



## Description

**[0001]** A device for inducing mechanical vibrations and a method for inducing mechanical vibrations are provided.

**[0002]** Distributed acoustic sensing can be employed in railway monitoring. For this purpose a laser pulse is fed into an optical fibre extending along the railway track. By analyzing the backscattered signal noise on and around the railway track can be detected. From the shape of the backscattered signal passing rail vehicles and different conditions of the rail can be distinguished from other noise. The position along the railway track where a particular signal is detected can be determined from the backscattered signal. Different events along the railway track can lead to a characteristic shape of the backscattered signal, respectively. In this way, the position of a passing rail vehicle or the position of other noise along the railway track can be determined.

**[0003]** However, some events that can occur along a railway track do not occur very frequently. An example are rail breaks. If a rail break occurs a characteristic shape can be detected in the backscattered signal when a rail vehicle passes over the rail break. However, due to the small number of events only a small number of examples can be employed to determine the characteristic shape of the backscattered signal for these events. With only a small number of examples, the reliability of identifying a certain event is low.

**[0004]** It is an objective to provide a device for inducing mechanical vibrations with an increased reliability. It is further an objective to provide a method for inducing mechanical vibrations with an increased reliability.

**[0005]** These objectives are achieved with the independent claims. Further embodiments are the subject of dependent claims.

**[0006]** According to at least one embodiment of the device for inducing mechanical vibrations, the device is configured to induce mechanical vibrations at the position of the device during the passage of a rail vehicle at the position of the device, wherein the device is connectable to a rail on which the rail vehicle is moving. That the device is configured to induce mechanical vibrations can mean that the device can cause mechanical vibrations at or around the rail at the position of the device during the passage of the rail vehicle over the rail at the position of the device. It is further possible that the presence of the device can lead to mechanical vibrations at or around the rail at the position of the device during the passage of the rail vehicle over the rail at the position of the device. It is further possible that the device is configured to produce mechanical vibrations at or around the rail at the position of the device during the passage of the rail vehicle over the rail at the position of the device. The rail can extend over several meters and kilometers. This means, when mechanical vibrations are induced at or around the rail the mechanical vibrations can propagate around the rail. For example, the mechanical vibrations

induced at the rail can propagate within the ground below the rail.

**[0007]** That the mechanical vibrations are induced at the position of the device means, that the mechanical vibrations originate at the position of the device and can then propagate. That the mechanical vibrations are induced during the passage of the rail vehicle at the position of the device means that the mechanical vibrations are induced at the moment when the rail vehicle passes the position where the device is arranged. The device can be configured to induce mechanical vibrations at or around a rail at the position of the device during the passage of one wheel of the rail vehicle over the rail at the position of the device. The device can be fixed to the rail. Thus, the mechanical vibrations can be induced by the device at the moment when one wheel of the passing rail vehicle passes over the position along the rail where the device is arranged.

**[0008]** Inducing mechanical vibrations during the passage of a rail vehicle at a certain position can be employed in different situations. The mechanical vibrations caused by the passage of a rail vehicle over a rail can be detected by a distributed acoustic sensor arranged along the rail. It is known to employ distributed acoustic sensing for the monitoring of rail vehicles moving along a railway track and for monitoring the condition of the rail or the condition of the wheels of the rail vehicle.

**[0009]** The distributed acoustic sensor comprises an optical fibre arranged along the railway track. The optical fibre can be arranged within the ground close to the railway track. It is further possible that the optical fibre is arranged above the ground close to the railway track. The optical fibre extends approximately parallel to the railway track. An input signal can be provided to the optical fibre. The input signal can be an optical signal, for example a laser pulse. The input signal is provided to the optical fibre at an input of the optical fibre. A small part of the laser light is reflected back to the input since the laser light is scattered at scatter sites, as for example impurities, in the optical fibre which can be natural or artificial. Changes in the backscattered signal are related to physical changes in the optical fibre which can be caused by noise, structure-borne noise, vibrations or soundwaves along the optical fibre. Therefore, a backscattered signal can be detected when a rail vehicle is moving on the track.

**[0010]** If the shape of the backscattered signal for the passage of a regular rail vehicle over the railway track is known it can be determined from the backscattered signal at which position additional mechanical vibrations are induced. In this way, it is possible to determine when the rail vehicle passes the position of the device where the additional mechanical vibrations are induced. Thus, the location of the rail vehicle can be determined. It is further possible to induce mechanical vibrations by the device that lead to a characteristic shape of the backscattered signal at the position of the device, wherein the shape of the backscattered signal can be characteristic for a cer-

tain event along the railway track. Such an event can be for example a rail break, other damages to the rail, other noise around the rail or a damage to the rail vehicle. At least for some of the events it is difficult to collect a large amount of data as these events do not occur very frequently. By inducing mechanical vibrations in such a way that the backscattered signal has a shape that is characteristic for one of these events, the event is only simulated but does not have to take place.

**[0011]** This means, the backscattered signal has a similar shape for on the one hand the passage of the rail vehicle over the rail in the region of the device and on the other hand for the passage of the rail vehicle over a rail where one of these events occurred or occurs. The mechanical vibrations caused in these two different situations can be similar in amplitude. Furthermore, the mechanical vibrations caused in these two different situations can be similar in amplitude for a certain period of time during and after the passage of the rail vehicle. Moreover, the mechanical vibrations caused in these two different situations can have similar frequencies. However, when the device is employed these events do not take place, they are only simulated.

**[0012]** This simulation has the advantage that data detected by a distributed acoustic sensor arranged along the rail can be collected without the disadvantages of a real event, such as a rail break. For algorithm development and validation as for example machine learning algorithms it is necessary to collect a large amount of data. By employing the device this collection is possible. Employing the device does not damage the rail and the rail vehicle, no material is removed from the rail and there is no risk of a derailment of the rail vehicle. Thus, no repair of the rail is required after using the device.

**[0013]** Furthermore, the device can be employed as often as it is required. It is thus not necessary as in the case of real events to wait for an event to happen. Moreover, the device can be employed in plannable test situations. It is further advantageous that the parameters of the situations in which an event is simulated can be controlled or chosen. It is possible to choose parameters as the location where the device is arranged along the track and along the rail, the speed of the passing rail vehicle, the time during the day and the type of the rail vehicle. For real events these parameters cannot always be chosen. By collecting more data about the shape of the backscattered signal detected by the distributed acoustic sensor in the situation of a simulated event increases the accuracy in determining the occurrence of a real event which increases the reliability.

