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(54) **Derailment detection device and method**

(57) The present invention relates to a derailment detection device for a rail vehicle (1), comprising a proximity sensor (12) mounted on a track brake (8) and/or a current sensor (11) connected to an axle (14). The present invention also relates to a method for detecting derailment of a rail vehicle (1) from a railway track (7), comprising

the steps of monitoring the distance of a track brake (8) of said rail vehicle (1) to a rail surface and/or an electric current flowing through said axle (14); and activating an alarm and/or an emergency brake if said distance is outside a predetermined safe range, and/or said current differs from a set current by more than a predetermined amount.

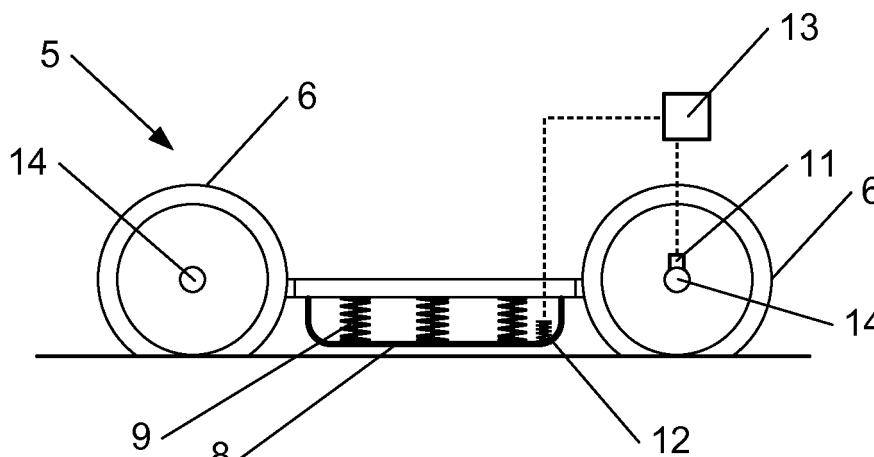


Fig. 2a

Description

[0001] The present invention relates to a derailment detection device for a rail vehicle.

[0002] By "rail vehicle", in the present specification and claims, it is understood any vehicle, self-propelled or not, adapted to run on wheels in engagement with a railway track.

[0003] By "derailment" we understand any situation where at least one of the wheels is no longer in stable engagement with the corresponding track. This includes total derailment, in which the wheel is completely out of engagement with the rail, as well as partial derailment, in which the wheel, while still in contact with the track, is in an anomalous position with respect to it which can lead to total derailment.

[0004] Derailment is a well-known hazard in the technical field of rail vehicles. It can cause serious material and even personal damage. However, due to the great length of rail vehicles, especially when they have the form of convoy of a plurality of cars linked to each other, derailment at the tail of the rail vehicle may not always be readily apparent at its head, where the driver is usually located. For this reason, significantly damage may be caused already before the driver notices and takes measures, such as stopping the vehicle. For this reason a number of derailment detection devices and methods have been proposed for assisting the driver.

[0005] Some such derailment detection devices, such as those disclosed in US patent 6,411,870, US patent application publication 2006/0122745, International patent publication application WO 03029059, and International Patent Application WO 0194176, comprise vibration sensors or accelerometers which issue a derailment alarm if a value mathematically derived from a measured acceleration or acceleration time series exceeds a certain threshold.

[0006] An alternative derailment detection device and method is disclosed in European patent application EP 1 422 119 A1. This derailment detection device for a wheeled rail vehicle comprises an inductive proximity sensor. The inductive sensor is mounted in proximity to one of the wheels, facing the railway track so as to monitor its distance to the track.

[0007] An object of the present invention is to provide an improved derailment detection device.

