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(54) **IN SITU REPAIRING OF A DEFECT IN A RAILWAY RAIL**

(57) A method of in situ repairing of a defect (15) in a rail (10) which comprises removing a piece of rail head (14) from the upper face of the rail head so that the rail web (13) and the rail foot (12), and optionally the lower part of the rail head (14) remain unaffected, so that in the rail head a recess, preferably a hole (20) is formed, wherein the recess debouches at its upper face, and teh method further comprises the filling of the recess (20) with a preformed, shape-retaining, preferably closely fitting, steel plug (21), the shape of the recess (20) and of the plug (21) being congruent in order to restore the original geometry of the rail.

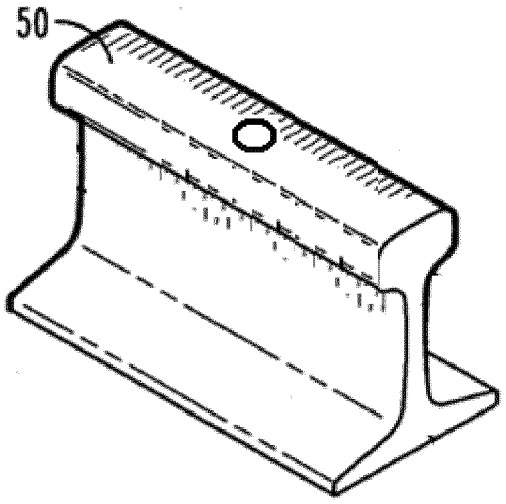

Fig. 5

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Description

[0001] This invention relates to a method of in situ repairing of a mechanical defect in a rail of an existing train track for transporting passengers or goods with two parallel steel rails for rail traffic. Optionally, the invention is applicable to crane track rail.

[0002] From WO2011119238A1, it is known to remove a wedge-shaped piece from the rail situated in the railroad, in such a way that the rail foot and the lower part of the rail web and along a length of the rail head and the upper part of the rail web remain unaffected and for some length the rail head and the upper part of the rail web are removed completely, to then be filled by an identical prefabricated, dimensionally stable (or shape-stable), and wedge-shaped plug of steel that is permanently welded to the surrounding rail to restore the original geometry of the rail. The steel type and hardness of the plug and the rail to be repaired are the same.

[0003] US-A-619 013 (published 1899) discloses the preventive, in the vicinity of an expansion joint in the rail, and at a fixed distance therefrom in the longitudinal direction of the rail, in the tread band of the rail head positioning of a prefabricated, cylindrical, smooth-walled plug of metal harder than the rail itself, in order to absorb impact of the train wheels in the vicinity of expansion joints in the rail. The distance to the expansion joint is not mentioned in this document, and is likely to be within 25 cm of the expansion joint, because the impacts of the train wheels also occur within this distance.

[0004] In the broadest sense, we dare to define our invention as follows: from the top surface (ie the tread) of the rail head of the rail present in the, preferably for direct resumed operation suited, railroad removing of a piece of rail head so that the rail web and the rail foot, and optionally the lower part of the rail head, remain unaffected, so that in the rail head an at its upper surface debouching recess is created, preferably situated at a distance (preferably of at least 10 mm) from the sides of the rail head (so that the sides of the rail head remain unaffected), and with a prefabricated, shape-retaining, preferably snugly fitting, steel plug filling the recess, wherein, preferably, the shape of the recess and of the plug is congruent, in order, to recover the original geometry of the rail.

[0005] By "for direct resumed operation suited railroad" is particularly understood to mean that the to be repaired rail in the operating state remains in the train line, for example, its for safe train traffic necessary mounting to the substrate, and its connection to the in its extension preceding and succeeding rail, for instance by a welded joint such as by welded or joint-free track, is maintained during the repair, so that, for example, the mounting of the damaged rail, is before, during and after the repair work substantially the same.By "upper face of the rail head" is in particular understood to mean the plane that contains the tread for the wheels of the train and at which, respectively, across which the driving wheels of the train rest and drive, so the plane that provides the upper surface thereof during operation of the rail and/or is facing upwards.

