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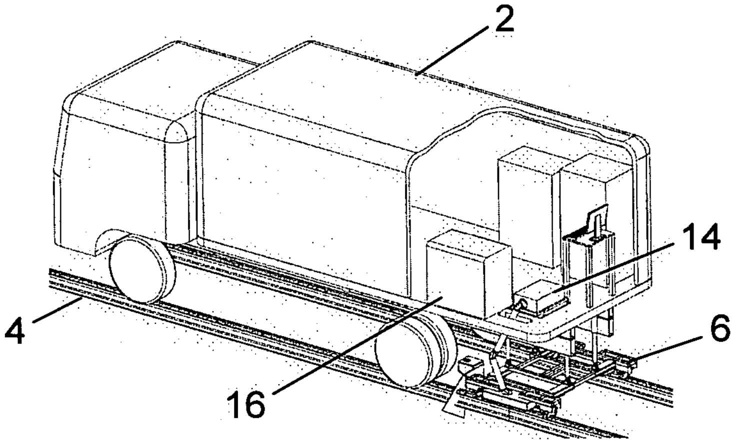
**(54) Title:** METHOD AND APPARATUS FOR THE CONTACTLESS DYNAMIC INSPECTION OF RAILWAY RAILS

FIG. 4



**(57) Abstract:** An apparatus for the contactless dynamic inspection of railway rails, characterised by comprising: - a railway trolley (6) slidable along the rail (4) to be inspected, - a measurement unit (12) for each rail (4) to be inspected, mounted on said trolley (6), - transverse stabilization means for said measurement unit (12) with respect to the rail (4) to be inspected, - at least one pulsed laser source (10) powering said measurement unit (12), - guide means (20) for the laser pulses generated by said laser source (10), - optical means (24) associated with said guide means (20) and able to focus said laser pulses onto that part of the rail (4) to be inspected, - at least one sensor (36, 38, 40, 41) for the ultrasonic signals generated by the impact of the laser pulses on said rail (4), - at least one computer (34) for acquiring and processing data, - means (32) for locating defects detected in the inspected rail (4).

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# METHOD AND APPARATUS FOR THE CONTACTLESS DYNAMIC INSPECTION OF RAILWAY RAILS

The present invention relates to a method and apparatus for the contactless dynamic inspection of railway rails.

Methods and apparatus for the dynamic inspection of railway rails are known.

In particular, apparatus for the dynamic inspection of rails based on the use of contact ultrasound are known, comprising piezoelectric transducers angularly inclined at 0°, 45° and 70° disposed within wheels filled with liquid and maintained in continuous rolling contact with the rail surface. Water is sprayed onto the probe carrier/rail interface to ensure ultrasound transmission from the device to the rail and vice versa.

The probe carrier wheels are mounted on a trolley which mechanically ensures their centering on the rails, the inspection velocity depending mainly on the track conditions, being about 28 km/h on average.

The rail section inspectionable by these known apparatus is limited to the central region extending from the head to the foot, as the ultrasonic waves can be introduced only from the rail upper surface.

Signal analysis for defect identification is achieved by monitoring the echoes created by any volumetric discontinuities.

Drawbacks of these known apparatus and the methods used thereby include:

- the need to use a coupling medium (water or solution with antifreeze for low temperatures) for transmitting the ultrasound from the transducer to the rail and vice versa,
- the large number of false defect indications,

- the limited rail area inspectionable,
- the limited defect types detectable,
- the influence of the rail surface condition.

Apparatus and methods for contactless dynamic inspection are also known.

US 2004/0003662 describes a contactless rail inspection method based on the principle of generating ultrasound with a controllable wave front and frequency in order to be sensitive to determined types of rail defect. The apparatus for implementing the method comprises a pulsed laser with focusing lens, a contactless receiver and a processor for the signal acquired by the receiver.

The document describes two specific situations, namely an internal defect within the rail head, detectable using a circular laser source, and a surface defect within the rail foot, detectable using a rectangular laser source.

A contactless ultrasonic method is also known from report RR05-07 of the Federal Railroad Administration (Mahmood F., "On-line high speed rail defect detection - phase III", US-FRA report RR05-07, 2005) for detecting transverse defects of the rail head, based on guided waves, and using signal processing algorithms able to eliminate noise and extract the information relative to defects.

Ultrasound generation is effected by lasers, with reception by capacitive transducers. The analysis of the transmitted and reflected waves uses damage indexes and enables the defect dimension to be evaluated by artificial neural networks.

Further details on this method, the apparatus used and the results obtained are provided in the Lanza document by Scalea F. Rizzo P., Coccia

S., Bertolini I. and Fateh M. "Laser bar air-coupled hybrid non-contact system for defect detection in rail tracks: status of FRA Prototype development at UC San Diego" presented at the Transportation Research Board Meeting del 2006.

From T.R. Hay, D.R. Hay, Don Plotking, GM Lee, J.L. Rose "Rail defect detection under shelling", *http:/www.wellsingsolids.com/pubblication/hayT1.ptf,* a contactless ultrasonic inspection method is also known, with electromagnetic acoustic transducers (EMAT), for detecting transverse defects within the head under a surface (shelling) defect using guided waves.