**[0014]** The simulation of an event is particularly advantageous for simulating a rail break. If a rail vehicle passes over a rail break of a rail mechanical vibrations are induced around the rail break. These mechanical vibrations can be caused by a slit or a step within the rail due to the rail break where the wheels of the rail vehicle have to overcome the slit or the step. Thus, in the region of the rail break wheels of the passing rail vehicle make an im-

pact when moving over a slit or a step. This means, in the region of the rail break wheels of the passing rail vehicle can hit the rail. It is also possible that within the broken rail an impact is induced by the passage of a rail vehicle. An impact or a hit causes mechanical vibrations around the rail in the region of the rail break.

**[0015]** At the position of a rail break the amplitude of the backscattered signal is usually increased in comparison to positions where there is no rail break. Furthermore, the backscattered signal usually has a characteristic shape at the position of a rail break.

**[0016]** When employing the device the mechanical vibrations that are induced at or around the rail during the passage of a rail vehicle over the rail in the region of the device are similar to the mechanical vibrations caused by the passage of the rail vehicle over a rail break. This means, the backscattered signal has a similar shape for on the one hand the passage of the rail vehicle over the rail in the region of the device and on the other hand for the passage of the rail vehicle over a rail break. The mechanical vibrations caused in these two different situations can be similar in amplitude. Furthermore, the mechanical vibrations caused in these two different situations can be similar in amplitude for a certain period of time during and after the passage of the rail vehicle. Moreover, the mechanical vibrations caused in these two different situations can have similar frequencies. However, when the device is employed no rail break is present in the region around the device. Thus, the device can be employed for simulating a rail break. When employing the device similar mechanical vibrations can be induced in comparison to the situation of a rail break. However, no rail break causes the mechanical vibrations but the device for simulating a rail break. Consequently, no real rail break is present but the rail break is only simulated. Thus, the device can be a device for simulating a rail break.

**[0017]** Advantageously, the device can be employed as often as it is required. It is thus not necessary as in the case of real rail breaks to wait for a rail break to happen. Collecting data about the shape of the backscattered signal detected by the distributed acoustic sensor in the situation of a simulated rail break increases the accuracy in determining the occurrence of a real rail break which increases the reliability and the overall safety.

**[0018]** According to at least one embodiment of the device for inducing mechanical vibrations, the device comprises a mounting part, that is connectable to the rail, and a noise part, wherein the noise part is configured in such a way that the intensity of mechanical vibrations caused by the passage of the rail vehicle on the rail at the position of the device is higher than without the device. The mounting part can be configured to be fixed to the rail at the side of the rail which faces away from the side where wheels of rail vehicles are passing. This means, the mounting part is arranged below the rail. The mounting part can be a rail claw. The mounting part and

the noise part are connected with each other. The mounting part and the noise part can be reversibly connected with each other. The noise part can comprise a metal and/or steel. The noise part can be configured to induce the mechanical vibrations at or around the rail during the passage of the rail vehicle over the rail, wherein the mechanical vibrations are similar to mechanical vibrations caused by the passage of the rail vehicle over the rail at the position of the device for the case that an event occurred or occurs at or around the rail. The intensity of the mechanical vibrations caused by the passage of the rail vehicle on the rail at the position of the device is higher than without the device in order to simulate an event, as for example a rail break. If a rail break is present the mechanical vibrations caused by the passage of a rail vehicle have a higher intensity at the position of the rail break in comparison to positions where there is no rail break. Thus, in order to simulate a rail break mechanical vibrations with an intensity that is higher than in a situation without a rail break are induced by the noise part. Also for other events along the railway track the mechanical vibrations caused by the passage of a rail vehicle at the position of the event have a higher intensity at the position of the event in comparison to positions where there is no event. By employing the device the disadvantages of real events such as rail breaks are avoided and a large amount of data detected by a distributed acoustic sensor can be collected.

**[0019]** According to at least one embodiment of the device for inducing mechanical vibrations, the noise part comprises a plate region and the plate region has a bottom area that faces a part of the mounting part. The plate region and/or the noise part can comprise a plate. Different shapes are possible for the plate region and/or the noise part. For example, the plate region and/or the noise part has the shape of a rectangle. The plate region and/or the noise part can comprise a metal and/or steel. The bottom area of the plate region can face the part of the mounting part that is arranged below the rail when mounted. This means, the bottom area of the plate region can face the rail when mounted. The bottom area of the plate region can face a top side of the rail head of the rail when mounted. The bottom area of the plate region can be in direct contact with the rail when mounted. The bottom area of the plate region can be in direct contact with the top side of the rail head of the rail when mounted. The bottom area of the plate region can extend exclusively within one plane. This means, the bottom area of the plate region can be flat.

**[0020]** In a direction that runs perpendicular to the direction of travel of a passing rail vehicle the plate region can have an extension that is at most three times the extension of the rail head in this direction. The plate region can have an extension in a direction that runs perpendicular to the direction of travel of a passing rail vehicle that is at most twice the extension of the rail head in this direction.

**[0021]** In order to employ the device for inducing me-

chanical vibrations the device is mounted to a rail in such a way that the noise part is in direct contact with the rail, in particular the bottom area of the plate region is in direct contact with the rail. The bottom area can be in direct contact with the top side of the rail head of the rail. This means, the plate region is arranged on the area of the railhead on which the wheels of a passing rail vehicle move. When a rail vehicle moves over the position of the device, the wheels of the rail vehicle move over the plate region. When moving onto the plate region or when moving back onto the rail or in between the passing wheel hits the plate region. A hit or mechanical impact occurs when the wheel has to overcome a step. This step can be formed when the wheel moves onto the plate region, when it moves back onto the rail or both. It is also possible that a step is arranged on a top area of the plate region where the top area faces away from the bottom area. The step extends in a vertical direction that runs perpendicular to the plane within which the bottom area of the plate region extends. The hit causes mechanical vibrations around the position of the device. The intensity of these mechanical vibrations is larger than for the case that no device for inducing mechanical vibrations is arranged at this position. By inducing these mechanical vibrations a rail break or another event can be simulated. The mechanical vibrations caused by the passage of a rail vehicle over the plate region can be similar to the mechanical vibrations caused by the passage of the rail vehicle over a rail break or over a position where another event occurred or occurs. Advantageously, in this way a large amount of data can be collected without the disadvantages of a real rail break or a real event. It is also possible that these mechanical vibrations are induced in another way than by passing of a wheel over a step.

