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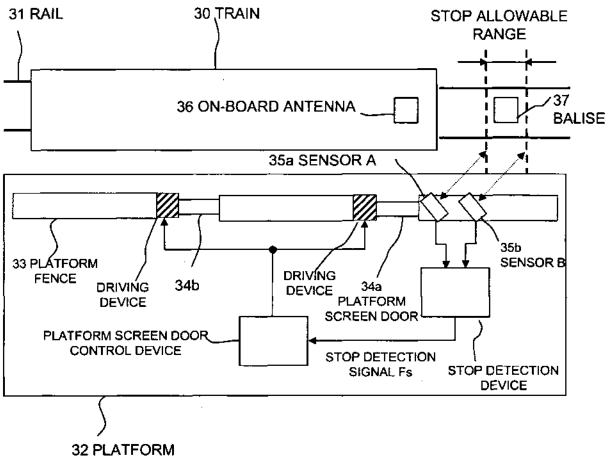
(54) **Train stop detection system**

(57) In the control of a conventional interlocking device and platform screen door, even when a train is actually stopped, the stop of the train cannot be detected until a predetermined allowance time elapses, so that in spite of the fact that a preceding train is stopped, a route for a succeeding train cannot be secured, and thereby the succeeding train is delayed more than needed. A train stop detection system according to the present invention is featured by including: a track circuit 20 which detects that a train is present in a specific section; a non-contact type sensor 3 which detects the speed of the train; a stop detection device which detects the stop of the train on the basis of a train occupancy signal output from the track circuit and the train speed detected by the sensor, and which generates a stop detection signal; and an interlocking device which controls a ground facility on the basis of the stop detection signal, and is featured in that the sensor is positioned before a predetermined train stop position in the train travel direction and is arranged so as to be close to the train.

FIG. 3



EP 2 159 129 A2

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to a train stop detection system used for an interlocking device and a platform screen door device of a railway vehicle.

Description of the Related Art

[0002] In order to safely secure the route of a train, it is necessary to control the interrelationship between a signal device and a point by an interlocking device.
When a platform screen door installed on a platform of a station is opened and closed, it is necessary to detect that a train is surely stopped at a predetermined stop position.
[0003] In the control of the signal device and the point by the interlocking device, when a preceding train is passed by a succeeding train while stopping at a station, the interlocking device first detects by train occupancy detection means, such as a track circuit and a wheel detector, the entry of the preceding train into a fixed section including the predetermined stop position.
[0004] Next, the interlocking device detects the stop of the preceding train on the basis of the lapse of a predetermined allowance time from the time of the entry of the preceding train into the fixed section. After detecting the stop of the preceding train, the interlocking device operates the signal device and the point, so as to secure a route which is necessary to allow the succeeding train to pass the preceding train.
[0005] In the control of the platform screen door, the stop of the train is detected by the side of the train. The train detects the train speed by a rotation sensor attached to the wheel. The stop of the train is detected on the basis of the fact that a state where the train speed is a predetermined value or less is continued for a predetermined allowance time. The platform screen door device receives stop detection information via an on-board antenna and a balise which have communication functions, so as to open the platform screen door.
[0006] In Japanese Patent Laid-Open Publication No. 10-338135, there is disclosed a platform monitoring device which by photographing the surrounding of a platform with a camera installed on the platform, performs determination of the presence or absence of a train, and determination of the start or entry of the train, and measures the speed of the train and a time period from the entry to the start of the train.
[0007] Further, in Japanese Patent Laid-Open Publication No. 2006-60434, it is disclosed that a radar device is installed on the side of a ground system of a station, to measure the distance to a train and the speed of the train.
[0008] In the interlocking device, the allowance time used to detect the stop of the preceding train is set to include a large allowance time as long as about several tens seconds in addition to the time needed for the normal stop, in consideration of the possibility that the preceding train cannot be sufficiently decelerated and enters the forward section beyond the predetermined stop position so as to become an obstacle in the route of the succeeding train. For this reason, in spite of the fact that the preceding train is stopped, the route of the succeeding train cannot be secured, so that the succeeding train is delayed more than needed.
[0009] Also in the platform screen door control, the detectable speed of the rotation sensor, which is required to have high robustness, is limited to a range of about 4 km/h or more, and hence an allowance time of about several seconds is taken into consideration in the stop detection. Thus, in the required operation time of a train, there is caused a large delay in which the respective allowance time periods are added at the stations where the train stops.
[0010] Further, in order to notify the stop detection information from an onboard location to a ground location, a balise having a power source and a communication function is needed, which causes a facility to be complicated.
[0011] A principal object of the present invention is to provide a train stop detection system which is capable of reducing the allowance time required for the train detection, and shorting the train operation time.

SUMMARY OF THE INVENTION

[0012] According to the present invention, there is provided a train stop detection system which is featured by including: a train occupancy detection device configured to detect the presence of a train in a specific section; non-contact type detection means configured to detect the speed of the train; a stop detection device configured to detect the stop of the train on the basis of a train occupancy signal output from the train occupancy detection device and the train speed detected by the detection means, so as to generate a stop detection signal; and an interlocking device configured to control a ground facility on the basis of the stop detection signal, and which is featured in that the detection means is positioned before a predetermined train stop position in the train travel direction and is arranged so as to be close to the train.

