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(54) Method and apparatus to monitor anomalies in railway and tramway superstructures

(57) Method and apparatus to monitor imperfections in rails (11), wherein a monitoring unit (13) is suitable to monitor the geometry and wear parameters both of each rail inspected and of the two rails (11) of the same track (12), a first electronic memory (55c) is suitable to memorise at least temporarily the data monitored, a second electronic memory (55a) is suitable to memorise the nominal or specification values of the geometric parameters, at least a calculator (50) is associated with the monitoring unit (13) and with the electronic memories (55c, 55a) to compare the data monitored with the nominal values, and a third memory (55b) is suitable to memorise data relating to the pre-determined tolerances of the nominal values, the calculator (50) is suitable to associate the data monitored with the data relating to the tolerances and wherein the display means (58, 59) are suitable to display the data relating to the tolerances together with the result of the comparison in order to show whether the data monitored is within or outside the pre-determined tolerances.

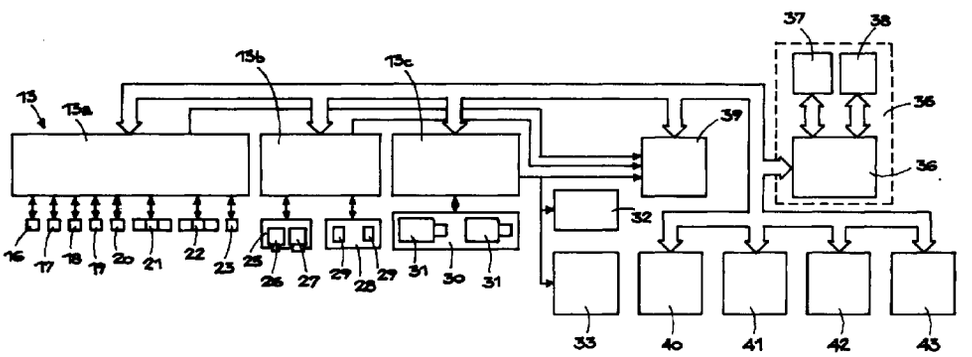

FIG. 2

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Description

FIELD OF THE INVENTION

[0001] This invention concerns a method and an apparatus to monitor anomalies in railway and tramway superstructures, as set forth in the main claims.

[0002] To be more exact, the invention refers to a method and an apparatus to analyse the real state of the superstructure of the track of a railway or tramway line, to monitor the values of a set number of parameters, geometry, wear and malfunction, and to compare them with nominal or specification values.

BACKGROUND OF THE INVENTION

[0003] The state of the art includes a machine suitable to monitor anomalies in the track, consisting of a railway or tramway rail car or motor car which can travel on the rails which have to be inspected and on which a plurality of sensors and measuring instruments are mounted.

[0004] As the rail car is made to advance along the track, at a set speed, the sensors and measuring instruments monitor, in a line and at pre-set intervals, the predefined geometric parameters, such as the skew, the camber of the two rails, the longitudinal level of the rails, the gauge, the super elevation, and also the speed and distance travelled from the starting point.

[0005] In this machine, all the data monitored is decoded and printed on board the rail car itself; therefore, when the inspection of a particular piece of track is finished, all the data collected is memorised only analogically on a paper support consisting of a continuous or tabulated sheet of paper.

[0006] This means that the data, collected over several hours, must be subsequently analysed and compared manually with the nominal values of the section of track inspected.

[0007] It is obvious that this operation of reading the data and comparing the data with the nominal, reference data, by qualified and competent personnel, takes a long time and entails considerable costs, which affects the overall costs of operating the line and therefore on the cost to the users; it also affects the times required for maintenance interventions and therefore entails a long time to restore working conditions.

[0008] Moreover, - and this is not unimportant - controlling and comparing by hand involves a risk of human error which should always be avoided, if the safety of the installations is to be improved.

[0009] This method of monitoring and comparing, moreover, does not allow to build up an archive of tables which will enable the data to be processed so as to evaluate if the temporal trend of the parameters monitored is coherent with normal wear due to progressive use or if there is an anomalous behaviour which needs to be attended to.

[0010] The state of the art also includes a machine to inspect rails in order to monitor undulatory wear. In this machine, magnetic sensors are assembled on a railway car, which can be attached to a locomotive car; the magnetic sensors monitor the variations in the level of the upper surface of the rails and indicate their deviation from a theoretical plane.

[0011] When the inspection is terminated, this machine too is able to provide the data collected only on paper and to approximate values, inasmuch as it is unknown at what point of the line the data refers to. In fact, it is necessary to monitor and process manually the length and amplitude of the wave of the undulatory wear, since there is a total lack of a data archive which would allow to make the necessary processing and maintenance operations. As seen in the previous case, this takes a long time and consequently entails the same disadvantages as explained before.

[0012] The review "Railway Gazette International", 151 (August 1995) N°. 8, Sutton, Surrey GB, discloses an apparatus able to monitor the geometric parameters of the rails, to memorise them and to process them by means of a calculator in order to compare them with the specification parameters. This article neither describes nor suggests how this apparatus is to be achieved, or how the parameters of wear, undulatory wear, and the profile of the head of the rail can be monitored and processed.

[0013] The review "Revue Generale des Chemins de Fer", (1994) May, n°. 5, Paris, FR, discloses that studies have been made on how to monitor data relating to the geometric parameters of the rails and that this data can be both processed in real time with a calculator installed on board the vehicle which is doing the monitoring, and also transferred to a disk and then subsequently processed by a land-based processor. This article also does not describe or suggest how to monitor and process the parameters of wear, undulatory wear, and the profile of the head of the rail.

