(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 785 333 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
16.05.2007 Bulletin 2007/20

(21) Application number: **05781528.4**

(22) Date of filing: **31.08.2005**

(51) Int Cl.:
B61L 23/06 *(2006.01)*

(86) International application number:
PCT/JP2005/015927

(87) International publication number:
WO 2006/025455 (09.03.2006 Gazette 2006/10)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **31.08.2004 JP 2004253408**

(71) Applicants:
- **Yugen Kaisha Takahagi Jiko**
  Takahagi-shi
  Ibaraki 3180014 (JP)
- **East Japan Railway Company**
  Tokyo 151-8578 (JP)

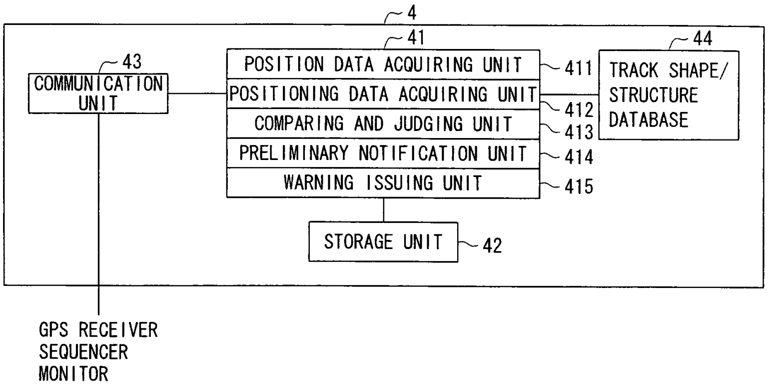
(72) Inventors:
- **MIDORIKAWA, Kazuhiko,**
  Yugen Kaisha Takahagi Jiko
  Takahagi-shi, Ibaraki 3180014 (JP)
- **WATANABE, Akihito,**
  East Japan Railway Company
  Shibuya-ku, Tokyo 1518578 (JP)

(74) Representative: **Verhasselt, Jörn**
Rethelstrasse 123
40237 Düsseldorf (DE)

(54) TRACK RAIL MAINTENANCE SYSTEM AND TRACK RAIL MAINTENANCE METHOD

(57) A track rail maintenance system performs maintenance work, and accurately grasps a shape of a track rail and positions of structures, using position data of a maintenance vehicle detected by a GPS. The maintenance vehicle includes positioning data acquiring means 412 for decoding the positioning signals to acquire positioning data, position data acquiring means 411 for acquiring position data of the maintenance vehicle on the basis of rotation of a predetermined axle attached to the maintenance vehicle, and comparing and judging means 413 for comparing the positioning data and the position data at a start point of maintenance work set on the basis of a track shape/structure database and judging whether a difference between the positioning data and the position data is within a predetermined range. The maintenance vehicle corrects the position data when the difference between the positioning data and the position data is not within the predetermined range as a result of the comparing and judging means 413.

F I G. 2



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Printed by Jouve, 75001 PARIS (FR)

Description

Technical Field

[0001] The present invention relates to maintenance of a track rail by a maintenance vehicle that runs on the track rail, and, more particularly to a track rail maintenance system and a track rail maintenance method for accurately performing maintenance work using a GPS (Global Positioning System) or the like.

Background Art

[0002] Maintenance vehicle that runs on a track rail needs to grasp a shape of the track rail and position data for obstacles such as structures, a stop target, or a work start point. In particular, in a maintenance vehicle that maintains and inspects a track rail, accuracy in m/m units may be required in maintenance work. Since the accuracy directly affects performance of a system and reliability of maintenance, it is particularly important to grasp precise position data. There is a well-known method of mounting a GPS receiver on a maintenance vehicle and performing maintenance work while grasping a shape of a track rail and positions of structures, a base point, and the like in order to detect this accurate positions.

[0003] A GPS receives a GPS signal pseudonoise-encoded and transmitted from a GPS satellite orbiting the Earth and decodes an arrival time of the GPS signal on the ground, and time information, navigation message, and the like included in the GPS signal to accurately acquire positional information on the Earth. A system using such a GPS acquires at least four GPS satellites orbiting in a visible space to decode GPS signals. In other words, the system independently catches orbiting satellites and subjects acquired GPS signals to positioning calculation to decode the GPS signals.

[0004] As a measuring apparatus using this GPS, a mobile-body-mounted GPS positioning apparatus is described in JP2001-056234A (hereinafter referred to as patent document 1). This apparatus includes a GPS receiver mounted on a mobile body that receives signals from plural GPS satellites, a route information storing device mounted on the mobile body, an information processing device that captures and processes information from the GPS receiver and the route information storing device, and an output device connected to the information processing device. The apparatus adopts a measuring method that makes it possible to specify a position of the mobile body on a route together with shape data in a three-dimensional space of the route from the route information storing device.

[0005] An apparatus, which prevents wrong placement of a rail maintenance vehicle, and which performs maintenance work while moving on a rail, is described in JP9-164952A (hereinafter referred to as patent document 2). This apparatus locates positions of a base station and a road railer using a GPS and compares information on a position where a vehicle should be placed on a rail and information on the positions located, thereby judging wrong placement on a rail.

Disclosure of the Invention

[0006] Regarding the invention described in the patent document 1, it is possible to measure a linear distance between the mobile body and a target point. Yet, because information which is actually usable for maintenance work should be accurate track distance information according to a shape of a track rail and structures, in a section with a large curvature and the like, a gap between a track distance and a curve distance is large, and accurate track distance information cannot be obtained.

[0007] In the invention described in the patent document 2, wrong placement of a vehicle on a rail is determined by comparing information on a position where the vehicle should be placed on the rail and information on a position located by the GPS. However, the GPS is used only when the vehicle is placed on the rail and is not used at a work start point. Thus, it is impossible to perform accurate maintenance work.

[0008] The invention has been devised, given the aforementioned circumstances. An object of the invention is to provide a track rail maintenance system and a track rail maintenance method that can perform maintenance work by accurately grasping a start point of maintenance work using positioning data of a maintenance vehicle detected by a positioning system.

[0009] In order to attain the object, a track rail maintenance system set forth in claim 1 is a track rail maintenance system that performs maintenance work for a track rail using a maintenance vehicle including: positioning signal receiving means for receiving positioning signals transmitted from plural positioning satellites; and a track shape/structure database that stores data concerning track shapes of the track rail, structures present along the track rail, and the like, characterized in that the maintenance vehicle includes: positioning data acquiring means for decoding the positioning signals to acquire positioning data; position data acquiring means for acquiring position data of the maintenance vehicle on the basis of rotation of a predetermined axle attached to the maintenance vehicle; and comparing and judging means for comparing the positioning data and the position data at a start point of maintenance work set on the basis of the track shape/ structure database and judging whether a difference between the positioning data and the position data is within a predetermined range, and, the maintenance vehicle corrects the position data when the difference between the positioning data and the position data is not within the predetermined range as a result of the comparing and judging means.

