(19) Europäisches Patentamt / European Patent Office / Office européen des brevets

(11) EP 3 141 449 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
02.07.2025 Bulletin 2025/27

(21) Application number: **16166281.2**

(22) Date of filing: **20.04.2016**

(51) International Patent Classification (IPC):
B61L 23/00 *(2006.01)* ***B61L 23/04*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
B61L 23/045; B61L 23/047

(54) **RAIL PROFILE MONITORING, E.G. GEOMETRY OF THE FROGS**

SCHIENENPROFILÜBERWACHUNG, Z. B. GEOMETRIE DER WEICHENHERZSTÜCKE

SURVEILLANCE DE PROFIL DE RAIL, PAR EXEMPLE GÉOMÉTRIE DES GRENOUILLES

(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

(30) Priority: **20.04.2015 NL 2014681**

(43) Date of publication of application:
15.03.2017 Bulletin 2017/11

(73) Proprietors:
- **Goldschmidt Holding GmbH
04109 Leipzig (DE)**
- **Przedsiebiorstwo Uslugowo-Techniczne
GRAW Sp. z o.o.
44-100 Gliwice (PL)**

(72) Inventor: **Jagtenberg, Hans
4131 NJ Vianen (NL)**

(56) References cited:
EP-A1- 1 391 690
WO-A1-01/86227
WO-A1-2012/161759
US-A1- 2002 024 677

EP 3 141 449 B1

Description

BACKGROUND

[0001] This invention relates to an apparatus and method for monitoring wear and deformation of a turnout (also called switch and crossing) of a railway or tramway line.

[0002] Prior art is e.g. provided by DE19510560A1, SE515091C2, WO2008146151A2, DE102010019618A1 and EP2165915. These prior art documents also explain the principle of triangulation and light sectioning measurement.

[0003] Prior art document WO 1/86227 A1 discloses a method for measuring track geometry using multiple lasers and cameras spaced along the length of the rail to render the measurements insensitive to oscillations of the measuring vehicle.

[0004] The wear or deformation of a turnout is rather irregular and typically concentrates on particular locations, such as the stock rails, wing rails, check rails, point blades, frog and crossing.

[0005] Laser measurement systems, e.g. measuring distance or a profile of e.g. the rail head or different track component, such as triangulation sensors (one dimension measurement) or light sectioning sensors (a two dimensional extension of the laser triangulation method, thus a two dimensional measurement), offer an accuracy in the range of several micrometers at a bandwidth of 10 kHz or even higher. Their speed is therefore sufficient to measure from moving platforms (e.g. a measuring train), but it is difficult or often impossible to guide the platform with a precision comparable to the measurement accuracy. To compensate this uncertainty of the relative position of the measurement system, from practice there is known to apply an acceleration sensor to establish a virtual reference line for the value measured. A typical example known from prior art practice is the corrugation measurement of the rail head with a spectral accuracy better than 10 mu m from a running train superimposed to a vertical movement of about 10 mm.

[0006] During measurement, the vehicle speed is preferably at least 40 or 60 km/h.

[0007] A rail profile monitoring system, e.g. using a laser measurement system, is designed to measure the rail profile e.g. for high speed lines, but also for conventional and metro lines. In all cases top performances and accuracies must be guaranteed, e.g. by use of a CMOS or CCD camera system able to acquire up to 500 frames/sec or even higher rates at high resolution. The camera could e.g. be of profile or area type.

[0008] Sunlight interference and blooming effects preferably need be removed, e.g. by one or more protection systems (camera technology, pulsed laser and camera acquisition synchronized, interferential filters and software filters). The main object of the monitoring system is to give integrated indications to the track maintenance responsible for planning the interventions for the short and long term. The system preferably is able to detect and quantify all the key WEAR PARAMETERS describing the qualitative status of the infrastructure (vertical wear, transversal wear, multi-point wear, gauge).

[0009] By application of data analysis and comparison procedures, it becomes possible to optimize track maintenance plans, periodically checking and keeping under control rail degradation due to mechanical wear.

[0010] Laser light is an example of an optically coherent radiation beam. The camera is an example of a light receiving unit for monitoring the focusing projection of the radiation beam on the object of interest and converts the radiation, reflected by the object, received on a measurement surface in the receiving unit into electrical signals which are entered into the connected computer. Typically a lens, e.g. Fresnel lens, is located between the object ad the camera for focusing the radiation from the object on the measurement surface of the camera.

GEOMETRY OF THE FROGS

[0011] An object of the invention is one or more of the following: a further improvement in an attempt to sufficiently eliminate the interference of the horizontal and/or vertical oscillating movement (caused by i.a. the fact that the railway track is not perfectly straight, however in stead undulates) of the measuring train, carrying the measuring system, with the measurement results; to measure the wear or deformation of the turnout; to measure parameters of a frog of a turnout of a railway track without any mechanical contact with the frog and without the need to use mechanical centring devices; to acquire information relating to the actual profile of the frog, its degree of wear and its vertical and transverse deformation; to be able to accurately locate the location of the measurements, particularly relative to a reference point; to effect the measurements while insensitive to oscillation and deformation of the vehicle on which the apparatus is mounted; to obtain desired results from measurements in real time; to be able to conduct the measurements at a high velocity of at least 10 or 20 km/hr of the measuring train.

[0012] This object is obtained by the invention such that the inaccuracy of a rail profile measurement is less than 0.1 millimeter.

[0013] The invention concerns a method for geometry measurement of the frog of a turnout of a railway track as defined in claim 1.

