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(54) **A MONITORING SYSTEM FOR ACQUIRING, PROCESSING AND TRANSMITTING OPERATING DATA OF A BOGIE AND BOGIE COMPRISING SAID SYSTEM**

(57) A monitoring system for acquiring, processing and transmitting operating data of a bogie (1), in which the bogie (1) comprises:

- a bogie frame (2) which supports at least one railway axle (3);
- at least one axle box (5) arranged at one end portion of the railway axle (3);
- at least one covering device (6) of the axle box attached to the axle box (5) and adapted to define a respective inner compartment between the axle box (5) and the covering device (6);

in which the monitoring system comprises:

- at least one sensor node (20a, 20b), associated with

the axle box (5) and comprising at least one sensor (21, 22) positioned in the inner compartment, adapted and configured to acquire operating data of the axle box (5) ;

- a concentrator node (50) attached to the bogie frame outside the covering device of the axle box (5), the concentrator node (50) being operatively connected to the at least one sensor node (20) by means of a wired connection line (40) to receive said acquired data, in which the concentrator node (50) comprises at least one local processing unit (51) adapted to process the acquired data and obtain processed data, and a radio communication interface (54, 55) for transmitting said processed data outside the concentrator node (50).

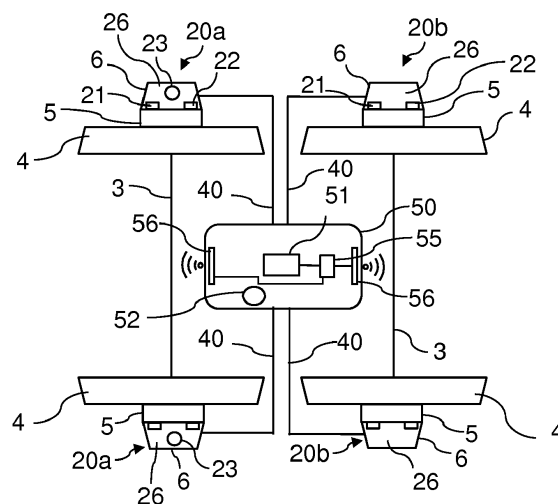


FIG. 2

Description

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to the technical field of diagnostic systems of railway trains, and in particular concerns a monitoring system for acquiring, processing and transmitting operating data of a bogie and a bogie comprising said monitoring system.

BACKGROUND ART

[0002] Condition-based maintenance on railway train vehicles is undoubtedly more effective and economical with respect to scheduled maintenance. The latter is notoriously based on periodically replacing elements according to probabilistic life expectancies, which are inaccurate and therefore require large safety margins; among other things, this type of approach sufficiently protects from normal wear but not from traumatic breakdowns or manufacturing defects, which are the causes of the most serious accidents.

[0003] Contrarily, condition-based maintenance results in the installation of also significantly complex monitoring apparatuses on board vehicles, often in prohibitive environments with contained spaces.

[0004] The performance and intervention readiness of condition-based maintenance span over a wide range of case studies.

[0005] In the simpler cases, a minimal telemetry is required and needed, based on sending limited sized messages at a relatively low frequency to the ground infrastructure. This configuration responds to most existing apparatuses today.

[0006] To instead have more significant diagnostic performance, the telemetry data flow required increases very quickly together with the processing power required and the number of sensors to manage.

[0007] The combination of multiple acquisitions, complex processing and quick and frequent communications further results in an exponential increase in the consumption of energy by the monitoring apparatuses. This is a relatively manageable problem on locomotives and on their passenger cars, where in any case there is an on-board electric system from which energy may be taken. It instead becomes prohibitive on goods wagons where, excepting exceptional cases, there is no on-board infrastructure, apart from the pneumatic line controlling braking.

[0008] Train axles and wheels are important safety elements: indeed the most significant causes of risk for the safety of things and people result therefrom (obviously in addition to the braking system). The breakdown of an axle or a wheel is a highly traumatic event and systematically causes a derailment, which then, when other circumstances concur, may result in serious accidents.

[0009] Low-frequency conventional monitoring is not capable of detecting a crack of the axle unless it is obvi-

ous, but at that point it evolves quickly and breaks and there is no guarantee whatsoever of succeeding in stopping the train before the risky event.

[0010] In order to be truly effective, a condition-based maintenance of the axles therefore requires predictive diagnostic techniques which consist in analyzing highly detailed vibration data (that is acquired frequently) and sophisticated algorithms which allow signs of deterioration to be detected well in advance with respect to the occurrence of the risky event. To obtain this, there is a need to be able to process the on-board data (large processing power) or transmit large volumes of data to the ground.

[0011] In the typical configuration, each train wagon has two bogies with two axles each. More complex configurations - vehicles with more than two bogies or bogies with more than two axles - are limited to locomotives and particular applications for transporting goods.

[0012] The most significant diagnostics values - that is the operating data involved for a bogie - are the axle vibrations and the temperature of the bearing in which the axle rotates, which axle is contained in the so-called axle box. The positioning of the sensors therefore is a factor that significantly affects the performance of diagnostics systems. The positioning of the on-board monitoring apparatuses requires considering severe environmental stresses to which such apparatuses are subjected, as well as small spaces. Moreover, it generally is problematic to bring external power also in the case (locomotives, passenger cars) in which it is available on the vehicle.

