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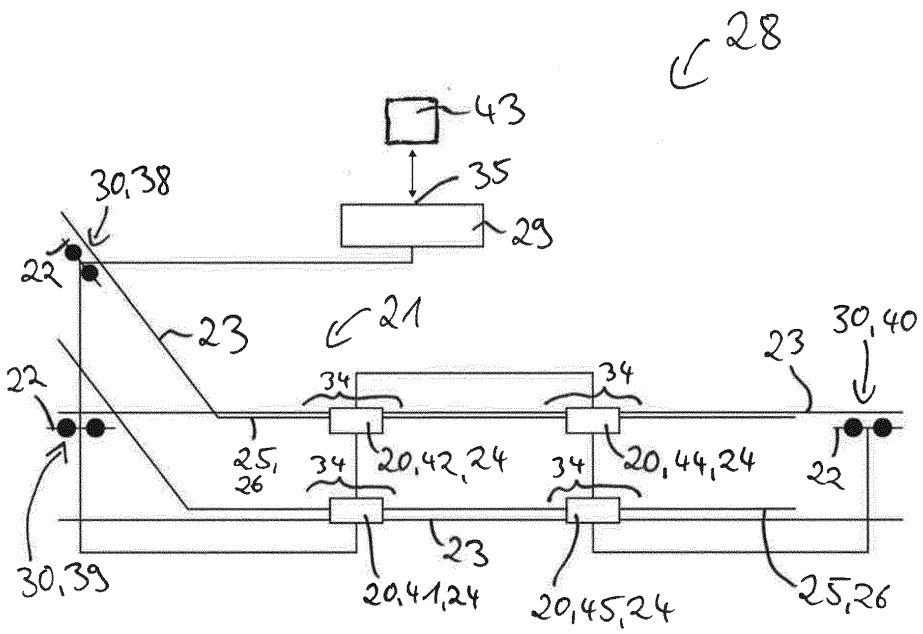
(54) MONITORING UNIT FOR MONITORING A RAILWAY TRACK AND METHOD FOR MONITORING A RAILWAY TRACK

(57) A monitoring unit (28) for monitoring a railway track is provided, the monitoring unit (28) comprising a processing unit (29), at least one wheel sensor (30) connectable to a rail (23) of the railway track, and a sensor arrangement (20) connectable to a railway switch (21) of the railway track, wherein the wheel sensor (30) and the sensor arrangement (20) are connected with the processing unit (29), and the processing unit (29) comprises an output (35) that is connectable to a signaling system (43). Furthermore, a method for monitoring a railway track is provided.

FIG. 1



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Description

[0001] A monitoring unit for monitoring a railway track and a method for monitoring a railway track are provided.

[0002] For monitoring a railway track it is necessary to monitor the state of movable railway elements such as parts 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 of the railway switch 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] In addition, it is necessary to monitor the position of rail vehicles on the railway track. In order to avoid collisions it is necessary to monitor where a rail vehicle is positioned and where it is moving. It is also possible to monitor other conditions of rail vehicles or the railway track.

[0004] It is an objective to provide a monitoring unit for efficiently monitoring a railway track. It is further an objective to provide an efficient method for monitoring a railway track.

[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 monitoring unit for monitoring a railway track, the monitoring unit comprises a processing unit. The processing unit can be configured to process and or evaluate signals. The processing unit can also be configured to receive and/or to combine signals. Furthermore, the processing unit can be configured to provide signals. The railway track can comprise one or more tracks.

[0007] According to at least one embodiment of the monitoring unit, the monitoring unit comprises at least one wheel sensor connectable to a rail of the railway track. The wheel sensor can be configured to detect a wheel of a rail vehicle passing the position of the wheel sensor. The wheel sensor can comprise a metal sensor. The wheel sensor can be configured to detect the passage of a wheel of a rail vehicle in a contactless measurement. It is also possible that the wheel sensor is configured to detect the movement of electrically conductive material. The wheel sensor can be configured to detect the movement of electrically conductive material in the vicinity of the wheel sensor. The wheel sensor can be configured to determine at least one of the velocity of a rail vehicle passing the position of the wheel sensor, the direction of travel of the rail vehicle, the number of wheels of the rail vehicle. The wheel sensor can be an axle counter.

[0008] The wheel sensor can be configured to be connected to a rail of the railway track. The wheel sensor can be connected with the rail via a rail claw. This means, a rail claw can be fixed to a rail and the wheel sensor is mechanically connected with the rail claw. The rail claw is arranged at a side of the rail which faces away from the side where wheels of rail vehicles can pass over the rail. Thus, the wheel sensor is arranged at a fixed position with respect to the rail.

[0009] According to at least one embodiment of the monitoring unit, the monitoring unit comprises a sensor arrangement connectable to a railway switch of the railway track. The sensor arrangement can be configured to be connected to the railway switch. Other expressions for "railway switch" are "point switch", "railroad switch", "track switch", "turnout", "set of point", "points", "switch", "point". The sensor arrangement can be connectable to a non-movable part of the railway switch. The non-movable part of the railway switch can be a stock rail. Another expression for "stock rail" is "closure rail". The sensor arrangement can have a setup which is different from the setup of the wheel sensor. The sensor arrangement can comprise a rail claw. The rail claw can be connectable to a non-movable part of the railway switch.

[0010] The wheel sensor and the sensor arrangement are connected with the processing unit. The wheel sensor and the sensor arrangement can each be connected with the processing unit. It is also possible that the wheel sensor and the sensor arrangement are connected with each other and that there is a connection from the wheel sensor and the sensor arrangement to the processing unit. For example, the wheel sensor and the sensor arrangement are connected with each other and the sensor arrangement is connected with the processing unit. It is also possible that the wheel sensor and the sensor arrangement are connected with each other and the wheel sensor is connected with the processing unit. The wheel sensor and the sensor arrangement can be connected with the processing unit via at least one cable. It is also possible that the wheel sensor and the sensor arrangement are connected with the processing unit in a wireless way. The processing unit, the wheel sensor and the sensor arrangement can be comprised by a bus system. It is also possible that the processing unit, the wheel sensor and the sensor arrangement are arranged within a bus system or form a bus system.

