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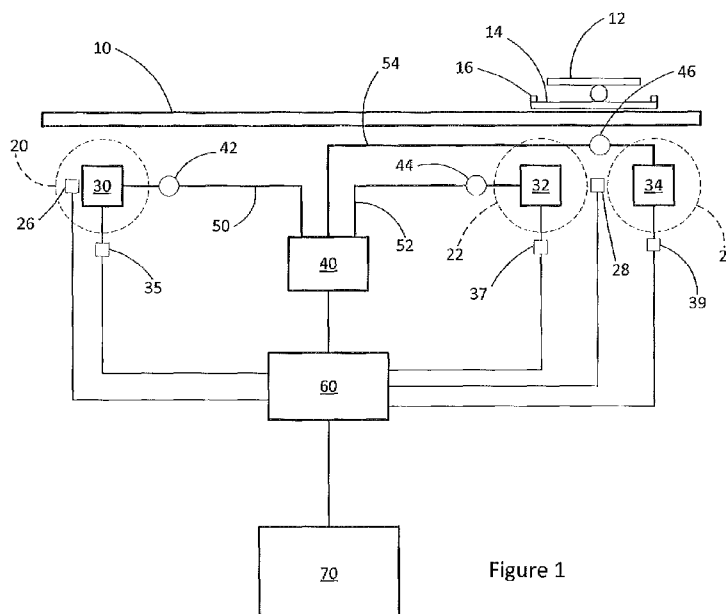
(54) **Title:** METHOD OF CONTROLLING LOAD ON A TRUCK STEER AXLE

Figure 1

(57) **Abstract:** A method for distributing load forces among axles of a truck having a front steer axle and two rear axles, the rear axles including an air suspension, includes the steps of monitoring a load on each of the axles and generating a load signal therefrom, increasing a pressure in a forward rear axle air suspension relative to a pressure in a rearward rear axle suspension to decrease a load on the steer axle, and decreasing a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle.

Method of Controlling Load on a Truck Steer Axle

Field of the invention

The invention is directed to a control method to selectively increase or decrease the load on the front axle by adjusting the pressure in the rear tandem axle set suspension air springs.

5 Background and Summary

Commercial vehicle weight is regulated and typically each axle of truck has a load limit. For example, according to US DOT regulations, the gross vehicle weight limit for a Class 8 truck in combination with a loaded trailer is 80,000 lbs. The load limit on the tractor steer axle is 12,000 lbs and the tractor rear tandem has a limit of 34,000 lbs, with the trailer tandem
10 having a limit of 34,000 lbs. A problem in loading trucks, including straight trucks and trailers hitched to truck tractors, is to maximize the vehicle load while not exceeding the axle limits, including the load limit on the steer axle.

In truck tractors having movable or sliding fifth wheels, one practice for adjusting the weight on the steer axle involves sliding the fifth wheel behind the center of the rear tandem axles
15 to transfer load off the steer axle. This has the detrimental effect of increasing the gap between the back of the cab and the front of the trailer, which increases aerodynamic drag on the vehicle combination. The result is decreased fuel economy.

The invention provides a solution to this problem.

According to the invention, a method of controlling load on the steer axle of a truck tractor
20 having a front steer axle and two rear axles, the rear axles including an air suspension, shifts load from the steer axle without moving the fifth wheel. The method redistributes load forces on the vehicle's axles to control the loading of the steer axle.

The method according to the invention includes controlling a pressure in the forward rear axle air suspension and a pressure in the rearward rear axle air suspension to maintain a
25 steer axle load below a threshold value.

A method according to the invention includes the steps of monitoring a load on each of the axles, generating load signals representative of the load on each axle, and, responsive to the load signals, one of increasing a pressure in a forward rear axle air suspension relative to a

pressure in a rearward rear axle suspension to decrease a load on the steer axle or decreasing a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle.

5 According to an aspect of the invention, the steps of increasing a pressure in a forward rear axle air suspension and decreasing a pressure in a forward rear axle air suspension are done responsive to the load signal on the front axle to attain a desired load on the front axle.

