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(71) Applicant: **Alpha Caesar Srl**
**20131 Milano (IT)**

(72) Inventors:
- **Stoppini, Lorenzo**
  **06121 Perugia (PG) (IT)**
- **Maestroni, Valentina**
  **20010 Pregnana Milanese (MI) (IT)**
- **Cassano, Mauro**
  **20131 Milano (MI) (IT)**

(74) Representative: **Serravalle, Marco**
**Serravalle SAS**
**Via G. Matteotti, 21/23**
**26854 Cornegliano Laudense (LO) (IT)**

# (54) RADIO ELECTRO-MECHANICAL AUTOMATIC SYSTEM FOR DIRECT MEASUREMENT OF INTERNAL TENSION AND TEMPERATURE OF THE CONTINUOUSLY WELDED RAIL, DURING THERMAL REGULATION OPERATION OF RAIL, AND FOR THE ISSUE OF THE RELATED CERTIFICATE OF REGULAR EXECUTION OF CORRECT REGULATION

(57) The present invention is directed to a radio-electro-mechanical automatic system for the thermal regulation of the continuously welded rails, comprising at least 12 sensors for the direct measurement of the tensions inside the rails. The measurement of the tensions occurs preferably by load cells/sensors equipped with strain gages which are installed in the cell according to the electric scheme of a Wheatstone bridge, and the strain gages are preferably based on the Bragg filaments fiber technology.

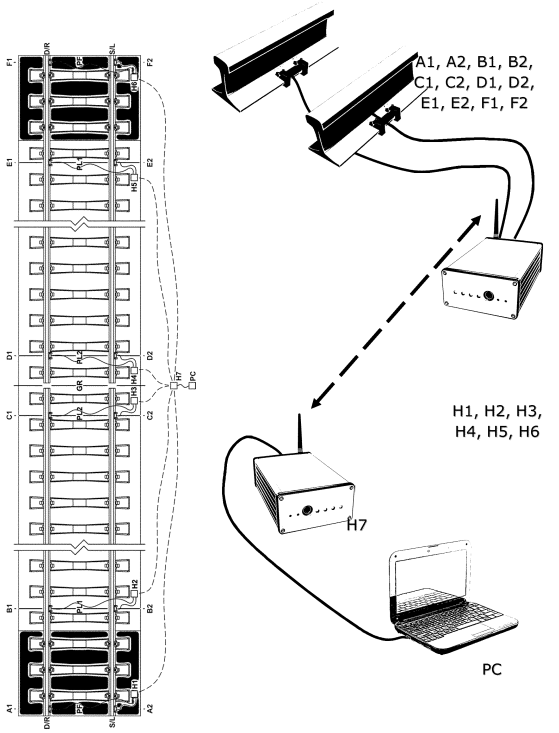
The system is composed by several electronic and electro-mechanics equipment belonging to three separate functional groups:

1) Measurement equipment,

2) Equipment of first processing and transmission of measurement data,

3) Equipment of final data processing and issue of regular execution certificate.

The system can automatically release, in the end, a document certifying the exact internal tensional condition of the rail and the accuracy of the thermal regulation, reporting exact information on tensional condition of the rails at the end of the stretching operations.

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## Description

### STATE OF THE ART

**[0001]** . Currently, rail technology is based on the use of the rail made up by a continuously welded rail (CWR); this consists of a unique rail, of undefined length, obtained by welding (alumino-thermic or flash welding) of rail elements of determined length.

**[0002]** . In order to guarantee that values of stress inside the rail, due to the thermal changes of the same, endure in whichever temperature condition inside a predefined allowable range, it is necessary to arrange for so called rail thermal regulation operations. These operations make use of specific rail stressor clamp, put together between two semi-sections to be calibrated in position by the joint of regulation.