[0014] The present Applicant has designed and embodied this invention to overcome these shortcomings and to obtain further advantages.

SUMMARY OF THE INVENTION

[0015] The invention is set forth and characterised in the respective main claims, while the dependent claims describe variants of the idea of the main embodiment.

[0016] The principle purpose of the invention is to achieve a method and an apparatus to monitor imperfections on the rails, the overall state of the superstructure meaning the measurement of the parameters, the wear and the malfunctions, particularly in metropolitan and tramway lines, which will provide an automatic and objective comparison of the data collected with the nominal values of the design specifications, and will give, in real time, clear and immediate indications on the imperfection monitored. The invention has elaborated a system to monitor wear on the rails - both railway and

tramway - within a framework which sequentially supplies: overall situation of the wear of the whole line; position on the line where the rails are worn; entity, type of wear and specific aspects thereof, identifying the point on the line where the imperfection is, with a maximum tolerance of one meter.

[0017] Another primary purpose of the invention is to achieve a method with an apparatus which allows to display the points where the imperfection monitored is beyond the tolerances as per the design specifications, locating them univocally and automatically in the correct segments of the line.

[0018] A further primary purpose of the invention is to achieve a method and an apparatus which will allow to know the trends of the most significant parameters, even though they are not yet outside the field of tolerance, or to know how these parameters vary in time and in what way, so as to be able to observe the various phenomena of wear and how they vary with time, and to use this information to program and optimise the maintenance operations and also the purchase of materials, according to the data acquired, with a considerable reduction in the operating costs and greater reliability and safety. In fact, until today, maintenance was carried out periodically or according to subjective evaluations, or again, when users complained, instead of according to real necessities due to the state of wear or imperfections in the rails.

[0019] A second purpose of the invention is to achieve a method and an apparatus which will allow a historic archive to be easily formed of the data monitored, in order to keep under control the situation of the lines inspected and the temporal evolution of the individual imperfections, possibly with indications of mutual correlation between the individual parameters monitored, with particular reference to the critical nature represented by vibrations and/or noise which, in the case of metropolitan lines, especially those in tunnels, are very important for the serious effects they have on buildings (theaters, churches, dwellings, etc.) which are near the metropolitan lines.

[0020] Moreover, the method and apparatus according to the invention not only supplies a system which is able to acquire an enormous quantity of technical information on the real state of the railway and tramway superstructure, it also allows to prepare plans to program maintenance and studies of innovative systems within the field of railway superstructure.

[0021] An important characteristic of this is represented by the mathematical models which are possible with the data as above, and which will allow to reproduce and simulate in the laboratory the most critical situations in terms of vibrations and noise, and find a suitable solution thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] These and other characteristics of the invention will become clear from the following description of a preferred embodiment, given as a non-restrictive example with the help of the attached drawings wherein:

- Fig. 1 is a prospective and schematic view of a rail car whereon the first part of an apparatus according to the invention is assembled;
- Fig. 2 is a block drawing of a first part of the apparatus according to the invention;
- Fig. 3 is a block drawing of the second part of the apparatus according to the invention;
- Fig. 4 is a graphical representation of some data monitored by the apparatus according to the invention;
- Fig. 5 is a graphical representation of a partial section of two rails inspected by the apparatus according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0023] With reference to the attached Figures, an apparatus 10 to monitor imperfections in the rails 11 of a railway track 12, for example a metropolitan line, comprises a monitoring device 13 assembled on a rail car 14 suitable to travel autonomously on the rails 11 to be inspected.

[0024] The device 13 (Fig. 2) comprises substantially three sections 13a, 13b, and 13c, and is electrically connected to a series of measuring instruments and of monitors of set geometrical and wear parameters, both of each rail 11 and of the track 12.

[0025] To be more exact, the section 13a of the device 13 is connected to an odometer 16 of the electronic type, suitable to accurately measure the distance travelled starting from a particular initial point, and a speedometer 17, also electronic, suitable to monitor, precisely and continuously, the speed at which the rail car 14 advances, which is also the speed at which the rails 11 are measured and inspected.

[0026] The section 13a is also connected to a clinometer 18 and two gyrometers 19 and 20, suitable to measure, in a manner known to the state of the art, the super elevation of the track 12, or its inclination in the direction perpendicular to the longitudinal, represented by the distance of one of the two wheel-surface planes of one rail 11 from the horizontal line which passes through the wheel-surface plane of the other rail 11. These instruments 18-20 also allow to monitor the skew, defined as the rate of variation in the super elevation.

[0027] To this end, the rail car 14 may also be equipped with an automatic sprayer, which is not shown in the Figures and is of a type known to the state of the art, provided with a nozzle directed towards the base of the rails 11 and commanded by an electromagnetic valve, suitable to automatically mark the rails 11 in the event that the skew should be imperfect by more than a pre-set value.

[0028] The section 13a is also connected to two series of transducers 21 and 22, assembled on the rail car 13, in order to measure the lateral alignment and the longitudinal alignment of the rails 11.

[0029] Finally, the section 13a is connected to a further transducer 23 suitable to measure the gauge, that is to say, the deviation of the real distance between the two rails 11 compared with a pre-defined standard value, for example 1435 mm.

[0030] The section 13b of the device 13 is connected to a measuring instrument 25 suitable to monitor the profile of the rails 11 so as to determine the wear thereof.

