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(54) WHEEL LUBRICATION CONTROLLING DEVICE, ASSOCIATED WHEEL LUBRICATION SYSTEM, RAILWAY VEHICLE, METHOD FOR CONTROLLING WHEEL LUBRICATION AND METHOD OF PARAMETRIZING A WHEEL LUBRICATION CONTROLLING DEVICE

(57) This wheel lubrication controlling device (32), comprises:
- a sensor, and
- a processing component comprising:
- an acquisition module, adapted to acquire a sensor information, and
- a command module, adapted to generate a lubrication instruction for a lubricator (30) as a function of the sensor information.

The sensor is a vibration sensor, and the command module is adapted to generate the lubrication instruction as a function of the sensor information.

The processing component comprises a filtering module adapted to filter the sensor information from the acquisition module, the filtering module being adapted to filter the sensor information depending on its frequency by forming a band-pass filter. The command module is configured for generating a lubrication instruction corresponding to a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold.

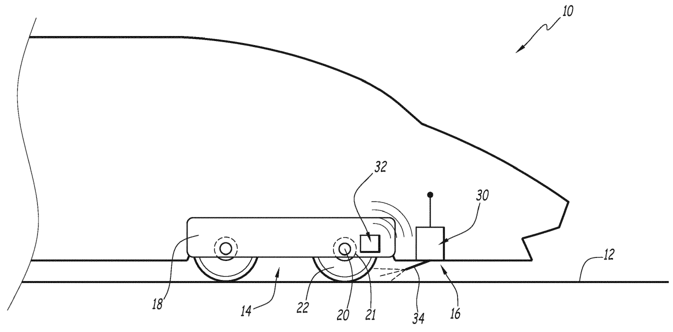

FIG.1

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Description

[0001] The invention relates to a wheel lubrication controlling device, comprising:

- a sensor, adapted to be installed on a railway vehicle, and
- a processing component comprising:
  - an acquisition module, adapted to acquire a sensor information measured by the sensor, and
- a command module, adapted to be connected to a lubricator and to generate a lubrication instruction for the lubricator as a function of the sensor information.

[0002] On vehicles, and particularly on railway vehicles travelling long distance such as freight or passenger vehicles, it is important to have long lasting components to avoid frequent maintenance and associated costs.

[0003] Wheel of railway vehicles are especially exposed to wear and solutions have been developed to increase the lifetime of the wheels in order to reduce maintenance costs. One of the solutions comprises the use of a lubricator, disposed in front of the forward wheel of the train. Such lubricator is configured to distribute lubricant on one wheel or on the rail to ensure lubrication of the interface between the wheels and the rail.

[0004] Wheel lubrication controlling devices have been developed to ensure a sufficient but not excessive lubrication of the interface between the wheels and the rail. Such devices comprise one or more sensors that are used to assess when lubrication is required to reduce wear of the wheel, but also to assess when lubrication is less required, to reduce consumption of lubricant for a more economical and ecological operation of the railway vehicle.

[0005] To that end, positioning sensors, acceleration sensors or timing sensors are known solutions, allowing to assess when lubrication is required. Positioning sensors and acceleration sensors are used to detect when the railway vehicle is turning, such vehicle operation generates a lot of friction between the wheels and the rails and requires an intensive lubrication. Timing sensors are programmed to instruct lubrication at regular intervals to reduce consumption of lubricant.

[0006] However, lubrication controlling devices comprising positioning sensors, acceleration sensors or timing sensors are not fully satisfying as they do not really measure a parameter relating to the friction between the rail and the wheel but only parameters that can be used to estimate such frictions. Therefore, the accuracy of lubrication controlling devices using such sensors can be improved.

[0007] To that end, lubrication controlling devices using vibration sensors have been developed. However, even if such sensors allow lubrication controlling using measurement of a parameter directly related to the friction at the interface between the wheel and the rail, such a device often does not allow an accurate enough lubrication, the device being for example subject to parasite vibrations leading to under- or over-lubrication.

[0008] An objective of the invention is to provide a wheel lubrication controlling device offering increased accuracy on the lubrication required and delivered at the rail-wheel interface.

[0009] To that end, the invention concerns a wheel lubrication controlling device as previously described, wherein:

- the sensor is a vibration sensor adapted to measure vibrations of said railway vehicle, and
- the command module is adapted to generate the lubrication instruction as a function of the sensor information representing the measured vibration ;

and wherein the processing component comprises a filtering module connected to the acquisition module and adapted to filter the sensor information from the acquisition module, the filtering module being adapted to filter the sensor information depending on its frequency by forming a band-pass filter, the lubrication instruction being a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator (30) as a command to distribute lubricant.

[0010] A wheel lubrication controlling device comprising a vibration sensor and such a filtering module is advantageous to ensure that the lubrication instruction complies with the actual lubrication need, by eliminating vibrations that are not generated by the interaction between the rail and the train, and especially by allowing to keep only vibrations exhibiting a frequency associated with a stick-slip interaction between the rails and the wheels of the railway vehicle.

[0011] According to specific embodiments of the invention, the wheel lubrication controlling device further comprises one or several of the features mentioned below, considered independently or along any technically possible combination:

- the lubrication instruction is an idle instruction if the amplitude of the filtered sensor information is below a predetermined lower threshold, the idle instruction being configured to be interpreted by the lubricator as a command to stop lubrication ;
- the lubrication instruction is a transitional instruction if the amplitude of the sensor information is between the predetermined lower threshold and the predetermined upper threshold, the transitional instruction being configured to be interpreted by the lubricator as a command to distribute lubricant at a distribution rate depending on the amplitude of the filtered sensor information, the distribution rate being preferably

directly proportional to the amplitude of the sensor information, and the release instruction being configured to be interpreted by the lubricator as a command to distribute lubricant at a maximum rate ;

- the transitional instruction is configured to be interpreted by the lubricator as a command to distribute lubricant with a varying flow rate and/or in sequences ; and
- the filtering module is configured to let pass only sensor information which frequencies are included between a first cut-off frequency and a second cut-off frequency, the first cut-off frequency being comprised between 600Hz and 1400Hz and the second cut-off frequency being comprised between 3000 and 5000Hz.

