



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
07.10.2020 Bulletin 2020/41

(51) Int Cl.:
B61L 15/00 ^(2006.01) **B61L 25/02** ^(2006.01)

(21) Application number: **20166170.9**

(22) Date of filing: **27.03.2020**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
KH MA MD TN

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(30) Priority: **28.03.2019 IN 201941012287**

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(54) **METHOD, SYSTEM AND VEHICLE FOR LOCALIZING DEFECTIVE PARTS OF POWER SUPPLY SYSTEMS IN RAILWAYS APPLICATIONS**

(57) A method (100) and system (200) for localizing defective parts of a power system (10) suitable for supplying railway vehicles, which power system (10) comprises a main power-carrying conductor (11) and an associated current collector equipment (12). The actual position (P) of a vehicle (2) travelling along a railway line is tracked and values ($V_{i,v}$) related to a first parameter (I, V) indicative of an actual operative status of the main power-carrying conductor (11) and values (V_F) related to a second parameter (F) indicative of an actual operative status of the current collector equipment (12) are first

calculated and then compared with a first predefined threshold ($Th_{i,v}$) and with a second predefined threshold (T_F), respectively, during a first predetermined interval of time (T_1) and a following second predetermined interval of time (T_2). Depending on the results of the comparison, the method and system are able to localize and discriminate if a defective part is present on the power-carrying conductor (11) or on the current collector equipment (12) and to generate a corresponding alarm signal for maintenance.

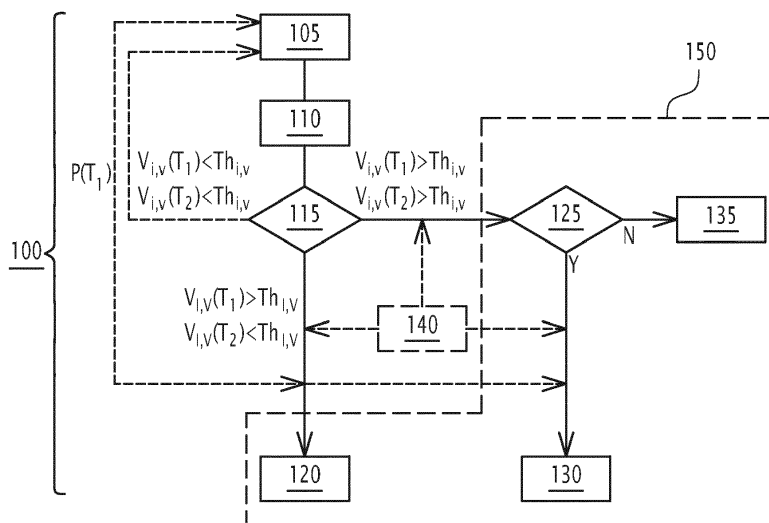


FIG.1

Description

[0001] The present invention relates to a method and system for localizing defective parts of a power supply system suitable for feeding vehicles, in particular railway vehicles travelling along a railway line, and to a related vehicle.

[0002] The method and system according to the present invention are particularly suitable for being applied to railways vehicles and will be described herein making specific reference to such applications; however, such reference should not be intended in any way as limiting the possibility of applications to other types of vehicles, and those skilled in the art would easily appreciate that they can be used in connection with any electrical vehicle adapted to be connected to a power conductor, for example cars, trucks, buses and the like, circulating on a road equipped with a main power supplying conductor, such as aerial lines or power cables placed on- or under-ground, or similar.

[0003] In the field of railway applications, it is well known the use of power lines which run along the extension of a railway line and are used for electrically feeding railway vehicles via an operative coupling with current collector equipment, usually provided on-board of the vehicles to be powered.

[0004] A typical example of such applications, used for example in urban or underground railways, is represented by the so-called third rail which runs on the ground along a side of and spaced from a track of the associated railway line.

[0005] In these applications, the third rail carries out the feeding power and is operatively associated with current collector equipment, e.g. the so-called shoe-gears, which are mounted on the bogies of a railway vehicle.

[0006] When a vehicle runs over the tracks of the railway line, a contact shoe slides on a surface of the third rail and, through the surface contact, allows the transfer of feeding power to the transiting vehicle.

[0007] Another example of such applications is represented by aerial lines suspended at a certain height above the rail tracks, namely the so-called catenaries, where electrical power is transferred to the travelling railway vehicles via roof-mounted pantographs, or similar current collector equipment, e.g. bow collectors, trolley poles, and the like.

[0008] In particular, in these applications, the pantograph, or like equipment, scrubs against the conductor of a catenary along which there flows the current from the power grid, thus allowing the transfer of feeding power to the transiting railway vehicle.

[0009] For such power systems, the risk of having defective parts is intrinsic and substantially unavoidable, for instance due to the working conditions under which they are used, e.g. climatic conditions which are usually variable and in some cases might be very harsh, or due to mechanical stresses exerted on the current collectors, for example by the friction with the catenaries or with third rails, or just due to the usual aging and mechanical wearing out of the various parts during lifetime service, et cetera.

