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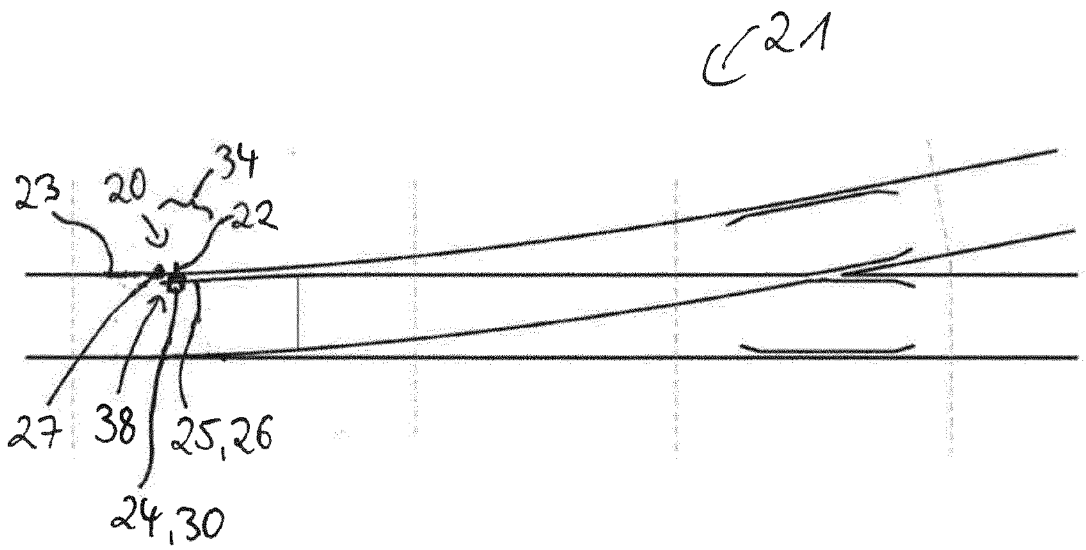
(54) SENSOR ARRANGEMENT FOR A RAILWAY SYSTEM AND METHOD FOR MONITORING A RAILWAY SYSTEM

(57) A sensor arrangement (20) for a railway system (21) is provided, the sensor arrangement (20) comprising a rail claw (22) that is connectable to a rail (23) of the railway system (21), and a sensor (24) that is configured to measure a spatial position of at least a segment (34) of a movable railway element (25) of the railway system (21) by a contactless measurement and to differentiate between at least two different spatial positions of the segment (34) of the movable railway element (25), wherein the sensor (24) is mechanically connected with the rail claw (22). Furthermore, a method for monitoring a railway system (21) is provided.

FIG. 1



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Description

[0001] A sensor arrangement for a railway system and a method for monitoring a railway system are provided.

[0002] For monitoring a railway track it is necessary to monitor the state of movable railway elements such as tongue rails and railway frogs. Tongue rails and railway frogs are components of railway switches. A prerequisite for a safe passage of a rail vehicle over a railway switch is that the movable railway elements of the railway switch are arranged at predefined positions. This can mean, that a tongue rail is either in a position where it is in direct contact or close to direct contact with a stock rail of the railway switch or in a position where the tongue rail is spaced apart from the stock rail far enough so that a wheel of a passing rail vehicle can safely pass the railway switch. The same is true for railway frogs. It is therefore necessary to monitor the state of these movable railway elements. Only if the movable railway elements are detected to be in a state in which a rail vehicle can safely, this means without the risk of a derailment, pass the railway switch, the rail vehicle is allowed to pass the railway switch. It is furthermore necessary to monitor if the movable railway elements stay at the measured positions.

[0003] It is an objective to provide a sensor arrangement for a railway system with an improved accuracy. It is further an objective to provide a method for monitoring a railway system with an improved accuracy.

[0004] These objectives are achieved with the independent claims. Further embodiments are the subject of dependent claims.

[0005] According to at least one embodiment of the sensor arrangement for a railway system, the sensor arrangement comprises a rail claw that is connectable to a rail of the railway system. A rail claw is a mounting device that is connectable to a rail. The rail claw can be configured to be connected or fixed to a rail at the side of the rail which faces away from the side where wheels of rail vehicles are passing. This means, the rail claw is configured to be arranged below the rail. The rail claw can comprise at least one screw. The rail claw can be configured to be connected to a rail of the railway system by the at least one screw. The rail of the railway system can be a stock rail. Another expression for "stock rail" is "closure rail". The stock rail is a non-movable rail of a railway switch. This means, the stock rail is arranged at a fixed position. Other expressions for "railway switch" are "point switch", "railroad switch", "track switch", "turnout", "set of point", "points", "switch", "point". The sensor arrangement can be a sensor arrangement for a railway switch.

[0006] According to at least one embodiment of the sensor arrangement the sensor arrangement comprises a sensor that is configured to measure a spatial position of at least a segment of a movable railway element of the railway system by a contactless measurement and to differentiate between at least two different spatial positions of the segment of the movable railway element. A spatial position can be a position in space. This means, the sensor can be configured to measure where the segment of the movable railway element is arranged.

[0007] The sensor can have a sensing range within which the sensor is configured to measure the spatial position of the segment of the movable railway element. The sensing range can be a volume or an area. The sensor can be configured to detect the movement of electrically conductive material within the sensing range. Thus, the sensing range is at least partially arranged outside of the sensor. The sensor can be configured to measure the spatial position of the segment for the whole range within which the movable railway element is configured to move.

[0008] The respective spatial position can relate to the distance between the segment of the movable railway element and the rail of the railway system. For the case that the movable railway element is in direct contact with the rail, the measured distance is 0. For the case that the movable railway element is not in direct contact with the rail, the distance between the segment and the rail is greater than 0. That the respective spatial position relates to the distance between the segment and the rail can mean, that the spatial position of the segment is measured in relation to the rail. In other words, the measured spatial position can give the distance between the segment and the rail.

