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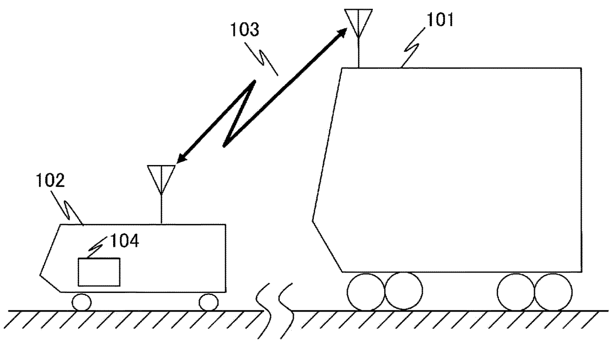
(54) TRACK TRANSPORT SYSTEM AND TRACK TRANSPORT SYSTEM OPERATING METHOD

(57) In a track transport system in which a transport car runs on a track, if there is an obstacle on the track, it cannot be avoided by steering. Thus, detecting the obstacle is an issue to improve the safety and operability of the transport system. In order to solve this problem, a transport car for transporting passengers, an obstacle detecting car that runs in front of the transport car and has a sensor for detecting an obstacle on a track, and communication means for connecting the transport car and the obstacle detecting car so as to be communicable are provided, and the transport car receives an obstacle detection signal from the sensor and decelerates.

FIG. 1



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Description

Technical Field

[0001] The present invention relates to a track transport system that runs on a track.

Background Art

[0002] In a track transport system in which a transport car runs on a track, if there is an obstacle on the track, it cannot be avoided by steering. Therefore, detecting an obstacle is important for improving the safety and operability of the transport system. In a manned operation system driven by a driver, most obstacles on the track and on the route are detected by the driver's visual observation. On the other hand, in an unmanned operation system that employs automatic driving, safety and operability are ensured by blocking other traffic on a dedicated track and preventing obstacles from entering.

[0003] In Patent Literature 1, as a technique for eliminating obstacles on a railway track, a track transport system is disclosed which causes an obstacle eliminating car to run in front of a transport car traveling on a track while maintaining a predetermined distance between the cars, and eliminates obstacles on a runway.

Citation List

Patent Literature

[0004] PTL 1: JP H5-338538 A

Summary of Invention

Technical Problem

[0005] To adopt a dedicated track, there are many limitations of cost, location and the like. Even in manned operation systems, it may be desired to improve further safety and operability. Further, an obstacle eliminating car of Patent Literature 1 is a system on the premise that the car collides with an obstacle, and if the obstacle cannot be eliminated, the operation may be greatly delayed.

[0006] An object of the present invention is to provide a track transport system with improved safety and operability in order to cope with the above problems.

Solution to Problem

[0007] In order to solve the above problems, a transport car for transporting passengers, an obstacle detecting car that runs in front of the transport car and has a sensor for detecting an obstacle on a track, and communication means for connecting the transport car and the obstacle detecting car so as to be communicable are provided, and the transport car receives an obstacle detection signal from the sensor and decelerates.

Advantageous Effects of Invention

[0008] According to the present invention, a track transport system with improved safety and operability can be provided. The problems, configurations, and effects other than those described above will be clarified from the description of the embodiments below.

Brief Description of Drawings

[0009]

[FIG. 1] FIG. 1 is a diagram showing a configuration of a track transport system in one embodiment of the present invention.

[FIG. 2] FIG. 2 is a flowchart showing the operation of an obstacle detecting car in one embodiment of the present invention.

[FIG. 3] FIG. 3 is a flowchart showing the operation of a transport car in one embodiment of the present invention.

[FIG. 4] FIG. 4 is an explanatory view of a sensor that copes with contact or collision in one embodiment of the present invention.

Description of Embodiments

[0010] Operational cost reduction is required due to a decrease in the number of users, etc., and there is a high need for unmanned operation of track transport systems. However, existing unmanned operation systems are limited to those using dedicated tracks. The dedicated track uses a dedicated track that blocks the entrance of other traffic by infrastructure such as elevation or underground, and the introduction cost is very high. When changing an existing open track to a dedicated track, it is necessary to consider further restrictions such as site and construction.