[0006] The hole is preferably vertical, or up to 10 degrees from the vertical, for example, the hole is made, for example, drilled with a drill, the orientation of which, for example, drill shaft, is vertical, or deviates up to 10 degrees from vertical during the operation, such as drilling.

[0007] Preferably, prior to removal of the piece of rail head an inspection is carried out to the rail, to detect a mechanical damage, for example, squat, and the repair is carried out at the site of the damage. In order to detect the damage, for example a measuring or inspection means is used, for example, a scanner (for example, equipped with a light source such as laser), or an image camera or with a magnetic field or electric or acoustic field or other field operating, that is, for example, on board of a vehicle such as a measuring train.

[0008] The location of the repair lengthwise of the track will usually be arbitrary and, for example, depend on the result of a damage detection. The distance in rail longitudinal direction will thus be variable with respect to an expansion joint. A repair according to the invention can also be found further than 25 cm from the dilatation joint, for example, more than 50 or 100 or or 150 or 200 cm.

[0009] It should be understood that it is preferable to wait for the repair until a damage occurs, which usually occurs only after the track is in use for some time, for example, a minimum of one month or a year or two or five years. The damage is mainly caused by train traffic that drives the railroad.

[0010] According to a preferred embodiment of our invention, a piece is removed from the upper part of the rail head of a steel rail situated in the railroad so that a hole is formed in the tread band while the lower portion of the rail head, the rail web and the rail foot are not affected. The hole is then filled with a prefabricated, tightly fitting and form-stable plug of steel which is permanently fixed to the surrounding material of the rail head in order to restore the original geometry of the rail. Preferably, securing involves an interference fit, for instance in that the plug in a shrunken state, for example in that it is significantly colder, for example at least 50 or 100 or 150 degrees Centigrade colder (e.g., cooled by liquid CO2 or N2 or 02), then to be repaired rail, is placed in the hole.

[0011] If in the shrunken state, the plug having a diameter equal to or slightly smaller than the hole diameter is placed in the hole and subsequently the plug is allowed to expand, for instance in that the plug heats up to the temperature of the rail head, so that the plug diameter is trying to increase and thus the plug clamps into the hole.

[0012] Alternatively, the plug is placed unshrunken, with the plug diameter initially greater than the hole diameter and by insertion into the hole is forced by the hole wall to decrease in diameter.

[0013] An effect of which the invention likely makes

use is that the wheels of a passing train, locally knead the steel in the upper layer of the top surface of the rail head in the area of contact between the running face of the wheel, and the rail head, so that the inserted plug and the material of the rail head around there experience cold plastic deformation and thus fuse cold. Thus, the plug will fit increasingly better into the hole and all gaps between the hole and the plug smoothly close. Thus it is sufficient to insert a dimensionally stable (or shape-stable) plug into a dimensionally stable (or shape-stable) hole without the use of shape free auxiliary material such as adhesive or molten steel to provide a durable, corrosion resistant fixation of the plug in the hole.

[0014] For the plug, one or more of the following applies: cylindrical or parallelepipedic; height greater than 5 or 10 mm and/or less than 30 or 20 or 15 mm; diameter greater than 5, or 10 mm and/or less than 40 or 30 or 25 mm; Contiguous edges are perpendicular to each other; an axial taper of not more than 3, 2 or 1 degrees; of an alloy substantially identical with those of the rail head; one or more of tensile strength, yield point, elongation at rupture and hardness, is substantially equal or greater to that of the rail head; flat bottom and/or top side; contains one or more of Fe, Cr, Mn, Si.

[0015] For the hole one or more of the following applies: cylindrical or parallelepiped; depth greater than 5 or 10 mm and/or less than 30 or 20 or 15 mm; depth less than 50% of the height of the rail head; diameter greater than 5 or 10 mm and/or less than 40 or 30 or 25 mm; diameter less than 50% of the width of the rail head; Contiguous edges are perpendicular to each other; an axial taper of no more than 3, 2 or 1 degrees; at least 10 or 15 or 20 mm distance from the sides of the rail head; is located in the contact area between the drive or running surface of the wheels of the train and the upper surface of the rail head; made by spark machining or drilling or milling, or other machining, preferably milling with a milling tool so that a flat hole bottom is created, and after milling the hole bottom and wall are not exposed to a the quality, in particular, the accuracy of one or more of roundness, depth and the diameter of the hole improving mechanical machining with a tool and/or with a milling tool of which the diameter is equal to the hole diameter; made with an indeed or not to center cutting mill; in depth and/or diameter smaller than that of the plug at the same temperature, preferably at least 0.005 mm at 20 degrees Celsius; flat bottom.