[0009] The movable railway element can for example be a tongue rail or a railway frog. Thus, the movable railway element is a part of a railway system or a part of a railway switch. The movable railway element can be a part of a rail or it can comprise a rail. Another expression for "tongue rail" is "switch rail". Another expression for "railway frog" is "movable frog". The movable railway element can have an elongated shape. As the sensor can only detect parts of the movable railway element that are arranged within the sensing range of the sensor, the sensor is configured to measure a spatial position of at least a segment of the movable railway element. This means, if the movable railway element is significantly larger than the sensor, the sensor can only measure the spatial position of a segment of the movable railway element. The sensor can be configured to measure the spatial position of that segment of the movable railway element that is arranged within the sensing range of the sensor. The segment of the movable railway element is a part of the movable railway element. The segment is not necessarily separated from other parts of the movable railway element. It is rather possible that it is not visible where the segment begins and where it ends. The position of the segment in the movable railway element is defined by the prerequisite that the segment is arranged within the sensing range of the sensor. This means, the segment of the movable railway element is that part of the movable railway element that the sensor is configured to detect. The sensor is not configured to detect the spatial position of parts of the movable railway element that are arranged outside of the sensing range.

[0010] The segment of the movable railway element can be a front segment of the movable railway element. This means, that the segment can be arranged at the position of the movable railway element which is configured to be moved by the largest distance compared to other segments of the movable railway element. If the movable railway element is a tongue rail, the segment can be arranged at that position of the tongue rail which is supposed to be in direct contact with a non-movable rail of the railway system in one of the end positions of the tongue rail.

[0011] That the sensor is configured to measure the spatial position in a contactless measurement can mean, that the sensor is not in direct contact with the movable railway element. This means, the sensor is arranged spaced apart from the movable railway element. The sensor can comprise a contactless position sensor or the sensor can be a contactless position sensor. This means, the sensor is configured to determine the position of the segment of the movable railway element without mechanical contact to the movable railway element.

[0012] That the sensor is configured to differentiate between at least two different spatial positions of the segment of the movable railway element can mean, that the sensor is configured to measure at least two different spatial positions of the segment of the movable railway element. Thus, for two different spatial positions of the segment of the movable railway element, the sensor is configured to determine the spatial position of the segment. The two different spatial positions are arranged spaced apart from each other. The two different spatial positions can be end positions of the movable railway element. The end positions can be the two positions that the movable railway element can reach that are arranged the furthest apart from each other. It is also possible that the two different spatial positions are end positions of the segment of the movable railway element. The sensor can be configured to detect movement of at least one first edge of the segment of the movable railway element. A second edge of the segment arranged opposite to the first edge can be arranged outside of the sensing range. In this case, the sensor can measure the spatial position of the segment by measuring the spatial position of the first edge of the segment. If the first edge is arranged outside of the sensing range, the second edge can be arranged within the sensing range. In this case, the sensor can measure the spatial position of the segment by measuring the spatial position of the second edge of the segment.

[0013] The sensor can be arranged below the movable railway element. In particular, the sensor can be arranged below the segment of the movable railway element. This means, the sensor is arranged at a side of the movable railway element that faces away from the side where wheels of a passing rail vehicle can move on the movable railway element.

[0014] The sensor is mechanically connected with the rail claw. The sensor can be connected with the rail claw via at least one screw. The sensor can be in direct contact with the rail claw.

[0015] The sensor arrangement has the advantage that the actual spatial position of the segment of the movable railway element can be measured. The sensor can be configured to measure the spatial position of the segment within the sensing range. Thus, the actual position of the segment is determined. In comparison to systems where only end positions of a movable railway element can be determined, with the sensor arrangement advantageously also positions of the segment between the end positions can be determined. This allows to analyze the state of the movable railway element with an improved accuracy. It is not only determined if the movable railway element reached one of its end positions but the actual spatial position of the segment can be determined. This allows to monitor defects and wear of the movable railway element.

[0016] Another advantage is that the spatial position is determined contactless. Thus, it is not necessary to mechanically connect the sensor to the movable railway element. In this way, installing and maintaining the sensor arrangement is simplified in comparison to a sensor arrangement which requires a mechanical contact to the movable railway element. The sensor arrangement described herein can be connected with a non-movable rail via the rail claw. The sensor is mechanically connected to the rail claw. A further mechanical connection of the sensor to other parts of the railway system is not required. Also, no drilling is required. This means that the time required for installing the sensor arrangement is reduced. With this, also the time for which it is required to stop railway traffic on the railway system can be reduced. This also increases the safety for personnel installing or maintaining the sensor arrangement as the time that they need to spend on or at the rails is reduced.

[0017] That the sensor is configured to measure contactless also has the advantage that the sensor is not exposed to friction or other mechanical impacts. Thus, a damage of the sensor due to mechanical contact to the movable railway element is avoided.

[0018] According to at least one embodiment of the sensor arrangement the movable railway element comprises a tongue rail. The movable railway element can be comprised by a railway switch. The sensor arrangement enables advantageously to monitor movable parts of the railway system such as a tongue rail. In order to avoid a derailment of a rail vehicle it is necessary to monitor movable parts of the railway system.

[0019] According to at least one embodiment of the sensor arrangement the movable railway element comprises a railway frog.

[0020] According to at least one embodiment of the sensor arrangement the sensor comprises at least one contactless position sensor. The contactless position sensor can be configured to measure the spatial position of the segment of the movable railway element in a contactless measurement. This means, the contactless position sensor is not in mechanical contact with the movable railway element. This has the advantage that the sensor is protected from damage caused by mechanical contact or friction.

[0021] According to at least one embodiment of the sensor arrangement the sensor comprises at least two or a plurality of contactless position sensors. The contactless position sensors can be arranged in a two-dimensional array. By employing more than one contactless position sensor the sensing range can be increased. At least two contactless position sensors can be redundant sensors. This increases the safety.

[0022] According to at least one embodiment of the sensor arrangement the sensor comprises at least one metal sensor. The metal sensor can be configured to measure the spatial position of the segment of the movable railway element in a contactless measurement. The metal sensor is configured to detect the movement of a metal within the sensing range or within a part of the sensing range. The metal sensor is not in mechanical contact with the movable railway element. This has the advantage that the sensor is protected from damage caused by mechanical contact or friction.

