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(54) Railway vehicle suspension provided with roll stiffness control means

(57) A pneumatic suspension comprises: at least one left air bellows (34L) and at least one right air bellows (34R) to be positioned between a vehicle body (12) of a railway vehicle (10) and a running gear (14) respectively on a left and on a right side of a median longitudinal vertical plane (102) of the running gear (14) to support the vehicle body (12) on the running gear (14), and additional air volume means (36L, 36R) connected to the left and right air bellows (34L, 34R) by means of anti-roll valve means (40L, 40R). A curve detector (42) is connected to the antiroll valve means (40L, 40R) such as to isolate the left and right air bellows (34L, 34R) from the additional air volume means (36L, 36R) when a curve is detected to stiffen the pneumatic suspension when a curve is detected.

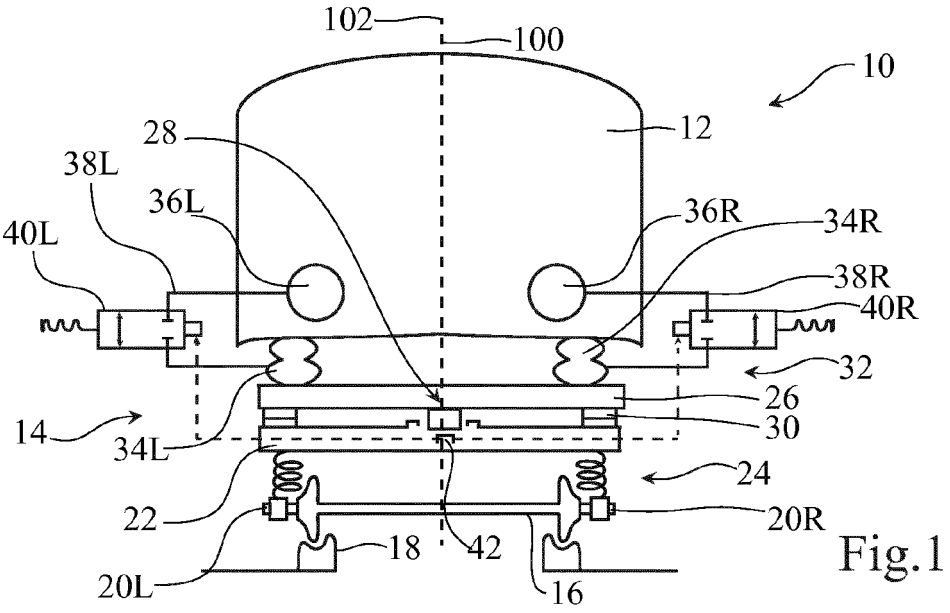

Fig.1

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Description

TECHNICAL FIELD OF THE INVENTION

[0001] This invention relates to a pneumatic suspension for a railway vehicle, in particular albeit not exclusively to a secondary pneumatic suspension. It also relates to a running gear, and in particular to a bogie provided with such a pneumatic suspension. It also relates to a railway vehicle provided with such pneumatic suspension and to a method of controlling such a pneumatic suspension.

BACKGROUND ART

[0002] A railway vehicle with a primary and a secondary suspension is disclosed in EP 0 568 043. The secondary suspension is a pneumatic suspension comprising toroidal air bellows located between a car body and a bogie frame on both sides of the bogie. Each air bellows is connected to a closed auxiliary volume by means of a pneumatic line to reduce the vertical stiffness of the air suspension and increase the perceived ride comfort. Unfortunately, this reduction of the vertical stiffness also leads to a reduction of the roll stiffness, with undesired effects when the railway vehicle negotiates a curve, such as an increased lateral acceleration perceived by the passengers, lateral displacement of the pantograph and car body width restrictions. To counteract this reduction of the roll stiffness, two three-way valves are disposed between the toroidal air bellows and the auxiliary volumes, to selectively isolate one of the air bellows on one side of the bogie from the associated auxiliary volume and simultaneously connect this auxiliary volume to the other air bellows on the other side of the bogie and to the associated auxiliary volume, when the vehicle enters a curve. When the vehicle enters a curve, the air bellows on the inner side of the curve is isolated, which reduces its active pneumatic volume and increases its stiffness, while the air bellows on the outer side of the curve is connected to the two air auxiliary volumes, which further reduces the stiffness on this side. Depending on the ratios of volume between the air bellows and auxiliary volumes, the overall roll stiffness of the secondary suspension may slightly increase or even decrease, which is detrimental in a curve.