[0013] It is possible to provide a train stop detection system which is capable of reducing the allowance time required for the train detection and reducing the train operation time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

FIG. 1 is a figure showing a first embodiment of a train stop detection system according to the present invention;
FIG. 2 is a figure showing a time chart of train stop detection in the first embodiment;
FIG. 3 is a figure showing a second embodiment of a train stop detection system according to the present invention;
FIG. 4 is a figure showing a time chart of train stop detection in the second embodiment; and
FIG. 5 is an illustration of a millimeter wave sensor installation method.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] With reference to FIG. 1, there will be described a first embodiment of a train stop detection system in which the present invention is applied to an interlocking device.

[0016] A train 1 is a preceding train. It is assumed that the train 1 moving along a railway track 9 stops near a predetermined stop target position of a platform 2, and that while the train 1 stops, a succeeding train (not shown) advances to a track circuit D from a track circuit B through a track circuit C, so as to pass the train 1. The train occupancy is detected by the track circuit.

[0017] On the platform 2, non-contact type detection means (sensor 3), for example, a millimeter wave sensor in the present embodiment, which detects the position and speed of the train entering the platform 2, is arranged so as to be close to the train and to face the side surface of the train. Note that the sensor 3 is not limited to the millimeter wave sensor as long as the non-contact type detection means is a non-contact type proximity sensor which can be arranged close to a train and detect the speed of the train.

[0018] A stop detection device 4 detects the stop of the train, on the basis of a train occupancy signal sent and input from a track circuit 20 which is a train occupancy detection device for detecting that the train 1 is present in a specific section, and on the basis of the train speed Vt detected by the millimeter wave sensor as the sensor 3, and generates a stop detection signal Fs.

[0019] On the basis of the train occupancy signal and the stop detection signal Fs, an interlocking device 6 controls, according to the movement of the train, signal devices 21 (a signal device A21a, a signal device B21b and a signal device C21c) and a point 22 (point A22a) which are ground facilities, and secures the route of the train. Prior to the entry of the train 1 to the vicinity of the platform 2, the interlocking device 6 switches the point A22a so as to allow the train 1 to enter from a track circuit A to the track circuit D, and thereby secures the route so as to allow the train 1 to run safely even in the case where the train 1 cannot stop at the predetermined stop target position to enter the protection area of the signal device C21c.

[0020] An example of an operation of the stop detection device 4 will be described with reference to FIG. 2.

[0021] When the train 1 enters the vicinity of the platform 2, the track circuit 20 detects the track occupancy by the train 1, and changes the train occupancy signal Ba from "0" to "1".

[0022] When the train 1 approaches the predetermine stop target position, the train 1 enters the detection range of the sensor 3 (millimeter wave sensor).

[0023] The millimeter wave sensor, which is installed so as to face the side surface of the train 1 entering the platform 2 and so as to be as close as possible to the train 1, detects the track occupancy by the train 1 on the basis of the intensity of a reflection wave from the train side surface, and also detects the train speed Vt of the train 1 on the basis of the Doppler shift caused in the reflection wave.

[0024] The signal strength Sd of the reflection wave is increased according to the entry of the train 1 to the detection range. At the time (assumed as a predetermined time t1) when the signal strength Sd exceeds a predetermined value Sd1, the stop detection device 4 starts to calculate the speed Vt of the train 1.

[0025] When the train 1 enters the detection range and when the train speed Vt of the train 1 exceeds a predetermined value Vt1, the stop detection device 4 changes a speed effective signal Fv from "0" to "1". When the train 1 approaches the stop target position and when the train speed Vt of the train 1 is reduced lower than a detection lower limit speed Vt2, the stop detection device 4 changes the speed effective signal Fv from "1" to "0".

[0026] On the basis of the fact that a predetermined time Ts1 elapses from the time when the sensor effective signal Fv is changed from "1" to "0", the stop detection device 4 detects the stop of the train 1, so as to change the stop detection signal Fs from "0" to "1".

[0027] On the basis of the train occupancy information obtained from each of the track circuits (track circuits A to D in FIG. 1), and the stop detection signal Fs of the train 1, the interlocking device 6 switches the point A22a so as to allow the advancement from the track circuit B toward the track circuit D, and sets the indication of the signal device B21b and the signal device C21c to an advance, so as to secure a passing route for the succeeding train.

[0028] That is, the stop detection device 4 is configured to output the stop detection signal at the time when the train speed detected by the sensor 3 as the detection means is lower than the predetermined speed value (the detection lower limit speed Vt2), and when the predetermined time (Ts1) elapses.

[0029] Next, there will be described the detection of the train occupancy and the train speed by the millimeter wave sensor.

[0030] The millimeter wave sensor is installed so as to form a depression angle θ to the side surface of the train. At this time, due to the Doppler effect, a frequency change proportional to the cos θ component of the train speed Vt is caused between a transmission wave from the millimeter wave sensor and the reflection wave.

[0031] The train speed Vt can be detected in such a manner that the transmission wave from the millimeter wave sensor and the reflection wave are processed by a mixer, and subjected to the FFT analysis so as to extract the Doppler frequency component.