An object of the invention is to propose a method and apparatus for the contactless dynamic inspection of railway rails which, compared with known solutions, offers better performance in terms of repeatability of acquired signals, immediate indication of any defects, reduction in the number of false indications, detection insensitivity due to the rail surface state, and automatic system control and signal interpretation.

This and further objects which will be apparent from the ensuing description are attained according to the invention by an apparatus for the contactless dynamic inspection of railway rails, as described in claim 1.

Again according to the invention, the method used by the apparatus is characterised by comprising the operational steps of claim 21.

A preferred embodiment of the present invention is described in detail hereinafter with reference to the accompanying drawings, in which:

Figure 1 is a schematic illustration showing a railway vehicle provided with an inspection trolley raised into its inactive condition,

Figure 2 shows it in the same view as Figure 1, with the inspection trolley lowered into its operative condition,

Figure 3 shows a variant thereof, in the condition illustrated in Figure 1,

Figure 4 shows a variant thereof, in the condition illustrated in Figure 2,

Figure 5 shows an enlarged detail of Figure 4,

Figure 6 shows a cross-section through a rail, with which two laser triangulation devices are associated for determining the complete rail profile,

Figure 7 shows an enlarged cross-section through a rail, showing three points of impact of the laser pulses for rail inspection,

Figures 8a-8c are schematic cross-sections through the system for detecting defects present in a rail head,

Figures 9a-9b are schematic cross-sections through the system for detecting defects present in the web, in the head central region and in the foot of a rail,

Figure 10 is a schematic cross-section showing a minimum configuration of laser terminations and sensors for the complete inspection of a rail,

Figure 11 shows the layout of the various hardware components and their connections,

Figure 12 shows the pattern of the ultrasonic signal sensed by a sensor in response to a laser pulse which impacts a rail surface,

Figure 13 shows the envelope of the signal of Figure 12,

Figure 14 shows the corresponding visualization of an assembly of characteristics of the sensed waves, and

Figure 15 shows the signal processed by the rail defect detection system.

As can be seen from the figures, the apparatus of the invention comprises a vehicle 2 movable along the rails of the track to be inspected. With the vehicle a trolley 6 is associated, shiftable between an inactive condition during transfer of the vehicle 2 (see Figures 1 and 3) and an operative inspection condition (see Figures 2 and 4).

The vehicle 2 can be exclusively a railway vehicle, i.e. intended to move exclusively along rails, or be of hybrid type, i.e. able to move both on rails and on the road.

Depending on the situation, the trolley can be positioned either to the rear of the vehicle 2 and be rotatable between an inactive vertical position, raised from the rails 4 (see Figure 1) and an operative horizontal position resting via wheels 8 on the rail (see Figure 2); or be positioned below the vehicle and be movable vertically between a raised inactive position (see Figure 3) and a lowered operative position (see Figure 4).

A laser source 10 is installed inside the vehicle 2 and comprises a laser head 14 mounted on supports with shock absorbers, which prevent the laser source from picking up mechanical vibrations, to which the railway vehicle 2 is inevitably subjected during its advancement along the rails 4. The laser source 10 also comprises a power unit 16 and a cooling unit 18.

For each rail 4, a measurement unit, indicated overall by 12, is mounted on the trolley 6. If both rails 4 are to be inspected, two measurement units 12 are provided, each operating on one rail 4.

If the trolley 6 is of suitable dimensions, the laser source 10 is mounted thereon.

The trolley 6 is provided with a self-centering device, the purpose of which is to maintain the trolley centered about the rails 4, and the position of each measurement unit 12 centered about the corresponding rail 4.

The self-centering device is of traditional type, independently of whether it is mechanical or hydraulic, and does not form an aspect of the invention.

Optical guides 20 are associated with the laser head 14, each comprising an entry termination coupled to the laser source 10, and an exit termination 22 facing the rail to be inspected and provided with a focusing lens 24.

Depending on the nature of the readings to be taken, a different number of optical guides 20 can be provided, which for the purposes of the present invention can be either traditional optical guides or optical fibres.

If the rail 4 is to be completely inspected, it can be preferable to have for each measurement unit three optical guides 20, of which one has its exit termination 22 directed horizontally towards the head 26 of the rail 4 and the other two have their exit termination 22 vertically facing the two ends of the rail foot 28.

Installed on the vehicle 2 there are also a GPS 30, the function of which is to locate with a certain precision, even if external reference points are absent, the position of the vehicle 2 on the rails 4 at inspection commencement, and also an encoder 32 of optical or magnetic type, to determine the distance between the position of the vehicle 2 at inspection commencement and the position in which a rail defect has been detected, and hence to determine the position of this defect.

A computer 34 is also installed on the vehicle 2 to process and save data and also for controlling the entire apparatus operation.

In order to limit the power of the laser source, a water system is provided on the vehicle 2 comprising sprayers able to strike with atomized jets those points on the rail 4 facing the terminations 22 of the optical guides 20.

Each measurement unit also comprises a plurality of sensors 36, 38, 40, positioned at suitable distances from the surface of the rail 4 to sense the direct waves, the reflected waves and those diffracted by possible volumetric and surface discontinuities.

Variable gain amplifiers for each signal component are associated with the sensors 36, 38, 40, together with filters for separating spurious signal components.

Foreign body sensing devices are also mounted on the trolley 6, possibly consisting of traditional laser triangulation devices able to read the rail profile and hence sense the presence of junction bars in the rail end portions, fixing holes in the web 42, and welds and connections or obstacles on the foot 28 of the rail 4.