[0014] The invention concerns a method designed to provide one or more of the following: emit by its light sources five or more light beams, designed to be projected as spaced or overlapping light points or lines or spots onto an object of interest; at least a number and preferably substantially all of these light beams are emitted such that during advancement of the measuring train these light beams are projected successively onto the same area of the object and/or their light lines successively cover the same area of the object; during train advancement the light beams and/or their light lines move along the object, one behind the other; the light beams are substantially simultaneously projected onto the object; light lines are provided by five or more light beams; the object of interest is of the railway track, specifically a frog preferably simultaneously detect these projections by a plurality of cameras; the data from these cameras is entered into a computer connected to and common to these cameras; the computer determines from this data a correction factor which is dependent from the horizontal and/or vertical oscillating movement of the measuring train and which correction factor is applied to computer calculations for a geometric feature of interest of the measured track object or an associated track object.

[0015] The five light lines are applied in a pattern including one or more of the following (in the following "light line" also means "light point" or "light spot") : spaced in longitudinal direction of the object, e.g. rail; close spacing between two adjacent light lines at least 10 millimeter and not more than 50 millimeter, e.g. approximately 30 millimeter or a single sample distance; wide spacing between two adjacent light lines at least 400 millimeter and not more than 800 millimeter, e.g. approximately 600 millimeter; spacing between the two outermost light not more than 1400 millimeter, e.g. approximately 1200 millimeter; a light line approximately centrally between two other light lines; two light lines with close spacing, separated from the other light lines by at least the wide spacing; two sets, each of two light lines with close spacing, preferably wherein these two sets are mutually separated by at least the wide spacing; a light line separated from the other light lines by at least the wide spacing; the at least five spaced light lines are present as two sets (which light lines could be named "reference light lines") and one individual light line (which could be named "accuracy light line").

[0016] A light line could include two or more light lines (e.g. each created by an individual light emitter, e.g. laser) which are exactly or virtually exactly mutually overlapping or precisely registered such that they are detected by the associated sensor as a single line. This is the case for the accuracy light line. In an alternative for such "double" light line the individual light lines could be spaced longitudinally or differ in frequency to avoid interference, e.g. as disclosed in EP2485010.

[0017] The light lines are associated with a sensor, two light lines having the close spacing are associated with a single sensor, such that the sensor (a camera) simultaneously detects both light lines, obviously wherein these light lines are projected at the light detecting part (e.g. the light sensitive matrix) of the sensor at different locations such that they are detected separately and can be discriminated by the sensor.

[0018] The width of a light line (as measured in longitudinal direction of the rail) is preferably smaller than 20 or 10 or 5 millimeter and/or is substantially constant along its length. The light line has preferably a green or red color.

[0019] The optical axis of the imaging device, including a, preferably flat, light detection element, makes a fixed angle (preferably at least 10 and/or not more than 50 degrees, e.g. approximately 30 degrees) relative to the emitting direction of the associated laser device while the imaging device and the associated laser device have mutually fixed locations.

AS PART OF TRACK GEOMETRY MEASURING SYSTEM

[0020] Prior art is e.g. disclosed in EP2485010 and EP2165915, the disclosures of which is enclosed herein by reference.

[0021] A light line could be associated with two or more sensors (e.g. each being a profile camera), according to the invention this is the light line for which the wide spacing with all the other light lines applies and this accuracy light line is provided by at least two light emitters, e.g. lasers.

[0022] The accuracy light line is associated with a group of two or three or four cameras such that in an embodiment the accuracy light line projected on a stock or running or different rail is simultaneously scanned by a group of at least two or three or four cameras. Thus the apparatus is provided with four cameras (two groups of two each) or even eight cameras (two groups of four each) in a preferred embodiment, to simultaneously monitor the accuracy light line projected on both opposite rails of the same track.

[0023] Preferably at least one or at least two cameras are located at both sides of the associated rail and monitor said rail obliquely from above. Preferably the location transverse to the longitudinal direction of the rail and/or the angle of inclination of the optical axis of the cameras at the same side of the associated rail mutually differs, preferably by at least 10 or 20 millimeter and 10 or 20 degrees, respectively.

[0024] Preferably the field of vision of a camera has overlapping edges with the field of vision of an adjacent camera. More preferably, the field of vision of a camera has only partly overlap, preferably not more than 20% or 50% overlap, with the field of vision of an adjacent camera at the same (one) side of the associated running or stock or different rail; (and/)or the field of vision of a camera has substantially complete overlap with the field of vision of an adjacent camera at the same (other) side of the associated running or stock or different rail.

[0025] Preferably the cameras associated with the one or other running or stock rail provide a common field of vision such that simultaneously the head of the stock or running rail and associated point blade or check rail or wing rail over its complete top and complete sides and a part of the stock or running rail and associated point blade or check rail or wing rail at least 30 or 50 millimeter below the top of the head, such as part of the foot at the bottom of the relevant rail, are scanned. For the point blade this applies preferably both in its position bearing against the stock rail and its position moved to a maximum distance from the stock rail.

[0026] The cameras are preferably connected directly to the frame grabber boards of the measurement computer. In this way images are acquired that are used to calculate the rail profile, particularly of the head and fragments of foot and web. The distance between a vision module and the relevant rail measures between 50 and 750 millimeter, particularly between 200 and 400 millimeter.

[0027] Preferably one or more of the following applies: Each emitter and receiver is dedicated to a single rail; each emitter and receiver has a fixed optical axis; each emitter and receiver is supported by or suspended from a bogy or different part of the measuring train.