[0008] In a first embodiment of the present invention, the derailment detection device comprises a proximity sensor mounted on a track brake. A track brake is a form of brake unique to rail vehicles, and intended to provide a braking force beyond the adhesion limit of the wheels, wherein the braking force is derived from the friction resulting from the application of a braking shoe directly to the track. For this reason, track brakes are kept in close proximity to the track. Typically, a track brake is mounted low and close to at least one of the wheels. Since the proximity sensor of the derailment detection device is also advantageously located low and in close proximity

to one of the wheels, the track brake offers a particularly advantageous platform for its installation. Moreover, since track brakes are normally used as emergency brakes, this arrangement facilitates an eventual direct connection of the derailment detection device to the emergency brake system.

[0009] Advantageously, said proximity sensor may comprise an electromagnetic coil. If the coil is within detection range of its corresponding track rail, an electromagnetic signal in the rail will be picked up by the coil.

[0010] Advantageously, said track brake may be an electromagnetic track brake. Electromagnetic track brakes are actuated by electromagnetic actuation coils which force the brake shoe against the track. They can generate very high braking forces and as such are particularly suitable for rail vehicles. Even more advantageously, an actuation coil of the electromagnetic track brake may double as electromagnetic coil of the proximity sensor. However, the electromagnetic coil of the proximity sensor may also be a dedicated detection coil, preferably mounted near an extremity of the track brake, so as to be closer to a wheel.

[0011] Advantageously, said electromagnetic coil may be connected to an oscillator, so as to form an inductive sensor. In use, an electromagnetic field is then created in the close surroundings of the coil. The presence of an electrically conductive object, such as the rail, in the proximity of the coil then causes a change of the oscillation.

[0012] The present invention also relates to a derailment detection device comprising, either in combination with said proximity sensor or alternatively to it, an electric current sensor for detecting an electric current flowing between an axle of said rail vehicle and said track. If the axle derails, this electric current will be interrupted.

[0013] Advantageously, said derailment detection device may further comprise a signal processor connected to both said induction and electric current sensors, and to an alarm and/or to an emergency brake. Such a signal processor can thus be programmed to issue an alarm and/or an automatic braking command when the combined signals of the proximity and electric current sensors indicate a derailment, thus suppressing false alarms by either sensor.

[0014] Advantageously, said electric current sensor may be a Hall effect sensor, which will minimise the impact on the overall rail vehicle design.

[0015] Various electrically-powered rail vehicles, in particular those known as "light rail" and used in urban areas, sometimes sharing the streets with other traffic, are powered by direct current from overhead power lines, earthed through the wheels to the railway tracks. As long as electrical systems (including the propulsion motors, but also ancillary systems such as lighting and air conditioning) are being powered within said rail vehicle, an electrical current will then flow through the wheels to the track. The electric current sensor may be connected to the axle so as to monitor this earth return current.

[0016] The derailment detection device may also com-

prise an electric power supply connected between two axles. In this case, the power supply, the axles and the track will form an electric circuit which will be interrupted if either axle derails. The electric current sensor may be connected to either axle so as to monitor the electric current flowing through this circuit.

[0017] The present invention also relates to a rail vehicle bogie and a rail vehicle comprising such a derailment detection device. In particular, the present invention relates to a light rail vehicle comprising such a derailment detection device. As light rail vehicles often operate in urban environments with numerous track switches and discontinuities, accelerometers and vibration sensors are not satisfactory as derailment detection devices on such light rail vehicles. As, however, ever longer light rail vehicles are operated on such urban environments, and mass transport authorities switch from conventional tramways to considerably longer multi-articulated light rail vehicles operating on the same lines, derailment detection devices are increasingly requested to alert the driver, in particular when the derailment occurs near the tail of the light rail vehicle.

[0018] The present invention relates also to a method for detecting derailment of a rail vehicle from a railway track, comprising the steps of:

- monitoring the distance of a track brake of said rail vehicle to a railway track surface; and
- activating an alarm and/or an emergency brake if said distance is outside a predetermined safe range.

[0019] It is a further object of the present invention to prevent a false alarm when the rail vehicle runs over a track discontinuity such as a track switch. For this purpose, said activation step may optionally only be carried out if said distance is outside said safe range for at least a predetermined period of time, wherein that predetermined period of time is preferably at least 120 ms, even more preferably at least 500 ms. False alarms over transient discontinuities are thus prevented.