[0012] The invention also concerns a wheel lubrication system comprising a lubricator and a wheel lubrication controlling device as previously described, the command module being connected to the lubricator and being configured to control said lubricator.

[0013] According to a specific embodiment of the wheel lubrication system, the command module is connected to the lubricator wirelessly.

[0014] Furthermore, the invention relates to a railway vehicle comprising:

- a bogie comprising at least two wheels, each wheel comprising
    - a running surface adapted to roll on a rail, and
    - a flange adapted to guide the wheel on the rail; and
- a wheel lubrication system as previously described ;

the sensor being installed on the bogie, sensor information measured from the sensor comprising vibrations generated by an interaction between the flange and the rail.

[0015] According to a specific embodiment of the railway vehicle, the bogie comprises:

- a supporting structure,
- at least one axle attached to at least one wheel,
- for each axle, at least two bearings connecting the axle to the supporting structure,

the sensor being further connected to a bearing monitoring device, the bearing monitoring device being configured to acquire sensor information from the sensor and to calculate health parameters of at least one of the bearings.

[0016] The invention also relates to a method for controlling wheel lubrication using a wheel lubrication controlling device, a wheel lubrication system or a railway vehicle as previously described, the method comprising the following steps:

- acquisition of a measured sensor information from the sensor,
- command of the generation of a lubrication instruction as a function of the sensor information,

wherein:

- the sensor information is a measured vibration of the railway vehicle, and
- the lubrication instruction is a function of the sensor information representing the measured vibration,

and in that the method comprises the following step:

- filtering of the sensor information depending on its frequency through a band-pass filtering,

the lubrication instruction being a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator as a command to distribute lubricant.

[0017] Furthermore, the invention relates to a method of parametrizing a wheel lubrication controlling device as previously described, the method comprising the following steps:

- determining a railway vehicle in which the wheel lubrication controlling device is to be installed, the railway vehicle comprising a wheel comprising a flange ;
- determining a railway on which the railway vehicle is determined to roll, the railway comprising a rail ;
- determining a characteristic frequency which corresponds to the vibration frequency characteristic of an interaction between the flange of the wheel of the determined railway vehicle and the rail of the determined railway ; and
- setting the filtering module to be configured to let pass the sensor information from the acquisition module which frequency is within a predetermined bandwidth around the determined characteristic frequency and to filter out the sensor information from the acquisition module which frequency is outside the predetermined bandwidth around the determined characteristic frequency.

[0018] Other features and advantages of the invention will become apparent from a detailed description which is given thereof below, as an indication and by no means as a limitation, with reference to the appended figures, wherein:

- figure 1 is a schematic side view of a railway vehicle, comprising a wheel lubrication system according to the invention,
- figure 2 is a schematic representation of the lubrication system of figure 1, comprising a wheel lubrication controlling device according the invention,

- figure 3 is a detailed view of a wheel of the railway vehicle of figure 1, represented on a rail, and
- figure 4 is an flowchart of a method for controlling wheel lubrication according to the invention.

[0019] In the following description, references to "front" and "back" are made to describe positions in the vehicle referential, along the vehicle's longitudinal direction. The front of the vehicle is the extremity of the vehicle oriented towards the vehicle's movement, the front extremity being opposed to the back extremity. By extension, a front position is closer to the front extremity than a back position.

[0020] In the following description, the term "connected" should be understood as logically connected, for example allowing data to circulate between two connected components, either electrically or wirelessly.

[0021] In reference to figure 1, a vehicle 10, preferably a railway vehicle, is represented on rails 12.

[0022] The vehicle 10 is in particular adapted to roll on the rails 12. The rails 12 are for example steel profiles with a standard I-shaped cross section, as partially represented on figure 3.

[0023] The vehicle 10 is for example a locomotive or an Electric Multiple Unit, also referred as EMU. The vehicle 10 is for example a freight vehicle or a passenger vehicle.

[0024] In reference to figure 1, the vehicle 10 comprises a bogie 14 and a wheel lubrication system 16.

[0025] The bogie 14 comprises a frame or supporting structure 18, at least one axle 20 and for each axle 20, at least two bearings 21 connecting the axle 20 to the supporting structure 18.

[0026] The bogie 14 comprises at least two wheels 22, each wheel being attached to one axle 20.

[0027] Each wheel 22 comprises a running surface 24 adapted to roll on the rail 12 and a flange 26 adapted to guide the wheel 22 on the rail 12.

[0028] In particular, the flange 26 extends radially on one axial side of the disc forming the rolling surface.

[0029] Each flange 26 comprises a guiding surface 28 which is adapted to interact with the rail 12, in other word, to be in contact with the rail, as presented in dashed lines in figure 3, the interaction resulting in an axial force applied to the wheel 22.

[0030] The wheel lubrication system 16 comprises a lubricator 30 and a wheel lubrication controlling device 32.

[0031] The lubricator 30 is adapted to deliver lubricant at an interface between the rail 12 and the wheels 22.

[0032] The lubricator 30 is in particular located at the front of the bogie 14 and preferably at the front of a front bogie 14, and is adapted to distribute lubricant at an interface between the rail 12 and a plurality of wheels 22.

[0033] The lubricator 30 comprises for example a lubricator tank (non-illustrated) and a lubricator nozzle 34.

[0034] The lubricator nozzle 34 is adapted to spray lubricant on a wheel 22, for example on the foremost front wheel 22 of the vehicle 10. In alternative or in complement, the lubricator nozzle 34 is adapted to spray lubricant on the rail 12, for example in front of the most front wheel 22 of the vehicle.

[0035] Lubricant distributed by the lubricator 30 is represented with dashed lines on figure 1. The lubricant is for example a grease or an oil adapted to reduce the friction between the wheels 22 and the rail 12.