[0028] Based on the measured rail profiles, one or more of the following parameters can also be calculated: rail head wear (vertical, horizontal, wear angle); slope of rails; track gauge; guiding rail groove width; width of the crossing nose groove; guiding width; groove width between the switch blade and the reaction rail. In the crossing of a switch there is a relationship between the frog, wing rail and checkrail, which can also be checked by the invention by measuring the gauge.

[0029] In addition, preferably one or more of the following applies: part of a system or method for measuring a rail profile by optical triangulation through optical detection systems operating by optical triangulation and moving along the rail at a movement speed, comprising respective, preferably pairs, of light emitting devices, e.g. lasers, and optical reading devices, e.g. camera's, including the steps of moving said optical detection systems along said rail at a movement speed, and lighting, preferably opposite, sides of the rail through the respective light emitting lasers, for projecting against said sides respective light spots adapted to generate respective optically detectable, preferably semi, profiles, preferably combinable, to obtain a measurement of the profile of a section of the rail, and detecting said semi-profiles through the respective optical reading devices; comprising a correcting system configured for measuring spatial variations of an optical detection system by optical triangulation with respect to the object, e.g. rail, wherein correcting the spatial position of at least one of the semi-profiles of a side through the values of the measured shifts through the correcting system; comprising cameras which operate by reading the image rows in a synchronous manner; the system comprises means configured for implementing the method; triangulation also means light sectioning.

ADDITIONAL ASPECTS

[0030] The measuring device is arranged on a measuring train travelling on or along the track; the device includes essentially a light emitting device adapted to emit a light blade onto a plane which could be substantially orthogonal to the longitudinal axis of the rail; Further, preferably one or more of the following applies: an acquisition device adapted to acquire an image containing a light row or light line generated by the intersection between the light blade and the rail; a processing module adapted to process the light line contained in the image to determine, according to the light line itself, a value correlated to the dimension of the rail; the light emitting device is arranged on the vehicle so as to be positioned over the rail and includes, e.g., a laser emitter and preferably an optical focusing assembly including a series of prisms and focusing lenses properly positioned and oriented with respect to the laser emitter to transform the focused beam into the light blade; the optical focusing assembly is capable of transforming the focused beam into the light blade having an opening angle between 20 degrees and 120 degrees so as to be able to intersect the external surface of the rail and define the light line on the external surface of the rail; the acquisition device is supported by the vehicle in a side position with respect to the emitting device so as to be arranged over the rail facing the light blade and includes a video camera or camera adapted to acquire the image of the light line projected on the rail, so as to provide in a digital format to the processing module; the processing module may include a central processing unit, e.g. a microprocessor, which is adapted to process the light line to obtain a profile measurement from part of the rail head; and a memory module for e.g. storage of data obtained from the camera or look up data, e.g. reference data; the monitoring device includes a device adapted to detect the geographic position of the detecting vehicle instant-by-instant, so as to identify, on the basis of the determined geographic position, the section of track on which the vehicle is travelling; this could include a GPS receiver (or a similar wireless operating positioning system) and/or an odometer or shaft encoder, and a memory containing, for each position, the data related to the corresponding track and to the particulars at the track; the method includes: emitting the light blade with an angular opening so as to intersect the rail head; acquiring the image containing the light line generated by the intersection of the light blade on the track; processing the image containing the light line so as to determine a feature of interest, e.g. the rail head profile and its position relative to the detecting vehicle; the method includes extrapolating the external contour of the rail head from the plurality of at least five light lines spaced along the track and provided by a plurality, e.g. equal number of laser devices; comparing this extrapolated contour and a sample contour stored in the memory module; if there is a difference between these two contours, calculating a correction factor from this difference and correcting the extrapolated contour by the correction factor.

[0031] Also, preferably one or more of the following applies: the control module is configured for actuating the laser emitters to emit the laser radiation kept switched on by each laser emitter for a time of exposure which determines the lighting of a section of length of the object; a laser emitter-camera pair obtains an image of a semi-profile for a period of exposure; the one emitter switches off before another emitter switches on, e.g. they switch alternating, or they switch simultaneous; a digital camera; a camera which operates at a high speed (normally greater than 400 frames per second); a camera operates to read all the image rows in a synchronous manner; a camera speed of acquisition of 700 images per second, processing 500 rows per image, for example using an FCAM DMA camera; emitters adapted to produce beams at the same wavelength; semiconductor lasers; the period of exposure varies between 0.2 and 3 milliseconds; CMOS or CCD camera; laser power between 4 and 40W;

EXAMPLE

[0032] A non-limiting, preferred embodiment is shown in the drawing.

Figure 1 shows in sectional view along line I - I of fig. 3 the Track Geometry Measuring System in combination with the rails 1 - 4 of the turnout. This TGMS contains two groups of four cameras (vision modules) 11 - 14 and 15 - 18, respectively, each group being assigned to the left or right side of the turnout. Of each group, two vision modules 11, 12 and 17, 18, respectively, are located to the outer side, directed obliquely downwards and two vision modules 13, 14 and 15, 16, respectively, are located to the inner side of the associated rail 1 and 2, respectively, and are oppositely oriented and directed obliquely downwards. Laser sources are shown by 5 and 7, the other two laser sources directed to the opposite object side are not visible. In an alternative the TGMS contains two groups of two vision modules, each group being assigned to the objects 1,3 or 2,4, for each group the one vision module directed to the one and the other to the opposite side of the object 1,3 or 2,4. Camera and associated laser source preferably operate according to the principle of triangulation or light sectioning measurement.