[0020] The present invention relates also to a method for detecting derailment of a rail vehicle from a railway track, comprising the steps of:

- monitoring an electric current between an axle of said railway vehicle and said railway track, either in combination with said distance or not;
- activating an alarm and/or an emergency brake only if said electric current differs from a set electric current by more than a predetermined threshold.

[0021] Advantageously, said electric current may be an earth return current from a direct current (DC) supply to the rail vehicle.

[0022] Alternatively, said electric current may be an electric current flowing through the railway track between to axles. This could take the form of a direct or alternative current, and be superposed onto said earth return current

or independent from it.

[0023] Particular embodiments of the invention will now be described in an illustrative, but not restrictive form, with reference to the following figures:

Fig. 1 shows a schematic side view of a light rail vehicle incorporating a derailment detection device according to a first embodiment of the invention;

Fig. 2a shows a schematic side view of a bogie of the light rail vehicle of Fig. 1;

Fig. 2b shows a schematic front view of the bogie of Fig. 2a;

Fig. 2c shows a schematic side view of a bogie incorporating a derailment detection device according to a second embodiment of the present invention;

Fig. 2d shows a schematic side view of a bogie incorporating a derailment detection device according to a third embodiment of the present invention;

Fig. 2e shows a schematic side view of a bogie incorporating a derailment detection device according to a fourth embodiment of the present invention;

Fig. 3 shows a flow chart representing a derailment detection method for said first embodiment of the invention;

Fig. 4 shows a flow chart representing a derailment detection method for said second embodiment of the invention;

Fig. 5 shows a flow chart representing a derailment detection method for said third embodiment of the invention; and

Fig. 6 shows a flow chart representing a derailment detection method for said fourth embodiment of the invention.

[0024] A light rail vehicle 1 is shown in Fig. 1. This light rail vehicle 1 runs on a railway track 2. In sections which the light rail vehicle 1 may have to share with other traffic, less obtrusive grooved section railway tracks are preferably used. The light rail vehicle 1 is electrically powered with direct current from an overhead line 3 over a pantograph 4. The illustrated light rail vehicle 1 is multi-articulated and supported by a plurality of wheeled bogies 5.

[0025] One such wheeled bogie 5 is illustrated in Figs. 2a and 2b. The shown bogie 5 comprises two axles 14 with two wheels 6 each, arranged so as to engage the rails 7 of the track 2. On each side of the bogie 5 a track brake 8 is arranged between the successive wheels 6, facing the surface of the respective rail 7. Each track brake 8 comprises electromagnetic actuation coils 9 for pressing the track brake 8 against the rail 7 by electromagnetic attraction when braking the rail vehicle 1.

[0026] In this first embodiment of the invention, the wheels 6, apart from supporting the vehicle 1, are also used for the current return to earth. The direct current supplied by the overhead line 3 through the pantograph 4, and which powers the electric motors 10 driving the wheels 6 as well as the ancillary equipment of the vehicle 1, is returned to earth through the wheels 6 and the rails

7. A current sensor 11, such as a Hall effect sensor, monitoring the return current through the wheels 6 can thus be used to determine whether the wheels 6 of each axle 14 are in correct engagement with their respective rails 7.

[0027] A sensor coil 12 is mounted near one extremity of the track brake 8 facing the surface of the rail 7 in proximity to a wheel 6. In the illustrated embodiment, the sensor coil 12 is connected to an oscillator so as to form an inductive sensor. When the oscillator is activated, an electromagnetic field is created in the close surroundings of the sensor coil 12. The presence of an electrically conductive object in the proximity of the coil then causes a change of the oscillation. The change of such oscillation can then be identified by a threshold circuit that changes the output of the inductive sensor. This inductive sensor could be an off-the-shelf sensor.

[0028] Alternatively, instead of connecting an oscillator to the sensor coil 12, the rail 7 could receive, by other means, an electromagnetic signal that would also be picked up by the sensor coil 12 as long as it was near enough to the rail 7.