[0010] Such defective parts, either being represented by a portion of the power supply conductor, or by any part of the current collection equipment mounted on-board of railways vehicles, must be detected as timely and as precisely as possible in order to introduce corrective actions and prevent malfunctioning or failure that could result in long and unacceptable perturbations, or even disruptions, of the railway traffic.

[0011] These issues have been faced over the years by implementing different types of measures.

[0012] One solution, adopted for instance for monitoring catenaries, foresees to measure the mechanical tension of the aerial power conductor by adding at its ends mechanical means capable of detecting the actual mechanical tension.

[0013] A significant tension drop detected by these mechanical means would constitute an indication of a breakage along the aerial power conductor.

[0014] This solution, despite efficiently detecting the occurrence of a breakage, is not entirely satisfactory since it detects when a break of the power conductor has occurred, but it does not give any early indication of the actual status, e.g. of the current wear out of the power conductor, nor it gives any indication about the position of the breakage along the power conductor.

[0015] In addition, the status of the current collector equipment, e.g. a pantograph, mounted on board of the powered vehicle, is not monitored at all.

[0016] Other classic solutions are based on specific maintenance plans which foresee the execution of periodic inspections and interventions for maintaining and/or replacing various components, according to relevant standards and/or regulations at various levels, e.g. regional, national, or federal ones.

[0017] To this end, an example is represented by the standard promulgated by the American Public Transportation Association (APTA) concerning periodic inspection and maintenance of third rail current collection equipment used on rail transit vehicles.

[0018] Generally, such maintenance plans are predominantly, if not completely, based on visual inspections carried out by service personnel on scheduled dates.

[0019] Hence, even if maintenance plans are properly executed, and usually mitigate the risk of unexpected events, they are not entirely satisfying for different reasons.

[0020] For example, they might be subject to human errors and, in any case, they cannot take into account the real evolution and actual operative conditions of power conductors and/or related current collection equipment between an executed intervention and the scheduled following one.

[0021] Therefore, it is evident from the above that there is substantial room and need for further improvements in the management, and in particular in the operation and maintenance of power systems used for supplying vehicles, in particular railway vehicles.

[0022] To this end, it is a main aim of the present invention to provide a solution for a more timely and precise detection of any defective part of a power system used for powering vehicles, in particular railway vehicles.

[0023] Within the scope of this aim, an object of the present invention is to provide a solution which allows monitoring the actual condition of a power system feeding vehicles, and in particular suitable to detect, substantially in real time, the onset of any defective part, either along the main conductor feeding travelling vehicles, and/or on any current collector equipment mounted on-board of a transiting vehicle.

[0024] Another object of the present invention is to provide a solution capable of preventing, or at least drastically reducing, the margins of errors in detecting any defective part of the monitored power system compared with state of the art solutions.

[0025] A further object of the present invention to provide a solution which is more flexible in applications and can be applied with minor modifications, if any at all, to power systems using as power conductors either aerial lines and/or third rails, in connection with whatever type of current collector equipment installed on-board of vehicles to be powered.

[0026] Yet a further object of the present invention is to provide a solution for the detection and localization of defective parts in power systems used for supplying vehicles, which is highly reliable, relatively easy to realize and implement at competitive costs.

[0027] This aim, these objects and others which will become apparent hereinafter are achieved by a method for localizing defective parts of a power system suitable for supplying vehicles, said power system comprising at least a main power-carrying conductor extending along at least a portion of a track, and an associated current collector equipment adapted for allowing transmission of power supply from the main power-carrying conductor to a vehicle travelling along said track, the method being characterized in that it comprises at least the following steps:

- (a): tracking the actual position of the vehicle travelling along the track;
- (b): calculating, at least values related to a first parameter indicative of an actual operative status of the main power-carrying conductor and values related to a second parameter indicative of an actual operative status of said current collector equipment;
- (c): comparing the values calculated for the first parameter during at least a first predetermined interval of time and a following second predetermined interval of time with a first predefined threshold respectively and the values calculated for the second parameter during at least one of the first predetermined interval of time and second predetermined interval of time with a second predefined threshold; and
- (d): generating alarm for maintenance according to the result of the comparing step.

[0028] The above mentioned aim and objects of the present invention are also achieved by a control system for localizing defective parts of a power system suitable for supplying vehicles, said power system comprising at least a main power-carrying conductor extending along at least a portion of a track, and an associated current collector equipment adapted for allowing transmission of power supply from the main power-carrying conductor to a vehicle travelling along said track, the control system being characterized in that it comprises at least:

- one or more sensors adapted to provide signals related to at least a first parameter indicative of an actual operative status of the main power-carrying conductor and to a second parameter indicative of an actual operative status of said current collector equipment;
- a position tracker adapted for tracking the actual position of the vehicle travelling along the track;
- an elaboration device an elaboration device which is configured first to calculate, based on the signals provided via said one or more sensors, at least values related to a first parameter indicative of an actual operative status of the main power-carrying conductor and values related to a second parameter indicative of an actual operative status of said current collector equipment, and then to compare the values calculated for the first parameter during at least a first predetermined interval of time and a following second predetermined interval of time with a first predefined threshold, respectively and the values calculated for the second parameter during at least one of the first predetermined interval of time and second predetermined interval of time with a second predefined threshold; said elaboration device being further configured to generate an alarm for maintenance according to the result of the comparison between the values calculated for the first parameter and for the second parameter and the respective first predefined threshold and second predefined threshold.