**[0003]** . Through the rail stressor clamp, a tension is imposed to both the semi-sections, generating to their interior a tractive effort output of suitable value, calculated considering the thermal gap between the real rail temperature and the so called Regulation Temperature. The latter represents rail temperature to which the tensional state of the same has to result void. This temperature value is calculated with reference to the average, on several years, between maximal and minimum temperatures reached by the rails and considering the speed of said railway line.

**[0004]** . Currently regulation of rails is done by imposing by the rail stressor a tension to the semi-section of the rail. Elongations are recorded by visually monitoring on intermediate quarts the position of specific marks traced by chalk on the sleepers of the rails.

**[0005]** . Due to the imprecision of naked-eye evaluation, the operator cannot identify with a good precision the moment when the stress made by the rail stressor clamp has to stop.

**[0006]** . It has to be pointed out that said rail regulation procedure does not include the automatic issue of any document certifying the right execution of the measurement: the accuracy of regulation operations is committed to competence and technical skills of the involved operators, without the possibility of verifying during either the working steps and later the real stretch condition of the rail.

**[0007]** . Recently, to verify the internal stretch condition of rails, the Company Net Tech Srl, disclosed a non-visual system to determine elongation, which makes use of electronic resistive position transducer (ITPV20040001).

### SCOPE OF THE INVENTION

**[0008]** . The technical object of the present invention, is the provision of a reliable rails regulation method not subjected to human error. Said method also offers the benefit to be able to issue a certificate upon the end of control procedure. The method is based on the direct measurement of internal rail tensional stress conditions using precision instruments. In this way it is possible to minimize measurement imprecisions, erasing evaluation errors due to operators visual perception.

**[0009]** . The system object of the present invention, once applied to the at least twelve predetermined rail points, supplies in continuous exact values of internal stress traction induced by rail stressors to rails. Thanks to this peculiarity, it is possible to interrupt the stress on both semi-sections exactly on reaching the suitable internal tensional condition.

**[0010]** . The system can automatically release, in the end, a document certifying the exact internal tensional condition of the rail and the accuracy of the thermal regulation, reporting exact information on tensional condition of the rails at the end of the stretching operations.

### DETAILED DESCRIPTION OF THE INVENTION

**[0011]** . The invention object of the present application is a system composed by several electronic and electromechanics equipment belonging to three separate functional groups:

1) Measurement equipment (Fig. 1 - section A),

2) Equipment of first processing and transmission of measurement data (Fig. 1 - Section B),

3) Equipment of final data processing and issue of regular execution certificate (Fig. 1 - Section C).

**[0012]** . Measurement equipment consist of at least twelve electro-mechanical sensors (stress/compression or torsion/cut, bend-type load cells) equipped of strain gages, installed as an electrical scheme of a Wheatstone bridge, or by an equal number of optical extensometers based on Bragg's filament fiber technology.

**[0013]** . Above mentioned sensors, commonly called charge cells, are present in at least 12 unities (Fig. 2 - A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1, F2) being 12 for wheel-track (6 for each rail) the minimum number required to guarantee the right functioning of the invention.

**[0014]** . In order to measure that the tensional stress of a rail free to move smoothly is homogeneously distributed along the rail, it would be enough to measure the tension in the cells on both its ends; eight cells would be needed (two for all the four rails semi-sections). For best practice, it is important to measure also the stress in four singular points, called fix points of the four rail semi-sections; on these four fixed points the internal stress to be measured has to be always zero, along all the regulation process.

**[0015]** . The possibility of using a larger number of cells (though not less than 3 for each of the four rail semi-sections to be regulated) it's not excluded, depending on the discretization around the results of power stress required by the Authority of the rail infrastructure.

**[0016]** . In the above mentioned standard configuration (Fig. 2 - left side) it is considered the need of measuring the stress status of two rails of the same track (4 rail semi-section) hence sensors, for each rail semi-section (following the most common rail rules relating to thermal regulation of the CWR), has to be placed respectively corresponding to the four fixed points (Fig. 2 - PF), of the first 4 moving points (Fig. 2 - PL1) and to the 4 heads of rail semi-sections (Fig. 2 - PL2) corresponding to the 2 regulation joints (Fig. 2 - GR).