[0003] Hence, there is a need for simple and reliable means to substantially increase the roll stiffness of a pneumatic suspension when a railway vehicle negotiates a curve.

SUMMARY OF THE INVENTION

[0004] According to one aspect of the invention, there is provided a pneumatic suspension comprising at least one left air bellows and at least one right air bellows to be positioned between a vehicle body and a running gear respectively on a left and on a right side of a median longitudinal vertical plane of the running gear to support the vehicle body on the running gear. Additional air volume means are connected to the left and right air bellows by means of anti-roll valve means. A curve detector is connected to the antiroll valve means such as to isolate the left and right air bellows from the additional air volume means when a curve is detected.

[0005] The vertical stiffness of an air bellows is inversely proportional to the volume of air in the air bellows. A first order approximation of the roll stiffness is the sum of the absolute values of the vertical stiffness of the suspension on the right and left side of the running gear. When the vehicle runs on a straight track, each air bellows is associated to one additional volume to provide a relatively soft suspension, i.e. a low vertical and roll stiffness of the suspension. When a curve is detected, both left and right air bellows are simultaneously isolated from the additional air volume means and the vertical stiffness increases on both sides of the running gear, which results in an increase of the roll stiffness.

[0006] According to an embodiment, the anti-roll valve means include a left anti-roll valve for connecting the additional air volume means to the left air bellows and a right anti-roll valve for connecting the additional air volume means to the right air bellows. According to one embodiment, each of the left and right anti-roll valves is a two- position, two-way valve, a particularly simple arrangement.

[0007] The additional air volume means may include one or several chambers. According to a preferred embodiment, the additional air volume means include at least one left additional air chamber connected to the left air bellows via the anti-roll valve means and at least one right additional air chamber connected to the right air bellows via the anti-roll valve means. The left and right additional air chambers may be completely isolated from one another or may be connected to one another by means of a differential pressure valve, with or without nozzle. As stated above, the anti-roll valve means can include one common valve or two individual valve, i.e. a left anti-roll valve between the left additional air chamber and the left air bellows, and a right anti-roll valve between the right additional air chamber and the right air bellows.

[0008] The additional air volume means may include one or more common air chambers connected both to the left and right air bellows via the anti-roll valve means. The common air chamber or chambers may be the only chambers of the additional air volume means or may be combined with left and right additional air chambers.

[0009] According to one embodiment, the additional air volume means may include at least one left additional air volume connected to the left air bellows via the anti-roll valve means and at least one right additional air volume connected to the right air bellows via the anti-roll valve means. The antiroll valve means may include a single two-position, four-way valve.

[0010] Preferably, the additional air volume means have a total volume, which is at least more than half a

total volume of the left and right air bellows.

[0011] The additional air volume means can be realised as one or more closed cavities realised in a frame of the running gear or in a frame of the car body. Alternatively, the additional air volume can comprise one or more pneumatic reservoirs.

[0012] The curve detector may include one or several lateral acceleration detectors, in particular one accelerometer which delivers an electrical signal or a couple of lateral accelerometers located at the front and rear end of the running gear or a pendular mass linked to the valve or valves by means of a linkage. The curve detector may also include a GPS system linked to a map of the track to predict the entry into a curve. It may also include a rotation sensor, which detects a rotation movement of the car body with respect to the running gear about a vertical axis. It may also include a roll sensor, e.g. a rotation sensor, which detects a rotation of the car body with respect to the running gear about a horizontal, longitudinal axis. It may also include a displacement sensor for detecting a lateral motion of the car body with respect to the running gear. The rotation sensor and/or displacement sensor may include a linkage, e.g. one or more connecting rods and/or levers connected between the car body and the running gear and mechanically linked to the valve(s).

[0013] According to a preferred embodiment, the anti-roll valve means are biased towards a closed position to isolate the left and right air bellows from the additional air volume means in the absence of signal from the curve detector. This provides a failsafe operation mode in case of malfunction of the detector.

[0014] According to another aspect of the invention, there is provided a running gear for a railway vehicle, comprising a set of wheels, a frame and the above-described pneumatic suspension associated with the running gear. The running gear may be a one-axle running gear, a two-axle bogie or a running gear with more than two wheelsets. It can be conventional bolster bogie or bolsterless bogie.