[0023] According to at least one embodiment of the sensor arrangement the sensor comprises at least two or a plurality of metal sensors. The metal sensors can be arranged in a two-dimensional array. By employing more than one metal sensor the sensing range can be enlarged.

[0024] According to at least one embodiment of the sensor arrangement the sensor comprises at least one inductive sensor. The inductive sensor can be configured to measure the spatial position of the segment of the movable railway element in a contactless measurement. The inductive sensor is configured to detect the movement of electrically conductive material within the sensing range or within a part of the sensing range. The inductive sensor can comprise at least one coil. The inductive sensor is not in mechanical contact with the movable railway element. This has the advantage that the sensor is protected from damage caused by mechanical contact or friction.

[0025] According to at least one embodiment of the sensor arrangement the sensor comprises at least two or a plurality of inductive sensors. The inductive sensors can be arranged in a two-dimensional array. By employing more than one inductive sensor the sensing range can be enlarged.

[0026] According to at least one embodiment of the sensor arrangement the sensor comprises at least one capacitive sensor. The capacitive sensor can be configured to measure the spatial position of the segment of the movable railway element in a contactless measurement. The capacitive sensor is configured to detect the movement of electrically conductive material within the sensing range or within a part of the sensing range. The capacitive sensor is not in mechanical contact with the movable railway element. This has the advantage that the sensor is protected from damage caused by mechanical contact or friction.

[0027] According to at least one embodiment of the sensor arrangement the sensor comprises at least two or a plurality of capacitive sensors. The capacitive sensors can be arranged in a two-dimensional array. By employing more than one capacitive sensor the sensing range can be enlarged.

[0028] According to at least one embodiment of the sensor arrangement the sensor is a two-channel sensor. This can mean, that the sensor comprises a first evaluation channel and a second evaluation channel. Some components of the sensor are connected with the first evaluation channel and other components of the sensor are connected with the second evaluation channel. The sensor can comprise a plurality of contactless position sensors or a plurality of other sensors. In this case some of the contactless position sensors or other sensors are connected with the first evaluation channel and others of the contactless position sensors or other sensors are connected with the second evaluation channel. The first evaluation channel and the second evaluation channel can be independent from each other. Employing two independent evaluation channels increases the safety. If a defect occurs in one of the channels, the other channel can operate independently from the defect channel.

[0029] According to at least one embodiment of the sensor arrangement the sensor arrangement comprises a further rail claw that is connectable to a rail of the railway system and the sensor arrangement comprises a further sensor that is configured to measure a spatial position of at least a further segment of the movable railway element of the railway system by a contactless measurement and to differentiate between at least two different spatial positions of the further segment of the movable railway element, wherein the further sensor is mechanically connected with the further rail claw. The further rail claw can have the same features as the rail claw. The further sensor can have the same features as the sensor. As the movable railway element can have an elongated shape the segment of the movable railway element can be at a different position in comparison to the further segment of the movable railway element. The segment can be arranged adjacent to the further segment. It is also possible that the segment is arranged spaced apart from the further segment. The movable railway element can be bent in different directions or in a different way at different positions along the movable railway element. For example, a stone or another obstacle such as snow or ice can be arranged between the movable railway element and a rail of the railway system. The movable railway element can be bent around the stone or the obstacle. However, it is possible that only a part or a segment of the movable railway element is bent. Other parts or segments of the movable railway element might not be influenced by the stone or the obstacle. For this situation it is advantageous to employ a sensor arrangement with the sensor and the further sensor. With this sensor arrangement it is possible to monitor two different segments along the movable railway element. It is also possible to employ a sensor arrangement which comprises more than one sensor and/or more than one further sensor. Monitoring different segments of the movable railway element increases the safety. Obstacles blocking at least a part or a segment of a movable railway element can be detected. If an obstacle blocks the movable railway element in such a way, that a safe passage of a rail vehicle is not possible anymore, the respective part of the railway system can be closed for railway traffic. Thus, a derailment of a rail vehicle can be prevented.

[0030] According to at least one embodiment of the sensor arrangement the sensor arrangement comprises at least two sensors or a plurality of sensors. Each sensor can be mechanically connected to its own rail claw. The more sensors the sensor arrangement comprises, the more accurate is the monitoring of the movable railway element.

[0031] According to at least one embodiment of the sensor arrangement, the sensor arrangement comprises a sensor that is configured to measure a spatial position of at least the segment of the movable railway element of the railway system by a contactless measurement and the sensor is configured to differentiate between at least three different spatial positions of the segment of the movable railway element. The sensor is configured to measure at least three different spatial positions of the segment of the movable railway element. Thus, for three different spatial positions of the segment of the movable railway element, the sensor is configured to determine the spatial position of the segment. The three different spatial positions are arranged spaced apart from each other. The sensor is thus not only configured to determine the end positions of the segment of the movable railway element but also at least one position which is no end position. With this, a defect of the movable railway element can be specified in more detail, as the actual spatial position of the segment of the movable railway element is measured. It is furthermore possible to monitor wear of the movable railway element as the change of the actual position of the segment when it is in its end positions can be monitored. After a movable railway element has been used for a while it is possible that the segment does not reach the exact spatial position where it is supposed to be in its closed or open state anymore. For example, in a closed state of a movable railway element, the movable railway element is supposed to be in direct contact with a neighboring rail. After a while, the movable railway element might not reach the position of direct contact with the neighboring rail anymore due to wear of the movable railway element. By measuring the actual spatial position of the segment of the movable railway element, this deviation from the position of direct contact with the neighboring rail can be detected and monitored. The same is possible for the open position of the movable railway element, where the movable railway element is in a position where a wheel of a passing rail vehicle can pass between the movable railway element and the neighboring rail. Consequently, the position of the movable railway element can be monitored with an increased accuracy.