[0013] It is the object of the present invention to make available a monitoring system for acquiring operating data of a bogie which allows the axles of bogies to be efficiently monitored and which is simple to install, also on bogies which initially do not have diagnostic systems.

[0014] Such an object is achieved by means of a monitoring system as defined in general in claim 1. Preferred and advantageous embodiments of the aforesaid system are defined in the appended dependent claims.

[0015] The invention will be better comprehended from the following detailed description of a particular embodiment thereof, given by way of example and therefore non-limiting in relation to the accompanying drawings briefly described in the paragraph below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Figure 1 shows a bottom perspective view of an embodiment of a bogie for a railway vehicle, in which the bogie comprises a monitoring system for acquiring, processing and transmitting operating data of the bogie.

Figure 2 shows a general block diagram of an embodiment of the monitoring system for acquiring,

processing and transmitting diagnostic data of the bogie in figure 1.

Figure 3 shows a general diagrammatic view of a first possible embodiment of a diagnostic system for a railway train which comprises a plurality of the monitoring systems in figure 2.

Figure 4 shows a general diagrammatic view of a second possible embodiment of a diagnostic system for a railway train, which is alternative to the monitoring system in figure 2.

Figure 5 shows a block diagram of a monitoring system for acquiring, processing and transmitting diagnostic data of the bogie that can be used in the train diagnostic system in figure 3, and is alternative with respect to the monitoring system in figure 2.

DETAILED DESCRIPTION

[0017] Figure 1 shows a non-limiting embodiment of a bogie 1. For example, however without any limitation, bogie 1 is one of two bogies of a railway freight wagon. The teachings herein proposed are also applicable to other types of bogies, hence the scope of protection should not be limited to bogies of railway freight wagons.

[0018] In the particular embodiment depicted, bogie 1 comprises two axles 3, each provided with two wheels 4. Bogie 1 comprises a bogie frame 2 which supports the two axles 3, and there is provided, between frame 2 and the axles 3, a suspension system 7, which in itself is generally known to those skilled in the art and for this reason not described in greater detail.

[0019] The bogie frame 2 comprises a lower face 8, facing the ground in a normal use condition and namely, facing a track and/or the ballast, and an opposite upper face 9, facing the frame of the railway vehicle, such as for example a wagon or car, in a normal use condition of bogie 2.

[0020] Bogie 1 comprises at least one axle box 5 arranged at one end portion of the railway axle 3 and at least one covering device 6 for covering the axle box 5, attached to the axle box 5. The covering device 6 is adapted to define a respective inner compartment 26 between the axle box 5 and the covering device 6. As is known, an axle box 5 generally comprises a bearing in which axle 3 rotates. As is further known, a bogie 1 comprises, for each axle 3, two axle boxes 5 arranged at opposite ends of axle 3. Since bogie 1 comprises two axles 3 in the embodiment in figure 1, it is apparent that in such an embodiment, bogie 1 will comprise four axle boxes 5 and four respective covering devices 6.

[0021] A monitoring system for acquiring, processing and transmitting operating data of bogie 1 is applied to bogie 1. The monitoring system comprises at least one sensor node 20a, 20b associated with the axle box 5 and comprising at least one sensor 21, 22 positioned in the

inner compartment 26 adapted and configured to acquire diagnostic data of the axle box 5.

[0022] The monitoring system further comprises a concentrator node 50 attached to the bogie frame 2 outside the covering device 6 of the axle box 5. The concentrator node 50 is operatively connected to at least the sensor node 20 by means of a wired connection line 40 to receive the diagnostic data acquired by sensor 21, 22. The concentrator node 50 comprises at least one local processing unit 51 adapted to process the operating data acquired and to obtain processed data, and a radio communication interface 55 to transmit said processed data outside the concentrator node 50, for example to a land control station or to a diagnostic system on board a railway train installed for example in a locomotive.

[0023] In the particular embodiment depicted, however without any limitation, the monitoring system comprises four sensor nodes 20a, 20b, each associated with a respective box 5. Moreover, in the particular embodiment depicted, for example in figures 1 and 2, there are provided four wired connection lines 40, that is one line 40 is provided between each of the sensor nodes 20a, 20b and the concentrator node 50. The wired connection lines 40 are for example, multipolar conductors preferably provided with an outer protective casing, for example a metal braiding.

[0024] With reference to figure 1, according to an advantageous embodiment, the concentrator node 50 is housed in a container attached to the lower face 8 of the bogie frame. Preferably, such a container is installed on the bogie frame 2 so that the elastic suspension system 7 is operatively interposed between axle 3 (or the axles 3) and the container itself in order to reduce the vibrations to which the concentrator node 50 is subjected.

[0025] In the particular embodiment depicted, however without any limitation, each of the sensor nodes 20, 20b comprises a temperature sensor 21 and an acceleration sensor 22, for example a MEMS triaxial accelerometer. The number and type of sensors in each sensor node 20a, 20b however may be varied according to the specific design needs.

[0026] According to an advantageous embodiment, at least one sensor node 20a, 20b comprises an electric generator 23 adapted to produce electrical power by converting part of the rotational kinetic energy of axle 3. The electrical power produced by the electric generator 23 is used to feed the processing unit 51 and the radio communication interface 55 of the concentrator node 50. For example, such electrical power is transferred by the sensor node 20a, 20b to the concentrator node 50 by means of the wired connection line 40.