[0029] Finally, the present invention provides also a vehicle, in particular a railway vehicle, characterized in that it comprises, or it is adapted to interact with, a control system previously indicated, and in particular according to the relevant appended claims, and as per details given hereinafter.

[0030] Further characteristics and advantages will become apparent from the description of some preferred but not exclusive exemplary embodiments of a method, system and related vehicle according to the invention, illustrated only by way of non-limitative examples with the accompanying drawings, wherein:

- 5 Figure 1 is a flow chart illustrating a method for localizing defective parts of a power system suitable for supplying vehicles, according to the present invention;
 Figure 2 is a block diagram schematically illustrating a control system for localizing defective parts of a power system suitable for supplying vehicles according to the invention;
 10 Figure 3 is a view schematically showing an exemplary railway vehicle suitable to comprise or interact with the control system illustrated in figure 2 and/or to operate according to the method illustrated in figure 1.

[0031] It should be noted that in order to clearly and concisely describe the present disclosure, the drawings may not necessarily be to scale and certain features of the disclosure may be shown in somewhat schematic form.

15 **[0032]** Further, when the term "adapted" or "arranged" or "configured" or "shaped", is used herein while referring to any component as a whole, or to any part of a component, or to a combination of components, it has to be understood that it means and encompasses correspondingly either the structure, and/or configuration and/or form and/or positioning.

[0033] In particular, for electronic and/or software means, each of the above listed terms means and encompasses electronic circuits or parts thereof, as well as stored, embedded or running software codes and/or routines, algorithms, or complete programs, suitably designed for achieving the technical result and/or the functional performances for which such means are devised.
 20

[0034] A method and a system for localizing defective parts of a power system suitable for supplying vehicles are schematically illustrated in figures 1 and 2, respectively, and therein indicated by the corresponding overall reference numbers 100 and 200.

25 **[0035]** In particular, in figure 3 there is illustrated a schematic example of a vehicle therein indicated by the reference number 2 and represented in the form of a railway vehicle.

[0036] As those skilled in the art would easily appreciate, the term railway vehicle herein used encompasses any type of railway vehicle which, when travelling along a railway line, a track of which is indicated in figure 2 by the reference number 1, is suitable to be electrically powered by a power system associated to the railway line itself. Hence such term encompasses any suitable type of underground or surface railway vehicles, such as subway or surface trains, tramways, which can be composed by one or more carriages or vehicles, or the like.
 30

[0037] The power system, indicated by the reference number 10 in figure 2, comprises at least a main power-carrying conductor 11 extending along at least a portion of a track 1 of a railway line, and an associated current collector equipment 12 adapted for allowing transmission of power supply from the main power-carrying conductor 11 to the railway vehicle 2 travelling along the track 1 of railway line.

35 **[0038]** In particular, depending on the applications, the main power-carrying conductor 11, can comprise a third rail 11', positioned on the ground and running for example on a side of the track of the railway line, and/or a catenary 11" suspended over the track at a certain height.

[0039] In turn, depending also on the applications, and in particular on the type of railway vehicle 2 and main power-carrying conductor 11 present along the railway line, the associated current collector equipment 12 can comprise, according to solutions well known in the art and therefore not described herein in details, one or more contact shoe-gears 12', suitable to slide relative to- while being in a surface contact-friction with- the associated third rail 11', and/or one or more pantograph 12" suitable to scrub the associated catenary power conductor 11".
 40

[0040] The method 100 according to the present invention comprises at least the following steps:

- 45 - 105: tracking the actual position P_a of the railway vehicle 2 travelling along a track 1;
 - 110: calculating, for example in real-time and via signals provided by one or more sensors 30, for instance all installed on-board of the railway vehicle 2 travelling along the railway line, at least values $V_{I,V}$ related to a first parameter I, V indicative of an actual operative status of the main power-carrying conductor 11, and values V_F related to a second parameter F indicative of an actual operative status of the associated current collector equipment 12;
 50 - 115: comparing the values $V_{I,V}$, V_F calculated for the first parameter I, V and for the second parameter F during at least a first predetermined interval of time T_1 and a following second predetermined interval of time T_2 with a first predefined threshold $Th_{i,v}$ and a second predefined threshold T_f , respectively; and
 - 150: generating an alarm for maintenance according to the result of the comparing step 115.

55 **[0041]** In particular, as illustrated in figure 1, the step 150 of generating an alarm for maintenance comprises a sub-step 120 wherein, if at least the values $V_{I,V}$ calculated for the first parameter I, V during the first predetermined interval of time T_1 violate the first predefined threshold $Th_{i,v}$ while the values $V_{I,V}$ calculated for the first parameter I, V during the second predetermined interval of time T_2 respect the predefined first threshold $Th_{i,v}$, then generating a first alarm

signal indicative of a defective part of the main power-carrying conductor 11 at a location related to the position $P(T_1)$ tracked for the railway vehicle 2 along the railway line at the first interval of time T_1 .

