

Description

Title of Invention: RAILROAD CAR POSITION DETECTION SYSTEM

5 Technical Field

[0001]

The present invention relates to a train position detecting system.

10 Background Art

[0002]

As a train position detecting system for detecting a position of a train travelling on a railway track, conventionally, there has been known a system that uses a transponder beacon or a track circuit
15 installed on a railway track. However, the transponder beacon is required to be highly durable and highly weather resistant, and is thus expensive. As for the track circuit, it is installed at the time of laying the track, according to the length of a block, and it is difficult to newly install the track circuit. Furthermore, the cost of
20 maintaining an impedance bond provided at a boundary of blocks, equipment for transmitting a signal current to the track circuit, and the like is great. Accordingly, a train position detecting system that uses the transponder beacon or the track circuit is highly costly.

[0003]

25 In recent years, to reduce the cost of the train position detecting system, use of radio frequency identification (RFID) is being examined. As a mode which is advantageous in terms of

cost, it is conceivable to install an RFID reader on a vehicle, and to install a beacon including an RFID tag on the ground. In this case, the RFID reader on the vehicle reads the RFID tag on the ground, and the position of the train is detected based on identification information that is read. For example, a database associating the identification information of an RFID tag and location information may be prepared on the vehicle, and when the RFID reader reads the identification information from an RFID tag and refers to the database on the vehicle, location information corresponding to the identification information can be obtained.

[0004]

The cost of a beacon that uses the RFID tag is significantly lower than that of a transponder beacon. Moreover, in the case of using a passive tag as the RFID tag, power does not have to be supplied, and thus, an installation cost and a maintenance cost can be reduced. In this manner, by using RFID, the cost of the train position detecting system can be reduced.

[0005]

The RFID originally aims to identify or manage products, for example, and does not aim to detect a position of an RFID tag. However, because received power at the RFID reader ideally draws a curve and is reduced as the RFID reader moves away from the RFID tag, it is possible to estimate the position of the RFID tag with a certain level of accuracy.

[0006]

However, with the train position detecting system, because the distance between a train and the ground is small, and also, a lower surface of the train is highly uneven due to presence of

underfloor devices and the like, radio waves emitted by the RFID tag are propagated in a complex manner due to reflection and diffraction. Accordingly, the received power at the RFID reader does not draw an ideally curved arch, and highly accurate detection
5 of the position of an RFID tag is difficult.

Citation List

Patent Literature

[0007]

- 10 Patent Literature 1: Japanese Patent Laid-Open No. 2009-149216

Summary of Invention

Technical Problem

[0008]

- 15 An object of the present invention is to provide a train position detecting system which is capable of detecting the position of a train with high accuracy by using a beacon including an RFID tag.

- 20 Solution to Problem

[0009]

- A train position detecting system according to an embodiment includes a beacon installed on a ground and including an RFID tag having identification information stored thereon, and an RFID
25 reader installed on a train and configured to read the identification information of the RFID tag, the train position detecting system being configured to detect a position of the train based on the identification information read from the RFID tag. The beacon

includes a radio shielding unit configured to shield radio waves emitted by the RFID tag. The radio shielding unit is provided on each side of the RFID tag in a train travelling direction so as to limit an angle of sight on the RFID tag seen from an antenna of the
5 RFID reader.

Brief Description of Drawings

[0010]

[Figure 1] Figure 1 is a diagram showing a schematic configuration
10 of a train position detecting system 1 according to an embodiment.

[Figure 2] Figure 2(a) is a perspective view of a beacon 10 according to the embodiment, and Figure 2(b) is a side view showing the beacon 10 according to the embodiment along a sleeper direction.

15 [Figure 3] Figure 3 is a diagram for describing an operation of the train position detecting system 1 according to the embodiment.

[Figure 4] Figure 4(a) is a side view of a beacon 10A according to a first modification, where the beacon 10A is provided with radio wave absorbers 14, 15, and Figure 4(b) is a side view of a beacon
20 10B according to a second modification, where the beacon 10B is provided with radio wave absorbers 14, 15, 16.

[Figure 5] Figure 5(a) is a top view of a beacon 10C according to a third modification, where an outer form of the beacon 10C is hemispherical shell-shaped, and Figure 5(b) is a cross-sectional
25 view taken along a line I-I in Figure 5(a).