[0032] According to at least one embodiment of the sensor arrangement, the sensor arrangement comprises a sensor that is configured to measure a spatial position of at least the segment of the movable railway element of the railway system by a contactless measurement and the sensor is configured to differentiate between at least four different spatial positions of the segment of the movable railway element. The sensor is configured to measure at least four different spatial positions of the segment of the movable railway element. Thus, for four different spatial positions of the segment of the movable railway element, the sensor is configured to determine the spatial position of the segment. The four different spatial positions are arranged spaced apart from each other. Monitoring the actual position of the segment improves the accuracy.

[0033] According to at least one embodiment of the sensor arrangement, the sensor arrangement comprises a sensor that is configured to measure a spatial position of at least the segment of the movable railway element of the railway system by a contactless measurement and the sensor is configured to differentiate between a plurality of different spatial positions of the segment of the movable railway element. The sensor is configured to measure a plurality of different spatial positions of the segment of the movable railway element. Thus, for a plurality of spatial positions of the segment of the movable railway element, the sensor is configured to determine the spatial position of the segment. The different spatial positions are arranged spaced apart from each other or next to each other. Monitoring the actual position of the segment improves the accuracy.

[0034] According to at least one embodiment of the sensor arrangement the sensor comprises an output and the sensor is configured to provide the measured spatial position at the output. The measured spatial position is the spatial position that the sensor measured for the segment of the movable railway element. The measured spatial position can advantageously be provided to a monitoring system outside of the sensor arrangement or to a signaling box. Thus, the measured spatial position can be employed in monitoring the railway system.

[0035] Furthermore, a method for monitoring a railway system is provided. The sensor arrangement can preferably be employed in the methods described herein. This means all features disclosed for the sensor arrangement for a railway system are also disclosed for the method for monitoring a railway system and vice-versa. The method can be carried out with the sensor arrangement.

[0036] According to at least one embodiment of the method for monitoring a railway system, the method comprises the step of connecting a rail claw to a rail of the railway system. The rail claw is mechanically connected to the rail. That the rail claw is connected to the rail can also mean that the rail claw is fixed to the rail.

[0037] The method further comprises the step of measuring a spatial position of at least a segment of a movable railway element of the railway system by a contactless measurement by a sensor. The method can further comprise the step of measuring the spatial position of the segment by a contactless measurement by the sensor at different points in time. The spatial position can be measured at a plurality of different points in time.

[0038] According to at least one embodiment of the method, the sensor is configured to differentiate between at least two different spatial positions of the segment of the movable railway element. This means, that for the measurement of the spatial position the sensor differentiates between at least two different spatial positions of the segment.

[0039] The sensor is mechanically connected with the rail claw. The sensor can be mechanically connected with the rail claw before the rail claw is connected to the rail or after the rail claw is connected to the rail.

[0040] The described method has the same advantages as the sensor arrangement. Furthermore, the measurement of the spatial position of the segment at different points in time enables a better monitoring of the movable railway element. It cannot only be controlled if the movable railway element is in a position where it is supposed to be, for example in its closed position, but it can also be monitored if the movable railway element stays in this position by measuring the spatial position of the segment at different points in time. It is also possible to analyze the dynamic behavior of the segment of the movable railway element. This can be achieved by measuring the spatial position of the segment during the movement of the segment at different points in time.

[0041] According to at least one embodiment of the method, the method further comprises arranging the sensor below the movable railway element. This can mean that the sensor is arranged at a side of the movable railway element which faces away from the side where wheels of a rail vehicle can pass over the movable railway element. At this position of the movable railway element the sensor can detect the spatial position of the segment in a contactless measurement. Furthermore, advantageously no mechanical contact to the movable railway element is required for the sensor.

[0042] According to at least one embodiment of the method the sensor is arranged below the movable railway element without mechanical contact to the movable railway element. This means, that the sensor is not in mechanical contact with the movable railway element. The sensor is arranged spaced apart from the movable railway element. This has the advantage that the sensor is protected from damage caused by mechanical contact or friction with the movable railway element.

[0043] According to at least one embodiment of the method, the method further comprises providing the measured spatial position at an output of the sensor. This means, that the sensor can provide the measured spatial position. If the spatial position is measured at different points in time the sensor can provide the measured spatial positions. Thus, advantageously the measured spatial position or the measured spatial positions can be employed for monitoring the railway system.

[0044] 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.

[0045] With figure 1 an exemplary embodiment of the sensor arrangement is shown.

Figure 2 shows a top view on an exemplary embodiment of the sensor arrangement.

Figures 3, 4 and 5 show cross sections through an exemplary embodiment of the sensor arrangement.

Figure 6 shows a further exemplary embodiment of the sensor arrangement.

[0046] With figure 7 an exemplary embodiment of the method for monitoring a railway system is described.

[0047] Figure 1 shows an exemplary embodiment of the sensor arrangement 20 for a railway system 21. In a top view the railway system 21 which is a railway switch is shown. The railway switch comprises a movable railway element 25. In figure 1, a front part 38 of the movable railway element 25 is not in direct contact with a rail 23 of the railway switch. The rail 23 is a stock rail. The movable railway element 25 comprises a tongue rail 26. The movable railway element 25 is arranged spaced apart from the rail 23. In this arrangement rail vehicles can move from the left to the top right position in figure 1 or the other way around. In another state, the movable railway element 25 can be in direct contact with the rail 23 at a contact position 27. In this arrangement a rail vehicle can move from the left to the bottom right position in figure 1 or the other way around. For a safe railway traffic it is necessary to monitor the position of the movable railway element 25.

[0048] The sensor arrangement 20 comprises a rail claw 22 that is connectable to the rail 23 of the railway system 21. In figure 1 the rail claw 22 is shown in its position when it is mounted to the rail 23. The rail claw 22 is arranged below the rail 23. This means, that the rail claw 22 is arranged at a side of the rail 23 which faces away from a side of the rail 23 at which wheels of a rail vehicle can pass over the rail 23. The rail 23 can be a stock rail.