[0031] The instrument 25 comprises a laser beam sender 26 and a high resolution matrix TV camera 27. To be more exact, the laser ray 26 is expanded by means of a cylindrical optical groups provided for this purpose, and projected with a particular angle orthogonal to the rail 11. The luminous line generated by the laser 26 on the surface of the rail 11 is monitored by the matrix camera 27 which, by properly evaluating the illuminated pixels, is able to return a numerical information on the position of each individual point monitored. By properly interpolating the points monitored, the apparatus 10 is able to reconstruct the entire profile of the section monitored and can determine any coordinate within this profile.

[0032] The section 13b of the device 13 is also connected to a measuring instrument 28 which has inductive sensors suitable to monitor the wear of the rails 11 due to undulatory wear, both in terms of amplitude and in terms of wave length, in order to correlate them with the other parameters relating to the superstructure. The instrument 28 is able to acquire data on the undulatory wear with values of wave length of between 20 and 80 mm and an amplitude of between 0.001 and 1 mm.

[0033] The section 13c of the device 13 is connected to a video-inspection device 30 to inspect the track 12, comprising a plurality of colour TV cameras 31, in this case five; the colour TV cameras 31 can be selectively orientated and are equipped with motorised zoom lenses and autonomous lighting; they are suitable to film the rails 11 and to transfer the relative images to a corresponding plurality of video recorders 32 and television monitors 33. In this way the images filmed by the cameras 31 can be seen both directly by the worker, in the driver's cab of the rail car 14, and also relayed to the ground, to be subsequently analysed more deeply.

[0034] The apparatus 10 also comprises four electronic calculators 35, of which only one is shown here, which acquire and process the respective parameters (geometry, rail wear, undulatory wear, video-inspection). The calculators 35 are assembled on board the rail car 14 and are connected to the respective devices 13a, 13b, 13c and 32.

[0035] Alternatively, there may be a single electronic calculator 35, more powerful, which fulfils the functions of all four calculators.

[0036] The calculators 35 each comprise a central processing unit (CPU) 36, a Read Only Memory (ROM) 37 wherein the management programs of the device 13 are memorised, and a Random Access memory (RAM) 38. Between the sections 13a, 13b, and 13c of the device 13 and the calculator 35 there is an analog-digital converter 39, suitable to convert into digital data all the analog data arriving from the various instruments of the device 13, including the images filmed by the cameras 31, which are also digitised.

[0037] There is also connected to each calculator 35 a keyboard 40, a monitor 41, a printer 42 and a unit 43 to process a removable data support, such as a disk or a magnetic tape, an optical or magneto-optical disk, or other support, which are also assembled on board the rail car 14.

[0038] The apparatus 10 also comprises another electronic calculator 50 (Fig. 3), installed on the ground, and suitable to process the data collected by the device 13 and to compare it with the specification data of the railway line inspected.

[0039] The calculator 50 comprises a central processor unit (CPU) 51, and a ROM 52 in which the programs to process and compare the data are memorised, and a RAM 53.

[0040] The following units are connected to the calculator 50: a mass memory 55, which is suitable to memorise the specification data of the different railway lines of the network to be inspected and also the historic data of the different inspections already made; a unit 56 to process a removable data support, similar to the unit 43, in such a way that the data recorded by the unit 43 can be read by the unit 56; a mouse 54, a keyboard 57, a printer 58 and a display unit 59.

[0041] The mass memory 55 contains a first database 55a, into which all the specification data of the line is inserted, that is, according to the progressive quota (measured in metres) the points are indicated wherein there are straight parts, bends, sidings, switch points, stations (start, end, middle).

[0042] The memory 55 also contains a second database 55b into which the data relating to the tolerances is inserted. To be more exact, for each specification datum and for each point of the line the tolerances are indicated which, as far as the geometric parameters are concerned, are fixed by the national and international norms, while for wear and undulatory wear the tolerances are usually fixed according to safety and maintenance criteria established by the Company which owns or manages the network.

[0043] To be more exact, for undulatory wear, a limit is established above which the maintenance intervention is carried out; this limit is chosen according to a series of factors such as: the level of vibration and acoustic disturbance produced when there is this kind of wear (this can also be monitored by the Company which owns or manages the network) and the consequent disturbance for residents; and the cost of the grinding oper-

ations and their frequency to maintain the desired level of quality.

[0044] The memory 55 also comprises a section 55c where the data monitored during the dynamic phase is memorised, and that is the seven geometric parameters, the wear of the head and the undulatory wear, and also the speed of the rail car 14 which is doing the monitoring.

[0045] According to a characteristic feature of the invention, the calculator 50 is able to process the data monitored and memorised in the memory 55c, associating it and comparing it with the characteristics of the theoretical line (data contained in the database 55a) and, according to the type of line and the datum desired, with the data of the relative tolerances (data contained in the database 55b).

[0046] The method to monitor the imperfections in the rails 11, according to the invention, comprises first of all a first step wherein all the specification data relating to the railway line or lines which make up the network which is to be inspected with the apparatus 10 according to the invention is memorised in the first database 55a.

[0047] The specification data is organized in purely linear sequential systems, each one codified and corresponding to a branch of line and on each branch a progressive system of quotas is defined, equal to the distance in meters from a conventional point of origin.

[0048] The specification data is defined in terms of contiguous elementary segments (elements). The types of elements which may be included are the straight line, the connecting curve, the circular arc, the switch points and the stations (start, end, middle).

[0049] For each meter of track 12 therefore, all the necessary data is memorized relating to the geometric parameters both of the track 12 and also of the individual rails 11 which form it.

[0050] The calculator 50 is able to display or print at any moment, on request from the worker, any specification data memorized in the memory 55a.

[0051] Then, all the values relating to the tolerances associated with the specification values are memorized in the second database 55b. To be more exact, for each specification value there may be defined different tolerances, which determine consequent thresholds, for example, warning, intervention advised, danger or obligatory intervention.