**[0022]** According to at least one embodiment of the device for inducing mechanical vibrations, the plate region has an extension in a vertical direction that runs perpendicular to the plane within which the bottom area of the plate region extends. This means, the plate region has a thickness in the vertical direction.

**[0023]** According to at least one embodiment of the device for inducing mechanical vibrations, the extension of the plate region in the vertical direction amounts to 5 cm at most. It is possible that the extension of the plate region in the vertical direction amounts to 3 cm at most. It is further possible that the extension of the plate region in the vertical direction amounts to 2,5 cm at most. In this way, a derailment of rail vehicles passing over the plate region is avoided.

**[0024]** According to at least one embodiment of the device for inducing mechanical vibrations, the plate region has a top area that extends in a plane that extends parallel to the plane within which the bottom area extends. This means, the top area and the bottom area of the plate region extend parallel to each other. It is possible that the whole bottom area of the plate region extends within one plane. It is also possible that the whole top area of the plate region extends within one plane.

This means, the plate region has a flat top area and a flat bottom area. Thus, the plate region can have the shape of a cuboid. A mechanical impact occurs once a wheel of a passing rail vehicle enters the plate region and once the wheel falls back onto the rail. With the device comprising the plate region an event occurring at the position of the device can be simulated by inducing mechanical vibrations that are similar to mechanical vibrations that occur during this event. For example, a rail break can be simulated.

**[0025]** According to at least one embodiment of the device for inducing mechanical vibrations, the extension of the plate region in the vertical direction changes along a lateral direction that runs perpendicular to the vertical direction. This means, the thickness of the plate region is not constant. The thickness of the plate region is different for different regions of the plate region. For example, the extension of the plate region in the vertical direction can increase and decrease again from a first side of the plate region to a second side of the plate region. With the device comprising the plate region an event occurring at the position of the device can be simulated by inducing mechanical vibrations that are similar to mechanical vibrations that occur during this event. For example, a rail break can be simulated.

**[0026]** According to at least one embodiment of the device for inducing mechanical vibrations, the extension of the plate region in the vertical direction is larger at a second side of the plate region than at a first side of the plate region. A wheel of a rail vehicle passing the position of the device at first reaches the first side of the plate region. The first side of the plate region can be very thin in the vertical direction. Thus, the wheel of the rail vehicle can easily move onto the plate region. At the second side of the plate region there is a larger distance than at the first side between the top side of the plate region and the top side of the rail. When the wheel reaches the second side it falls down back on the rail after passing the plate region. Thus, the wheel hits the rail after passing the plate region.

**[0027]** The thickness of the plate region is larger at the second side of the plate region than at the first side of the plate region. The thickness is given in the vertical direction. The thickness of the plate region can increase from the first side to the second side. Thus, the plate region can have the shape of a ramp. The first side of the plate region can be arranged at a side of the noise part that is reached at first, this means before the second side, by a wheel of a passing rail vehicle. Within a plane that extends perpendicular to the vertical direction the plate region can have the shape of a rectangle. With this shape of the plate region it is possible to induce mechanical vibrations during the passage of a rail vehicle that are similar to mechanical vibrations induced by the passage of a rail vehicle over a rail break.

**[0028]** According to at least one embodiment of the device for inducing mechanical vibrations, the extension of the plate region in the vertical direction increases from

the first side to the second side. Thus, the plate region can have the shape of a ramp. With this shape of the plate region it is possible to induce mechanical vibrations during the passage of a rail vehicle that are similar to mechanical vibrations induced by the passage of a rail vehicle over a rail break.

**[0029]** According to at least one embodiment of the device for inducing mechanical vibrations, the noise part comprises a connection region that is connected with the mounting part. The connection region can be a plate. The connection region can be in direct contact with the plate region. The connection region can be mechanically connected with the mounting part. At least a part of the connection region can extend transverse with respect to a side part of the mounting part. At least a part of the connection region can extend within the same plane as the bottom area of the plate region. The connection region has the advantage that via the connection region the noise part can be connected mechanically stable with the mounting part.

**[0030]** According to at least one embodiment of the device for inducing mechanical vibrations, at least a part of the connection region extends parallel to a top part of the mounting part. The top part of the mounting part can extend within a plane that extends parallel to the plane within which the bottom area of the plate region extends. The parallel extension of the connection region and the top part of the mounting part increases the mechanical stability of the connection between the noise part and the mounting part.

**[0031]** According to at least one embodiment of the device for inducing mechanical vibrations, the connection region comprises at least one mounting hole. The mounting hole can extend in the vertical direction. The mounting hole enables a mechanical connection between the connection region and the mounting part via a screw arranged within the mounting hole.

**[0032]** According to at least one embodiment of the device for inducing mechanical vibrations, the noise part is connected with the mounting part with at least one screw. The screw can be arranged within the mounting hole. The connection via at least one screw allows to reversibly fix the noise part to the mounting part in a stable way.

**[0033]** According to at least one embodiment of the device for inducing mechanical vibrations, the mounting part with the noise part is reversibly connectable to the rail. The mounting part can be connectable to the rail via at least one screw. As the mounting part is reversibly connectable to the rail it can advantageously be reused at different positions.

**[0034]** Furthermore, a method for inducing mechanical vibrations is provided. The device for inducing mechanical vibrations can preferably be employed in the method described herein. This means all features disclosed for the device for inducing mechanical vibrations are also disclosed for the method for inducing mechanical vibrations and vice-versa.

**[0035]** According to at least one embodiment of the method for inducing mechanical vibrations, the method comprises inducing mechanical vibrations by a device for inducing mechanical vibrations at the position of the device during the passage of a rail vehicle over a rail at the position of the device. In this way, an event along the railway track as for example a rail break can be simulated.