Fig. 2 illustrates the main parts of a turnout: (switch) point blades 21, tie bar 22, toe 23, heel 24, stock rails 25, check rails 26, crossing 27, wing rails 28 and running rails 29.

Fig. 3 illustrates the location of the five laser lines, mutually spaced in longitudinal rail direction. Two pairs 31 have small mutual spacing. Each pair 31 has wide spacing with the other pair and with the single line 32. The single line 32 has wide spacing with all other lines. The single line is located centrally between the pairs 31. The two pairs are spaced by 1.20 meter, the lines of a pair are spaced by 30 millimetre, which is equal to the distance covered by the train moving at 60 km/h during the time elapse between two subsequent samples at a sampling rate of 500 samples/minute.

Fig. 4 illustrates an alternative to fig. 3: a pair 31 is located centrally between the other pair 31 and the single line 32.

Fig. 3 + 4 show the system suspended from a bogy of the measuring train.

Fig. 5 shows the projection of a pair of mutually closely spaced laser lines onto the rail head, created by a dedicated light blade, while a single camera 17 receives the reflection from the rail head onto its CCD matrix.

Fig. 6 shows the image provided by the camera 17, as visible on a computer display screen.

Fig. 7 shows two alternative manners how light lines can be projected onto the rail from both its sides.

[0033] Thus, the invention provides a method for the contact less dynamic recording of the profile of a frog of a turnout to determine its condition, such as wear or deformation, comprising at least five light beams from e.g. a laser device are projected onto an area of the rail facing the opposite rail. Preferably the laser device is moved along the rail and the light reflected from said area of the rail is focused onto a flat light detection element of an imaging device of which the optical axis makes a fixed angle relative to the emitting direction of the laser device while the imaging device and the laser device have mutually fixed locations such that the signal coming from the light detection element is processed in a computer processor on the basis of a triangulation procedure or light sectioning procedure to detect the distance between the imaging device and the rail, the signal from preferably at least two, three or four vision modules, which preferably form a single or virtually single projection plane directed onto the rail, is applied, means for correcting the spatial position of a measured object profile through the values of a track measuring system shift measuring means.

Claims

1. Method for geometry measurement of the frog of a turnout of a railway track, by using a measuring train carrying optical means measuring the frog, wherein a correction factor is determined by the use of the optical means measuring the railway track frog and said correction factor is dependent from the horizontal and/or vertical oscillating movement of the measuring train during measuring of the railway track frog and which correction factor is applied to computer calculations for a geometric feature of interest of the measured railway track frog, wherein the optical means comprise light sources of the measuring train which provide emitting of five or more light beams such that during advancement of the measuring train these light beams are projected successively onto the same area of a rail of a railway track and the light beams are substantially simultaneously projected onto the rail which light beams provide onto the rail light lines in a pattern providing at least five spaced light lines, which are present as two sets, and one individual light line, wherein the light lines that are provided onto the rail by the light beams are spaced in longitudinal direction of the rail according to the following: close spacing between two adjacent light lines at least 10 millimeter and not more than 50 millimeter, e.g. approximately 30 millimeter; wide spacing between two adjacent light lines at least 400 millimeter and not more than 800 millimeter, e.g. approximately 600 millimeter; spacing between the two outermost light lines not more than 1400 millimeter, e.g. approximately 1200 millimeter and applying:

one light line approximately centrally between two other light lines;
two of the light lines with close spacing, separated from the other light lines by at least the wide spacing;
the two sets, each of two light lines having the close spacing, wherein these two sets are mutually separated by at least the wide spacing; and
the individual light line separated from the other light lines by at least the wide spacing;

and wherein the indiviual light line for which the wide spacing with all the other light lines applies is associated with two or more profile cameras and is provided by at least two light emitters, e.g. lasers, such that this light line projected on the rail is simultaneously scanned by a group of at least two cameras and each of the two sets of light lines having the close spacing are associated with a single camera, such that the camera simultaneously detects both light lines, wherein these light lines are projected at the light detecting part of the camera at different locations such that they are detected separately and are discriminated by the camera.

2. Method according to claim 1, wherein the individual light line projected onto the rail is simultaneously scanned by a group of at least four cameras.

Patentansprüche

1. Verfahren zur Geometriemessung der Herzstückspitze einer Weiche eines Eisenbahngleises, wobei ein Korrekturfaktor durch die Verwendung der optischen Mittel zur Messung des Herzstücks bestimmt wird und dieser Korrekturfaktor von der horizontalen und/oder vertikalen Schwingungsbewegung des Messzuges während der Messung des Herzstücks abhängt und welcher Korrekturfaktor auf Computerberechnungen für die geometrischen Merkmale von Interesse des gemessenen Herzstücks angewendet wird,