[0010] A track rail maintenance system set forth in claim 2 is a track rail maintenance system that includes a step of receiving positioning signals transmitted from plural positioning satellites; a step of storing data concerning track shapes of a track rail and structures and the like present along the track rail; and a step of performing maintenance work for the track rail, characterized by including: a step of decoding the positioning signals to acquire positioning data; a step of acquiring position data of a maintenance vehicle on the basis of rotation of a predetermined axle attached to the maintenance vehicle; and a step of comparing the positioning data and the position data at a start point of maintenance work set on the basis of the track shape/structure database and judging whether a difference between the positioning data and the position data is within a predetermined range, and in that the position data is corrected when the difference between the positioning data and the position data is not within the predetermined range.

Brief Description of the Drawings

[0011]

Figure 1 is a block diagram showing an overall structure of a track rail maintenance system according to a first embodiment of the invention;
Figure 2 is a block diagram showing a structure of a control device in the track rail maintenance system according to the first embodiment of the invention;
Figure 3 is a flowchart showing an operation of the track rail maintenance system according to the first embodiment of the invention;
Figures 4A to 4D are schematics showing types of a track shape, wherein Figure 4A shows a single curve, Figure 4B shows a compound curve, Figure 4C shows a reverse curve, and Figure 4D shows a total transition curve;
Figures 5A and 5B are schematics showing types of a track shape;
Figures 6A and 6B are schematics showing types of a track shape;
Figures 7A and 7B are schematics showing types of a track shape;
Figures 8A and 8B are schematics showing types of a track shape;
Figures 9A and 9B are schematics showing types of a track shape;
Figures 10A and 10B are schematics showing methods of lining and leveling in vehicle setting; and
Figure 11 is a table showing devices used according to types of structures.

Best Mode for carrying Out the Invention

[0012] An embodiment of a track rail maintenance system of the invention will be hereinafter explained in detail with reference to the drawings. In the explanation of this embodiment, a GPS (Global Positioning System) is used as a positioning system as an example.

[0013] Figure 1 is a schematic block diagram showing an overall structure of a track rail maintenance system according to the embodiment of the invention.

[0014] As shown in the figure, this system consists of a GPS satellite 1, a maintenance vehicle 2, a GPS receiver 3, a control device 4, an interface 5, a sequencer 6, an encoder range finder 7, a sound unit 8, an inspection system 9, and a monitor 10. An analog input unit 11 and an analog output unit 12 are set between the control device 4 and the inspection system 9.

[0015] As the GPS satellite 1, plural GPS satellites are used. The GPS satellites transmit GPS signals including positioning data, respectively. In this embodiment, since three-dimensional positioning data is required, at least four GPS satellites are used.

[0016] The maintenance vehicle 2 runs on a track rail and is mounted with various devices for performing maintenance work of a track rail in a specific section.

[0017] The GPS receiver 3 is mounted on the maintenance vehicle 2, receives GPS signals transmitted from the GPS satellite 1, and sends the GPS signals which is received to a control unit of the control device 4 via the interface 5.

[0018] The control device 4 is equipped with the control unit, analyzes the GPS signals received from the GPS receiver 3, converts the GPS signals into positioning data, processes data from the encoder range finder 7 and data from the inspection system 9, and displays a result of the processing on the monitor 10. In this embodiment, a general-purpose personal computer is used.

[0019] The interface 5 is arranged near the control device 4 and connects the control device 4 and the GPS receiver 3 or other various external apparatuses. In this embodiment, a USB interface is used as the interface 5. The interface 5 is extendable ($21 \times 12.4 \times 3.7$) with 2-port conversion of RS-232C.

[0020] The sequencer (PLC) 6 uses a CQM, inputs data measured by the encoder range finder using a high-speed counter, and sends the data to the control device 4.

[0021] The encoder range finder 7 is a device that is positioned right behind a predetermined axle positioned at a leading portion in a work direction and detects rotation of the axle, thereby measuring a traveling distance.

[0022] The sound unit 8 is a device that is optionally disposed and issues a warning by sound and gives predetermined information by sound when the maintenance vehicle 2 approaches a base point or other extraordinary events occur.

[0023] The inspection system 9 is a system for performing inspection of a track, checking whether or not abnormal track correction is performed. It stores a degree of correction of the track by an actual correction amount or storing a remaining correction amount when correction is unsuccessful to utilize the degree of correction or the remaining correction amount for the next work. This system consists of a potentiometer for vertical measurement and a transducer for passing direction measurement on an inspection truck (wheels X, Y, and Z) towed behind the maintenance vehicle. An analog signal corresponding to a track shape is obtained. In this embodiment, displacements in the center between two points set (usually 10 m:10 m versed sine, 40 m for Shinkansen) can be compared by converting the displacements (finished displacements) into displacements of an actual length of a vehicle. Inspected data is passed to the analog input unit 11, analog-inputted to the control device 4, and analog-outputted from the control device 4 via the analog output unit 12.

[0024] The monitor 10 is arranged near the control unit 4 and performs check of a correction state (display of a present position, a correction value, etc.). The monitor 10 is also used as an operator of a touch panel type.

[0025] Figure 2 is a block diagram showing a functional structure in the control device of the track rail maintenance system according to the embodiment of the invention.

[0026] As shown in the figure, the control device 4 is equipped with a control unit 41, a storage unit 42, a communication unit 43, and a track shape/structure database 44.

[0027] A CPU (Central Processing Unit) is used as the control unit 41. The control unit 41 controls a position data acquiring unit 411 that automatically corrects distance data sent from the encoder 7 and acquires position data, a positioning data acquiring unit 412 that converts a GPS signal sent from the GPS receiver 3 into positioning data, a comparing and judging unit 413 that compares and judges the data from the encoder 7 and the positioning data by the GPS signal, a preliminary notification unit 414 that performs preliminary notification when the maintenance vehicle approaches the base point, and a warning issuing unit 415 that issues a warning when abnormality occurs.

[0028] A RAM, a ROM, or another recording medium is used as the storage unit 42. The storage unit 42 stores information obtained and notifies the control unit 41 of information stored. The storage unit 42 may be constituted to be detachably attachable using an external storage device.