[0029] Since under normal circumstances the track brake 8 is close to the electrically conductive surface of the rail 7 within a narrow distance range, an inductive proximity sensor, mounted on the track brake 8 can sense the proximity of the track 7. For example, the track brake 8 may be mounted so that its lower surface is at a distance of 8 mm, with a maximum wear limit of 3 mm. An inductive proximity sensor with a detection range of 14 mm can then be mounted on the track brake 8 at a distance of 11 mm from the rail surface.

[0030] In case of derailment, the sensor coil 12 will move beyond its detection range from the rail 7. Its signal can then be used to detect the derailment. However, on some track discontinuities, such as track switches, the sensor coil 12 may also momentarily move out of range from the metallic surface of the track 7, which could result in a false alarm if only the signal of the inductive sensor 12 was used to determine derailment. In the illustrated embodiment, both the inductive proximity sensor, and the current sensor 11 are thus connected to a signal processor 13, and used conjointly to detect derailment.

[0031] The derailment detection method used in this embodiment of the invention is illustrated in Figure 3. In a first step 301, signals from both the inductive sensor and the current sensor 11 are sampled by the signal processor 13. The inductive sensor may, for example, produce a voltage of -0.2V when the rail surface is within range, or -2V when the track surface is out of range. The current sensor 13 may, for example, produce a voltage of 1mV per 1A of return current. The sampling frequency of the signal processor may be, for example, 25 Hz. In the next step 302, the signal processor determines whether the signal from the inductive sensor 12 indicates whether the track surface is outside of its detection range. If the track surface remains within the detection range of the inductive sensor, the signal processor 13 goes back to the first step 301. If, however, the track surface is out-

side the detection range of the inductive sensor 12, the signal processor 13 checks in step 303 whether the return current indicated by the signal from the current sensor 11 has also fallen under a minimum level, for instance 10A. If this is also the case, the signal processor 13, in step 304, activates a derailment alarm, and/or an emergency brake.

[0032] In a second embodiment of the present invention, illustrated in Fig. 2c, an actuation coil 9 of the track brake 8 is used as sensor coil. As in the first embodiment, it may be connected to an oscillator so as to form an inductive sensor, or pick up electromagnetic signals sent through the rail 7. Either way, it will work as a proximity sensor connected to the signal processor 13.

[0033] In this second embodiment of the invention, the current detector 11 is also dispensed with. A derailment detection method for use with such a derailment detection device is illustrated in Fig. 4. In this method a derailment is detected if the rail 7 is out of range of the sensor coil for at least a predetermined minimum period of time, such as at least 120 ms, or preferably at least 500 ms. In this manner, false alarms are prevented when the vehicle 1 runs over a discontinuity in the rail surface, such as a track switch. In steps 401 and 402, the signal from the inductive sensor 12 is sampled and checked as in steps 301 and 302 of the previous method. If the signal indicates that the track surface is out of range from the inductive sensor, a timing counter is added in step 405. In step 406, if the predetermined minimum period of time has not been reached, the signal processor 13 goes back to step 401 for the next sample. The timing counter will be set to zero in step 407 if in the next sample the inductive sensor 12 returns a positive reading. If, however, in step 406, the timing counter indicates that the predetermined minimum time has been reached, the signal processor, in step 404, will activate a derailment alarm, and/or an emergency brake.

[0034] In a third embodiment of the invention, illustrated in Fig. 2d, the rail proximity sensor is dispensed with. Only the current sensor 11 is thus connected to the signal processor 13 for detecting an eventual derailment. However, the earth return current may be inverted when the motors 10 are used for regenerative braking. If the overhead line 2 cannot absorb this current, the control system of the rail vehicle may command a current interruption. This could then result in a false alarm if interruption of the earth return current alone was used to determine derailment. A derailment detection method adapted to this third embodiment of the invention is thus illustrated in Fig. 5. As in the method of Fig. 3, the signal from the current sensor 11 is sampled in a first step 501. In the next step 503, it is checked whether this signal indicates a current interruption. However, before activating the alarm and/or emergency brake in step 504, it is also checked in step 508 that the current interruption is not caused by a current interruption command.