10 According to another aspect of the invention, the step of increasing a pressure in the forward rear axle air suspension relative to relative to a pressure in a rearward rear axle suspension to decrease the load on the steer axle includes adding air to the forward rear axle air suspension.

Alternatively, the step of increasing a pressure in a forward rear axle air suspension relative to relative to a pressure in a rearward rear axle suspension to decrease the load on the steer axle includes removing air from the rearward rear axle air suspension.

15 According to the invention, the step of decreasing a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle includes removing air from the forward rear axle to increase the load on the steer axle.

Alternatively, according to the invention, the step of decreasing a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle includes adding air to the rearward rear axle suspension.

20 Brief Description of the Drawings

The invention will be better understood by reference to the following detailed description read in conjunction with the appended drawings, in which:

Figure 1 is a schematic showing an apparatus in accordance with the invention; and,

Figure 2 is a flow diagram illustrating a method in accordance with the invention.

25 Detailed Description

Figure 1 shows a schematic of an apparatus according to the invention. A truck is represented by a frame 10, a fifth wheel 12 mounted to a rear of the frame, and three

wheel axles, shown by the broken line circles as a front or steer axle 20 and a rear tandem axle having a forward tandem axle 22 and a rearward tandem axle 24. The fifth wheel 12 is preferably mounted on a movable mounting 14 that allows the fifth wheel to move on the frame 10 forward or backward relative to the tandem axles 22, 24. A position sensing
5 device 16 may be included to provide a signal indicating the position of the fifth wheel 12 on the mounting 14.

A ride height sensor 26, 28 is associated with, respectively, the steer axle 20 and the rear tandem axle set 32, 34. The rear ride height sensor 28 may be a single sensor positioned to measure the height of one of the rear tandem axles, the forward tandem axle 32, for
10 example. Alternatively, ride height sensors may be positioned for each of the forward tandem 32 and rearward tandem 34 axles.

The steer axle 20 includes an air suspension 30 which includes at least one air spring. Similarly, the forward tandem axle 22 includes an air suspension 32 having at least one air spring, and the rearward tandem axle 24 includes an air suspension 34 also having at least
15 one air spring. More typically, an air suspension 30, 32, 34 will include one air spring at each end of the axle, as is known in the art. Each air suspension 30, 32, 34 also includes a pressure sensor 35, 37, 39 to measure the air pressure in the associated air spring or springs.

Air is supplied to the air suspensions 30, 32, and 34 by an on-board air supply 40, such as an
20 on-board compressor and tank system, as is known in the art for supplying air under pressure to air suspensions and braking systems. Air supply to the air suspensions 30, 32, and 34 is controlled by valves 42, 44, 46 disposed on the supply lines 50, 52, 54 connecting the air supply 40 to the air suspensions. In addition, the valves 42, 44, 46 include vents to selectively vent air to the atmosphere to reduce the air pressure in the associated air spring,
25 as described below.

An electronic control unit 60 (ECU) is connected to the air supply 40 and to each of the air suspensions 30, 32, 34. The ECU 60 is also connected to the ride height sensors 26, 28 and to the pressure sensors 35, 37, 39 associated with each air suspension 30, 32, 34. The ECU 60 monitors air pressure in the air suspensions 30, 32, 34, and ride height for the steer axle

20 and rear tandem axle set 32, 34. In routine operation, the ECU 60 controls the air supply 40 and the valves 42, 44, 46 to supply air or vent air to establish correct ride height.

The ECU 60 also monitors load on the axles 20, 22, 24. There are different ways to measure load, for example, a load sensor, such as a strain gauge, incorporated in the suspension.

- 5 Alternatively, the ECU 60 can monitor the air pressure in the associated air spring and monitor the deflection of the air spring, for example, the diameter of the air bag of the air spring. Using an algorithm or look up the table, the combination of air pressure and deflection of the air spring can be used to determine the load on the axle.