[0052] There then follows the inspection step proper, wherein the rails 11 of a track 12 are inspected. To do this the rail car 14, the device 13 and the on-board calculator 35 are used.

[0053] The initial monitoring point of the track 12 to be inspected is determined, and the numerical code identifying said point is introduced into the on-board calculator 35, by means of the key board 40. The numerical code comprises the line code, the code of the branch travelled, the progressive quota, the identification of the odd/even track, and the direction of travel.

[0054] The device 13 is activated, so that all the instruments 16-31 are operational, and then the rail car 14 is made to advance; its instantaneous speed is controlled by the speedometer 17, in order to allow all the instruments 16-31 to operate correctly.

[0055] As the rail car 14 advances, the instruments monitor the geometrical data of the rails 11 and the track 12, and also the data relating to the state of wear of each rail 11.

[0056] As the data is monitored, it is instantaneously associated with the distance travelled from the initial monitoring point. To do this, the data supplied by the odometer 16 is used, even if this instrument could be replaced by, or integrated with, a monitoring system associated with fixed markers.

[0057] During the inspection step, the data monitored by the instruments of the device 13 is sent instantaneously to the analog-digital converter 39 which, after converting it to digital data, transfers it to the on-board calculator 35.

[0058] The on-board calculator 35 is programmed to be able to display on the display unit 41 and also to print with the printer 42, on the worker's command, the data just monitored.

[0059] This data, according to a characteristic of the invention, is also memorised by the unit 43 on a removable support, such as for example a magnetic disk.

[0060] As an operating choice, and so as not to have to memorise an enormous quantity of information, the data monitored, depending on the scanning resolution, is reduced before being memorised and, in a certain sense, concentrated according to a memorisation resolution, pre-defined, equal to one datum (for each parameter) for every meter of track 12 inspected.

[0061] The section 13a thus supplies the data on the seven properly geometric parameters: the camber of both lines of rails 11, and therefore their lateral and longitudinal alignment, the super elevation, the skew and the gauge of the track 12.

[0062] The section 13b supplies data on the wear of each of the rails 11, and also the data relating to the imperfection caused by undulatory wear. To be more exact, as described above, this monitoring is made by means of the laser beam sender 26 and the matrix camera 27 of the measuring instrument 25.

[0063] With regard to the video-inspection of the track 12, this is carried out by means of the TV cameras 31, which send the images both to the video-recorder unit 32, and to the television monitor 33 and also to the analog-digital converter 39.

[0064] In any case, the images of the film taken during the inspection can be seen live on the monitor 33 and are also recorded, for example on VHS videocassettes, in analog and/or digital form, so that they can be seen again later, so that the images recorded can be printed, and that the prints may be accompanied by a brief comment.

[0065] At the end of the inspection step proper, the

data collected and memorised on the removable support is transferred to the calculator on the ground 50.

[0066] Once the calculator 50 has acquired the data, it is able to do any processing operation thereof. The data monitored is codified, catalogued and memorised in such a way that it can be compared with the specification data memorised in the database 55a and respectively 55b, or with other data monitored previously.

[0067] Thus it is possible to form several data archives, concerning for example: the structural data of the line and its superstructure; data relating to wear, with particular reference to undulatory wear (amplitude and length of wave, limit values accepted in each zone, differentiation by chord) and the wear on the profile of the rails (date of monitoring, limit values and differentiation by chord); data relating to the maintenance of the line, such as the grinding of the rails (date of last grinding, number of passes performed, quantity removed, date of future grinding), reinforcement of the bed, change of iron and the maintenance of switch points (for each, the date of previous and future interventions).

[0068] The calculator 50 is also able to display on the monitor 59, for any segment of track 12 inspected, both the geometric parameters and the values of wear monitored, representing them graphically and comparing them with the specification values and those relating to the allowed tolerances. In order to make them more evident, those values which are outside the tolerance limits can also be shown or with more or less bold lines, or flashing, or in a different colour, as green, orange, red and blue, in accordance with the value of the considered parameter.

[0069] Associated with each graphical representation all the data relating to the line and the type of track inspected can also be displayed automatically: number, section, starting point, length, type of rail, position of the pointer, comment (rectilinear, right curve or left curve) date and time, maximum, minimum and average wear, maximum, minimum and average tolerance, and so on.

[0070] Moreover, the calculator 50 is able to print each image displayed on the monitor 59, by means of the printer 58.

[0071] Fig. 4 shows an example of this graphical representation, relating to the monitoring of wear made by the measuring instrument 25, wherein it is clear that for the left rail, shown by the line 70 in the upper part of the graph, the profile is all inside the limits of tolerance, which in this particular example is shown by the straight line 71 at -6 mm, while for the right rail, represented by the line 80 in the lower part of the graph, the profile is for a certain part, that further to the right, between the linear distance 2006 m and 2129 m, outside the limit of tolerance of -6 mm, or below the straight line 71, with points actually below the straight line 72, which represents the quota of -9 mm and near the straight line 73 which represents the quota of -12 mm. The straight lines 74 and 75, which represent the quotas of -15 and respectively of -20 mm, are never, in this case, reached.

[0072] The calculator 50 is also able to represent the section of any point of the rails 11, so as to compare it with the specification value. By means of the keyboard 57 or the mouse 54, it is possible, with the help of a movable pointer 63, to choose any point, for example the point identified by the vertical segment 60 shown in Fig. 4, and to have the profile of the two rails 11 represented at that point, as shown in Fig. 5. To be more exact, the profiles 61 are the nominal ones of the design specifications, while the profiles 62 are the real ones, monitored with the device 13.