[0016] The shape of the hole and the plug are preferably adjusted to each other such that when the plug is inserted into the hole, the bottom and/or side walls of the hole and plug make large-scale intimate contact with each other.

[0017] Preferably, it is ensured that after the placing of the plug is completed, the upper surface of the plug protrudes slightly above the upper side (the top side is the tread band) of the rail head, preferably at least 0.05 and/or less than 0.1 mm, and then the upper surface of the plug is reduced by a machining operation such as grinding or sanding so that the upper surface of the plug comes to lie flush with the upper surface of the rail head.

[0018] In an alternative, it is conceivable that the plug is located in the hole in a sunk state, and after the placing of the plug is completed liquid steel is poured onto the plug in the hole so that the sink above the plug is completely filled with the initially shape free steel.

[0019] For example, the plug is driven into the hole by hammering or pressing.

[0020] This repair is particularly suitable for so-called. squats. A squat or other damage of the tread band is detected in the rail of the railway taken into operation, is removed by making the hole with a diameter and depth so that the damaged area is completely removed, then the gap is filled up with the plug.

[0021] This repair is primarily intended for one or more of: welded or jointless track; rail curve; switch, for example, frog or stock rail or tongue.

[0022] This repair is primarily intended for a rail with one of the following steel alloys: manganese steel; Hadfield steel; rail according to EN 13674-1 and/or ProRail RLN 00127-1; Steel with apart from one or more other elements, constituents and/or impurities, Fe (iron) and one or more of: C (carbon); Si (silicon); Mn (manganese); Cr (chromium).

[0023] The hardness (Brinell) of the track head and/or the driving surface is preferably at least 200 or 220 or 250 or 260 or 300 or 320 or 350 or 370 or 375 or 400. The rail may be heat treated.

[0024] The preferred amounts present in the steel (in wt.%) are as follows: Fe is the main component, for example at least 50% or 80%. C: minimum 0.3 or 0.4 or 0.5 or 0.6 or 0.7 or 0.9 and/or up to 0.6 or 0.8 or 1 or 1.1 or 1.2 or 1, 3 or 1.5. Si: minimum 0.1 or 0.15 or 0.2 or 0.4 or 0.5 and/or up to 0.6 or 0.8 or 1 or 1.1 or 1.2 or 1.5. Mn: minimum 0.1 or 0.5 or 0.7 or 0.8 or 1 or 1.3 and/or up to 1.1 or 1.2 or 1.3 or 1.7 or 2. Cr: minimum 0, 1 or 0.2 or 0.4 or 0.8 and/or up to 0.15 or 0.3 or 0.6 or 1.2 or 1.5 or 2.

[0025] The rail to be repaired is, for example, of Vignole type or grooved rail type, for example, UIC54 or UIC60 or S33 or EB63 or MRS73 or PRI85 and/or has a weight of at least 40 or 45 or 50 kilos per linear meter. For example, the repair is performed to jointless track and/or a track for which the neutral temperature is between 20 and 27, for example is 23, 24, 25 or 26 degrees Celsius.

%C	%Si	%Mn	%Cr
0,40-0,60	0,15-0,58	0,70-1,20	max. 0,15
0,50-0,60	0,20-0,60	1.00-1,25	0.80-1,20
0,62-0,80	0,15-0,60	1,30-1,70	max 0,30
0,55-0,75	0,50-1,10	0,80-1,20	0,40-0,60
0,60-0,80	0,40-1,00	0,70-1,10	max. 0,60
0,72-0,80	max. 0,80	0,80-1,10	max. 0,30
0,70-0,82		1,00-1,30	

(continued)

%C	%Si	%Mn	%Cr
0,72-0,82			
0,90-1,05			

[0026] This table gives examples of preferred ranges for the elements C, Si, Mn and Cr in wt.%, All combinations and permutations are possible. For example,% C0, 62-0,80 combined with% Si0,20-0,60, no Mn and Cr.