**[0017]** . The fixing method of the sensor is entirely mechanic and is done, preferably, through a joint friction created between the sleeper of the rail and the sensor or through another appropriate fixing system. The obtained joint friction is made through appropriate mechanical clamping. Said fixing method allows to made in-built the sensors application points to the rail sleeper without damaging or disturbing the structure of the rail or of the track.

**[0018]** . Installed sensors, properly fed by a low voltage direct current, would release, upon the change of rails internal tensional status, a mV tension variable together with the tensional status. Said tension, properly amplified through a signal conditioner (either analogic or digital) will be sent via cable to the first elaboration and measurement data transmission machine.

**[0019]** . In one preferred embodiment, the sensors installed along the rail (Fig. 2 - A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1, F2) are connected via cable in couples (one for right rail and one for left rail), to the first elaboration and data transmission apparatuses (one for each couple) (Fig. 2 - H1, H2, H3, H4, H5, H6) composed by a container, e.g. a PVC or metal one (minimum degree of protection to water and dusts IP65), inside which the following described electronics apparatuses are installed. Preferably the container will have properly shaped holes to allow the fixing of two panel connectors for the wiring of cables coming from the sensors, a panel switch activating a status led allowing the switching-on of the electronic apparatuses and then the feeding of the sensors, a panel connector for bipolar jack plug allowing the recharge from outside of the inside container battery, a USB panel connector allowing the connection between the electronic apparatuses and a PC during the system periodic maintenance operations, one high gain antenna allowing the long length data transmission, preferably via radio.

**[0020]** . In this preferred embodiment, electronic apparatuses inside the container include a rechargeable battery of proper amperage, preferably allowing an autonomy of at least 8 hours, an electronic circuitry with micro-controller able to receive sensors' amplified stress or related Digit through analogic or digital doors. Signals, codified for the identification of every single cell, are converted in a numeric value and sent through a serial communication to a second electronic circuitry which will take care of data transmission, either via cable or via ether, to final data elaboration apparatuses.

**[0021]** . Again, as for this preferred embodiment, the final data elaboration and final certification issue apparatuses (Fig. 2 - H7) are composed by a container, preferably a PVC or metal one (minimum degree of protection to water and dusts IP65), inside which the electronic apparatuses described here below are installed. The container will have properly shaped holes to allow the fixing of one USB panel connector allowing the connection between electronic apparatuses and a PC (Fig. 2 - PC), one high gain antenna to allow long distance data receiving.

**[0022]** . Preferably, electronic apparatuses inside the container include an electronic circuitry which takes care of data reception from apparatuses placed on those twelve points above described and placed along the rail. Data are then transferred preferably via USB cable to a laptop to be elaborated through a proper dedicated software.

**[0023]** . In the illustrated embodiment, the data elaboration software has been properly studied to elaborate all data received by sensors, parameterize and verify them upon specific technics effective in matter of rail thermal regulation issued by the Authority of the rail infrastructure.

**[0024]** . Particularly, the software will collect all basic information needed for filling the final prospect of the regular execution certificate, will check data sent by sensors and will verify the accuracy of rails regulation operations. With the aim of facilitating the comprehension and give the operator a general and precise outline of the situation, the interface shows markers (one for each sensor) visualizing in real time rails tensional stress status.

**[0025]** . In the end, results of the completed thermal regulation are showed and the certification form of the completed execution of thermal regulation is saved as a non-modifying electronic output. Once memorized in a specific directory located into pc's hard disk, the file is available for the operator to be printed and signed.

**[0026]** . One more encrypted file , saved on a hidden directory, containing all input data, of both process and output, is available for infrastructure's manager in case of further verifications of the made work.