[0011] The processing unit comprises an output that is connectable to a signaling system. The signaling system can comprise or be a signal box, a signal tower, a railway control center, an interlocking, a safety system or a zone controller. It is also possible that the signaling system comprises or is a diagnostic system, a maintenance system or a monitoring system of one or more of

the aforesaid components or systems. The output of the processing unit can be configured to be connected to the signaling system. The output can be connectable to the signaling system via a cable or in a wireless way. The connection between the processing unit and the signaling system can be a data connection.

[0012] According to at least one embodiment of the monitoring unit, the monitoring unit comprises a processing unit, at least one wheel sensor connectable to a rail of the railway track, and a sensor arrangement connectable to a railway switch of the railway track, wherein the wheel sensor and the sensor arrangement are connected with the processing unit, and the processing unit comprises an output that is connectable to a signaling system.

[0013] The monitoring unit has the advantage that two different types of sensors for monitoring a railway track are connected with the processing unit. The wheel sensor is connectable to a rail of the railway track and thus configured to monitor railway traffic on the rail. For example, the wheel sensor is configured to detect the passage of a rail vehicle over the position of the wheel sensor. The sensor arrangement is connectable to a railway switch. The sensor arrangement can be configured to monitor the movement of at least one movable part of the railway switch. This means, that the wheel sensor can be employed for monitoring the railway traffic and the sensor arrangement can be employed for monitoring the railway switch. Advantageously, the wheel sensor and the sensor arrangement are not separately connected with the signaling system but they are both connected with the processing unit. In this way, the processing unit can evaluate and/or combine signals received from both the wheel sensor and the sensor arrangement. The evaluated and/or combined signals can be provided at the output of the processing unit and they can be provided to the signaling system. With this, the monitoring unit complies with safety standards as both the movement of rail vehicles and the position of at least one movable part of a railway switch are monitored. Furthermore, as the signaling system can receive evaluated data, less evaluation is required in the signaling system. Therefore, the monitoring unit enables an efficient monitoring of the railway track.

[0014] It is required to monitor both the movement of rail vehicles and the movement of at least a movable part of the railway switch in order to avoid the collision of rail vehicles, to avoid a derailment of a rail vehicle because of a positioning of a movable part of the railway switch leading to a derailment and to avoid damage of the railway switch which can be caused by a rail vehicle passing over the railway switch for the case that a movable part of the railway switch is in a position that is not configured for the passage of a rail vehicle. If a rail vehicle passed over the railway switch for the case that a movable part of the railway switch is in a position that is not configured for the passage of a rail vehicle, the rail vehicle and the position of the movable railway element are detected by the monitoring unit. The evaluation unit can be configured to combine these information. This combined information can advantageously be provided to the signaling system which allows that further steps are carried out. It might for example be necessary to repair or maintain the movable railway element after this passage of the rail vehicle. Thus, the safety is increased.

[0015] The rail that the wheel sensor is connectable to can be a rail of the railway switch. The rail that the wheel sensor is connectable to can be a non-movable rail of the railway switch. Thus, the railway switch can be monitored with the wheel sensor and the sensor arrangement. This improves the accuracy of monitoring the railway track.

[0016] According to at least one embodiment of the monitoring unit, the monitoring unit comprises at least one further wheel sensor connectable to a further rail of the railway track. It is also possible that the monitoring unit comprises a plurality of further wheel sensors that are each connectable to a rail of the railway track. If the monitoring unit comprises more than one wheel sensor, the railway track can be monitored with an improved accuracy. The more wheel sensors the monitoring unit comprises, the more positions along the railway track can be monitored. Thus, the movement of rail vehicles on the railway track be detected.

[0017] According to at least one embodiment of the monitoring unit, the processing unit is configured to receive signals detected by the wheel sensor and/or signals detected by the sensor arrangement. The wheel sensor and the sensor arrangement can each be configured to detect signals. The wheel sensor and the sensor arrangement can each comprise an output where detected signals can be provided. The processing unit can comprise an input. The processing unit can be configured to receive signals detected by the wheel sensor and/or signals detected by the sensor arrangement at its input. Thus, advantageously the signals detected by the wheel sensor and by the sensor arrangement can be evaluated and combined by the processing unit before the evaluated signals are provided to the signaling system. Therefore, less evaluation of the signaling system is required.

[0018] According to at least one embodiment of the monitoring unit, 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 switch in a contactless measurement. 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. 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.

[0019] The respective spatial position can relate to the distance between the segment of the movable railway element and the non-movable part of the railway switch. For the case that the movable railway element is in direct contact with the non-movable part, the measured distance is 0. For the case that the movable railway element is not in direct contact with the non-movable part, the distance between the segment and the non-movable part is greater than 0. That the respective spatial position relates to the distance between the segment and the non-movable part can mean, that the spatial position of the segment is measured in relation to the non-movable part. In other words, the measured spatial position can give the distance between the segment and the non-movable part.

[0020] The movable railway element can for example be a tongue rail or a railway frog. Thus, the movable railway element is a part of the railway switch. The movable railway element can be a movable part of the 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.

[0021] 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 switch in one of the end positions of the tongue rail.

[0022] 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. The sensor can comprise at least one contactless position sensor, at least one metal sensor, at least one inductive sensor or at least one capacitive sensor. It is also possible that the sensor comprises at least two or a plurality of one or more than one of these sensors. The sensor can comprise a two-dimensional array of one or more than one of these sensors. The sensor can be a two-channel sensor.

[0023] According to at least one embodiment of the monitoring unit, the sensor is configured to differentiate between at least two different spatial positions of the segment of the movable railway element. This 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.

[0024] 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.

[0025] The sensor can be mechanically connected with a 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. The rail claw can be connected with a stock rail of the railway switch. The setup of the sensor can be different from the setup of the wheel sensor.