[0032] When the depression angle θ is varied, an error is caused in the detection speed. When the external surface, such as the side surface and the upper surface of the train, which is formed in the direction of the speed of the train is set as the detection object, the depression angle θ can be substantially fixed so that the speed detection error can be reduced.

[0033] Further, since the detection object is continuously present from the leading edge of the train to the trailing edge, it is possible to continuously detect the train speed. In such a case where the detection object has recessions and projections, there are also considered cases where the depression angle θ is changed, and where the intensity of the reflection wave cannot be sufficiently obtained. In these cases, filtering may be performed by application of the least square method, and the like, or a failure by the sensor may be detected by comparison with the intensity of the reflection wave and the deceleration which can be actually performed by the train, so that the speed may be interpolated by using the deceleration, and the like, immediately before the occurrence of the failure.

[0034] The millimeter wave sensor is installed so as to be close to the train. In the case where the sensor is installed near the construction limit of a railway facility, when the train enters the detection range, the sensor is made to approach the train at a distance as short as about 40 cm, which distance is a difference between the construction limit and the vehicle limit. On the other hand, in the case where the train is located outside the detection range, the distance between the sensor and the detection object can be greatly changed to about 4 m or more which is the width of the train. As a result, the intensity of the reflection wave is greatly changed so that the train occupancy can be detected.

[0035] Further, when the sensor is installed so as to be close to the train, there is no possibility that a passenger, and the like, may intervene between the sensor and the train, and hence it is possible to prevent the erroneous detection of the train occupancy and the train speed.

[0036] FIG. 5 shows installation places of a non-contact proximity sensor such as the millimeter wave sensor.

[0037] The installation position of the sensor 3 as the detection means is positioned before the predetermined train stop position in the train travel direction, and arranged so as to be close to the train.

[0038] As the installation place of the sensor 3, there are considered such places as a platform outer edge 55a, a platform fence 55b, and posts 55d and 55e installed on a platform roof 52 provided above the platform. The post 55d is provided so as to extend in the direction from the platform roof 52 to the side where the platform 51 is arranged. On the other hand, the post 55e is provided on the side of the platform roof 52, which side is opposite to the side where the platform 51 is arranged, so that the sensor can detect the speed of the train 50 from above the train 50. That is, the sensor is installed via the post extending from the platform roof. Further, when the sensor is installed on a post 55c disposed at the side of the railway track, that is, on the side of the train 50 which side is opposite to the platform 51, the sensor can also be applied to an interlocking device which is operated in a place away from the station platform.

[0039] Next, with reference to FIG. 3, there will be described a second embodiment of a train stop detection system in which the present invention is applied to the platform screen door control.

[0040] A plurality of platform fences 33 are installed on a platform 32, and each of platform screen doors 34 (34a, 34b) is provided between the platform fences 33 and at a position to face the door of a train 30. When the train 30 is stopped away from the predetermined stop position, the door of the train 30 is dislocated from the platform screen door 34, so that the getting on and off of passengers is hindered. Therefore, the train 30 is controlled by ATO (Automatic Train Operation) and TASC (Train Automatic Stop Control) so as to stop within a predetermined stop allowable range from the predetermined stop target position, for example, a stop allowable range of about ±35 cm.

[0041] Two sensors (first detection means (sensor A35a), second detection means (sensor B35b)) are installed. In the present embodiment, two millimeter wave sensors are provide on the platform fence 33 near the stop target position (and may be provided on one of the platform fences 33 or respectively provided on the two platform fences 33), so as to respectively form a predetermined depression angle θ to the side surface of the train 30.

[0042] The sensor A35a which is first detection means is arranged so as to detect the speed of the train which occupies a track position before the stop allowable range predetermined with respect to the stop position in the train travel direction. The sensor B35b which is second detection means is arranged so as to detect the speed of the train which occupies a track position after the stop allowable range in the train travel direction.

[0043] A balise 37 is installed between rails 31 near the stop target position and transmits, toward an on-board antenna 36 installed on the train 30, information, such as stop position information, necessary for the ATO operation. Here, the balise 37 is installed within the stop allowable range, that is, in the range (stop allowable range) between the position where the transmission wave from the sensor A35a strikes the train 30 and the position where the transmission wave from sensor B35b strikes the train 30. Conventionally, it has been necessary to notify the stop of the train 30 to the ground, and hence it has been necessary to provide a power source for the balise. However, in the present embodiment, since the stop of the train is detected on the ground side, it is only necessary to install the simple balise 37 with no power source.

[0044] Further, the opening and closing of the platform fence 33 is performed in such a manner that a driving device provided on the platform fence 33 is controlled by a platform screen door control device. The platform screen door control device performs the control on the basis of the stop detection signal Fs from the stop detection device which generates the stop detection signal Fs on the basis of the train speed Vt detected by the sensor and outputs the stop detection signal Fs to the platform screen door control device.

[0045] An example of an operation of the stop detection device will be described with reference to FIG. 4.

[0046] When the train enters the stop allowable range (time t1), so as to be located within the detection range of the sensor A35a, the sensor signal intensity Sda of the sensor A35a is increased. When the sensor signal intensity Sda exceeds the predetermined value Sd1, the stop detection device starts to calculate the train speed Vta.