The operation of the apparatus of the invention, which in the illustrated examples provides, as stated, for feeding three laser beams horizontally onto the head 26 of the rail 4 and vertically onto the two ends of its foot 28, will be clearer by referring to each laser beam and to the sensors 36, 38, 40 applied to the measurement unit 12 and positioned at a certain distance from the rail 4.

With reference to Figures 8a-8c, these show the system for determining the laser pulses directed by the laser source 10 onto the head 26 of the rail 4 and sensed by the sensors 36 and 38. Specifically, Figure 8a shows the propagation of the longitudinal waves L and transverse waves T within the volume of the head 26 and the propagation of the surface waves S along its surface. If there is no internal or surface discontinuity the waves undergo no variation and the sensor 36 receives the waves reflected from the opposite surface of the rail, while the sensor 38 receives the transmitted waves (of volume L and surface S). If the rail head 26 presents an internal discontinuity or defect 44 (see Figure 8b) the volume waves L and T are reflected by the defect itself (waves R) and sensed by the sensor 36 before the waves reflected by the opposite surface of the rail. The sensor 38 instead senses the longitudinal volume waves, attenuated by the defect 44, and the non-attenuated surface waves S.

Likewise, in the case of a surface defect 46 (see Figure 8c) the sensor 36 receives the surface wave R reflected by the defect 46 (see Figure 8c), while the sensor 38 receives the attenuated surface wave R.

The sensors 36 and 38 can be positioned within the same cross-section of the rail 4 as that in which the laser beam strikes, or at a certain distance therefrom in the longitudinal direction. Within certain limits the distance between the sensors 36 and 38 and the rail 4 can have any value.

It is evident that this method of operation enables defects present in any region of the head 26 to be detected.

With reference to Figures 9a and 9b, these show schematically the method of operation for detecting any internal defect and/or surface defect on that side of the foot 28 of the rail 4 to which the laser beam is applied, on the rail web 42 and on the central part of the head 26.

Again in this case the behaviour of the apparatus of the invention differs depending on whether defects are absent or present within the rail portion under examination.

According to the present method of operation, the laser source 10 is positioned in proximity to one end of the rail foot 28 and is orientated such as to feed a laser pulse vertically to said foot. The sensor 40 is positioned with its axis vertical above the surface of the head 26, at a certain distance therefrom.

If internal or surface defects are absent, the waves undergo no variation and the sensor 40 receives the volume waves L and surface waves S, which propagate from the foot 28 to the upper surface of the head 26.

If instead an internal defect 44 or a surface defect is present, the volume waves L (in the first case) or the surface waves S (in the second case) are attenuated in relation to the extent of the defect.

This method of operation evidently enables inspection of one side of the foot 28, the web 42 and the central region of the head 26 with a single laser pulse, it likewise being evident that if the measurement unit 12 uses two laser terminations 22 positioned at the two ends of the foot 28 and orientated vertically, and a third termination 22 orientated horizontally towards the rail head 26, the entire rail 4 can be inspected by a single laser pulse.

The signals acquired by the sensors are then amplified with variable gains for each component and filtered.

Naturally, the number and arrangement of the terminations 22 which feed the laser pulses onto the rail 4, and the arrangement and orientation of the sensors 36, 38 and 40 which sense the ultrasonic waves, vary depending on the types and location of the defects to be detected.

For a complete inspection of the rail 4 it is advantageous to use the minimum configuration, illustrated in Figure 10 and comprising the laser terminations 22 shown in Figure 5 and four sensors 36, 38, 40, 41. Of these, two sensors 41 are disposed on the two sides of the rail 4 to vertically face the two flanges of the foot 28 in order to detect defects present therein, a third sensor 40 vertically faces the upper surface of the rail head 26 to detect defects in the rail web 42 and in the central part of the head 26 and foot 40, and a fourth sensor 38 faces the lateral surface of the head, opposite that facing the horizontal laser termination.

Figure 11 shows the apparatus layout. The connections used are of the wireless/Ethernet type, TCP/IP, optical fibre type or cable type.

It is preferable to use three separate computers, for signal acquisition and processing, for supervision and for their saving respectively.

As stated, a GPS 30 is installed on the vehicle 2 to identify the vehicle position, and usable both for identifying the defect position and the position of the vehicle 2 at inspection commencement.

An encoder 32 of optical or magnetic type is also installed on the vehicle 2 to define the distance travelled by the vehicle from commencement of inspection, and then to accurately locate the position of any detected defects.

The invention also proposes an original method for detecting the presence of defects in a rail 4, using sequences of laser pulses "fired" by the terminations 22 of the optical guides 20 associated with the laser source 10, at a preferred frequency of 150 hertz.

Each laser pulse which impacts the surface of the rail head 26 generates ultrasonic waves which propagate along the rail. They are divided into longitudinal volume waves L and transverse waves T, and surface waves S. Overall they generate a complex waveform which is sensed by the sensor 38 and transformed into electrical signals.

The other sensors also sense different waveforms following the impact of the laser pulses on other points on the surface of the rail 4.

Figure 12 shows an example of an ultrasound trace received by a single sensor 38 within the time range considered (for example 100 microseconds).

