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(54) **An antenna arrangement and a method for determining the absolute speed of a rail vehicle**

(57) The invention relates to an antenna arrangement, in particular an antenna arrangement (7, 7a) of a rail vehicle (1) for receiving signals (10) transmitted by a track-sided transmitter (9), and a method for determining an absolute speed of a rail vehicle (1), wherein the antenna arrangement (7, 7a) is mounted on a rail vehicle (1), wherein the antenna arrangement (7, 7a) comprises a first antenna element (11, 11 a) and at least another antenna element (12, 12a) for receiving a signal (10) transmitted by the track-sided transmitter (9), and wherein the first and the other antenna element (11, 11a, 12, 12a) are designed as separate antenna elements (11, 11 a, 12, 12a), wherein the first and the other antenna element (11, 11 a, 12, 12a) are arranged with a predetermined displacement (A) along a direction of travel of the rail vehicle (1).

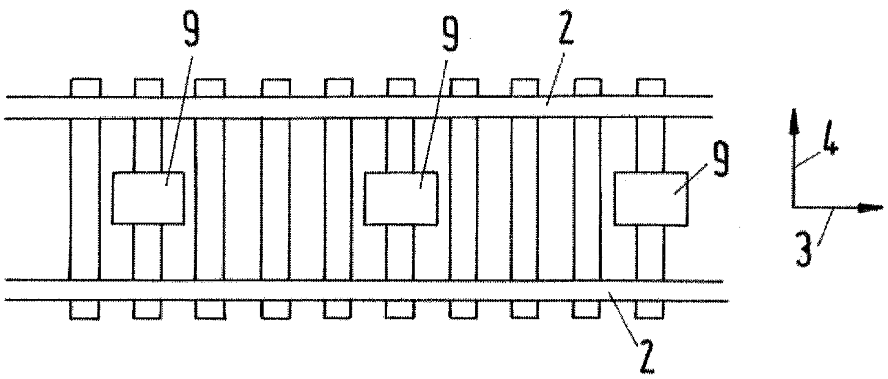

Fig.1

EP 2 851 262 A1

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Description

[0001] The invention relates to an antenna arrangement, in particular an antenna arrangement of a rail vehicle, for receiving signals transmitted by a track-sided transmitter and a method for determining the absolute speed of the rail vehicle.

[0002] Measuring the travel speed of moving rail vehicles is the basis for some of the fundamental functions of onboard railway safety systems. Physical constraints like slip and slide between vehicular wheels and the railway tracks, radar reflectiveness of the track area and cost constraints limiting the number and the location of sensors that can be installed on a rail vehicle usually do not permit a technical optimal solution to determine the travel speed.

[0003] EP 2527225 A1 discloses a magnetic induction antenna arrangement comprising an electrically conducting loop forming a first antenna for powering tags over the entire range from high to low distances between the first antenna and the tag by producing a first electromagnetic field. The conducting loop or a second conducting loop forms at least one second antenna, which is arranged in such a manner that a second electromagnetic field produced by the second antenna partially cancels the first electromagnetic field produced by the first antenna.

[0004] It is an object of the present invention to provide an antenna arrangement, in particular of a rail vehicle, for receiving signals transmitted by a track-sided transmitter, and a method for determining the absolute speed of the rail vehicle which allow a simple, fast, accurate and reliable determination of the absolute speed of a moving rail vehicle.

[0005] The solution is provided by the subject-matter having the features of claims 1 and 9.

[0006] It is a basic idea of the invention to provide an antenna arrangement for a rail vehicle which comprises at least two separate antenna elements which are arranged such that a signal which is transmitted by a track-sided transmitter, e.g. a balise, is received with a time shift by the at least two antenna elements if the rail vehicle moves. Depending on the time shift and the known displacement between the antenna elements, the absolute speed of the rail vehicle can be determined.

[0007] An antenna arrangement, in particular an antenna arrangement of a rail vehicle for receiving signals transmitted by a track-sided transmitter, in particular a balise, is proposed. The antenna arrangement is mounted on a rail vehicle. For example, the antenna arrangement can be mounted on a bottom side of a wagon of the rail vehicle.

[0008] The antenna arrangement comprises a first antenna element and at least another antenna element for receiving a signal transmitted by the track-sided transmitter. The antenna elements can be magnetic induction antenna elements. By the antenna elements, the signal, which is provided by an electromagnetic wave, can be received and transformed into an electric voltage.

[0009] The first and the other antenna element are designed as separate antenna elements. This means that the antenna elements are not electrically connected. For example, the antenna elements can be insulated against each other. Also, each of the antenna elements can be separately connected to an evaluation unit, e.g. a voltage sensor. In summary, the first and the other antenna element can receive the transmitted signal independent from each other.

[0010] Furthermore, the first and the other antenna element are arranged with a predetermined displacement or distance along a direction of travel of the rail vehicle. This means that the displacement comprises at least one portion along the direction of travel. It is, however, possible that the displacement comprises other portions in other spatial directions.

[0011] The direction of travel can be the direction of travel if the rail vehicle travels forward on the rail tracks. The direction of travel can, if the rail vehicle travels straightforward, be parallel to a longitudinal axis of the rail vehicle.

[0012] In other words, the first and the other antenna element are arranged with a predetermined displacement or distance along the direction of travel such that a signal, in particular the same part or portion of the signal which is transmitted by the track-sided transmitter is received by the at least two antenna elements with a time shift if the rail vehicle is travelling with a speed higher than zero.