[Figure 6] Figures 6(a) and 6(b) are diagrams for describing the train position detecting system 1, where position detection accuracy is adjusted depending on a travelling location of a train.

Description of Embodiment

[0011]

Hereinafter, a train position detecting system according to an
5 embodiment will be described with reference to the drawings.
Additionally, structural elements in the drawings having a same
function will be denoted by a same reference sign.

[0012]

As shown in Figure 1, a train position detecting system 1
10 includes a beacon 10 installed on the ground, and an RFID reader
21 installed on a train 20.

[0013]

The beacon 10 includes an RFID tag 11 having identification
information stored thereon. The type of the RFID tag 11 is not
15 particularly limited, and the RFID tag 11 may be a passive tag not
requiring power, or may be an active tag. For example, the
beacon 10 is installed on a sleeper or between sleepers of a railway
track 30. Moreover, the beacon 10 may be installed at an
intermediate position of an upbound railway track and a
20 downbound railway track.

[0014]

The RFID reader 21 includes an antenna 21a, and reads the
identification information (ID) of the RFID tag 11 by the antenna
21a. For example, the RFID reader 21 reads the identification
25 information of the RFID tag 11 at a predetermined cycle, and
determines on the identification information in a case where the
identification information that is read takes the same value
successively for a predetermined number of times.

[0015]

Additionally, usable RFID schemes in Japan are roughly divided based on a usable frequency band (13.56 MHz band, 920 MHz band (UHF band), 2.45 GHz band). Generally, RFID reading characteristics are dependent on output power of the RFID reader 21 and a property of the RFID tag 11 (mainly an antenna gain of the RFID tag 11). In the case of RFID in the UHF band, maximum output power of the RFID reader 21 is different between a premises radio station and a specified low power radio station. In the former case, transmission power is 1 W and antenna gain is 6 dBi (maximum output power of antenna; 36 dBm EIRP), and in the latter case, transmission power is 250 mW and antenna gain is 3 dBi (27 dBm EIRP). For its part, the properties of the RFID tag 11 are various depending on the type. In the case of using RFID in the UHF band, a readable distance depends on the type of the RFID reader 21 (premises radio station type, specified low power radio station type), and the type of the RFID tag 11, but is a relatively great distance of about several tens of centimeters to several meters.

20 [0016]

The train position detecting system 1 detects the position of the train 20 based on the identification information read by the RFID reader 21 from the RFID tag 11. For example, a database having identification information stored thereon and location information in association with each other is prepared in advance, and location information is acquired by searching the database with the identification information of the RFID tag 11 as a key. Alternatively, the identification information of the RFID tag 11 itself

may indicate the location information. Additionally, the location information may be acquired by the train 20, or may be acquired by an external device communicably connected to the RFID reader 21.

5 [0017]

Next, the beacon 10 including the RFID tag 11 will be described in detail with reference to Figures 2(a) and 2(b).

[0018]

The beacon 10 includes radio shielding units 12 for shielding
10 radio waves emitted by the RFID tag 11. The "radio waves emitted by the RFID tag 11" here means radio waves emitted by the antenna 21a of the RFID reader 21 and reflected by an antenna (not shown) of the RFID tag 11, in the case where the RFID tag 11 is a passive tag, and means radio waves emitted by the antenna
15 due to power of a power source connected to the RFID tag 11, in the case where the RFID tag 11 is an active tag.

[0019]

Moreover, to "shield radio waves" is to not transmit radio waves, and includes a case of reflecting the radio waves. For
20 example, the radio shielding unit 12 is formed of metal or the like that sufficiently shields radio waves in a usable frequency band.

[0020]

As shown in Figures 1, 2(a) and 2(b), the radio shielding units 12 are provided on both sides of the RFID tag 11 in a train
25 travelling direction so as to limit an angle of sight on the RFID tag 11 seen from the antenna 21a of the RFID reader 21 (hereinafter also simply referred to as "angle of sight"). Additionally, depending on the RFID tag, an antenna and an electronic

component, such as an IC chip, connected to the antenna are installed at separate locations, but the radio shielding units 12 are provided on both sides of the antenna of the RFID tag 11 in the train travelling direction. That is, the radio shielding units 12 are provided to sandwich, in the train travelling direction, at least the antenna among structural elements of the RFID tag 11.

