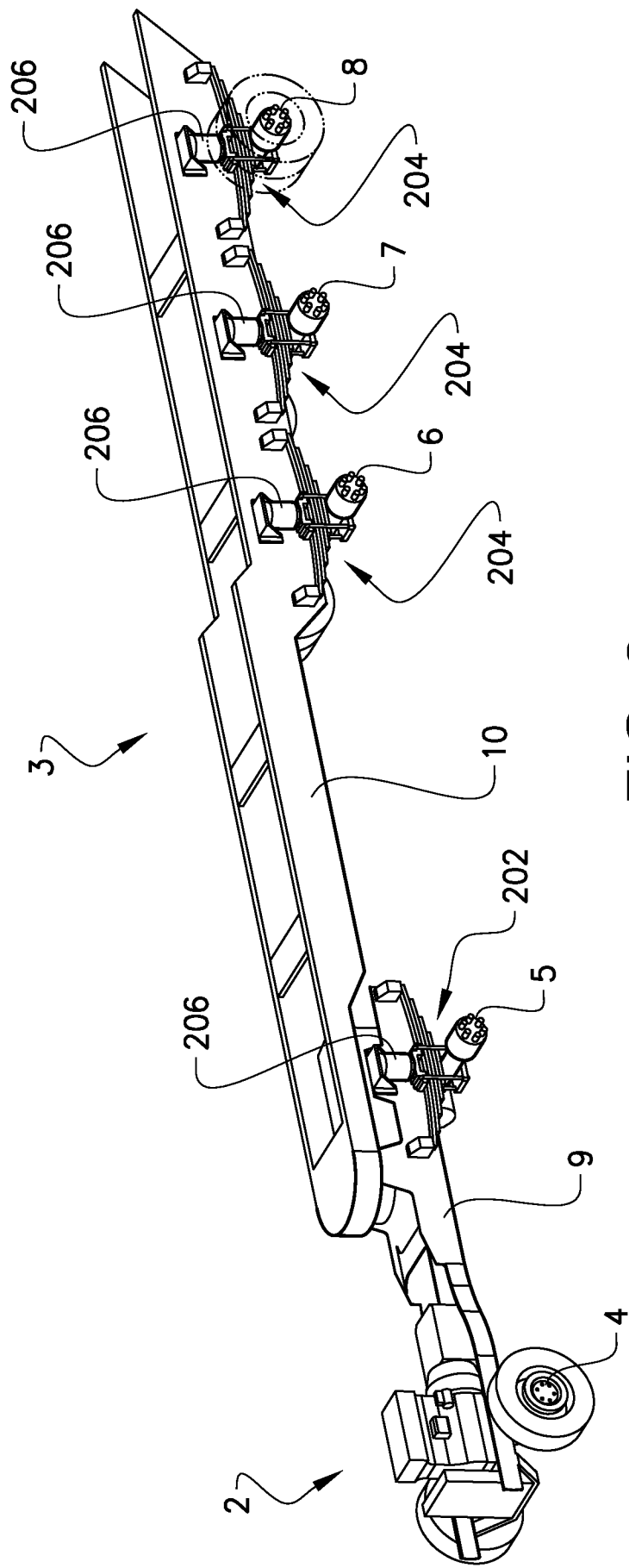


FIG. 2

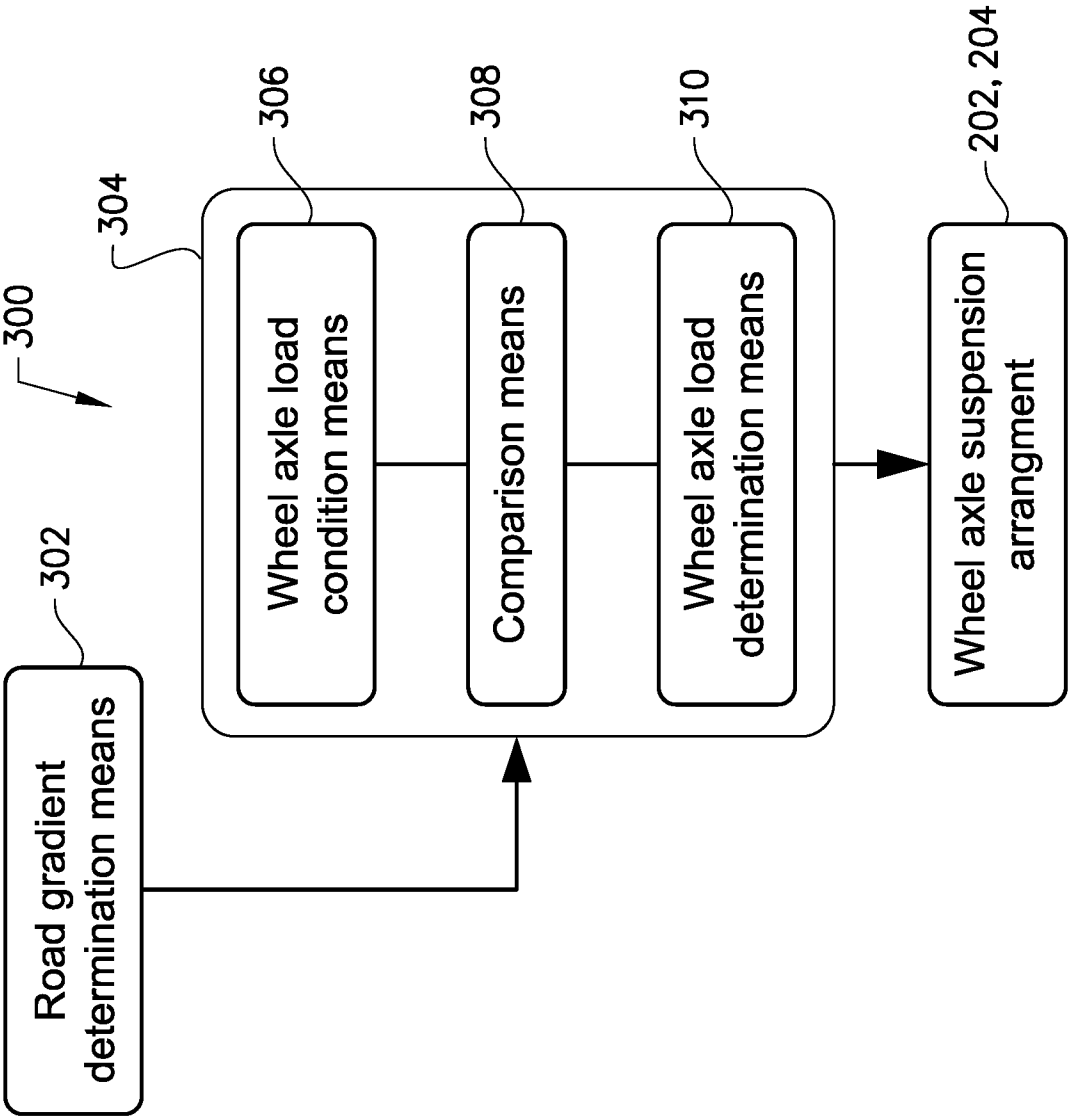


FIG. 3

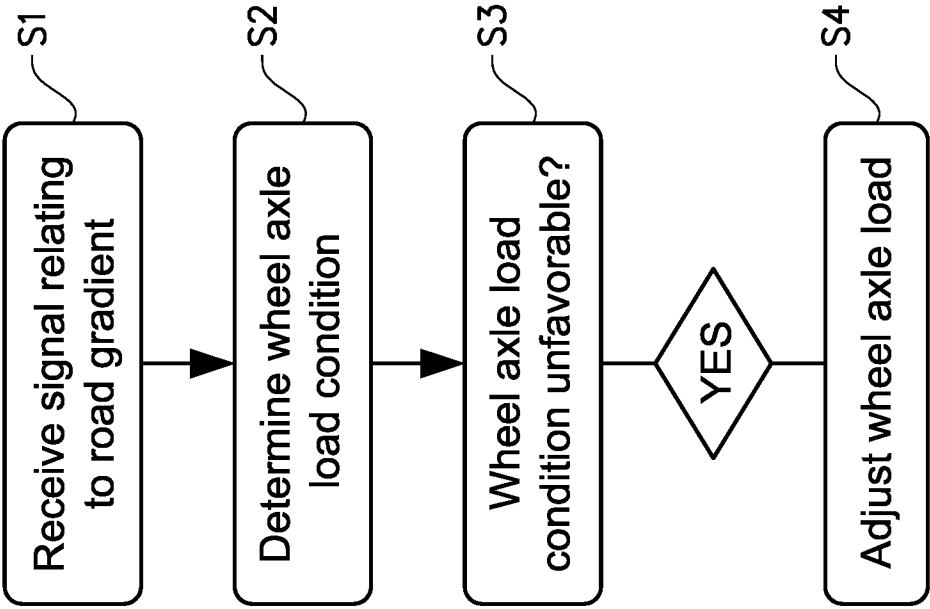


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/053635

A. CLASSIFICATION OF SUBJECT MATTER
INV. B60G17/0165
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2012/002878 A1 (SCANIA CV AB [SE]; HESSE JOHAN [SE]) 5 January 2012 (2012-01-05)	1,2,12, 13,17
Y	the whole document	3-11, 14-16, 18-30
Y	----- WO 2006/043872 A1 (VOLVO LASTVAGNAR AB [SE]; REGNELL HANS [SE]; LILJEBLAD BENNY [SE]) 27 April 2006 (2006-04-27) the whole document	3-11, 14-16, 18-30
A	----- EP 2 634 073 A2 (WABCO GMBH [DE]) 4 September 2013 (2013-09-04) the whole document ----- -/-	1-30



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

11 May 2016

Date of mailing of the international search report

25/05/2016

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/053635

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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International application No

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