[0049] The sensor arrangement 20 further comprises a sensor 24 that is configured to measure a spatial position of at least a segment 34 of the movable railway element 25 of the railway system 21 by a contactless measurement and to differentiate between at least two different spatial positions of the segment 34 of the movable railway element 25. The sensor 24 is mechanically connected with the rail claw 22. The sensor 24 can comprise at least one contactless position sensor, at least one metal sensor, at least one inductive sensor or at least one capacitive sensor. The sensor 24 can be a two-channel sensor. The two channels can be redundant. It is also possible that the sensor arrangement 20 comprises two redundant sensors 24.

[0050] The sensor 24 can be configured to differentiate between at least three or a plurality of different spatial positions of the segment 34 of the movable railway element 25. The sensor 24 can comprise an output 30 and the sensor 24 can be configured to provide the measured spatial position at the output 30.

[0051] Figure 2 shows an exemplary embodiment of the sensor arrangement 20 mounted to the rail 23 of the railway system 21. The sensor arrangement 20 comprises the rail claw 22 that is connected to the rail 23 of the railway system 21. Figure 2 shows a top view on the rail 23. The rail claw 22 is arranged below the rail 23. Thus, only parts of the rail claw 22 are visible in figure 2. The sensor 24 is mechanically connected with the rail claw 22. Adjacent to the rail 23 the movable railway element 25 is arranged. The sensor 24 is arranged below the movable railway element 25. Therefore, the sensor 24 is not visible in figure 2.

[0052] In figure 3 a cross section through another exemplary embodiment of the sensor arrangement 20 is shown. The sensor arrangement 20 can have the same setup as shown and described with figures 1 and 2. Figure 3 shows a side view where a cross section through the rail 23 is shown. The rail claw 22 is arranged below the rail 23 and fixed to the rail 23 with two clamp parts 31. The different parts of the rail claw 22 are connected with each other by screws 32. The sensor 24 is arranged adjacent to the rail claw 22 and mechanically connected with the rail claw 22. Above the sensor 24 and adjacent to the rail 23, the movable railway element 25 is arranged. The sensor 24 is arranged spaced apart from the movable railway element 25. This means, the sensor 24 and the movable railway element 25 are not in mechanical contact. The movable railway element 25 is configured to be moved along a lateral direction x. The lateral direction x is indicated by an arrow in figure 3.

[0053] In figure 3 a situation is shown, where the movable railway element 25 is not in direct contact with the rail 23. The movable railway element 25 is positioned spaced apart from the rail 23. However, a top part 33 of the movable railway element 25 has a shape which fits to the shape of the top part 33 of the rail 23. At the side facing the movable railway element 25, the rail 23 comprises a region whose shape is adapted to the shape of the movable railway element 25. This means, the top part 33 of the rail 23 comprises a surface which faces the top part 33 of the movable railway element 25 and which extends parallel to a surface of the movable railway element 25 which faces the rail 23. This shape of the rail 23 and the movable railway element 25 enables the closed position of the movable railway element 25 where it is in direct contact with the rail 23. Because of the two surfaces extending parallel to each other a slit between the rail 23 and the movable railway element 25 in the closed position is avoided.

[0054] The sensor 24 can comprise a plurality of sensor components as for example coils. The sensor components can each be configured to detect the movement of electrically conductive material within a sensing range of the respective sensor component. By employing a plurality of sensor components the sensing range of the sensor 24 can be increased. The movable railway element 25 can comprise an electrically conductive material.

[0055] Figure 4 shows the exemplary embodiment of figure 3 in another state. In figure 4 the movable railway element 25 is in direct contact with the rail 23. In a calibration step the spatial position measured by the sensor 24 for this situation can be saved. This measured spatial position can be employed as a reference value for the furthest position in one direction that the movable railway element 25 can reach. This measured spatial position is also the reference value for the closed position of the movable railway element 25. This means, if this spatial position is measured for the movable railway element 25, the movable railway element 25 is in direct contact with the rail 23. Therefore, a rail vehicle can safely pass the railway switch. The other spatial positions that are measured by the sensor 24 can be given with respect to this reference value. Thus, it can be measured how far the movable railway element 25 is arranged from the closed position. This information can be employed for deciding if it is safe for a rail vehicle to pass the railway switch.

[0056] In figure 4 a first edge 36 of the movable railway element 25 is arranged above the sensor 24 and a second edge 37 is not arranged above the sensor 24. The second edge 37 is the edge which is arranged close to the rail 23. The first edge 36 is arranged opposite to the second edge 37. The sensor 24 can detect the movement of the first edge 36.

[0057] If the sensor 24 comprises a plurality of coils, each coil has a sensing range within which it is configured to sense the movement of electrically conductive material. This means, if the movable railway element 25 enters the sensing range of a coil, the coil is partially damped. Thus, this movement of the movable railway element 25 can be detected. Once the movable railway element 25 extends over the whole sensing range of a coil, the coil is fully damped and a further movement of the movable railway element 25 does not change the state of the coil. This means, in this situation a further movement of the movable railway element 25 cannot be detected by the coil. A further movement of the movable railway element 25 can only be detected once the movable railway element 25 does not extend over the whole sensing range of the coil anymore. By evaluating the signals of the plurality of coils, the position of the movable railway element

25 can be determined.

[0058] Figure 5 shows the exemplary embodiment of the sensor arrangement 20 of figure 3 in a different state in comparison to figures 3 and 4. The movable railway element 25 is in its position where it is arranged at the maximum possible distance from the rail 23. Also the measured spatial position of this arrangement can be saved in a calibration step as a further reference value. The further reference value can be employed in the same way as the reference value for providing the spatial position of the movable railway element 25.

[0059] Figure 6 shows a top view on another exemplary embodiment of the sensor arrangement 20. In comparison to the embodiment shown in figure 1 the sensor arrangement 20 further comprises a further rail claw 28 that is connected to the rail 23 of the railway system 21 and the sensor arrangement 20 comprises a further sensor 29 that is configured to measure a spatial position of at least a further segment 35 of the movable railway element 25 by a contactless measurement and to differentiate between at least two different spatial positions of the further segment 35 of the movable railway element 25. The further sensor 29 is mechanically connected with the further rail claw 28. The further sensor 29 is arranged below a different position of the movable railway element 25 in comparison to the sensor 24. The further sensor 29 is arranged below the further segment 35. With this sensor arrangement 20 different segments 34, 35 of the movable railway element 25 can be monitored.