[0035] While in the first and third embodiments the current sensor 11 is arranged so as to detect an earth return

current, a fourth embodiment of the invention could also be adapted to rail vehicles powered by other means than a direct current returned to earth over the wheels 6 and rails 7. In this fourth embodiment, an electric power supply 16 is connected between the two axles 14 of the bogie. When the wheels 6 of both axles 14 contact the rails 7, an electric circuit is thus formed between the two axles 14, wherein the return current flows through the track segment between the axles. By monitoring this current with the current sensor 11, it is possible to determine whether either one of both axles 14 has derailed, as this current will be interrupted. This current may thus be superposed with the earth return current, or completely independent from any earth return, and it may be direct or alternating. Fig. 6 illustrates a derailment detection method adapted to this fourth embodiment of the invention. In this method, the signal from the current sensor 11 is sampled in a first step 601, and in the next step 603, it is checked whether this signal indicates a current interruption. If this is the case, in the next step 604, the alarm and/or emergency brake are directly activated.

[0036] Although the present invention has been described with reference to specific exemplary embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader scope of the invention as set forth in the claims. For instance, both the proximity sensors of the first and second embodiments could be used independently or in combination with a current sensor. Other types of proximity sensor, such as, for example, optical sensors, could also be used instead. Whereas in the illustrated methods, the signals from the sensors are periodically sampled and may be digitally processed, the signals may also be analogously processed, preferably in a continuous manner. Accordingly, the description and drawings are to be regarded in an illustrative sense rather than a restrictive sense.

Claims

1. Derailment detection device for a rail vehicle, comprising at least a proximity sensor, and **characterised in that** said proximity sensor is mounted on a track brake.
2. Derailment detection device according to claim 1, wherein said proximity sensor comprises an electromagnetic coil.
3. Derailment detection device according to claim 2, wherein said track brake is an electromagnetic track brake.
4. Derailment detection device according to claim 3, wherein said electromagnetic coil is an actuation coil of the electromagnetic track brake.
5. Derailment detection device according to any one of claims 2 to 4, wherein said electromagnetic coil is connected to an oscillator, so as to form an inductive sensor.
6. Derailment detection device according to one of the previous claims, further comprising an electric current sensor for detecting an electric current flowing between an axle of said rail vehicle and said track.
7. Derailment detection device according to any one of claims 1 to 6, further comprising a signal processor connected to both said proximity and electric current sensors, and to an alarm and/or to an emergency brake.
8. Derailment detection device for a rail vehicle, **characterised in that** it comprises an electric current sensor for detecting an electric current flowing between an axle of said rail vehicle and said track.
9. Derailment detection device according to claim 8, wherein said electric current sensor is a Hall effect sensor.
10. Method for detecting derailment of a rail vehicle from a railway track, comprising the steps of:
 - monitoring a distance of a track brake of said rail vehicle to a rail surface; and
 - activating an alarm and/or an emergency brake if said distance is outside a predetermined safe range.
11. Method according to claim 10, wherein said activation step is only carried out if said distance is outside said safe range for at least a predetermined period of time.
12. Method according to any one of claims 10 or 11, wherein an electric current between an axle of said rail vehicle and said railway track is also monitored, and said activation step is only carried out if said electric current differs from a set electric current by more than a predetermined threshold.
13. Method for detecting derailment of a rail vehicle from a railway track, comprising the steps of:
 - monitoring an electric current between an axle of said railway vehicle and said railway track;
 - activating an alarm and/or an emergency brake if said electric current differs from a set electric current by more than a predetermined threshold.
14. Method according to claim 13, wherein said monitored electric current is an earth return current from a DC supply to the rail vehicle.

15. Method according to claim 14, wherein said monitored electric current is an electric current flowing from an axle of said railway vehicle, through the track, to another axle of said railway vehicle.