[0029] The communication unit 43 is connected to the interface 5, the monitor 10, the analog input unit 11, the analog output unit 12, and the like, acquires information from the GPS receiver 3, the encoder range finder 7, the inspection system 9, and the like, and notifies the monitor 10 and the like of the information to display the information.

[0030] A RAM, a ROM, or another recording medium is used for the trackshape/structure database 44. Information necessary for maintenance work concerning track shapes of track rails, structures, and the like is stored and formed as a database such that the information can be extracted with predetermined simple operation.

[0031] Figure 3 is a flowchart of a track rail maintenance method of the invention.

[0032] First, a track shape of a track rail and positional information of structures and the like are inputted in advance and a database thereof is formed (step S31). This is for the purpose of performing a correction value (analog) and operation support according to a work position (a work vehicle). Subsequently, a position at the start of work is manually inputted (step S32). When a maintenance vehicle reaches the work start point which was manually inputted, a GPS signal is received and GPS positioning data is acquired (step S33). The value manually inputted and the GPS positioning data are compared (step S34) to judge whether a difference between the value and the GPS positioning data is within a predetermined range (step S35). In that case, in order to judge whether the difference is within the predetermined range, a predetermined threshold is set in advance and, when the difference is equal to or smaller than the threshold, it is judged that the difference is within the acceptable range and, when the difference exceeds the threshold, it is judged that the difference is not within the acceptable range. When the difference is not within the predetermined range, a warning is issued, the value manually inputted is corrected (step S36), and work is started (step S37). When the difference is within the predetermined range in step S35, work is started directly (step S37).

[0033] After the work is started, when the maintenance vehicle approaches a transition curve or a structure, the approach is notified in advance before the transition curve or the structure (step S38). It is possible to set a position of preliminary notification to be different depending on a type of a curve or a type of a structure. As for a method of preliminary notification, for example, it is possible to notify the approach to the transition curve with sound or screen displayby issuing a signal to a sound unit before the transition curve. As types of an alarm in performing the preliminary notification, a curve alarm and a GPS alarm are provided. As the curve alarm, a first alarm for issuing a warning in a place X m before a start point of the curve and a second alarm for issuing a warning in a place Y m before the start point of the curve are set. The GPS alarm is set to issue a warning by setting the latitude and the longitude.

[0034] In this way, when the preliminary notification is issued before the transition curve, after encoder distance correction is performed at the transition curve start point, a start position is manually inputted (step S39). In that case, correction values Y and C are calculated according to a traveling distance and analog-outputted. For the vertical curve, a correction value Z is calculated according to a traveling distance and analog-outputted. Track content inputted once is recorded in a memory or the like such that the track content can be used in the same position again. On the other hand, after a preliminary notification is issued before a structure, when the structure and a device set in the vehicle overlap, device control (operation lock) is performed to prevent the device from coming into contact with the structure simultaneously with a warning notifying that the device hinders the work. About ten types of structures and about six types of devices are provided. Content of the structure inputted once is recorded in a memory or the like such that the content can be used in the same position again. When the transition curve start point or the position of the structure is decided in this way, a value of the transition curve start point or the position of the structure is manually inputted (step S39). At that point, a GPS signal is received and GPS data is acquired (step S40). The value manually inputted and the GPS positioning data are compared (step S41) to judge whether the difference is within a predetermined range (step S42). In that case, as described above concerning step S35, concerning the judgment on whether the difference is within the predetermined range, a predetermined threshold is set in advance and, when the difference is equal to or smaller than the threshold, it is judged that the difference is within the predetermined range and, when the difference exceeds the threshold, it is judged that the difference is not within the predetermined range. When the difference is not within the predetermined range, a warning is issued, the value manually inputted is corrected (step S43), and the next work is started. When the difference is within the predetermined range, the next work is started directly. As described above, the operations after staring the work are repeated. When manual input is performed at a transition start point, a reference position, or the like, it is also possible to record GPS positioning data every time and set an average of the GPS positioning data and the last data as record data.

[0035] Concerning the encoder distance correction, a service distance and a work distance are displayed to make it possible to compare the distances with the present location and check the distances. As distance correction, a manual correction switch of "+10 cm" and "-10 cm" are provided. Automatic correction for a distance is performed at the transition curve start point and the like. Moreover, it is also possible to perform automatic correction using a distance correction signal (a photoelectric switch) inputted at every 100 m (there maybe no signal). In this automatic correction, a reflection plate is stuck to a rail side at every 100 m to obtain a change in a reflectance of a photoelectric sensor with this reflection plate and obtain a signal with a laser sensor or the like. In that case, a mark (the reflection plate) is checked using reflection of light on the reflection plate. Thus, when a mirror body or an object similar to the mirror body is present at the time of a rainy weather or when dust or other obstacles is present on a track, malfunction occurs. In order to avoid the malfunction, a signal is received only in positions several meters (a maximum correctable distance) before and after a planned reference position and processing for distance correction is not performed when a signal is received in other places.

[0036] The database is adopted such that track shape and structure data can be created, added, and changed with simple operation. When a work position range is inputted in the day of work, a file is automatically created and written in a memory card or the like.

[0037] Now, formation of a database of track shapes will be explained.

[0038] First, types of curves will be explained. Plane curves are classified into a circle curve and a transition curve. These curves are classified into a single curve, a compound curve, a reverse curve, and a total transition curve.

[0039] Figures 4A to 4D schematics showing the types of curves. Figure 4A shows a single curve, Figure 4B shows a compound curve, Figure 4C shows a reverse curve, and Figure 4D shows a total transition curve.

[0040] As shown in Figure 4A, concerning the single curve, a BTC (beginning of Transition Curve: a transition curve start point), a BCC (beginning of Circle Curve: a circle curve start point), an ECC (End of Circle Curve: a circle curve end point), and an ETC (End of Transition Curve: a transition curve end point) are used as reference points. A circle curve with a radius R is present between the reference point BTC at the start point of the transition curve and the reference point ETC at the end point of the transition curve. The circle curve is drawn as an arc with the radius R connecting the reference point BCC at the startpoint of the circle curve and the reference point ECC at the end point of the circle curve. A maintenance vehicle passes the reference points on the track rail in an order of BTC, BCC, ECC, and ETC.