[0047] The stop detection device changes the speed effective signal Fva from "0" to "1" at the time when the train enters the detection range, and when the train speed Vta exceeds the predetermined value Vtl. At the time when the train approaches the stop target position, and when the train speed is reduced lower than the detection lower limit speed Vt2, the stop detection device changes the speed effective signal Fva from "1" to "0". On the basis of the fact that the predetermined time Ts1 elapses from the time (time t2) when the speed effective signal Fva is changed from "1" to "0", the stop detection device detects the stop of the train, and changes the stop detection signal Fs from "0" to "1".

[0048] Here, when the train overruns the stop allowable range, the speed effective signal Fvb which is to be normally always set to "0" is also set to "1". Further, when the train does not reach the stop allowable range, the speed effective signal Fva which is to be normally changed form "0" to "1" is always set to "0". The stop detection signal Fs is generated according to the relationships shown in Table 1 which is stored beforehand by using these relationships.

[Table 1]

Table 1

<table>
<tr><th colspan="2" rowspan="2">Output</th><th colspan="2">Input</th><th colspan="3">Previous state</th></tr>
<tr><th>Fva</th><th>Fvb</th><th>Fs0</th><th>Fva</th><th>Fvb</th></tr>
<tr><td rowspan="6">Fs0</td><td rowspan="2">1</td><td colspan="2"></td><td>1</td><td colspan="2"></td></tr>
<tr><td rowspan="4">0</td><td rowspan="3">0</td><td rowspan="5">0</td><td rowspan="2">1</td><td>0</td></tr>
<tr><td rowspan="4">0</td><td>1</td></tr>
<tr><td>0</td><td></td></tr>
<tr><td>1</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>1</td><td></td></tr>
</table>

[0049] In Table 1, the input represents the speed effective signals Fva and Fvb generated by the stop detection device in a certain calculation period, and the previous state represents the stop detection signal Fs0 and the speed effective signals Fva and Fvb which are generated by the stop detection device in the last calculation period. Here, it is assumed that the stop detection signal Fs is a signal obtained by delaying the stop detection signal Fs0 by the predetermined time Ts1. Further, the output represents the stop detection signal Fs0 generated from the input and the previous state by the stop detection device in a certain calculation period. When the speed effective signal Fvb is "0", and when the speed effective signal is changed from "1" to "0", the stop detection signal Fs0 is changed from "0" to "1", and thereafter is held at "1". That is, the stop detection device generates and outputs the stop detection signal in the case where the train speed can be detected by the sensor A35a as the first detection means, and where the train speed cannot be detected by the sensor B35b as the second detection means, and in the case where the train speed detected by the first detection means is lower than the predetermined speed value (detection lower limit speed Vt2), and where the predetermined time (predetermined time Ts1) elapses.

[0050] When detecting that the stop detection signal Fs of the train 30 is changed from "0" to "1", the platform screen door control device controls the driving device so as to open the platform screen door 34 corresponding to the door position of the train. In the case where the train is dislocated from the stop allowable range, the train operator performs a manual operation so as to stop the train within the stop allowable range.

[0051] In each of the embodiments, the millimeter wave sensor is used as the detection means of the position and speed. However, non-contact type sensors, such as a spatial filter system optical sensor, a laser sensor, an image sensor, can be applied as long as the sensors are capable of detecting the position and speed of a train by being arranged close to the surface formed in the direction of the train speed.

Claims

1. A train stop detection system comprising:

a train occupancy detection device which detects that a train is present in a specific section;
non-contact type detection means which detects the speed of the train;
a stop detection device which detects the stop of the train on the basis of a train occupancy signal output from the train occupancy detection device and the train speed detected by the detection means, and which generates a stop detection signal; and
an interlocking device which controls a ground facility on the basis of the stop detection signal,

wherein the detection means is positioned before a predetermined train stop position in the train travel direction, and is arranged so as to be close to the train.

2. The train stop detection system according to claim 1,
wherein when the train speed detected by the detection means is lower than a predetermined speed value, and when a predetermined time elapses, the stop detection device outputs the stop detection signal.

3. The train stop detection system according to claim 1, further comprising:

a platform;
a plurality of platform fences provided on the platform; and
a platform screen door provided between the platform fences,

wherein the detection means is provided at an outer edge of the platform.

4. The train stop detection system according to claim 1, further comprising:

a platform;
a plurality of platform fences provided on the platform; and
a platform screen door provided between the platform fences,

wherein the detection means is provided on the platform fence.

5. The train stop detection system according to claim 1, further comprising:

a platform; and
a platform roof provided above the platform,

wherein the detection means is installed on the platform roof via a post.

6. The train stop detection system according to claim 1, further comprising

a platform,
wherein the detection means is provided on the side of the train that is opposite to the side where the platform

is installed.

7. The train stop detection system according to claim 1,
wherein the detection means includes first detection means and second detection means,
wherein the first detection means is arranged so as to detect the speed of the train which occupies a track position before a stop allowable range predetermined with respect to the stop position in the train travel direction, and
wherein the second detection means is arranged so as to detect the speed of the train which occupies a track position after the stop allowable range in the train travel direction.

