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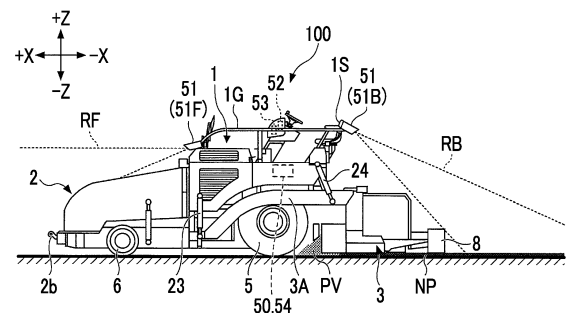
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(54) **ASPHALT FINISHER AND ROAD SURFACE PAVING SYSTEM**

(57) An asphalt finisher includes a tractor, a hopper that is provided on a front side of the tractor, a conveyor that transports a paving material in the hopper to a rear side of the tractor, a screw that spreads the paving material, which is transported by the conveyor and is sprinkled on a road surface, in a vehicle width direction, a screed device that levels the paving material spread by the screw on a rear side of the screw, and a measuring device that measures compaction information indicating a degree of compaction, which is a ratio of the paving material leveled on the road surface to voids.

FIG. 1A



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Description

Technical Field

5 **[0001]** The present invention relates to an asphalt finisher and a road surface paving system.

Background Art

10 **[0002]** In the related art, an asphalt finisher including a tractor, a hopper that is provided on a front side of the tractor and that receives a paving material, a conveyor that feeds the paving material in the hopper to a rear side of the tractor, a screw that spreads the paving material fed by the conveyor on the rear side of the tractor, and a screed that levels the paving material spread by the screw on a rear side of the screw is known.

15 **[0003]** When the asphalt finisher performs construction, a design drawing is prepared, and construction is performed to level the paving material on the road surface based on the design drawing. Various techniques in order to make the construction easy are proposed. For example, PTL 1 proposes a technique for displaying situation of a road in order to recognize a required mixture amount.

Citation List

20 Patent Literature

[0004] [PTL 1] International Publication No. 2020/196540

Summary of Invention

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Technical Problem

30 **[0005]** However, when the asphalt finisher levels the paving material, the compaction degree of the paving material (in other words, the ratio of the paving material to the voids) spread on each region of the road surface may differ from the compaction degree assumed when creating the design drawing.

[0006] In view of the above, it is easy to identify the situation of the constructed road surface, by measuring the compaction degree (ratio of the paving material to the voids) of the paving material leveled on the road surface.

Solution to Problem

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40 **[0007]** According to an aspect of the present invention, there is provided an asphalt finisher including a tractor, a hopper that is provided on a front side of the tractor, a conveyor that transports a paving material in the hopper to a rear side of the tractor, a screw that spreads the paving material, which is transported by the conveyor and is sprinkled on a road surface, in a vehicle width direction, a screed device that levels the paving material spread by the screw on a rear side of the screw, and a measuring device that measures compaction information indicating a degree of compaction, which is a ratio of the paving material leveled on the road surface to the voids.

Advantageous Effects of Invention

45 **[0008]** According to one aspect of the present invention, it is easy to identify the situation of the constructed road surface, by measuring the degree of compaction (ratio of the paving material to the voids) of the paving material leveled on the road surface.

Brief Description of Drawings

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[0009]

55 Fig. 1A is a left side view showing an asphalt finisher which is an example of a road paving machine according to an embodiment.

 Fig. 1B is an upper view showing the asphalt finisher which is an example of the road paving machine according to the embodiment.

 Fig. 2A is a left side view showing an asphalt finisher which is an example of a road paving machine according to a modification example.

Fig. 2B is an upper view showing the asphalt finisher which is an example of the road paving machine according to the modification example.

Fig. 3 is a block diagram showing a configuration example of a controller and devices connected to the controller according to the embodiment.

Fig. 4 is a diagram illustrating an average value of a compaction degree for each predetermined region calculated by a compaction degree calculation unit according to the embodiment.

Fig. 5 is a diagram showing a configuration example of a construction management system according to an embodiment.

Fig. 6 is a view showing an asphalt finisher, a dump truck, and a road roller, which are examples of the road paving machine according to the embodiment.

Fig. 7 is a view showing a situation of a road surface where construction is performed by the asphalt finisher according to the embodiment.

Fig. 8 is a diagram illustrating a construction information management sheet generated by an information generation unit according to the embodiment.

Description of Embodiments

[0010] Hereinafter, an embodiment of the present invention will be described with reference to the drawings. In each of the drawings, the same or corresponding configurations will be assigned with the same reference symbols, and description thereof will be omitted.

[0011] Figs. 1A and 1B are views showing an asphalt finisher 100 which is an example of a road paving machine according to an embodiment. Specifically, Fig. 1A is a left side view, and Fig. 1B is a top view.

[0012] The asphalt finisher 100 is mainly configured by a tractor 1, a hopper 2, and a screed 3 (an example of a screed device). Hereinafter, a direction of the hopper 2 viewed from the tractor 1 (+X direction) will be referred to as forward, and a direction of the screed 3 viewed from the tractor 1 (-X direction) will be referred to as rearward. The road paving machine may be a base paver, a tack paver, a multi-asphalt paver, or the like. A compaction degree measuring instrument 8 is further provided behind the asphalt finisher 100 of the present embodiment.

[0013] The tractor 1 is a mechanism for moving the asphalt finisher 100. In the present embodiment, the tractor 1 rotates a rear wheel 5 using a rear wheel traveling hydraulic motor and rotates a front wheel 6 using a front wheel traveling hydraulic motor to move the asphalt finisher 100. The rear wheel traveling hydraulic motor and the front wheel traveling hydraulic motor rotate by receiving supply of a hydraulic oil from a hydraulic pump. The rear wheel 5 and the front wheel 6 may be replaced with a crawler. The traveling motor may be an electric motor.

[0014] The hopper 2 is a mechanism for receiving a paving material. In the present embodiment, the hopper 2 is provided on a front side of the tractor 1 and is configured to be able to be opened and closed in a vehicle width direction (Y-axis direction) by a hopper cylinder. The asphalt finisher 100 usually receives a paving material (for example, an asphalt mixture) from a loading platform of a dump truck when the hopper 2 is in a fully open state. The dump truck is an example of a transport vehicle that transports the paving material. Figs. 1A and 1B show that the hopper 2 is in the fully open state. The hopper 2 is closed when the paving material in the hopper 2 decreases, and the paving material near an inner wall of the hopper 2 is collected at a central portion of the hopper 2. This is to enable a conveyor CV which is at the central portion of the hopper 2 to feed the paving material to the rear side of the tractor 1. The paving material fed to the rear side of the tractor 1 is spread in the vehicle width direction on the rear side of the tractor 1 and the front side of the screed 3 by a screw SC. In the present embodiment, the screw SC is in a state where an extension screw is connected right and left. Figs. 1A and 1B show the paving material PV spread by the screw SC in a dot pattern.

[0015] The screed 3 is a mechanism for leveling the paving material PV. In the present embodiment, the screed 3 includes a front side screed 30 and a rear side screed 31, as shown in Fig. 1B. The front side screed 30 includes a left front side screed 30L and a right front side screed 30R. The rear side screed 31 includes a left rear side screed 31L and a right rear side screed 31R. The screed 3 is a floating screed pulled by the tractor 1 and is connected to the tractor 1 via a leveling arm 3A.

[0016] The screed 3 is moved up and down together with the leveling arm 3A in response to expansion and contraction of a screed lift cylinder 24.

[0017] A leveling cylinder 23 is a hydraulic cylinder that moves a front end portion of the leveling arm 3A up and down in order to adjust a leveling thickness of a paving material. In the present embodiment, the leveling cylinder 23 has a cylinder portion connected to the tractor 1 and a rod portion connected to a connection portion of the leveling arm 3A with the tractor 1. In a case of increasing the leveling thickness, the controller 50 causes a hydraulic oil discharged by the hydraulic pump to flow into a rod-side oil chamber of the leveling cylinder 23 and contracts the leveling cylinder 23 to raise the leveling arm 3A. On the other hand, in a case of reducing the leveling thickness, the controller 50 causes the hydraulic oil in the rod-side oil chamber of the leveling cylinder 23 to flow out and expands the leveling cylinder 23 to lower the leveling arm 3A.

[0018] The screed lift cylinder 24 is a hydraulic cylinder for lifting the screed 3. In the present embodiment, a cylinder portion of the screed lift cylinder 24 is connected to the tractor 1, and a rod portion thereof is connected to a rear end portion of the leveling arm 3A. In a case of lifting the screed 3, the controller 50 causes a hydraulic oil discharged by the hydraulic pump to flow into a rod-side oil chamber of the screed lift cylinder 24. As a result, the screed lift cylinder 24 contracts, the rear end portion of the leveling arm 3A is lifted, and the screed 3 is lifted. On the other hand, in a case of lowering the lifted screed 3, the controller 50 enables the hydraulic oil in the rod-side oil chamber of the screed lift cylinder 24 to flow out. As a result, the screed lift cylinder 24 is expanded by the weight of the screed 3, the rear end portion of the leveling arm 3A is lowered, and the screed 3 is lowered.

[0019] A mold board 43 is attached to a front portion of the screed 3. The mold board 43 is configured to be able to adjust the amount of the paving material PV staying in front of the screed 3. The paving material PV reaches under the screed 3 through a gap between a lower end of the mold board 43 and a roadbed BS.