[0036] The lubricator 30 is adapted to distribute lubricant in response to lubrication instructions, lubrication instructions being sent to the lubricator by the wheel lubrication controlling device 32.

[0037] The wheel lubrication controlling device 32 comprises a sensor 36 and a processing component 38, the sensor 36 being connected the processing component 38.

[0038] The sensor 36 is adapted to be installed on the vehicle 10. The sensor 36 is preferably installed on the bogie 14. The sensor 36 is in particular attached to the bogie 14 and preferably on the supporting structure 18.

[0039] The sensor 36 is adapted to measure a sensor information. The sensor 36 is a vibration sensor adapted to measure vibrations of the vehicle 10, the sensor information representing the measured vibration. The sensor 36 is for example specifically adapted to measure vibrations of the axle 20 or of the wheels 22. The vibrations measured by the sensor 36 are characterised by their frequency and their amplitude. The amplitude of the vibration is for example a root mean square amplitude or a peak-to-peak amplitude.

[0040] The sensor 36 is for example adapted to measure vibrations of the wheels 22 in an axial direction along the central axis of the wheels 22.

[0041] The sensor information measured from the sensor preferably comprises vibrations generated by an interaction between the flange 26 and the rail 12.

[0042] The sensor 36 is for example an accelerometer adapted to measure vibrations. In alternative, the sensor 36 is a displacement sensor or a proximity sensor adapted to measure vibrations.

[0043] In a specific embodiment, the vehicle 10 comprises a bearing monitoring device (not represented). The bearing monitoring device is for example connected to the sensor 36 and is configured to acquire sensor information from the sensor 36 and to calculate health parameters of at least one of the bearings 21 as a function of the sensor information. In this specific embodiment, the sensor 26 is connected both to the processing component 38 and to the bearing monitoring device. The sensor 36 is advantageously a standard sensor for bearing monitoring, the wheel lubrication controlling device 32 and notably the processing component 38 being advantageously connected to the sensor 36 to exploit the sensor information for lubrication controlling.

[0044] The processing component 38 comprises an acquisition module 40 adapted to acquire a sensor information measured by the sensor 36, a filtering module 42 adapted to filter the sensor information from the acquisition module 40 and a command module 44 adapted to generate the lubrication instruction for the lubricator as a function of the sensor information, in particular as a function of the filtered sensor information.

[0045] In the example of figure 2, the processing component 38 comprises an information processing unit 50 comprising, for example, a memory 52 associated with a processor 54.

[0046] In the example of figure 2, the acquisition module 40, the filtering module 42 and the command module 44 are each produced in the form of software executable by the processor 54. The memory 52 is then able to store an acquisition software, designed to acquire a sensor information measured by the sensor 36, a filtering software 42 designed to filter the sensor information from the acquisition module 40 and a command software 44 designed to generate a lubrication instruction for the lubricator 30 as a function of the sensor information. The processor 54 of the information processing unit 50 is then able to execute the acquisition software, the filtering software and the command software.

[0047] In a variant (not shown), the acquisition module 40, the filtering module 42 and the command module 44 are each produced in the form of a programmable logic components, such as a FPGA (Field Programmable Gate Array), or in the form of a dedicated integrated circuit, such as an ASIC (Application Specific Integrated Circuit), or in the form of any combination of ASIC, FPGA and/or software.

[0048] In another variant (not shown) the acquisition module 40, the filtering module 42 and the command module 44 are each implemented as analog signal processing devices.

[0049] When the processing component 38 is made in the form of one or several software programs, i.e., in the form of a computer program, it is further able to be stored on a medium, not shown, readable by computer. The computer-readable medium is for example a medium suitable for storing electronic instructions and able to be coupled with a bus of a computer system. As an example, the readable medium is an optical disc, a magnetic-optical disc, a ROM memory, a RAM memory, any type of non-volatile memory (for example, EPROM, EEPROM, FLASH, NVRAM), a magnetic card or an optical card. A computer program including software instructions is then stored on the readable medium.

[0050] The acquisition module 40 is connected to the sensor 36 and to the filtering module 42. The acquisition module 40 is adapted to, after acquiring the sensor information, transmit the sensor information to the filtering module 42.

[0051] The filtering module 42 is, additionally to being connected to the acquisition module 40, connected to the command module 44.

[0052] The filtering module 42 is adapted to filter the sensor information depending on its frequency by forming a band-pass filter. The filtering module 42 is adapted to filter the sensor information to provide a filtered sensor information to the command module 44.

[0053] The filtering module 42 is configured to let pass only sensor information which frequencies are included between a first-cut off frequency and a second cut-off frequency. The filtering module 42 is for example configured to have a gain tending towards zero for frequencies below the first cut-off frequency or above the second cut-off frequency and tending towards one for frequencies between the first cut-off frequency and the second cut-off frequency.

[0054] The first cut-off frequency is preferably comprised between 600Hz and 1400Hz, and more preferably comprised between 800Hz and 1200Hz.

[0055] The second cut-off frequency is preferably comprised between 3000Hz and 5000Hz, and more preferably comprised between 3500Hz and 4500Hz.

[0056] The amplitude of the filtered sensor information is for example a root mean square amplitude or a peak-to-peak amplitude.

[0057] The command module 44 is adapted to be connected to the lubricator 30. In a specific embodiment, represented in figure 1, the command module 44 is connected to the lubricator wirelessly. The wheel lubrication controlling device 32 and the lubricator form then for example two different units wirelessly connected.

[0058] The command module is adapted to transmit the lubrication instruction it generates to the lubricator 30, the lubricator being adapted to interpret the lubrication instruction and to distribute lubricant according to the lubrication instruction.

[0059] The command module 44 is adapted to generate a lubrication instruction corresponding to a release instruction if the amplitude of the filtered sensor information exceeds a predetermined upper threshold, the predetermined upper threshold being for example set to correspond to a filtered sensor information defining a vibration amplitude characteristic of an interaction between the flange 26 and the rail 12.