[0021]

In the present embodiment, as shown in Figures 2(a), 2(b), an inner side surface 12a of the radio shielding unit 12 is a flat surface that faces the RFID tag 11, and that is substantially perpendicular to the train travelling direction (i.e., substantially parallel to a sleeper direction). Furthermore, the beacon 10 includes a plate-shaped bottom portion 13, and the RFID tag 11 is mounted on an upper surface 13a of the bottom portion 13.

[0022]

Additionally, the radio shielding unit 12 and the bottom portion 13 may be formed in an integrated manner. For example, formation is performed by bending a metal plate. Furthermore, for protection from water, dust and the like, the RFID tag 11 may be sealed by a material (such as resin) that does not prevent propagation of radio waves.

[0023]

Moreover, as shown in Figures 2(a), 2(b), the beacon 10 does not have to include the radio shielding unit for shielding radio waves emitted by the RFID tag 11 on either side of the RFID tag 11 in the sleeper direction. The beacon 10 may thereby be installed between an upbound railway track and a downbound railway track to be used for both upbound and downbound ways, for example.

[0024]

As described above, in the present embodiment, the radio shielding units 12 are provided on both sides of the RFID tag 11 in the train travelling direction so as to limit the angle of sight. A readable range of the RFID reader 21 can thus be narrowed. The "readable range" here is a range where the RFID reader 21 is able to read the identification information of the RFID tag 11. In the present embodiment, by narrowing the readable range by the radio shielding units 12 in the above manner, the position of the train 20 can be detected with high accuracy. This point will be more specifically described with reference to Figure 3.

[0025]

A solid line A in Figure 3 indicates received power at the RFID reader 21 in a case where the radio shielding units 12 are provided, and a broken line B indicates received power at the RFID reader 21 in a case where the radio shielding units 12 are not provided. Moreover, a solid line P indicates a reception status of the RFID reader 21 in a case where the radio shielding units 12 are provided, and a broken line Q indicates a reception status of the RFID reader 21 in a case where the radio shielding units 12 are not provided. The reception status indicates a range where the received power at the RFID reader 21 exceeds a threshold, and the RFID tag 11 can be read.

[0026]

The threshold for the received power is set to a value with a certain margin (i.e., a somewhat low value) so that the RFID reader 21 can reliably read the identification information of the RFID tag 11 in the readable range.

[0027]

Ideally, the received power at the RFID reader 21 draws a curve and is reduced as the RFID reader 21 moves away from the RFID tag 11. However, because the distance between the train 20 and the ground is small, and also, a lower surface of the train is highly uneven due to presence of underfloor devices 22 of the train 20(see Figure 1), intensity of the received power is possibly increased in the manner shown by the broken line B in Figure 3 due to diffraction, reflection or the like of radio waves.

10 [0028]

Due to the reasons mentioned above, there are ranges, outside the readable range of the RFID reader 21, where the intensity of the received power exceeds the threshold and the identification information of the RFID tag 11 can be read, as shown in Figure 3.

15 [0029]

On the other hand, in the present embodiment, the radio shielding units 12 are provided on both sides of the RFID tag 11 so as to limit the angle of sight. Accordingly, radio waves emitted by the RFID tag 11 are prevented from propagating in the train travelling direction beyond the readable range and directly reaching the RFID reader 21. That is, as can be seen from the solid line A in Figure 3, by providing the radio shielding units 12, sensitivity of the RFID tag 11 outside the readable range can be reduced while maintaining the sensitivity of the RFID tag 11 within the readable range. The readable range of the RFID reader 21 can thus be narrowed, and the position of the train 20 can be detected with high accuracy.

[0030]

Next, three modifications (first to third modifications) of the beacon 10 will be described. Figure 4(a) shows a side view of a beacon 10A provided with radio wave absorbers 14, 15, and Figure 4(b) shows a side view of a beacon 10B provided with radio wave absorbers 14, 15, 16. For example, the radio wave absorbers 14, 15, 16 are formed of a conductive material obtained by mixing carbon particles into sponge-like synthetic resin, but this is not restrictive so long as radio waves in the usable frequency band can be sufficiently absorbed.

[0031]

As shown in Figure 4(a), the beacon 10A according to the first modification includes the radio wave absorbers 14 disposed on the inner side surfaces 12a of the radio shielding units 12. Additionally, the radio wave absorber 14 desirably covers the inner side surface 12a.