[0020] The screed 3 is provided with a left front side tamper 25L, a right front side tamper 25R, a left rear side tamper 26L, and a right rear side tamper 26R (hereinafter, collectively referred to as tampers 25 and 26). The left front side screed 30L finishes the road surface tamped and compacted by the left front side tamper 25L. The right front side screed 30R finishes the road surface tamped and compacted by the right front side tamper 25R. The left rear side screed 31L finishes the road surface tamped and compacted by the left rear tamper 26L. The right rear side screed 31R finishes the road surface tamped and compacted by the right rear tamper 26R.

[0021] The tampers 25 and 26 move a tamper edge (not shown) up and down through a tamper shaft (not shown) that is partially eccentric by rotation of a motor (not shown) provided in the screed 3. Accordingly, the tampers 25 and 26 tamp down the road surface.

[0022] The screed 3 is provided with a left front side vibrator 27L, a right front side vibrator 27R, a left rear side vibrator 28L, and a right rear side vibrator 28R (hereinafter, collectively referred to as vibrators 27 and 28). Then, the left front side screed 30L is vibrated by the left front side vibrator 27L, and the right front side screed 30R is vibrated by the right front side vibrator 27R. The left rear side screed 31L is vibrated by the left rear side vibrator 28L, and the right rear side screed 31R is vibrated by the right rear side vibrator 28R.

[0023] The vibrators 27 and 28 are vibration devices for compacting the pavement surface. In the present embodiment, the vibrators 27 and 28 are eccentric vibrators driven by a hydraulic motor. However, the vibrator may be driven by an electric motor, or may be a linear vibrator. The vibration frequency of the present embodiment is changed according to the type of the paving material and the like.

[0024] The compaction degree measuring instrument 8 is provided behind the screed 3 (in the direction of -X). The compaction degree measuring instrument 8 of the present embodiment is directly connected to the screed 3. The compaction degree measuring instrument 8 may be provided with wheels (not shown). Accordingly, the road surface of which the compaction degree is to be measured can be changed according to the progress of the asphalt finisher 100.

[0025] The compaction degree measuring instrument 8 measures the degree of compaction (hereinafter, also referred to as the compaction degree), which is a ratio between the paving material spread on the road surface and the voids. In the compaction degree measuring instrument 8, for example, a positive electrode and a negative electrode are disposed on the bottom surface of the compaction degree measuring instrument 8. Then, the degree of compaction of the paving material that has been spread is measured based on the magnetic field generated between the positive electrode and the negative electrode and the electromagnetic characteristics of the paving material. In addition, the present embodiment shows an example of a method for measuring the compaction degree of the paving material that has been spread, and any method may be used regardless of a well-known method.

[0026] A plurality of the compaction degree measuring instruments 8 of the present embodiment are provided in the vehicle width direction (Y-axis direction). The asphalt finisher 100 according to the present embodiment is disposed such that all regions in the width direction of the screed 3 can be measured in order to measure the compaction degree of the paving material PV leveled by the screed 3. In the present embodiment, six compaction degree measuring instruments 8 are provided. In a case where each of the compaction degree measuring instruments 8 is indicated, the compaction degree measuring instruments 8_1 to 8_6 are referred to as each. In the present embodiment, the number of the compaction degree measuring instruments 8 to be provided is not limited to six, and an appropriate number of the compaction degree measuring instruments 8 may be provided according to the length in the vehicle width direction in which the asphalt finishers 100 spreads the paving material.

[0027] As shown in Figs. 1A and 1B, in the present embodiment, a gap is provided between the compaction degree measuring instruments 8. However, the present embodiment is not limited to a method of installing the compaction degree measuring instruments 8 with a gap, and for example, the measurement ranges may overlap between the compaction degree measuring instruments 8. As an example of the disposition in which the measurement ranges overlap, it is conceivable that two rows of the compaction degree measuring instruments 8 are alternately disposed (disposed in a staggered-array) in the vehicle width direction (Y-axis direction) and the end portions of the compaction degree measuring instruments 8 in one row overlap the end portions of the compaction degree measuring instruments 8 in the other row overlap in the vehicle width direction (Y-axis direction).

[0028] The controller 50 is a control device that controls the asphalt finisher 100. In the present embodiment, the controller 50 is composed of a microcomputer including a CPU, a memory, a non-volatile storage device, and the like, and is mounted on the tractor 1. Each function of the controller 50 is implemented by the CPU executing a program stored in the non-volatile storage device. However, each function of the controller 50 may be configured by hardware or firmware.

[0029] The communication device 53 is configured to be able to control communication between the asphalt finisher 100 and devices outside the asphalt finisher 100. The communication device 53 according to the present embodiment is installed in front of a driver's seat 1S and controls communication via a mobile phone communication network, a short-range wireless communication network, a satellite communication network, or the like.

[0030] A GPS module 54 is an example of a global navigation satellite system (GNSS) module, and receives position information indicating a two-dimensional positioning result through the global positioning system (GPS). The position information includes information representing the position of the asphalt finisher 100 in latitude and longitude. Although the GPS is used as a position information acquisition method in the present embodiment, the position information acquisition method is not limited, and other known methods may be used.

[0031] A space recognition device 51 is attached to the tractor 1. The space recognition device 51 acquires information related to a space around the asphalt finisher 100 and is configured to be able to output the acquired information to the controller 50. The space recognition device 51 according to the present embodiment includes a front monitoring device 51F and a rear monitoring device 51B.

[0032] The front monitoring device 51F is configured to be able to monitor the front of the asphalt finisher 100. In the present embodiment, the front monitoring device 51F is a LIDAR with a space in front of the tractor 1 as a monitoring range RF, and is attached to a front end central portion of an upper surface of the tractor 1. The front monitoring device 51F may be attached to other parts of the asphalt finisher 100.

[0033] The rear monitoring device 51B is configured to be able to monitor the rear of the asphalt finisher 100. In the present embodiment, the rear monitoring device 51B is a LIDAR with the space behind the screed 3 as the monitoring range RB, and is attached to a guide rail 1G that functions as a handrail for the operator of the asphalt finisher 100. The rear monitoring device 51B may be attached to a lower portion of the driver's seat 1S or may be attached to other parts of the asphalt finisher 100.

[0034] The space recognition device 51 may include a side monitoring device configured to be able to monitor the side of the asphalt finisher 100. In this case, the side monitoring device is, for example, a LIDAR with a space to the left of the tractor 1 as the monitoring range, and may be attached to a left end portion of the upper surface of the tractor 1 on the front side of the rear wheel 5. The side monitoring device is, for example, a LIDAR with a space to the right of the tractor 1 as the monitoring range, and may be attached to a right end portion of the upper surface of the tractor 1 on the front side of the rear wheel 5.

[0035] The LIDAR measures, for example, a distance between a million or more points within the monitoring range and the LIDAR. However, at least one of the front monitoring device 51F and the rear monitoring device 51B may be a monocular camera, a stereo camera, a millimeter-wave radar, a laser radar, a laser scanner, a distance image camera, a laser range finder, or the like. The same applies to the side monitoring device. An example in which the LIDAR is used as an example of the space recognition device 51 has been described in the embodiment. However, the present embodiment does not limit the space recognition device 51 to the LIDAR. That is, a space recognition device that can recognize a space with reference to the asphalt finisher 100 may be used.

[0036] The monitoring range RF of the front monitoring device 51F desirably includes the roadbed BS. The same applies to the monitoring range of the side monitoring device. In the present embodiment, the monitoring range RF has a width larger than the width of the roadbed BS.

[0037] The monitoring range RB of the rear monitoring device 51B desirably includes a newly constructed pavement body NP. In the present embodiment, the monitoring range RB has a width larger than the width of the newly constructed pavement body NP.

[0038] The measurement information detected by the space recognition device 51 according to the present embodiment is transmitted to the controller 50. The controller 50 may automatically steer the asphalt finisher 100 or may notify the driver of an alarm or the like, based on the received measurement information.

[0039] Further, in the present embodiment, an aspect in which the compaction degree measuring instruments 8 are provided on the asphalt finisher 100 is not limited to an aspect in which the compaction degree measuring instruments 8 are directly connected to the screed 3.

[0040] Figs. 2A and 2B are views showing an asphalt finisher 100 which is an example of a road paving machine according to a modification example. Specifically, Fig. 2A is a left side view, and Fig. 2B is a top view. In the modification example shown in Figs. 2A and 2B, the compaction degree measuring instruments 8 and the tractor 1 are connected to each other via the frame members 81A and 81B.

[0041] That is, the frame member 81B extends from the tractor 1 to the rear side (X-axis negative direction side) in the traveling direction. Then, the frame member 81A is connected to an end portion of the frame member 81B on the

rear side (X-axis negative direction side) in the traveling direction. The frame member 81A extends in the vehicle width direction (Y-axis direction) of the asphalt finisher. Further, in the frame member 81A, six compaction degree measuring instruments 8_1 to 8_6 are provided at predetermined intervals. Further, wheels (not shown) may be provided on the six compaction degree measuring instruments 8_1 to 8_6 or the frame member 81A. With this configuration, the compaction degree measuring instrument 8 is pulled as the asphalt finisher 100 moves.

[0042] Further, the frame member 81A is not limited to the aspect of extending from the tractor 1, and may extend from the leveling arm 3A. The present embodiment and the modification example show one aspect of connection of the compaction degree measuring instruments 8_1 to 8_6, and other connection modes may be used.