The processing system preferably provides for firstly transforming each ultrasonic signal into the corresponding envelope shown in Figure 13. In this, the different wave "packets" can be recognized, representing the different wave types (longitudinal L and surface S) which pass in front of the sensor 38. As the sensor also senses spurious waves due to phenomena not of interest (for example reflections, signals in air, etc.), the system provides for extracting from the signal the waves of interest and discarding those not of interest. This is achieved on the basis of theoretical and/or experimental considerations, which take account of the physical location of the sensors, of the predictable theoretical behaviour of the phenomenon of propagation of the different ultrasonic waves in terms of propagation velocity and propagation attenuation, and of the slow variance of the wave propagation phenomenon between two successive inspection points along the rail 4.

On the basis of these considerations, the processing programme is able to identify within the envelope those signal portions corresponding to the various waves (L and S).

The processing programme then associates with each wave a series of numbers representative of predetermined characteristics of that wave (presence, amplitude, extension, gaussianity, etc.) and constructs the corresponding visualization of an assembly of characteristics of the waves sensed by six sensors for the head 26 (see Figure 14). This shows at successive moments of time the behaviour of that rail portion passing in front of the considered sensor, in the case of defect absence or presence. It should be noted in particular that in the absence of defects the individual squares representing that certain characteristic of that wave at that moment are clear, whereas if a deviation from theoretical behaviour is present, signifying a behaviour alteration due to a defect, they are dark.

On sensing this deviation the programme automatically compares the detected anomaly and the theoretically or experimentally determined anomalies for the defect types present in rails in practice.

When the system senses a similarity, the presence of which is displayed by a peak (see Figure 15), it is able to indicate not only the existence of this particular type of rail defect, but also the moment of its detection, this information, correlated with the indication provided by the encoder 32, enabling determination of the exact rail point in which the defect was detected.

The information is evidently more precise the more accurate the position of the terminations and of the sensors relative to the rail 4.

In practice it has been found that a complete inspection of the rail requires three terminations 22, able to direct three laser pulse signals horizontally onto the rail head 26 and vertically onto the two ends of the foot 28, and four sensors, one on each side of the foot, one at the head and one at the web.

Moreover, as the rail geometry can be different for different railway networks or as a result of rail wear, the position and orientation of the laser terminations and sensors can vary to adapt to the different rail geometries. This adaptation can be made manually or automatically, using suitable actuators controlled by the processing system.

From the aforegoing it is apparent that the apparatus of the invention is particularly advantageous compared with traditional apparatus, and in particular:

- it ensures substantial reproducibility of the sensed signals,
- it enables an indication in real time to be provided of rail integrity or the presence of discontinuities,
- it reduces the number of false defect indications,
- it is substantially insensitive to the surface state of the rail under inspection,
- it provides self-sufficiency of system handling and signal interpretation,
- the use of optical fibres or optical guides eliminates laser beam alignment problems,
- as the laser source 10 is stationary within the vehicle 2 relative to the measurement unit 12 in the trolley 6, there is no laser beam power loss,
- the fact of determining t he entire rail profile enables the presence of other parts on the rail to be identified, hence providing additional information,
- the rail can also be inspected under unfavourable environmental conditions, with external temperatures variable between -25°C/45°C +60°C,
- it ensures substantial position stability of the measurement unit relative to the rail 4 and hence reliable and repeatable measurements.

# CLAIMS

1. An apparatus for the contactless dynamic inspection of railway rails, characterised by comprising:

- a railway trolley (6) slidable along the rail (4) to be inspected,
- a measurement unit (12) for each rail (4) to be inspected, mounted on said trolley (6),
- transverse stabilization means for said measurement unit (12) with respect to the rail (4) to be inspected,
- at least one pulsed laser source (10) powering said measurement unit (12),
- guide means (20) for the laser pulses generated by said laser source (10),
- optical means (24) associated with said guide means (20) and able to focus said laser pulses onto that part of the rail (4) to be inspected,
- at least one sensor (36, 38, 40, 41) for the ultrasonic signals generated by the impact of the laser pulses on said rail (4),
- at least one computer (34) for acquiring and processing data,
- means (32) for locating defects detected in the inspected rail (4).

2. An apparatus as claimed in claim 1, characterised in that said trolley (6) is mounted on a vehicle (2) movable along the rails (4) and is itself movable between an inactive position during transfer of said vehicle (2) and an operative inspection position.

3. An apparatus as claimed in claim 2, characterised in that said trolley (6) is hinged to said vehicle (2) and is rotatable between an inactive vertical position, raised from said rail (4) and an operative horizontal position resting on said rail via wheels (8).

4. An apparatus as claimed in claim 2, characterised in that said trolley (6) is positioned below said vehicle (2) and is movable vertically between an

inactive position raised from said rails (4) and an operative position resting on the rails via wheels (8).

5. An apparatus as claimed in claim 1, characterised in that the pulsed laser source (10) is mounted on the vehicle (2) via supports with shock absorbers.

6. An apparatus as claimed in claim 1, characterised in that the pulsed laser source (10) is connected to said measurement unit (12) by means of optical guides (20).

7. An apparatus as claimed in claim 6, characterised in that each optical guide (20) is provided with a termination (22) facing the rail (4) to be inspected and provided with a focusing lens (24).