[0015] The suspension is preferably a secondary suspension, i.e. a suspension stage for supporting the vehicle body of the railway vehicle, e.g. a car or coach body, on the frame of the running gear. This secondary suspension may or may not be complemented by a primary suspension stage between the wheels and frame of the running gear. According to one embodiment, the pneumatic suspension is preferably connected with the frame of the running gear. The pneumatic suspension can also be connected to a bolster of the running gear, in which case it can extend between the bolster and the frame, or between the bolster and the car body.

[0016] The running gear may further include a primary suspension for supporting the frame on the set of wheels.

[0017] The running gear may include a bolster provided with a pivot for guiding the rotation movement of the running gear with respect to the vehicle body, in which case, the secondary air suspension may be active between the bolster and the vehicle body, between the bolster and the running gear frame or between the vehicle body and the running gear frame.

[0018] According to another aspect of the invention, there is provided a railway vehicle comprising a vehicle body supported on at least one, preferably at least two running gears as described above. The running gear can be located between the two ends of a car body. Alternatively, the running gear can also be a so-called Jacob-type or articulated running gear located between two adjacent carriages, supporting the rear end of the front carriage and the front end of the adjacent rear carriage.

[0019] According to another aspect of the invention, there is provided a method of controlling a rolling movement of a railway vehicle running on a track, the railway vehicle being provided with a pneumatic suspension comprising left and right vertical air bellows and additional air volume means, the method comprising:

- detecting a curve of the track;
- isolating the left and right air bellows from the additional air volume means to stiffen the pneumatic suspension when a curve is detected;
- connecting the left and right air bellows to the additional air volume means to soften the pneumatic suspension when no curve is detected.

[0020] The stiffening of the left and right vertical air bellows results in an increase of the roll stiffness.

DESCRIPTION OF THE FIGURES

[0021] Illustrative embodiments of the invention will now be described, purely by way of examples and without limitation to the scope of the claims, and with reference to the accompanying drawings, in which:

- Fig. 1 is a schematic diagram of railway vehicle according to a first embodiment of the invention;
- Fig. 2 is a schematic diagram of railway vehicle according to a second embodiment of the invention;
- Fig. 3 is a schematic diagram of railway vehicle according to a third embodiment of the invention.
- Fig. 4 is a schematic diagram of railway vehicle according to a fourth embodiment of the invention.
- Fig. 5 is a schematic diagram of railway vehicle according to a fifth embodiment of the invention.
- Fig. 6 is a schematic diagram of railway vehicle according to a sixth embodiment of the invention.

[0022] Corresponding reference numerals refer to the

same or corresponding parts in each of the figures.

DETAILED DESCRIPTION OF PREFERED EMBODIMENTS

[0023] Referring to Fig. **1,** a railway vehicle **10** comprises a car body **12** supported on one or more running gears, in the present instance bogies **14.** Each bogie **14** includes at least one wheelset **16** running on a rail track **18** and journalled in a pair of axle boxes **20L, 20R,** a bogie frame **22** linked to the axle boxes **20** by means of a primary suspension **24,** which may be a pneumatic or mechanic suspension e.g. with helicoidal and/or rubber springs or any combination of different springs.

[0024] The bogie frame **22** supports a bolster **26,** which can freely rotate about a vertical axis **100** with respect to the bogie frame **22** by means of a central pivot **28.** Side bearers **30** limit the other degrees of freedom between the two components. The bolster **26** is linked to the car body **12** by a secondary suspension **32** comprising at least one left bellows **34L** and one right bellows **34R,** located respectively on a left and a right side of a vertical longitudinal plane **102** of the car body. The left and right bellows **34L, 34R** support the car body **12** in the vertical direction and may or may not present stiffness in the lateral and longitudinal directions. One or several longitudinal connecting rods (not shown) are also provided to integrally transmit longitudinal forces between the car body **12** and the bolster **26.** A lateral shock absorber (not shown) may complement the mechanical connection between the bolster **26** and the car body **12.**

[0025] Each of the left and right bellows **34L, 34R** is connected to a left, respectively right additional air chamber **36L, 36R** by means of a left, respectively right air connection line **38L, 38R** which includes a left, respectively right antiroll valve **40L, 40R.** Each antiroll valve **40L, 40R** is a two-way, two-position valve, in this particular case a solenoid valve electrically connected to a curve detector **42.**