- 10 The ECU 60 will store data relevant to the truck tractor, such as whether the fifth wheel 12 mounting is movable relative to the frame 10, the wheel base dimension, and other data.

- When the axle loading system is activated, the ECU 60 controls air pressure in the air suspensions according to a method of the invention. The system is configured to achieve certain conditions. A first condition is to supply sufficient air to the steer axle, front tandem axle, and rearward tandem axle to provide the correct vehicle ride height. A second
15 condition is to provide sufficient air to the rear tandem axle set (the front tandem and rearward tandem) to support the load on the tandem axle set. A third condition is to provide a balance of air pressure in the front tandem axle and the rear tandem axle to achieve a desired load on the steer axle.

- 20 The system may be activated through a driver interface 70 connected to the ECU 60. The system will typically be activated when the vehicle load has changed, for example, when a loaded trailer is hitched to the fifth wheel 12, or when load has been added to or removed from a hitched trailer.

- Figure 2 provides a flow diagram of a method according to the invention. Once the system has been activated, a first step 100 is to determine that the ride height of the axles is
25 correct. If incorrect, air is added or removed from the relevant air suspension (or suspensions) as needed to achieve correct ride height. The method then performs the step 102 determining the load on the steer axle 20 and each of the tandem axles 22, 24. In step 104, the system determines that air pressure in the rear tandem is sufficient to support the measured load. The system adjusts the air pressure in the tandem axles as necessary.

According to a step 106, the load on the steer axle 20 is compared to a load limit (typically 12,000 lbs for a Class 8 tractor) to determine whether the measured load exceeds the limit.

If the load on the steer axle 20 exceeds the load limit, the system performs the step 108 of increasing the air pressure in the forward tandem axle air suspension relative to the air pressure in the rearward tandem axle. This may be done by adding air to the forward tandem axle air suspension, or removing (venting) air from the rearward tandem axle air suspension, or a combination of both. The pressure differential is believed to create a moment between the forward tandem axle and the rearward tandem axle that shifts load from the steer axle. The system returns to the step 100.

If the load on the steer axle is not above the steer axle load limit, the system determines in step 110 whether the load on the tandem axle exceeds a load limit. It is noted that if the steer axle load is below the limit value, the steer axle may have usable load capacity; it may be possible to shift load from the tandem axle to the steer axle to avoid unloading or reloading the trailer or truck box. The method in step 112 then decreases the air pressure in the forward tandem axle air suspension relative to the rearward tandem axle air suspension. This may be done by removing air from the forward tandem axle air suspension or adding air to the rearward tandem air suspension, or a combination of both. The pressure differential is believed to create a moment between the forward tandem axle and the rearward tandem axle that shifts load to the steer axle. The method returns to step 100.

If the load on the tandem axles is not above the load limit, the method allows the driver to consider moving the fifth wheel to a more favorable location for vehicle aerodynamics. In step 114 the system determines if the fifth wheel is in a desired position relative to the truck frame. A desired position may be sufficiently far forward so that a gap between the rear of the truck cab and the front of the trailer is at a practical minimum (allowing for turning of the trailer relative to the tractor) for low air resistance. The fifth wheel mount 14 may include position sensors 18 whose signals are communicated to the ECU 60. The ECU 60 would include stored information on fifth wheel position to compare to the measured data. However, because trailers may differ in the distance from the front of the trailer to the king pin, the system may not be able on its own to determine if the fifth wheel is in a desired

position. Alternatively, the system may through the driver interface 70 ask for input on whether the fifth wheel is in a desired position.

If the fifth wheel is not in a desired position as determined by step 114, the system will in step 116 indicate to the driver that the fifth wheel may be moved forward on the frame, that is, in the direction of the steer axle 20 (see Figure 1). Alternatively, the vehicle may be equipped so that the ECU 60 can control the fifth wheel movement and will move the fifth wheel. The method returns to step 100 to determine load on the axles.