[0013] In the proposed arrangement, the signal or a part of the signal transmitted by the track-sided transmitter is first received by the antenna element which is arranged ahead of the remaining antenna element (s) with respect to the direction of travel. Depending on the absolute speed of the rail vehicle, the signal of the said part of the signal will be received by the other antenna element (s) which is/are arranged behind the aforementioned antenna element with respect to the direction of travel of the rail vehicle later in time. The absolute speed can e.g. correspond to a travel speed of the rail vehicle.

[0014] It is of course possible that the proposed antenna arrangement comprises more than two antenna elements which are arranged with predetermined displacements along the direction of travel of the rail vehicle.

[0015] The antenna elements are used to receive a signal which codes or contains information of a communication between vehicle-sided units and track-sided units.

[0016] The proposed antenna arrangement thus advantageously provides an antenna arrangement which allows a simple, robust and accurate determination of the absolute speed of the rail vehicle based on the reception of one signal transmitted by a track-sided transmitter, in particular a balise.

[0017] In a preferred embodiment, the first antenna element comprises an electrically conducting loop, wherein the other antenna element is arranged at least partially in an area enclosed by the conducting loop. The loop can provide a winding structure for receiving an alternating electromagnetic field.

[0018] In this case, the first antenna element provides a magnetic induction antenna element. The loop can comprise one or multiple turns. It is, of course, possible that the other antenna element also comprises an electrically conducting loop, wherein the electrically conducting loop of the other antenna element is arranged at least partially in the area enclosed by the conducting loop of the first antenna element.

[0019] The conducting loop can be a closed loop or a partially open loop.

[0020] In the proposed configuration, the first antenna element will, if the rail vehicle travels with a speed higher than zero, receive the signal transmitted by the track-sided transmitter before the other antenna element. The displacement along the direction of travel can e.g. be determined as the displacement between a centre point of the conducting loop of the first antenna element and a centre point of the other antenna element, in particular a centre point of the conducting loop of the other antenna element. It is, however, also possible that the displacement is determined as a displacement between front sections or front-sided sections of the at least two antenna elements, wherein the front section is a section of the respective antenna element which is arranged at a front part of the antenna with respect to the direction of travel.

[0021] This advantageously provides a simple configuration of a magnetic induction antenna element for receiving an electromagnetic signal transmitted by the track-sided transmitter. Also, the arrangement of the other antenna element inside the first antenna element provides a space saving configuration, wherein a required installation space for the proposed antenna arrangement is reduced.

[0022] In another embodiment, the other antenna element is fully arranged in the area enclosed by the conducting loop. In particular, a front-sided section of the other antenna element can be arranged with a predetermined displacement along the direction of travel of the rail vehicle from a front-sided section of the first antenna element. Front-sided in this context relates to the direction of travel. In this case, the transmitted signal is first received by the first antenna element and later received by the other antenna element.

[0023] If the antenna elements partially overlap in a common plane of projection, it depends on the arrangement of front-sided sections of the different antenna elements which antenna element first receives the transmitted signal.

[0024] In another embodiment, the other antenna element or a central axis of the other antenna element is arranged with a predetermined displacement to a central axis of the first antenna element. The central axis can e.g. be an axis of symmetry or a longitudinal axis of a conducting loop of the respective antenna element. The displacement can be a displacement exclusively along the direction of travel of the rail vehicle. It is, however, possible that the displacement also comprises portions of other spatial directions.

[0025] This advantageously provides an accurate displacement of the two antenna elements which, in turn, advantageously allows an accurate determination of the absolute speed.

[0026] In an alternative embodiment, the first antenna comprises an electrically conducting loop, wherein the other antenna element, in particular the complete other antenna element, is arranged outside an area enclosed by the conducting loop. In this case, also the other antenna element can comprise an electrically conducting loop.

[0027] This advantageously provides a large displacement between the two antenna elements which, in turn, allows a robust and reliable discrimination between the signals received by the respective antenna elements. This, in turn, enhances a comparison of the signals received by the respective antenna elements in order to determine corresponding signal parts.

[0028] In another embodiment, the first antenna element and the other antenna element have the same geometrical shape or spatial configuration. This especially holds for embodiments where the complete other antenna element is arranged outside the area enclosed by the conducting loop of the first antenna element or only partially arranged in the area enclosed by the conducting loop of the first antenna element.

[0029] This advantageously reduces a fabrication effort of the antenna elements as only one type of antenna element has to be provided.

[0030] In another embodiment, the other antenna element comprises an electrically conducting loop, wherein a central axis of the other antenna element is arranged with a predetermined displacement to or from a central axis of the first antenna element along the direction of travel. The central axes denote the axes of symmetry or longitudinal axes of the conducting loops. Depending on said predetermined displacement of the central axes, the absolute speed of the rail vehicle can be determined.

[0031] This advantageously provides a configuration of the antenna arrangement which is suited for magnetic induction reception of the transmitted signal and allows accurate determination of the absolute speed.

[0032] In another embodiment, the conducting loop of the first antenna element and/or the conducting loop of the other antenna element is oval-shaped.

[0033] This advantageously provides a simple configuration of the respective antenna element. It is, however, possible that other geometrical shapes, e.g. a rectangular or a circular shape, is used.