8. The train stop detection system according to claim 7,
wherein the stop detection device outputs the stop detection signal in the case where the speed of the train can be detected by the first detection means, and where the speed of the train cannot be detected by the second detection means, and in the case where the train speed detected by the first detection means is lower than a predetermined speed value, and where a predetermined time elapses.

9. The train stop detection system according to claim 7, further comprising:

a platform;
a plurality of platform fences provided on the platform; and
a platform screen door provided between the platform fences,
wherein the detection means is provided on one platform fence of the plurality of platform fences.

10. The train stop detection system according to claim 9, further comprising

a platform screen door control device which controls the opening and closing of the platform screen door on the basis of the stop detection signal output from the stop detection device.

FIG. 1

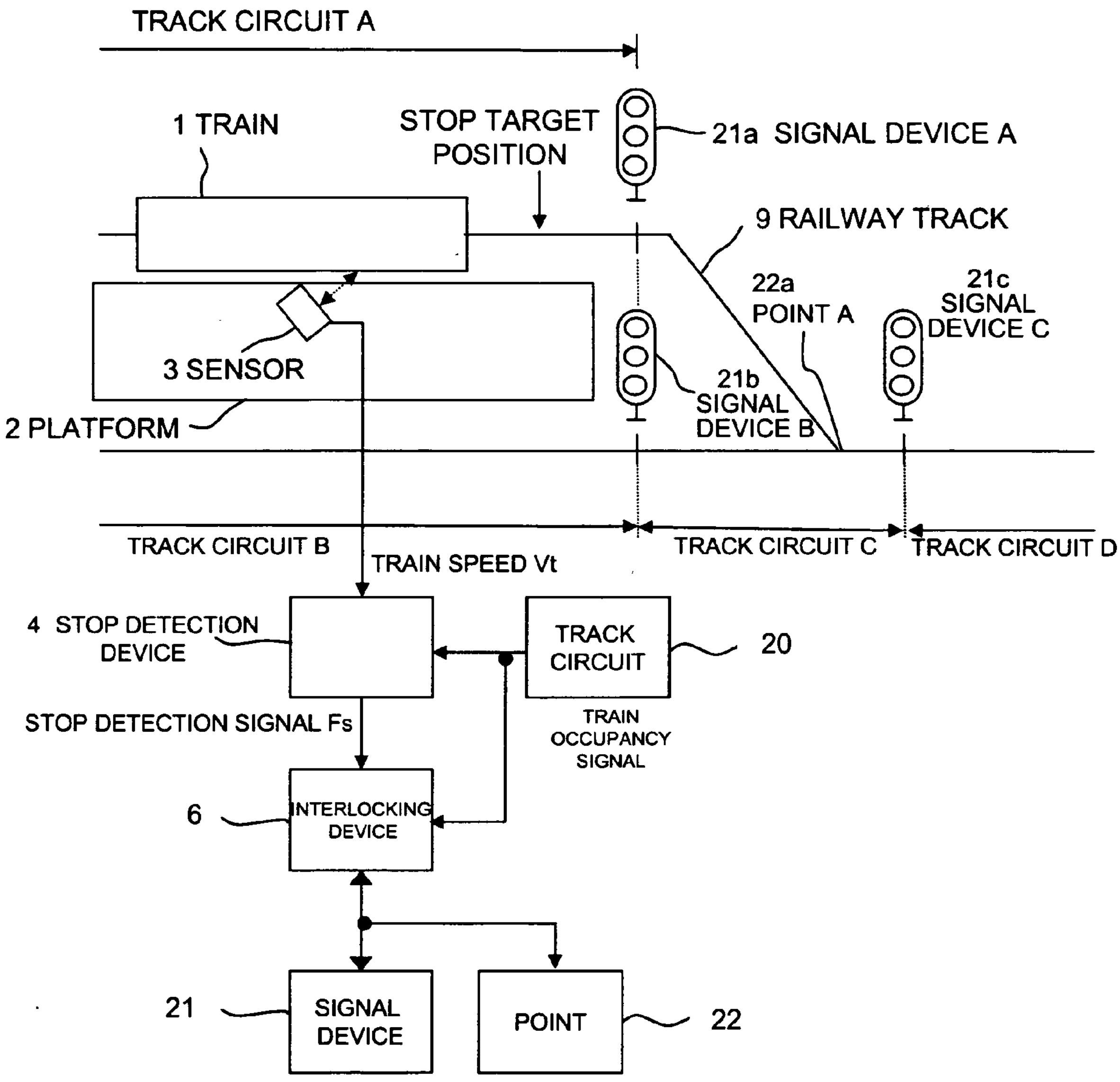
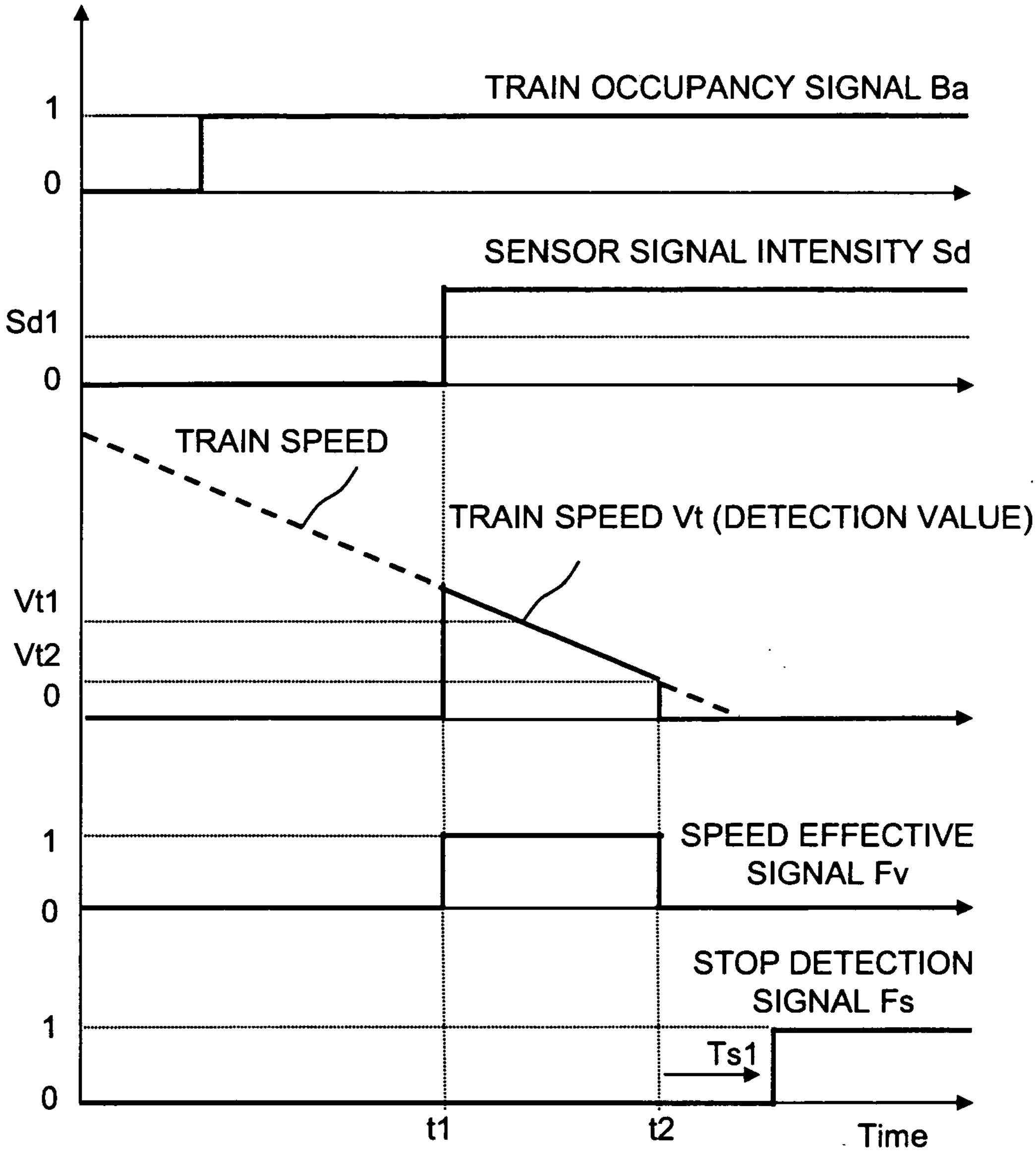