[0032]

By providing the radio wave absorber 14 on the inner side surface 12a of the radio shielding unit 12 in the above manner, reflection of radio waves by the inner side surface 12a is suppressed. Accordingly, reception, by the antenna 21a of the RFID reader 21, of radio waves emitted by the RFID tag 11 and reflected by the inner side surface 12a may be suppressed. As a result, the readable range of the RFID reader 21 can be more effectively narrowed, and the position of the train 20 can be detected with even higher accuracy.

[0033]

Additionally, as shown in Figure 4(a), the radio wave absorber 15 may be disposed on the bottom portion 13. The radio wave absorber 15 desirably covers the upper surface 13a. By providing the radio wave absorber 15, radio waves reflected by the lower surface of the train 20 may be prevented from being reflected again by the upper surface 13a to be diffusely reflected. Accordingly, the intensity of the received power may be prevented from being increased outside the readable range of the RFID reader 21. As a result, the position of the train 20 can be detected with even higher accuracy.

[0034]

As shown in Figure 4(b), the beacon 10B according to the second modification includes the radio wave absorbers 16 disposed on upper end portions of the radio shielding units 12. The radio wave absorber 16 desirably covers the upper end portion of the radio shielding unit 12.

[0035]

By providing the radio wave absorber 16 on the upper end portion of the radio shielding unit 12 in the above manner, diffraction, of radio waves emitted by the RFID tag 11, at the upper end portion of the shielding unit 12 may be suppressed. As a result, the intensity of the received power may be prevented from being increased outside the readable range of the RFID reader 21, and the position of the train 20 can be detected with even higher accuracy.

[0036]

Next, a beacon 10C according to the third modification will be described with reference to Figures 5(a) and 5(b). Figure 5(a) is a

top view of the beacon 10C, and Figure 5(b) is a cross-sectional view taken along a line I-I in Figure 5(a).

[0037]

The beacon 10C includes the RFID tag 11, radio shielding
5 units 17 for shielding radio waves emitted by the RFID tag 11, and a disc-shaped bottom portion 18 having the RFID tag 11 mounted on an upper surface 18a.

[0038]

Like the radio shielding units 12 described above, the radio
10 shielding units 17 are provided on both sides of the RFID tag 11 in the train travelling direction so as to limit the angle of sight on the RFID tag 11 seen from the antenna 21a of the RFID reader 21. As shown in Figure 5(b), the radio shielding unit 17 has a shape which is a part of a spherical shell, and an inner side surface 17a is a
15 curved surface. The same advantageous effects as the beacon 10 described above can be achieved also by the beacon 10C having such a hemispherical shell-shaped outer form.

[0039]

Additionally, as in the cases of the beacons 10A, 10B, a radio
20 wave absorber (not shown) may be disposed on the inner side surface 17a of the radio shielding unit 17 and/or the upper surface 18a of the bottom portion 18.

[0040]

Next, with respect to the train position detecting system 1,
25 adjustability of the readable range of the RFID reader 21 according to a travelling location of the train 20 will be described.

[0041]

With respect to the train position detecting system, position detection accuracy which is necessary is different depending on the travelling location of a train. For example, when a train is travelling in a station or a periphery of the station (hereinafter referred to as "station or the like"), the position of the train is required to be detected with high accuracy such that the train is stopped at a target stop position at the station, or in alignment with platform screen doors. On the other hand, when a train is travelling between stations, the position of the train may be detected with relatively low accuracy. With respect to this point, it is conceivable to install low-sensitivity RFID tags at a station or the like to narrow the readable range of the RFID reader 21 and secure high position detection accuracy, and to install high-sensitivity RFID tags between stations. However, a phenomenon that the intensity of received radio waves is increased outside the readable range due to reflection or diffraction of radio waves may still be caused, and sufficient position detection accuracy cannot be secured.

[0042]

In the present embodiment, the angle of sight on the RFID tag 11 seen from the antenna 21a of the RFID reader 21 is smaller for the beacon 10 installed at a station or the like than for the beacon 10 installed between stations. That is, the angle of sight of the beacon 10 installed at a station or the like is made smaller than the angle of sight of the beacon 10 installed between stations. This allows the readable range of the RFID reader 21 to be adjusted to achieve required position detection accuracy.