8. An apparatus as claimed in claim 1, characterised in that the pulsed laser source (10) and the measurement unit (12) are positioned on said trolley (6).

9. An apparatus as claimed in claim 1, characterised in that said pulsed laser source comprises a laser head (14), a power unit (16) and a cooling unit (18).

10. An apparatus as claimed in claim 1, characterised by comprising, for each rail (4) to be inspected, three optical guides (20) having the corresponding terminations (22) facing horizontally towards the rail head (26) and vertically towards the ends of the rail foot (28).

11. An apparatus as claimed in claim 1, characterised by comprising at least one sensor disposed on one side of the rail foot (28), at least one sensor facing in inclined disposition towards the rail head (26), and at least one sensor facing in vertical disposition towards the rail head (26).

12. An apparatus as claimed in claim 1, characterised by comprising a GPS (30) rigid with the trolley (6).

13. An apparatus as claimed in claim 1, characterised by comprising at least one encoder (32) rigid with the trolley (6).

14. An apparatus as claimed in claim 13, characterised in that said encoder (32) is of optical type.

15. An apparatus as claimed in claim 13, characterised in that said encoder (32) is of magnetic type.

16. An apparatus as claimed in claim 10, characterised by comprising a water system with sprayers able to strike with atomized jets those points on the rail (4) facing the terminations (22) of the optical guides 20.

17. An apparatus as claimed in claim 1, characterised in that said optical means (24) and said sensor (36, 38, 40, 41) are mounted on supports able to modify their position/orientation on the basis of the geometry of the rail (4) to be inspected and its possible wear.

18. An apparatus as claimed in claim 17, characterised in that actuators are associated with said supports able to modify the position/orientation of said optical means (24) and of said sensor (36, 38, 40, 41) on programmed command.

19. An apparatus as claimed in claim 1, characterised by comprising at least one triangulation device for reading the profile of the rail (4).

20. An apparatus as claimed in claim 1, characterised by comprising means for synchronizing the operativity of the rail profile reading device with the operativity of said sensor (36, 38, 40, 41).

21. A method for the contactless dynamic inspection of railway rails, characterised by:

- generating pulse sequences by at least one laser signal source,
- striking the successive points of a rail (4) under inspection with said sequence of laser pulses, to generate at the points of impact ultrasonic waves which propagate along the rail,
- sensing said ultrasonic waves with sensors (36, 38, 40, 41) which are movable along the rail rigid with the laser signal source (10), but stabilized transversely relative thereto, and are able to transform them into electrical signals,
- on the basis of the physical location of the sensors (36, 38, 40, 41), of the predictable theoretical behaviour of the ultrasonic wave propagation and of the slow variance of the ultrasonic wave propagation phenomenon along the rail (4), extracting from each signal those signal portions representative of the different ultrasonic waves of interest,
- associating with each ultrasonic wave of interest a series of parameters representative of the characteristics of the wave, to obtain assemblies of parameters which characterise it at the moment of sampling,
- comparing each assembly of parameters with corresponding assemblies stored in a database and corresponding to the various types of defects,
- if a positive match is found, determining that point on the rail (4) at which the defect has been detected.

22. A method as claimed in claim 21, characterised by transforming the electrical signals generated by said sensors into corresponding envelope signals, from which those signal portions representative of the different ultrasonic waves of interest are extracted.

23. A method as claimed in claim 21, characterised by constructing the database by theoretical and/or experimental considerations on the behaviour

of the ultrasonic wave propagation along a rail (4) in the presence of different types of defect.

24. A method as claimed in claim 21, characterised by comparing the assembly of parameters representative of the sensed ultrasonic wave with the parameter assemblies stored in the database which corresponding to the various defect types, only if a significant variation is found in said parameters representative of the ultrasonic wave sensed during successive determinations along the rail under inspection.

25. A method as claimed in claim 21, characterised by associating with each sampling moment the position of the sampling system along the rail (4) under inspection.

26. A method as claimed in claim 21, characterised by feeding three sequences of laser signals, of which one is fed onto the head of the rail under inspection and two are fed onto the two ends of the rail foot.

27. A method as claimed in claim 21, characterised by using at least four sensors for sensing the ultrasonic waves, of which:

- two sensors are positioned one on each side of the rail to detect defects present in the corresponding flanges of the foot,
- one is disposed inclined at the rail head top detect defects present in the rail head,
- one is disposed vertically above the rail head to detect defects present in the central part of the foot, of the web and in the central part of the head.

28. A method as claimed in claim 21, characterised by feeding at least one jet of atomized liquid onto that region of the rail under inspection which is struck by the laser pulses.

29. A method as claimed in claim 21, characterised by determining the profile of the rail under inspection during sampling.