[0011] In contrast, the inventors have created a new idea for realizing an unmanned operation system on an open track. That is, it is an idea to run a unit (obstacle detecting car) with a sensor having an obstacle detection function separately from a transport car for transporting passengers. In an embodiment described later, an example will be described in which unmanned operation is realized by an operation causing an obstacle detecting unit to run in front of a passenger car. According to this example, even if there is an obstacle on the track, the obstacle can be detected at an early stage and the vehicle can be stopped. Therefore, the track transport system with improved safety and operability can be provided. If the obstacle detecting car has an unmanned operation function, the system can be introduced without increasing the number of drivers. Furthermore, if the transport car has an unmanned operation function, the car can be operated without a driver. If it does so, the freedom degree of operation will increase, such as increasing the number of trains while reducing the number of cars per train.

[0012] In Patent Literature 1, as a technique for eliminating obstacles on a railway track (paragraph 0002), a track transport system (paragraph 0001) is disclosed in which an obstacle eliminating car is made to run in front of a transport car that runs on a track while maintaining a predetermined distance between the cars and eliminates obstacles on a runway. This obstacle eliminating car of Patent Literature 1 is a system based on the premise of eliminating an obstacle by collision, for example, as described in paragraph 0012, "the obstacle is eliminated by an obstacle eliminating car if it is a small obstacle, and even if the obstacle eliminating car collides with an obstacle that cannot be eliminated and cannot run, the transport car can be safely stopped". In the unlikely event that an obstacle cannot be eliminated, there may be a significant delay in operation. This obstacle eliminating car is equipped with an automatic driving device to reduce the vehicle weight and increase the payload while making the leading shape of the leading car of the subsequent transport car an ideal shape with low aerodynamic resistance. The function of detecting an obstacle is not disclosed.

[0013] On the other hand, the track transport system of the embodiment is a system based on the premise that a unit having an obstacle detection function and the transport car are stopped before the collision occurs by detecting an obstacle at an early stage by the unit. Thereby, any safety of the unit, the transport car, and the obstacle can be made high. In addition, by providing the obstacle detection function to the unit that runs ahead, it is possible to realize a system with high safety and operability which can exhibit sufficient detection and braking functions as a whole without providing a high detection function and braking function to the transport car itself. Furthermore, since obstacles can be eliminated while avoiding collisions with obstacles, it is possible to operate with high operability while suppressing delays in operation.

[0014] By the way, research on obstacle detection technology is being promoted for automatic driving of automobiles, and millimeter wave radar, laser radar, camera, etc. are generally used. Even with millimeter wave radars and cameras that have long detection distances, the detection distance is about 200 m. The braking distance of an automobile is about 200 m at 120 km/h, and it can be stopped in front of the obstacle even if the brake is applied after detecting the obstacle with millimeter wave radar or camera. The reason why the braking distance of an automobile is short is that a high deceleration performance is set on the assumption that an occupant is seated and a seat belt is worn.

[0015] On the other hand, in a track transport system represented by a train, it is assumed that passengers are on the train in a standing state, and generally a deceleration performance lower than that of an automobile is set. As a result, the braking distance required to stop from the same speed is longer in the track transport system than in the automobile. For example, the braking distance from 120 km/h is about 500 m. Therefore, when the sensor for automobiles is applied to the track transport system as it is, the detection distance of the sensor may be shorter than the required braking distance. As a result, a safety problem arises that even if the obstacle is detected by the sensor, the track transport system cannot be stopped before the obstacle. In addition, when the maximum speed is lowered to a speed at which it can be stopped after detection by a sensor, operational problems such as reduction in rapid delivery and transport capacity occur. In response to this problem, if the maximum deceleration of a separate unit is made larger than that of the passenger car, the distance from the detection by the sensor to the stop can be shortened compared to when the separate unit is not used. By doing so, it is possible to realize a track transport system with high safety and operability while using sensors developed for automatic driving of automobiles. It can be said that the distance that cannot be stopped by millimeter waves is covered by the distance of the preceding unit.

[0016] Hereinafter, as an embodiment of the present invention, an example of an open track railway will be described with reference to the drawings.