[0060] With figure 7 an exemplary embodiment of the method for monitoring a railway system 21 is described. In a first step S1 of the method the rail claw 22 is connected to a rail 23 of the railway system 21. Furthermore, the sensor 24 is arranged below the movable railway element 25 without mechanical contact to the movable railway element 25. In a second step S2 of the method a spatial position of at least a segment 34 of the movable railway element 25 is measured by a contactless measurement by the sensor 24. In an optional third step S3 of the method the measured spatial position is provided at an output 30 of the sensor 24.

Reference numerals

[0061]

20	sensor arrangement
21	railway system
22	rail claw
23	rail
24	sensor
25	movable railway element
26	tongue rail
27	contact position
28	further rail claw
29	further sensor
30	output
31	clamp part
32	screw
33	top part
34	segment
35	further segment
36	first edge
37	second edge
38	front part
x	lateral direction
S1-S3	steps

Claims

1. Sensor arrangement (20) for a railway system (21), the sensor arrangement (20) comprising:

   - a rail claw (22) that is connectable to a rail (23) of the railway system (21), and
   - a sensor (24) that is configured to measure a spatial position of at least a segment (34) of a movable railway element (25) of the railway system (21) by a contactless measurement and to differentiate between at least two different spatial positions of the segment (34) of the movable railway element (25), wherein
   - the sensor (24) is mechanically connected with the rail claw (22).

2. Sensor arrangement (20) according to claim 1, wherein the movable railway element (25) comprises a tongue rail (26).

3. Sensor arrangement (20) according one of the preceding claims, wherein the sensor (24) comprises at least one contactless position sensor (24).

4. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) comprises at least one metal sensor (24).

5. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) comprises at least one inductive sensor (24).

6. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) comprises at least one capacitive sensor (24).

7. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) is a two-channel sensor (24).

8. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor arrangement (20) comprises a further rail claw (28) that is connectable to a rail (23) of the railway system (21) and the sensor arrangement (20) comprises a further sensor (29) that is configured to measure a spatial

position of at least a further segment (35) of the movable railway element (25) of the railway system (21) by a contactless measurement and to differentiate between at least two different spatial positions of the further segment (35) of the movable railway element (25), wherein the further sensor (29) is mechanically connected with the further rail claw (28).

9. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) is configured to differentiate between at least three different spatial positions of the segment (34) of the movable railway element (25) .

10. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) is configured to differentiate between a plurality of different spatial positions of the segment (34) of the movable railway element (25) .

11. Sensor arrangement (20) according to one of the preceding claims, wherein the sensor (24) comprises an output (30) and the sensor (24) is configured to provide the measured spatial position at the output (30).

12. Method for monitoring a railway system (21), the method comprising:

- connecting a rail claw (22) to a rail (23) of the railway system (21), and
- measuring a spatial position of at least a segment (34) of a movable railway element (25) of the railway system (21) by a contactless measurement by a sensor (24), wherein
- the sensor (24) is configured to differentiate between at least two different spatial positions of the segment (34) of the movable railway element (25), and
- the sensor (24) is mechanically connected with the rail claw (22).

13. Method according to claim 12, the method further comprising arranging the sensor (24) below the movable railway element (25).

14. Method according to claim 12, wherein the sensor (24) is arranged below the movable railway element (25) without mechanical contact to the movable railway element (25).

15. Method according to one of claims 12 to 14, the method further comprising providing the measured spatial position at an output (30) of the sensor (24).