**[0027]** . Via radio communication can make use of any commonly used protocol. In the present invention it is preferably used a transfer protocol based on standard IEEE802.15.4, in order to guarantee the possibility of creation of a WPAN (Wireless Personal Area Network). The used transmission protocol works into radio frequencies reserved for industrial, scientific and medical aims (ISM), e.g. 868 Mhz in Europe, 915 Mhz in the USA and 2,4 Ghz for larger part of the rest of the world.

**[0028]** . Low transfer rate and low energy consumption required by the system allow to create through this type of protocol transmission a Wireless Mesh Network inside which Final Transmitters (transmission apparatuses of the sensors) get a two way dialogue with the Coordinator Receiver connected to pc.

**[0029]** . In the following, just as an example and in no way limiting the scope of the claims, there are described

in details operations that are made by the operators using a standard configuration of the invention, for a classical rail thermal regulation along the line. It is reiterated that the following described configuration is not the only possible one.

**[0030]** . During the preparation phase of the rail, track operators set the rails free from sleepers joints. Then the system operator clamps measurement apparatuses A1, A2, B1, B2, C1, C2, D1, D2, E1, E2, F1, F2 in position by points PF, PL1 e PL2. Later, measurement apparatuses are connected via cable to transmission apparatuses H1, H2, H3, H4, H5, H6 which are fed.

**[0031]** . At a later stage, apparatus H7 is connected to a PC and both are fed.

**[0032]** . While waiting for the start of rail stress operation, the system will be completely reset via software in order to delete possible old measurement values made by measurement apparatuses during clamping operations.

**[0033]** . Later on, during the rail stress operation the rails tensional state is revealed and monitored.

**[0034]** . Once the desired stress point is reached, the stress of the jack is blocked, reached tensions are registered and rail thermal regulation regular execution is certified.

**[0035]** . In support of the description of this patent, two drawings are provided.

**[0036]** . Fig. 1 represents a functional scheme of the invention giving a line on different types of apparatuses for use in the invention.

**[0037]** . Inside the left box, marked A, the Measurement Apparatuses are represented.

**[0038]** . Inside the central box, marked B, the Equipment of First Elaboration and Survey data Transmission are represented.

**[0039]** . Inside the right box, marked C, the Apparatuses of Final Data Elaboration and the Issuing of the Regular Execution Certificate are represented.

**[0040]** . Continuous lines connecting section A and section B apparatuses suggest that communication between them is made via cable, but is not excluded the possibility that said transmission could be made via radio.

**[0041]** . Dotted lines, arrow ended on both sides, connecting the apparatuses of Section B one another with section C ones, suggest that communication between these apparatuses takes place via radio in a two way mode, creating a mesh of data, not excluding that said communication could take place via-cable.

**[0042]** . Continuous lines connecting one another section C apparatuses suggest that communication between these apparatuses takes place via cable not excluding that said communication could take place via radio.

**[0043]** . The number of the represented apparatuses is not binding: in configurations for use with the invention a higher or lower number of apparatuses can be used as appropriate.

**[0044]** . Fig. 2 represents an implementation scheme of the invention in its standard configuration.

**[0045]** . On left side is represented the apparatuses positioning along the rail, and particularly:

- Apparatuses A1, A2, F1 and F2 corresponding to the fixed points PF, connected via cable/radio to apparatuses H1 and H6;
- Apparatuses B1, B2 E1 and E2, corresponding to the First Free Points PL1, connected via cable/radio to apparatuses H2 e H5;
- Apparatuses C1, C2, D1 and D2 corresponding to the Second Free Points PL2 (around the regulation jack GR), connected via cable/radio to apparatuses H3 and H4;
- Apparatuses H1, H2, H3, H4, H5, H6 are connected via radio/cable to apparatuses H7;
- Apparatuses H7 are connected via cable/radio to PC apparatuses.

**[0046]** . On the right side of the figure a simulation of said implementation scheme is represented for a better understanding of apparatuses communication methods.