[0041] As shown in Figure 4B, concerning the compound curve, a BTC (a transition curve start point), a BCC (a circle curve start point), a BIT (an intermediate transition curve start point), an EIT (an intermediate transition curve end point), an ECC (a circle curve end point), and an ETC (a transition curve end point) are used as reference points. Two circle curves with a radius R1 and a radius R2 are present between the reference point BTC at the start point of the transition curve and the reference point ETC at the end point of the transition curve. The circle curves are drawn as an arc connecting the reference point BCC at the start point of the circle curve and the reference point ECC at the end point of the circle curve. In the arc, an arc with the radius R1 between the reference point BCC at the start point of the circle curve and the reference point BIT at the start point of the intermediate transition curve and an arc with the radius R2 between the reference point EIT at the end point of the intermediate transition curve and the reference point ECC at the end point of the circle curve are drawn. The maintenance vehicle passes the reference points on the track rail in an order of BTC, BCC, BIT, EIT, ECC, and ETC.

[0042] As shown in Figure 4C, for the reverse curve, a BTC (a transition curve start point), a BCC (a circle curve start point), a BRT (a reverse transition curve start point), an ERT (a reverse transition curve end point), an ECC (a circle curve end point), and an ETC (a transition curve end point) are used as reference points. Two circle curves with a radius R3 and a radius R4 are present between the reference point BTC at the start point of the transition curve and the reference point ETC at the end point of the transition curve. The circle curves are arcs in opposite directions. An arc with the radius R3 connecting the reference point BCC at the start point of the circle curve and the reference point BRT at the start point of the reverse transition curve and an arc with the radius R4 connecting the reference point ERT at the end point of the reverse transition curve and the reference point ECC at the end point of the circle curve are drawn. The maintenance vehicle passes the reference points on the track rail in an order of BTC, BCC, BRT, ERT, ECC, and ETC.

[0043] As shown in Figure 4D, concerning the total transition curve, a BTC (a transition curve start point), a JTC (a transition curve joint point), and an ETC (a transition curve end point) are used as reference points. The JTC is set as a joint point of the transition curves between the reference point BTC at the start point of the transition curve and the reference point ETC at the end point of the transition curve. The maintenance vehicle passes the reference points on the track rail in an order of BTC, JTC, and ETC.

[0044] The transition curve points to a curb, which is both inserted in the connecting part, and changeable. This prevents the loss of riding comfortability and running function, which would be caused by a dramatic change in a curvature of a curve point (a value of the curve radius R) in a connecting place of the curve portion and a straight line portion.

[0045] When track shape data is inputted, first, a work planned day, a work section (... km, ... m, from .. to .., ... m, 00), and the like are inputted and, then, reference points of a track shape are inputted. As the reference points of the track shape, as described above, there are a BTC (a transition curve start point), a BCC (a circle curve start point), an ECC (a circle curve end point), an ETC (a transition curve end point), a BIT (an intermediate transition curve start point), an EIT (an intermediate transition curve end point), a BRT (a reverse transition curve start point), an ERT (a reverse transition curve end point), a JTC (a transition curve joint point), and the like.

[0046] Subsequently, types of track shapes are inputted.

[0047] Figures 5A and 5B to 9A and 9B are schematics showing type of track shapes. Figures 5A and 5B are diagrams showing a single curve (in), Figures 6A and 6B are diagrams showing a single curve (out), Figures 7A and 7B are diagrams showing a compound curve, Figures 8A and 8B are diagrams showing a reverse curve, and Figures 9A and 9B are diagrams showing a total transition curve.

[0048] In the case of a right-handed turn of the single curve (in), as shown in Figure 5A, the maintenance vehicle proceeds in an order of a straight line (2), a transition curve (4), and a circle curve (9). In the case of a left-handed turn of the single curve (in), as shown in Figure 5B, the maintenance vehicle proceeds in an order of the straight line (2), the transition curve (4), and a circle curve (7). In the case of a left-handed turn of the single curve (out), as shown in Figure 6A, the maintenance vehicle proceeds in an order of a circle curve (1), the transition curve (4), and a straight line (8). In the case of a right-handed turn of the single curve (out), as shown in Figure 6B, the maintenance vehicle proceeds in an order of a circle curve (3), the transition curve (4), and the straight line (8). In the case of the compound curve (left), as shown in Figure 7A, the maintenance vehicle proceeds in an order of the circle curve (1), the transition curve (4), and the circle curve (7). In the case of the compound curve (right), as shown in Figure 7B, the maintenance vehicle proceeds in an order of the circle curve (3), the transition curve (4), and the circle curve (9). In the case of the reverse curve (left), as shown in Figure 8A, the maintenance vehicle proceeds in an order of the circle curve (1), the transition curve (5), the transition curve (6), and the circle curve (9). In the case of the compound curve (right), as shown in Figure 8B, the maintenance vehicle proceeds in an order of the circle curve (3), the transition curve (5), the transition curve (6), and the circle curve (7) . In the case of the total transition curve (left), as shown in Figure 9A, the maintenance vehicle proceeds in an order of the straight line (2), the transition curve (5), the transition curve (6), and the circle curve (9). In the case of the total transition curve (right), as shown in Figure 9B, the maintenance vehicle proceeds in an order of the straight line (2), the transition curve (5), the transition curve (6), and the circle curve (7).

[0049] In forming a database of the track shapes, first, a work section and a work planned day are inputted and, then, a type of the track shape is inputted. As the type of the track shape, as described above, there are a single curve (in), a single curve (out), a compound curve, a reverse curve, a total transition curve, and the like. As a type of transition, there are two types of plane curves, a "third-order parabolic transition curve (linear diminution)" and a "sine half-wave-length transition curve (sine diminution) " and three types of vertical curves, a "linear gradient", a "gradient with a gradient change point", and a "gradient with a reverse curve". Subsequently, a maximum cant C1, a correction value Y, and the like are calculated.

[0050] A cant will be hereinafter explained.

[0051] When a train passes a curve at a certain velocity, since a centrifugal force acts outward, there are adverse effects described below. (1) A danger of a turnover of a vehicle to the outside of the curve occurs, (2) a large wheel load acts on an outer track side rail and a large lateral pressure is caused by turning of the vehicle, a lateral pressure is further applied by the centrifugal force, and track breakage is increased by these factors, (3) passengers are drawn to the outer side and riding comfortableness is deteriorated, and (4) a resistance of the train increases. The cant means an inclination applied to the track such that the centrifugal force is offset or reduced in order to prevent the adverse effects due to the centrifugal force.

[0052] In the narrow-gauge rail (with a gauge of 1,067m/m), a difference of heights of inner and outer tracks is defined as a cant amount. However, in the standard gauge (Shinkansen, etc.), a difference of elevation in a center distance 1, 500m/m of inner and outer track rails is defined as a cant amount worldwide.