FIG. 1

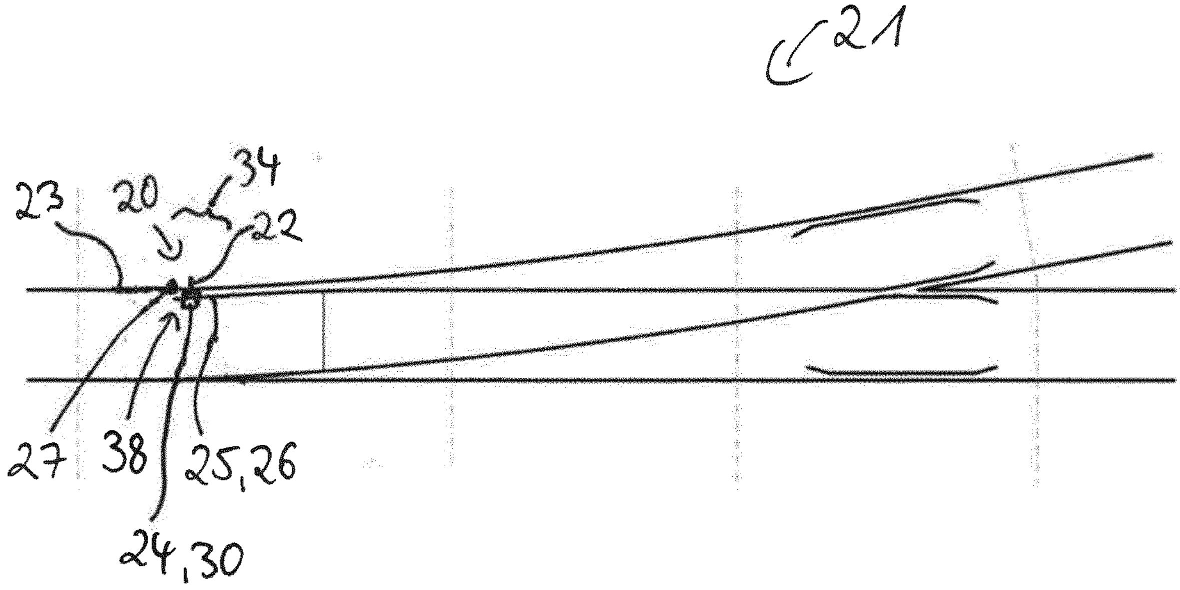


FIG. 2

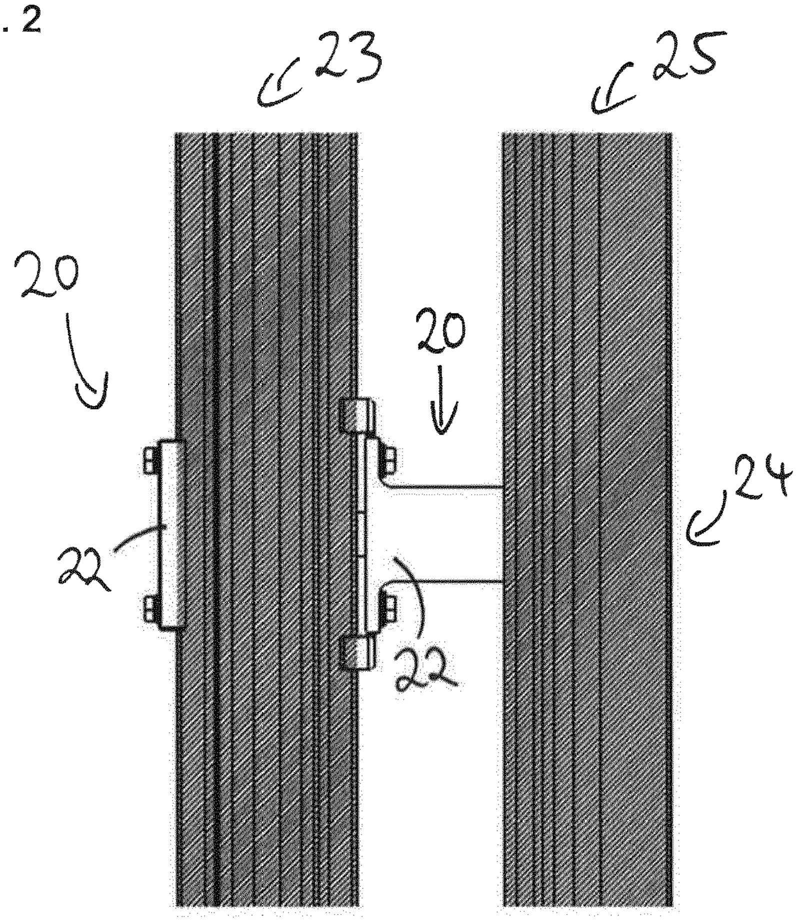


FIG. 3

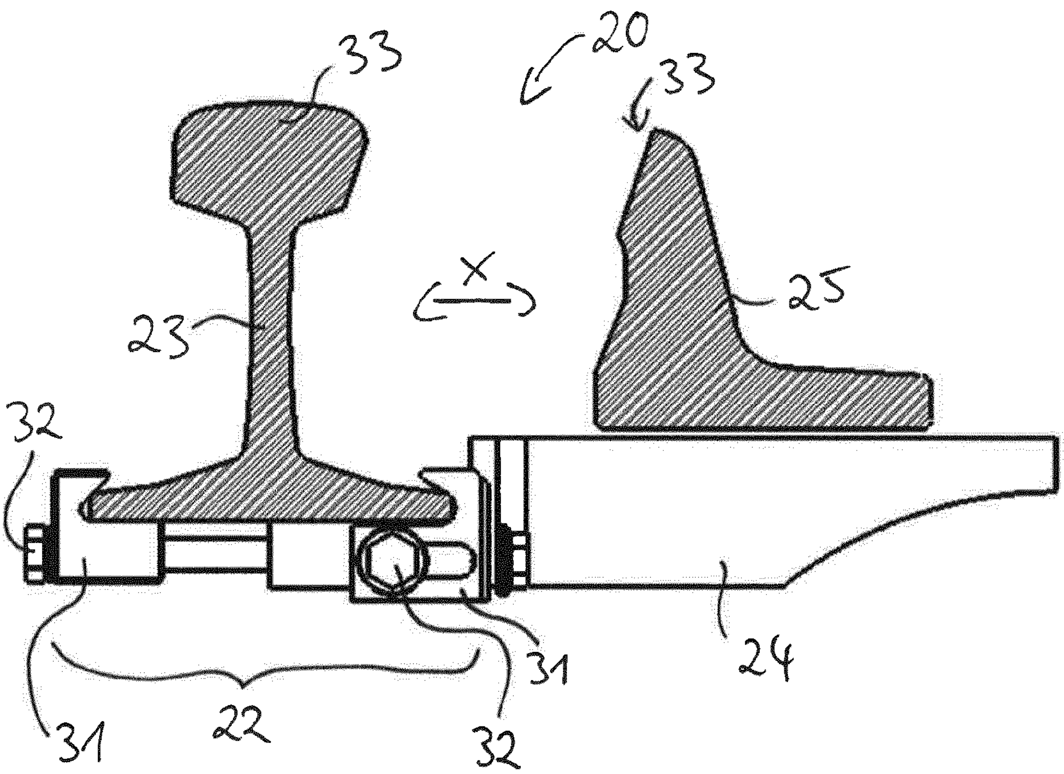


FIG. 4

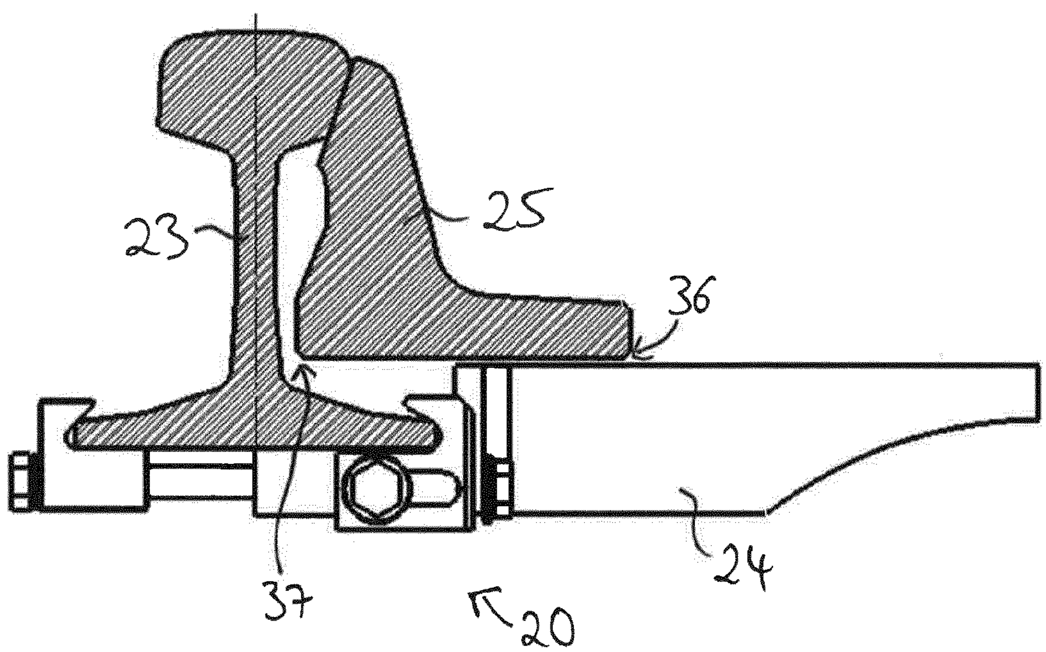


FIG. 5

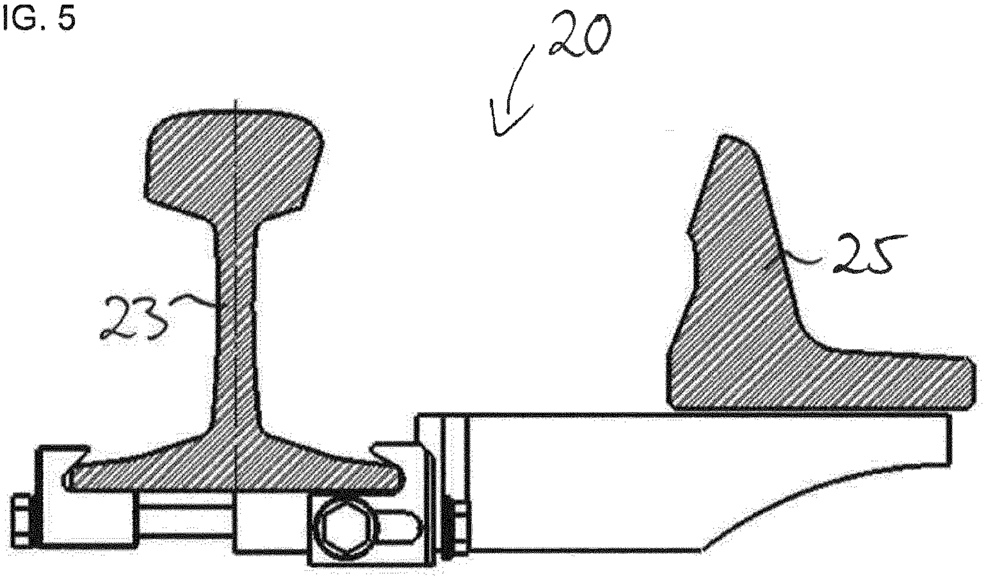


FIG. 6

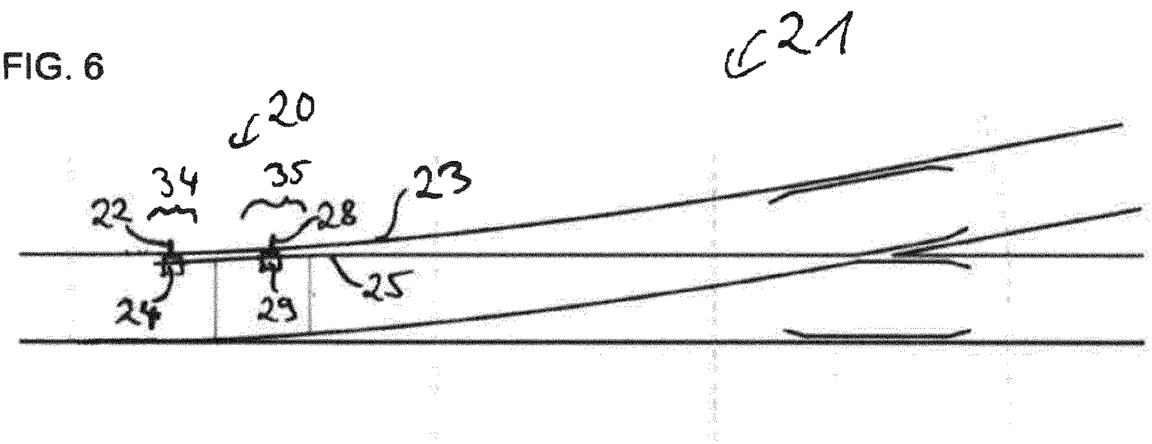
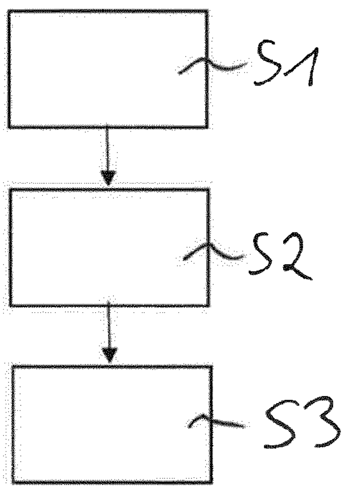


FIG. 7



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Application Number
EP 21 20 3952

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X Y	WO 97/33784 A1 (VAE AG [AT]; SEIDL KURT [AT]; FRAUSCHER JOSEF [DE]) 18 September 1997 (1997-09-18) * figures 1 - 4; page 2, lines 10 - 12; page 4, lines 12 - 19; page 5, lines 24 - 27; page 7, lines 30 - 35; page 9, lines 5, 6, 35 and 35 *	1-15 8	INV. B61L5/10
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B61L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	29 March 2022	Plützer, Stefan

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