[0043] Returning to the present embodiment, the controller 50 mounted on the asphalt finisher 100 will be described. Fig. 3 is a block diagram showing a configuration example of the controller 50 and devices connected to the controller 50.

[0044] As shown in Fig. 3, the controller 50 is connected to six compaction degree measuring instruments 8_1 to 8_6, a GPS module 54, a front monitoring device 51F, a rear monitoring device 51B, an in-vehicle display device 52, and a communication device 53.

[0045] The controller 50 includes a readable and writable (not shown) non-volatile storage medium, and includes a storage unit 501 for storing various types of information in the storage medium.

[0046] The storage unit 501 stores the design information. The design information indicates information preset for each predetermined item for paving with asphalt. The design information includes, for example, a set length indicating the length of the road surface on which the asphalt is laid, a set width indicating the width of the road surface on which the asphalt is laid, a set thickness indicating the thickness at which the asphalt is planned to be laid, and a set compaction degree indicating the degree of compaction of the asphalt planned to be laid on the road surface.

[0047] The controller 50 includes, as functional elements, an acquisition unit 50a, a thickness calculation unit 50b, a compaction degree calculation unit 50c, a volume calculation unit 50d, a weight calculation unit 50f, a planned weight estimation unit 50g, a control correction unit 50h, a communication control unit 50i, an information generation unit 50j, and a display control unit 50k. In the present embodiment, the above-described functional elements are shown to be distinguished for convenience of description, but do not need to be distinguished physically, and may consist wholly or partially of common software components or hardware components.

[0048] The acquisition unit 50a acquires measurement information from various types of sensors. For example, the acquisition unit 50a acquires measurement information from the front monitoring device 51F and the rear monitoring device 51B.

[0049] Further, the acquisition unit 50a acquires the degree of compaction from each of the compaction degree measuring instruments 8_1 to 8_6. Further, the acquisition unit 50a acquires the position information from the GPS module 54.

[0050] The thickness calculation unit 50b calculates the thickness of the pavement body NP newly constructed on the road surface. The thickness calculation unit 50b according to the present embodiment calculates the thickness of the pavement body NP (distance in the vertical direction from the surface of the roadbed BS to the surface of the pavement body NP), based on the distance in the Z-axis direction of the surface of the roadbed BS with reference to the asphalt finisher 100, indicated by the measurement information from the front monitoring device 51F, and the distance in the Z-axis direction of the surface of the pavement body NP newly constructed with reference to the asphalt finisher 100, indicated by the measurement information from the rear monitoring device 51B.

[0051] Further, the thickness calculation unit 50b may calculate the thickness of the pavement body NP from the position coordinates on the three-dimensional coordinate system. The three-dimensional coordinate system used to calculate the thickness of the pavement body NP is, for example, a world geodetic system. The world geodetic system is a three-dimensional orthogonal XYZ coordinate system in which the origin is at the center of gravity of the earth, the X-axis is in a direction of an intersection point of the Greenwich meridian and the equator, the Y-axis is in a direction of 90 degrees east longitude, and the Z-axis is in a direction of the North Pole. Specifically, the thickness calculation unit 50b derives the height of the surface of the roadbed BS in the reference coordinate system through the coordinate conversion between the local coordinate system and the reference coordinate system relating to the front monitoring device 51F. Further, the thickness calculation unit 50b derives the height of the surface of the newly constructed pavement body NP in the reference coordinate system through the coordinate conversion between the local coordinate system and the reference coordinate system relating to the rear monitoring device 51B. Then, the thickness calculation unit 50b calculates the thickness of the pavement body NP from the difference in surface height.

[0052] The thickness calculation unit 50b according to the present embodiment calculates the thickness of the pavement body NP for each predetermined region to be described later by using the above-described calculation method.

[0053] In addition, in the present embodiment, the thickness calculation method is not limited to the method using the front monitoring device 51F and the rear monitoring device 51B, and the thickness may be used by another method. For example, the thickness calculation unit 50b may calculate the thickness, based on the difference between the height of the road surface before being leveled and the bottom surface of the screed 3, which are measured by the measuring instrument.

[0054] The compaction degree calculation unit 50c according to the present embodiment calculates the average value

of the degree of compaction (the ratio of paving material in the space composed of voids and paving material, and hereinafter, it is also referred to as compaction degree), leveled by the asphalt finisher 100, for each region corresponding to each of the compaction degree measuring instruments 8_1 to 8_6.

[0055] Fig. 4 is a diagram illustrating an average value of the compaction degree for each predetermined region calculated by the compaction degree calculation unit 50c. As shown in Fig. 4, in the vehicle width direction (Y-axis direction), the regions 701 to 706 are divided for respective lengths to which the compaction degree measuring instruments 8_1 to 8_6 are assigned. The length that divides the region in the traveling direction (X-axis direction) is a predetermined length and is determined according to an embodiment.

[0056] In the example shown in Fig. 4, regions 721 to 726 where the compaction degree is lower than a predetermined range are shown, and regions 711 and 712 where the compaction degree is higher than a predetermined range are shown. The predetermined range indicates an appropriate range as the compaction degree of the paving material leveled by the asphalt finisher 100. It is assumed that the predetermined range is determined according to the type of paving material and the like. In the present embodiment, various controls are performed according to the average value of the compaction degree for each of the calculated regions.

[0057] Returning to Fig. 3, the volume calculation unit 50d calculates the volume of the paving material leveled on the actually leveled road surface (an example of the leveled road surface). The volume calculation unit 50d of the present embodiment calculates the volume of the paving material leveled, based on the thickness of the pavement body NP calculated by the thickness calculation unit 50b, the construction distance, and the construction width. The construction distance may be calculated from the position information acquired by the acquisition unit 50a at the start of the construction and the position information currently acquired by the acquisition unit 50a, or may be calculated from the movement distance of the asphalt finisher 100 acquired from a distance sensor or the like. The construction width may be the width and length of the screed 3 of the asphalt finisher 100, or may be the width of the road indicated in the design information stored in the storage unit 501. The volume calculation unit 50d may derive the calculated volume as a combination of volumes for each predetermined region.

[0058] The weight calculation unit 50f calculates the weight of the paving material used on the road surface on which the paving material is leveled (an example of the leveled road surface), based on a compaction degree (ratio of the paving material to the voids) for each predetermined region calculated by the compaction degree calculation unit 50c, and a leveled volume (combination of volume for each predetermined region) calculated by the volume calculation unit 50d.

[0059] The weight calculation unit 50f calculates the weight for each predetermined region, from the compaction degree for each predetermined region and the weight (specific gravity) of the paving material per unit volume. Then, the weight calculation unit 50f calculates the weight of the paving material used in the construction from the weight of each predetermined region and the combination of the volume for each predetermined region calculated by the volume calculation unit 50d.

[0060] The planned weight estimation unit 50g estimates the weight (hereinafter, also referred to as an estimated weight) of the paving material actually used by the asphalt finisher 100 from now on. The planned weight estimation unit 50g according to the present embodiment calculates a difference (for example, the ratio) between the weight RW1 of the paving material already used and the set weight SW1 of the paving material planned to be used up to the current position indicated in the design information. Further, the planned weight estimation unit 50g calculates the estimated weight RW2 of the paving material estimated to be used on the road surface planned to be constructed from the current position to the position where the construction is completed, based on the calculated difference (for example, weight ratio) and the set weight SW2 of the paving material planned to be used from the current position indicated in the design information to the position where the construction is completed. In the present embodiment, the estimated weight RW2 of the paving material estimated to be actually used can be calculated by the following Equation (1). In addition, the calculation method is shown as an example, and other methods may be used.

$$RW2 = SW2 \times (RW1 / SW1) \dots\dots (1)$$

[0061] The control correction unit 50h corrects the control of the screed 3, based on the average value of the compaction degree for each predetermined region calculated by the compaction degree calculation unit 50c.

[0062] In the related art, in the case of leveling asphalt, roughness may occur in the compaction degree of the leveled surface due to an operation of the asphalt finisher or a change in external conditions such as a mixture temperature. When such roughness occurs, there is a possibility that the construction surface after being compacted by the road roller may be affected. Therefore, the control correction unit 50h according to the present embodiment corrects the control of the screed 3 to reduce the roughness of the compaction degree.

[0063] For example, in a case where a region having a compaction degree lower than a predetermined range is continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the

control correction unit 50h performs control to increase the number of tamping of the tampers 25 and 26 (increase the rotation speed of the motor) of the screed 3 corresponding to the region. Further, in a case where a region having a compaction degree higher than a predetermined range is continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the control correction unit 50h performs control to reduce the number of tamping of the tampers 25 and 26 (reduce the rotation speed of the motor) of the screed 3 corresponding to the region.

[0064] Further, the control of the screed 3 is not limited to the control of tampers 25 and 26. For example, the control correction unit 50h may control the vibrators 27 and 28.

[0065] For example, in a case where a region having a compaction degree lower than a predetermined range is continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the control correction unit 50h performs control to increase the frequencies of the vibrators 27 and 28 of the screed 3 corresponding to the regions. Further, in a case where regions having compaction degrees higher than a predetermined range are continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the control correction unit 50h performs control to reduce the frequencies of the vibrators 27 and 28 of the screed 3 corresponding to the regions.

[0066] Further, as the control of the screed 3, the control correction unit 50h may adjust the leveling height of the screed 3. In the present embodiment, the control correction unit 50h controls the leveling arm 3A to move upward or downward as the leveling height of the screed 3. The leveling thickness can be increased by performing control to raise the leveling arm 3A, and the leveling thickness can be decreased by performing control to lower the leveling arm 3A.