[0034] Further proposed is a method for determining an absolute speed of a rail vehicle. The rail vehicle comprises an antenna arrangement according to one of the previously described embodiments.

[0035] The method comprises the steps of transmitting or generating a signal by a track-sided transmitter, in particular a balise. The transmitted signal or a part of the signal is received by the first antenna element of the antenna arrangement. Time information, e.g. time stamps, can be recorded simultaneously to the reception of the transmitted signal, in particular simultaneously to the reception of parts of the signal.

[0036] The transmitted signal is also received by the other antenna element. Correspondingly, time information, e.g. time stamps, can be recorded simultaneously to the reception of the transmitted signal, in particular simultaneously to the reception of parts of the transmitted signal.

[0037] Depending on the displacement of the first and the other antenna element, there will be a difference of the point in time of the reception of the same part of the transmitted signal by the different antenna elements. It is, for instance, possible that the other antenna element receives a part of the transmitted signal later than the first antenna element or vice versa. The same part of the signal can also be referred to as corresponding part of the signal.

[0038] Furthermore, the method comprises the steps of determining the rail vehicle absolute speed depending on the predetermined displacement and the time shift between the reception of the same or corresponding part of the signal by the first and the other antenna element. The time shift can be determined depending on the recorded time information.

[0039] The same or corresponding part of the signal can be determined by comparing at least one characteristic of the received signal and/or at least a part of the content of the received signal. To determine the at least one part of the signal content, the received signal can be decoded.

[0040] As the displacement is accurately known beforehand, the proposed method allows an accurate determination of the absolute speed by receiving only one transmitted signal.

[0041] In a preferred embodiment, the time shift and/or the same part of the signal is determined by a correlation of the signal received by the first antenna element and the signal received by the other antenna element. In this case, a time course of the signal received by one of the antenna elements can be correlated with a time course of the signal received by the other antenna element, wherein the time courses are delayed with respect to each other with multiple time shifts. The resulting time shift is chosen as the time shift which yields the highest correlation coefficient.

[0042] The same part of the signal and the time shift can be determined, for example, if a correlation coefficient of the correlation of both received signals is higher than a predetermined value, e.g. higher than 0.6.

[0043] This advantageously allows a simple determination of the time shift and/or the same part of the signal as a correlation operation can be easily implemented, e.g. within an evaluation unit such as a microcontroller.

[0044] In another embodiment, the same part of the signal is determined by evaluating time information of the received signal. It is possible that time information, e.g. a transmitting time, is encoded within the transmitted signal. By decoding the transmitted signal, said time information can be extracted. If the said time information is determined for the signals received by both antenna elements, the same part of the signal can be determined depending on the time information.

[0045] In addition or alternatively, the same part of the signal can be determined depending on a field intensity of the transmitted signal. In this case, a field intensity signal value or an amplitude signal value of the received signal is determined. Characteristics of said values over time can be determined and compared between the signal parts received by both antenna elements.

[0046] Alternatively or in addition, a transmission content is determined. Depending on the transmission content, the same part of the signal can be determined. In this case, the transmitted signal has to be decoded in order to analyse the transmission content. The same part of the signal can e.g. be a part which comprises the same transmission content.

[0047] In addition or alternatively, the same part of the signal is determined by evaluating a waveform of the transmitted signal. It is for instance possible to compare the waveforms of the signal received by the first antenna element and the other antenna element. As for the case of the field intensity, characteristics describing the waveform of the transmitted signal can be determined, e.g. a maximal amplitude, a frequency content or other characteristics. The waveform can, in this case, also be compared to each other by comparing said characteristics.

[0048] This advantageously allows a reliable determination of the same part of the signal.

[0049] In another embodiment, only the transmission content of the raw signal received by one of the antenna elements is decoded, wherein the same part of the signal is determined by evaluating the raw signals received by the first and the other antenna element.

[0050] This especially holds for the embodiment where the other antenna element is arranged at least partially, in particular fully, in the area enclosed by the conducting loop of the first antenna element. In this case, only the transmission content of the raw signal received by the first antenna element is decoded for a communication between vehicle-sided units and track-sided units. The other antenna element is only used to receive the transmitted signal and to generate a corresponding raw signal, wherein no decoding of the signal received by the other antenna element is performed.

[0051] In this case, the other antenna element is only provided in order to allow the proposed determination of the absolute speed but not for communication between vehicle-sided units and track-sided units.

[0052] In an alternative embodiment, the transmission content of the raw signals received by the first and the other antenna element is decoded. This means, that both antenna elements are used for the communication between track-sided units and vehicle-sided units. This, in turn, allows minimizing communication errors as the transmission content is determined on raw signals received by two independent antenna elements. It is therefore possible to compare the transmission content of the signals received by the two antenna elements and determine a transmission error.

[0053] The invention will be described with reference to the attached figures. The figures show:

Fig. 1 a schematic top view on a rail track with multiple track-sided transmitters,

Fig. 2 a schematic side view of a rail vehicle with a proposed antenna arrangement,

Fig. 3 a schematic bottom view of the rail vehicle shown in Fig. 2,

Fig. 4 a schematic bottom view of the rail vehicle with another proposed antenna arrangement,

Fig. 5 a schematic top view on a rail vehicle with a proposed antenna arrangement,

Fig. 6 a schematic side view of the rail vehicle shown in Fig. 5,

Fig. 7 a schematic top view on a rail vehicle with another proposed antenna arrangement and

Fig. 8 a schematic side view of the rail vehicle shown in Fig. 7.