## Claims

1. Radio-electro-mechanical automatic system for the thermal regulation of the continuously welded rails, comprising at least 12 sensors for the direct measurement of the tensions inside the rails.
2. System according to claim 1 wherein the tensions measurement occurs by load cells/sensors equipped with strain gages which are installed in the cell according to the electric scheme of a Wheatstone bridge.
3. System according to claim 2 wherein the Wheatstone bridge is selected from a whole Wheatstone bridge, a half Wheatstone bridge and a quarter of a Wheatstone bridge.
4. System according to claims 2-3 wherein the strain gages are selected from the following types:

   traction and compression, flexion, torsion and cut.
5. System according to claim 1 wherein the tensions measurement occurs by the use of optical strain gages based on the Bragg filaments fiber technology.
6. System according to claims 1-5 further comprising the temperatures measurement by sensors equipped with strain gages which are installed ac-

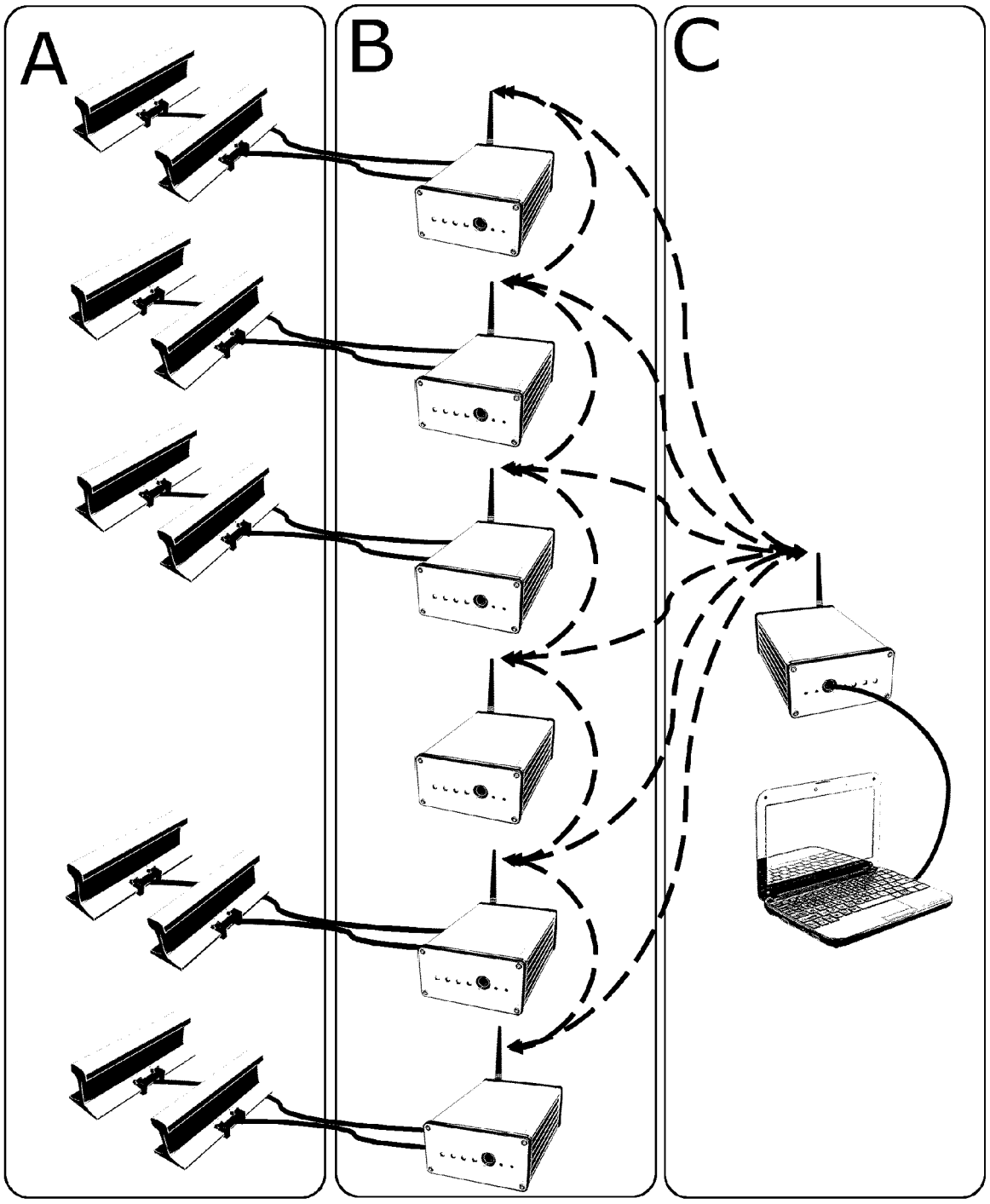
cording to the electric scheme of a Wheatstone bridge.