[0026] 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.

[0027] 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 switch 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 switch 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.

[0028] 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.

[0029] According to at least one embodiment of the monitoring unit, the movable railway element comprises a tongue rail. The sensor arrangement enables advantageously to monitor movable parts of the railway switch 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 switch.

[0030] According to at least one embodiment of the monitoring unit, the movable railway element comprises a railway frog.

[0031] According to at least one embodiment of the monitoring unit, 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 monitoring unit, 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 monitoring unit, 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 monitoring unit, the sensor arrangement is configured to provide a sensor signal to the processing unit and the sensor signal comprises the measured spatial position. Thus, the sensor arrangement is configured to provide the information to the processing unit where the segment of the movable railway element is arranged. From this information it can be determined if a rail vehicle can safely pass the railway switch. Thus, the processing unit can be configured to evaluate the sensor signal.

[0035] According to at least one embodiment of the monitoring unit, the sensor arrangement is configured to provide a sensor signal to the processing unit and the sensor signal comprises a status indicator of the railway switch. The status indicator of the railway switch can comprise any information about the status of the railway switch, for example whether or not the railway switch has been trailed.

[0036] According to at least one embodiment of the monitoring unit, the processing unit is configured to provide an output signal at its output to the signaling system and the output signal comprises information from the sensor signal. The output signal can be an evaluated signal. It is also possible that the output signal is a combined signal. The output signal can comprise the sensor signal. It is also possible that the output signal comprises the spatial position measured by the sensor. In this way, the information where a movable railway segment of the railway switch is positioned can be provided to the signaling system.

[0037] According to at least one embodiment of the monitoring unit, the wheel sensor comprises an inductive sensor. The inductive sensor can be configured to detect movement of electrically conductive material in the vicinity of the inductive sensor. The inductive sensor can comprise one or more coils. The monitoring unit can also comprise a further wheel sensor which also comprises an inductive sensor. The wheel sensor and the further wheel sensor can have the same setup. The wheel sensor and the further wheel sensor can be redundant. With the inductive sensor the passage of a rail vehicle over the position of the wheel sensor can be detected in a reliable way.

[0038] According to at least one embodiment of the monitoring unit, the processing unit is configured to receive a position signal from the wheel sensor, the processing unit is configured to provide an output signal at its output to the signaling system and the output signal comprises information from the position signal. The position signal can comprise a signal detected by the wheel sensor. For example, the position signal comprises the information that a rail vehicle passed the position of the wheel sensor or how many axles were counted by the wheel sensor. It is also possible that the position signal comprises the information where the wheel sensor is arranged along the railway track. The output signal can be an evaluated signal. It is also possible that the output signal is a combined signal. The output signal can comprise the position signal. It is also possible that the output signal comprises the information where the wheel sensor is arranged along the railway track. The output signal can further comprise the information if a rail vehicle passed over the position of the wheel sensor. In this way, the information where a rail vehicle is moving on the railway track can be provided to the signaling system.

[0039] According to at least one embodiment of the monitoring unit, the position signal comprises the information that a wheel of a rail vehicle passed the position of the wheel sensor. In this way, advantageously the movement of rail vehicles along the railway track can be monitored.

[0040] Furthermore, a method for monitoring a railway track is provided. The monitoring unit can preferably be employed in the methods described herein. This means all features disclosed for the monitoring unit for monitoring a railway track are also disclosed for the method for monitoring a railway track and vice-versa. The method can be carried out with the monitoring unit.

[0041] According to at least one embodiment of the method for monitoring a railway track, the method comprises the step of detecting at least one position signal by a wheel sensor connected to a rail of the railway track. The position signal can be detected while a rail vehicle passes the position where the wheel sensor is arranged. This means, the wheel of the rail vehicle passes over the rail at that position where the wheel sensor is arranged.

[0042] The method further comprises transferring the position signal to a processing unit. This can mean, that the position signal is sent or transmitted to the processing unit.

[0043] The method further comprises detecting at least one sensor signal by a sensor arrangement arranged at a railway switch of the railway track. The sensor signal can be detected by a sensor which is comprised by the sensor arrangement.

[0044] The method further comprises transferring the sensor signal to the processing unit. This can mean, that the sensor signal is sent or transmitted to the processing unit. The processing unit, the wheel sensor and the sensor arrangement can be comprised by a monitoring unit.

[0045] The method further comprises providing an output signal by the processing unit to a signaling system. The output signal is provided to the signaling system after the position signal and the sensor signal were transmitted to the processing unit.

[0046] The method has the advantage that the position signal and sensor signal are at first transmitted to processing unit and afterwards the output signal of the processing unit is provided to the signaling system. Thus, it is not necessary to transmit the position signal and the sensor signal to the signaling system. The processing unit can evaluate and/or combine the position signal and the sensor signal. The evaluated and/or combined signal can be provided to the signaling system. With this, the monitoring unit complies with safety standards as both the movement of rail vehicles and the position of at least

one movable part of a railway switch are monitored. Furthermore, as the signaling system can receive evaluated data, less evaluation is required in the signaling system. Therefore, the method enables an efficient monitoring of the railway track.

[0047] According to at least one embodiment of the method the output signal comprises information from the position signal and information from the sensor signal. The output signal can comprise the position signal and/or the sensor signal. The output signal can be an evaluated signal which is based on the position signal and the sensor signal. The output signal can thus comprise information that are derived from an evaluation of the position signal and the sensor signal. For example, the output signal comprises the information that a railway switch can be safely passed by a rail vehicle. A safe passage of a rail vehicle can be possible if a movable railway element of the railway switch is measured to be at a predefined position and the wheel sensor does not detect another rail vehicle along the way that the rail vehicle is supposed to move in the vicinity of the railway switch. These two conditions have to be monitored in order to comply with safety requirements. Advantageously, by employing the method the safety requirements can be fulfilled.