**[0036]** Simulating an event such as a rail break has the advantage that the disadvantages of a real event are avoided and that the simulation can be carried out under predefined conditions. In this way, a large amount of data can be collected from the simulation of events. The data can for example be collected by a distributed acoustic sensor arranged along the railway track.

**[0037]** According to at least one embodiment of the method for inducing mechanical vibrations, the device comprises a mounting part and a noise part, wherein the noise part is configured in such a way that the intensity of mechanical vibrations caused by the passage of the rail vehicle is higher than without the device. The device can be a device for simulating a rail break.

**[0038]** According to at least one embodiment of the method for inducing mechanical vibrations, the device is connected to the rail. The device can be connected to the rail in such a way that at least a part of the mounting part is arranged at a side of the rail that faces away from the neighboring part of the rail. For a railway track two parts of a rail extend parallel to each other. At least a part of the mounting part can be arranged at the side of a part of the rail that faces away from the other part of the rail. The device has the advantage that it can be reused and it does not damage the rail.

**[0039]** According to at least one embodiment of the method for inducing mechanical vibrations, the noise part comprises a plate region, wherein a bottom area of the plate region is in direct contact with a top side of the rail head of the rail. The bottom area of the plate region is in direct contact with the top side of the rail head of the rail when the device is connected to the rail and when the device is employed. In this way, wheels of a passing rail vehicle can easily move over the plate region.

**[0040]** The plate region can have the shape of a ramp. Thus, the plate region can have a slope. In order to simulate different rail break situations it is possible to employ different plate regions that have different slopes. Therefore, the method enables to collect data from a simulated rail break and it is possible to collect the data for different conditions.

**[0041]** According to at least one embodiment of the method for inducing mechanical vibrations, signals of a distributed acoustic sensor arranged along the rail are detected during the passage of the rail vehicle over the rail. This means, signals of the distributed acoustic sensor can be detected during the passage of the rail vehicle over the rail at the position of the device. In this way, mechanical vibrations induced by the passage of the rail vehicle over the plate region can be detected by the distributed acoustic sensor. Thus, it is possible to collect a

large amount of signals detected by the distributed acoustic sensor in case of a simulated event such as a rail break.

**[0042]** The following description of figures may further illustrate and explain exemplary embodiments. Components that are functionally identical or have an identical effect are denoted by identical references. Identical or effectively identical components might be described only with respect to the figures where they occur first. Their description is not necessarily repeated in successive figures.

Figures 1 and 2 show exemplary embodiments of the device for inducing mechanical vibrations.

Figures 3, 4, 5 and 6 show noise parts of an exemplary embodiment of the device for inducing mechanical vibrations.

Figure 7 shows another exemplary embodiment of the device for inducing mechanical vibrations.

With figure 8 an exemplary embodiment of the method for inducing mechanical vibrations is described.

Figure 9 shows an exemplary embodiment of the device with a rail.

Figures 10 and 11 show noise parts of further exemplary embodiments of the device for inducing mechanical vibrations.

**[0043]** Figure 1 shows an exemplary embodiment of the device 10 for inducing mechanical vibrations. The device 10 is configured to induce mechanical vibrations at the position of the device 10 during the passage of a rail vehicle at the position of the device 10, wherein the device 10 is connectable to a rail 11 on which the rail vehicle is moving. The device 10 comprises a mounting part 12 that is connectable to the rail 11. In figure 1 the device 10 is shown in its configuration where it is connected to the rail 11. The mounting part 12 can comprise a rail claw. A part of the mounting part 12 is arranged below the rail 11 and it is fixed to the rail 11 from below. The mounting part 12 is fixed to the rail 11 by screws 21. The mounting part 12 comprises a side part 22 that is fixed to the part of the mounting part 12 below the rail 11 by screws 21. The mounting part 12 further comprises a top part 19 that is connected to the side part 22. The top part 19 has a main plane of extension which extends perpendicular to a main plane of extension of the side part 22.

**[0044]** The device 10 further comprises a noise part 13. The noise part 13 is configured in such a way that the intensity of mechanical vibrations caused by the passage of the rail vehicle on the rail 11 at the position of the device 10 is higher than without the device 10. For this purpose the noise part 13 comprises a plate region

14, which has a bottom area 15 that faces a part of the mounting part 12. When the device 10 is mounted to the rail 11 the bottom area 15 faces the rail 11. As the mounting part 12 is partially arranged below the rail 11 the bottom area 15 also faces a part of the mounting part 12. The plate region 14 has an extension in a vertical direction  $z$  that runs perpendicular to the plane within which the bottom area 15 of the plate region 14 extends.

[0045] In figure 1, the extension of the plate region 14 in the vertical direction  $z$  changes along a lateral direction  $l$  that runs perpendicular to the vertical direction  $z$ . The lateral direction  $l$  extends along the main direction of extension of the rail 11. The extension of the plate region 14 in the vertical direction  $z$  is larger at a second side 17 of the plate region 14 than at a first side 16 of the plate region 14.

[0046] In figure 1 the first side 16 of the plate region 14 is shown in the front and the second side 17 is shown in the back. The extension of the plate region 14 in the vertical direction  $z$  increases from the first side 16 to the second side 17. The extension of the plate region 14 in the vertical direction  $z$  amounts to 5 cm at most.

[0047] When the device 10 is connected to the rail 11 as it is shown in figure 1 the bottom area 15 of the plate region 14 is in direct contact with a top side 24 of the rail head 23 of the rail 11. In this way, rail vehicles moving on the rail 11 can move onto the plate region 14 at the first side 16 and drop back onto the rail 11 at the second side 17.

[0048] The noise part 13 further comprises a connection region 18 that is connected with the mounting part 12. The connection region 18 is also connected with the plate region 14. The plate region 14 and the connection region 18 together form a plate. The thickness of the connection region 18 in the vertical direction  $z$  is larger than the thickness of the plate region 14 at the second side 17. At least a part of the connection region 18 extends parallel to the top part 19 of the mounting part 12. The connection region 18 comprises two mounting holes 20. The connection region 18 can be connected with the mounting part 12 with screws 21 arranged within the mounting holes 20.