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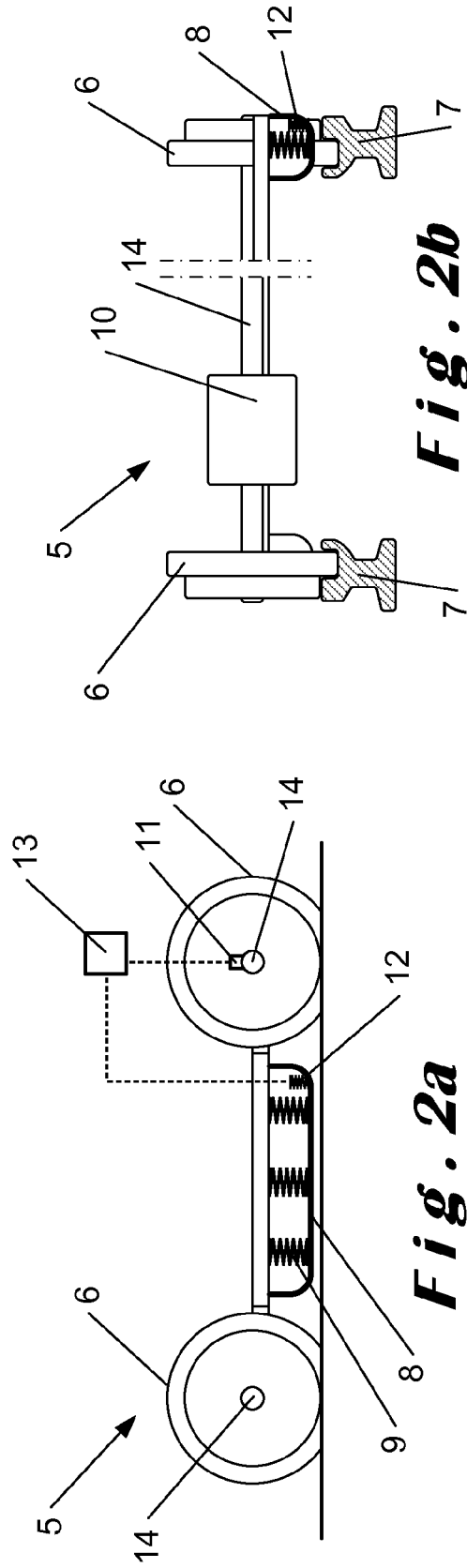
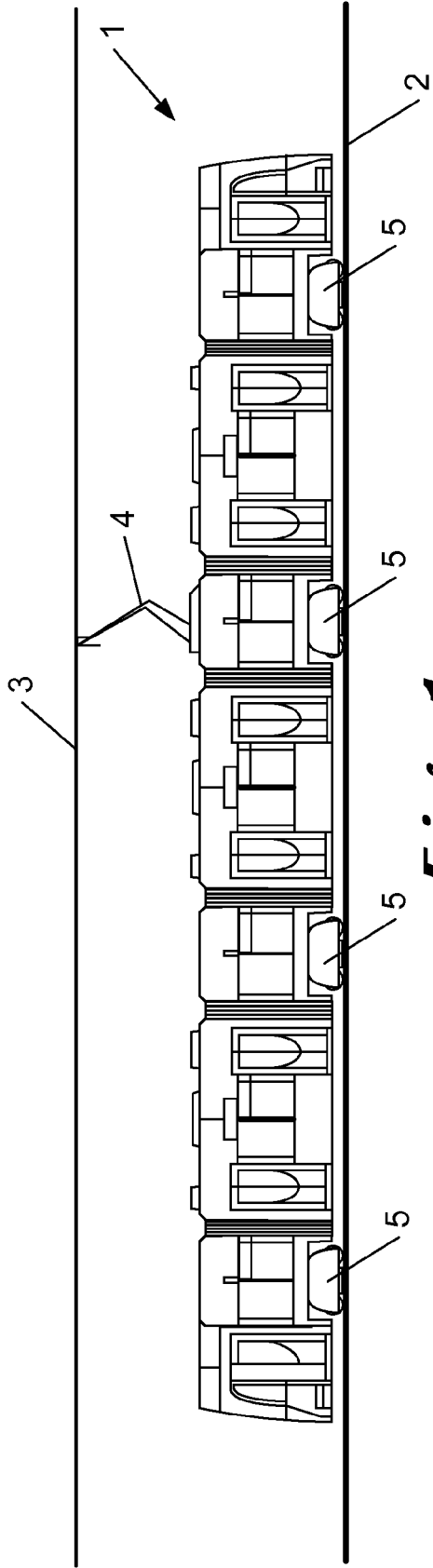