First embodiment

[0017] FIG. 1 is a diagram showing a configuration of a track transport system. The track transport system includes a transport car 101 for carrying passengers and cargo, an obstacle detecting car 102 for detecting obstacles ahead, and communication means 103 between the transport car 101 and the obstacle detecting car 102. The communication means may connect the transport car 101 and the obstacle detecting car 102 by inter-vehicle communication, or may communicate via ground equipment. In the present embodiment, it is sufficient that the data communication can be performed between the transport car 101 and the obstacle detecting car 102 with a sufficiently small transmission delay for the control described below, and the method is not limited.

[0018] The obstacle detecting car 102 includes an obstacle detection sensor 104 that is a sensor for detecting an obstacle. The main purpose of the obstacle detection sensor 104 is to detect an obstacle in advance. However, as a precaution, it may be possible to detect that the obstacle detecting car 102 has come into contact or collided with the obstacle.

[0019] FIG. 4 is an explanatory diagram of sensors that cope with contact and collision. The obstacle detecting car 402 that runs in front of the transport car 401 includes a collision sensor 414 and a contact sensor 424. In this embodiment, as an example of an obstacle, a collision with a person on a railway track such as a railroad crossing, an automobile, a fallen object, or the like, or contact with a plant or a protrusion that violates clearance gauge is assumed. The clearance gauge refers to the clearance in which a building must not be installed on the railway track. As the collision sensor 414, a detection sensor for an automobile airbag can be used. As the contact sensor

424, a hollow structure that surrounds all or part of the clearance gauge, a solid structure that covers the same area, or the like can be used.

[0020] The deceleration performance of the obstacle detecting car 102 is set higher than the deceleration performance of the transport car 101. As for the deceleration performance of the current train, there are those that can stop at 600 m from the maximum speed, whereas the obstacle detecting car 102 of this embodiment is assumed to stop at 300 m. It is desirable that the deceleration performance set for the obstacle detecting car 102 be equal to the deceleration performance of an automobile, for example. For example, if the vehicle is stopped from a maximum speed of 120 km at 200 m, many obstacle detection sensors used in automobiles can be easily used. Furthermore, it is more desirable to set the maximum level of deceleration performance that can be physically exhibited in the track transport system.

[0021] The acceleration performance of the obstacle detecting car 102 is set higher than the acceleration performance of the transport car 101. The acceleration performance of the obstacle detecting car 102 is expressed by equation (1).

[Math. 1]

$$\alpha_1 = \frac{\alpha_2 \cdot \beta}{\beta - \alpha_2}$$

[0022] Here, $\alpha 1$ is the required acceleration of the obstacle detecting car 102, α_2 is the maximum acceleration of the transport car 101, and β is the maximum deceleration of the transport car 101.

[0023] It is desirable that the obstacle detecting car 102 be lightweight so that the obstacle detecting car 102 can be easily retreated from the track if it cannot run due to contact or collision with the obstacle. Moreover, if it is lightweight, even if it should come into contact or collide with an obstacle, damage to the obstacle can be minimized. If it is less than 2 tons like a car, it is desirable because it can be moved without heavy machinery.

[0024] It is desirable that the leading material of the obstacle detecting car 102 can absorb shock. This is because the impact of the collision can be alleviated in case it collides with an obstacle. Further, it is desirable that the leading shape of the obstacle detecting car 102 has an obstacle eliminating structure that facilitates the removal of the obstacle. This is because even if the car collides with an obstacle, it is possible to suppress the situation where the obstacle detecting car 102 involves the obstacle, which is advantageous for early restart of operation.

[0025] The transport car 101 is controlled by a control device (not shown) so that the distance from the obstacle detecting car 102 is not less than a distance necessary for stopping when the car is decelerated with the maximum deceleration performance from the current vehicle speed of the transport car 101 as described later.

[0026] Next, the operation of the obstacle detecting car will be described. FIG. 2 is a flowchart showing a processing procedure executed by the obstacle detecting car 102.

[0027] In steps 201 to 206, a stop instruction for the transport car 101 and a current position of the obstacle detecting car 102 are created. This processing is executed every control cycle (for example, 20 milliseconds) of the obstacle detecting car 102. The operation based on the flowchart of FIG. 2 is as follows.

Step 201:

[0028] Sensor information related to the obstacle on the track is acquired from the obstacle detection sensor 104. It is determined from the sensor information whether an obstacle exists on the track. The process proceeds to step 202.

Step 202:

[0029] Sensor information regarding obstacles on the track is acquired from the collision sensor 414 and the contact sensor 424. It is determined from the sensor information whether there has been contact or collision with an obstacle on the track. The process proceeds to step 203.