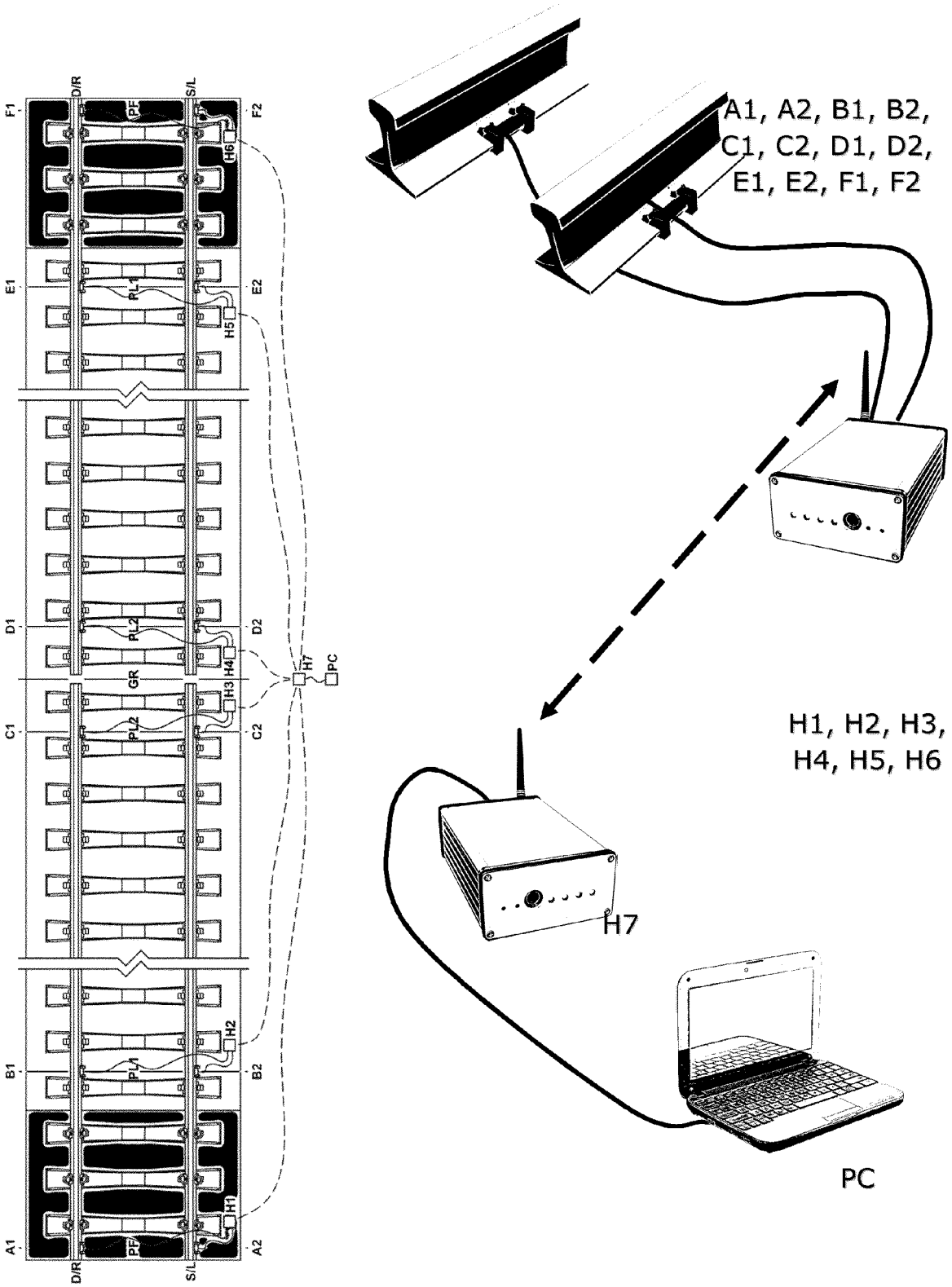
**7.** System according to claims 1-6 further comprising data transmission from sensors to a first processing equipment, and the transmission from the first processing equipment to a final processing equipment.