[0027] Hereinafter, the invention is illustrated by means of an example shown in the drawing. Other embodiments are also included in the invention. Shown in:

Fig. 1 in side elevation view a rail with a defect
Fig. 2 shows the section II-II of Fig. 1
Fig. 3 view of the hole in the rail
Fig. 4 in perspective the rail with defect;
Fig. 5 shows the rail of Figure 4 with the hole;
Fig. 6 the track of Fig. 1, repaired.

[0028] The rail 10 has a foot 12, web 13 and head 14. The head 14 includes a squat 15 caused by the train wheels. From the tread surface 50 is machined a vertical hole 20 at the place of the squat 15 (FIG. 3).

[0029] The defect 15 is located, is removed so that a cylindrical hole 20 is formed, a precisely fitting, slightly upwards protruding plug 21 is placed in the hole, the top of the plug is machined with a tool 120 (Fig. 6), so that a smooth riding surface is obtained.

[0030] Fig. 3 shows dotted the wedge-shaped repair described in WO2011119238A1 which extends through the entire rail head and continues into the rail web. This clearly shows the difference with our invention.

[0031] Fig. 3 also shows in sectional side view a detail of the rail head to show the pure cylindrical shape of the hole.

Claims

1. A method of in situ repairing of a defect in a rail which comprises removing a piece of rail head from the upper face of the rail head so that the rail web and the rail foot, and optionally the lower part of the rail head remain unaffected, so that in the rail head a recess is formed which debouches at its upper face, preferably located at a distance (preferably of at least 10 mm) from the sides of the rail head (so that the sides of the rail head remain unaffected), and with a preformed, shape-retaining, preferably closely fitting, steel plug filling of the recess, preferably the shape of the recess and of the plug being congruent in order to restore the original geometry of the rail.

2. A method of in situ repairing of a defect in a rail wherein, in the upper face of the rail head a preferably blind hole is made by removing rail material, so that the rail web and the rail foot, and optionally the lower part of the rail head remain unaffected, so that in the rail head a hole is created that debouches at its upper surface, preferably located at a distance (preferably of at least 10 mm) from the sides of the rail head (so that the sides of the rail head remain unaffected), and with a preformed shape-stable, preferably closely fitting, steel plug filling of the recess, preferably the shape of the recess and of the plug being congruent in order to restore the original geometry of the rail.

3. A method according to claim 1 or 2, wherein the piece of rail head to be removed contains a damage such as a crack, for example, a squat.

4. A method according to any one of claims 1-3, wherein the piece of rail head is located at a location that is determined by a preliminary to the repair carried out inspection of the rail head, preferably by a measurement or inspection means is moving along the track.

5. A method according to any one of claims 1-4,after the placing of the plug is completed, the top surface of the plug projects slightly above the top of the rail head, preferably at least 0.05 and/or less than 0.1 mm, and then preferably the upper surface of the plug is lowered by a machining operation such as grinding or sanding so that the top surface of the plug will be flush with the top surface of the rail head; and/or the recess is made in the tread of the train wheels.

6. A method according to any one of claims 1-5, prior to removal of the piece of rail head an inspection is performed on the rail, to detect a mechanical damage thereto, for example, a squat, and the repair is carried out at the site of the damage.

7. A method according to claim 6, to detect the damage a measuring or inspection means is used, for example, a scanner (for example, equipped with a light source such as laser), or an image camera or with a magnetic field or electric or acoustic field or other field operating, in that e.g. present on board of a vehicle, such as a measuring train.

8. A method according to any one of claims 1-7, of a in the rail track present steel rail a piece is removed from the upper portion of the rail head so that a hole is created in the tread face and the lower portion of the rail head, the rail web and the rail foot remain unaffected, the hole is then filled with a prefabricated, closely fitting and form-retaining steel plug that is permanently attached to the surrounding material of

the rail head to restore the original geometry of the rail; preferably, the attachment is a clamping fit, for example, because the plug is applied to the hole in a shrunken state, for example, because it is considerably colder, for example, at least 50 or 100 or 150 degrees Celsius (for example, cooled by liquid CO2 or N2 or 02) than the rail to be repaired.