[0027] According to an advantageous embodiment, the electric generator 23 is designed and sized so as to provide 1 Watt when axle 3 rotates at a speed equal to one revolution per second. With the standard dimensions of the wheels, this corresponds to a speed of bogie 1 equal to 10 km/hour. Preferably, the power generated increases with almost quadratic trend as the rotation

speed of the axle increases. This allows the concentrator node 50 to be continuously fed, even if it is provided with a processing unit with increased processing power and large data flows to be transmitted outside.

[0028] According to a particularly advantageous embodiment, the electric generator 23 comprises a rotor attached to an end portion of axle 3 adapted to integrally rotate with axle 3 along the rotation axis of axle 3, and at least one stator external to box 5 (and therefore are also external to the bearing therein housed) and attached to the latter, for example attached to the covering device 6.

[0029] Preferably, the electric generator 23 is a synchronous polyphase alternator, e.g. a three-phase alternator.

[0030] According to a particularly advantageous embodiment, the electric generator 23 comprises a stator winding wound on metal plate rather than in the air. This advantageously allows to minimize the air gaps and optimize the production of energy at low revolutions.

[0031] In the particular embodiment depicted in figure 2, two sensor nodes 20a out of four comprise an electric generator 23, this both to increase the electrical power produced and to ensure a given redundancy, for example when one of the two generators breaks down. It is apparent that a different number of electric generators 23, or one electric generator 23 alone, may be provided.

[0032] Conveniently, the concentrator node 50 comprises a storage device for the power produced by the electric generator 23. Preferably, the aforesaid storage device comprises a supercapacitor 52. This type of capacitor is a device similar to a normal capacitor, but it is particularly advantageous because it is made with techniques which allow capacities of hundreds or thousands of farads to be reached. Such a supercapacitor 52 serves the function of tank for momentarily overcoming absorptions of energy by the monitoring system which are greater than the electrical power generated and, unlike a rechargeable battery, does not require any periodic maintenance given that it has an operating life at least of a greater order of magnitude with respect to a rechargeable battery.

[0033] According to one embodiment, the radio communication interface 55 comprises a pair of directional Wi-Fi antennas 56 reciprocally oriented in opposite directions along, or parallel to, a driving axis of the bogie 1. In this case, the radio communication interface 55 comprises at least one Wi-Fi transceiver 55 operatively connected to the two antennas 56. If the concentrator node 50 is installed on the lower face of the frame 2 of bogie 1 and includes two opposed Wi-Fi antennas 56, the positioning of the Wi-Fi antennas is optimal because the ballast, the tracks and the frame itself of bogie 1 form a waveguide for the frequencies involved. This allows reliable communications to be carried out and the energy output to be reduced.

[0034] For example, with reference to the diagram in figure 3, using the Wi-Fi communication interfaces, sev-

eral bogies 1 of a railway train 100 may be put into communication with one another to create a train network by putting several concentrator nodes 50 into communication with one another, each associated with the respective bogie 1. In the railway train 100 in figure 3, all bogies 1 of all train wagons 101 are provided with the concentrator node 50 (with which there are associated one or more respective sensor nodes, not shown in figure 3). The plurality of bogies 1 of the railway train 100 defines as a whole a linear array of two-by-two adjacent boogies, and in the linear array, the concentrator node 50 of a bogie 1 is adapted and configured to communicate by means of the radio communication interface 55 with the concentrator nodes 50 of the bogies of the railway train 100 which are adjacent thereto along the linear array. The above-described monitoring system also may be associated with the axles 3 of locomotive 110 of the railway train 100, for example by associating a concentrator node 50 of the type described above with each of the two bogies of locomotive 110. An on-board diagnostic unit 111 operatively connected to all the concentrator nodes 50 may also be provided on board the locomotive 110, which nodes practically serve as signal repeaters for the adjacent concentrator nodes 50. The on-board diagnostic unit 111 is a hardware and software system which allows the operating or maintenance personnel on board the train to be informed, for example by means of a graphic interface, of possible breakdowns or the risk of breakdowns. The same information may alternatively or additionally be sent to a ground control station. The configuration of the diagnostic system in figure 3 from now on will be called "full train equipment".

[0035] The concentrator nodes 50 process the data (or the signals) acquired by the sensor nodes 20a, 20b. Processing means any analog and/or digital processing, including filtering, sampling, executing algorithms adapted to identify if the components of the bogie satisfy a condition of regularity or anomaly, generating alarms, coding and compressing data.

[0036] The container of the concentrator node 50 preferably is made of metal material, e.g. steel. If there are provided Wi-Fi antennas on board the concentrator node 50, they may be installed outside the container or alternatively inside, by providing dielectric material windows in the container which allow to transmit and receive the radiofrequency signals.

[0037] Figure 4 shows a general block diagram of an alternative embodiment of the diagnostic system in figure 3, in a configuration which here will also be called "vehicle equipment".

[0038] Here, rather than equipping all cars 101 and possibly also locomotive 110 with the above-described monitoring system, to meet given needs or comply with set constraints, only certain cars 101 (or only certain bogies 1) may be equipped, for example the ones deemed to undergo increased stresses.