Step 203:

[0030] It is determined in step 201 whether an obstacle exists, or in step 202 whether there has been contact or collision with the obstacle. If it is determined that an obstacle exists, or there has been contact or collision with the obstacle, the process proceeds to step 204. If it is determined that an obstacle does not exist and there has been no contact or collision with the obstacle, the process proceeds to step 205.

Step 204:

[0031] If it is determined in step 203 that an obstacle exists, or there has been contact or collision with the obstacle, the transport car 101 needs to be immediately stopped, and thus a stop instruction is generated. The process proceeds to step 205.

Step 205:

[0032] The current position of the obstacle detecting car 102 necessary for calculating the distance between the transport car 101 and the obstacle detecting car 102 is calculated. The calculation of the current position is generally performed based on the integration of the vehicle speed, but other methods may be used. For example, a global positioning system (GPS) or the like may be used. The process proceeds to step 206.

Step 206:

[0033] The current position of the obstacle detecting car 102 and the presence/absence of a stop instruction for the transport car 101 are transmitted to the transport car 101 via the communication means 103.

[0034] Next, the operation of the transport car 101 will be described. FIG. 3 is a flowchart showing a processing procedure executed by the transport car 101.

[0035] In steps 301 to 306, when an obstacle exists on the track, or the obstacle detecting car 102 has contacted or collided with the obstacle, the transport car 101 is stopped. Alternatively, when an obstacle does not exist on the track and the obstacle detecting car 102 has not contacted or collided with the obstacle, the car runs with the obstacle detecting car 102 at a necessary interval. This processing is executed every control cycle of the transport car 101 (for example, 20 milliseconds). The operation based on the flowchart of FIG. 3 is as follows.

Step 301:

[0036] The current position of the obstacle detecting car 102 and the stop instruction for the transport car 101 are received from the obstacle detecting car 102. The process proceeds to step 302.

Step 302:

[0037] In step 302, the current position of the transport car 101 necessary for calculating the distance between the transport car 101 and the obstacle detecting car 102 is calculated. The calculation of the current position is generally performed based on the integration of the vehicle speed, but other methods may be used. For example, a global positioning system (GPS) or the like may be used. The process proceeds to step 303.

Step 303:

[0038] In step 303, an interval between the obstacle detecting car 102 and the transport car 101 is calculated from the current position of the obstacle detecting car 102 and the current position of the transport car 101. The process proceeds to step 304.

Step 304:

[0039] In step 304, the transport car is controlled so that the distance between the obstacle detecting car 102 and the transport car 101 is equal to or greater than the distance that the transport car 101 runs before stopping when the transport car 101 decelerates from the current vehicle speed with the maximum deceleration performance. In general, the distance required to decelerate from a certain speed at a constant deceleration and stop is expressed by equation (2).

[Math. 2]

$$L = \frac{V^2}{2 \cdot \beta}$$

[0040] Here, L is a distance required until the car stops, V is a vehicle speed when deceleration is started, and β is a deceleration of the transport car. In step 304, control is performed so that L is smaller than the distance between the obstacle detecting car 102 and the transport car 101. Specifically, the vehicle speed of the transport car 101 should be controlled so that it becomes equal to or less than V obtained by substituting the distance between the obstacle detecting car 102 and the transport car as L in the equation (2), and substituting the maximum deceleration of the transport car 101 into β. If the distance between the obstacle detecting car and the transport car 101 can be controlled to be equal to or greater than the distance that the transport car 101 runs before stopping when the transport car 101 decelerates from the current vehicle speed with the maximum deceleration performance, it is possible to prevent the transport car 101 from colliding with the obstacle detecting car 102. The process proceeds to step 305.

Step 305:

[0041] In step 301, it is determined whether a stop instruction is received from the obstacle detecting car 102. If a stop instruction is received, the process proceeds to step 306.

Step 306:

[0042] When a stop instruction is received from the obstacle detecting car 102, the transport car 101 is decelerated with the maximum deceleration and stopped.

[0043] In addition, although the first embodiment shows the example in which the transport car 101 and the obstacle detecting car 102 are decelerated with the maximum deceleration and stopped, it is not restricted to this, and it does not matter if just deceleration is performed if the collision between the respective cars or the collision with the obstacle can be suppressed.