[0042] Moreover, if the values $V_{I,V}$ calculated for the first parameter I, V during the first and second predetermined interval respect/are below the first predefined threshold $Th_{i,v}$, then steps 105 to 115 are repeated.

[0043] Advantageously, during the sub-step 120, if the values $V_{I,V}$ and V_F calculated for the first parameter I, V, respectively the second parameter F, during the first predetermined interval of time T_1 violate the first threshold $Th_{i,v}$, respectively, the second predefined threshold T_f , while the values $V_{I,V}$ and V_F calculated for the first parameter I, V respectively the second parameter F during the second predetermined interval of time T_2 respect the predefined first threshold $Th_{i,v}$, respectively the predefined second threshold $Th_{i,v}$, then the first alarm signal, indicative of a defective part of the main power-carrying conductor 11 at a location related to the position $P(T_1)$ tracked for the railway vehicle 2 along the railway line 1 at the first interval of time T_1 , is generated.

[0044] According to the invention, the step 150 of generating an alarm for maintenance comprises advantageously also the following sub-steps:

- 125: if the values $V_{I,V}$ calculated for the first parameter I, V exceed/violate the predefined first threshold $Th_{i,v}$ during both the first and second predetermined interval of times T_1, T_2 , checking if also the values V_F calculated for the second parameter F for a first part (i.e. a front part) and a second part (i.e. a rear part) of a same current collector or for a first and a second current collectors of the vehicle 2 both exceed/violate or both respect/or are below the corresponding second predefined threshold Th_F during at least one of the first and second predetermined interval of times T_1, T_2 ; then
 - 130: in the affirmative case, generating a second alarm signal indicative of a defective part of the main power-carrying conductor 11 at least at the location related to the position $P(T_1)$ tracked for the railway vehicle 2 along the railway line 1 at one of the first and second intervals of time T_1 ;
 - 135: in the non-affirmative case, if the second parameter for only one of the first part and second parts or only one of the first and second current collectors exceed/violate the corresponding second predefined threshold during at least one of the first and second predetermined interval of times T_1, T_2 , generating a third alarm signal indicative of a defective part of the current collector equipment 12 and in particular for only one of the first part or second part of the same current collector 12" or one of the first and second current collectors 12'.

[0045] In particular, if the vehicle 2 has just one current collector, for example a pantograph 12", then the indicated first part and second part would correspond, relative to the direction of travelling of the vehicle 2, for instance to a front part and a rear part of the pantograph 12". If instead, the vehicle 2 is provided with two current collectors (or even more), such as the illustrated shoe-gears 12', then the first and second current collectors would be the first and second shoe-gears 12' positioned on the vehicle 2 with reference to the travelling direction.

[0046] In step 135, the third alarm will refer to the first or second part or current collector corresponding at the interval of time T_1 , or T_2 for which the calculated values V_F of the second parameter F exceed/violate the second predefined threshold T_f .

[0047] The indicated thresholds $Th_{I,V}$ and Th_F can be represented by corresponding standard values of the relevant power system 10, e.g. values specified in operational/maintenance manuals for the power system, or they can be selected by users case by case.

[0048] In practice, during a trip, the above indicated values are calculated during series of successive interval of times T, for example each lasting 5 sec. When such values exceed the relevant threshold in an interval of time, such interval represents the first interval of time T_1 and the following one represents the second interval of time T_2 .

[0049] The indication of first, second, and third alarm signals are expressed in such a way just for the sake of clarity of description and should not be interpreted as related to a specific sequence, since they clearly relate each to a specific operational situation the occurrence of which would exclude the others.

[0050] According to an embodiment, the above indicated step 110 comprises calculating values V_I related the current I flowing along the main power-carrying conductor 11 and/or values V_V related to its operating voltage V.

[0051] For example, in case of DC power systems, the direct voltage can be calculated, while for AC power systems, it is possible to calculate the peak voltage.

[0052] According to an embodiment, the above indicated step 110 comprises calculating values V_F related to friction exerted between the main power-carrying conductor 11 and one or more parts of the associated current collector equipment 12 mounted on-board of the railway vehicle 2 which travels along the railway line 1 and is supplied by the power carried by the conductor 11.

[0053] According to a possible embodiment, the method 100 further comprises a step 140 of verifying if the main power-carrying conductor 11 materially extends along the railway line 1 at one or more locations corresponding to actual positions P_a tracked for the railway vehicle 2 along the railway line 1.

[0054] To this end, a database or equivalent storage unit (not illustrated) storing information about the layout of tracks

of the railway line 1 and related power system 10 can be used.

[0055] Such step 140 of verifying is advantageously carried out before generating any alarm signal and, thanks to this verification, the generation of undue alarm signals is prevented for all applications where, for whatever reason, the main power-carrying conductor 11 is not present along a section of the associated railway line 1.

[0056] For ease of illustration, in figure 1, the step 140 of verifying has been illustrated as a dotted box in the middle of and as being executed after the step 115 and/or 125.