[0073] By automatically comparing the values memorised in the section 55c with those memorised in the databases 55a and 55b, it is possible to obtain, with the calculator 50, the following information relating to wear and undulatory wear: a summary of the quality of the situation of the whole line, by plotting a band which assumes the different colors from green to orange, red and blue, according to the values assumed by the parameter considered and by how much this exceeds the band of values of established tolerances (blue shows the worst situation): this first graph shows the presence along the whole line, in one video screen only, of sections characterised by anomalies and the seriousness thereof. By clicking on the interesting points on this band, we obtain the graph of the values assumed by the parameter considered.

[0074] During this step, by choosing a point on the graph and clicking with the mouse 54, we can know the exact position (line, track, section, curve or straight, progressive quota) of the point and the precise value of the parameter considered.

[0075] If the value is outside the tolerances, the corresponding section of graph assumes a red, orange or blue color, depending on how much the value is outside the band of pre-set values.

[0076] To monitor wear, it is also possible, by double-clicking on the interesting points, to obtain the profile monitored of the head of the rails, compared with the norm.

[0077] With regard to wear, it is also possible to automatically compare two files of data monitored on different dates.

[0078] When this option is used, the two graphs are superimposed and the comparison stops automatically at all those points where the discrepancy between the two graphs exceeds a previously set value.

[0079] That is to say, we have an automatic identification of all those points on the line which have most significantly altered over the same interval of time considered.

[0080] It is possible on each occasion to choose what variation of the value considered is significant for the survey being done.

[0081] Also for the geometric parameters of the rails 11 and the track 12 it is possible to make a comparison between the data of two files registered on different dates. In this case, the data of each file is represented

with colored bands, one for each file, and by comparing the colors we know the trend of the parameter observed.

[0082] There is also the possibility of representing the values of the parameters not only in the form of a linear graph, but also with bars.

[0083] This kind of representation, using bars, can be made by sub-dividing the line into significant segments, for example, to observe the trend of a certain parameter on the straight sections, or on all the bends with a radius included between different radii of curvature.

[0084] Moreover, all the functions listed here, which are available for monitoring both wear and undulatory wear, can also be extended to monitoring the geometry; vice versa, what has been done for the geometry can be reproduced in the same way for monitoring wear and undulatory wear.

[0085] The system also allows: the activation of the same functions for all the parameters recorded, the simultaneous representation of different information, the filing of data suitable to study the phenomena and to construct mathematical models which allow to know the evolution of the phenomena as time passes, in such a manner as to optimise maintenance and provide useful information for a better design of new installations, and also to implement the technical information with economic and management information.

[0086] These possibilities just shown are just some of those that the calculator 50 is able to supply and manage; it will not be difficult for a person of skill in the art to program the calculator 50 so as to obtain therefrom any other type of processing operation, starting from the specification data memorised in the database 55a and 55b and using the data monitored by the device 13.

[0087] It is evident that it is possible to make modifications and/or additions to the apparatus and the method to monitor imperfections in rails as described so far, and still remain within the scope of the invention.

[0088] For example, the data monitored by the on-board calculator or calculators 35 can be transmitted live to the calculator on the ground 50 which will first memorise and then process the data.

[0089] Moreover, a single calculator could be used to manage the devices on board the rail car and also the peripheral devices installed on the ground; also, each of the electronic calculators could be of the portable type.

Claims

1. Apparatus to monitor imperfections in rails (11), comprising monitoring means (13) suitable to monitor the geometry and wear parameters both of each rail inspected and of the two rails (11) of the same track (12), an analog-digital converter (39) suitable to convert the values monitored by the monitoring means (13) into digital data, a first electronic memory (55c) suitable to memorise at least temporarily the digital data, a second electronic memory (55a) suitable to memorise the nominal or specification values of the geometric parameters, processing means (50) associated with the monitoring means (13) and with the first and second electronic memory (55c, 55a) to compare the digital data with the nominal values and display means (58, 59) to selectively display the result of the comparison, the apparatus being characterised in that a third memory (55b) is provided to memorise data relating to the pre-determined tolerances of the nominal values and in that the processing means (50) are suitable to associate the digital data with the data relating to the tolerances and in that the display means (58, 59) are suitable to display the data relating to the tolerances together with the result of the comparison in order to show whether any of the digital data is within or outside the predetermined tolerances.

2. Apparatus as in Claim 1, characterised in that the second memory comprises a first database (55a) and that the third memory comprises a second database (55b).

3. Apparatus as in Claim 2, characterised in that the first database (55a), the second database (55b) and the first electronic memory (55c) are contained in a mass memory (55) connected to the processing means (50).

4. Apparatus as in Claim 3, wherein the monitoring means (13) are assembled on a movable means (14) suitable to move on the track (12) to be inspected, and wherein the processing means comprise a first electronic calculator (35) installed on the movable means (14), characterised in that the processing means comprise a second electronic calculator (50) connected to the mass memory (55), there being included means to transfer the digital data from the first to the second electronic calculator.

5. Apparatus as in Claim 4, wherein the first electronic calculator (35) is connected to a unit (43) to record, on a removable support, the digital data output from the converter (39), characterised in that the second electronic calculator (50) is connected to a unit (56) to read the digital data memorised on the removable support.

6. Apparatus as in Claim 1, characterised in that the processing means (50) are suitable to print, by means of printing means (58) connected thereto, each of the images displayed on the display means (59).

7. Apparatus as in Claim 1, characterised in that the monitoring means (13) comprise means (30, 31) for

the video-inspection of the rails (11), connected to means suitable to reproduce, live or relayed, the corresponding images, including the possibility of printing the recorded images and accompanying the printed images with a brief commentary.