FIG. 1

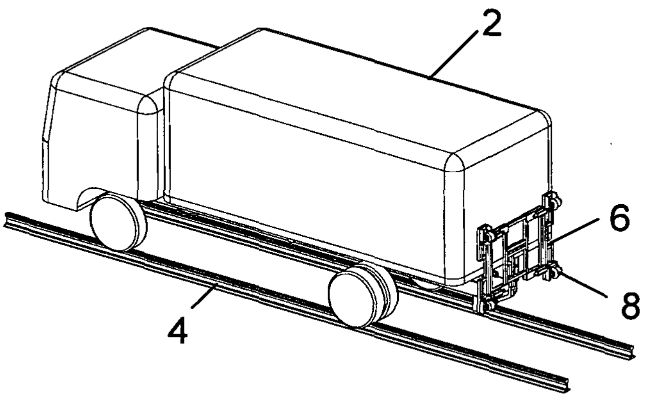


FIG. 2

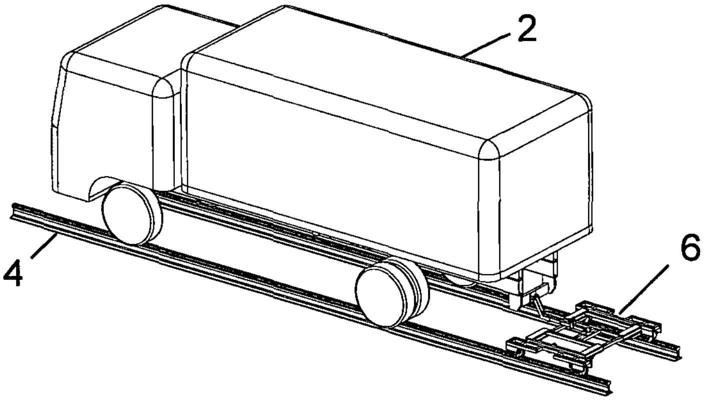


FIG. 3

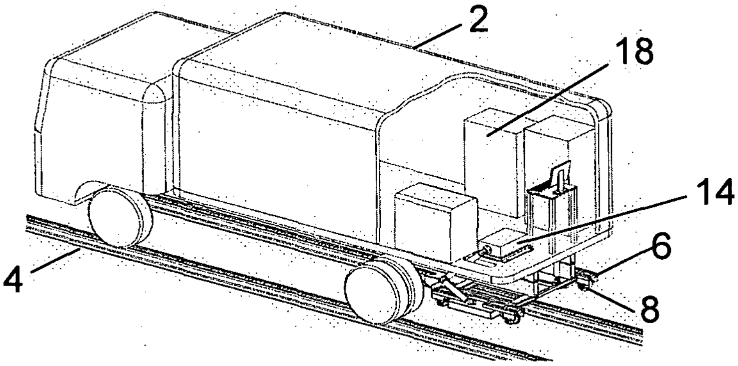


FIG. 4

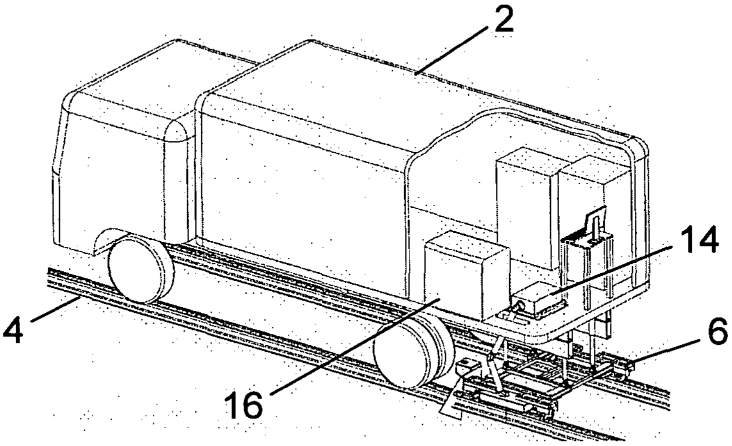


FIG. 5

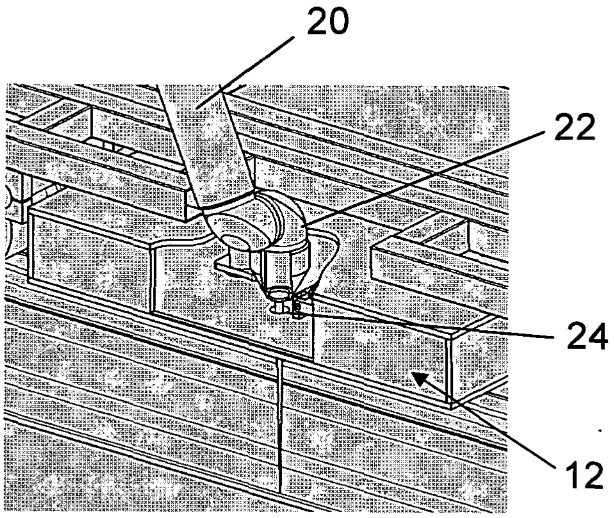