[0044] As described above, the track transport system according to the first embodiment includes the transport car 101 for transporting passengers, the obstacle detecting car 102 that runs in front of the transport car 101 and has the sensor 104 for detecting the obstacle on the track, and communication means 103 for communicatively connecting the transport car 101 and the obstacle detecting car 102. The transport car 101 is configured to receive an obstacle detection signal from the sensor 104 and decelerate. Then, even if a general obstacle detection sensor developed for automobiles is used, the transport car of the track transport system is stopped before the obstacle or the collision can be avoided while maintaining rapid delivery and transport capacity. Thus, it is possible to improve the safety and operability of the track transport system. In addition, it is possible to replace the driver's visual obstacle detection with this embodiment, which makes it possible to make the track transport system that is currently driven by a driver unmanned and reduce operating costs.

[0045] This effect becomes greater as the braking distance of the obstacle detecting car 102 is shorter than the braking distance of the transport car 101.

[0046] In the first embodiment, the obstacle detecting car 102 determines whether an obstacle exists from the information of the obstacle detection sensor 104, or whether there has been contact or collision with the obstacle from the information of the collision sensor 414 and the contact sensor 424, and creates a stop instruction. However, information of the obstacle detection sensor 104 or the like may be transmitted to the transport car 101, and the transport car 101 may determine whether an obstacle exists, or there has been contact or collision with the obstacle, and create a stop instruction. In short, it is sufficient that the transport car 101 can stop or sufficiently decelerate when an obstacle exists, or when there has been contact or collision with the obstacle. In the present invention, the determination on whether the obstacle exists or whether there has been contact or collision with the obstacle, or which device creates a stop instruction based on the determination does not matter.

[0047] In the first embodiment, the transport car 101 is controlled so that the distance between the obstacle detecting car 102 and the transport car 101 is equal to or more than the distance that the transport car 101 runs before stopping when the transport car 101 decelerates with the maximum deceleration performance from the current vehicle speed. However, the obstacle detecting car 102 may be controlled so that the distance between the obstacle detecting car 102 and the transport car 101 is equal to or more than the distance that the transport car 101 runs before stopping when the transport car 101 decelerates with the maximum deceleration performance from the current vehicle speed. In the present embodiment, it is sufficient that the control is performed so that the distance between the obstacle detecting car 102 and the transport car 101 is equal to or more than the distance (that is, a braking distance) that the transport car runs before stopping when the transport car decelerates with the maximum deceleration performance from the current vehicle speed, and it does not matter which device controls the distance.

Reference Signs List

[0048]

101	transport car
102	obstacle detecting car
103	communication means
104	obstacle detection sensor
401	transport car
402	obstacle detecting car
414	collision sensor
424	contact sensor

Claims

1. A track transport system, comprising:

   a transport car for transporting passengers;
   an obstacle detecting car that runs in front of the transport car and has a sensor for detecting an obstacle on a track; and
   communication means for connecting the transport car and the obstacle detecting car so as to be communicable,
   wherein the transport car receives an obstacle detection signal from the sensor and decelerates.

2. The track transport system according to claim 1, further comprising a control device configured to control the obstacle detecting car to run in front of the transport car by a braking distance or more required until the transport car stops.

3. The track transport system according to claim 1, wherein a braking distance of the obstacle detecting car is shorter than a braking distance of the transport car.

4. The track transport system according to claim 1, further comprising a control device configured to stop the transport car when the obstacle is detected by the sensor, or collision or contact between the obstacle detecting car and the obstacle occurs.

5. The track transport system according to claim 1, wherein the obstacle detecting car has an unmanned operation function.

6. The track transport system according to claim 5, wherein the transport car has an unmanned operation function.

7. A track transport system operating method, causing an obstacle detecting car having a sensor for detecting an obstacle on a track to run in front of a transport car for transporting passengers.