TRACK CIRCUIT A
1 TRAIN
STOP TARGET POSITION
21a SIGNAL DEVICE A
9 RAILWAY TRACK
22a POINT A
21c SIGNAL DEVICE C
3 SENSOR
21b SIGNAL DEVICE B
2 PLATFORM
TRACK CIRCUIT B
TRACK CIRCUIT C
TRACK CIRCUIT D
TRAIN SPEED Vt
4 STOP DETECTION DEVICE
TRACK CIRCUIT
20
TRAIN OCCUPANCY SIGNAL
STOP DETECTION SIGNAL Fs
6
INTERLOCKING DEVICE
21
SIGNAL DEVICE
POINT
22

FIG. 2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SENSOR SIGNAL INTENSITY Sd
Sd1
0
TRAIN SPEED
TRAIN SPEED Vt (DETECTION VALUE)
Vt1
Vt2
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1
0
SPEED EFFECTIVE SIGNAL Fv
STOP DETECTION SIGNAL Fs
1
Ts1
0
t1
t2
Time

FIG. 3

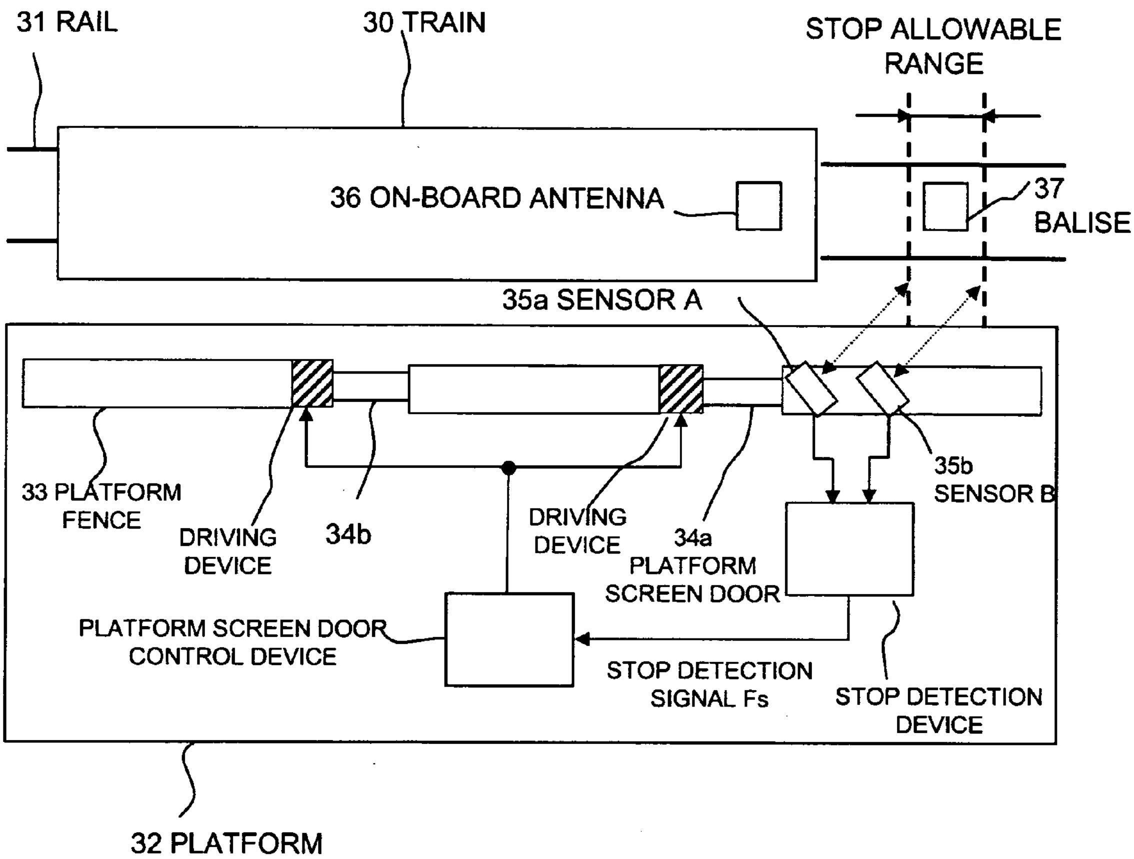

31 RAIL
30 TRAIN
STOP ALLOWABLE RANGE
36 ON-BOARD ANTENNA
37 BALISE
35a SENSOR A
33 PLATFORM FENCE
DRIVING DEVICE
34b
DRIVING DEVICE
34a PLATFORM SCREEN DOOR
35b SENSOR B
PLATFORM SCREEN DOOR CONTROL DEVICE
STOP DETECTION SIGNAL Fs
STOP DETECTION DEVICE
32 PLATFORM