[0053] Equations for calculating cants are described below.

$$\text{Narrow-gauge rail (with a gauge of 1,067m/m) cant } C = 8.4\times\text{velocity } V^2/\text{curve radius } R$$

$$\text{Standard gauge rail (with a gauge of 1,500m/m) cant } C = 11.8\times\text{velocity } V^2/\text{curve radius } R$$

[0054] Peg work for performing correction using external data will be explained.

[0055] The peg work is a work method of inputting a movement amount in advance on a separate sheet and outputting a correction amount according to switching of a peg switch. As the external data, data measured in other vehicles dedicated to track inspection or data measured by a human is used. In this work, each movement amount can be inputted for every 1 m in 1500 m and Y lining to the left and the right and Z leveling to the left and the right are performed. In that case, a correction voltage input from the outside is also taken into account. In the leveling, adjustment of height of a rail is performed. In the lining, correction of bending of a rail is performed.

[0056] Figures 10A and 10B are schematics showing methods of the lining and the leveling in vehicle setting.

[0057] Figure 10A is a diagram showing the method of the lining.

[0058] A method of calculating a maximum value of lining Y on an arc will be described below. Assuming that an end point of a lateral curve has an arc shape, a radius of the arc is set as r.

$$B=(9.15+5.4)\div 2=7.275$$

$$A=B-5.4=7.275-5.4=1.875$$

$$\text{Ratio } k = 14.55\div 5.4=2.6944$$

$$Y/k=(r^2-A^2)^{1/2}-(r^2-B^2)^{1/2}$$

[0059] Therefore, $Y= (r^2-A^2)^{1/2}-(r^2-B^2)^{1/2}\times k$

[0060] Figure 10B is a diagram showing the method of the leveling.

[0061] A method of calculating a maximum value of leveling Z on an arc will be described below. As in the case of the lateral curve, assuming that a gradient end point of a longitudinal curve has an arc shape, a radius of the arc is set as r.

$$B=(9.15-0.5+5.4)\div 2=7.075$$

$$A=B-5.4=7.075-5.4=1.625$$

$$\text{Ratio } kz = 14.05 \div 5.4 = 2.60185$$

$$Z/kz=(r^2-A^2)^{1/2}-(r^2-B^2)^{1/2}$$

[0062] Therefore, $Z= (r^2-A^2)^{1/2}-(r^2-B^2)^{1/2} \times kz$

[0063] A and B in the equations are explained. Values of A and B represent positional deviation of a wheel base of the vehicle. When vehicles at three points are placed on an actual arc, since a position of the vehicle in the middle is not in a half position of a total length, an imaginary vehicle position B is calculated and an actual amount of deviation A from the imaginary vehicle position is set.

[0064] Values of A and B are different in calculating a Y value and in calculating a Z value because positions of an apparatus measuring track shapes in the longitudinal direction and the lateral direction deviates from each other.

[0065] Since an amount of this deviation is different depending on a type and a form of a wheel base, the amount of deviation is subjected to variable processing so that the amount of deviation can be changed on the outside.

[0066] Formation of a database of structures will be explained.

[0067] Figure 11 is a table showing devices used according to types of structures.

[0068] The structures are roughly classified into ten types, namely, a ground element, a transverse cable, a railroad crossing, a rail joint, a bridge, a disabled section, an obstacle, a right side obstacle, a left side obstacle, a both side obstacle. The disabled section includes a stabilizer and the obstacle includes a trough. For example, as shown in the figure, any one of devices 1 to 6, which are externally set devices, can be selected for the ground element, the cable, the railroad crossing, the joint, and the bridge. A clamp (side left) 9, a tamping (side right), a compactor right (front), a compactor left (stabilizer), a sweeper (brush), not used (sweeper), and the like are set as the devices 1 to 6. Device names are not limited to these and can be set freely. ON is written in sections of the devices used and OFF is written in sections of the devices not used among the devices 1 to 5. In this example, in the case of the ground element, the device 1 is not used, the device 2 is used, the device 3 is not used, the device 5 is used, and the device 6 is not used. Similarly, in the case of the cable, all the devices 1 to 5 are used. The devices used are clearly indicated in the case of the railroad crossing, in the case of the joint, and in the case of the bridge in the same manner.

[0069] The track rail maintenance system of the invention has been explained according to the embodiment. However, the invention is not limited to this embodiment. Various modifications of the invention are possible without departing from the spirit of the invention.

[0070] For example, in the embodiment, the positioning system by the GPS is explained. However, the invention is not limited to this. It is also possible to use other positioning systems.

[0071] In the example explained in the embodiment, sound is synthesized and outputted in order to issue a warning or an alarm. However, the invention is not limited to this. It is possible to issue a warning or an alarm using other methods.

Industrial Applicability

[0072] As explained above, according to the invention, since a start point of maintenance work is accurately grasped using positioning data of a maintenance vehicle detected by the positioning system, there is an effect that it is possible to perform accurate maintenance work.

Claims

1. A track rail maintenance system that performs maintenance work for a track rail using a maintenance vehicle that includes:

positioning signal receiving means for receiving positioning signals transmitted from plural positioning satellites; and

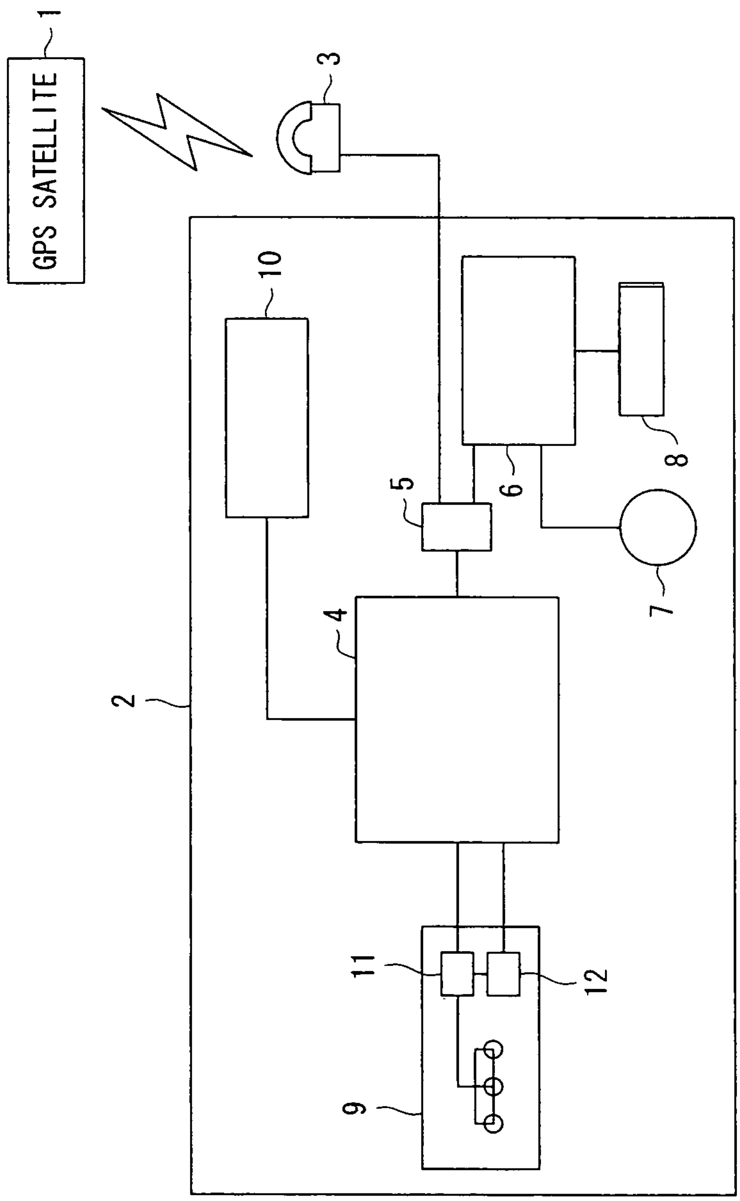
a track shape/structure database that stores data concerning track shapes of the track rail, structures present along the track rail, and the like, **characterized in that** the maintenance vehicle includes:

positioning data acquiring means for decoding the positioning signals to acquire positioning data;
position data acquiring means for acquiring position data of the maintenance vehicle on the basis of rotation of a predetermined axle attached to the maintenance vehicle; and
comparing and judging means for comparing the positioning data and the position data at a start point of maintenance work set on the basis of the track shape/structure database and judging whether a difference between the positioning data and the position data is within a predetermined range, and
the maintenance vehicle corrects the position data when the difference between the positioning data and the position data is not within the predetermined range as a result of the comparing and judging means.

2. A track rail maintenance method includes a positioning signal receiving step of receiving positioning signals transmitted from plural positioning satellites; and a step of storing data concerning track shapes of a track rail and structures and the like present along the track rail to form a database thereof, and performs maintenance work for the track rail, **characterized by** comprising:

a positioning data acquiring step of decoding the positioning signals to acquire positioning data;
a position data acquiring step of acquiring position data of a maintenance vehicle on the basis of rotation of a predetermined axle attached to the maintenance vehicle; and
a comparing and judging step of comparing the positioning data and the position data at a start point of maintenance work set on the basis of the track shape/structure database and judging whether a difference between the positioning data and the position data is within a predetermined range, and in that
the position data is corrected when the difference between the positioning data and the position data is not within the predetermined range as a result of the comparing and judging step.

FIG. 1



F I G. 2

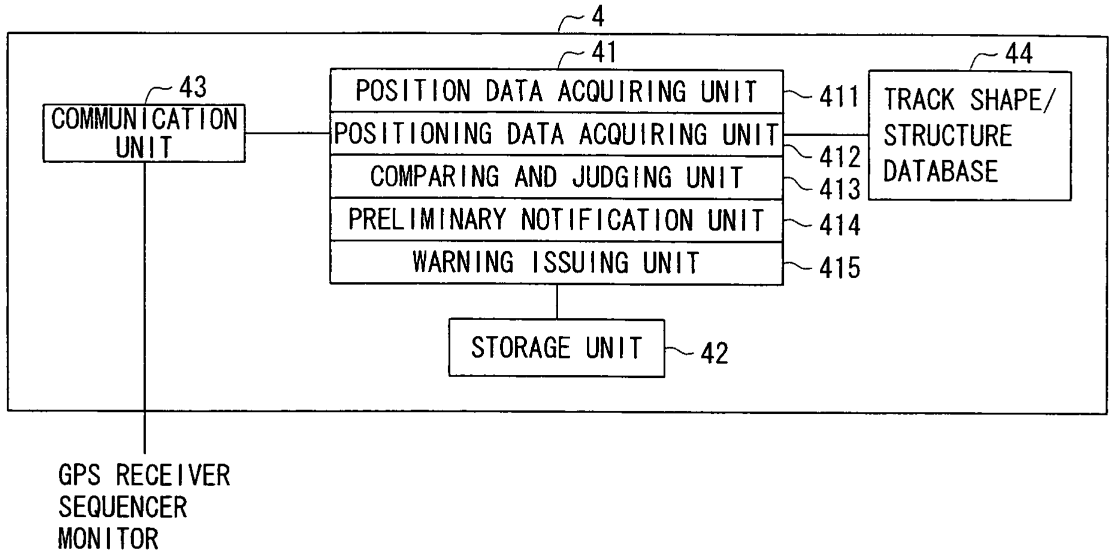

4
41
43
COMMUNICATION UNIT
POSITION DATA ACQUIRING UNIT
POSITIONING DATA ACQUIRING UNIT
COMPARING AND JUDGING UNIT
PRELIMINARY NOTIFICATION UNIT
WARNING ISSUING UNIT
411
412
413
414
415
44
TRACK SHAPE/ STRUCTURE DATABASE
STORAGE UNIT
42
GPS RECEIVER
SEQUENCER
MONITOR