wobei die optischen Mittel Lichtquellen des Messzugs umfassen, welche mindestens fünf Lichtstrahlen erzeugen, die während der Fahrt des Messzugs nacheinander auf denselben Bereich eines Schienenkopfes projiziert werden und gleichzeitig Lichtlinien auf der Schiene bilden,
diese Lichtlinien mindestens fünf in Längsrichtung der Schiene voneinander getrennte Lichtlinien bereitstellen, die als zwei Paare und jeweils eine einzelne Lichtlinie angeordnet sind, wobei
zwischen zwei benachbarten Lichtlinien ein enger Abstand von mindestens 10 mm und höchstens 50 mm (z. B. ca. 30 mm) besteht, zwischen zwei benachbarten Lichtlinien ein weiter Abstand von mindestens 400 mm und höchstens 800 mm (z. B. ca. 600 mm) besteht, der Abstand zwischen den beiden äußersten Lichtlinien höchstens 1400 mm (z. B. ca. 1200 mm) beträgt, eine einzelne Lichtlinie etwa mittig zwischen zwei anderen Lichtlinien angeordnet ist, jedes der beiden Paare aus zwei eng beieinander liegenden Lichtlinien besteht, die jeweils durch mindestens den weiten Abstand von den übrigen Lichtlinien getrennt sind, die einzelne Lichtlinie durch mindestens zwei Laseremitter erzeugt wird und von zwei oder mehr Profilkameras gleichzeitig erfasst wird, während jedes der beiden Paare von Lichtlinien von jeweils einer Kamera detektiert wird, sodass alle Lichtlinien getrennt erkannt und unterschieden werden können.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die einzelne, weitabstehende Lichtlinie von einer Gruppe von mindestens vier Kameras simultan abgetastet wird.

Revendications

1. Procédé de mesure de la géométrie d’un cœur de croisement d’un aiguillage d’une voie ferrée, en utilisant un train de mesure portant des moyens optiques mesurant le cœur de croisement, dans lequel un facteur de correction est déterminé par l’utilisation des moyens optiques mesurant le cœur de croisement de la voie ferrée et ledit facteur de correction dépend du mouvement oscillatoire horizontal et/ou vertical du train de mesure pendant la mesure du cœur de croisement de la voie ferrée et dont le facteur de correction est appliqué aux calculs informatiques pour une caractéristique géométrique d’intérêt du cœur de croisement de la voie ferrée mesurée, dans lequel les moyens optiques comprennent des sources lumineuses du train de mesure qui permettent l'émission de cinq faisceaux lumineux ou plus, de telle sorte que pendant l'avancement du train de mesure, ces faisceaux lumineux soient projetés successivement sur la même zone d'un rail d'une voie ferrée et les faisceaux lumineux sont projetés sensiblement simultanément sur le rail dont les faisceaux lumineux produisant sur le rail des lignes lumineuses selon un schéma permettant de produire au moins cinq lignes lumineuses espacées, qui se présentent sous la forme de deux ensembles, et une ligne lumineuse individuelle, dans lequel

> les lignes lumineuses qui sont produites sur le rail par les faisceaux lumineux sont espacées dans la direction longitudinale du rail selon ce qui suit: espacement étroit entre deux lignes lumineuses adjacentes d'au moins 10 millimètres et n'excédant pas 50 millimètres, par exemple environ 30 millimètres; espacement large entre deux lignes lumineuses adjacentes d'au moins 400 millimètres et n'excédant pas 800 millimètres, par exemple environ 600 millimètres; espacement entre les deux lignes lumineuses les plus extérieures n'excédant pas 1400 millimètres, par exemple environ 1200 millimètres et appliquant:
>
> > un ligne lumineuse approximativement centrale entre deux autres lignes lumineuses;
> > deux des lignes lumineuses à espacement rapproché, séparées des autres lignes lumineuses par au moins l'espacement large;
> > les deux ensembles, chacun de deux lignes lumineuses présentant l'espacement rapproché, dans lequel ces deux ensembles sont mutuellement séparés par au moins l'espacement large; et
> > la ligne lumineuse individuelle séparée des autres lignes lumineuses par au moins l'espacement large;
>
> et dans lequel la ligne lumineuse individuelle pour laquelle l'espacement large avec toutes les autres lignes lumineuses s'appliquent est associée à deux ou plusieurs caméras de profil et est produite par au moins deux émetteurs de lumière, par exemple des lasers, de telle sorte que cette ligne lumineuse projetée sur le rail est balayée simultanément par un groupe d'au moins deux caméras et chacun des deux ensembles de lignes lumineuses présentant l'espacement rapproché sont associés à une seule caméra, de telle sorte que la caméra détecte simultanément les deux lignes lumineuses, dans lequel ces lignes lumineuses sont projetées sur la partie de détection de lumière de la caméra à des endroits différents de telle sorte qu'elles sont détectées séparément et sont distinguées par la caméra.

2. Procédé selon la revendication 1, dans lequel la ligne lumineuse individuelle projetée sur le rail est balayée simultanément par un groupe d'au moins quatre caméras.