[0039] Here, it generally is not possible to put concentrator nodes 50 into communication with one another by

means of Wi-Fi connections; for this reason, alternative radio interfaces may be provided. With reference to figure 5, it is indeed worth noting that in the embodiment therein depicted, as possible alternative to the embodiment in figure 2, the concentrator node 50 may be provided without the Wi-Fi transceiver 55 and the Wi-Fi antennas 56, or at least it may be provided for such elements not to be used, when present. However, the concentrator node 50 may be provided to have a radio communication interface 54 which is a GSM and/or GPRS modem or generally a digital mobile radio communication interface. Here, it is advantageous and possible to provide for at least one of the sensor nodes (here, one of the two sensor nodes 20b) to comprise a GSM and/or GPRS antenna 24 or generally an antenna adapted and configured to establish a radio connection with a digital mobile radio network. Here, antenna 24 housed in the sensor node 20b is connected to the mobile radio communication interface 54 of the concentrator node 50 by means of the wired connection line 40. Here, it is also advantageous if at least one of the sensor nodes 21a, 21b of bogie 1 also comprises a GPS antenna 25. Here, the concentrator node 50 further comprises a satellite tracking unit (not shown in the drawings) operatively connected to said GPS antenna 25, for example by means of the wired connection line 40. The presence of the GPS antenna and of the satellite tracking unit advantageously allows the position of bogie 1 to be detected, or the position to be identified of a stretch of track at which the monitoring system detects anomalous vibrations.

[0040] In the embodiment in figure 5, however without any limitation, one same sensor node 21b comprises both the mobile radio antenna 24 and the GPS antenna 25, but a different distribution of such antennas may clearly be provided.

[0041] If for example, as with the sensor nodes 20b, one sensor node comprises one or more antennas, the covering device 6 may be made of metal material, as long as there is provided one or more dielectric windows which are transparent to the electromagnetic radiations in the band involved.

[0042] Embodiments of monitoring systems have been hereto described without getting into the details of contrivances which may be used to make the monitoring system sound against breakdowns and/or errors. If instead the system is to be made as strong as possible, the processing unit 50 may be provided with two channels, for example two separate processors, and have two radio communication interfaces.

[0043] In the configuration in figure 2, which is applicable to the diagnostic system configuration in figure 3 and for this also called full train equipment, the processing unit 51 in the concentrator node 50 may be split into two separate processing units (also called channels), there may be provided two radio communication interfaces 55 and four antennas 56 arranged so as to form two pairs of directional antennas directed in opposite directions to each other, in which two antennas oriented in

opposite direction are operatively connected to one of the two radio communication interfaces and the remaining to the other radio communication interface. There is no need instead to duplicate supercapacitor 52 or generally an electrical power storage device.

[0044] In the configuration in figure 5, which is applicable to the diagnostic system configuration in figure 4 and for this also called vehicle equipment, the processing unit 51 in the concentrator node 50 may be split into two separate processing units (or channels), there may be provided two mobile radio communication interfaces 54, one mobile radio antenna 24 in each sensor 20b and possibly two GPS antennas in each sensor 20b. Also in this case, there is no need instead to duplicate supercapacitor 52 or generally an electrical power storage device.

[0045] Preferably, in the above-described redundant configurations, there are two channels and the redundancy is for availability (configuration 1oo2 "1 out of 2"), in redundancy for availability (configuration 1oo2 - 1 out of 2), i.e. there are 2 channels but 1 is needed to make the apparatus completely operational.

[0046] Preferably, each channel is connected to the four triaxial accelerometers, i.e. the ones as a whole existing in the four sensor nodes 20a, 20b of bogie 1. For each channel, two inlets are considered primary and two secondary. The triaxial accelerometers connected to the primary inlets of one channel are connected to the secondary inlets of the other channel, and vice versa.

[0047] Preferably, each channel is connected to the four temperature sensors, that is the ones as a whole existing in the four sensor nodes of bogie 1. For each channel, two inlets are considered primary and two secondary. The temperature sensors connected to the primary inlets of one channel are connected to the secondary inlets of the other channel, and vice versa.

[0048] Preferably, each channel is connected to four antennas. In the "vehicle equipment" configuration, they are the existing two GPS antennas and the two GSM antennas in two sensor nodes 2b of a bogie. In the "full train equipment" system configuration, they are the four directional Wi-Fi antennas comprised in the concentrator node 50. For each channel, two antennas are considered primary and two secondary.

[0049] Preferably, in the "vehicle equipment" system configuration, each of the 2 GSM antennas contained in the two sensor nodes 20b connected to the primary interface of one channel, is connected to the secondary interface of the other channel. In the "vehicle equipment" system configuration, each of the two GPS antennas contained in the two sensor nodes 20b connected to the primary interface of one channel, is connected to the secondary interface of the other channel.

[0050] Preferably, in the "full train equipment" system configuration, two directional antennas oriented in opposite direction to each other are connected to the primary interfaces of one channel. The other two are connected to the secondary interfaces. The connections are invert-

ed on the other channel.

[0051] The two channels preferably are designed to create a hybrid mechanism of cooperation based both on the sharing of memory and on the exchange of messages. The first mechanism is more effective when significant quantities of data are to be transferred between the channels. The second mechanism is more effective for sharing events with short latency periods.

[0052] Preferably, the concentrator node 50 includes a memory bank shared between the two channels, and furthermore the channels are connected to each other by means of fast serial lines.