9. A method according to any one of claims 1-8, while in the temporary shrunken state the plug, with a diameter being equal to or slightly smaller than the hole diameter, is placed in the hole after which the plug is allowed to expand, for instance in that the plug heats up to the temperature of the rail head so that the plug diameter seeks to increase and thus the plug becomes jammed into the hole.

10. A method according to any one of claims 1-9, for the plug one or more of the following applies: a cylindrical or parallelepiped; height greater than 5 or 10 mm and/or less than 30 or 20 or 15 mm; diameter greater than 5 or 10 mm and/or less than 40 or 30 or 25 mm; contiguous edges are perpendicular to each other; an axial taper of no more than 3, 2 or 1 degrees; of an alloy substantially identical to that of the rail head; one or more of tensile strength, yield strength, elongation at break and hardness substantially equal to or greater than that of the rail head; flat bottom and/or top; contains one or more of Fe, Cr, Mn, Si.

11. A method according to any one of claims 1-10, for the hole one or more of the following applies: a cylindrical or parallelepiped; a depth greater than 5 or 10 mm and/or less than 30 or 20 or 15 mm; depth less than 50% of the height of the rail head; diameter greater than 5 or 10 mm and/or less than 40 or 30 or 25 mm; diameter less than 50% of the width of the rail head; contiguous edges are perpendicular to each other; an axial taper of no more than 3, 2 or 1 degrees; at least 10 or 15 or 20 mm distance from the sides of the rail head; is located in the contact area between the driving or tread face of the wheels of the train and the upper surface of the rail head; made by spark milling or drilling or milling or another machining operation, preferably milling with a milling tool to create a flat hole bottom and after milling the hole bottom and wall are not exposed to a the quality, in particular, the accuracy of one or more of roundness, depth and the diameter of the hole improving mechanical machining with a tool and/or with a milling tool of which the diameter is equal to the hole diameter; made with an indeed or not to center cutting mill; in depth and/or diameter smaller than that of the plug at the same temperature, preferably at least 0.005 mm at 20 degrees Celsius; flat bottom.

12. A method according to any one of claims 1-11, applied to one or more of: welded or jointless track; rail curve; switch, for example, frog or stock rail or tongue.

13. A method according to any one of claims 1-12, the recess is vertical, or up to 10 degrees from the vertical oriented, and/or is made, with tool, the orientation of which during making the recess is oriented vertical, or deviates up to 10 degrees from vertical.

14. A method according to any one of claims 1-13, the repair is carried out:

a) at a distance to the dilatation joint beyond 50 or 100 or 150 or 200 cm: and/or
b) after the track is used for intensive train traffic for a minimum of one month or a year or two or five years.