[0057] Clearly, as those skilled in the art would readily appreciate, the step 140 can be carried out continuously, or it can be executed only when there is found that for a certain interval of time, the values calculated for the monitored parameters exceed the relevant threshold; it can be carried in parallel with or in whatever suitable order with respect to the steps preceding the generation of an alarm signal.

[0058] In one possible embodiment, the step 105 of tracking comprises recording the actual position P_a of the railway vehicle 2 at regular interval of times based on position identifiers 43, e.g. one or more balises, distributed over the railway line 1 at regular intervals, and on the actual speed of the railway vehicle 1.

[0059] For example, when a possible fault is detected at unknown point P_a , namely when calculated values of the parameters monitored exceed the relevant threshold, the specific location of a railway vehicle 2 travelling along the railway line 1 can be calculated via the following formula:

$$(1) \quad \text{ABS} ([\text{ODO_VALUE_AT_X} + \text{DELTA}] - [\text{ODO_VALUE_AT_X}]) \text{ meters}$$

where X is a point corresponding to a balise location, $[\text{ODO_VALUE_AT_X}]$ is the odometer value of the railway vehicle 1 at point X at first time interval T_1 , $[\text{ODO_VALUE_AT_X} + \text{DELTA}]$ is the odometer value of the railway vehicle 1 at a second time interval T_2 .

[0060] Correspondingly, the control system 200 illustrated in figure 2 comprises at least:

- the one or more sensors 30 adapted to provide signals related to at least a first parameter I and/or V, indicative of an actual operative status of the main power-carrying conductor 11 and to a second parameter F indicative of an actual operative status of said current collector equipment 12;
- a position tracker 40 adapted for tracking the actual position of the railway vehicle 2 travelling along the railway line 1; and
- an elaboration device 50 which is configured first to calculate, based on the signals provided via the one or more sensors 30, at least values $V_{I,V}$ related to the first parameter I and/or V, and values V_F related to the second parameter F, and then to compare the values calculated for the first parameter I, V and for the second parameter F during at least a first predetermined interval of time T_1 and a following second predetermined interval of time T_2 with a first predefined threshold $Th_{I,V}$ and a second predefined threshold Th_F , respectively and then to generate alarm for maintenance according to the result of the comparison(s) carried out.

[0061] In the system 200 according to the invention, the elaboration device 50 is further configured to generate a first alarm signal indicative of a defective part of the main power-carrying conductor 11 at least at a location corresponding to the position tracked for the railway vehicle 2 along the railway line 1 at the first interval of time T_1 , if at least the values $V_{I,V}$ calculated for the first parameter I, V during the first predetermined interval of time T_1 violate the first predefined threshold $Th_{I,V}$ while the values $V_{I,V}$ calculated for the first parameter I, V during the second predetermined interval of time T_2 respect the predefined first threshold.

[0062] In particular, the elaboration device 50 is further configured to generate the first alarm signal indicative of a defective part of the main power-carrying conductor (11) at a location corresponding to the position ($P(T_1)$) tracked for the vehicle (2) along the track (1) at said first interval of time (T_1), if the values ($V_{I,V}, V_F$) calculated for the first parameter (I, V) and respectively for the second parameter (F) during the first predetermined interval of time (T_1) violate the corresponding first predefined threshold ($Th_{I,V}$) and second predefined threshold (Th_F), while the values ($V_{I,V}, V_F$) calculated for the first parameter (I, V) and respectively for the second parameter (F) during the second predetermined interval of time (T_2) respect the corresponding first predefined threshold ($Th_{I,V}$) and second predefined threshold (Th_F).

[0063] Preferably, the elaboration device 50 of the system 200 is further configured to execute the process described on figure 1 and its steps described here-above.

[0064] An alarm signal generated can be output for example to a display unit 60, e.g. positioned on-board of the railway vehicle 2, and/or to a remote-control room.

[0065] The elaboration device 50 can be constituted by any suitable processor-based device 50, e.g. a processor of a type commercially available and suitably programmed in order to perform the functionalities it is devised for.

[0066] According to a possible embodiment, the one or more sensors 30 comprise at least a current sensor, and/or

a voltage sensor 30, or it is possible to use a combined current-voltage sensor.

[0067] The one or more sensors 30 can comprise also a friction sensor adapted for detecting the dynamic coefficient of friction at least between the main power-carrying conductor 11 and one or more parts of associated current collector equipment 12 mounted on-board of the railway vehicle 2.

[0068] For instance, such friction sensor may be constituted by any MEMS sensor commercially available and suitable for the scope of the present invention.

[0069] In turn, and according to one possible embodiment of the system 200 according to the invention, the position tracker 40 comprises for example a memory 41, or any equivalent storage unit, for storing data indicative of the location of position identifiers 43, e.g. balises, distributed along the railway line 1, and an associated detector 42 which, when the railway vehicle 2 is travelling along the line 1, detects the presence of a balise and outputs a corresponding signal to the elaboration device 50.

[0070] Hence, it is evident from the foregoing description and appended claims that the method 100, the control system 200, and the related railway vehicle 2 according to the present invention, achieve the intended aim and objects, since they allow detecting the presence of a defective part of a system powering railway vehicles timely and precisely.