[0049] The mounting part 12 with the noise part 13 is reversibly connectable to the rail 11 as the mounting part 12 is connected to the rail 11 by screws 21.

[0050] Figure 2 shows a different view on the exemplary embodiment of the device 10 for inducing mechanical vibrations shown in figure 1.

[0051] Figure 3 shows the noise part 13 of the exemplary embodiment of the device 10 for inducing mechanical vibrations shown in figures 1 and 2. The noise part 13 is shown without the other parts of the device 10. The noise part 13 comprises the plate region 14 and the connection region 18. The noise part 13 is shown in its position when the device 10 is mounted to the rail 11 so that the bottom area 15 of the plate region 14 is in direct contact with the rail 11.

[0052] Figure 4 shows the noise part 13 shown in figure

3 without the rail 11, wherein the noise part 13 comprises the plate region 14 and the connection region 18.

[0053] Figure 5 shows a different view on the noise part 13 shown in figure 3. The noise part 13 is shown in its position when the device 10 is mounted to the rail 11.

[0054] Figure 6 shows the noise part 13 shown in figure 5 without the rail 11.

[0055] Figure 7 shows another exemplary embodiment of the device 10 for inducing mechanical vibrations. The device 10 has the same setup as shown in figure 1 with the only differences that the noise part 13 is connected with the mounting part 12 with two screws 21 and that the side part 22 comprises two screws 21 arranged within mounting holes 20. In order to connect the noise part 13 with the mounting part 12, in each mounting hole 20 of the connection region 18 one screw 21 is arranged. Thus, the screws 21 are arranged within the mounting holes 20 of the connection region 18 and within mounting holes 20 of the top part 19 of the mounting part 12. In this way, the noise part 13 can be reversibly connected with the mounting part 12. The side part 22 of the mounting part 12 comprises two mounting holes 20 within which one screw 21 is arranged, respectively. In this way, different parts of the mounting part 12 are connected with each other.

[0056] With figure 8 an exemplary embodiment of the method for inducing mechanical vibrations is described. In a first step S1 a rail vehicle passes over a rail 11. In a second step S2 mechanical vibrations are induced by the device 10 for inducing mechanical vibrations at the position of the device 10 during the passage of a rail vehicle over the rail 11 at the position of the device 10. The device 10 is connected to the rail 11 and the bottom area 15 of the plate region 14 is in direct contact with a top side 24 of the rail head 23 of the rail 11. Signals of a distributed acoustic sensor 25 arranged along the rail 11 can be detected during the passage of the rail vehicle over the rail 11.

[0057] Figure 9 shows an exemplary embodiment of the device 10 with a rail 11. The device 10 is connected to the rail 11. A distributed acoustic sensor 25 comprising an optical fibre 26 extends along the rail 11.

[0058] Figure 10 shows a noise part 13 of a further exemplary embodiment of the device 10. The plate region 14 of the noise part 13 has a top area 27 that extends in a plane that extends parallel to the plane within which the bottom area 15 extends. The plate region 14 is thin enough so that the wheel of a passing rail vehicle can pass over the plate region 14. For this purpose the extension of the plate region 14 in the vertical direction  $z$  amounts to 5 cm at most.

[0059] Figure 11 shows a noise part 13 of a further exemplary embodiment of the device 10. The extension of the plate region 14 in the vertical direction  $z$  increases and decreases again from the first side 16 of the plate region 14 to the second side 17 of the plate region 14. This means, the plate region 14 has the shape of two ramps that are connected with each other at their posi-

tions of maximum extent in the vertical direction z.

#### Reference numerals

#### [0060]

10: device  
 11: rail  
 12: mounting part  
 13: noise part  
 14: plate region  
 15: bottom area  
 16: first side  
 17: second side  
 18: connection region  
 19: top part  
 20: mounting hole  
 21: screw  
 22: side part  
 23: rail head  
 24: top side  
 25: distributed acoustic sensor  
 26: optical fibre  
 27: top area  
 l: lateral direction  
 S1, S2: steps  
 z: vertical direction

#### Claims

1. Device (10) for inducing mechanical vibrations, the device (10) being configured to induce mechanical vibrations at the position of the device (10) during the passage of a rail vehicle at the position of the device (10), wherein the device (10) is connectable to a rail (11) on which the rail vehicle is moving.
2. Device (10) for inducing mechanical vibrations according to the preceding claim, wherein the device (10) comprises
  - a mounting part (12), that is connectable to the rail (11), and
  - a noise part (13), wherein
  - the noise part (13) is configured in such a way that the intensity of mechanical vibrations caused by the passage of the rail vehicle on the rail (11) at the position of the device (10) is higher than without the device (10).
3. Device (10) for inducing mechanical vibrations according to the preceding claim, wherein the noise part (13) comprises a plate region (14), the plate region (14) has a bottom area (15) that faces a part of the mounting part (12), and the plate region (14) has an extension in a vertical direction (z) that runs perpendicular to the plane within which the bottom area

(15) of the plate region (14) extends.

4. Device (10) for inducing mechanical vibrations according to claim 3, wherein the extension of the plate region (14) in the vertical direction (z) amounts to 5 cm at most.
5. Device (10) for inducing mechanical vibrations according to one of claims 3 or 4, wherein the plate region (14) has a top area (27) that extends in a plane that extends parallel to the plane within which the bottom area (15) extends.
6. Device (10) for inducing mechanical vibrations according to one of claims 3 or 4, wherein the extension of the plate region (14) in the vertical direction (z) changes along a lateral direction (l) that runs perpendicular to the vertical direction (z).
7. Device (10) for inducing mechanical vibrations according to claim 6, wherein the extension of the plate region (14) in the vertical direction (z) is larger at a second side (17) of the plate region (14) than at a first side (16) of the plate region (14).
8. Device (10) for inducing mechanical vibrations according to one of claims 2 to 7, wherein the noise part (13) comprises a connection region (18) that is connected with the mounting part (12).
9. Device (10) for inducing mechanical vibrations according to the preceding claim, wherein at least a part of the connection region (18) extends parallel to a top part (19) of the mounting part (12).
10. Device (10) for inducing mechanical vibrations according to one of claims 2 to 9, wherein the noise part (13) is connected with the mounting part (12) with at least one screw (21).
11. Device (10) for inducing mechanical vibrations according to one of claims 2 to 10, wherein the mounting part (12) with the noise part (13) is reversibly connectable to the rail (11).
12. Method for inducing mechanical vibrations, the method comprising inducing mechanical vibrations by a device (10) for inducing mechanical vibrations at the position of the device (10) during the passage of a rail vehicle over a rail (11) at the position of the device (10).
13. Method for inducing mechanical vibrations according to the preceding claim, wherein the device (10) comprises a mounting part (12) and a noise part (13), wherein the device (10) is connected to the rail (11) and the noise part (13) is configured in such a way that the intensity of mechanical vibrations caused by

the passage of the rail vehicle is higher than without the device (10).