[0067] For example, in a case where a region having a compaction degree lower than a predetermined range is continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the control correction unit 50h performs control to increase the number of tamping of the tampers 25 and 26 of the screed 3 corresponding to the region, and performs control to lower the leveling arm 3A by contracting the leveling cylinder 23. In this case, when the tampers 25 and 26 are increased, the paving material easily enters the lower surface of the screed, and thus the leveling thickness also increases, but the leveling arm 3A is lowered to maintain the leveling thickness. Accordingly, the amount of the paving material to be sprinkled on the road surface from now on can be increased, and the compaction degree can be increased. As a result, the leveling thickness can be kept constant even when the compaction degree is increased. Further, control may be performed to increase the frequencies of the vibrators 27 and 28 of the screed 3 corresponding to the regions, and contract the leveling cylinder 23 to raise the leveling arm 3A. In this case, when the frequencies of the vibrators 27 and 28 of the screed 3 are increased, the pressing force of the lower surface of the screed against the paving material increases, and the leveling thickness decreases, but the leveling arm 3A is raised to maintain the leveling thickness. Further, control may be performed to increase the number of tamping of the tampers 25 and 26 of the screed 3 corresponding to the region, and the frequencies of the vibrators 27 and 28 may be increased. On the other hand, in a case where a region where the compaction degree is higher than a predetermined range is continuously generated in the traveling direction (X-axis direction) by the compaction degree calculation unit 50c, the control correction unit 50h performs control to decrease the number of tamping of the tampers 25 and 26 of the screed 3 corresponding to the region, and performs control to raise the leveling arm 3A by extending the leveling cylinder 23. In this case, when the tampers 25 and 26 are reduced, it becomes difficult for the paving material to enter the lower surface of the screed, and thus the leveling thickness also decreases, but the leveling arm 3A is raised to maintain the leveling thickness. Accordingly, it is possible to reduce the amount of the paving material to be sprinkled and leveled from now on, and to reduce the compaction degree. As a result, the leveling thickness can be kept constant even when the compaction degree is reduced. Further, control may be performed to decrease the frequencies of the vibrators 27 and 28 of the screed 3 corresponding to the region and contract the leveling cylinder 23 to lower the leveling arm 3A. In this case, when the frequencies of the vibrators 27 and 28 of the screed 3 are reduced, the pressing force of the lower surface of the screed against the paving material is reduced and the leveling thickness increases, but the leveling arm 3A is lowered to maintain the leveling thickness. Further, control may be performed to reduce the number of tamping of the tampers 25 and 26 of the screed 3 corresponding to the regions, and the frequencies of the vibrators 27 and 28 may be reduced.

[0068] In the example illustrated in Fig. 4, the control correction unit 50h determines that, in the regions 721 to 724, regions having a compaction degree lower than a predetermined range continuously exist in the traveling direction. Therefore, the control correction unit 50h performs control in which increasing the number of tamping of the tampers 25 and 26, increasing the frequencies of the vibrators 27 and 28, and control to raise or control to lower the leveling arm 3A is combined. Accordingly, the laid road surface from now on is constructed such that the compaction degree is increased and the leveling thickness is also constant.

[0069] Returning to Fig. 3, the information generation unit 50j generates compaction information in which the average value of the compaction degree (one aspect of the ratio of the paving material to the void) for each predetermined region calculated by the compaction degree calculation unit 50c is associated with the position information (an example of the position information) indicating the region of which the average value of the compaction degree is measured. The

compaction information to be generated may include image information. Further, the compaction information may include information indicating a time when the screed 3 levels the paving material each predetermined region. The information generation unit 50j generates a distribution of the compaction degree of the laid road.

[0070] As the position information (an example of the position information) indicating the region of which the average value of the compaction degree is measured, for example, a combination of the position information received from the GPS module 54 when the compaction degree is measured and relative position information from the GPS module 54 to the compaction degree measuring instrument 8 that has measured the compaction degree is considered. Accordingly, the position information indicating the region of which the compaction degree has been measured can be specified as the position by the world geodetic system.

[0071] Then, the information generation unit 50j stores the generated compaction information in the storage unit 501. The information generation unit 50j according to the present embodiment stores a set value (including a set compaction degree) for each predetermined region indicated in the design information and an average value of the compaction degree measured in the region in association with each other.

[0072] Accordingly, in the present embodiment, it is possible to manage the construction result by the asphalt finisher 100.

[0073] The communication control unit 50i transmits and receives information to and from external devices.

[0074] For example, the communication control unit 50i transmits the compaction information generated by the information generation unit 50j and a compaction instruction based on the compaction information, to the road roller 500 to be described later. As another example, the communication control unit 50i may transmit to the road roller 500, a compaction instruction including a movement path for adjusting the compaction degree of the road surface, based on the compaction information generated by the information generation unit 50j. Further, the communication control unit 50i transmits, to the road roller 500, the compaction degree associated with the position information of the road surface (position information indicating a predetermined region may be used), based on the compaction information generated by the information generation unit 50j, and the road roller 500 may generate a movement path or the like for compaction control, based on the compaction degree associated with the received position information. Further, the communication control unit 50i may transmit to a management device 400 a compaction degree associated with the position information of the road surface (for example, indicating a predetermined region), based on the compaction information generated by the information generation unit 50j. In this case, the management device 400 may generate a movement path for the road roller 500 to control the compaction based on the received compaction degree, and then transmit the movement path to the road roller 500. Further, the compaction instruction transmitted to the road roller 500 may include the required compaction power associated with the position information of the road surface.

[0075] Further, in a case where the estimated weight RW2 of the paving material calculated by the planned weight estimation unit 50g is different from the weight SW2 of the paving material planned to be used, the communication control unit 50i transmits an instruction for adjusting the supply amount of the paving material to the management device 400. The instruction for adjusting may be an instruction according to an embodiment and may be an instruction for adjusting the amount to be supplied according to the weight RW2 of the paving material that is estimated to be actually used.

[0076] The communication control unit 50i receives road roller compaction information (an example of road roller compaction degree) after the road roller 500 compacts the road surface. The road roller compaction information includes correspondence between a position indicating a predetermined region after the road roller 500 compacts the road surface and an average value of the compaction degree measured after the compaction by the road roller 500.

[0077] The road roller compaction information may be information indicating an average value of the compaction degree measured for each predetermined region by a compaction degree measuring device (not shown) provided in the road roller 500. In this case, the road roller compaction information is received from the road roller 500. Further, the road roller compaction information may include compaction power associated with the position information of the road surface.

[0078] Further, the road roller compaction information may be information indicating a result of measurement by a compaction degree measuring device operated by the worker after compaction by the road roller 500. In this case, the communication control unit 50i receives the road roller compaction information from the communication device owned by the worker.

[0079] The information generation unit 50j generates construction management information (hereinafter, referred to as a construction information management sheet) representing information indicating the average value of the compaction degree for each predetermined region leveled by the asphalt finisher 100 and information indicating the average value of the compaction degree for each predetermined region after being pressed by the road roller 500, based on the road roller compaction information and the compaction information. The construction information management sheet will be described later.

[0080] The display control unit 50k displays various types of information on the in-vehicle display device 52. For example, the display control unit 50k displays the construction information management sheet generated by the infor-

mation generation unit 50j.

[0081] A construction management system (an example of a road surface paving system) of the present embodiment will be described. Fig. 5 is a diagram showing a configuration example of a construction management system SYS according to the present embodiment.

[0082] The construction management system SYS mainly includes an asphalt finisher 100, a dump truck 200, a plant 300, a management device 400, a road roller 500, and a portable information terminal 600.

[0083] The plant 300 is an example of a paving material production facility. In the example shown in Fig. 5, the plant 300 mainly includes a mixer 301, a trolley 302, a hot silo 303, and the like.

[0084] The mixer 301 is a device for uniformly mixing aggregate, filler (stone powder), asphalt, and the like. The trolley 302 is a device for transporting the mixture discharged from the mixer 301 to the hot silo 303. The hot silo 303 is a device for heat-retaining and storing the mixture produced by the mixer 301.

[0085] Further, a controller 311, a space recognition device 312, and a communication device 313 are installed in the plant 300.

[0086] The controller 311 is a control device installed in the plant 300. The controller 311 is a computer including a CPU, a volatile storage device, and a non-volatile storage device, and is disposed in a building attached to the plant 300. For example, the controller 311 is implemented by the CPU executing a program stored in the non-volatile storage device.

[0087] The communication device 313 is configured to control communication between the plant 300 and external devices. The communication device 313 controls wireless communication with a communication device 204 mounted on the dump truck 200. Further, the communication device 313 controls wireless communication with the management device 400.

[0088] The controller 311 controls the movements of the mixer 301, the trolley 302, the hot silo 303, and the like. Further, the controller 311 manages the paving material produced in the plant 300.

[0089] Further, the controller 311 recognizes the dump truck 200, based on the information from the space recognition device 312.

[0090] The space recognition device 312 is configured to be able to monitor the state of the dump truck 200 on which the paving material is loaded in the plant 300. The space recognition device 312 is, for example, a monocular camera, a stereo camera, a millimeter-wave radar, an ultrasonic sensor, a laser radar, or a LIDAR.

[0091] The space recognition device 312 may identify the dump truck 200 by recognizing characters displayed on the number plate based on the unevenness on the surface of the number plate of the dump truck 200. The controller 311 can determine the position, shape, and type of the dump truck 200 by using the space recognition device 312.