[0071] In particular, according to the present invention, it is possible to discriminate whether a defective part is present on a main power-carrying conductor or any current collector associated therewith and mounted on board of a railway vehicle supplied by the power conductor.

[0072] These results are achieved according to a solution very flexible that can be applied in principle to any type of vehicles, in particular railway vehicles, supplied by external electrical lines, and for any type of current collectors used, where the margins of errors and delays in identifying the onset and location of defective parts are eliminated, or at least drastically reduced, with respect to current state of the art solutions, thus improving efficiency of maintenance and reducing service downtime.

[0073] The method 100, system 200 and vehicle 2 thus conceived are susceptible of modifications and variations, all of which are within the scope of the inventive concept as defined in particular by the appended claims; for example, some parts of the control system 200 may reside on the same electronic unit, or they can even be realized as subparts of a same component or circuit of an electronic unit, or they can be placed remotely from each other and in operative communication there between. For example, while the sensors 30 are placed on board of a vehicle, the display unit can reside in a remote-control room. The position tracker can be replaced or integrated with GPS systems where available. The indicated track 2 of the railway line 1, can be represented by a road, and the pantograph 12" or shoe-gears 12' can be represented by any suitable type of current collector mounted on board of a vehicle 2.

[0074] All the details may furthermore be replaced with technically equivalent elements.

Claims

1. A method (100) for localizing defective parts of a power system (10) suitable for supplying vehicles, said power system (10) comprising at least a main power-carrying conductor (11) extending along at least a portion of a track (1), and an associated current collector equipment (12) adapted for allowing transmission of power supply from the main power-carrying conductor (11) to a vehicle (2) travelling along said track (1), the method (100) being **characterized in that** it comprises at least the following steps:

- (105): tracking the actual position (P) of the vehicle (2) travelling along the track (1);
- (110): calculating, at least values ($V_{I,V}$) related to a first parameter (I, V) indicative of an actual operative status of the main power-carrying conductor (11) and values (V_F) related to a second parameter (F) indicative of an actual operative status of said current collector equipment (12);
- (115): comparing the values ($V_{I,V}$, V_F) calculated for the first parameter (I, V) during at least a first predetermined interval of time (T_1) and a following second predetermined interval of time (T_2) with a first predefined threshold ($Th_{i,v}$), respectively and the values calculated for the second parameter (F) during at least one of the first predetermined interval of time (T_1) and second predetermined interval of time (T_2) with a second predefined threshold (T_f); and
- (150): generating an alarm for maintenance according to the result of the comparing step (115).

2. A method (100) for localizing defective parts of a power system (10), according to claim 1, wherein said step (150) of generating an alarm for maintenance comprises a sub-step (120) wherein, if at least the values ($V_{I,V}$) calculated for the first parameter (I, V) during the first predetermined interval of time (T_1) violate the first predefined threshold ($Th_{i,v}$) while the values ($V_{I,V}$) calculated for the first parameter (I, V) during said second predetermined interval of time (T_2) respect the first predefined threshold ($Th_{i,v}$), then generating a first alarm signal indicative of a defective part of the main power-carrying conductor (11) at a location corresponding to the position (P(T_1)) tracked for the

vehicle (2) along the track (1) at said first interval of time (T_1).

3. A method (100) for localizing defective parts of a power system (10), according to claim 2, wherein said sub-step (120) comprises:

- if the values ($V_{I,V}, V_F$) calculated for the first parameter (I, V) and respectively for the second parameter (F) during the first predetermined interval of time (T_1) violate the corresponding first predefined threshold ($Th_{I,V}$) and second predefined threshold (Th_F), while the values ($V_{I,V}, V_F$) calculated for the first parameter (I, V) and respectively for the second parameter (F) during the second predetermined interval of time (T_2) respect the corresponding first predefined threshold ($Th_{I,V}$) and second predefined threshold (Th_F), then generating the first alarm signal indicative of a defective part of the main power-carrying conductor (11) at a location corresponding to the position ($P(T_1)$) tracked for the vehicle (2) along the track (1) at said first interval of time (T_1).

4. A method (100) for localizing defective parts of a power system (10), according to one or more of the previous claims, wherein said step (150) of generating an alarm for maintenance comprises the following sub-steps:

- (125): if the values ($V_{I,V}$) calculated for the first parameter (I, V) exceed the first predefined threshold ($Th_{I,V}$) during both the first and second predetermined interval of times (T_1, T_2), checking if also the values (V_F) calculated for the second parameter (F) for a first part and a second part of a same current collector (12'') or for a first and a second current collector (12') both violate or respect the corresponding second predefined threshold (Th_F) during at least one of the first and second predetermined interval of times (T_1, T_2), then

- (130): in the affirmative case, generating a second alarm signal indicative of a defective part of the main power-carrying conductor (11) at least at the location corresponding to the position tracked for the railway vehicle (2) along the railway line (1) at one of the first and second intervals of time;

- (135): or alternatively, generating a third alarm signal indicative of a defective part for one of the first part or second part of the same current collector (12'') or for one of the first and second current collectors (12').