FIG. 3

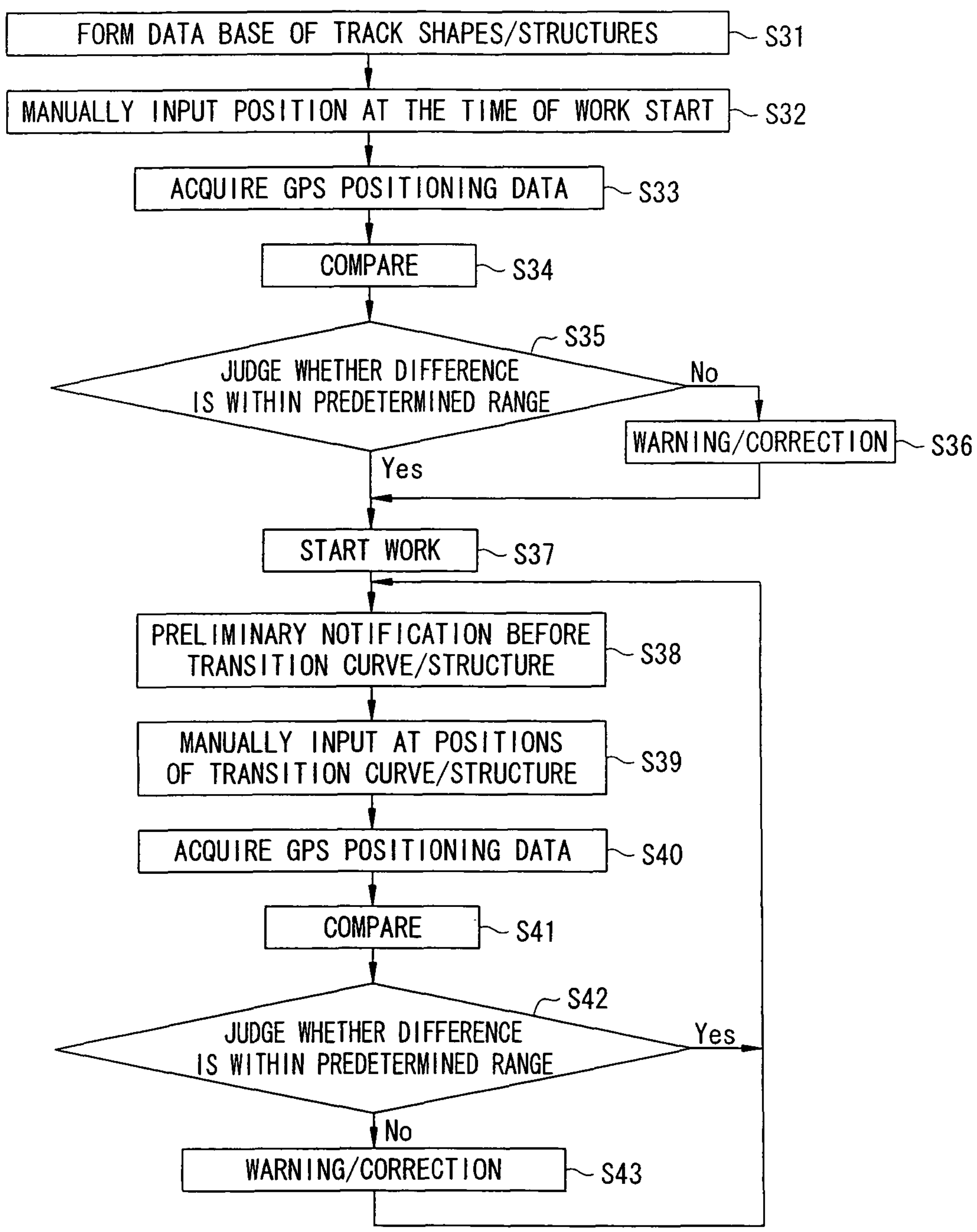

FORM DATA BASE OF TRACK SHAPES/STRUCTURES
S31
MANUALLY INPUT POSITION AT THE TIME OF WORK START
S32
ACQUIRE GPS POSITIONING DATA
S33
COMPARE
S34
S35
JUDGE WHETHER DIFFERENCE IS WITHIN PREDETERMINED RANGE
No
WARNING/CORRECTION
S36
Yes
START WORK
S37
PRELIMINARY NOTIFICATION BEFORE TRANSITION CURVE/STRUCTURE
S38
MANUALLY INPUT AT POSITIONS OF TRANSITION CURVE/STRUCTURE
S39
ACQUIRE GPS POSITIONING DATA
S40
COMPARE
S41
S42
JUDGE WHETHER DIFFERENCE IS WITHIN PREDETERMINED RANGE
Yes
No
WARNING/CORRECTION
S43

FIG. 4A

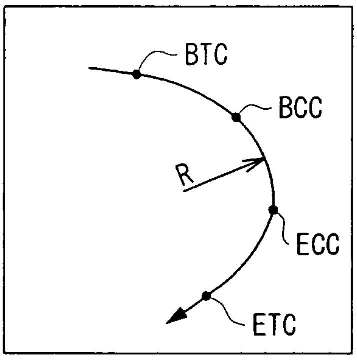


FIG. 4B

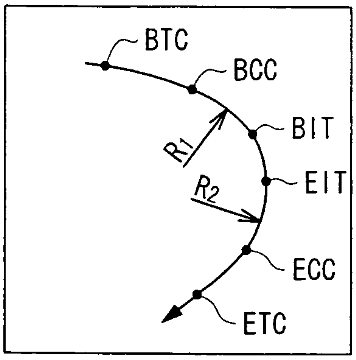


FIG. 4C

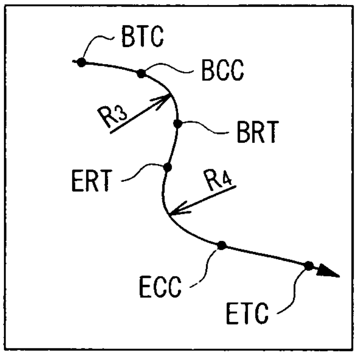


FIG. 4D

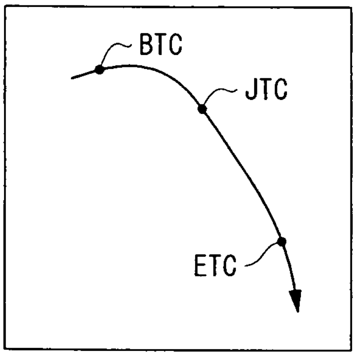


FIG. 5A

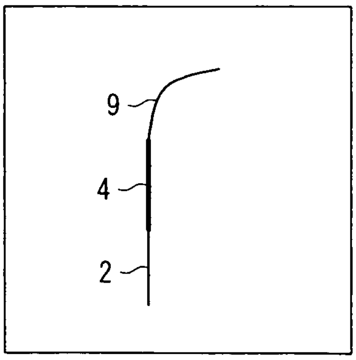
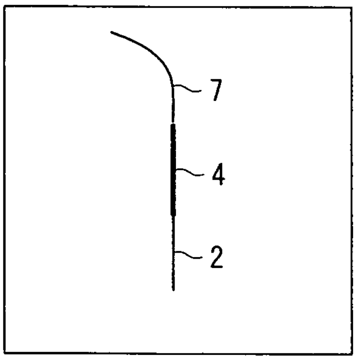
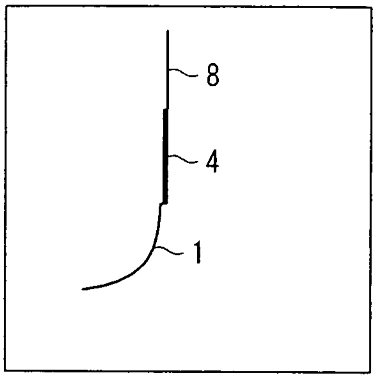