[0092] The controller 311 receives information regarding the supply of the paving material to the dump truck 200, from the management device 400. For example, the controller 311 receives an instruction to change the amount of the paving material used in the construction, from the management device 400. Then, the controller 311 performs control to supply the paving material to the dump truck 200 identified by the space recognition device 312, based on the instruction.

[0093] The dump truck 200 is an example of a transport vehicle that transports the paving material supplied into the hopper 2 of the asphalt finisher 100. The dump truck 200 is a dedicated dump truck for transporting the paving material, which is provided with a movable bumper.

[0094] The dump truck 200 includes a cab 201 and a loading platform 202. Further, the dump truck 200 is provided with a controller 203 and the communication device 204 in the vicinity of the cab 201.

[0095] The controller 203 may transmit and receive information to and from the communication device 53 of the asphalt finisher 100 via the communication device 204. Further, the controller 203 may transmit and receive information to and from the communication device 313 of the plant 300 via the communication device 204.

[0096] In the road roller 500, a compaction roller 502 is pivotally attached to the front portion of the vehicle body 501, and the mileage meter 503 is mounted on the axle of the compaction roller 502. The road roller 500 reads the axle rotation speed of the compaction roller 502 by the mileage meter 503, and calculates the moving distance of the vehicle body 501 based on the axle rotation speed. Further, in the road roller 500, another compaction roller 504 is pivotally attached to the rear portion of the vehicle body 501.

[0097] Further, the road roller 500 includes a controller 511 in a driving operation unit 510. Further, the road roller 500 includes a GPS module 512 and a communication device 513.

[0098] A GPS module 512 is an example of a global navigation satellite system (GNSS) module, and receives position information indicating a two-dimensional positioning result through the global positioning system (GPS). The position information includes information representing the position of the asphalt finisher 100 in latitude and longitude. Although the GPS is used as a position information acquisition method in the present embodiment, the position information acquisition method is not limited, and other known methods may be used.

[0099] The communication device 513 controls wireless communication with the communication device 53 of the asphalt finisher 100. For example, the communication device 513 receives, from the communication device 53 of the asphalt finisher 100, compaction information indicating an average value of the compaction degree for each predeter-

mined region for the road surface to be constructed.

[0100] The controller 511 controls the movement of the vehicle body 12 and compacts the road surface by the front and rear compaction rollers 502 and 504. For example, the controller 511 of the embodiment may automatically control the compaction of the road surface. The controller 511 compacts the road surface to be constructed, based on the roller design information indicating the range of compacting the road surface and the position information of the road roller 500 received by the GPS module 512.

[0101] When the communication device 513 receives the compaction information, the controller 511 compacts the road surface based on the received compaction information. For example, the controller 511 increases the number of times of compaction for a region where the compaction degree is smaller than a predetermined range according to the compaction information, and decreases the number of times of compaction for a region where the compaction degree is greater than a predetermined range. Accordingly, the compaction degree is adjusted. Further, the compaction degree may be adjusted by control to change the compaction power.

[0102] Similar to the asphalt finisher 100 described above, the road roller 500 may be provided with a compaction degree measuring instrument (not shown). Similar to the asphalt finisher 100, a plurality of compaction degree measuring instruments may be provided in the vehicle width direction.

[0103] In a case where the road roller 500 is provided with the compaction degree measuring instrument, the road roller compaction information indicating the average value of the compaction degree measured after the construction, for each predetermined region by the compaction degree measuring instrument may be transmitted to the asphalt finisher 100 via the communication device 513.

[0104] Further, the road roller compaction information may be transmitted from the communication device of the worker as a result of measurement by the worker with the compaction degree measuring device, after the road roller 500 performs compaction.

[0105] Further, the present embodiment is not limited to a method in which the information generation unit 50j of the asphalt finisher 100 generates only the compaction information as the information to be transmitted to the road roller 500. For example, the information generation unit 50j may generate movement paths having different numbers of compaction for each movement point to reduce the roughness of the paving material, based on the compaction information. Then, the communication control unit 50i transmits the generated movement path to the road roller 500. The road roller 500 performs steering control according to the received movement path. Accordingly, it is possible to reduce a variation in the roughness of the paving material that occurs on the road surface.

[0106] In addition, the present embodiment does not limit the aspect of the road roller 500, and a plurality of the road rollers 500 including the tire roller may be used. In a case where a plurality of road rollers are used, the process performed by the road roller 500 described in the present embodiment may be performed by any of the plurality of road rollers.

[0107] The portable information terminal 600 is, for example, a device possessed by a worker boarding the tractor 1, a worker working around the asphalt finisher 100, a manager of a construction site thereof, or the like. The portable information terminal 600 may be attached to a mounting bracket provided in the driver's seat 1S of the asphalt finisher 100. The portable information terminal 600 may be, for example, a portable device such as a tablet PC or a smartphone.

[0108] The portable information terminal 600 may display information (for example, a construction information management sheet) received from the asphalt finisher 100 or the management device 400.

[0109] Assuming that the asphalt finisher 100 has the above-described configuration, the description thereof will be omitted.

[0110] Further, the controller 50 enables information to be transmitted to and received from other devices via the communication device 53. The controller 50 recognizes the vicinity of the asphalt finisher 100, based on the measurement information from the front monitoring device 51F and the rear monitoring device 51B. Further, the controller 50 performs various controls based on the compaction degree of the paving material measured by the compaction degree measuring instrument 8.

[0111] Further, the controller 50 transmits and receives information to and from devices configuring the construction management system SYS via the communication device 53.

[0112] For example, the controller 50 transmits an instruction for adjusting the supply amount of the paving material to the management device 400 via the communication device 53.

[0113] As another example, the controller 50 transmits the compaction information or the movement path to the road roller 500 via the communication device 53.

[0114] Further, the controller 50 receives road roller compaction information indicating the average value of the compaction degree for each predetermined region after the road roller 500 performs compaction, from the road roller 500 or the communication device of the worker. Accordingly, the controller 50 generates the construction information management sheet (refer to Fig. 8).

[0115] The controller 50 transmits the generated construction information management sheet to the management device 400.

[0116] The management device 400 controls the entire construction management system SYS according to the present

embodiment. For example, the management device 400 may be a computer including a CPU, a volatile storage device, and a non-volatile storage device, and a server having a communication unit capable of transmitting and receiving information via a network may be used. Further, the management device 400 includes a storage device 401.

[0117] The management device 400 transmits and receives information to and from the asphalt finisher 100. For example, in a case where the controller 50 determines that the weight of the paving material estimated to be actually used, calculated by the asphalt finisher 100, is different from the weight of the paving material planned to be used, indicated in the design information, the management device 400 receives an instruction for adjusting the supply amount of the paving material from the asphalt finisher 100.

[0118] The management device 400 transmits an instruction to change the amount of the paving material used in the construction to the communication device 313 of the plant 300. Accordingly, the management device 400 can adjust the paving material to be supplied to the asphalt finisher 100.

[0119] The management device 400 stores the construction information management sheet in the storage device 401, when the construction information management sheet is transmitted from the asphalt finisher 100. Accordingly, the manager manages the construction information.

[0120] Further, the management device 400 may transmit the received construction information management sheet to the portable information terminal 600. Accordingly, the worker can check the detailed construction result with reference to the construction information management sheet.

[0121] Further, the present embodiment is not limited to a method of transmitting the construction information management sheet to the portable information terminal 600 from the management device 400. The communication device 53 of the asphalt finisher 100 may transmit the construction information management sheet to the portable information terminal 600.

[0122] Fig. 6 is a view showing the asphalt finisher 100, the dump truck 200, and the road roller 500, which are examples of the road paving machine according to the present embodiment. Specifically, 800A is a left side view and 800B is a top view. Fig. 6 shows an example in which the dump truck 200 approaches the asphalt finisher 100 while retreating.

[0123] As shown in 800A, the dump truck 200 is brought into contact with the asphalt finisher 100 from the traveling direction (+ X-axis positive direction) side. The dump truck 200 supplies the paving material to the hopper 2 of the asphalt finisher 100.

[0124] The controller 50 of the asphalt finisher 100 according to the present embodiment transmits a control command to the communication device 204 of the dump truck 200 via the communication device 53. The controller 203 of the dump truck 200 performs control according to a control command. For example, the control command includes a control command for steering such that the loading platform 202 of the dump truck 200 is positioned at a designated position of the asphalt finisher 100. The other control command includes, for example, a control command instructing the dump truck 200 to move backward or stop in order to bring the rear wheel of the dump truck 200 into contact with the roller 2b.

[0125] The controller 50 of the asphalt finisher 100 according to the present embodiment transmits the compaction information to the communication device 513 of the road roller 500 via the communication device 53 during the construction.

[0126] The controller 511 of the road roller 500 performs compaction control according to compaction information, on the road surface, for each predetermined region. The compaction information indicates the compaction degree of the paving material for each predetermined region. After the current position is specified by the GPS module 512, the controller 511 of the road roller 500 performs control such as making the number of compactions different, based on the average value of the compaction degree of a predetermined region including the current position. In the present embodiment, the width of the compaction degree measuring instrument 8 of the asphalt finisher 100 and the width of the road roller 500 are different from each other. Therefore, the controller 511 performs compaction control in consideration of the width. For example, the average value of the compaction degree for each region indicated by the width of the road roller 500 may be recalculated, and the compaction control or the like may be performed based on the result of the recalculation.