5. A method (100) for localizing defective parts of a power system (10), according to at least one of claims 1 to 3, wherein said step (110) of calculating values ($V_{I,V}$) related to a first parameter comprises calculating at least values ($V_{I,V}$) related to at least one of the current (I) flowing along and voltage (V) of the main power-carrying conductor (11).

6. A method (100) for localizing defective parts of a power system (10), according to at least one of claims 1 to 3, wherein said step (110) of calculating values ($V_{I,V}$) related to a second parameter comprises calculating at least values (V_F) related to friction between the main power-carrying conductor (11) and one or more parts of associated current collector equipment (12) mounted on-board of the vehicle (2) travelling along the track (1).

7. A method (100) for localizing defective parts of a power system (10), according to at least one of claims 1 to 3, wherein it comprises a step (140) of verifying if the main power-carrying conductor (11) materially extends along the track (1) at one or more locations corresponding to positions (P) tracked for the vehicle (2) along the track (1).

8. A method (100) for localizing defective parts of a power system (10), according to at least one of claims 1 to 3, wherein said step (105) of tracking comprises recording the actual position (P) of the railway vehicle (2) at regular interval of times based on position identifiers (43) distributed over the railway line (1) and the actual speed of the railway vehicle (1).

9. A control system (200) for localizing defective parts of a power system (10) suitable for supplying vehicles, said power system (10) comprising at least a main power-carrying conductor (11) extending along at least a portion of a track (1), and an associated current collector equipment (12) adapted for allowing transmission of power supply from the main power-carrying conductor (11) to a vehicle (2) travelling along said track (1), the control system (200) being **characterized in that** it comprises at least:

- one or more sensors (30) adapted to provide signals related to at least a first parameter (I, V) indicative of an actual operative status of the main power-carrying conductor (11) and to a second parameter (F) indicative of an actual operative status of said current collector equipment (12);

- a position tracker (40) adapted for tracking the actual position of the vehicle (2) travelling along the track (1);

- an elaboration device (50) which is configured first to calculate, based on the signals provided via said one or more sensors (30), at least values ($V_{I,V}$) related to a first parameter (I, V) indicative of an actual operative status of the main power-carrying conductor (11) and values (V_F) related to a second parameter (F) indicative of an

actual operative status of said current collector equipment (12), and then to compare the values ($V_{I,V}$, V_F) calculated for the first parameter (I, V) during at least a first predetermined interval of time (T_1) and a following second predetermined interval of time (T_2) with a first predefined threshold ($Th_{I,V}$), respectively and the values calculated for the second parameter (F) during at least one of the first predetermined interval of time (T_1) and second predetermined interval of time (T_2) with a second predefined threshold (T_f); said elaboration device (50) being further configured to generate an alarm for maintenance according to the result of the comparison between the values ($V_{I,V}$, V_F) calculated for the first parameter (I, V) and for the second parameter (F) and the respective first predefined threshold ($Th_{I,V}$) and second predefined threshold (Th_F).

10 **10.** A railway vehicle (2), **characterized in that** it comprises, or it is adapted to interact with, a control system (200) according to claim 9.