[0048] According to at least one embodiment of the method a spatial position of at least a segment of a movable railway element of the railway switch is measured in a contactless measurement by a sensor of the sensor arrangement, wherein the sensor is configured to differentiate between at least two different spatial positions of the segment of the movable railway element.

[0049] According to at least one embodiment of the method the sensor signal comprises the measured spatial position. This means, the sensor signal comprises the spatial position measured by the sensor. This has the advantage that the actual position of the movable railway element is determined and provided to the processing unit for a further evaluation. For example, by evaluating the sensor signal the condition of the railway switch can be monitored and wear of the movable railway element can be detected. This enables to repair or maintain the railway switch before the railway switch reaches a condition that is could be dangerous for a passing rail vehicle.

[0050] According to at least one embodiment of the method the position signal comprises the information that a wheel of a rail vehicle passed the position of the wheel sensor. Thus, wheel sensor can be employed for monitoring railway traffic on the railway track.

[0051] 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.

[0052] Figure 1 shows an exemplary embodiment of the monitoring unit for monitoring a railway track.

[0053] Figure 2 shows an exemplary embodiment of the monitoring unit for monitoring a railway track with a railway switch.

[0054] With figures 3, 4 and 5 an exemplary embodiment of the sensor arrangement of the monitoring unit is described.

[0055] Figure 6 shows a top view on an exemplary embodiment of a sensor arrangement.

[0056] With figure 7 an exemplary embodiment of a method for monitoring a railway track is described.

[0057] Figure 1 shows a schematic view on an exemplary embodiment of a monitoring unit 28 for monitoring a railway track. The monitoring unit 28 comprises a processing unit 29. The processing unit 29 is arranged spaced apart from the railway track. The monitoring unit 28 further comprises three wheel sensors 30 that are each connected to a rail 23 of the railway track, respectively. Figure 1 shows a part of the railway track. In this part the railway track comprises a railway switch 21. The three wheel sensors 30 are arranged at different positions around the railway switch 21. Each wheel sensor 30 is connected to a rail 23 by a rail claw 22, respectively.

[0058] The monitoring unit 28 further comprises four sensor arrangements 20 that are each connected to a rail 23 of the railway switch 21 of the railway track. The sensor arrangements 20 each comprise a rail claw 22 that is connected to a rail 23 of the railway switch 21, respectively. The rail 23 can be a stock rail, respectively.

[0059] The wheel sensors 30 and the sensor arrangements 20 are connected with the processing unit 29. The processing unit 29 comprises an output 35 that is connected to a signaling system 43.

[0060] In figure 1 the three wheel sensors 30 are numbered as a first wheel sensor 38, a second wheel sensor 39 and a third wheel sensor 40. Furthermore, the sensor arrangements 20 are numbered as a first sensor arrangement 41, a second sensor arrangement 42, a third sensor arrangement 44 and a fourth sensor arrangement 45. The first wheel sensor 38 is connected with the processing unit 29. The second wheel sensor 39 is connected with the first wheel sensor 38. The first sensor arrangement 41 is connected with the second wheel sensor 39. The second sensor arrangement 42 is connected with the first sensor arrangement 41. The third sensor arrangement 44 is connected with the second sensor arrangement 42. The fourth sensor arrangement 45 is connected with the third sensor arrangement 44. The third wheel sensor 40 is connected with the fourth sensor arrangement 45. In this way, the wheel sensors 38, 39, 40 and the sensor arrangements 41, 42, 44, 45 are connected with the processing unit 29. The connections can be formed by cables or in a wireless way. The processing unit 29 is configured to receive signals detected by the wheel sensors 30 and signals detected by the sensor arrangements 20.

[0061] Each sensor arrangement 20 comprises a sen-

sor 24 that is configured to measure a spatial position of at least a segment 34 of a movable railway element 25 of the railway switch 21 in a contactless measurement and to differentiate between at least two different spatial positions of the segment 34 of the movable railway element 25. The movable railway element 25 comprises a tongue rail 26. The railway switch 21 shown in figure 1 comprises two movable railway elements 25. Adjacent to each of the movable railway elements 25 a rail 23 of the railway switch 21 is arranged. To each of the rails 23 two sensor arrangements 20 are connected. For the four sensor arrangements 20 the sensor 24 is arranged below the respective movable railway element 25.

[0062] For each sensor arrangement 20 it is also possible that the sensor 24 is configured to differentiate between at least three different spatial positions of the segment 34 of the movable railway element 25. Each sensor arrangement 20 is configured to provide a sensor signal to the processing unit 29 and the sensor signal comprises the measured spatial position. The processing unit 29 is configured to provide an output signal at its output 35 to the signaling system 43 and the output signal comprises information from the sensor signal.

[0063] Each wheel sensor 30 comprises an inductive sensor. It is also possible that each wheel sensor 30 comprises two inductive sensors. The processing unit 29 is configured to receive a position signal from each wheel sensor 30, the processing unit 29 is configured to provide an output signal at its output 35 to the signaling system 43 and the output signal comprises information from the position signals. Each position signal comprises the information that a wheel of a rail vehicle passed the position of the respective wheel sensor 30.

[0064] Figure 2 shows an exemplary embodiment of the monitoring unit 28 with a railway switch 21. The railway switch comprises a movable railway element 25. In figure 2, a front part 46 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 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 2 or the other way around. In another state the movable railway element 25 can be in direct contact with the rail 23. In this arrangement a rail vehicle can move from the left to the bottom right position in figure 2 or the other way around. For a safe railway traffic it is necessary to monitor the position of the movable railway element 25.

[0065] The processing unit 29 is arranged spaced apart from the railway track. One wheel sensor 30 is connected to the rail 23 and one sensor arrangement 20 is connected to the rail 23 of the railway switch 21. The wheel sensor 30 and the sensor arrangement 20 are connected with the processing unit 29 and the processing unit 29 comprises an output 35 that is connectable to a signaling system 43.