14. Method for inducing mechanical vibrations according to the preceding claim, wherein the noise part (13) comprises a plate region (14), wherein a bottom area (15) of the plate region (14) is in direct contact with a top side (24) of the rail head (23) of the rail (11). 5
15. Method for inducing mechanical vibrations according to one of claims 12 to 14, wherein signals of a distributed acoustic sensor (25) arranged along the rail (11) are detected during the passage of the rail vehicle over the rail (11) . 10

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FIG. 1

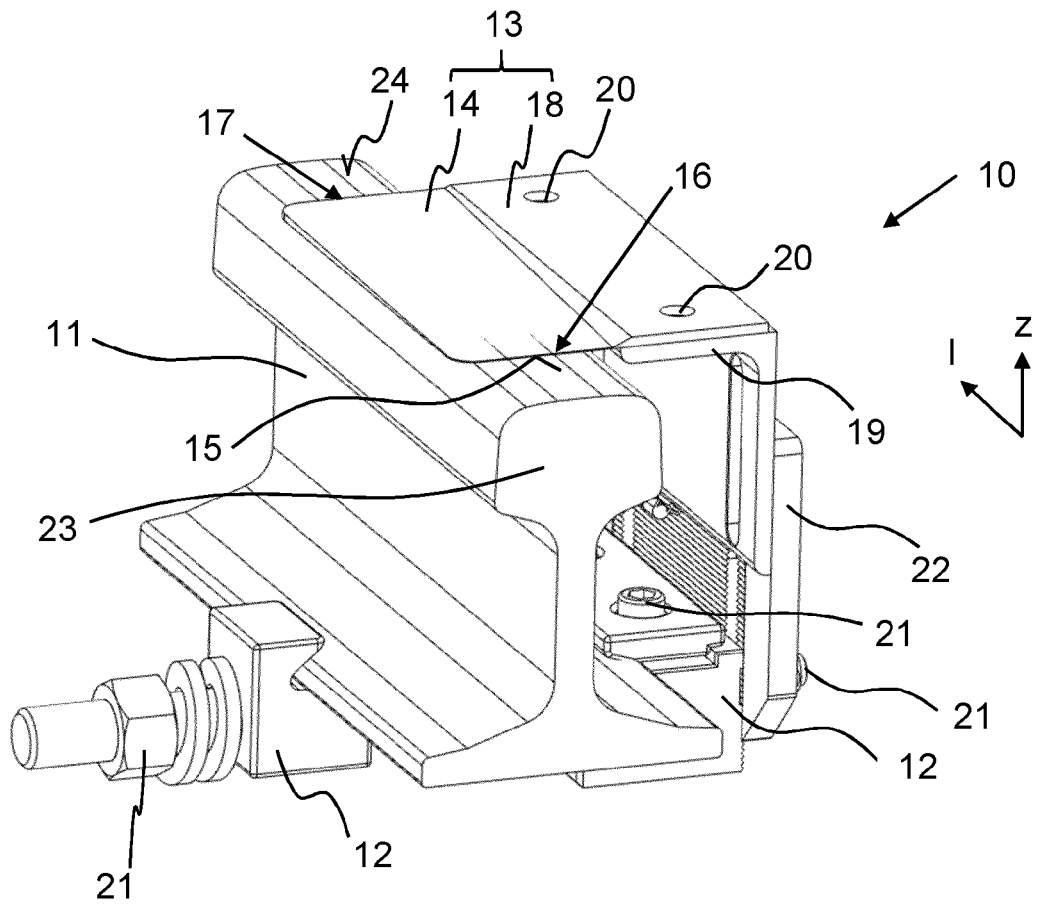