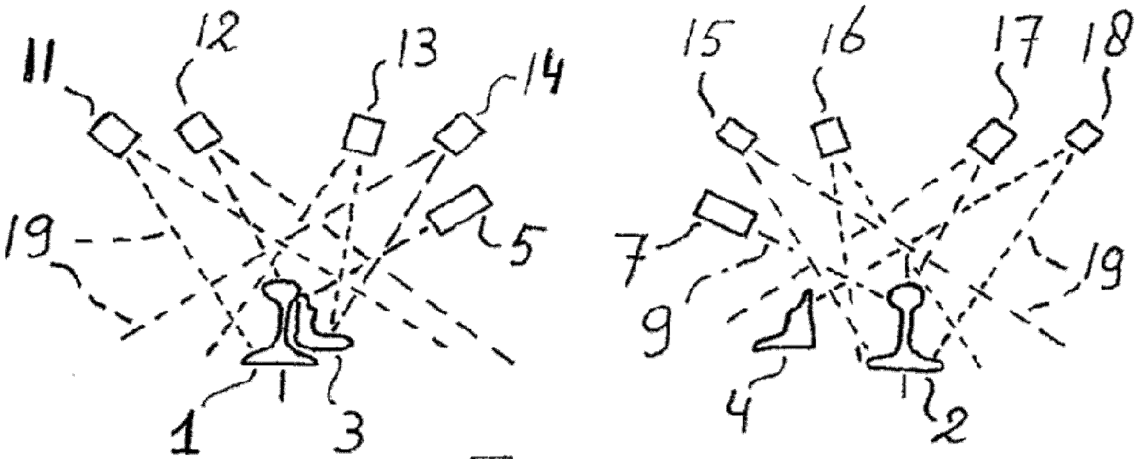

Fig.1

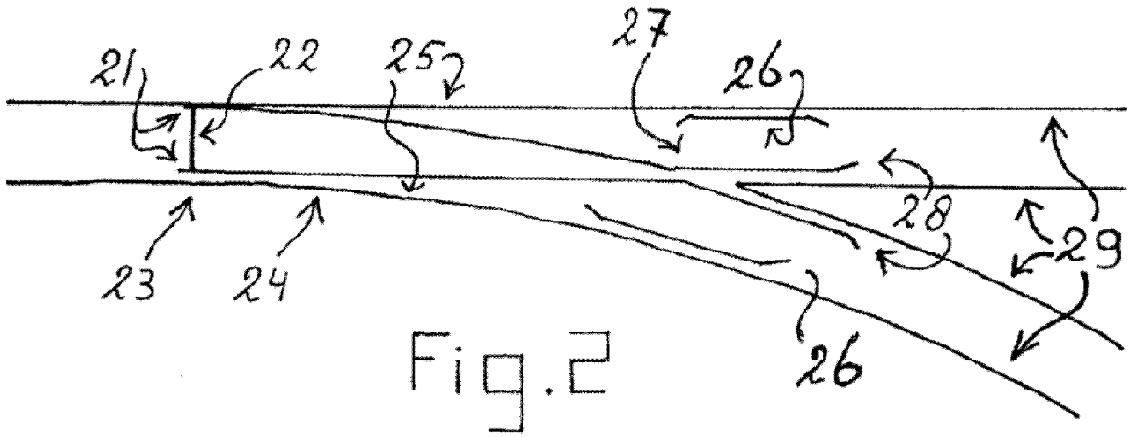

Fig.2

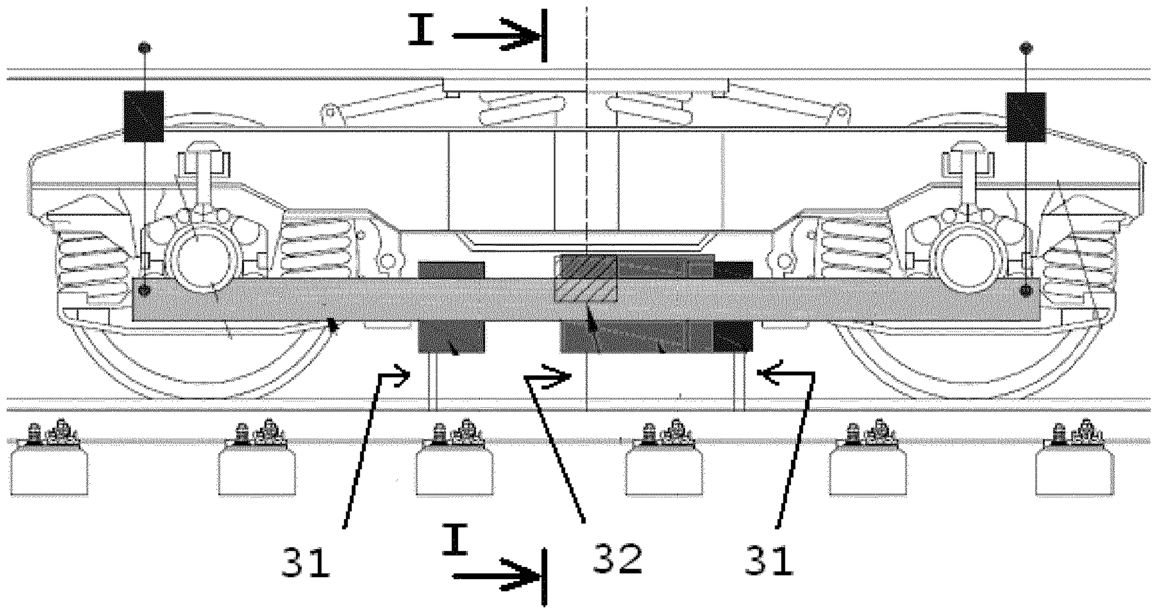

Fig. 3