[0054] Fig. 1 shows a schematic top view on rail tracks 2 with multiple track-sided transmitters 9. A rail vehicle 1 (see Fig. 2) is travelling on rail tracks 2. A direction of travel is indicated by an arrow 3. This direction of travel can also be denoted as longitudinal direction 3. The longitudinal direction 3 extends parallel to a longitudinal axis of the rail vehicle 1. Also shown is a lateral direction indicated by an arrow 4 which is oriented perpendicular to the longitudinal direction 3. Both, the longitudinal and the lateral direction 3, 4 are oriented perpendicular to a vertical direction which is indicated by an arrow 5 (see Fig. 2) and which is oriented from a ground 6, in particular orthogonal to the ground 6, towards the rail vehicle 1. The multiple track-sided transmitters 9 are arranged along the longitudinal direction 3 with a predetermined distance.

[0055] Fig. 2 shows a rail vehicle 1 which is travelling on rail tracks 2. A direction of travel is indicated by an arrow 3. Further shown is a vertical direction which is indicated by an arrow 5 (see Fig. 2) and which is oriented from a ground 6, in particular orthogonal to the ground 6, towards the rail vehicle 1. The rail vehicle 1 comprises an antenna arrangement 7 which is mounted on a bottom side 19 of the rail vehicle 1. Also shown are multiple stationary track-sided transmitters 9 which each transmit a communication signal indicated by an arrow 10 towards the rail vehicle 1. The antenna arrangement 7 comprises a first antenna element 11 and another element 12. The first and the other antenna element 11, 12 are arranged with a predetermined displacement A (see Fig. 3) along direction of travel of the rail vehicle 1. Thus, if the rail vehicle 1 travels along the rail tracks 2 with a speed higher than zero, the communication signal 10 from each track-sided transmitter 9 will be first received by the first antenna element 11 and with a time shift by the other antenna element 12, wherein the time shift depends on the absolute speed and the displacement A. It can be assumed that the contribution of the propagation velocity of the communication signal 10 to the time shift is small, and thus does not need to be considered. It is, however, also possible to take the propagation velocity into account for determining the time shift.

[0056] Further shown are wheels 20 of the rail vehicle 1 and two evaluation units 13, 15, wherein the first antenna element 11 is connected to a first evaluation unit 13 and the other antenna element is connected to another evaluation unit 15.

[0057] Fig. 3 shows a schematic bottom view of the rail vehicle 1 shown in Fig. 2. The first antenna element 11 comprises a rectangular conducting loop which is connected to the first evaluation unit 13 (see Fig. 2). Shown is a central axis 14 of the conducting loop of the first antenna element 11. The other antenna element 12 also comprises a conducting loop which has the same dimensions as the conducting loop of the first antenna element 11. The other antenna element 12 is connected to the other evaluation unit 15 (see Fig. 2). Also shown is a central axis 16 of the conducting loop of the other antenna element 12.

[0058] The displacement A is provided by displacement along the longitudinal direction 3 of the central axes 14, 16 of the conducting loops of both antenna elements 11, 12. The central axes 14, 16 e.g. extend perpendicular to an area enclosed by the conducting loops, e.g. in the vertical direction 5 (see Fig. 2).

[0059] It is, of course, possible that the antenna elements 11, 12 have another geometric shape.

[0060] Fig. 4 shows a schematic bottom view of a rail vehicle 1 with another proposed antenna arrangement 7a. The other antenna arrangement 7a comprises a first antenna element 11 a and another antenna element 12a. Both, the first antenna 11 a and the other antenna element 12a are designed as conducting loops. Shown are also central axes 14a, 16a of the first and the other antenna element 11 a, 12a.

[0061] In contrast to the embodiment shown in Fig. 3, the other antenna element 12a or at least the conducting loop of the other antenna element 12a is fully arranged in an area enclosed by the conducting loop of the first antenna element 11 a.

[0062] The displacement A is again provided by displacement along the longitudinal direction 3 of the central axes 14a, 16a of the conducting loops of both antenna elements 11a, 12a.

[0063] Also shown is a front-sided section 17 of the conducting loop of the first antenna element 11 a which is arranged with a predetermined displacement in the longitudinal direction 3 ahead of a front-sided section 18 of the conducting loop of the other antenna element 12a.

[0064] Due to the displacement A and/or the displacement between the front-sided sections 17, 18, the communication signal 10 transmitted by the track-sided transmitter 9 will be first received by the first antenna element 11 a and, depending on the displacement and the absolute speed, later by the other antenna element 12a.

[0065] Fig. 5 shows a top view on a rail vehicle 1 which is travelling on rail tracks 2. A direction of travel is indicated by an arrow 3. Also shown is a lateral direction indicated by an arrow 4 which is oriented perpendicular to the longitudinal direction 3. Both, the longitudinal and the lateral direction 3, 4 are oriented perpendicular to a vertical direction which is indicated by an arrow 5 (see Fig. 6) and which is oriented from a ground 6, in particular orthogonal to the ground 6, towards the rail vehicle 1.

[0066] The rail vehicle 1 comprises an antenna arrangement 7 which is mounted on a side wall 8 of the rail vehicle 1. Also shown is a stationary track-sided transmitter 9 which transmits a communication signal indicated by an arrow 10 towards the rail vehicle 1. The antenna arrangement 7 comprises a first antenna element 11 and another element 12. The first and the other antenna element 11, 12 are arranged with a predetermined displacement A (see Fig. 6) along direction of travel of the rail vehicle 1.