[0053] In the rated operation, in the absence of breakdowns, each channel processes the information from the triaxial accelerometers and from the temperature sensors connected to its primary inlets. In the rated operation, in the absence of breakdowns, in the "vehicle equipment" system configuration, each channel of the data concentrator (50) geo-references its processed data by means of its GPS control electronics and the GPS antenna connected to the primary interface thereof, and sends its processed data by means of its GSM control electronics and the GSM antenna connected to the primary interface thereof.

[0054] Again, in the rated operation, in the absence of breakdowns, in the "full train equipment" system configuration, each channel of the data concentrator participates in creating the wireless train network by means of its Wi-Fi communication apparatus and the directional Wi-Fi antennas connected to its primary interfaces. Each channel sends its processed data on the wireless train network to the diagnostic unit 111, which collects the data of all the concentrator nodes on the train and executes the predictive diagnostic analysis. In this configuration, the diagnostic unit 111 preferably includes a GSM apparatus and a GPS apparatus and is responsible for all communications with the ground subsystem and for data localization.

[0055] Preferably, each channel is capable of diagnosing the breakdown condition for each of the connected elements, sensors and antennas, and for its communication electronics, GPS, GSM, Wi-Fi. Using the serial lines, each channel is capable of informing the other channel of the breakdown of its elements, the other channel accordingly is responsible for some of the actions which the first channel may no longer execute.

[0056] Preferably, in the "vehicle equipment" system configuration, in the case of the breakdown of the GPS control electronics of one channel or of the GPS antenna connected to its primary interface, the other channel provides its GPS localization on the shared memory bank.

[0057] Preferably, in the "vehicle equipment" system configuration, in the case of the breakdown of the GSM control electronics of one channel or of the GSM antenna connected to its primary interface, the channel provides its messages to be transmitted on the shared memory bank and the other channel transmits them.

[0058] In the "full train equipment" system configura-

tion, in the case of the breakdown of the Wi-Fi communication apparatus of one channel or of both the directional Wi-Fi antennas connected to its primary interface, the channel provides its messages to be transmitted on the shared memory bank and the other channel transmits them on the wireless train network. The integral channel also provides the incoming messages from the wireless train network on the shared memory bank.

[0059] Each channel preferably is capable of diagnosing the condition of complete breakdown of the other channel using periodic vitality messages exchanged on the serial lines.

[0060] In the case of complete breakdown of one channel, the other channel also processes the data of the triaxial accelerometers and of the temperature sensors connected to its secondary inlets and sends the processing results to the ground subsystem or to the on-board diagnostic unit, according to the system configuration.

[0061] In the case of complete breakdown of one channel, the other channel executes, in its place, all the actions required to manage the wireless train network.

[0062] In the degraded configuration of complete breakdown of one channel, the surviving channel, in the case of the breakdown of one of the antennas thereof, uses the corresponding antenna of the malfunctioning channel connected to its secondary interface.

[0063] Preferably, no redundancy for the triaxial accelerometers and the temperature sensors is provided in a sensor node. In the case of a breakdown of one of these sensors, the data are no longer available. However, the axle has a sensor at both ends and the data thereof are not unrelated.

[0064] Preferably, all the breakdowns identified are reported to the ground subsystem for planning maintenance actions.

[0065] With the above-described system architecture, no single breakdown results in any loss of functionality. A chain of successive breakdowns does not result in any loss of functionality so long as the breakdowns are of various elements.

[0066] In the "vehicle equipment" system configuration, the minimum degraded configuration in which all the functionalities are still active is the one in which one channel survives with all the GPS and GSM communication electronics thereof, either one of the two GPS antennas, either one of the two GSM antennas, either one of the two electric generators 23.

[0067] In the "full train equipment" system configuration, the minimum degraded configuration in which all the functionalities are still active is the one in which one channel survives with all the Wi-Fi communication electronics thereof, either one of the two directional Wi-Fi antennas and either one of the two directional Wi-Fi antennas facing in the opposite direction, either one of the two electric generators 23.

[0068] In the "vehicle equipment" system configuration, only one breakdown chain which includes both the channels and/or both the GSM antennas results in the

loss of all the functionalities. The breakdown of both the GPS antennas prevents the geo-referencing of the data, however if both the bogies are equipped, then there is in any case the possibility of reconstructing this datum.

[0069] In the "full train equipment" system configuration, only a chain of breakdowns which includes both the channels and/or both the directional Wi-Fi antennas oriented in the same direction results in the loss of all the functionalities.

[0070] It is apparent from that described above that the monitoring system of the type described above allows the preset objects to be completely achieved in terms of overcoming the drawbacks of the known art. Indeed, due to the architecture thereof, the aforesaid system is particularly simple to install. For example, the concentrator node may be attached to the lower face of the bogie by means of one or more permanent magnets so as not to require modifications to the bogie. The sensor nodes 20a may be attached to the bearings by attaching the covering device 6 in place of the covering devices generally provided on the bearings so as to use fastening elements already provided on the bearings.

[0071] The principle of the invention being understood, the embodiments and manufacturing details may largely vary with respect to that described and illustrated by mere way of non-limiting example, without departing from the scope of the invention as defined in the appended claims.