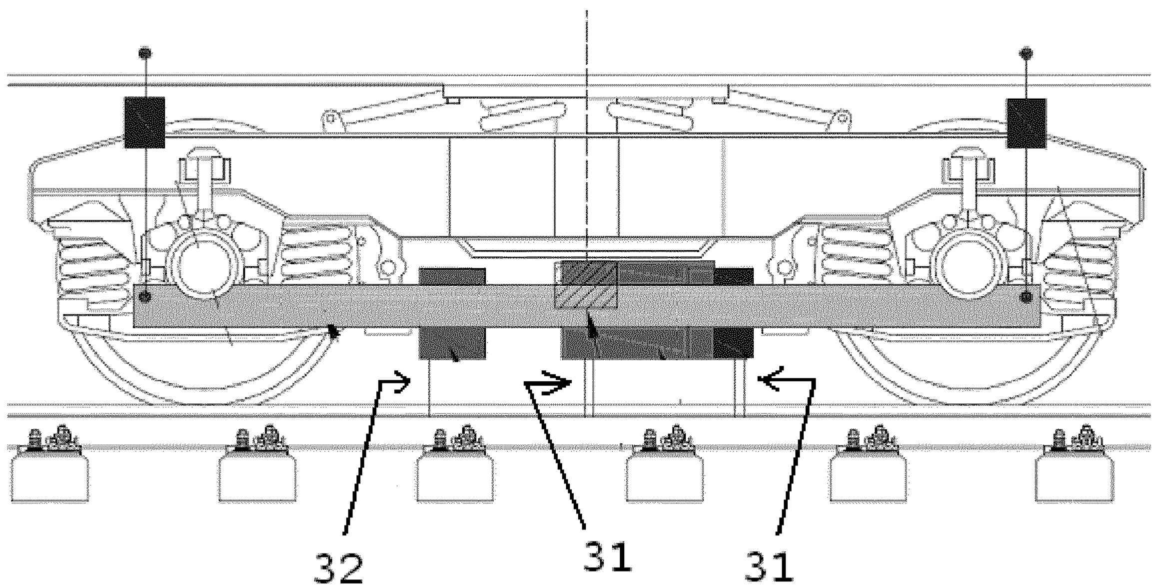

Fig. 4

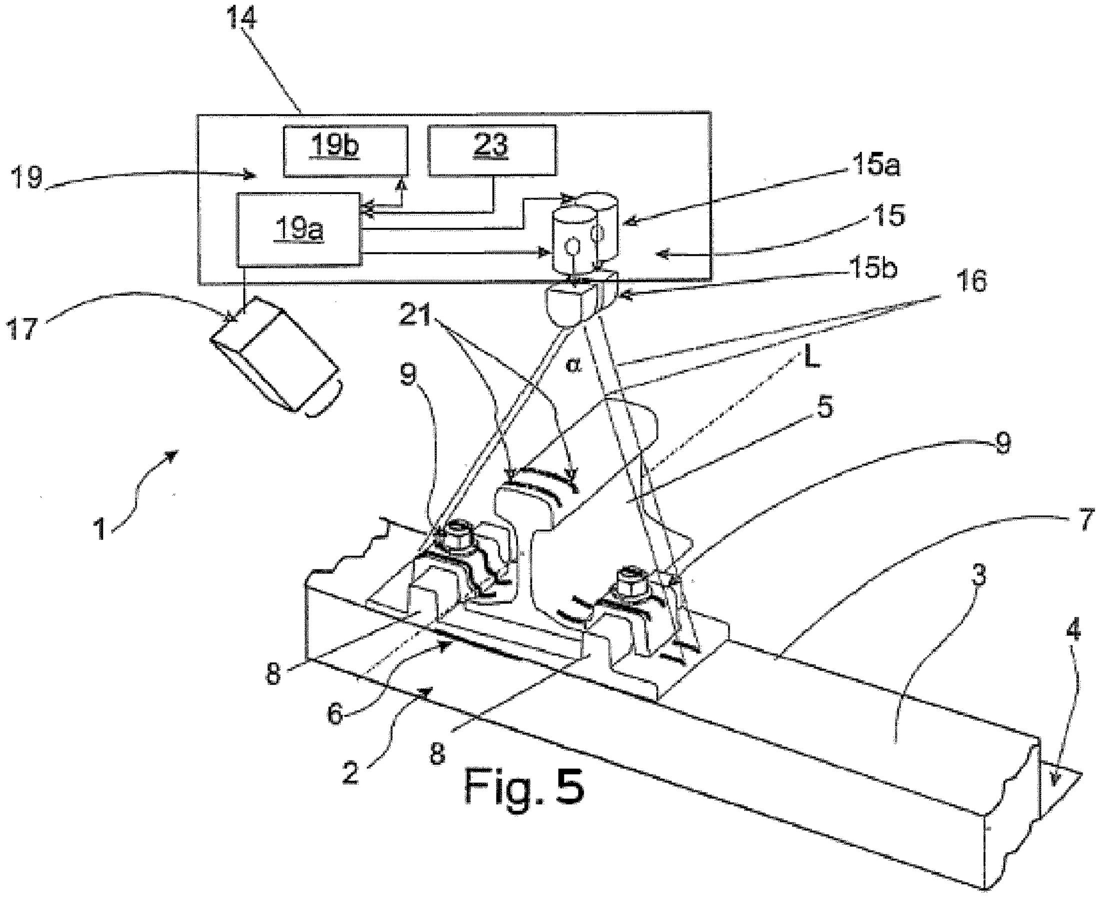
14
19b
23
19
19a
15a
15
15b
16
17
21
α
L
9
5
9
7
1
3
4
8
6
2
8