If the fifth wheel is in a desired position, the system may optionally in step 118 make some load capacity available on the tandem axle set by decreasing the air pressure in the forward tandem axle air suspension relative to the rearward tandem axle air suspension. This may be done by removing air from the forward tandem axle air suspension or adding air to the rearward tandem air suspension, or a combination of both. The pressure differential is believed to create a moment between the forward tandem axle and the rearward tandem axle that shifts load to the steer axle. If step 118 is performed, the system may then in step 120 indicate by way of the operator interface 70 that load capacity on the tandem axle set is available, along with an estimated value of the increased load capacity. The method returns to step 100 to determine the load on the axles.

Alternatively, the system can be configured for manual operation. According to an alternative embodiment of the invention, an operator interface includes a knob or lever that can be manipulated to selectively increase pressure in a forward rear axle air suspension relative to a pressure in a rearward rear axle suspension to decrease a load on the steer axle or decrease a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle. This embodiment may be useful for applications in which the truck tractor is not equipped with load sensors on the steer axle, for example, and the operator would use a scale at a terminal or truck stop to measure the load. A method according to this alternative includes the steps of positioning the fifth wheel to place the trailer in an aerodynamically advantageous position, monitoring the load on the steer axle by way of the truck scale, and by way of a manual control, adjusting the pressure balance in the rear tandem axles until the correct load on the steer axle is achieved.

One advantage of the invention is that customers will be able to order a shorter wheelbase truck to maximize for fuel economy with smaller cabs. This system can also be used to load or unload front axle weight for optimum transport effectiveness on short wheelbase tractors that have optimized the air gap between the back of the cab and the front of the trailer. With this system enabled a customer can actually order a truck based on clearance needed for trailer swing, not just weight transfer positive or negative.

The invention has been described in terms of preferred principles, embodiments, method steps, and components; however, those skilled in the art will recognize that substitutions for what is described may be done without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A method for distributing load forces among axles of a truck having a front steer axle and two rear axles, the rear axles including an air suspension, comprising the steps of:

monitoring a load on each of the axles and generating a load signal therefrom;

5 increasing a pressure in a forward rear axle air suspension relative to a pressure in a rearward rear axle suspension to decrease a load on the steer axle; and,

decreasing a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle.

2. The method of claim 1, wherein the steps of increasing a pressure in a forward rear axle air suspension and decreasing a pressure in a forward rear axle air suspension are done
10 responsive to the load signal on the front axle to attain a desired load on the front axle.

3. The method of claim 1, comprising adding air to the forward rear axle air suspension to decrease the load on the steer axle.

4. The method of claim 1, comprising removing air from the rearward rear axle air
15 suspension to decrease the load on the steer axle.

5. The method of claim 1, comprising removing air from the forward rear axle to increase the load on the steer axle.

6. The method of claim 1, comprising adding air to the rearward rear axle suspension to increase the load on the steer axle.

20 7. The method of claim 1, comprising controlling the pressure in the forward rear axle suspension and rearward rear axle suspension to maintain a steer axle load below a threshold value.

8. A method for distributing load forces among axles of a truck having a front steer axle and two rear axles, the rear axles including an air suspension, comprising the steps of:

25 monitoring a load on each of the axles;

increasing a pressure in a forward rear axle suspension relative to a pressure in a rearward rear axle air suspension to decrease a load on the steer axle.

9. A method for distributing load forces among axles of a truck having a front steer axle and two rear axles, the rear axles including an air suspension, comprising the steps of:

5 monitoring a load on each of the axles; and,

 decreasing a pressure in a forward rear axle suspension relative to a rearward rear axle air suspension to increase a load on the steer axle.

10. A system for distributing load forces among axles of a truck having a front steer axle and two rear axles, comprising:

10 an air suspension associated with each of a steer axle, a forward rear axle and a rearward rear axle;

 an air supply apparatus for selectively adding and removing air from the air suspension;

 load sensors mounted on each of the axles for generating a load signal;

15 a controller connected to receive the load signals and configured, responsive thereto, to increase a pressure in a forward rear axle air suspension relative to a pressure in a rearward rear axle suspension to decrease a load on the steer axle, and, decrease a pressure in a forward rear axle air suspension relative to a rearward rear axle suspension to increase a load on the steer axle.