Claims

1. A monitoring system for acquiring, processing and transmitting operating data of a bogie (1), wherein the bogie (1) comprises:

- a bogie frame (2) which supports at least one railway axle (3),
- at least one axle box (5) arranged at one end portion of the railway axle (3);
- at least one covering device (6) of the axle box attached to the axle box (5) and adapted to define a respective inner compartment between the axle box (5) and the covering device (6); wherein the monitoring system comprises:
- at least one sensor node (20a, 20b), associated with the axle box (5) and comprising at least one sensor (21, 22) positioned in the inner compartment, adapted and configured to acquire operating data of the axle box (5) ;
- a concentrator node (50) attached to the bogie frame outside the covering device of the axle box (5), the concentrator node (50) being operatively connected to the sensor node (20a, 20b) by means of a wired connection line (40) to receive said acquired data, wherein the concentrator node (50) comprises at least one local processing unit (51) adapted to process the acquired data and obtain processed data, and a

radio communication interface (54, 55) for transmitting said processed data outside the concentrator node (50).

2. A monitoring system according to claim 1, wherein the bogie frame comprises a lower face (8), facing the ground in a normal use condition of the bogie (1), and an opposite upper face (9), and wherein the concentrator node (50) is housed in a container attached to the lower face (8) of the bogie frame.
3. A monitoring system according to claim 2, wherein the communication interface comprises a pair of directional Wi-Fi antennas reciprocally oriented in opposite directions along, or parallel to, a driving axis of the bogie.
4. A monitoring system according to any one of the preceding claims, wherein the bogie (1) comprises a pair of axles (3), and wherein the monitoring system comprises two sensor nodes (2a, 2b) for each axle (3), each sensor node being connected to the concentrator node (50) by means of a respective wired connection line (40).
5. A monitoring system according to any one of the preceding claims, wherein said at least one sensor node (20a, 20b) comprises an electric generator (23) adapted to produce electrical power by converting part of the rotational kinetic energy of the axle, and wherein the electrical power produced by the electric generator (23) is used to feed the processing unit (51) and the radio communication interface (54, 55) of the concentrator node (50).
6. A monitoring system according to claim 5, wherein the concentrator node (50) comprises a storage device (52) for the power produced by the electric generator (23).
7. A monitoring system according to claim 6, wherein said storage device (52) comprises a supercapacitor.
8. A monitoring system according to any one of claims 5 to 7, wherein the electric generator (23) is a synchronous polyphase alternator.
9. A monitoring system according to any one of the preceding claims, wherein said at least one sensor node (20a, 20b) comprises a GPS antenna and wherein the concentrator node contains a satellite tracking unit operatively connected to said GPS antenna.
10. A monitoring system according to any one of the preceding claims, wherein said at least one sensor node (20a, 20b) comprises an antenna suitable for mobile radio connection and wherein said radio communi-

cation interface is, or comprises, a mobile radio communication interface operatively connected to said antenna.

11. A diagnostic system of a railway train, wherein the railway train comprises a plurality of bogies which define as a whole a linear array of two-by-two adjacent bogies, wherein the diagnostic system comprises a system according to any one of the preceding claims installed on each bogie, and wherein, in the linear array, the concentrator node of a bogie is adapted and configured to communicate by means of said radio communication interface with the concentrator nodes of the bogies of the railway train which are adjacent thereto along the linear array.

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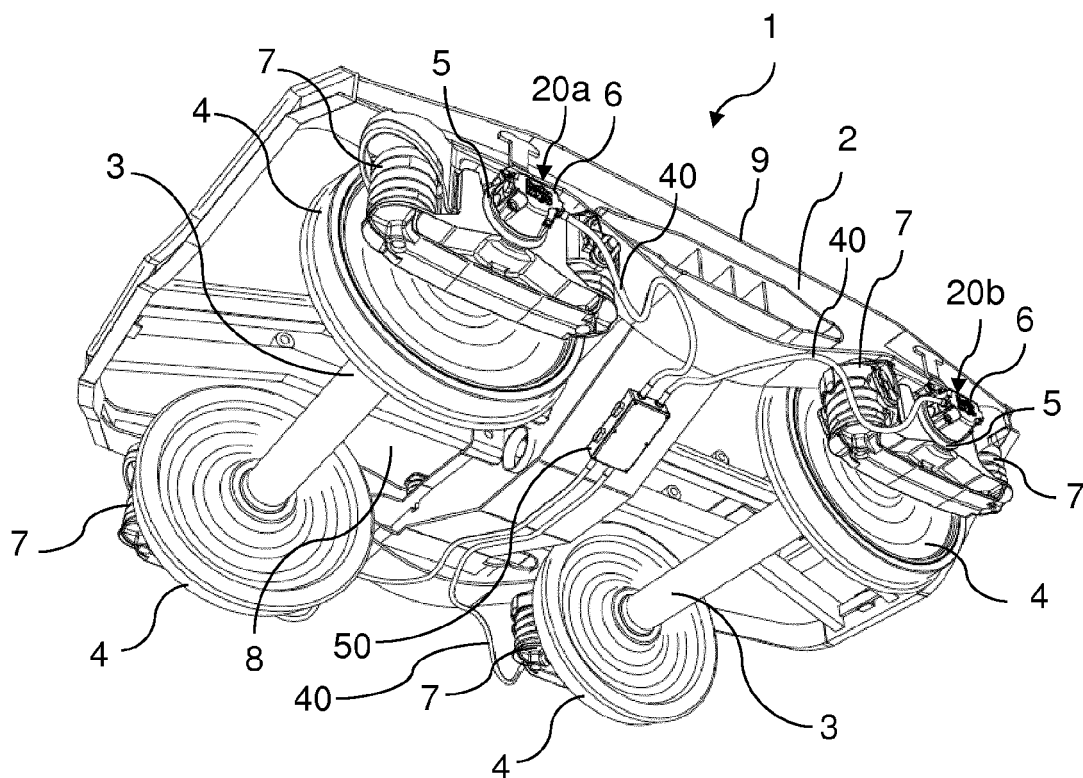