Fig. 5

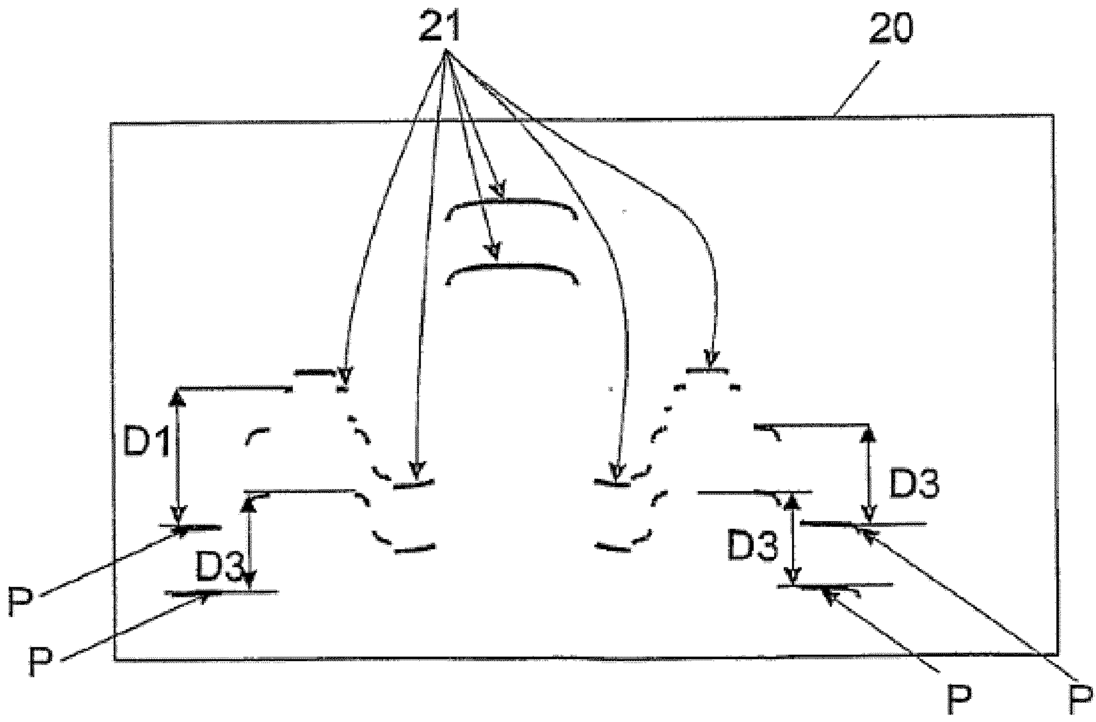
21
20
D1
D3
D3
D3
P
P
P
P

Fig. 6

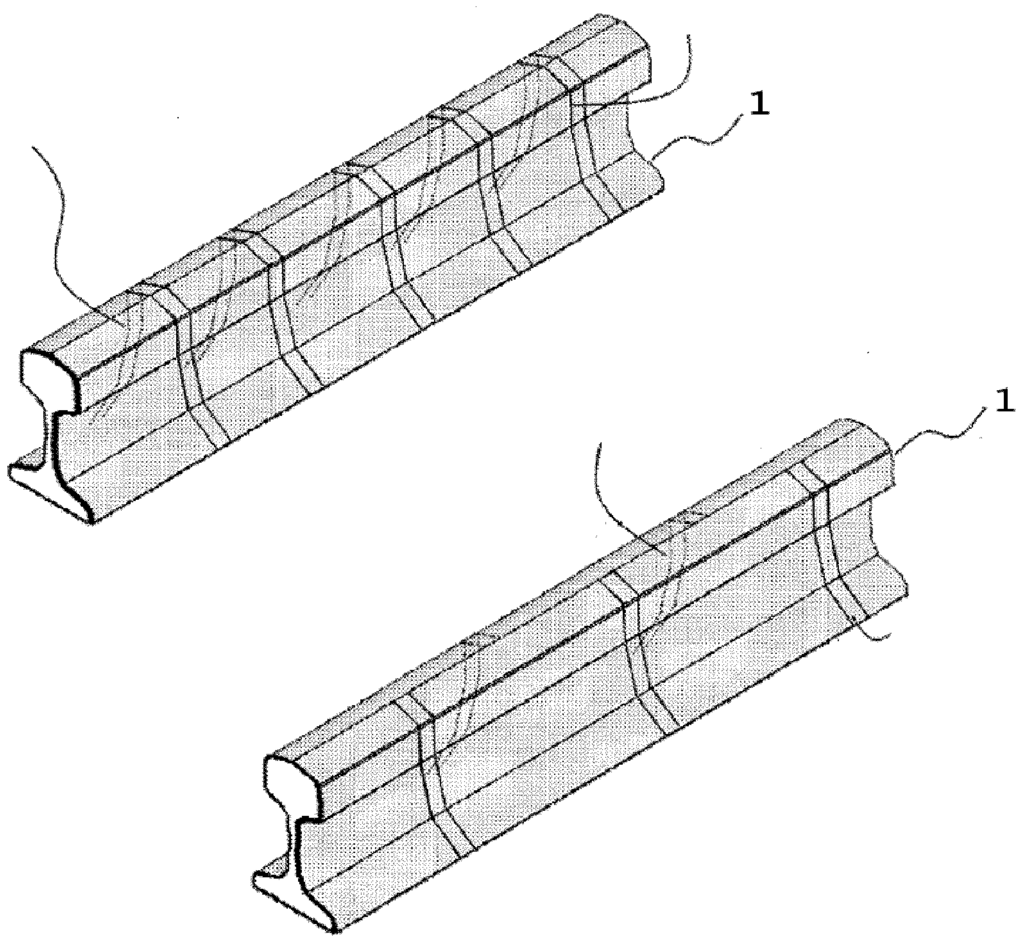

Fig. 7

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 19510560 A1 **[0002]**
- SE 515091 C2 **[0002]**
- WO 2008146151 A2 **[0002]**
- DE 102010019618 A1 **[0002]**
- EP 2165915 A **[0002] [0020]**
- WO 186227 A1 **[0003]**
- EP 2485010 A **[0016] [0020]**