[0060] The release instruction is adapted to be interpreted by the lubricator 30 as a command to distribute lubricant.

[0061] The command module 44 is preferably adapted to generate a lubrication instruction corresponding to an idle instruction if the amplitude of the filtered sensor information is below a predetermined lower threshold, the predetermined lower threshold being for example set to correspond to a filtered sensor information defining a vibration amplitude characteristic of the absence of interaction between the flange 26 and the rail 12. The idle instruction is configured to be interpreted by the lubricator as a command to stop lubrication. A command to stop lubrication is a command adapted to block the distribution of lubricant by the lubricator 30.

[0062] In a specific embodiment, the command module 44 is preferably adapted to generate a lubrication instruction being a transitional instruction if the amplitude of the sensor information is between the lower threshold and the upper threshold. The transitional instruction is preferably configured to be interpreted by the lubricator as a command to distribute lubricant at a distribution rate depending on the amplitude of the filtered sensor information. The distribution rate is preferably directly proportional to the amplitude of the sensor information. The release instruction is then configured to be interpreted by the lubricator 30 as a command to distribute lubricant at a maximum rate.

[0063] In variants of this embodiment, the transitional instruction is configured to be interpreted by the lubricator as a command to distribute lubricant with a varying flow rate and/or in sequences. For example, the distribution rate over a defined period of time is modified by pulsating lubricant over varying pulsation times.

[0064] In an alternative embodiment, the lower threshold is equal to the upper threshold and there is no transitional instruction. The lubricator 30 is then configured exclusively either to distribute lubricant or to stop lubrication, depending on the amplitude of the filtered sensor information.

[0065] A method 100 for controlling wheel lubrication using a wheel lubrication system 16 or a wheel lubrication controlling device 32 as previously described will now be presented.

[0066] The method 100 comprises an acquisition step 110, a filtering step 120 and a command step 130.

[0067] During the acquisition step 110, the acquisition module acquires a measured sensor information from the sensor 36. The measured sensor information depends on the interaction between the wheel 22 and the rail 12 during rolling. The measured sensor information depends for example on the interaction, for example on the friction during rolling, between the flange 26 and the rail 12. In particular, the interaction between the flange 26 and the rail 12 generates a vibration having a specific amplitude peak within a frequency range comprised between the first cut-off frequency and the second cut-off frequency.

[0068] The acquisition step 110 is followed by the filtering step 120. During the filtering step 120, the sensor information is filtered by the filtering module 42 depending on its frequency through a band-pass filtering. In particular, the filtering step is adapted to let pass only vibrations which frequency are within the frequency range characteristic of the interaction between the flange 26 and the rail 12.

[0069] The filtering step 120 is followed by the command step 130. During the command step 130, the command module 44 is commanding the generation of a lubrication instruction as a function of the filtered sensor information. In particular, during the command step 130, the command module command the generation of a release instruction if the amplitude of the filtered sensor information exceeds the predetermined upper threshold. The command module is then generating a release instruction if the vibration with a frequency between the first cut-off point and the second cut-off point has a sufficient amplitude, such vibration being for example a vibration generated by the interaction between the wheels 22 and the rail 12.

[0070] A method of parametrizing a wheel lubrication controlling device 32, more exactly a method for setting the filtering module 42 of the wheel lubrication controlling device 32 as previously described, to form a band-pass filter, will now be presented.

[0071] The method comprises a railway vehicle 10 determination step and a railway determination step, that can be performed in any order. The railway vehicle 10 determination step and the railway determination step is followed by a characteristic frequency determination step, which is followed by a filtering module configuring step.

[0072] During the railway vehicle determination step is determined a railway vehicle 10 in which the wheel lubrication controlling device 32 is to be installed or is already installed. The railway vehicle 10 is as previously described and comprises a wheel 22 comprising a flange 26. An operator inputs for example in the wheel lubrication controlling device 32 the railway vehicle in which the wheel lubrication controlling device 32 is configured to be installed. The railway vehicle 10 is for example input with respect of its category such as metro, Tramway, Regional Electrical Multiple Unit, Regional Diesel Multiple Unit, high speed train, or with its mass.

[0073] During the railway determination step is determined the railway on which the railway vehicle 10 is determined to roll and will roll in operation. The railway comprises a rail 12 as previously described. An operator inputs for example in the wheel lubrication controlling device 32 the railway on which the railway vehicle 10 is configured to roll. The operator inputs for example a category of railway, such as regional railway or high speed railway. Alternatively or additionally, the operator inputs railway routes on which the railway vehicle is determined to roll and is scheduled to roll.

[0074] During the characteristic frequency determination step a characteristic frequency is determined. The characteristic frequency corresponds to the vibration frequency characteristic of an interaction between the flange 26 of the wheel 22 of the determined railway vehicle 10 and the rail 12 of the determined railway. The characteristic frequency is for example determined from the determined railway vehicle 10 and the determined railway. For example, the characteristic frequency is determined from test data from various combination of railway vehicles 10 and railways.

[0075] During the configuration step, the filtering module 42 is set to be configured to let pass the sensor information from the acquisition module 40 which frequency is within a predetermined bandwidth around the determined characteristic frequency and to filter out the sensor information from the acquisition module 40 which frequency is outside the predetermined bandwidth around the determined characteristic frequency. In particular, the bandwidth extends from a first cut-off frequency to a second cut-off frequency and/or is limited by these frequencies.

[0076] A wheel lubrication controlling device 32 wherein the sensor is a vibration sensor and comprising a filtering module forming a band pass filter is advantageous for precisely detecting friction between the flange 26 and the rail 12, the filtering module 42 avoiding false detection, for example when the unfiltered vibration amplitude is high but not within the expected vibration range. The command module 44 adapted to generate the lubrication instruction as a function of the sensor information, in other words as a function of the measured vibration, allows commanding the lubricant distribution directly in link with the lubrication need, ensuring a sufficient lubrication but also avoiding lubricant waste.