[0067] Thus, if rail vehicle 1 travels along the rail tracks 2 with a speed higher than zero, the communication signal 10 will be first received by the first antenna element 11 and with a time shift by the other antenna element 12, wherein the time shift depends on the absolute speed and the displacement A. Again, it can be assumed that the contribution of the propagation velocity of the communication signal 10 to the time shift is small, and thus does not need to be considered. It is, however, also possible to take the propagation velocity into account for determining the time shift.

[0068] Fig. 6 shows a schematic side view of the rail vehicle 1 shown in Fig. 5. Shown is the side wall 8 of the rail vehicle 1 and the antenna arrangement 7. The first antenna element 11 comprises a rectangular conducting loop which is connected to a first evaluation unit 13. Shown is a central axis 14 of the conducting loop of the first antenna element 11.

[0069] The other antenna element 12 also comprises a conducting loop which has the same dimensions as the conducting loop of the first antenna element 11. The other antenna element 12 is connected to another evaluation unit 15. Also shown is a central axis 16 of the conducting loop of the other antenna element 12. The displacement A is provided by displacement along the longitudinal direction 3 of the central axes 14, 16 of the conducting loops of both antenna elements 11, 12. The central axes 14, 16 e.g. extend perpendicular to an area enclosed by the conducting loops, e.g. in the lateral direction 4 (see Fig. 1). Again, the antenna elements 11, 12 can have another geometric shape than the rectangular shape shown in Fig. 6.

[0070] Fig. 7 shows a schematic top view on a rail vehicle 1 travelling on rail tracks 2 with another antenna arrangement 7a. The antenna arrangement 7a comprises a first antenna element 11a and another antenna element 12a. Shown is also the track-sided transmitter 9 which transmits the communication signal 10. Fig. 7 shows that the other antenna element 12a is arranged with a displacement in the longitudinal direction 3 as well as in the lateral direction 4 from the first antenna element 11 a. It is, however, possible that the other antenna element 12a is arranged within the same plane as the first antenna element 11 a with respect to the lateral direction 4.

[0071] In Fig. 8 a schematic side view of the rail vehicle 1 shown in Fig. 7 is shown. Both, the first antenna 11 a and the other antenna element 12a are designed as conducting loops. Shown are also central axes 14a, 16a of the first and the other antenna element 11 a, 12a.

[0072] In contrast to the embodiment shown in Fig. 6, the other antenna element 12a or at least the conducting loop of the other antenna element 12a is fully arranged in an area enclosed by the conducting loop of the first antenna element 11 a. The displacement A is provided by displacement along the longitudinal direction 3 of the central axes 14a, 16a of the conducting loops of both antenna elements 11 a, 12a.

[0073] Also shown is that a front-sided section 17 of the conducting loop of the first antenna element 11 a is arranged with a predetermined displacement in the longitudinal direction 3 ahead of a front-sided section 18 of the conducting loop of the other antenna element 12a.

[0074] Due to the displacement A and/or the displacement between the front-sided sections 17, 18, the communication signal 10 transmitted by the track-sided transmitter 9 will be first received by the first antenna element 11a and, depending on displacement and the absolute speed, later by the other antenna element 12a.

[0075] As balises are standard systems installed along a railway track, the proposed antenna arrangement 7, 7a can be used for the purpose of a communication between track-sided units and vehicle-sided units as well as for the proposed determination of the vehicle speed. Advantageously, costs for the installation of such a speed measuring system are low as only one special antenna arrangement needs to be installed.

[0076] The proposed method for determining the vehicle speed advantageously allows recalibrating the vehicle speed at each balise passage in a very accurate way. Thus, configuration errors, e.g. an incorrect wheel diameter, can be determined. Also a wheel wear compensation without additional equipment can be performed by using the absolute speed determined with the proposed method.

Claims

1. An antenna arrangement, in particular an antenna arrangement (7, 7a) of a rail vehicle (1) for receiving

signals (10) transmitted by a track-sided transmitter (9), wherein the antenna arrangement (7, 7a) is mounted on a rail vehicle (1), wherein the antenna arrangement (7, 7a) comprises a first antenna element (11, 11a) and at least another antenna element (12, 12a) for receiving a signal (10) transmitted by the track-sided transmitter (9),

characterized in that

the first and the other antenna element (11, 11a, 12, 12a) are designed as separate antenna elements (11, 11a, 12, 12a), wherein the first and the other antenna element (11, 11a, 12, 12a) are arranged with a predetermined displacement (A) along a direction of travel of the rail vehicle (1).

2. The antenna arrangement according to claim 1, wherein the first antenna element (11 a) comprises an electrically conducting loop, wherein the other antenna element (12a) is arranged at least partially in an area enclosed by the conducting loop of the first antenna element (11a).

3. The antenna arrangement according to claim 2, wherein the other antenna element (12a) is fully arranged in the area enclosed by the conducting loop of the first antenna element (11 a).

4. The antenna arrangement according to one of the claims 2 or 3, wherein the other antenna element (12a) or a central axis (16a) of the other antenna (12a) element is arranged with a predetermined displacement (A) to a central axis (14a) of the first antenna element (11a).