[0127] Further, the controller 511 of the road roller 500 may receive the movement path instead of the compaction information. The controller 511 performs steering control according to a movement path, and thus can implement compaction control in consideration of the compaction degree for each predetermined region.

[0128] Fig. 7 is a view showing a state of a road surface where construction is performed by the asphalt finisher 100 according to the present embodiment. In the example shown in Fig. 7, as road surfaces to be constructed, a first straight section SC1, a widened section SC2, and a second straight section SC3 are included. The widened section SC2 also includes a bus stop section SC4 surrounded by a broken line.

[0129] The design information includes the road width W1 and the length L1 of the first straight section SC1, the road width W1 + W2 and the length L2 + L3 of the widened section SC2 including the road width W2 of the bus stop section SC4, and the road width W3 and the length L4 of the second straight section SC3. Further, the design information includes the lengths L11 and L12 of the section where the road width changes, in the widened section SC2. Furthermore, the design information includes the set thickness. As described above, the controller 50 according to the present em-

bodiment can specify the preset volume for each section, based on the design information. Accordingly, the controller 50 can also specify the set weight of the paving material planned to be used for each section. The present embodiment is not limited to the method of calculating the set weight of the paving material planned to be used for each section, and the design information may include the set volume or the set weight for each section.

[0130] For example, in a case where the asphalt finisher 100 according to the present embodiment reaches the end position 100A of the first straight section SC1, the weight calculation unit 50f of the controller 50 of the asphalt finisher 100 calculates the weight of the paving material actually used in the first straight section SC1, based on the volume of the first straight section SC1.

[0131] The planned weight estimation unit 50g of the controller 50 determines whether or not there is a difference between the weight of the paving material used in the first straight section SC1 calculated by the weight calculation unit 50f and the set weight of the paving material scheduled planned to be used in the first straight section SC1 indicated in the design information. When it is determined that a difference has occurred, the planned weight estimation unit 50g calculates the estimated weight of the paving material estimated to be actually used in the widened section SC2 and the second straight section SC3. Since the calculation method is as described above, the description thereof will be omitted.

[0132] When the planned weight estimation unit 50g determines that there is a difference between the set weight indicated in the setting information and the estimated weight calculated by the planned weight estimation unit 50g, the communication control unit 50i transmits to the management device 400, an instruction to change the weight of the paving material supplied in the widened section SC2 and the second straight section SC3 estimated to be actually used by the planned weight estimation unit 50g. Accordingly, deviation in the paving material supplied during the construction can be reduced.

[0133] Further, in a case where the control correction unit 50h performs control for adjusting the compaction degree of the paving material to be leveled, the planned weight estimation unit 50g may calculate the estimated weight of the paving material estimated to be actually used on the road surface to be paved from now on (for example, the widened section SC2 and the second straight section SC3) with taking into consideration the adjustment result.

[0134] Further, a one-dot chain line G2 is a position where the supply of the paving material is started by the second dump truck 200, a one-dot chain line G3 is a position where the supply of the paving material is started by the third dump truck 200, and a one-dot chain line G4 is a position where the supply of the paving material is started by the fourth dump truck 200.

[0135] In a case where there is a difference between the set weight of the paving material indicated in the setting information by the planned weight estimation unit 50g and the estimated weight of the paving material actually used, the communication control unit 50i may transmit to the management device 400, an instruction to change the position where the supply of the paving material is started for each dump truck 200. Accordingly, the management device 400 instructs the dump truck 200 to change the arrival point on the road surface.

[0136] As described above, the information generation unit 50j of the controller 50 of the asphalt finisher 100 according to the present embodiment generates a construction information management sheet indicating the average value of the compaction degree stored in the storage unit 501 (measured by the compaction degree measuring instruments 8) and the average value of the compaction degree after the construction of the storage unit 501, for each predetermined region assigned to each of the compaction degree measuring instruments 8.

[0137] Fig. 8 is a diagram illustrating a construction information management sheet generated by the information generation unit 50j according to the present embodiment. As shown in Fig. 8, the construction information management sheet includes the construction date and time, the construction location, and the machine number of the construction machine (asphalt finisher 100), as basic information. Further, the construction conditions include a construction distance and a construction width. Further, the setting information and the setting conditions include an average set thickness, an average measured thickness, an average set void ratio, an average measured void ratio, a set paving material amount, and an actual amount of used paving material.

[0138] The average set thickness, the average set void ratio, and the set paving material amount are information derived from the above-described design information. The average measured thickness, the average measured void ratio, and the actual amount of used paving material are information measured after the construction by the asphalt finisher 100.

[0139] The information generation unit 50j inputs and processes the measured information and the character information based on the design information, for each of the above-described items. Accordingly, the burden on the worker can be reduced.

[0140] Further, the construction information management sheet represents a field (AF measurement result field) 861 showing information indicating the average value of the compaction degree for each predetermined region leveled by the asphalt finisher 100, and a field (road roller measurement result field) 862 showing the average value of the compaction degree for each predetermined region after being pressed by the road roller 500. For example, the AF measurement result field and the road roller measurement result field may indicate road surface information of 200m. That is, a plurality

of construction information management sheets may be generated depending on the construction distance.

[0141] In the AF measurement result field 861, information indicating the compaction degree for each predetermined region indicated by the compaction information is displayed. Specifically, in the AF measurement result field 861, regions 811 to 814 in which the compaction degree is lower than a predetermined range are represented. Further, in the AF measurement result field 861, regions 821 and 822 in which the compaction degree is higher than a predetermined range are represented. Further, in the AF measurement result field 861, the time (including the start time and the end time) at which the screed 3 levels the paving material for each predetermined region is represented.

[0142] In the road roller measurement result field 862, information indicating the compaction degree for each predetermined region indicated by the road roller compaction information received from the road roller 500 is displayed. Specifically, in the road roller measurement result field 862, regions 851 and 852 in which the compaction degree after compaction by the road roller 500 is higher than a predetermined range are represented. In the road roller measurement result field 862, the regions 831 to 834 indicate that the compaction degree is within a predetermined range due to the compaction by the road roller 500.

[0143] As described above, since the worker can check the construction information management sheet, the worker can check the comparison between the construction result of the asphalt finisher 100 and the compaction result of the road roller 500. In the example illustrated in Fig. 8, the region where the compaction degree is lower than a predetermined range is reduced based on the compaction result of the road roller 500, and thus it can be checked that the quality of the asphalt is improved.

[0144] In addition, the construction information management sheet shown in the present embodiment is shown as an example, and may have other aspects. For example, the construction information management sheet may not include the road roller measurement result field 862. Further, each item shown in the construction information management sheet is shown as an example, and for example, other items may be included.

[0145] For example, the information generation unit 50j according to the present embodiment may generate a construction information management sheet as image information, as information that can be visually recognized by a person. Furthermore, the information generation unit 50j according to the present embodiment may generate a construction information management sheet as document information that can be read by a predetermined application.

[0146] In the present embodiment, the information generation unit 50j generates the above-described construction information management sheet (an example of construction management information), thereby reducing the burden on the worker to create a document. Further, the construction information management sheet shows the processing results of the asphalt finisher 100 and the road roller 500 for each predetermined region. Accordingly, it is possible to generate a construction information management sheet that facilitates identifying the construction situation, as compared with a case where the worker manually creates the sheet.

[0147] The information generation unit 50j stores the generated construction information management sheet in the storage unit 50l. The communication control unit 50i transmits the construction information management sheet generated by the information generation unit 50j to the management device 400.

[0148] The management device 400 stores the received construction information management sheet in the storage device 401. Accordingly, the management device 400 can manage the construction result.

[0149] The present embodiment is not limited to a method in which the asphalt finisher 100 generates a construction information management sheet. For example, the asphalt finisher 100 may transmit the compaction information or the like to the management device 400, and a construction information management sheet may be generated on the management device 400 side.

[0150] In the present embodiment, in the asphalt finisher 100, an example in which the asphalt finisher 100 side generates the compaction information based on the information measured from the compaction degree measuring instrument 8 has been described. However, the present embodiment is not limited to a method in which the asphalt finisher 100 side generates the compaction information. For example, the controller 50 of the asphalt finisher 100 may transmit the signal received from the compaction degree measuring instrument 8 and the position information acquired from the GPS module 54 to the management device 400 via the communication device 53, and the management device 400 may generate compaction information. In this case, the management device 400 transmits the compaction information or the movement path generated based on the compaction information to the road roller 500.

[0151] As described above, all the processes (for example, calculation of the difference between the weight of the paving material actually used and the set weight indicated by the design information) performed by the controller 50 described above may be performed on the management device 400 side.

[0152] In the above-described embodiment, the asphalt finisher 100 has the above-described configuration, thereby calculating the average value of the compaction degree of the paving material for each predetermined region of the road surface. Accordingly, various controls can be implemented in order to improve the quality of the road surface. For example, since the asphalt finisher 100 controls the screed 3 to adjust the compaction degree, it is possible to improve the quality of the road surface. Further, since the asphalt finisher 100 transmits the compaction information or the movement path to the road roller 500, the road roller 500 can adjust the compaction degree of the paving material, based

on the received compaction information or movement path. Accordingly, it is possible to improve the quality of the road surface.

[0153] Further, the weight of the paving material actually used can be calculated from the compaction information measured by the compaction degree measuring instrument 8. Accordingly, the controller 50 can transmit an instruction to change the weight of the paving material supplied to the asphalt finisher 100, to the management device 400. Accordingly, it is possible to prevent a shortage and a surplus of the paving material to be supplied. Accordingly, the cost can be reduced.