[0066] In figure 3 a cross section through another exemplary embodiment of the sensor arrangement 20 is shown. Figure 3 shows a side view where a cross section through the rail 23 is shown. A rail claw 22 is arranged below the rail 23 and fixed to the rail 23 with two clamp parts 31. The rail 23 is comprised by the railway switch 21. 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.

[0067] In figure 3 an arrangement of the movable railway element 25 is shown, which is referred to as a first arrangement. In the first arrangement of the movable railway element 25 the segment 34 of the movable railway element 25 is in its closest position with respect to the rail 23. In this case the movable railway element 25 is in direct contact with the rail 23. 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 this 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.

[0068] 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.

[0069] The movable railway element 25 comprises a first edge 36 and a second edge 37 which is arranged opposite to the first edge 36. In figure 3 the second edge 37 is arranged closer to the rail 23 than the first edge 36. In the first arrangement the second edge 37 is not arranged above the sensor 24. However, the first edge 36 is arranged above the sensor 24. The first edge 36 of the movable railway element 25 is detected by the sensor 24.

[0070] 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. In the first arrangement the movement of the first edge 36 induces a change in the signal of the sensor 24. Thus, the first edge 36 of the movable railway element 25 is detected by the sensor 24.

[0071] Figure 4 shows the same cross section through the sensor arrangement 20 as figure 3 but the movable railway element 25 is arranged at a different position. The movable railway element 25 is arranged in a second arrangement where the segment 34 of the movable railway element 25 is arranged spaced apart from the rail 23. This means, that in the second arrangement the segment 34 is arranged spaced apart from the rail 23 further than in the first arrangement. In the second arrangement of the movable railway element 25 the segment 34 of the movable railway element 25 can be arranged at its maximum distance from the rail 23.

[0072] In the second arrangement the first edge 36 of the movable railway element 25 is not arranged above the sensor 24 and the second edge 37 is arranged above the sensor 24. Thus, in the second arrangement the second edge 37 of the movable railway element 25 is detected by the sensor 24.

[0073] Figure 5 shows the same cross section through the sensor arrangement 20 as figure 3 but the movable railway element 25 is arranged at a different position. In figure 5 the movable railway element 25 is arranged at a position between the position shown in figure 3 and the position shown in figure 4. The movable railway element 25 is not in direct contact with the rail 23 and arranged spaced apart from the rail 23.

[0074] Figure 6 shows an exemplary embodiment of the sensor arrangement 20 mounted to the rail 23 of the railway system 21. The sensor arrangement 20 comprises a rail claw 22 that is connected to the rail 23 of the railway system 21. Figure 6 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 6. 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 6.

[0075] With figure 7 an exemplary embodiment of the method for monitoring a railway track is described. In a first step S1 of the method at least one position signal detected by the wheel sensor 30 that is connected to a rail 23 of the railway track. In a second step S2 of the method the position signal is transmitted to the processing unit 29. In a third step S3 of the method at least one sensor signal is detected by the sensor arrangement 20 that is connected with the railway switch 21. In a fourth step S4 of the method the sensor signal is transferred to the processing unit 29. The second step S2 of the method is carried out after the first step S1 of the method. The fourth step S4 of the method is carried out after the third step S3 of the method. The first step S1 and the third step S3 can be carried out in any order or at the same time. In a fifth step S5 of the method an output signal is provided by the processing unit 29 to the signaling system 43. The output signal comprises information from the position signal and information from the sensor signal. For obtaining the sensor signal a spatial position of at least a segment 34 of the movable railway element 25 is measured in a contactless measurement by the sensor 24 of the sensor arrangement 20. The sensor signal comprises the measured spatial position. The position signal comprises the information that a wheel of a rail vehicle passed the position of the wheel sensor 30.

Reference numerals

[0076]

20	sensor arrangement
21	railway switch
22	rail claw
23	rail
24	sensor
25	movable railway element
26	tongue rail
28	monitoring unit
29	processing unit
30	wheel sensor
31	clamp part
32	screw
33	top part
34	segment
35	output
36	first edge
37	second edge
38	first wheel sensor
39	second wheel sensor
40	third wheel sensor
41	first sensor arrangement
42	second sensor arrangement
43	signaling system
44	third sensor arrangement
45	fourth sensor arrangement
46	front part
x	lateral direction S1-S5 steps

Claims

1. Monitoring unit (28) for monitoring a railway track, the monitoring unit (28) comprising:

   - a processing unit (29),
   - at least one wheel sensor (30) connectable to a rail (23) of the railway track, and
   - a sensor arrangement (20) connectable to a railway switch (21) of the railway track, wherein
   - the wheel sensor (30) and the sensor arrangement (20) are connected with the processing unit (29), and
   - the processing unit (29) comprises an output (35) that is connectable to a signaling system (43).

2. Monitoring unit (28) according to claim 1, wherein the processing unit (29) is configured to receive signals detected by the wheel sensor (30) and/or signals detected by the sensor arrangement (20).

3. Monitoring unit (28) according to one of the preceding claims, wherein the sensor arrangement (20) comprises 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 switch (21) in a contactless measurement and to differentiate between at least two different spatial positions of the segment (34) of the movable railway element (25) .

4. Monitoring unit (28) according to claim 3, wherein the movable railway element (25) comprises a tongue rail (26).

5. Monitoring unit (28) according to one of claims 3 or 4, 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).

6. Monitoring unit (28) according to one of claims 3 to 5, wherein the sensor arrangement (20) is configured to provide a sensor signal to the processing unit (29) and the sensor signal comprises the measured spatial position.

7. Monitoring unit (28) according to claim 6, wherein the processing unit (29) is configured to provide an output signal at its output (35) to the signaling system (43) and the output signal comprises information from the sensor signal.

8. Monitoring unit (28) according to one of the preceding claims, wherein the wheel sensor (30) comprises an inductive sensor (24).

9. Monitoring unit (28) according to one of the preceding claims, wherein the processing unit (29) is configured to receive a position signal from the wheel sensor (30), the processing unit (29) is configured to provide an output signal at its output (35) to the signaling system (43) and the output signal comprises information from the position signal.