[0043]

For example, the angle of sight is adjusted by changing a gap between the inner side surfaces 12a depending on an installation location of the beacon 10. That is, the gap between the inner side surfaces 12a of the radio shielding units 12 provided on both sides of the RFID tag 11 is made smaller at a station or the like than between stations. In this case, as shown in Figure 6(a), a gap W1 between the inner side surfaces 12a of the beacon 10 installed at a station or the like is smaller than a gap W2 between the inner side surfaces 12a of the beacon 10 installed between stations (i.e., $W1 < W2$).

[0044]

Alternatively, the angle of sight may be adjusted by changing a height of the inner side surfaces 12a depending on an installation location of the beacon 10. That is, the height of the inner side surfaces 12a of the radio shielding units 12 provided on both sides of the RFID tag 11 is made higher at a station or the like than between stations. In this case, as shown in Figure 6(b), a height H1 of the inner side surfaces 12a of the beacon 10 installed at a station or the like is higher than a height H2 of the inner side surfaces 12a of the beacon 10 installed between stations (i.e., $H1 > H2$).

[0045]

As described above, with the train position detecting system 1, the readable range can be adjusted according to required position detection accuracy, without increasing the types of the RFID tags 11. As a result, position detection accuracy according to the travelling location of a train may be secured.

[0046]

According to at least one of the embodiment/modifications described above, a train position detecting system which is capable of detecting the position of a train with high accuracy by using a beacon including an RFID tag can be provided.

5 [0047]

Although embodiments of the present invention have been described, the embodiments are illustrated as examples, and do not intend to limit the scope of the invention. The embodiments can be can be carried out in other various modes, and various
10 omissions, replacements and modifications can be made within the scope of the gist of the present invention. The embodiments and modifications are included in the scope and the gist of the invention, and are also included in the invention described in the claims and equivalents of the invention.

15

Reference Signs List

[0048]

1: train position detecting system

10, 10A, 10B, 10C: beacon

20 11: RFID tag

12, 17: radio shielding unit

12a, 17a: inner side surface

13, 18: bottom portion

13a, 18a: upper surface

25 14, 15, 16: radio wave absorber

20: train

21: RFID reader

21a: antenna

22: underfloor device

30: railway track

A, P: solid line

B, Q: broken line

5 H1, H2: height (of inner side surface)

W1, W2: gap (between inner side surfaces)

- 18 -

Claims

[Claim 1]

A train position detecting system comprising a beacon installed
5 on a ground and including an RFID tag having identification
information stored thereon, and an RFID reader installed on a train
and configured to read the identification information of the RFID tag,
the train position detecting system being configured to detect a
position of the train based on the identification information read from
10 the RFID tag, wherein

the beacon includes a radio shielding unit that is provided on
each side of the RFID tag in a train travelling direction so as to limit
an angle of sight on the RFID tag seen from an antenna of the RFID
reader, and that is configured to shield radio waves emitted by the
15 RFID tag, and

wherein the beacon does not include a radio shielding unit
configured to shield radio waves emitted by the RFID tag on either
side of the RFID tag in a sleeper direction.

20 [Claim 2]

The train position detecting system of Claim 1, wherein a radio
wave absorber configured to absorb radio waves emitted by the RFID
tag is disposed on an inner side surface of the radio shielding unit.

25 [Claim 3]

The train position detecting system of Claim 1, wherein the
beacon further includes a bottom portion where the RFID tag is
mounted, and a radio wave absorber configured to absorb radio
waves emitted by the RFID tag is disposed on the bottom portion.

[Claim 4]

The train position detecting system of Claim 1, wherein a radio wave absorber configured to absorb radio waves emitted by the RFID tag is disposed on an upper end portion of the radio shielding unit.

5

[Claim 5]

The train position detecting system of Claim 1, wherein the angle of sight of a beacon installed at a station is smaller than the angle of sight of a beacon installed between stations.

10

[Claim 6]

The train position detecting system of Claim 5, wherein a gap between the inner side surfaces of the radio shielding unit provided on each side of the RFID tag is smaller for the beacon installed at a station than for the beacon installed between stations.

15

[Claim 7]

The train position detecting system of Claim 5, wherein a height of the inner side surface of the radio shielding unit provided on each side of the RFID tag is higher for the beacon installed at a station than for the beacon installed between stations.

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