[0154] According to one aspect of the present disclosure, the control of the screed device is corrected based on the degree of compaction, thereby reducing the roughness of the leveled paving material.

[0155] According to one aspect of the present disclosure, the roughness of the paving material leveled on the road surface is measured, and the position and the measurement result are managed in association with each other, so that it is possible to deal with the roughness of the leveled paving material.

[0156] According to one aspect of the present disclosure, the burden on the worker is reduced by generating the construction management information indicating the degree of compaction measured at each position where the asphalt finisher levels the paving material.

[0157] Although embodiments of the asphalt finisher and the construction management system (an example of a road surface paving system) have been described above, the present invention is not limited to the above-described embodiments. Various types of changes, modifications, substitutions, additions, deletions, and combinations thereof are possible within the scope of the claims. It is evident that these belong to the technical scope of the present invention.

Reference Signs List

[0158]

100 asphalt finisher
 50 controller
 50a acquisition unit
 50b thickness calculation unit
 50c compaction degree calculation unit
 50d volume calculation unit
 50f weight calculation unit
 50g planned weight estimation unit
 50h control correction unit
 50i communication control unit
 50j information generation unit
 50k display control unit
 50l storage unit
 8_1 to 8_6 compaction degree measuring instrument
 54 GPS module
 51F front monitoring device
 51B rear monitoring device
 52 in-vehicle display device
 53 communication device
 400 management device
 401 storage device
 500 road roller
 511 controller
 512 GPS module
 513 communication device
 600 portable information terminal

Claims

1. An asphalt finisher comprising:

a tractor;
 a hopper that is provided on a front side of the tractor;

a conveyor that transports a paving material in the hopper to a rear side of the tractor;
a screw that spreads the paving material, which is transported by the conveyor and is sprinkled on a road surface, in a vehicle width direction;
a screed device that levels the paving material spread by the screw on a rear side of the screw; and
a measuring device that measures a degree of compaction, which is a ratio of the paving material leveled on the road surface to voids.

2. The asphalt finisher according to claim 1, wherein
based on the degree of compaction and a distance from a leveled road surface on which the paving material is leveled, a weight of the paving material sprinkled on the leveled road surface is calculated.

3. The asphalt finisher according to claim 2, wherein
when there is a difference between the weight of the paving material sprinkled on the leveled road surface and a set weight of the paving material that is designated for use on the leveled road surface, an estimated weight of the paving material estimated to be used on the road surface planned to be constructed is calculated based on the difference and the set weight of the paving material that is designated for use on the road surface planned to be constructed.

4. The asphalt finisher according to claim 3, further comprising:
a communication device that transmits information to a management device, wherein
the estimated weight of the paving material is transmitted to the management device via the communication device.

5. The asphalt finisher according to claim 1, wherein
a plurality of the measuring devices are provided in a width direction of the asphalt finisher.

6. The asphalt finisher according to claim 1, wherein
control of the screed device is corrected based on the degree of compaction.

7. The asphalt finisher according to claim 6, wherein
among a plurality of the screed devices, control of the screed device corresponding to a position where the degree of compaction is measured is corrected.

8. The asphalt finisher according to claim 1, further comprising:
a control device that associates a position where the paving material is leveled and the degree of compaction measured by the measuring device.

9. The asphalt finisher according to claim 8, wherein
an instruction based on the position where the paving material is leveled and the degree of compaction measured by the measuring device, which are associated by the control device, is transmitted to a road roller that compacts the road surface after being leveled by the screed device.

10. The asphalt finisher according to claim 9, wherein
the instruction based on the position and the degree of compaction is an instruction for making the number of times of compaction on the road surface different, based on the degree of compaction.

11. The asphalt finisher according to claim 9, wherein
road roller compaction information in which a position of the road surface and the degree of compaction, which is a ratio of the paving material after being compacted by the road roller to voids, are associated with each other, is received.

12. The asphalt finisher according to claim 1, wherein
the degree of compaction measured at each position where the paving material is leveled is generated as construction management information that can be visually recognized by humans.

13. The asphalt finisher according to claim 12, wherein

a road roller compaction degree indicating a ratio of the paving material to the voids, which is measured for each position of the road surface after the road roller performs construction, is received, from a road roller that compacts the road surface after the paving material is leveled, and
 the construction management information further including a ratio of the paving material to the voids measured for each position of the road surface, after being compacted by the road roller, is generated based on the road roller compaction degree.

14. A road surface paving system comprising:

an asphalt finisher includes a tractor, a hopper that is provided on a front side of the tractor, a conveyor that transports a paving material in the hopper to a rear side of the tractor, a screw that spreads the paving material, which is transported by the conveyor and is sprinkled on a road surface, in a vehicle width direction, a screed device that levels the paving material spread by the screw on a rear side of the screw, a measuring device that measures a degree of compaction representing a ratio of the paving material leveled on the road surface to voids, and a communication device that transmits information; and
 a management device that receives the information, wherein
 the asphalt finisher
 calculates, based on the degree of compaction and a distance from a leveled road surface on which the paving material is leveled, a weight of the paving material sprinkled on the leveled road surface,
 when there is a difference between the weight of the paving material sprinkled on the leveled road surface and a set weight of the paving material that is designated for use on the leveled road surface, calculates an estimated weight of the paving material estimated to be used on the road surface planned to be constructed, based on the difference and the set weight of the paving material that is designated for use on the road surface planned to be constructed, and
 transmits the estimated weight of the paving material to the management device via the communication device.

15. A road surface paving system comprising:

an asphalt finisher includes a tractor, a hopper that is provided on a front side of the tractor, a conveyor that transports a paving material in the hopper to a rear side of the tractor, a screw that spreads the paving material, which is transported by the conveyor and is sprinkled on a road surface, in a vehicle width direction, a screed device that levels the paving material spread by the screw on a rear side of the screw, a measuring device that measures a degree of compaction which is a ratio of the paving material leveled on the road surface to voids, and a control device that associates a position where the paving material is leveled and the degree of compaction measured by the measuring device; and
 a road roller that compacts the road surface after being leveled by the screed device, wherein
 the asphalt finisher transmits, to the road roller, an instruction based on a position where the paving material is leveled and a degree of compaction measured by the measuring device, which are associated by the control device.