10. Monitoring unit (28) according to claim 9, wherein the position signal comprises the information that a wheel of a rail vehicle passed the position of the wheel sensor (30).

11. Method for monitoring a railway track, the method comprising:

    - detecting at least one position signal by a wheel sensor (30) connected to a rail (23) of the railway track,
    - transferring the position signal to a processing unit (29),
    - detecting at least one sensor signal by a sensor arrangement (20) connected with a railway switch (21) of the railway track,
    - transferring the sensor signal to the processing unit (29), and
    - providing an output signal by the processing unit (29) to a signaling system (43).

12. Method for monitoring a railway track according to claim 11, wherein the output signal comprises information from the position signal and information from the sensor signal.

13. Method for monitoring a railway track according to one of claims 11 or 12, wherein a spatial position of at least a segment (34) of a movable railway element (25) of the railway switch (21) is measured in a contactless measurement by a sensor (24) of the sensor arrangement (20), 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).

14. Method for monitoring a railway track according to claim 13, wherein the sensor signal comprises the measured spatial position.

15. Method for monitoring a railway track according to one of claims 11 to 14, wherein the position signal comprises the information that a wheel of a rail vehicle passed the position of the wheel sensor (30).

FIG. 1

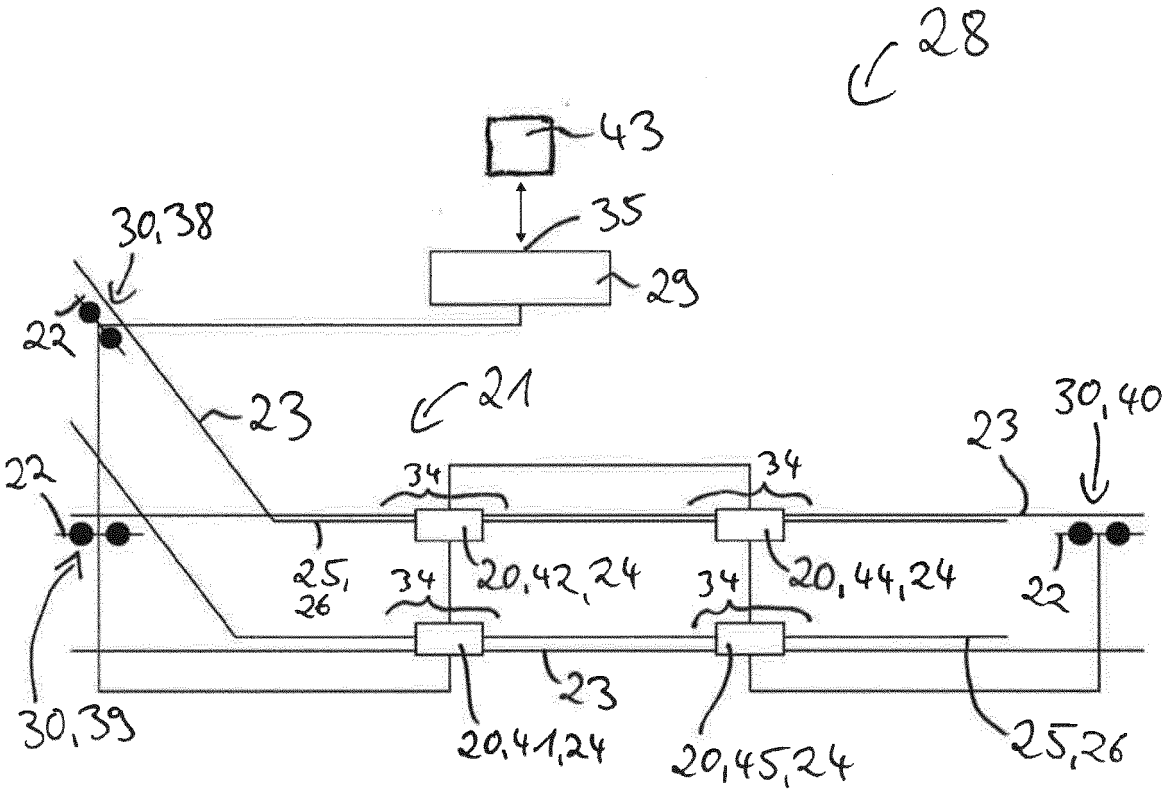
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FIG. 2

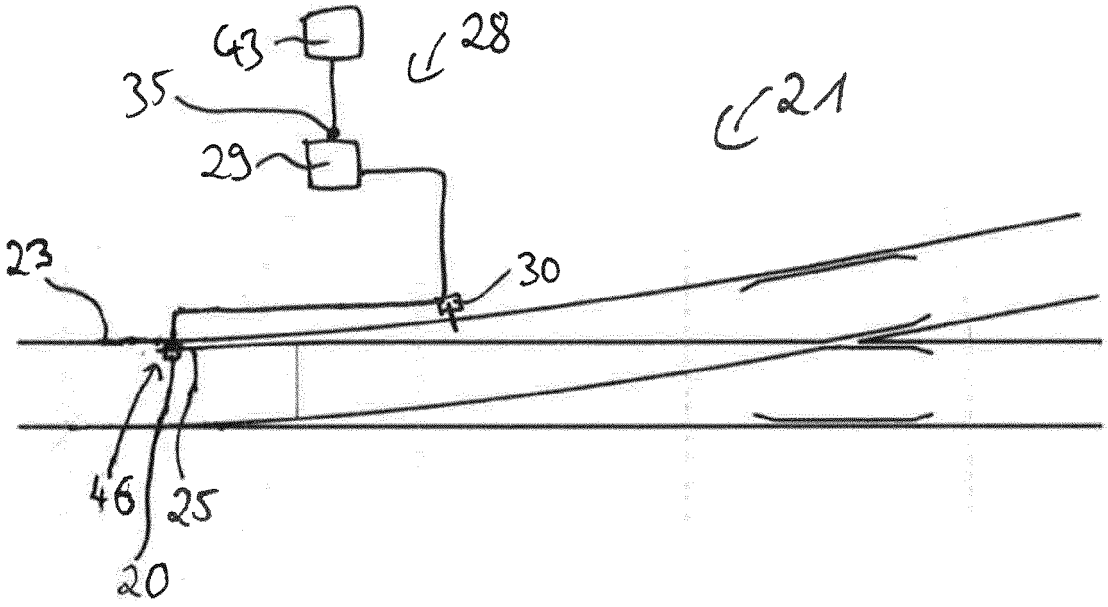
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FIG. 3