8. Apparatus as in Claim 1, characterised in that the monitoring means (13) comprise means (25) to monitor the wear of each rail (11), that in the said third memory (55b) different, pre-determined levels of tolerance associated with the wear on the rails (11) are memorised and that the display means (58, 59) are suitable to display all the different levels of tolerance associated with the wear on the rails (11).

9. Apparatus as in Claim 8, characterised in that the display means (58, 59) are suitable to show in a differentiated manner the digital data included in each of the different fields defined by the different levels of tolerance associated with the wear on the rails (11).

10. Apparatus as in Claim 9, characterised in that the display means (58, 59) are suitable to show the digital data included in the said different fields with a different color.

11. Apparatus as in Claim 1, characterised in that movable pointer means (54) are provided in association with the display means (58, 59) to click on each of the digital data displayed and to cause the visual display of the cross section of the rail (11) at the corresponding point of its nominal profile, using the data memorised in the second electronic memory (55a), and also of its real profile, using the data memorised in the first electronic memory (55c).

12. Method to monitor imperfections in rails (11), comprising a step to monitor the geometry and wear parameters both of each rail inspected by monitoring means (13), the conversion into digital data of the values monitored by the monitoring means (13), the at least temporary memorisation in a first electronic memory (55c) of the said digital data, the memorisation in a second electronic memory (55a) of the said nominal or specification values of the geometric parameters, the comparison by processing means (50) of the said digital data and the said nominal values and the selective display by display means (58, 59) of the result of this comparison, the method being characterised in that data relating to the pre-determined tolerances of the said nominal values are memorised in a third memory (55b) associated with the processing means (50) and that the display means (58, 59) selectively display the said data relating to the tolerances together with the result of the comparison so as to show whether any of the said digital data is within or outside the said pre-determined tolerances.

13. Method as in Claim 12, characterised in that the second memory comprises a first database (55a), that the third memory comprises a second database (55b), and that the first database (55a), the second database (55b) and the first electronic memory (55c) are contained in a mass memory (55) connected to the processing means (50).

14. Method as in Claim 12, wherein the monitoring means (13) are assembled on a movable means (14) suitable to move on the track (12) to be inspected, and wherein the processing means comprise a first electronic calculator (35) installed on the movable means (14), characterised in that the processing means comprise a second electronic calculator (50) connected to the electronic memories (55a, 55b, 55c), and that the digital data are transferred from the first to the second electronic calculator (35, 50).

15. Method as in Claim 12, wherein the digital data is memorised on a removable support, characterised in that the second electronic calculator (50) is connected to a unit (56) to read the digital data memorised on the removable support.

16. Method as in Claim 12, characterised in that each of the images displayed on the display means (59) is selectively printed, by means of printing means (58) connected to the processing means.

17. Method as in Claim 12, characterised in that the monitoring means (13) comprise means (30, 31) for the video-inspection of the rails (11), connected to means suitable to reproduce, live or relayed, the corresponding images, and possibly to print them.

18. Method as in Claim 12, characterised in that the monitoring means (13) comprise means (25) to monitor the wear of each rail (11), that in the said third memory (55b) different, pre-determined levels of tolerance associated with the wear on the rails (11) are memorised and that the display means (58, 59) are suitable to display all the different levels of tolerance associated with the wear on the rails (11).

19. Method as in Claim 18, characterised in that the display means (58, 59) are suitable to show in a differentiated manner the digital data included in each of the different fields defined by the different levels of tolerance associated with the wear on the rails (11).

20. Method as in Claim 19, characterised in that the display means (58, 59) are suitable to show the digital data included in the said different fields with a

different color.

21. Method as in Claim 12, characterised in that movable pointer means (54) are provided in association with the display means (58, 59) to click on each of the digital data displayed and to cause the visual display of the cross section of the rail (11) at the corresponding point of its nominal profile, using the data memorised in the second electronic memory (55a), and also of its real profile, using the data memorised in the first electronic memory (55c).