[0026] The curve detector **42** may include a lateral accelerometer located on the bogie frame for detecting the lateral acceleration of the bogie, linked to a control circuit including a low-pass filter and a power unit. The control circuit is such as to send a control signal to activate the two solenoids and connect the left and right bellows to the respective left and right additional chambers when the vehicle is on a straight line, i.e. when the absolute value of a low-pass component of the lateral acceleration measured by the accelerometer is below a predetermined threshold. When the vehicle enters a curve, the absolute value of the low-pass component of the lateral acceleration measured by the accelerometer increases above the predetermined threshold and the control signal is switched off to de-energise the solenoids. The spring-biased left and right antiroll valves return to their closed position to isolate the left and right bellows from the left and right additional chambers.

[0027] The embodiment of Fig. **2** differs from the previous embodiment in that the left and right air bellows **34L, 34R** are located between the bogie frame **22** and a bolster **26,** which is provided with a pivot connection **28** with the car body **12.**

[0028] The left and right bellows **34L, 34R** are connected to left, respectively right additional air chambers **36L, 36R** in a manner similar to the first embodiment.

[0029] The embodiment of Fig. **3** illustrates a railway vehicle **10** provided with a bolsterless bogie **14.** A secondary suspension system **32** of the invention is arranged directly between the frame **22** of the bogie **14** and the car body **12.** Anti-yawing dampers **44** may be provided to limit the relative yawing motion between the bogie frame and the vehicle body. Longitudinal connecting rods **46** transfer the longitudinal forces between the car body and the bogie frame.

[0030] The left and right bellows **34L, 34R** are connected to left, respectively right additional air chambers **36L, 36R** in a manner similar to the first embodiment.

[0031] The embodiment of Fig. **4** differs from the previous embodiments merely in that a single two-position, four-way anti-roll valve **140** is used instead of the left and right anti-roll valves **40L, 40R** of the previous embodiments to the same effect.

[0032] A simplified arrangement is illustrated in Fig. **5,** with a common additional air chamber **236** instead of two separate air chambers **36L, 36F.** In this example, the circuit is provided with two individual anti-roll vales **40L, 40R,** which, however, could be replaced with a single two-position four-way anti-roll valve **140.**

[0033] Should the arrangement comprise more than one left bellows, e.g. a front and a rear left air bellows **34LF, 34LR** and more than one right bellows e.g. a front and a rear right air bellows **34RF, 34RR,** the bellows on each side of the vehicle can be connected to a common additional air chamber as illustrated in Fig. **6** or to individual air chambers. It would also be possible to connect the air bellows on both sides of the vehicle to a common air chamber.

[0034] While the above example illustrates preferred embodiments of the present invention, it is noted that various other arrangements of the antiroll suspension means may also be considered, which fall within the scope of the appended claims.

[0035] In particular, details of the various arrangements of Figs. **1** to **6** can be combined with one another, e.g. a common additional air chamber **236** can be added to individual air chambers **36L, 36R.** Anti-yaw dampers may be left out in the embodiment of Fig. **3,** and can be added in the other embodiments.

[0036] Many types of detectors or combination of detectors can be used to detect that the vehicle is entering a curve. The detectors may send an electrical or mechanical signal to the valve. The detector should preferably send a signal when a threshold is reached.

Claims

1. A pneumatic suspension comprising:

   - at least one left air bellows (34L) and at least one right air bellows (34R) to be positioned between a vehicle body (12) of a railway vehicle (10) and a running gear (14) respectively on a left and on a right side of a median longitudinal vertical plane (102) of the running gear (14) to support the vehicle body (12) on the running gear (14), and
   - additional air volume means (36L, 36R, 236) connected to the left and right air bellows (34L, 34R) by means of anti-roll valve means (40L, 40R, 140);

   characterised in that it further comprises a curve detector (42) for detecting a curve, the curve detector being connected to the antiroll valve means (40L, 40R, 140) such as to isolate the left and right air bellows (34L, 34R) from the additional air volume means (36L, 36R, 236) when a curve is detected.

2. The pneumatic suspension of claim 1, **characterised in that** the anti-roll valve means include a left anti-roll valve (40L) for connecting the additional air volume means (36L, 36R) to the left air bellows (34L) and a right anti-roll valve (40R) for connecting the additional air volume means (36L, 36R) to the right air bellows (34R).

3. The pneumatic suspension of claim 2, **characterised in that** each of the left and right anti-roll valve (40L, 40R) is a two- position, two-way valve.