FIG. 1

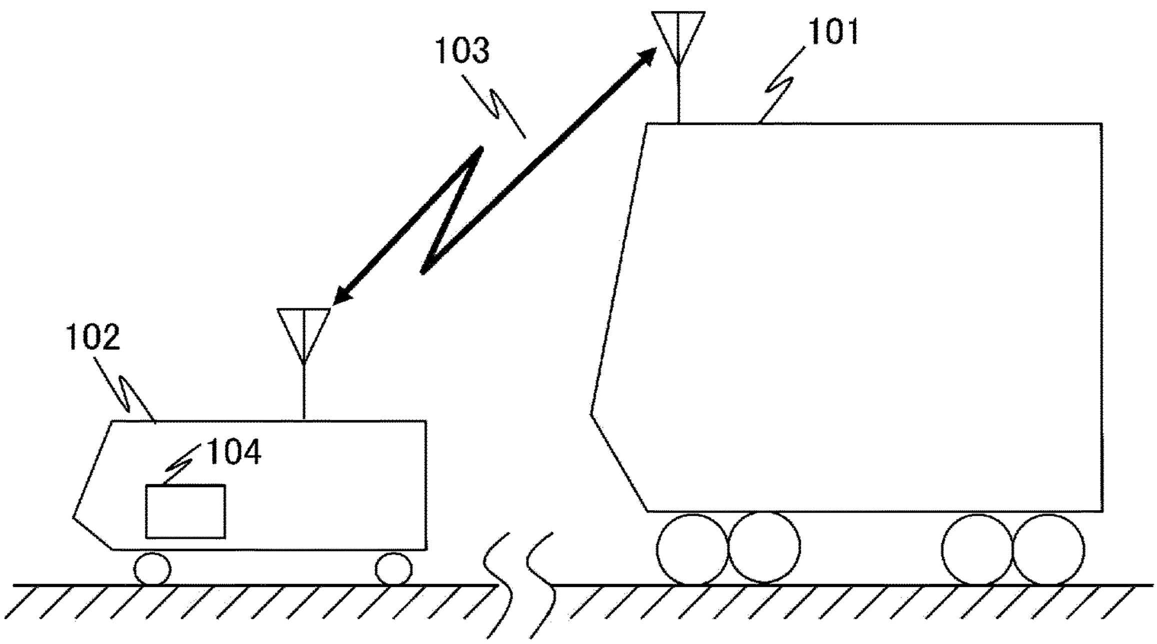


FIG. 2

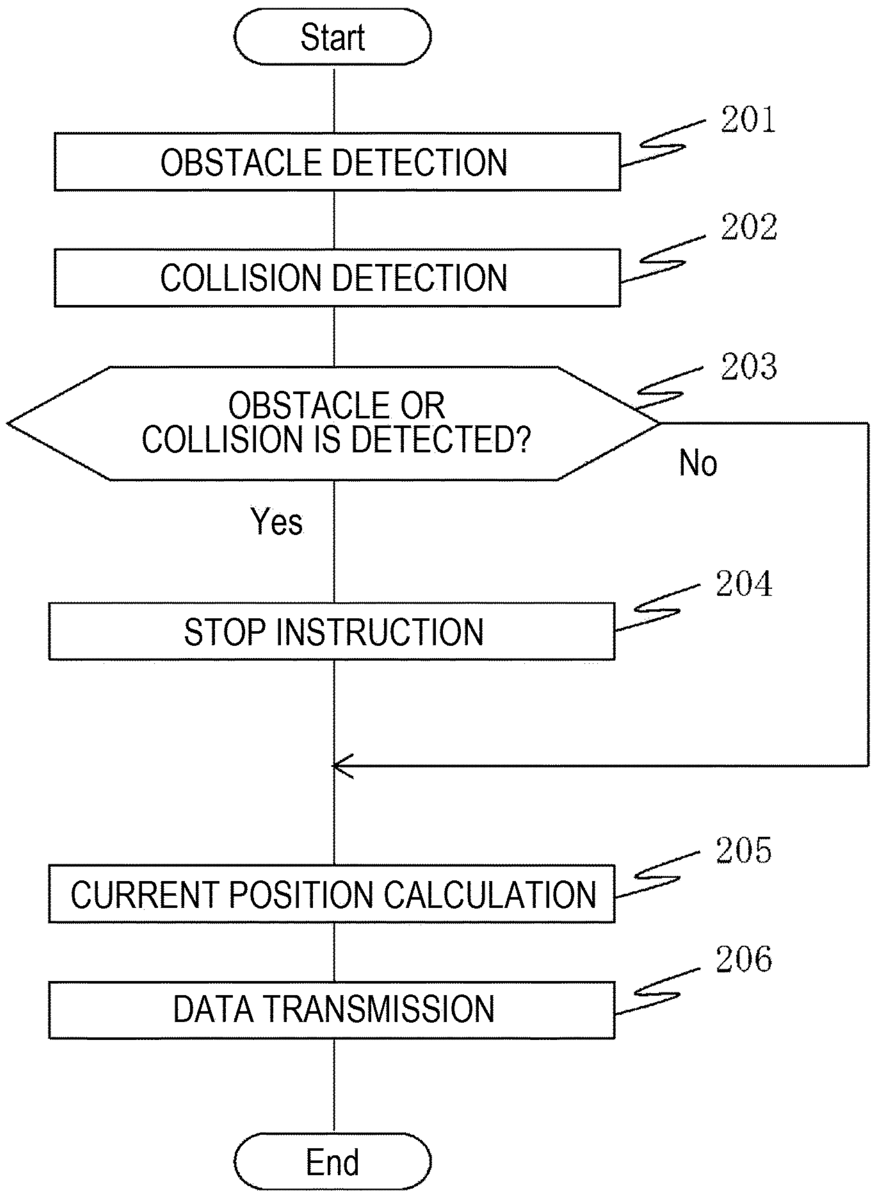

Start
201
OBSTACLE DETECTION
202
COLLISION DETECTION
203
OBSTACLE OR COLLISION IS DETECTED?
No
Yes
204
STOP INSTRUCTION
205
CURRENT POSITION CALCULATION
206
DATA TRANSMISSION
End