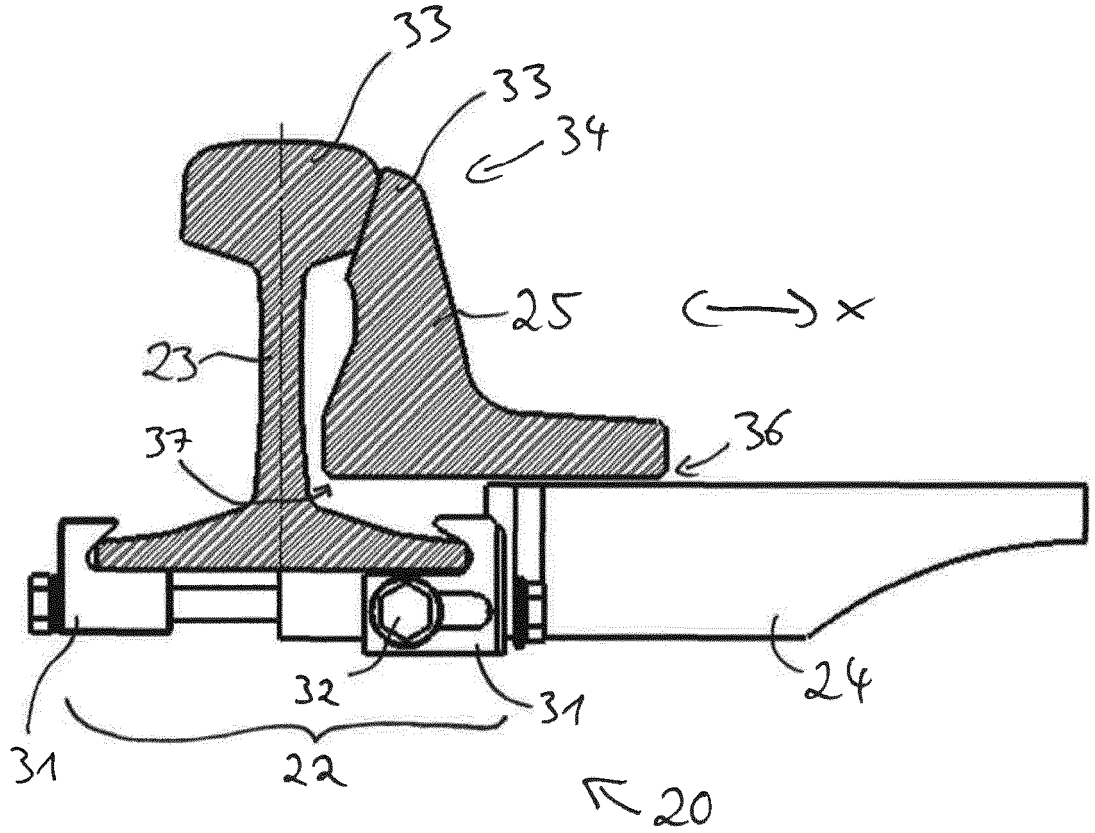


FIG. 4

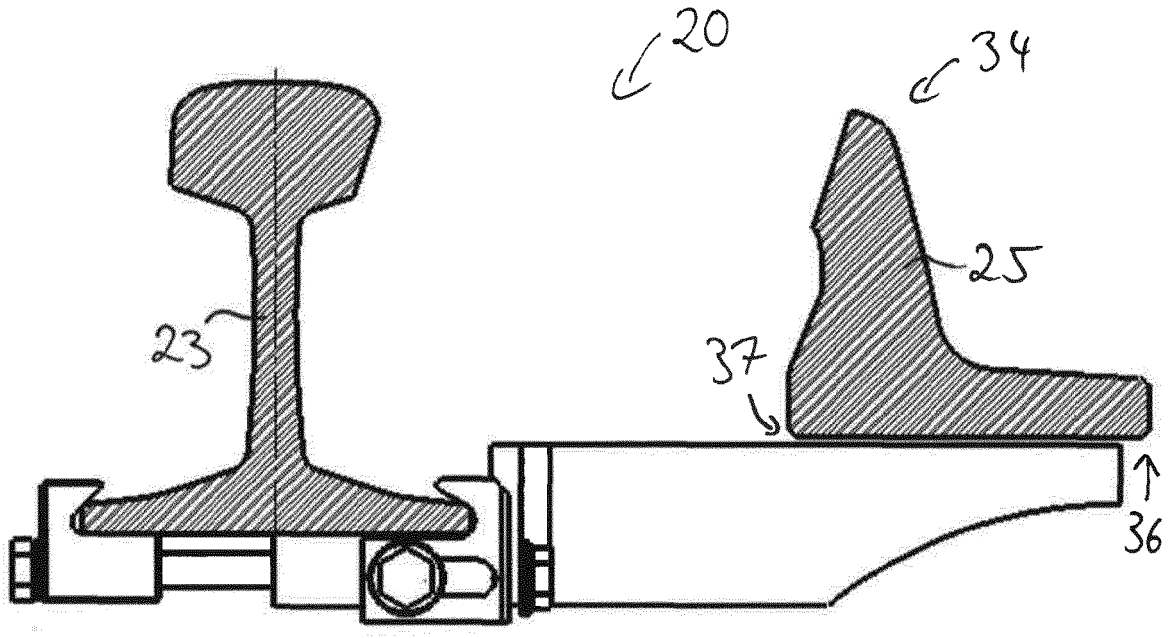


FIG. 5

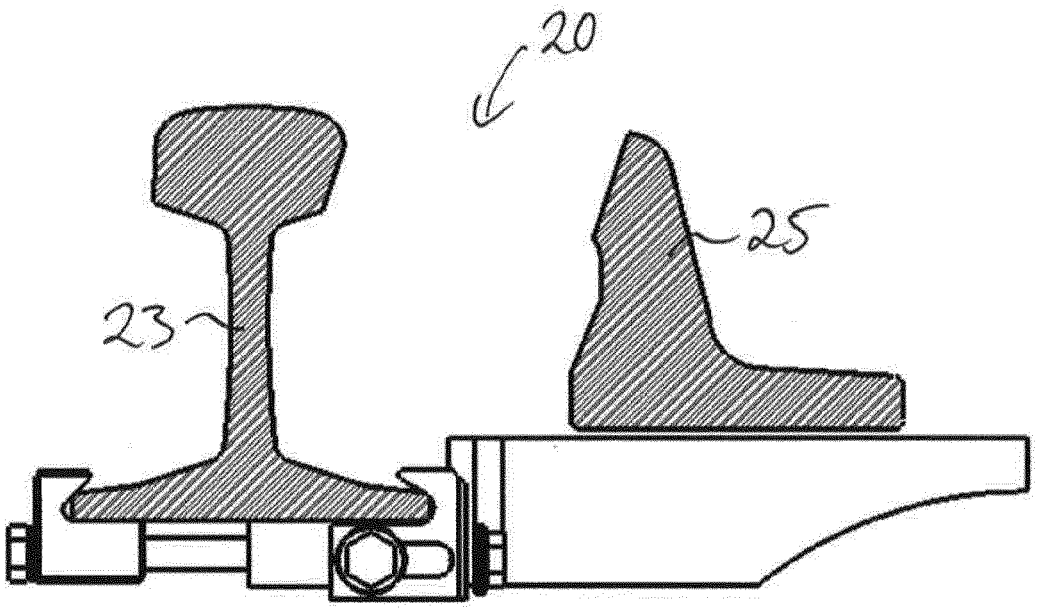


FIG. 6

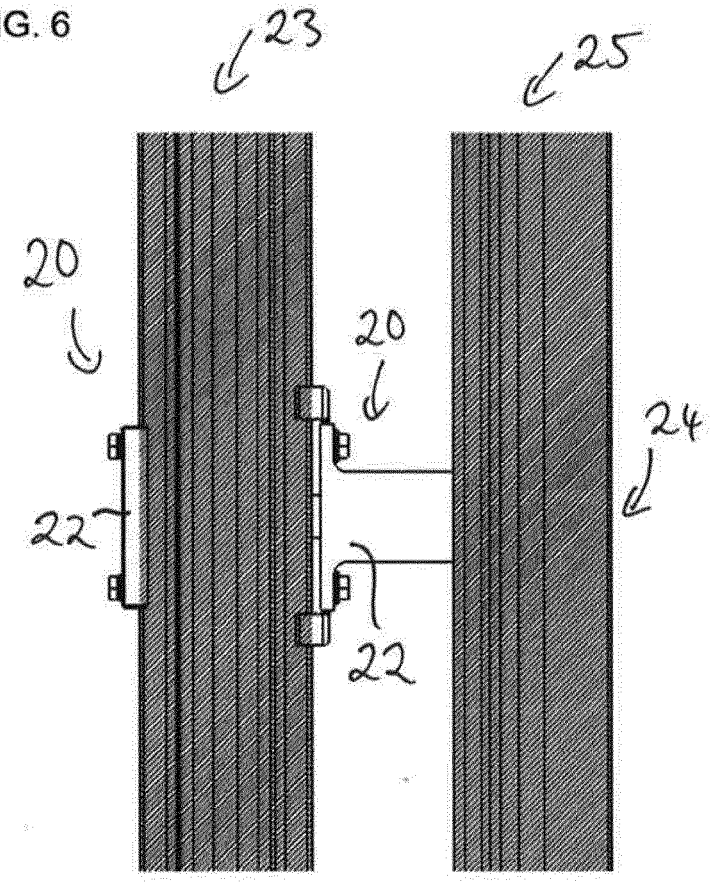
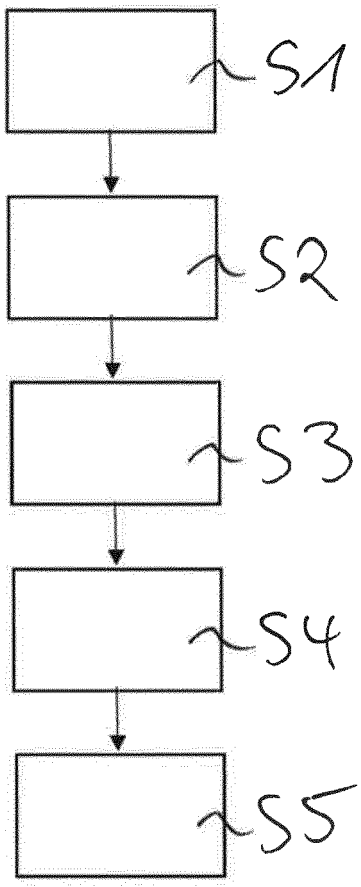


FIG. 7



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EUROPEAN SEARCH REPORT

Application Number
EP 21 20 3954

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 3 612 429 B1 (SIEMENS MOBILITY GMBH [DE]) 28 July 2021 (2021-07-28) * figure 1; paragraphs [0027] - [0030] *	1-15	INV. B61L1/16 B61L5/10 B61L19/06
A	EP 1 270 363 A1 (SIEMENS AG [DE]) 2 January 2003 (2003-01-02) * figures 1 and 2; paragraphs [0012] - [0014] *	1-15	B61L21/04

TECHNICAL FIELDS SEARCHED (IPC)

B61L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 April 2022	Plützer, Stefan

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