5. The antenna arrangement according to claim 1, wherein the first antenna element (11) comprises an electrically conducting loop, wherein the other antenna element (12) is arranged outside an area enclosed by the conducting loop of the first antenna element (11).

6. The antenna arrangement according to one of the claims 1 to 5, wherein the first antenna element (11) and the other antenna element (12) have the same geometrical shape or spatial configuration.

7. The antenna arrangement according to one of the claims 1 to 6, wherein the other antenna (12, 12a) element comprises an electrically conducting loop, wherein a central axis (16, 16a) of the other antenna element (12, 12a) is arranged with a predetermined displacement (A) to a central axis (14, 14a) of the first antenna element (11, 11a) along the direction of travel.

8. The antenna arrangement according to one of the claims 2 to 7, wherein the conducting loop is oval-shaped.

9. A method for determining an absolute speed of a rail vehicle (1), wherein the rail vehicle (1) comprises an antenna arrangement (7, 7a) according to one of the claims 1 to 8, wherein

- a track-sided transmitter (9) transmits a signal (10),
- the transmitted signal (10) is received by the first antenna element (11, 11a),
- the transmitted signal (10) is received by the other antenna element (12, 12a),
- the rail vehicle (1) absolute speed is determined depending on the predetermined displacement (A) and the time shift between the reception of the same part of the signal (10) by the first and the other antenna element (11, 11a, 12, 12a).

10. The method according to claim 9, wherein the time shift and/or the same part of the signal (10) is determined by a correlation of the signal (10) received by the first antenna element (11, 11a) and the signal (10) received by the other antenna element (12, 12a).

11. The method according to one of the claims 9 or 10, wherein the same part of the signal (10) is determined by evaluating a time information and/or a field intensity and/or a transmission content and/or a waveform of the transmitted signal (10).

12. The method according to one of the claims 9 to 11, wherein only the transmission content of the raw signal (10) received by one of the antenna elements (11, 11a, 12, 12a) is decoded, wherein the same part of the signal (10) is determined by evaluating the raw signals (10) received by the first and the other antenna element (11, 11a, 12, 12a).

13. The method according to one of the claims 9 to 11, wherein the transmission content of the raw signal (10) received by the first and the other antenna element (11, 11a, 12 12a) is decoded.