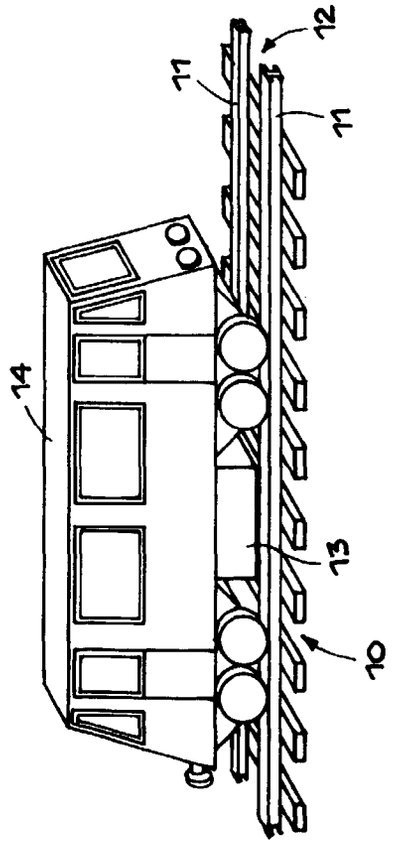
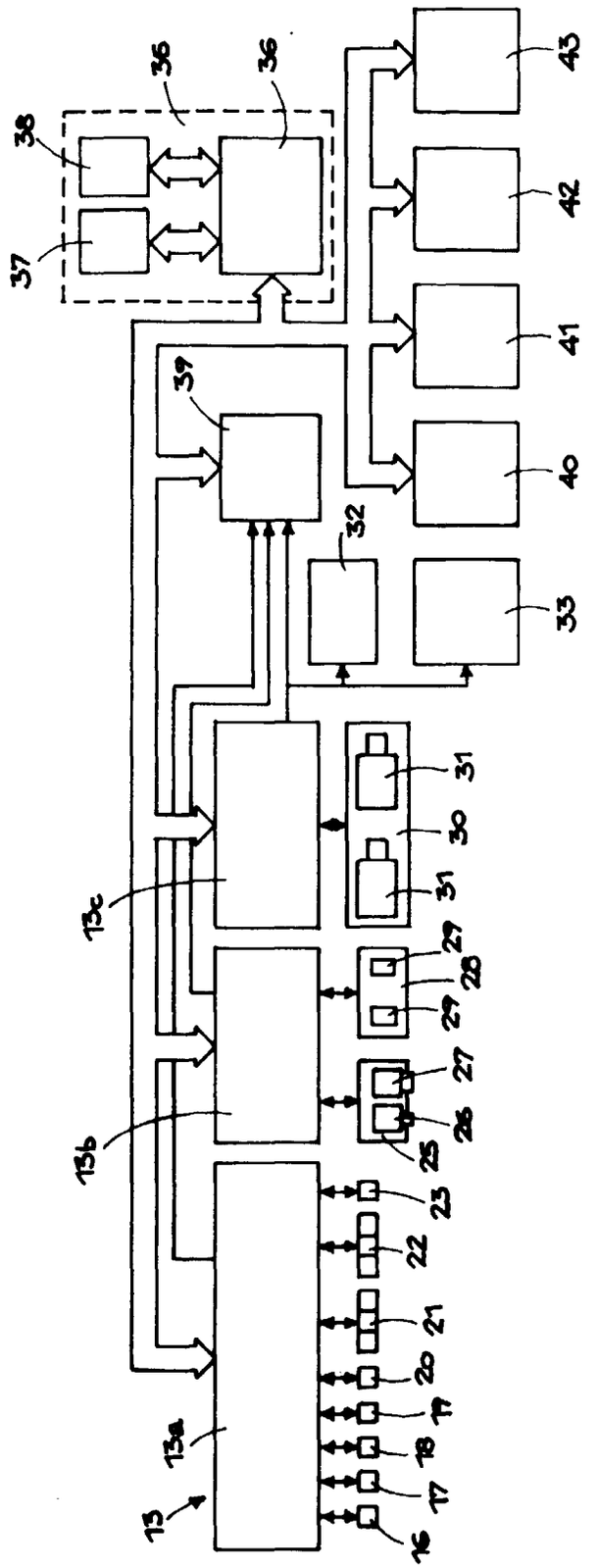

12
11
11
14
13
10

FIG. 1


36
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40
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33
31
30
31
13c
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28
27
13b
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26
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23
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19
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17
16
13a
13