4. The pneumatic suspension of claim 1, **characterised in that** the antiroll valve means consists of a two-position, four-way valve (140) for connecting the additional air volume means (36L, 36R, 236) to the left air bellows (34L) and to the right air bellows (34R).

5. The pneumatic suspension of claim 1, **characterised in that** the additional air volume means include at least one left additional air chamber (36L) connected to the left air bellows (34L) via the anti-roll valve means (40L, 40R, 140) and at least one right additional air chamber (36R) connected to the right air bellows (34R) via the anti-roll valve means (40L, 40R, 140).

6. The pneumatic suspension of any one of the preceding claims, **characterised in that** the additional air volume means include at least one common additional air chamber (236) connected to the left air bellows (34L) and to the right air bellows (34R) via the anti-roll valve means (40L, 40R, 140).

7. The pneumatic suspension of any one of the preceding claims, **characterised in that** the antiroll valve means (40L, 40R, 140) are biased towards a closed position to isolate the left and right air bellows (34L, 34R) from the additional air volume means (36L, 36R, 236) in the absence of signal from the curve detector (42).

8. The pneumatic suspension of any one of the preceding claims, **characterised in that** the additional air volume means (36L, 36R, 236) have a total volume, which is more than half a total volume of the left and right air bellows (34L, 34R).

9. The pneumatic suspension of any one of the preceding claims, **characterised in that** the curve detector (42) includes a lateral acceleration detector.

10. A running gear (14) for a railway vehicle, comprising a set of wheels (16), a frame (22) and the pneumatic suspension of any one of the preceding claims borne on the frame (22).

11. The running gear of claim 10, **characterised in that** it further comprises a primary suspension (24) for supporting the frame (22) on the set of wheels (16).

12. The running gear of claim 10 or claim 11, **characterised in that** the running gear further comprises a bolster (26) provided with a pivot bearing (28) for supporting a vehicle body (12), wherein the left and right bellows (34L, 34R) bear on the bolster (26).

13. A railway vehicle (10) comprising a vehicle body (12), **characterised in that** the vehicle body (12) is supported on at least one and preferably at least two running gears (14) according to any one of claim 10 to 12.

14. A method of controlling a rolling movement of a railway vehicle (10) running on a track, the railway vehicle (10) being provided with a pneumatic suspension comprising left and right air bellows (34L, 34R) and additional air volume means (36L, 36R), the method comprising:

   - detecting a curve of the track;
   - isolating the left and right air bellows (34L, 34R) from the additional air volume means (36L, 36R) to stiffen the pneumatic suspension when a curve is detected;
   - connecting the left and right air bellows (34L, 34R) to the additional air volume means (36L, 36R) to soften the pneumatic suspension when no curve is detected.