FIG. 1

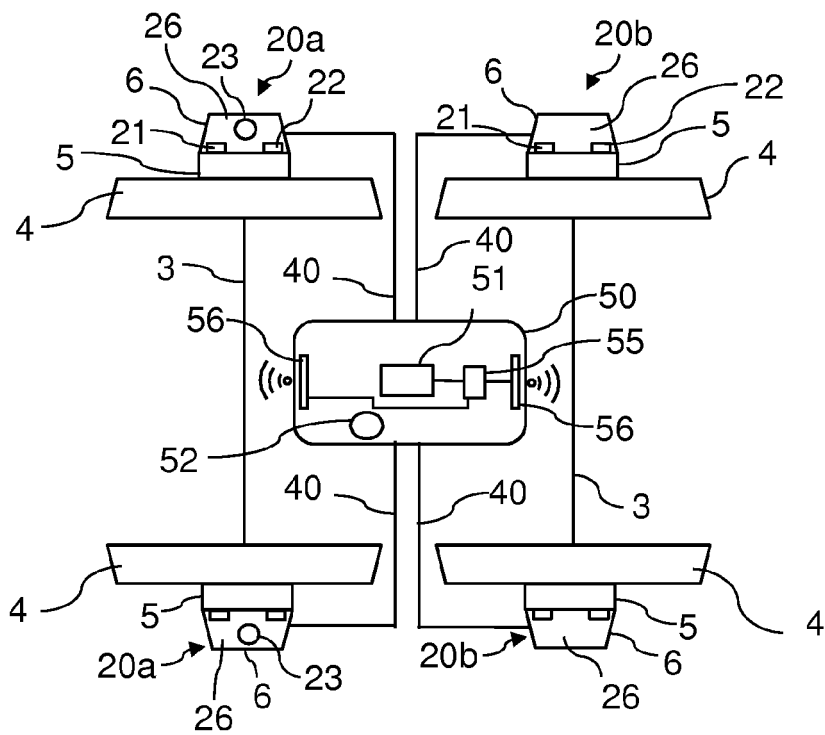


FIG. 2

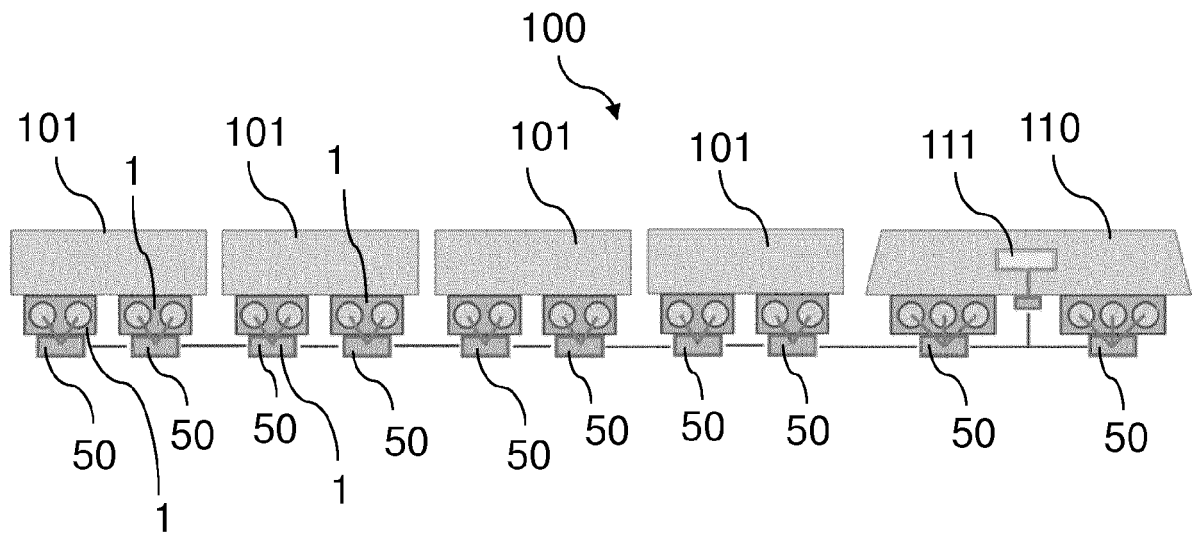


FIG. 3

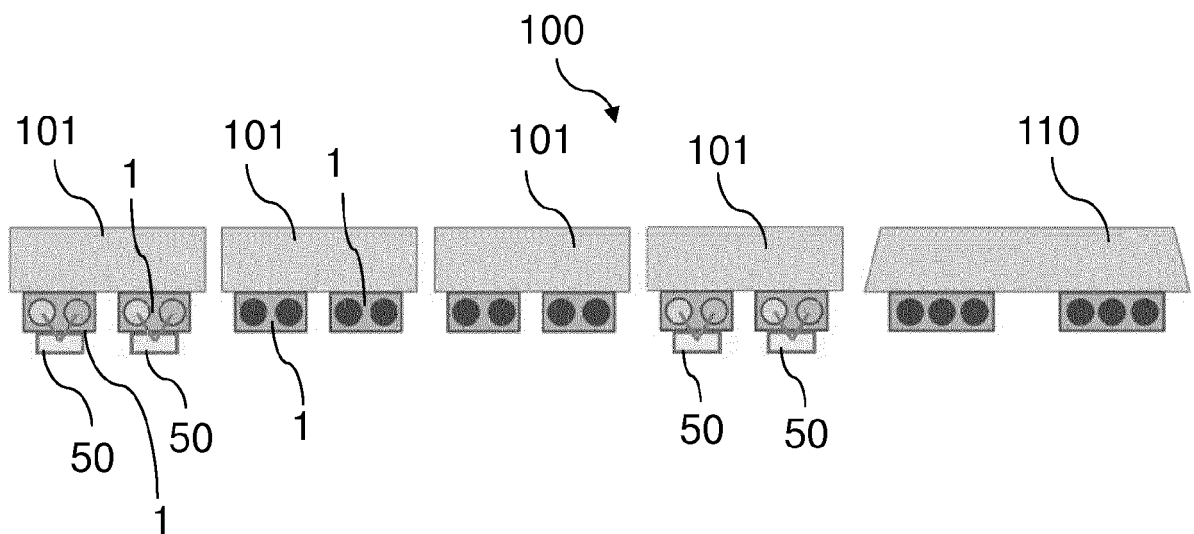