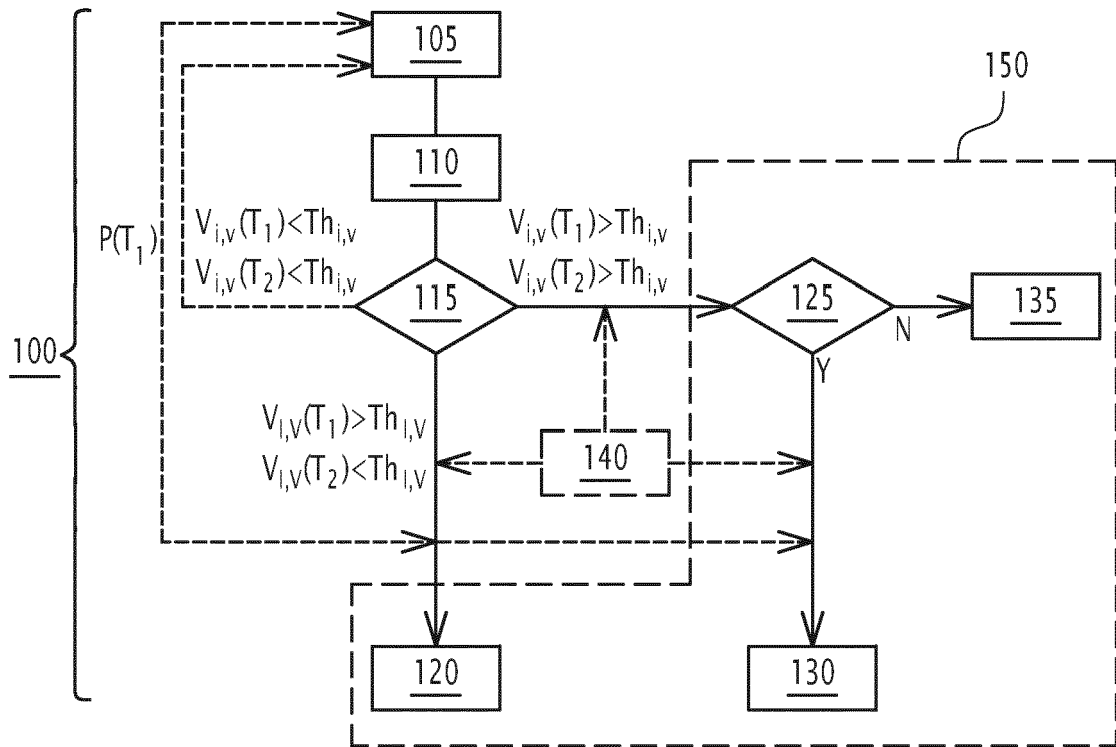


FIG. 1

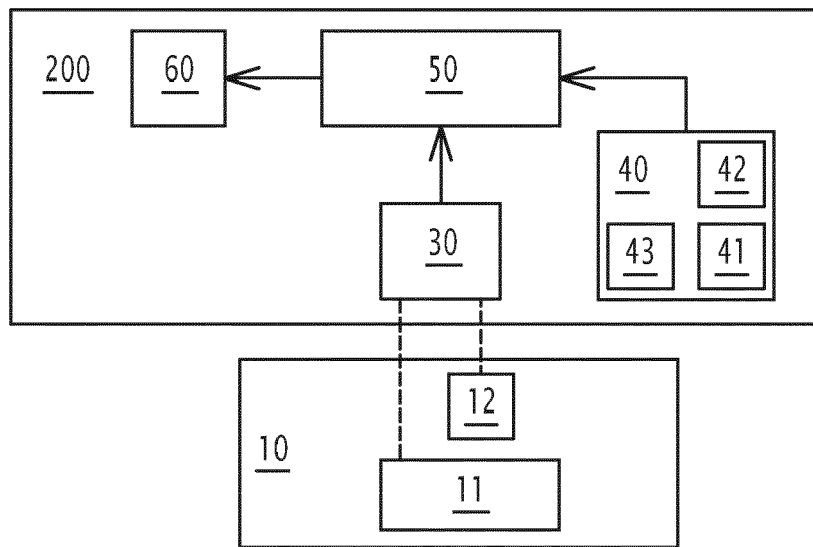


FIG. 2

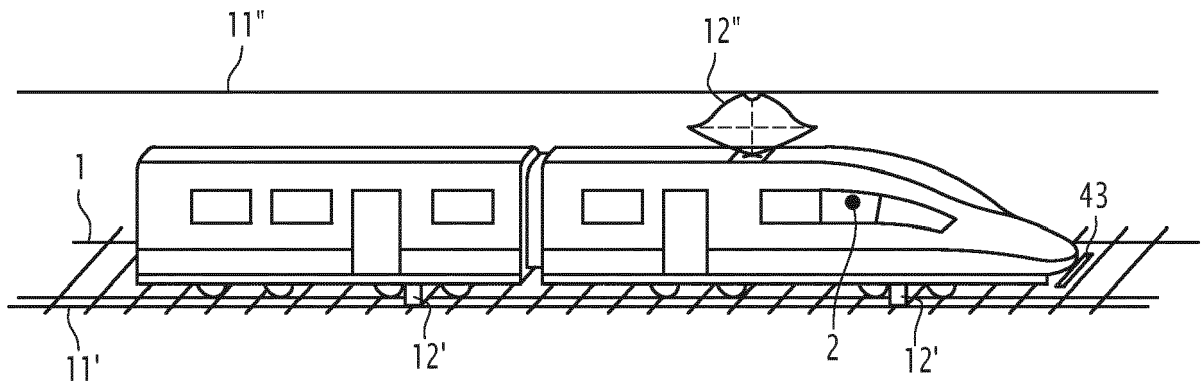


FIG.3



EUROPEAN SEARCH REPORT

Application Number
EP 20 16 6170

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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	WO 2005/044614 A1 (MORGANITE ELECT CARBON [GB]; CRAIG MARTIN [GB] ET AL.) 19 May 2005 (2005-05-19)	1-3,6-10	INV. B61L15/00
Y	* the whole document *	4,5	ADD. B61L25/02
Y	DE 10 2014 226694 A1 (SIEMENS AG [DE]) 31 December 2015 (2015-12-31) * the whole document *	4	
Y	EP 3 165 398 A1 (ALSTOM TRANSP TECH [FR]) 10 May 2017 (2017-05-10)	5	
A	* the whole document *	7	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			B61L
Place of search		Date of completion of the search	Examiner
Munich		30 August 2020	Robinson, Victoria
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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 20 16 6170

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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30-08-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2005044614 A1	19-05-2005	CN 1898103 A	17-01-2007
		EP 1678003 A1	12-07-2006
		GB 2408570 A	01-06-2005
		US 2007000744 A1	04-01-2007
		WO 2005044614 A1	19-05-2005

DE 102014226694 A1	31-12-2015	NONE	

EP 3165398 A1	10-05-2017	EP 3165398 A1	10-05-2017
		US 2017131337 A1	11-05-2017

EPO FORM P0459

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