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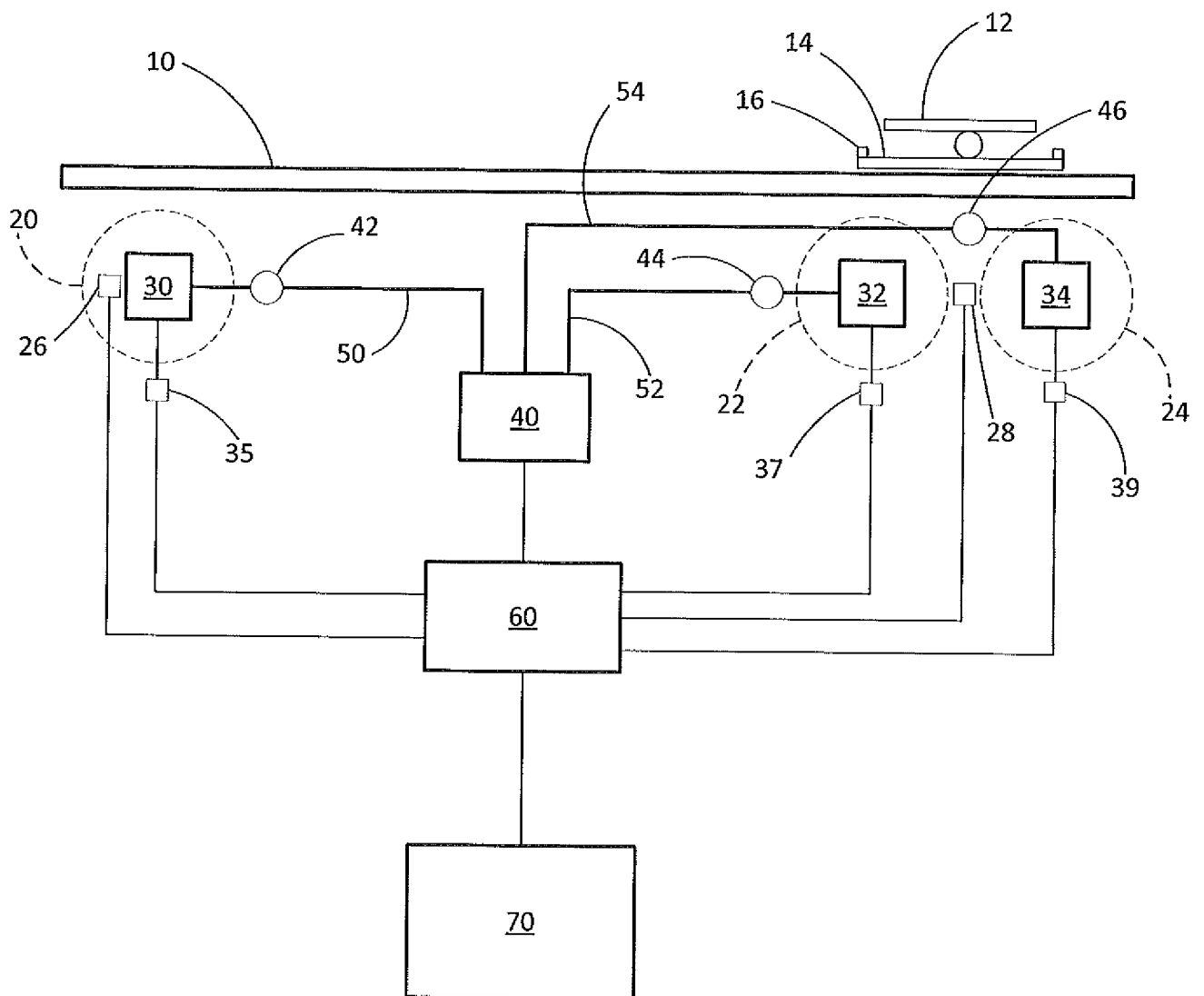