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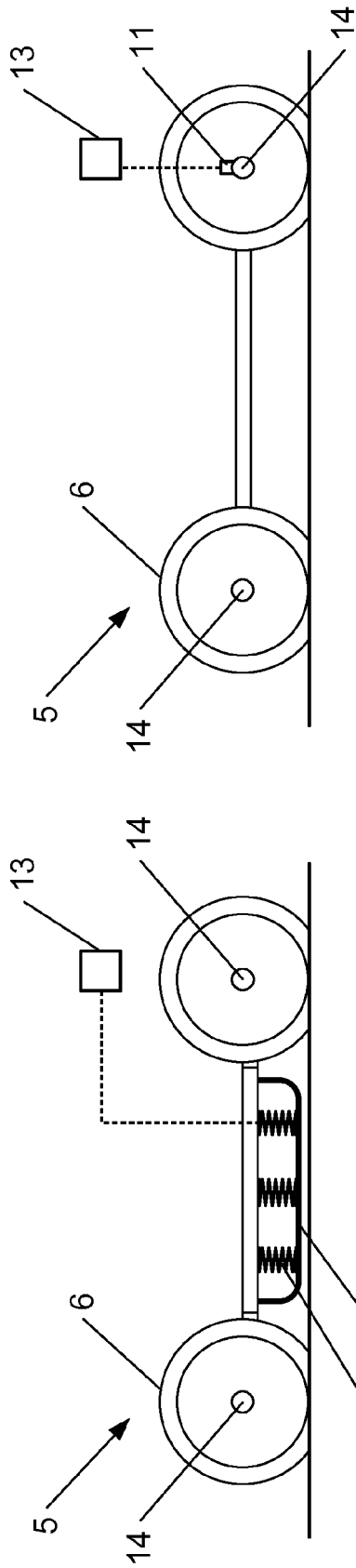