FIG. 2

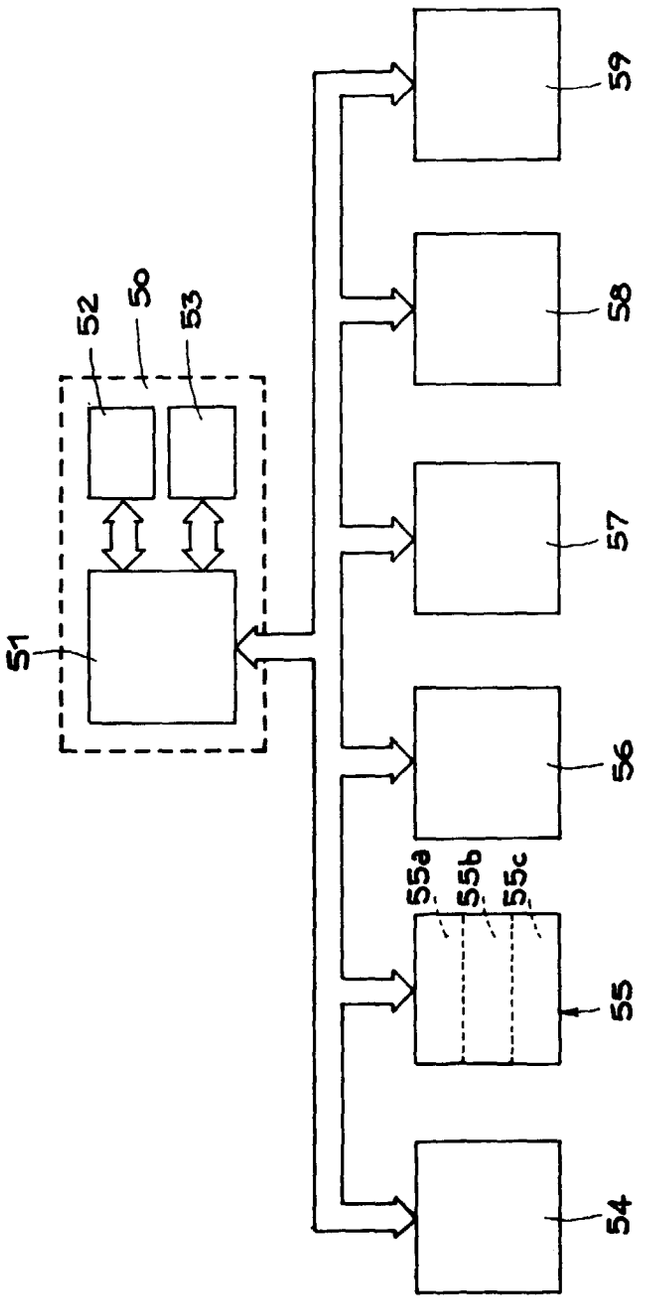

FIG. 3

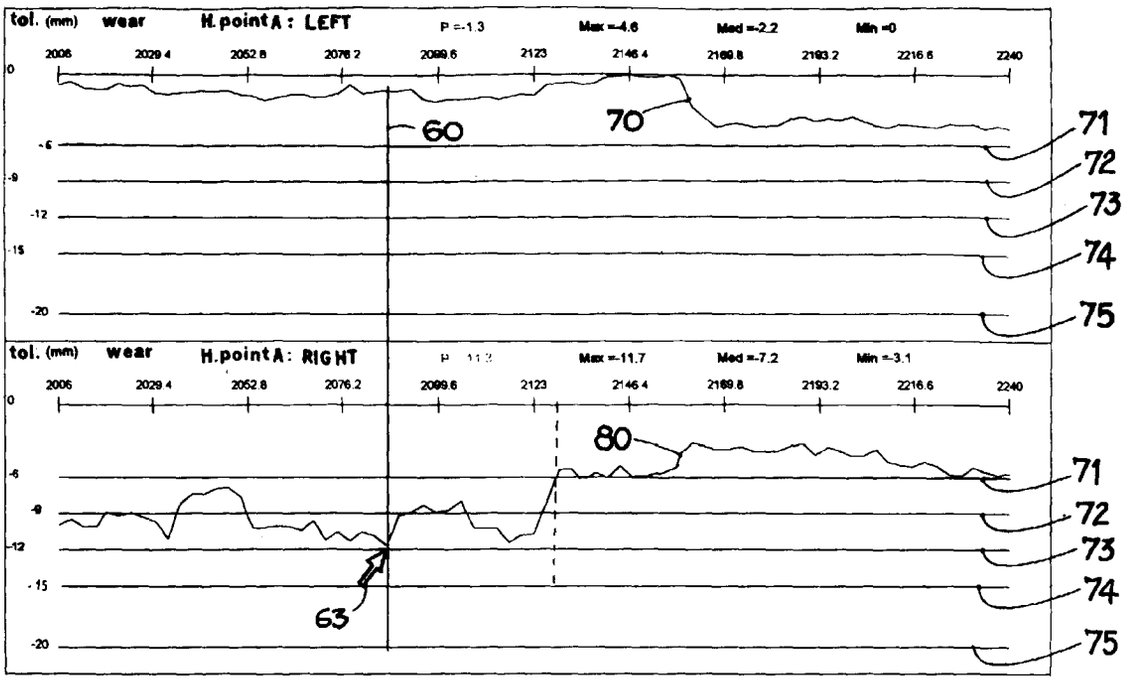
tol. (mm) wear H.point A : LEFT
Max =-4.6
Med =-2.2
Min =0
2006
2029.4
2052.8
2076.2
2099.6
2123
2146.4
2169.8
2193.2
2216.6
2240
0
-6
-9
-12
-15
-20
60
70
71
72
73
74
75
tol. (mm) wear H.point A : RIGHT
Max =-11.7
Med =-7.2
Min =-3.1
80
63

FIG. 4

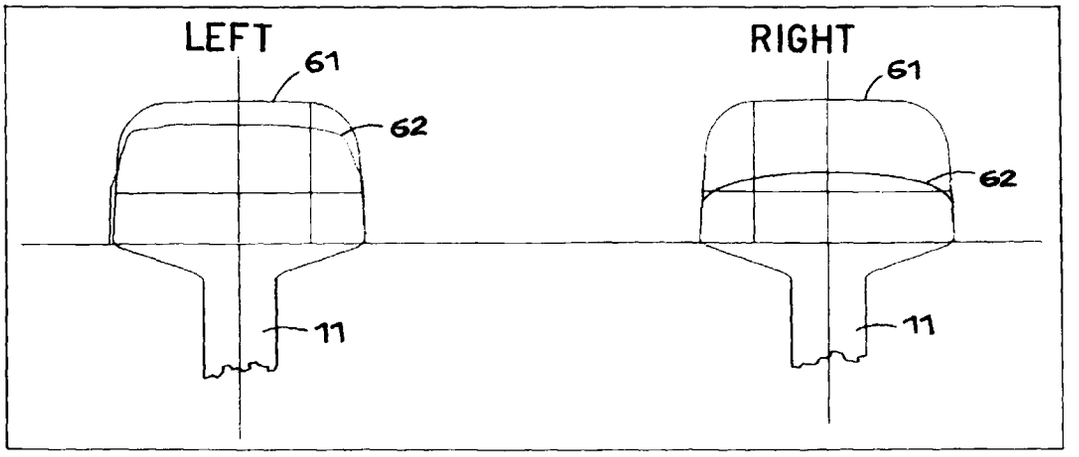
LEFT
RIGHT
61
62
11

FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 99 10 7267

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A,D	RAILWAY GAZETTE INTERNATIONAL, vol. 151, no. 8, August 1995 (1995-08), pages 507-509, XP000524875 SUTTON,GB * the whole document *	1,12	B61K9/08
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A	US 3 924 461 A (STOVER HARRIS A) 9 December 1975 (1975-12-09) * column 2, line 4 - column 4, line 16; figures 1-14 *	1,12	
A	WO 96 00159 A (GROENSKOV LEIF) 4 January 1996 (1996-01-04) * page 6, line 33 - page 9, line 28; figures 1-4 *	1,12	TECHNICAL FIELDS SEARCHED (Int.Cl.6) B61K G01B E01B
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	27 July 1999	Chlosta, P

CATEGORY OF CITED DOCUMENTS

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