FIG. 4

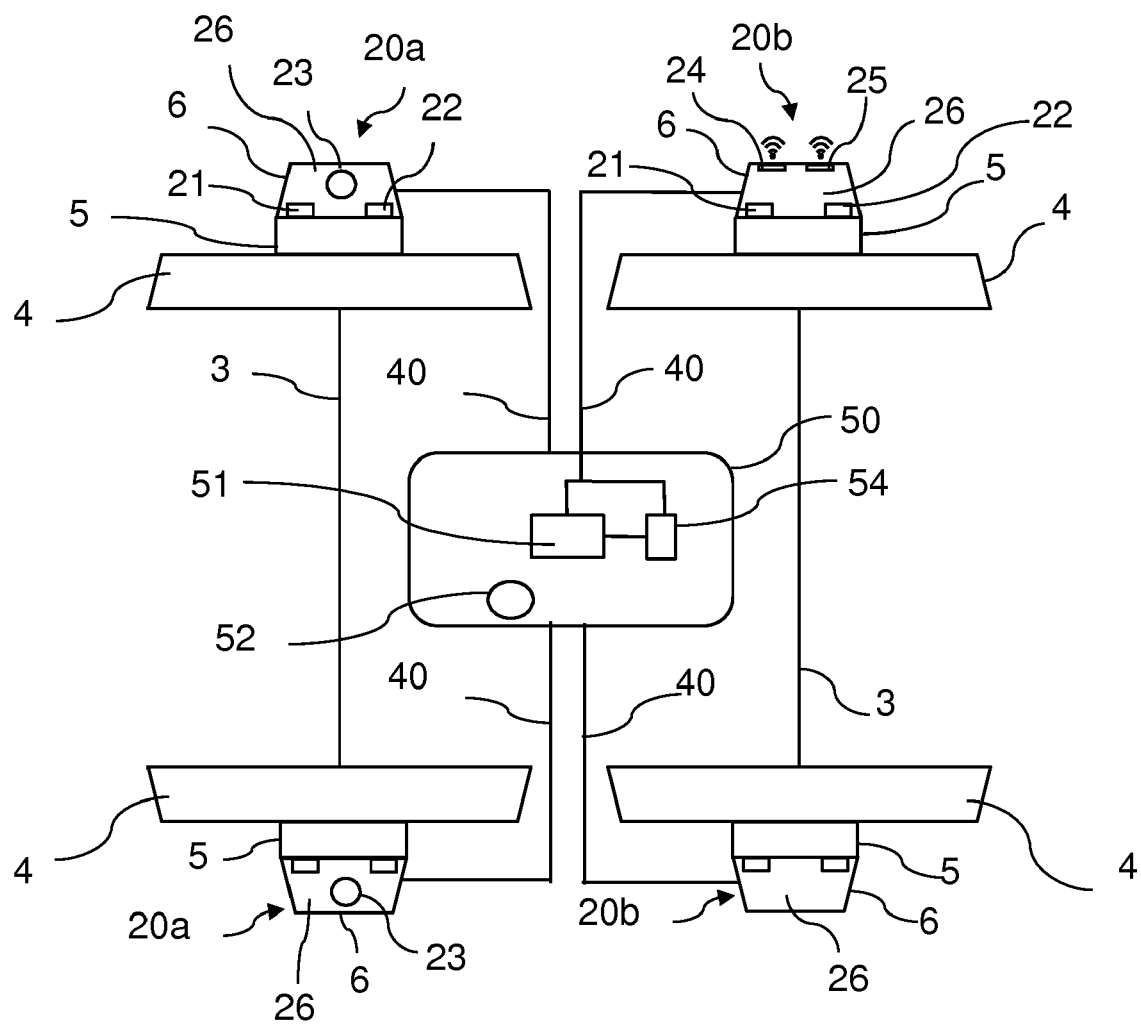


FIG. 5



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