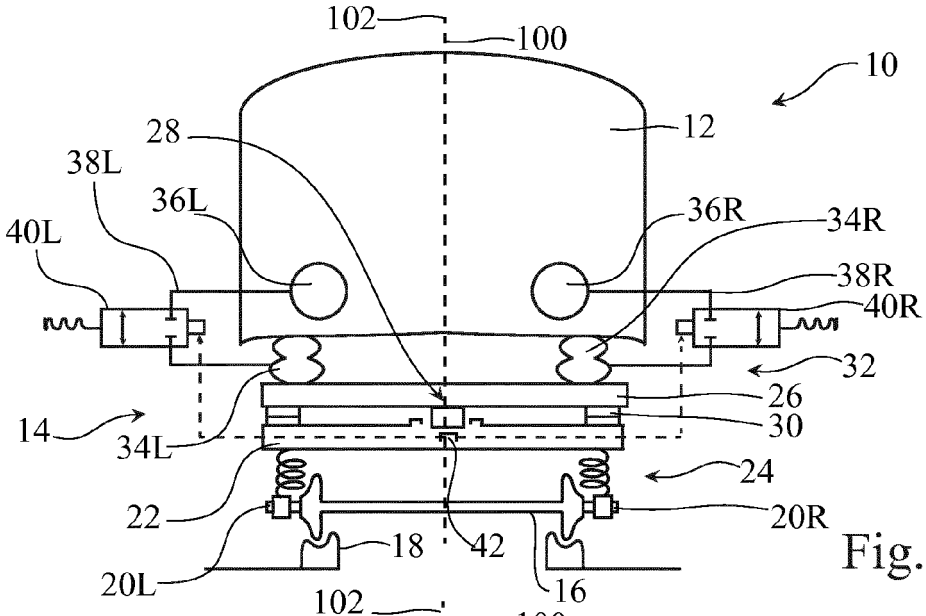


Fig.1

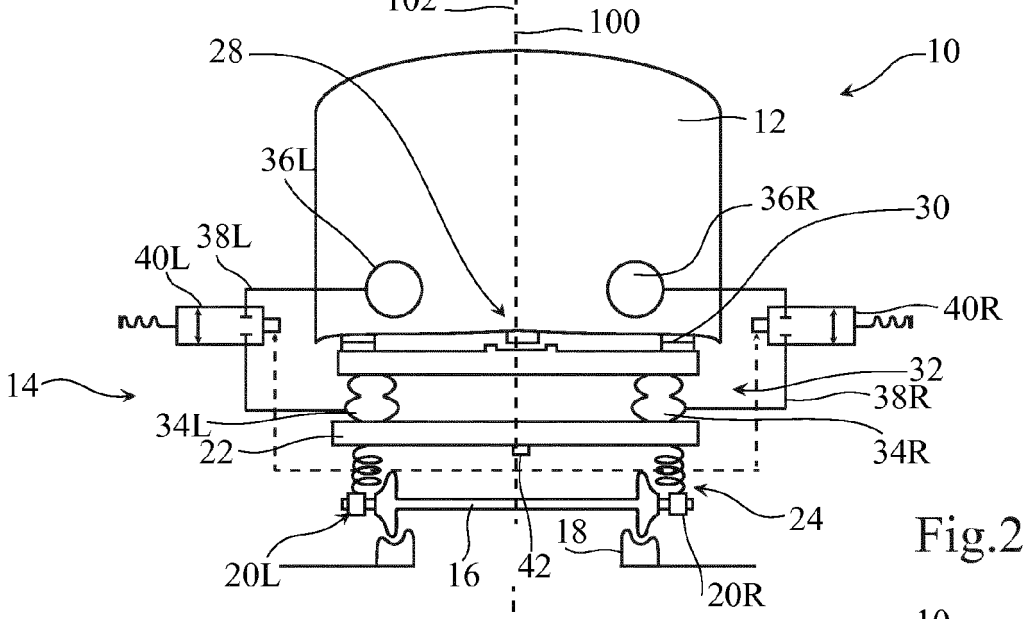


Fig.2

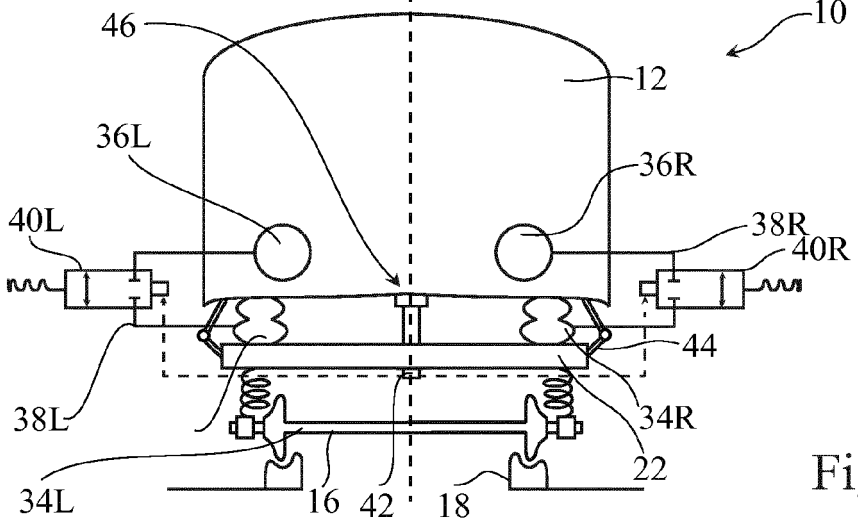


Fig.3

Fig.4

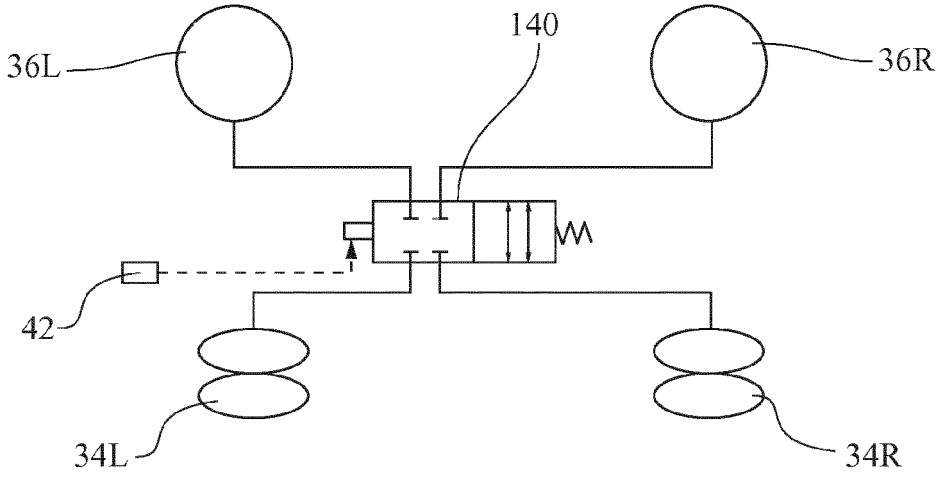


Fig.5

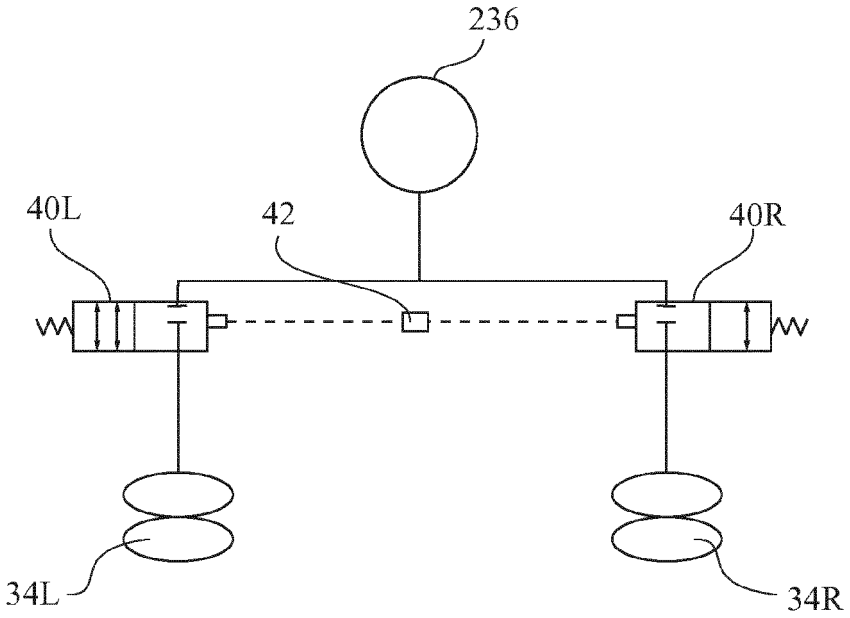
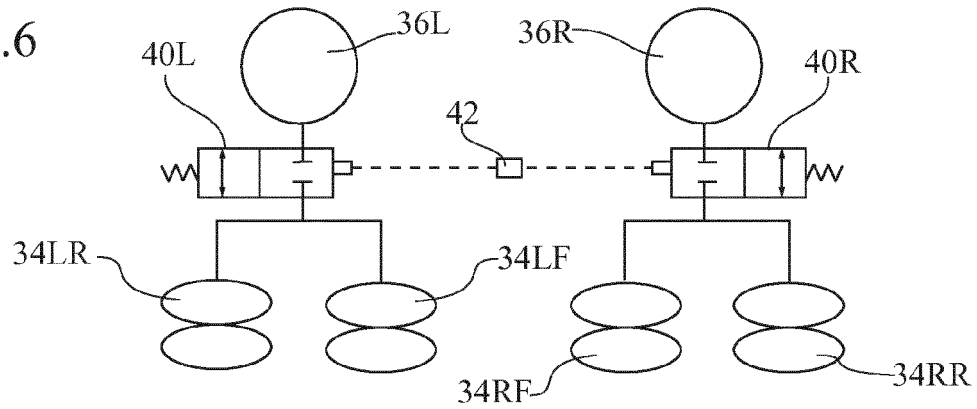


Fig.6



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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 9656

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	21 March 2013	Schultze, Yves

CATEGORY OF CITED DOCUMENTS

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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