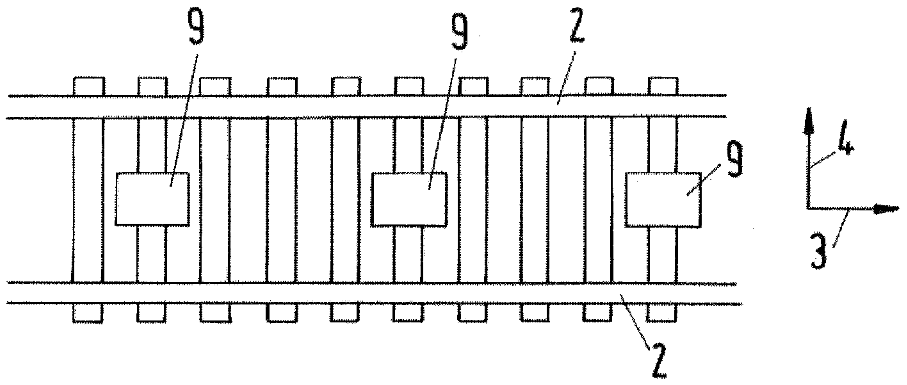

Fig.1

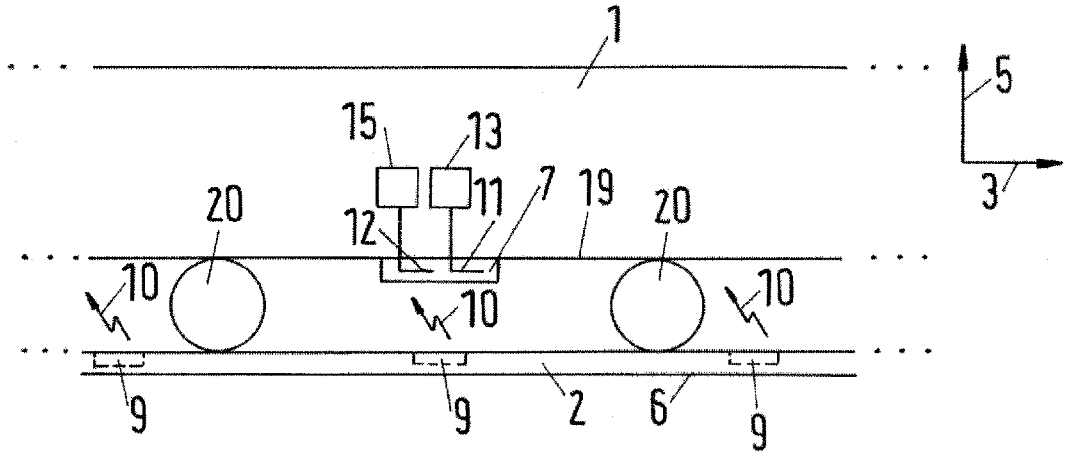

Fig.2

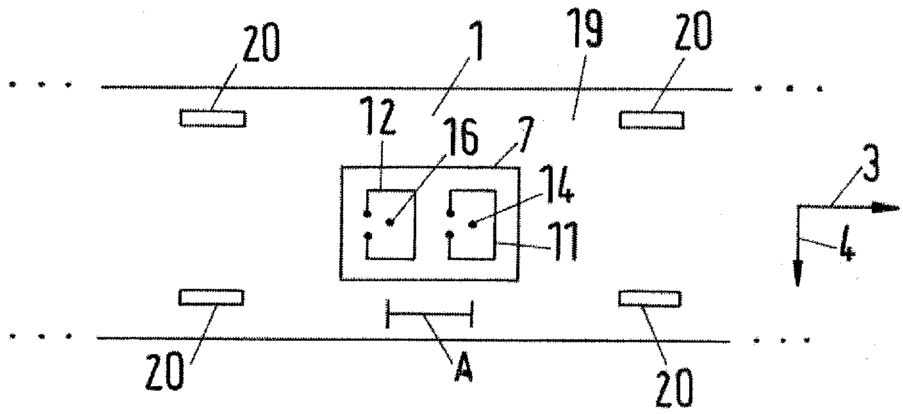
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Fig.3

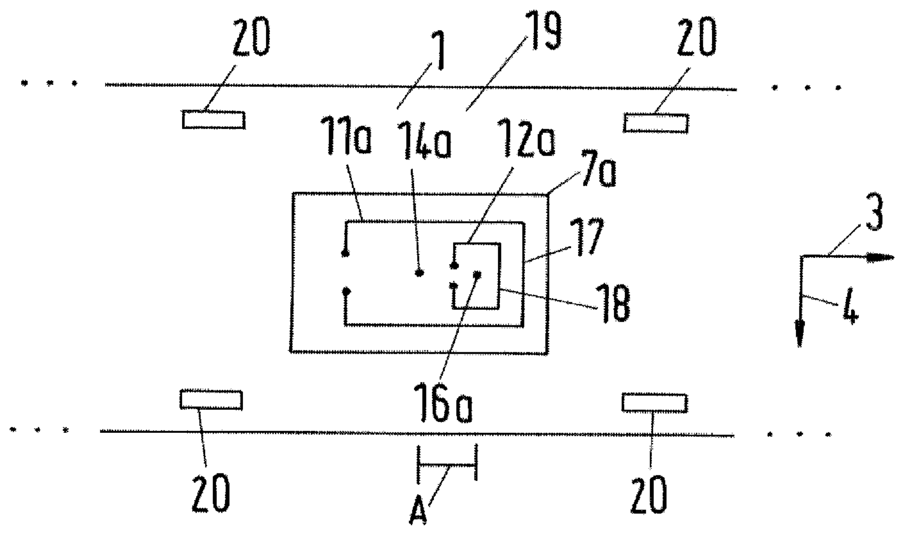
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Fig.4