FIG. 6

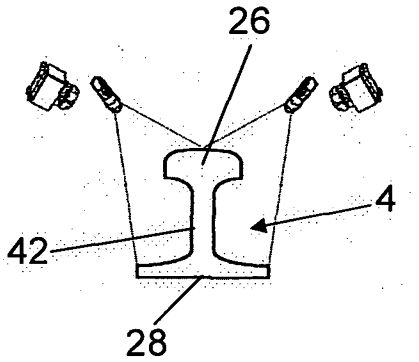
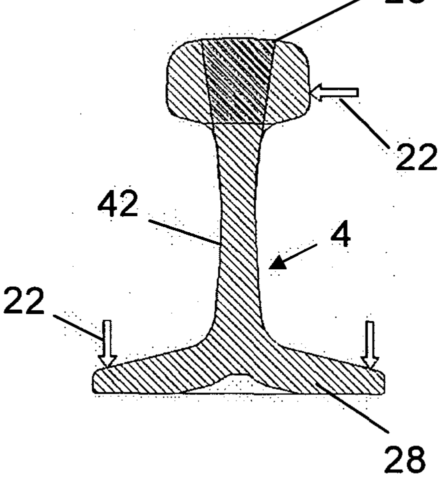
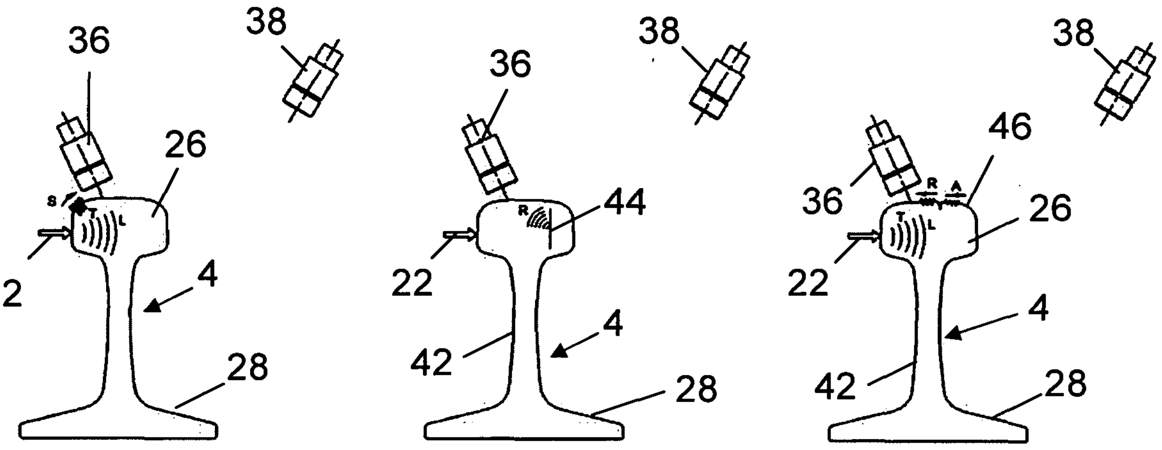


FIG. 7

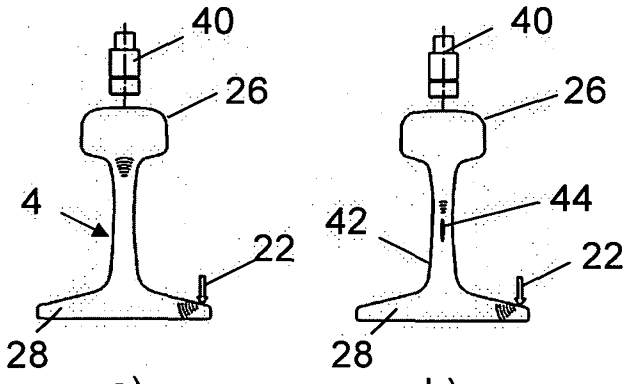




a) b) c)

FIG. 8

FIG. 9



a) b)