[0077] The lower threshold under which the lubrication instruction is an idle instruction allow the device not to lubricate the rail-wheel interface for low amplitude vibration, for example generated by the vehicle when rolling on a straight line.

[0078] The transitional instruction, for example interpreted by the lubricator as a command to lubricate with a varying flow rate and/or in sequences is especially advantageous for adapting the lubrication to the lubrication needs.

[0079] The filtering module 42 configured to let pass only frequencies included between the first cut-off frequency and the second cut-of frequency ensures that the filtered sensor information comprises vibrations with only frequencies in the frequency range characteristic of the interaction between the flange 26 and the rail 12.

[0080] A wheel lubrication system 16 comprising the wheel lubrication controlling device 32 and wherein the command module is connected to the lubricator 30 wirelessly allows an easy integration of the system 16 on a vehicle 10.

[0081] A vehicle 10 wherein the sensor 36 is further connected to a bearing monitoring device allows using a single sensor 36 for both monitoring the health of the bearings 21 and to command lubrication. It allows for example an easy integration of the wheel lubrication controlling device 32 by using existing sensors 36 used for bearing monitoring.

Claims

1. Wheel lubrication controlling device (32), comprising:

- a sensor (36), adapted to be installed on a railway vehicle (10), and
- a processing component (38) comprising:
  - an acquisition module (40), adapted to acquire a sensor information measured by the sensor (36), and
  - a command module (44), adapted to be connected to a lubricator (30) and to generate a lubrication instruction for the lubricator (30) as a function of the sensor information,

characterized in that:

- the sensor (36) is a vibration sensor adapted to measure vibrations of said railway vehicle (10), and
- the command module (44) is adapted to generate the lubrication instruction as a function of the sensor information representing the measured vibrations;

and **in that** the processing component (38) comprises a filtering module (42) adapted to filter the sensor information from the acquisition module (40), the filtering module (42) being adapted to filter the sensor information depending on its frequency by forming a band-pass filter, the command module being configured for generating a lubrication instruction corresponding to a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator (30) as a command to distribute lubricant.

2. Wheel lubrication controlling device (32) according to claim 1, wherein the command module is configured for generating a lubrication instruction corresponding to an idle instruction if the amplitude of the filtered sensor information is below a predetermined lower threshold, the idle instruction being configured to be interpreted by the lubricator (30) as a command to stop lubrication.

3. Wheel lubrication controlling device (32) according to claim 2, wherein the command module is configured for generating a lubrication instruction corresponding to a transitional instruction if the amplitude of the filtered sensor information is between the predetermined lower threshold and the predetermined upper threshold, the transitional instruction being configured to be interpreted by the lubricator (30) as a command to distribute lubricant at a distribution rate depending on the amplitude of the filtered sensor information, the distribution rate being preferably directly proportional to the amplitude of the filtered sensor information, and the release instruction being configured to be interpreted by the lubricator (30) as a command to distribute lubricant at a maximum rate.

4. Wheel lubrication controlling device (32) according to claim 3, wherein the transitional instruction is configured to be interpreted by the lubricator (30) as a command to distribute lubricant with a varying flow rate and/or in sequences.

5. Wheel lubrication controlling device (32) according to any of the preceding claims, wherein the filtering module (42) is configured to let pass only sensor information which frequencies are included between a first cut-off frequency and a second cut-off frequency, the first cut-off frequency being comprised between 600Hz and 1400Hz and the second cut-off frequency being comprised between 3000Hz and 5000Hz.

6. Wheel lubrication system (16) comprising a lubricator (30) and a wheel lubrication controlling device (32) according to any of the claims 1 to 5, the command module (44) being connected to the lubricator (30) and being configured to control said lubricator (30).

7. Wheel lubrication system (16) according to claim 6, wherein the command module (44) is connected to the lubricator (30) wirelessly.

8. Railway vehicle (10) comprising:

- a bogie (14) comprising at least two wheels (22), each wheel (22) comprising
- a running surface (24) adapted to roll on a rail (12), and
- a flange (26) adapted to guide the wheel on the rail (12); and
- a wheel lubrication system (16) according to claim 6 or 7;

the sensor (36) being installed on the bogie (14), sensor information measured from the sensor (36) comprising vibrations generated by an interaction between the flange (26) and the rail (12).

9. Railway vehicle (10) according to claim 8, wherein the bogie (14) comprises:

- a supporting structure (18),
- at least one axle (20) attached to at least one of the wheels (22),
- for each axle (20), at least one bearing (21) connecting the axle (20) to the supporting structure (18),

the sensor (36) being further connected to a bearing monitoring device, the bearing monitoring device being configured to acquire sensor information from the sensor (36) and to calculate health parameters of the at least one bearing (21).

10. Method (100) for controlling wheel lubrication using a wheel lubrication controlling device (32) according to any of the claims 1 to 5 or a wheel lubrication system (16) according to claim 6 or 7 or a railway vehicle according to claim 8 or 9, the method (100) comprising the following steps:

- acquisition (110) of a measured sensor information from the sensor (36),
- command (130) of the generation of a lubrication instruction as a function of the sensor information,

characterized in that:

- the sensor information is a measured vibration of the railway vehicle (10), and
- the lubrication instruction is a function of the sensor information representing the measured vibration,

and **in that** the method (100) comprises the following step:

- filtering (120) of the sensor information depending on its frequency through a band-pass filtering,

the lubrication instruction being a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator (30) as a command to distribute lubricant.

11. Method of parametrizing a wheel lubrication controlling device (32) according to any of the claims 1 to 5, the method comprising the following steps:

- determining a railway vehicle (10) in which the wheel lubrication controlling device (32) is to be installed, the railway vehicle (10) comprising a wheel (22);
- determining a railway on which the railway vehicle (10) is determined to roll, the railway comprising a rail (12);
- determining a characteristic frequency which corresponds to the vibration frequency characteristic of an interaction between the wheel (22) of the determined railway vehicle (10) and the rail (12) of the determined railway; and
- setting the filtering module (42) to be configured to let pass the sensor information from the acquisition module (40) which frequency is within a predetermined bandwidth around the determined characteristic frequency and to filter out the sensor information from the acquisition module (40) which frequency is outside the predetermined bandwidth around the determined characteristic frequency.