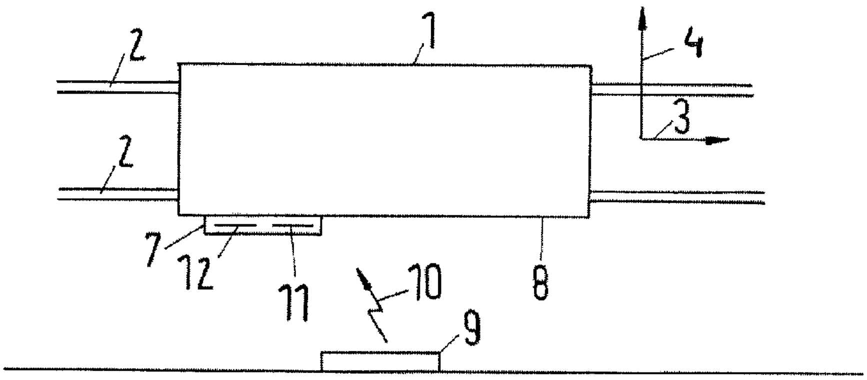

Fig.5

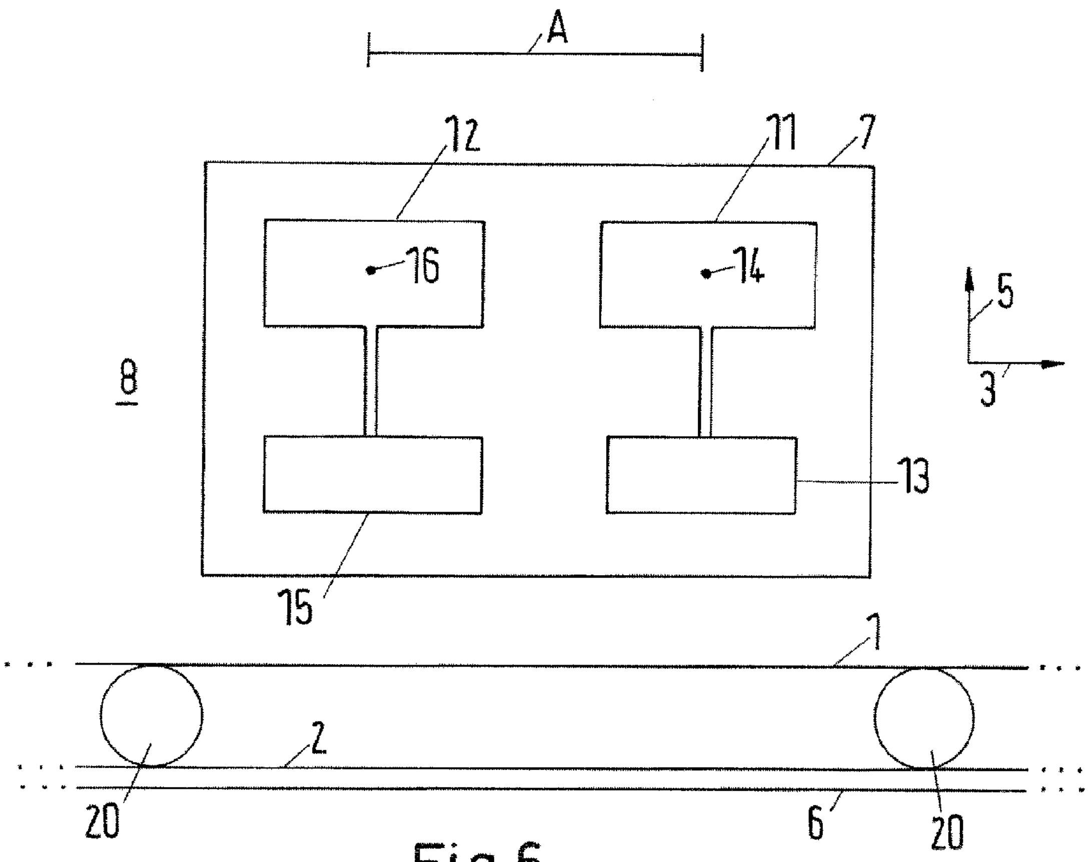

Fig.6

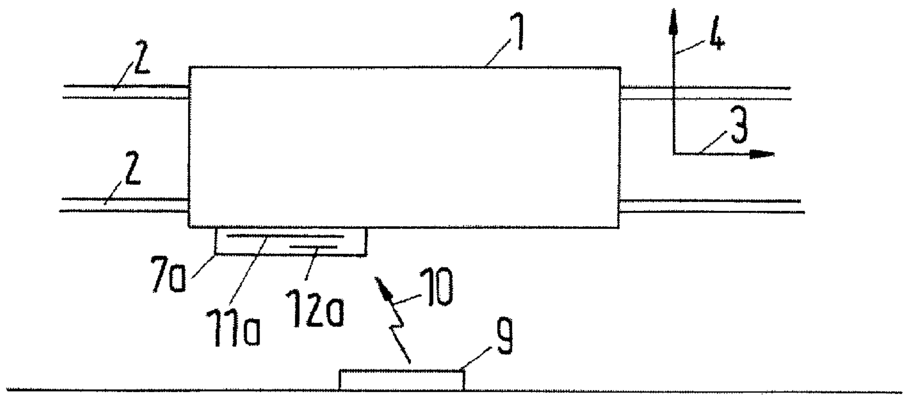

Fig.7

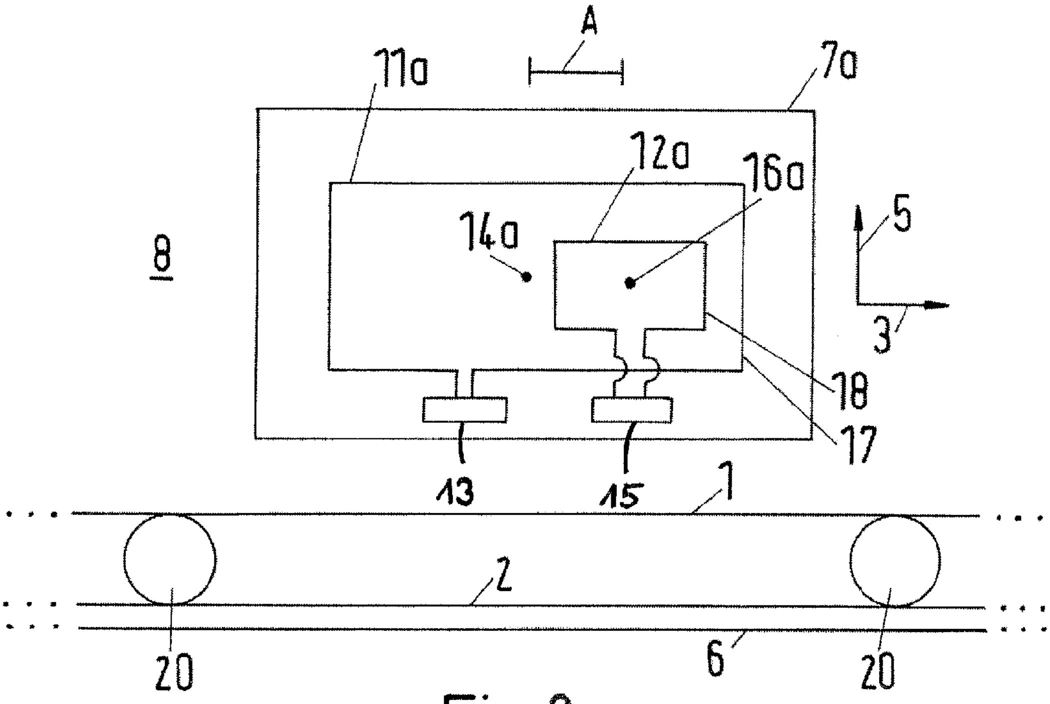

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 13 18 4954

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2

Place of search	Date of completion of the search	Examiner
Munich	13 February 2014	Janhsen, Axel

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