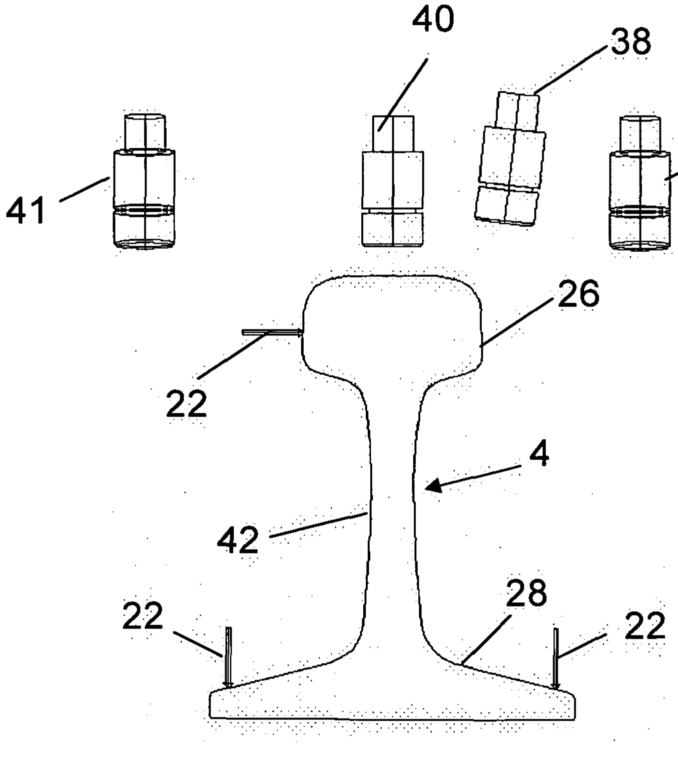


FIG. 10

FIG. 11

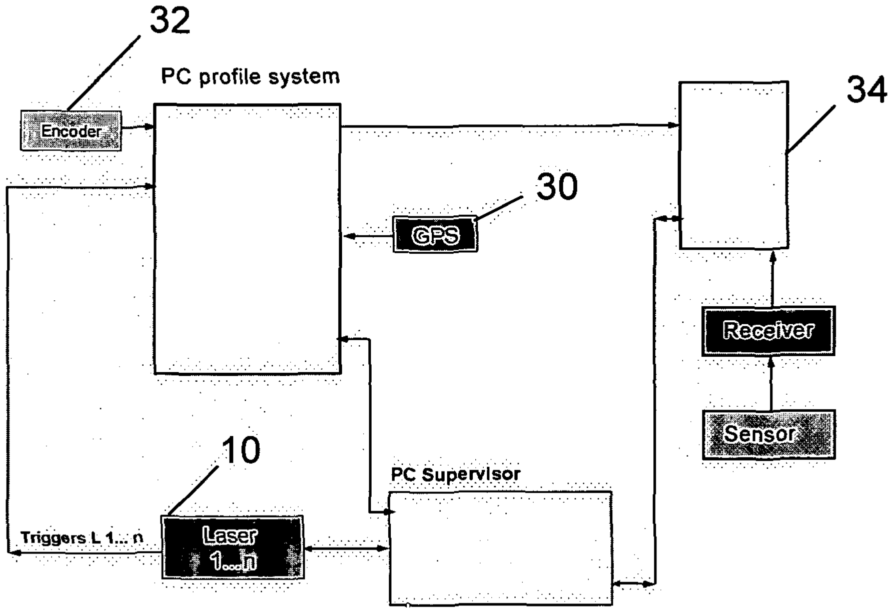
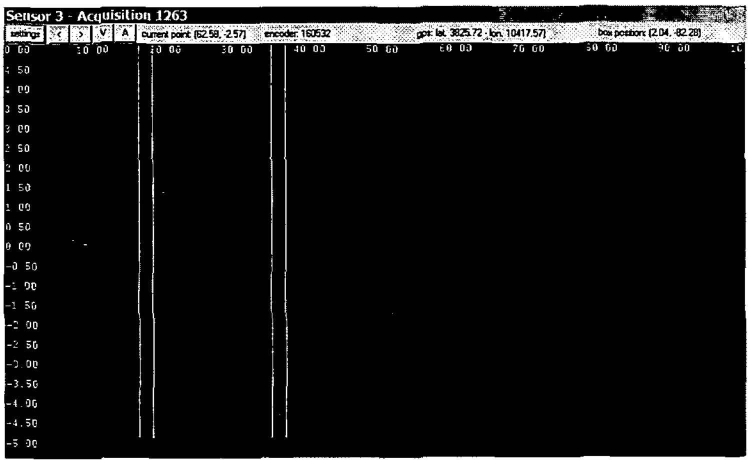
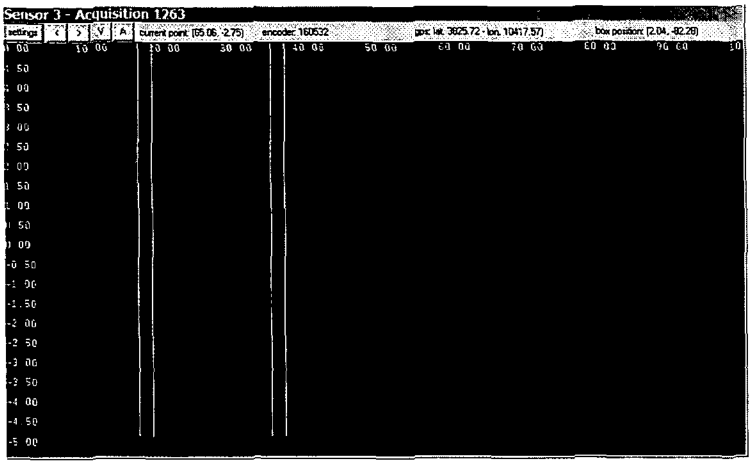


FIG. 12


Sensor 3 - Acquisition 1263

current point: (62.58, -2.57) encoder: 160532 gps: lat. 3825.72 - lon. 10417.57) box position: (2.04, -82.28)


Sensor 3 - Acquisition 1263

current point: (65.06, -2.75) encoder: 160532 gps: lat. 3825.72 - lon. 10417.57) box position: (2.04, -82.28)

FIG. 13

FIG. 14

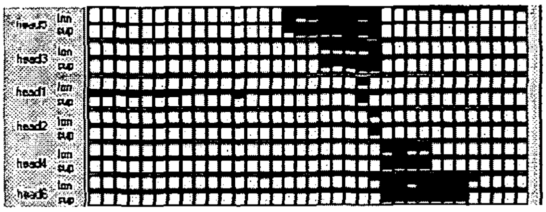
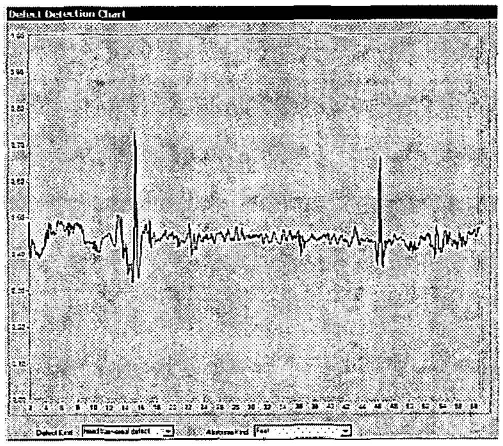


FIG. 15



Defect Kind: Head transversal defect

Abscissa Kind: Feet