**8.** System according to claim 7 wherein the data transmission from first processing equipment to final processing equipment occurs by radio, preferably at a wavelength selected from microwave, short wave, medium wave and long wave.

**9.** System according to claims 7-8 wherein the first processing equipment are analog or digital signal amplifiers/conditioners and they amplify the signal in mV received by sensors.

**10.** System according to claim 9 wherein the final processing equipment manage a dedicated software, develop and verify all the received data and issue a certificate of regular execution of the performed thermal regulation of the rails.


A
B
C


A1, A2, B1, B2,
C1, C2, D1, D2,
E1, E2, F1, F2
H1, H2, H3,
H4, H5, H6
H7
PC
F1
F2
E1
E2
D1
D2
C1
C2
B1
B2
A1
A2
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PL1
PL2
GR
H1
H2
H3
H4
H5
H6
H7
PC

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# EUROPEAN SEARCH REPORT

Application Number
EP 15 16 9088

## 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<br>Y | US 2007/044566 A1 (HARRISON HAROLD [US])<br>1 March 2007 (2007-03-01)<br>* paragraph [0012] - paragraph [0013] *<br>* paragraph [0029] - paragraph [0033] *<br>* paragraph [0038] - paragraph [0039] *<br>* paragraph [0051] - paragraph [0056] *<br>* figures 1,2,7 *<br>----- | 1-4,6-10<br>5 | INV.<br>B61L23/04 |
| Y | US 2005/205718 A1 (TSAI JOHN C [US])<br>22 September 2005 (2005-09-22)<br>* paragraph [0005] *<br>* paragraph [0038] *<br>----- | 5 | |

TECHNICAL FIELDS SEARCHED (IPC)

B61L

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| Munich | 5 October 2015 | Janhsen, Axel |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 15 16 9088

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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05-10-2015

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
|---|---|---|---|
| US 2007044566 A1 | 01-03-2007 | AT 528192 T | 15-10-2011 |
| | | AU 2007231641 A1 | 08-05-2008 |
| | | CA 2607634 A1 | 24-04-2008 |
| | | CN 101229814 A | 30-07-2008 |
| | | DK 1918172 T3 | 09-01-2012 |
| | | EP 1918172 A1 | 07-05-2008 |
| | | ES 2374948 T3 | 23-02-2012 |
| | | HK 1116146 A1 | 27-07-2012 |
| | | JP 5410669 B2 | 05-02-2014 |
| | | JP 2008106603 A | 08-05-2008 |
| | | US 2007044566 A1 | 01-03-2007 |
| US 2005205718 A1 | 22-09-2005 | US 2005205718 A1 | 22-09-2005 |
| | | WO 2006112959 A2 | 26-10-2006 |

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