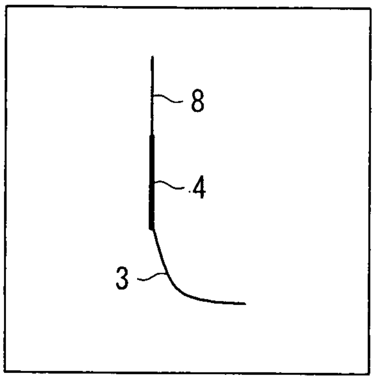
FIG. 5B



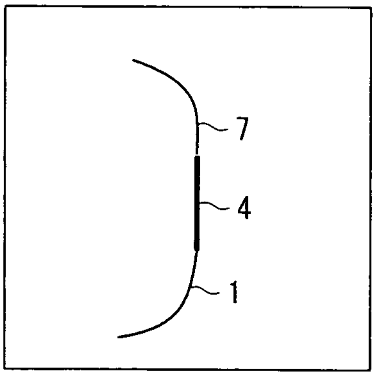
F I G. 6 A



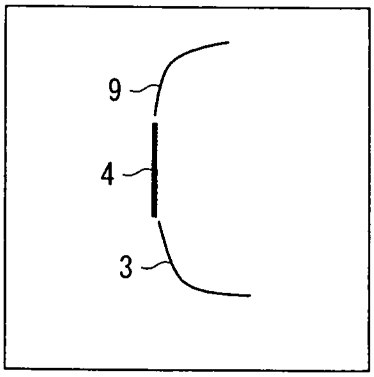
F I G. 6 B



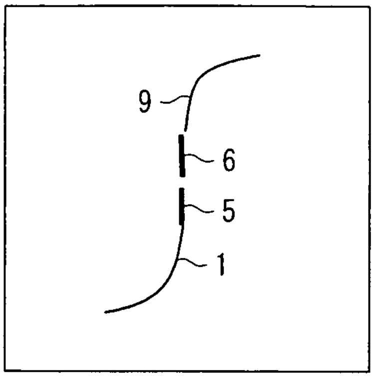
F I G. 7 A



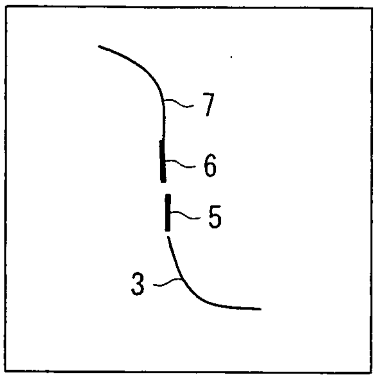
F I G. 7 B



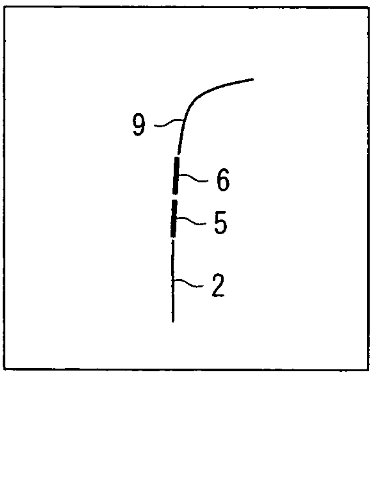
F I G. 8 A



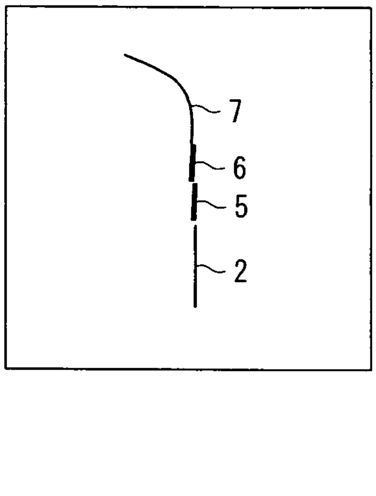
F I G. 8 B



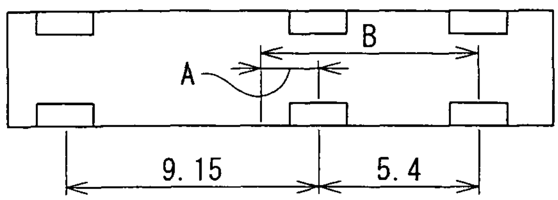
F I G. 9 A



F I G. 9 B



F I G. 1 0 A



F I G. 1 0 B

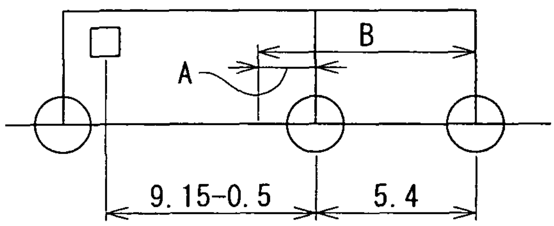


FIG. 11

DEVICE / STRUCTURE	DEVICE 1 (CLAMP) (SIDE LEFT)	DEVICE 2 (TYPING) (SIDE RIGHT)	DEVICE 3 (COMPACTOR RIGHT) (FRONT)	DEVICE 4 (COMPACTOR LEFT) (STABILIZER)	DEVICE 5 (SWEEPER) (BRUSH)	DEVICE 6 (NOT USED) (SWEEPER)
1 GROUND ELEMENT	OFF	ON	OFF	OFF	ON	OFF
2 CABLE	ON	ON	ON	ON	ON	ON
3 RAILROAD CROSSING	ON	OFF	ON	ON	OFF	ON
4 JOINT	OFF	ON	ON	ON	OFF	ON
5 BRIDGE	ON	OFF	ON	ON	ON	OFF

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/015927

A. CLASSIFICATION OF SUBJECT MATTER
B61L23/06(2006.01)

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)
B61L23/06(2006.01)

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2005
Kokai Jitsuyo Shinan Koho	1971-2005	Toroku Jitsuyo Shinan Koho	1994-2005

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.
Y	JP 2002-225708 A (Omron Corp.), 14 August, 2002 (14.08.02), Par. Nos. [0003], [0013], [0014], [0017] to [0026] (Family: none)	1,2
Y	JP 8-14926 A (Matsushita Electric Industrial Co., Ltd.), 19 January, 1996 (19.01.96), Par. Nos. [0011] to [0014] (Family: none)	1,2
Y	JP 2002-67960 A (Kawasaki Heavy Industries, Ltd.), 08 March, 2002 (08.03.02), Par. Nos. [0006] to [0010] (Family: none)	1,2

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 November, 2005 (07.11.05)	15 November, 2005 (15.11.05)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

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- JP 2001056234 A **[0004]**
- JP 9164952 A **[0005]**