FIG. 2

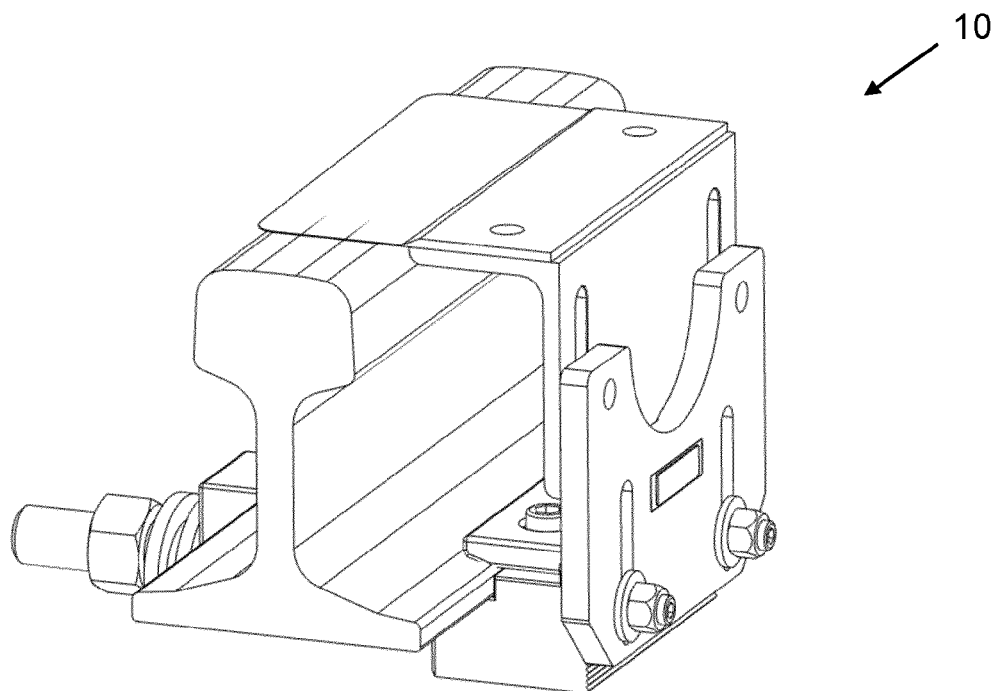


FIG. 3

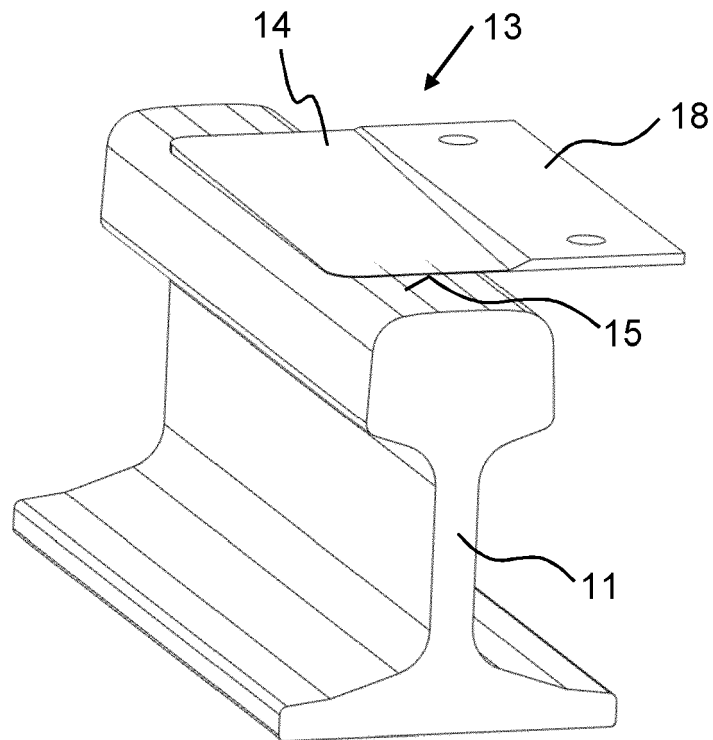


FIG. 4

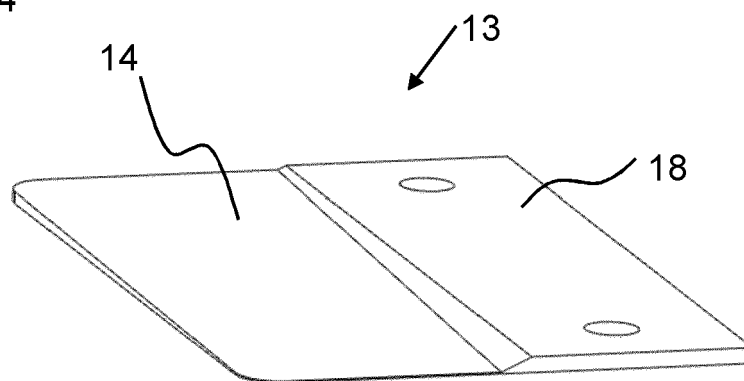


FIG. 5

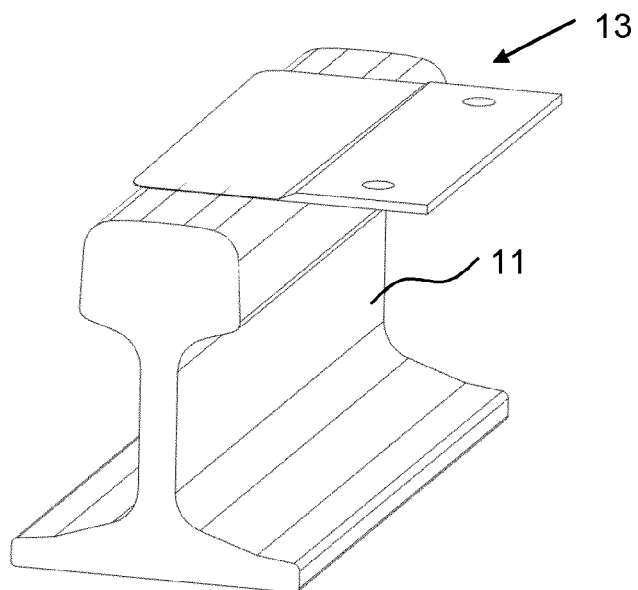


FIG. 6

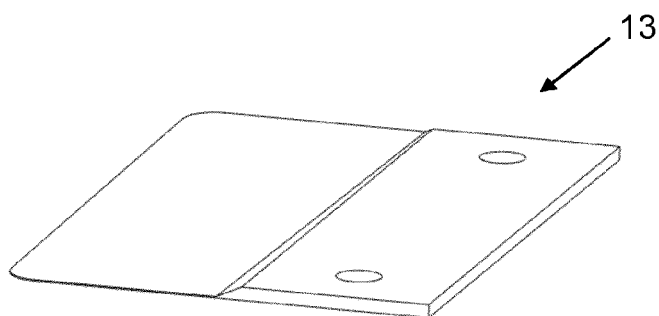


FIG. 7

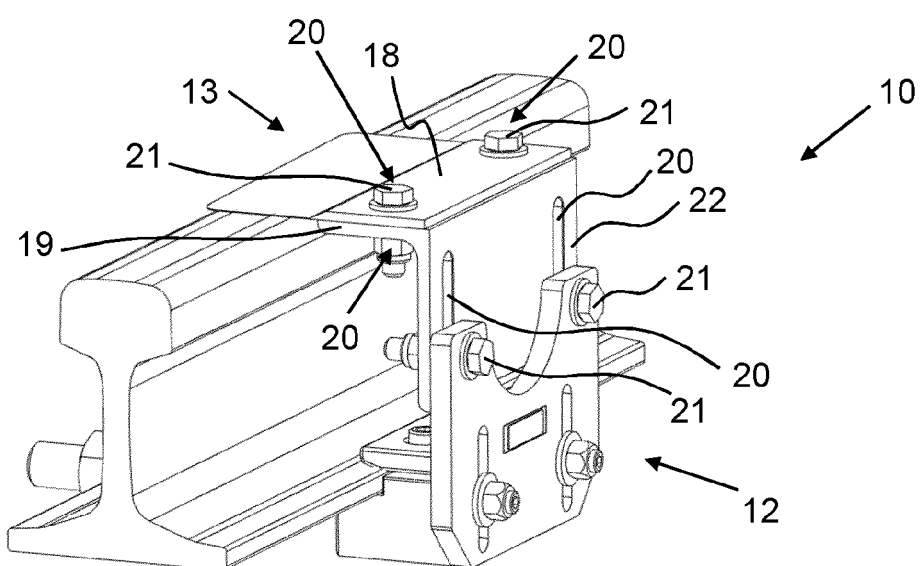


FIG. 8

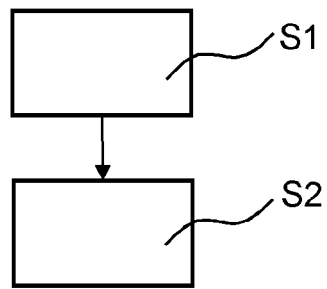


FIG. 9

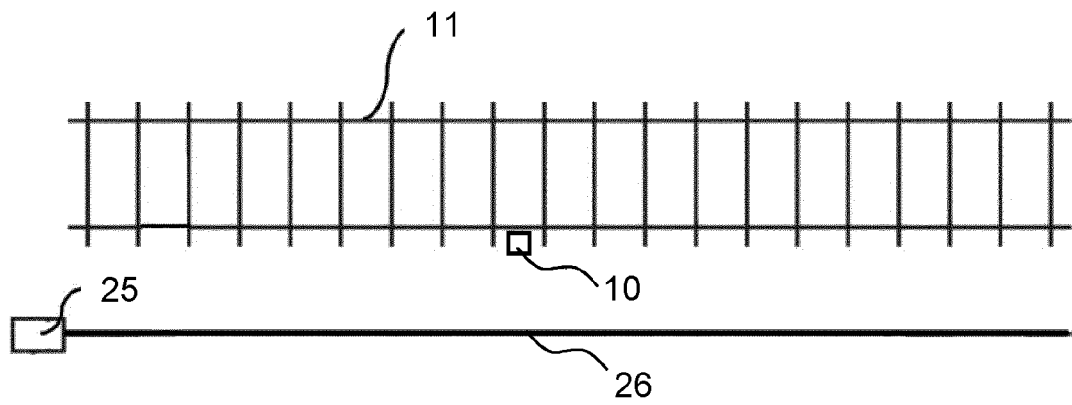


FIG. 10

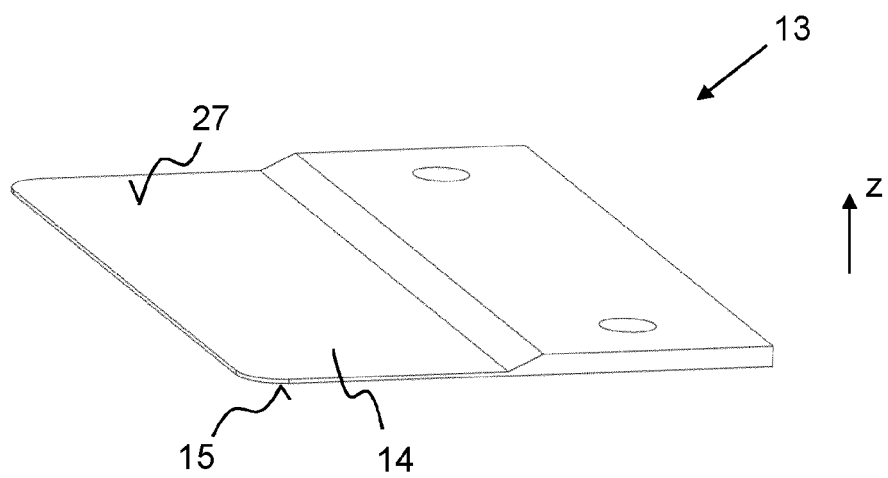
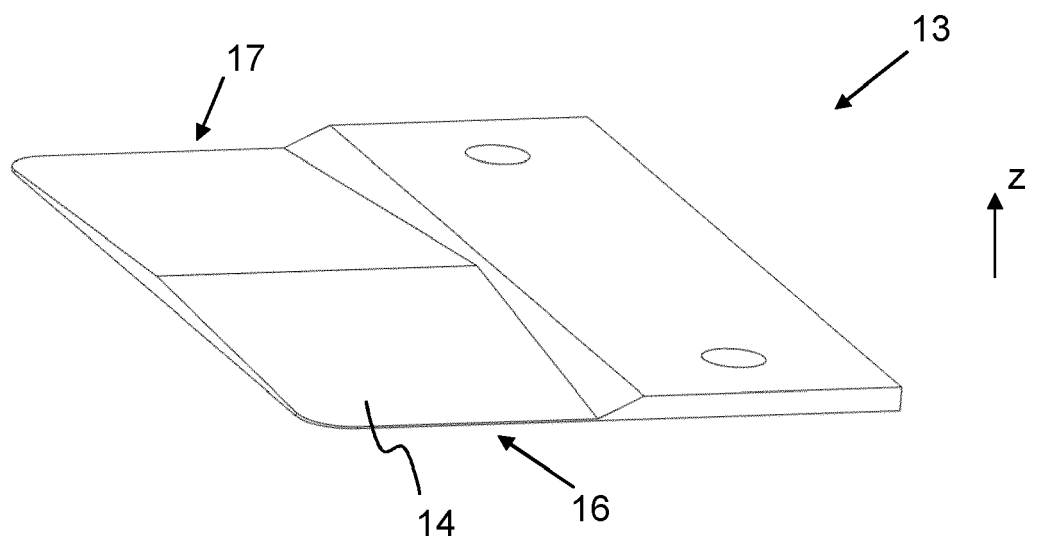


FIG. 11





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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                      |                                  |                                                        |
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| Munich                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                      | 15 October 2021                  | Plützer, Stefan                                        |
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The members are as contained in the European Patent Office EDP file on  
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15-10-2021

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