Amended claims in accordance with Rule 137(2) EPC.

1. Wheel lubrication controlling device (32), comprising:

- a sensor (36), adapted to be installed on a railway vehicle (10), and
- a processing component (38) comprising:

- an acquisition module (40), adapted to acquire a sensor information measured by the sensor (36), and
- a command module (44), adapted to be connected to a lubricator (30) and to generate a lubrication instruction for the lubricator (30) as a function of the sensor information,

characterized in that:

- the sensor (36) is a vibration sensor adapted to measure vibrations of said railway vehicle (10), the sensor being adapted to measure vibration of wheels (22) in an axial direction along a central axis of the wheels (22), and
- the command module (44) is adapted to generate the lubrication instruction as a function of the sensor information representing the measured vibrations;

and **in that** the processing component (38) comprises a filtering module (42) adapted to filter the sensor information from the acquisition module (40), the filtering module (42) being adapted to filter the sensor information depending on its frequency by forming a band-pass filter, the command module being configured for generating a lubrication instruction corresponding to a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator (30) as a command to distribute lubricant.

2. Wheel lubrication controlling device (32) according to claim 1, wherein the command module is configured for generating a lubrication instruction corresponding to an idle instruction if the amplitude of the filtered sensor information is below a predetermined lower threshold, the idle instruction being configured to be interpreted by the lubricator (30) as a command to stop lubrication.

3. Wheel lubrication controlling device (32) according to claim 2, wherein the command module is configured for generating a lubrication instruction corresponding to a transitional instruction if the amplitude of the filtered sensor information is between the predetermined lower threshold and the predetermined upper threshold, the transitional instruction being configured to be interpreted by the lubricator (30) as a command to distribute lubricant at a distribution rate depending on the amplitude of the filtered sensor information, the distribution rate being preferably directly proportional to the amplitude of the filtered sensor information, and the release instruction being configured to be interpreted by the lubricator (30) as a command to distribute lubricant at a maximum rate.

4. Wheel lubrication controlling device (32) according to claim 3, wherein the transitional instruction is configured to be interpreted by the lubricator (30) as a command to distribute lubricant with a varying flow rate and/or in sequences.

5. Wheel lubrication controlling device (32) according to any of the preceding claims, wherein the filtering module (42) is configured to let pass only sensor information which frequencies are included between a first cut-off frequency and a second cut-off frequency, the first cut-off frequency being comprised between 600Hz and 1400Hz and the second cut-off frequency being comprised between 3000Hz and 5000Hz.

6. Wheel lubrication controlling device (32) according to any of the claims 1 to 5, wherein the sensor (36) is an accelerometer adapted to measure vibrations.

7. Wheel lubrication controlling device (32) according to any of the claims 1 to 5, wherein the sensor (36) is a displacement sensor adapted to measure vibration.

8. Wheel lubrication controlling device (32) according to any of the claims 1 to 5, wherein the sensor (36) is a proximity sensor adapted to measure vibrations.

9. Wheel lubrication system (16) comprising a lubricator (30) and a wheel lubrication controlling device (32) according to any of the claims 1 to 8, the command module (44) being connected to the lubricator (30) and being configured to control said lubricator (30).

10. Wheel lubrication system (16) according to claim 9, wherein the command module (44) is connected to the lubricator (30) wirelessly.

11. Railway vehicle (10) comprising:

- a bogie (14) comprising at least two wheels (22), each wheel (22) comprising
- a running surface (24) adapted to roll on a rail (12), and
- a flange (26) adapted to guide the wheel on the rail (12); and
- a wheel lubrication system (16) according to claim 9 or 10;

the sensor (36) being installed on the bogie (14), sensor information measured from the sensor (36) comprising vibrations generated by an interaction between the flange (26) and the rail (12).

12. Railway vehicle (10) according to claim 11, wherein the bogie (14) comprises:

- a supporting structure (18),
- at least one axle (20) attached to at least one of the wheels (22),
- for each axle (20), at least one bearing (21) connecting the axle (20) to the supporting structure (18),

the sensor (36) being further connected to a bearing monitoring device, the bearing monitoring device being configured to acquire sensor information from the sensor (36) and to calculate health parameters of the at least one bearing (21).

13. Method (100) for controlling wheel lubrication using a wheel lubrication controlling device (32) according to any of the claims 1 to 8 or a wheel lubrication system (16) according to claim 9 or 10 or a railway vehicle according to claim 11 or 12, the method (100) comprising the following steps:

- acquisition (110) of a measured sensor information from the sensor (36),
- command (130) of the generation of a lubrication instruction as a function of the sensor information,

characterized in that:

- the sensor information is a measured vibration of the railway vehicle (10), and
- the lubrication instruction is a function of the sensor information representing the measured vibration,

and **in that** the method (100) comprises the following step:

- filtering (120) of the sensor information depending on its frequency through a band-pass filtering,

the lubrication instruction being a release instruction if an amplitude of the filtered sensor information exceeds a predetermined upper threshold, the release instruction being adapted to be interpreted by the lubricator (30) as a command to distribute lubricant.

14. Method of parametrizing a wheel lubrication controlling device (32) according to any of the claims 1 to 8, the method comprising the following steps:

- determining a railway vehicle (10) in which the wheel lubrication controlling device (32) is to be installed, the railway vehicle (10) comprising a wheel (22);
- determining a railway on which the railway vehicle (10) is determined to roll, the railway comprising a rail (12);
- determining a characteristic frequency which corresponds to the vibration frequency characteristic of an interaction between the wheel (22) of the determined railway vehicle (10) and the rail (12) of the determined railway; and
- setting the filtering module (42) to be configured to let pass the sensor information from the acquisition module (40) which frequency is within a predetermined bandwidth around the determined characteristic frequency and to filter out the sensor information from the acquisition module (40) which frequency is outside the predetermined bandwidth around the determined characteristic frequency.