FIG. 4

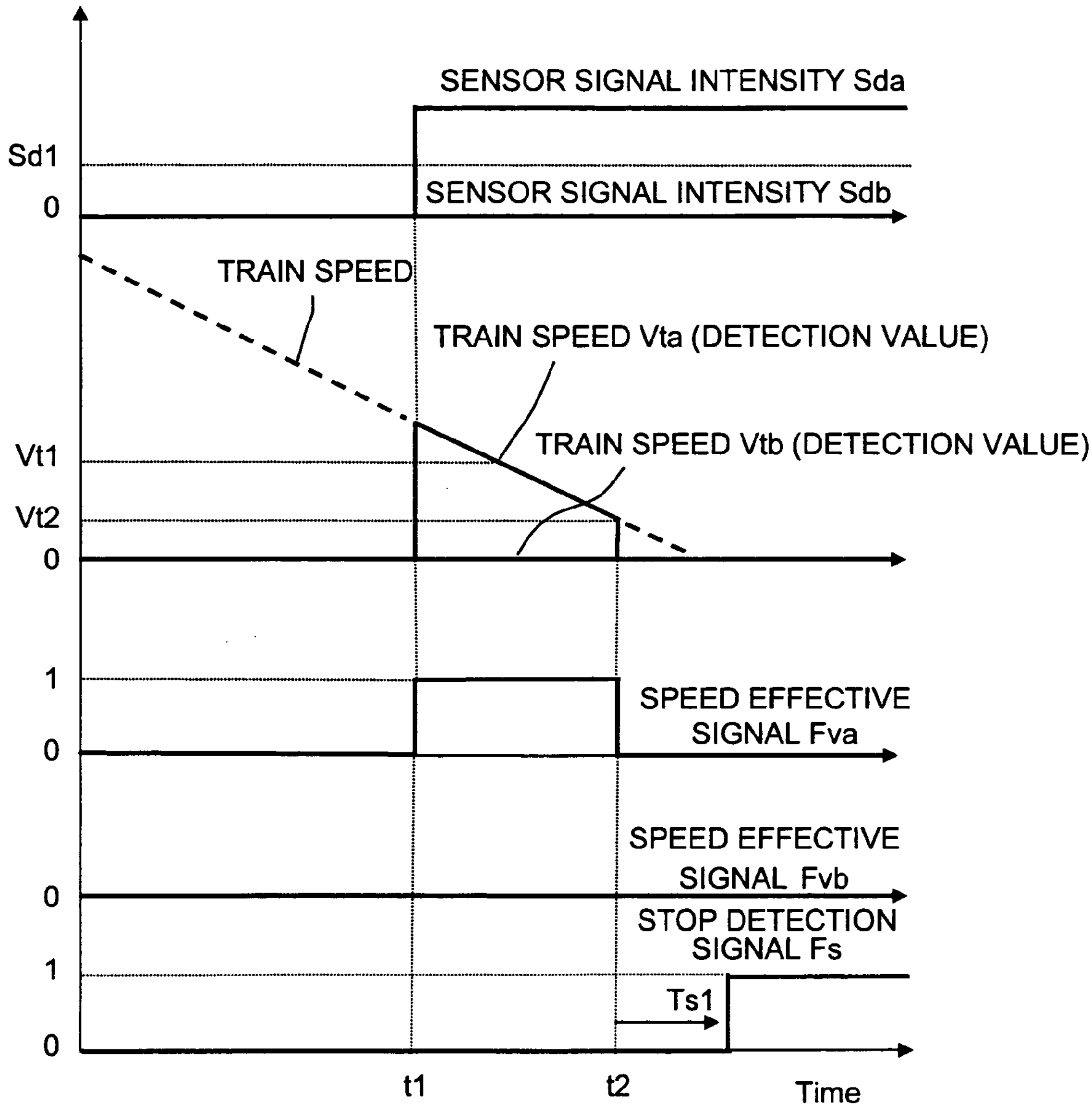
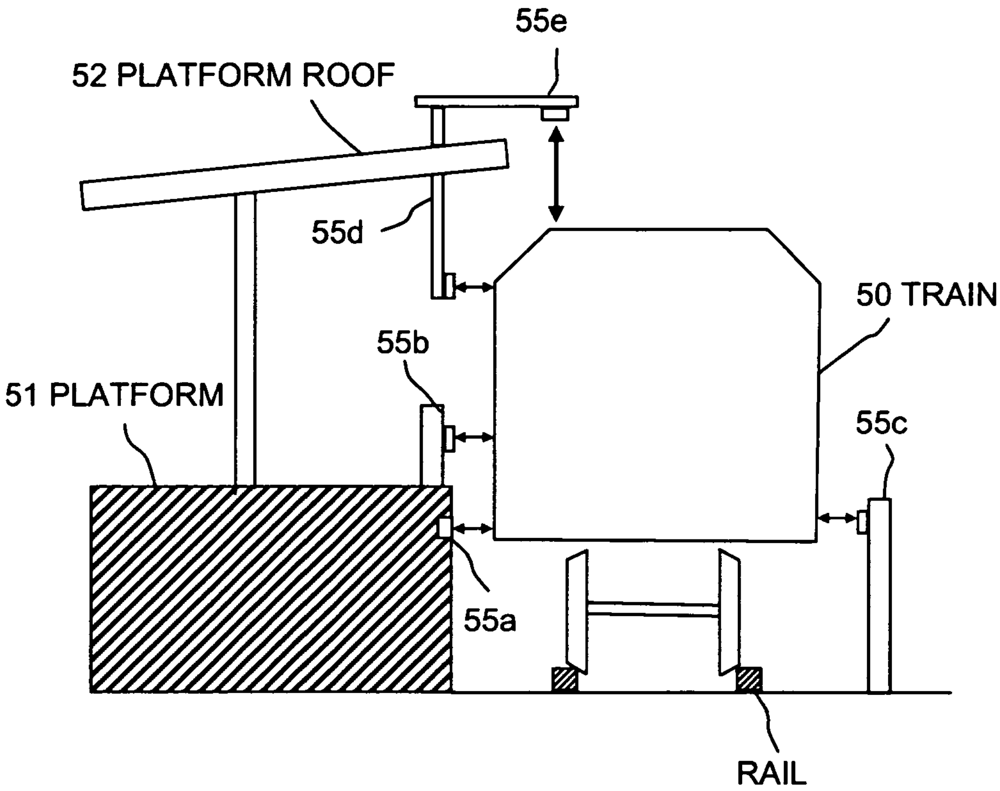

SENSOR SIGNAL INTENSITY Sda
Sd1
0
SENSOR SIGNAL INTENSITY Sdb
TRAIN SPEED
TRAIN SPEED Vta (DETECTION VALUE)
TRAIN SPEED Vtb (DETECTION VALUE)
Vt1
Vt2
0
1
0
SPEED EFFECTIVE SIGNAL Fva
SPEED EFFECTIVE SIGNAL Fvb
0
STOP DETECTION SIGNAL Fs
1
Ts1
0
t1
t2
Time

FIG. 5


55e
52 PLATFORM ROOF
55d
50 TRAIN
55b
51 PLATFORM
55c
55a
RAIL

REFERENCES CITED IN THE DESCRIPTION

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