FIG. 3

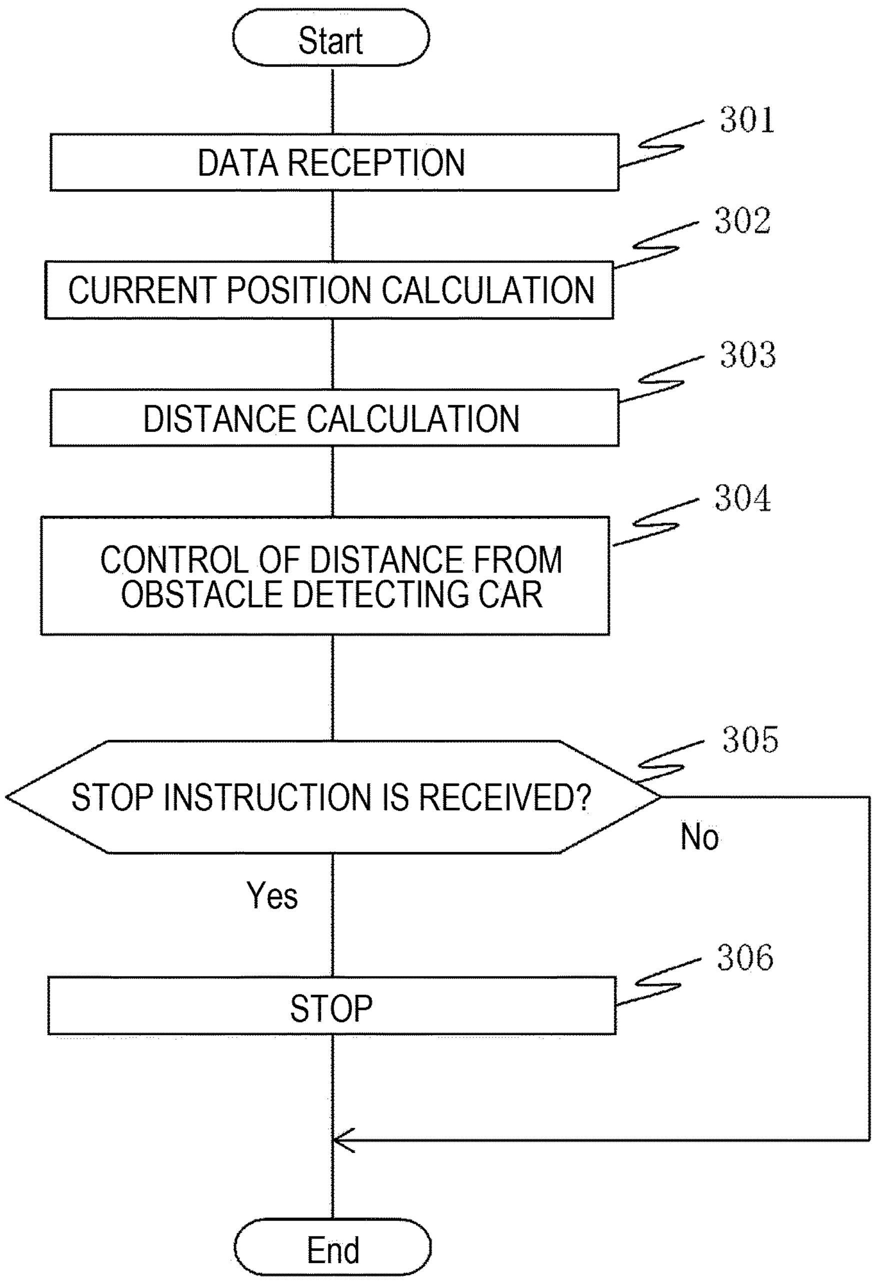
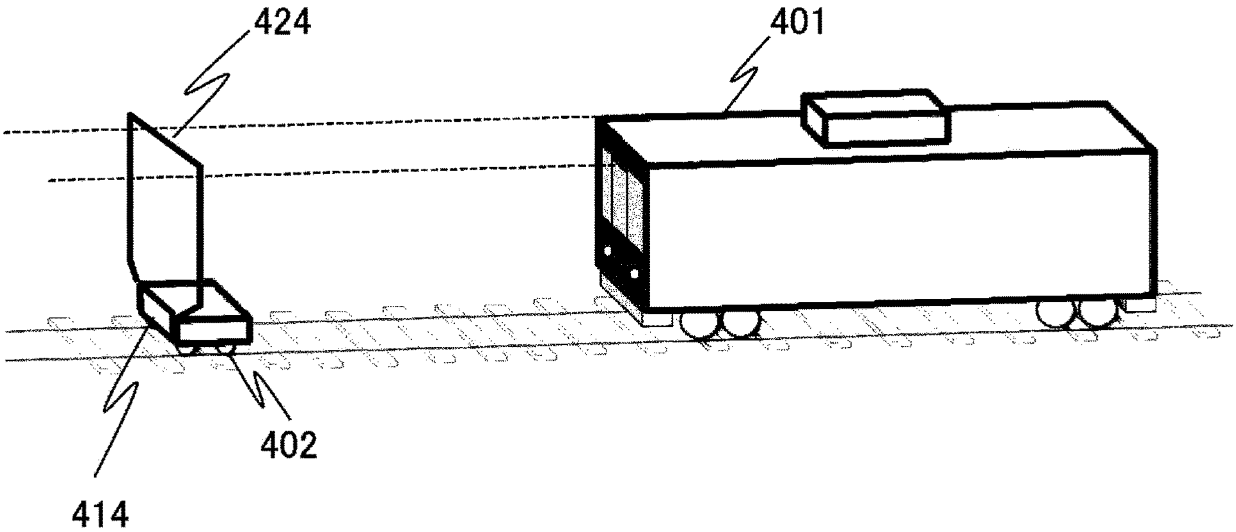

Start
DATA RECEPTION
301
CURRENT POSITION CALCULATION
302
DISTANCE CALCULATION
303
CONTROL OF DISTANCE FROM OBSTACLE DETECTING CAR
304
STOP INSTRUCTION IS RECEIVED?
305
No
Yes
STOP
306
End

FIG. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/007675

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl. B61L23/00(2006.01)i, B61L23/34(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int.Cl. B61L23/00, B61L23/34

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 8-130801 A (OSHIRO, Isamu) 21 May 1996, column 1, line 43 to column 4, line 5, fig. 1 (Family: none)	1-7
A	JP 5-338538 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 21 December 1993, entire text, all drawings (Family: none)	1-7
A	JP 7-10003 A (EAST JAPAN RAILWAY CO.) 13 January 1995, fig. 1, 2 (Family: none)	1-7

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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Date of the actual completion of the international search	Date of mailing of the international search report
22.05.2018	05.06.2018

Name and mailing address of the ISA/	Authorized officer
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Form PCT/ISA/210 (second sheet) (January 2015)

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Patent documents cited in the description

- JP H5338538 A **[0004]**