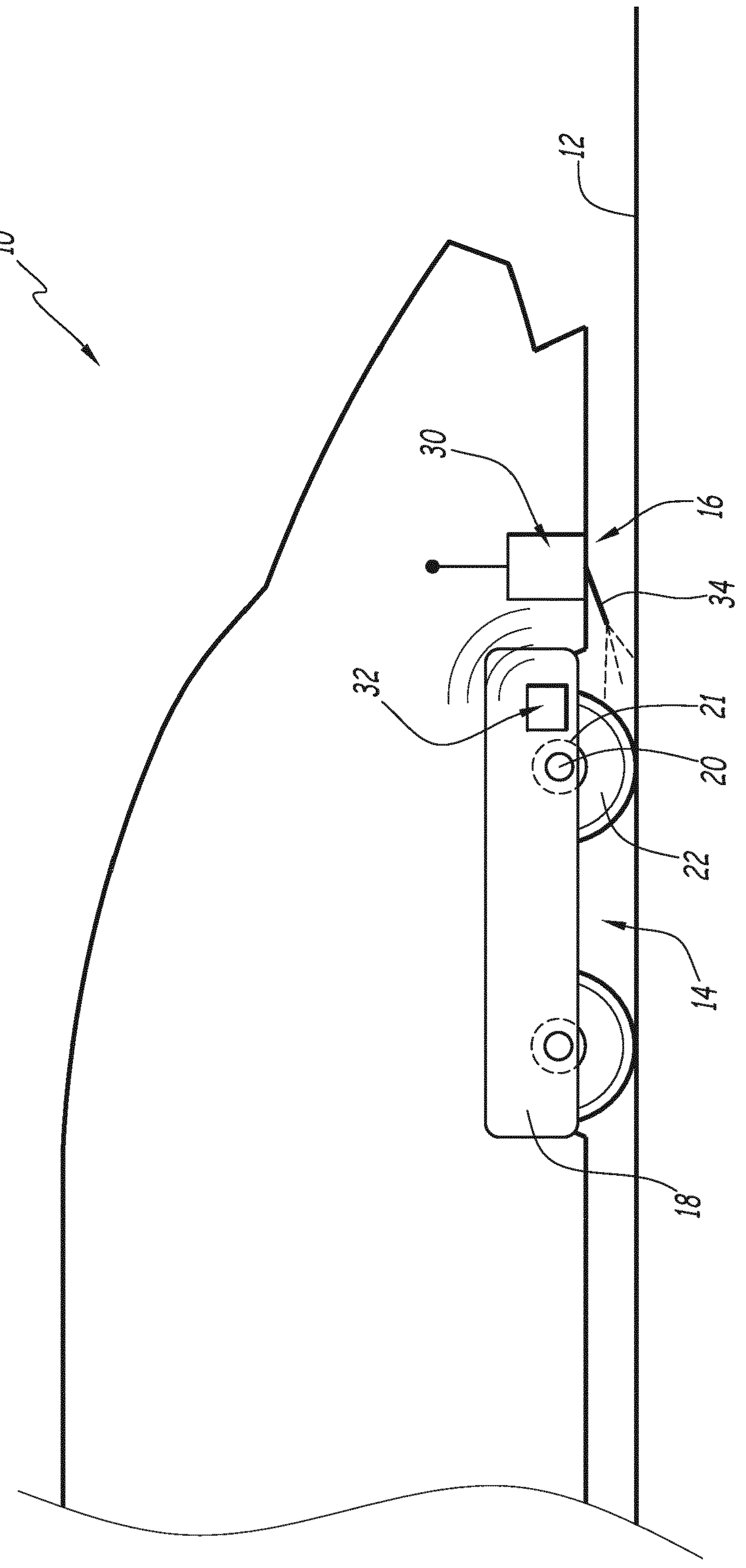

FIG.1

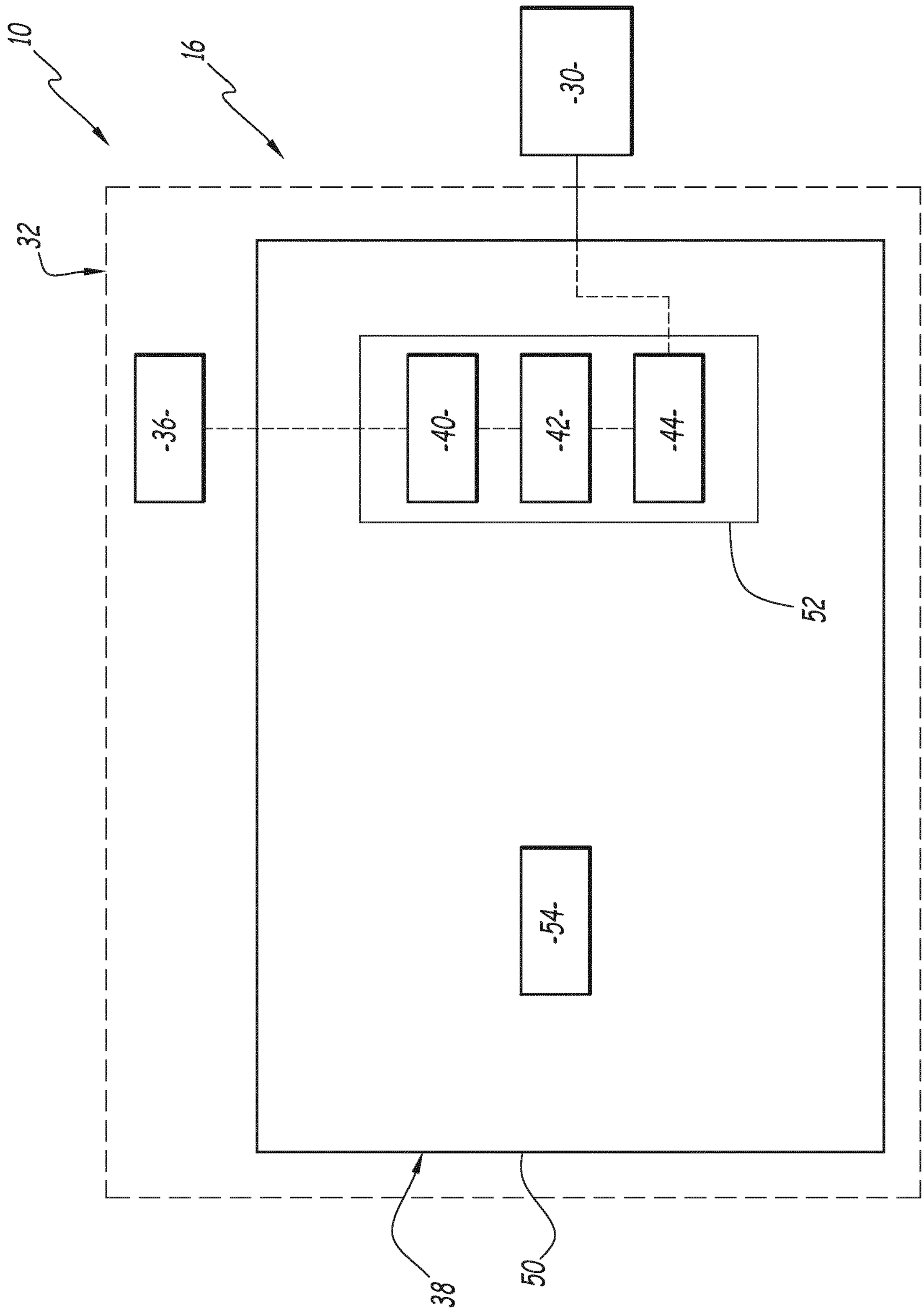

FIG.2

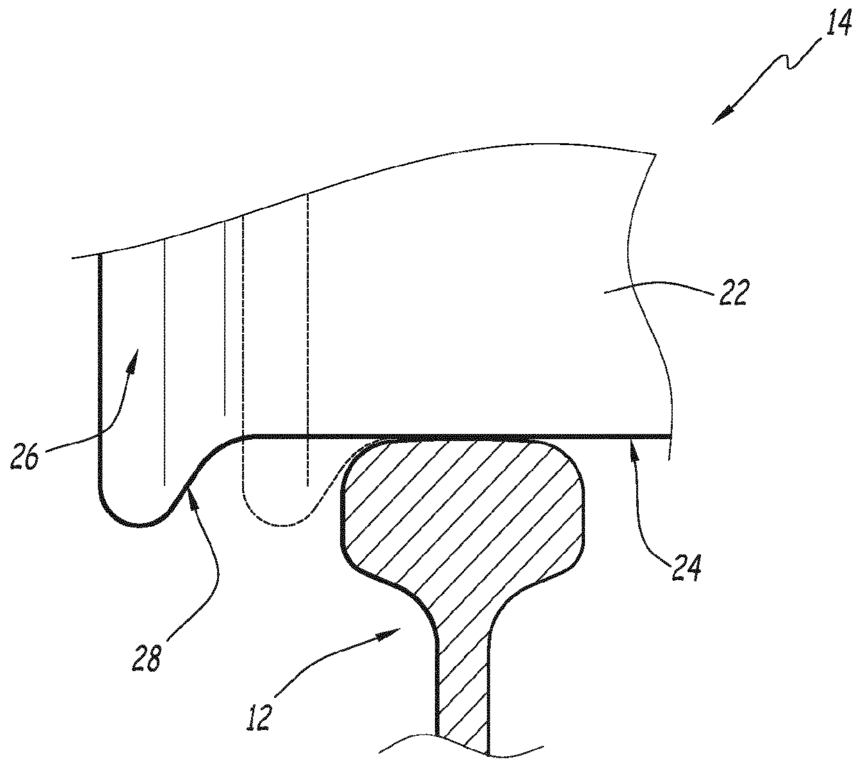

FIG.3

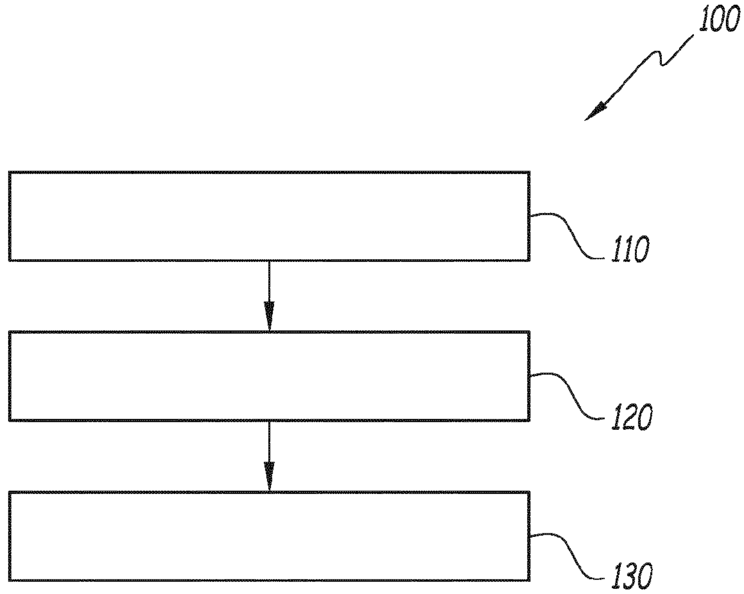

FIG.4

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EUROPEAN SEARCH REPORT

Application Number
EP 20 30 5132

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The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
Munich	3 August 2020	Schultze, Yves

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