Fig. 2c

Fig. 2d

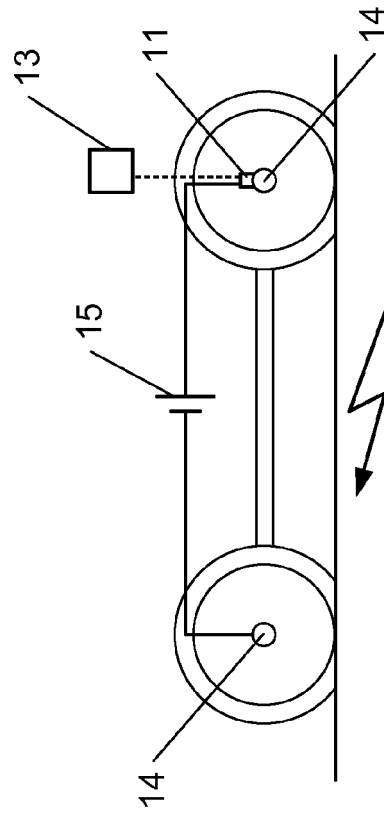


Fig. 2e

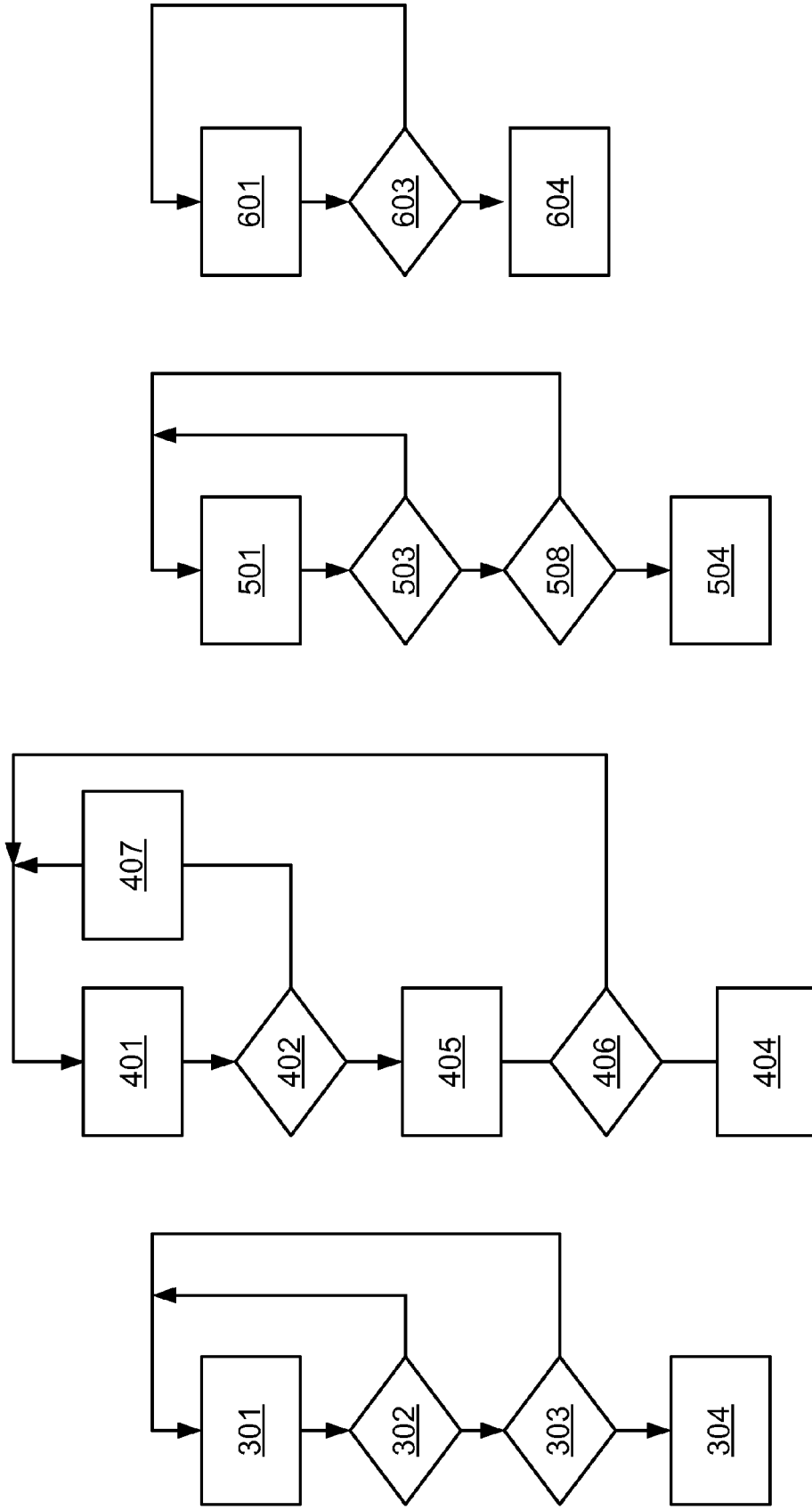


Fig. 3

Fig. 4

Fig. 5

Fig. 6



EUROPEAN SEARCH REPORT

Application Number
EP 09 16 0638

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2006 199170 A (RAILWAY TECHNICAL RES INST) 3 August 2006 (2006-08-03) * the whole document * -----	1-5, 10-12	INV. B61F9/00
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A		1,5	
			TECHNICAL FIELDS SEARCHED (IPC)
			B61F B61L
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 30 October 2009	Examiner Fuchs, Aloïse
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 09 16 0638

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30-10-2009

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

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