Figure 1

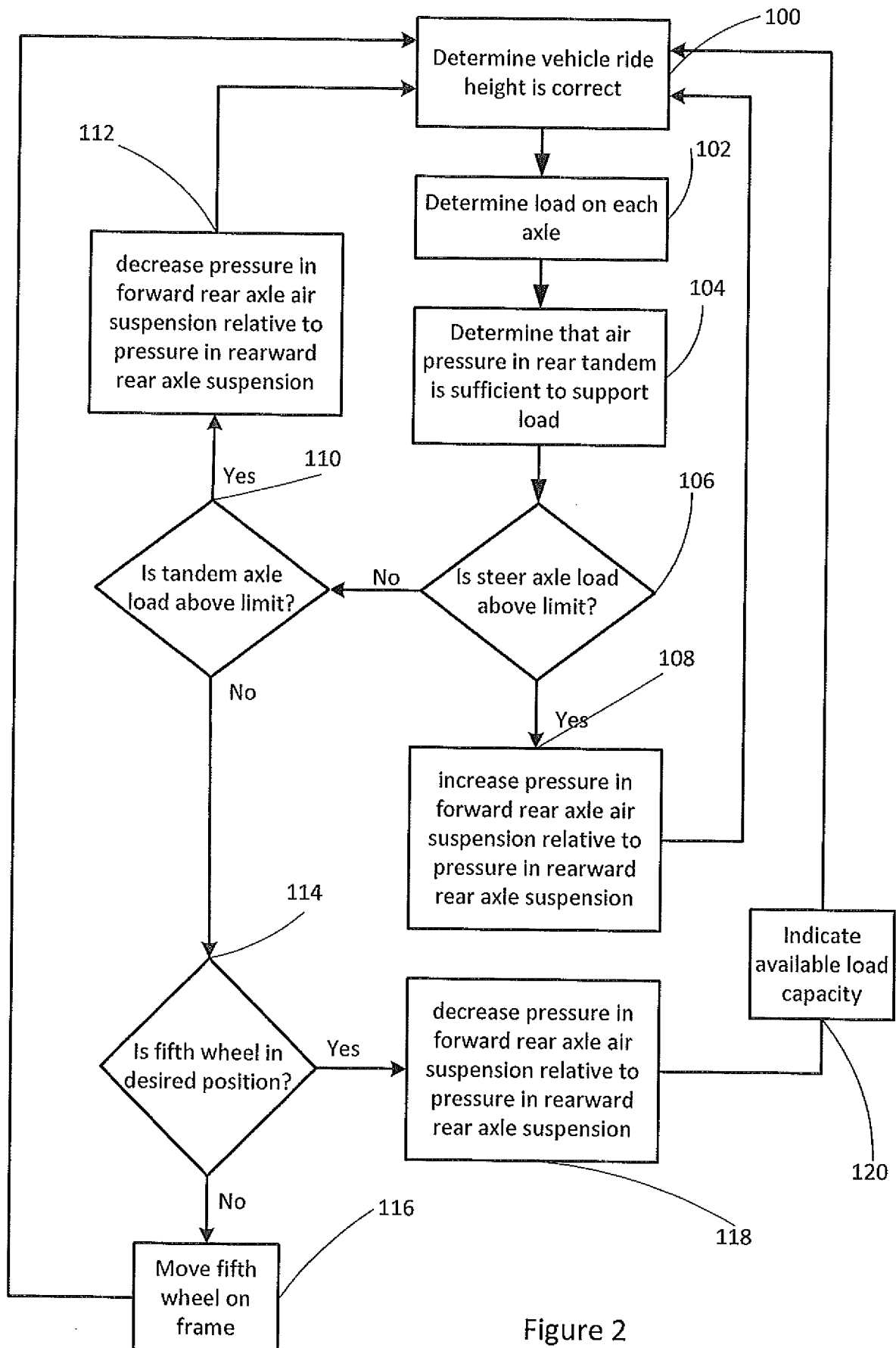


Figure 2