15. Plug, intended for the repair as claimed in any one of claims 1-14.

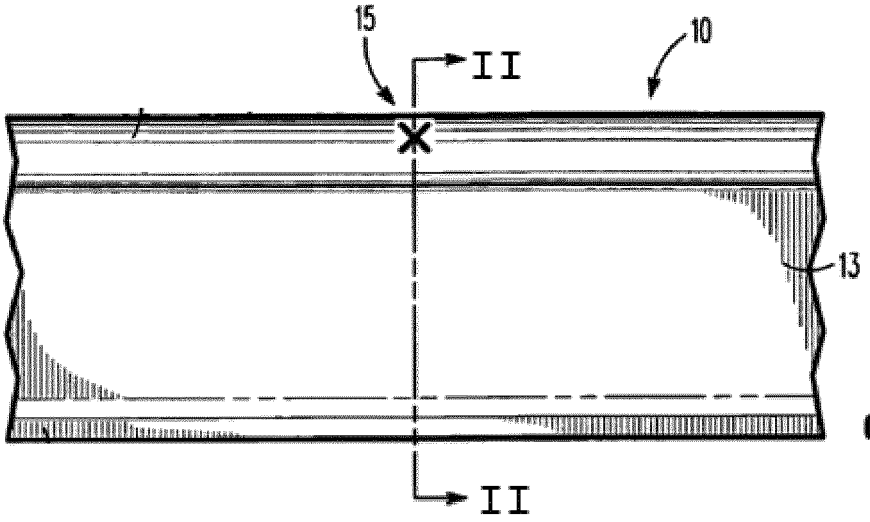

Fig. 1

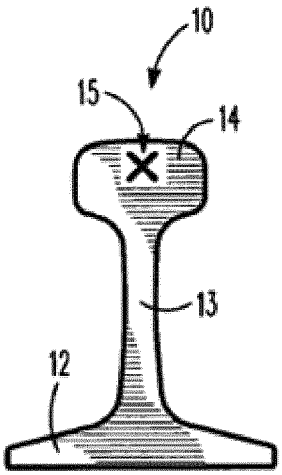

Fig. 2

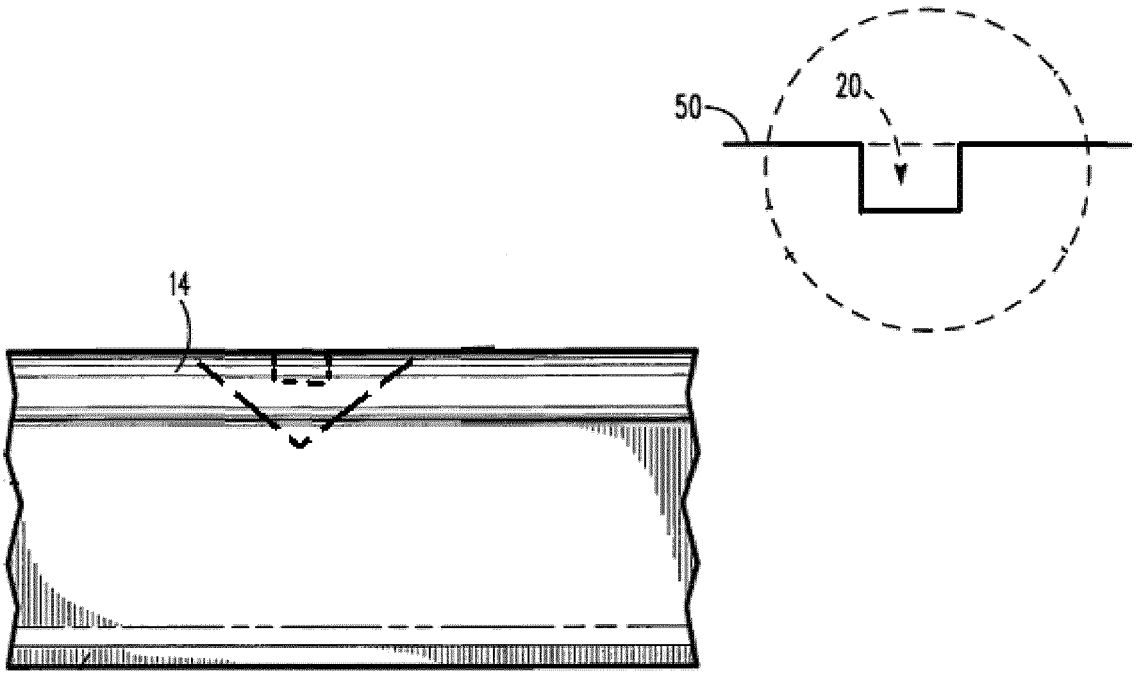

Fig. 3

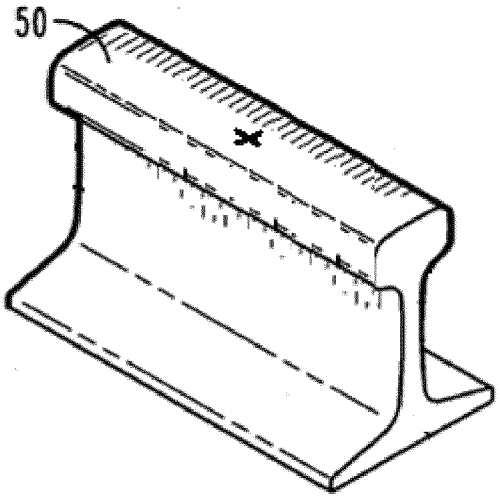

Fig. 4

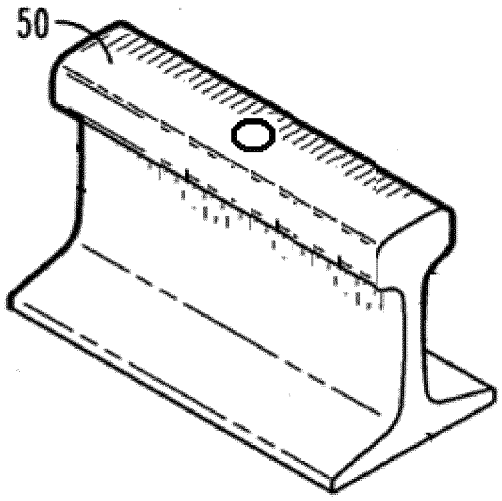

Fig. 5

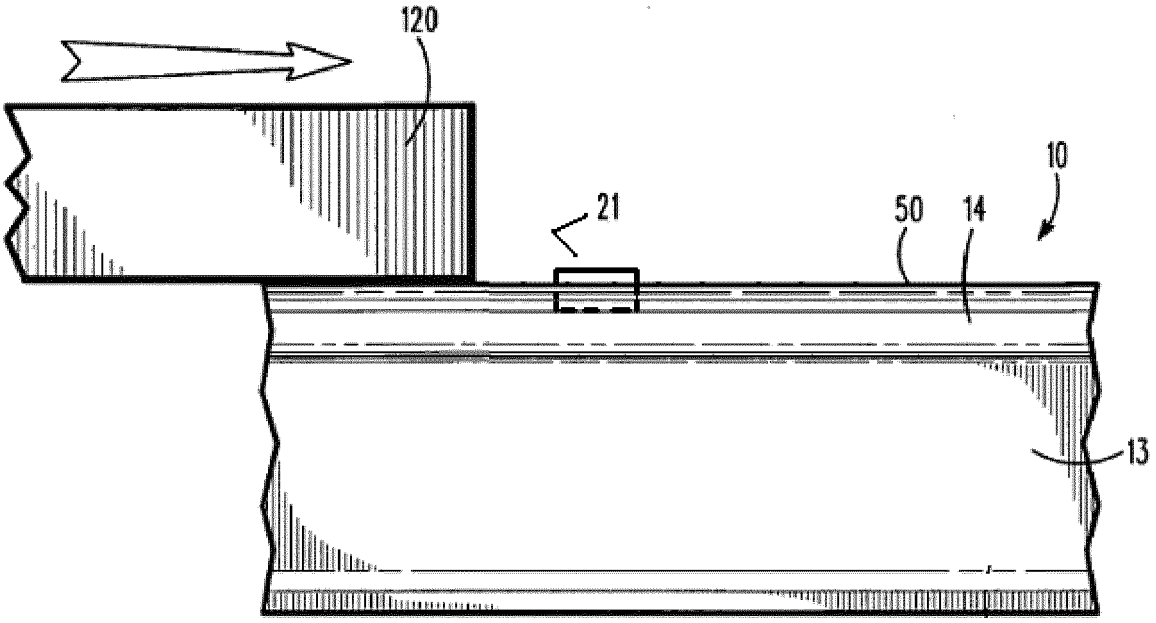

Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 17 17 6510

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,D A	WO 2011/119238 A1 (HOLLAND LP [US]) 29 September 2011 (2011-09-29) * claim 1; figures 1-18 *	1,3-7, 12,14,15 2	INV. E01B31/18
X A	FR 772 282 A (GENNEVILLIERS ACIERIES [FR]) 26 October 1934 (1934-10-26) * claim 1; figures 1-9 *	1,3, 12-15 2	
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A	WO 2004/014708 A2 (HOLLAND LP [US]; COOMER DANIEL J [US]) 19 February 2004 (2004-02-19) * claim 1; figures 1-4 *	1-4,6,7, 12-14	

TECHNICAL FIELDS SEARCHED (IPC)
B23K B23P E01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	26 October 2017	Fernandez, Eva

CATEGORY OF CITED DOCUMENTS

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26-10-2017

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

REFERENCES CITED IN THE DESCRIPTION

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