FIG. 1A

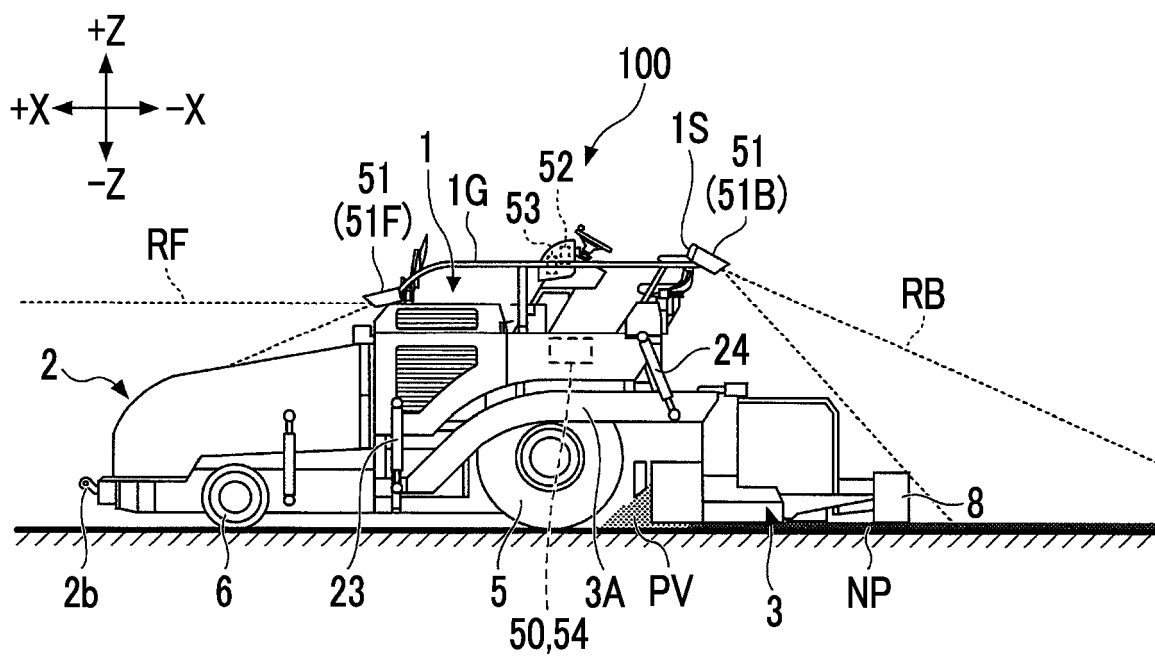


FIG. 1B

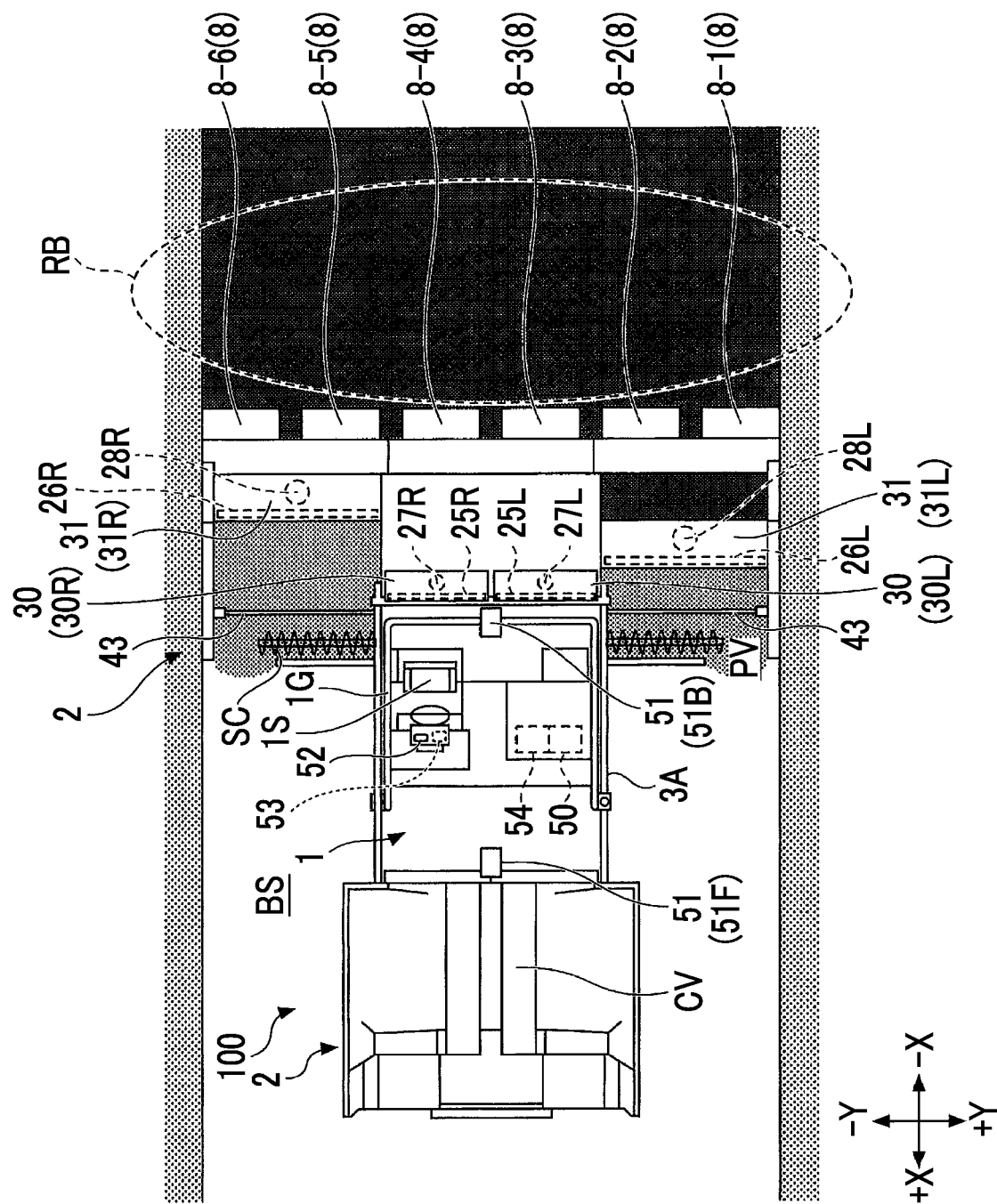


FIG. 2A

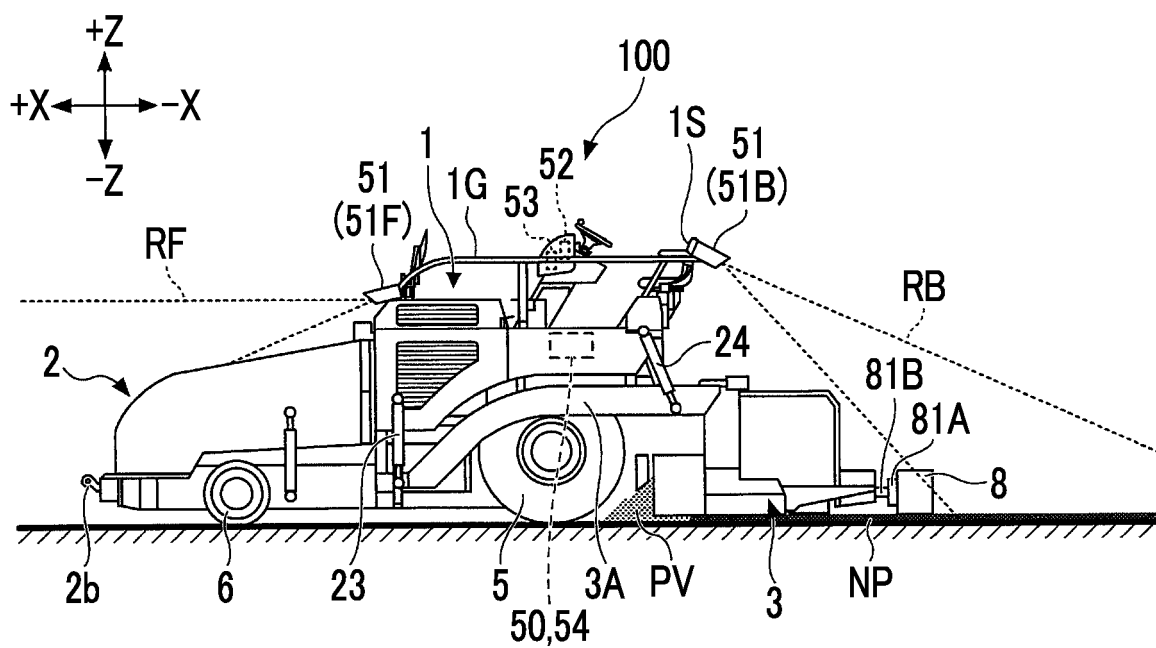


FIG. 2B

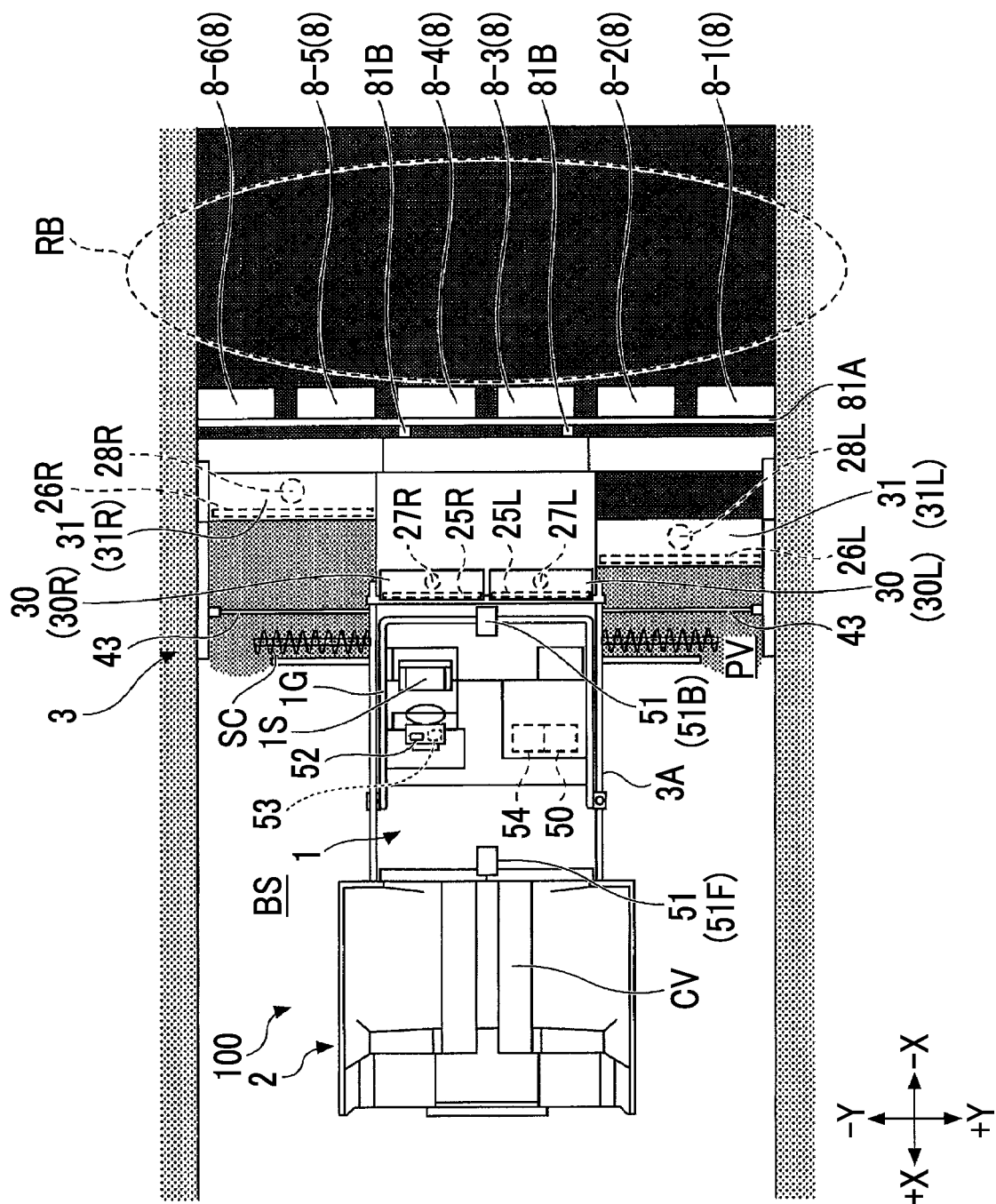


FIG. 3

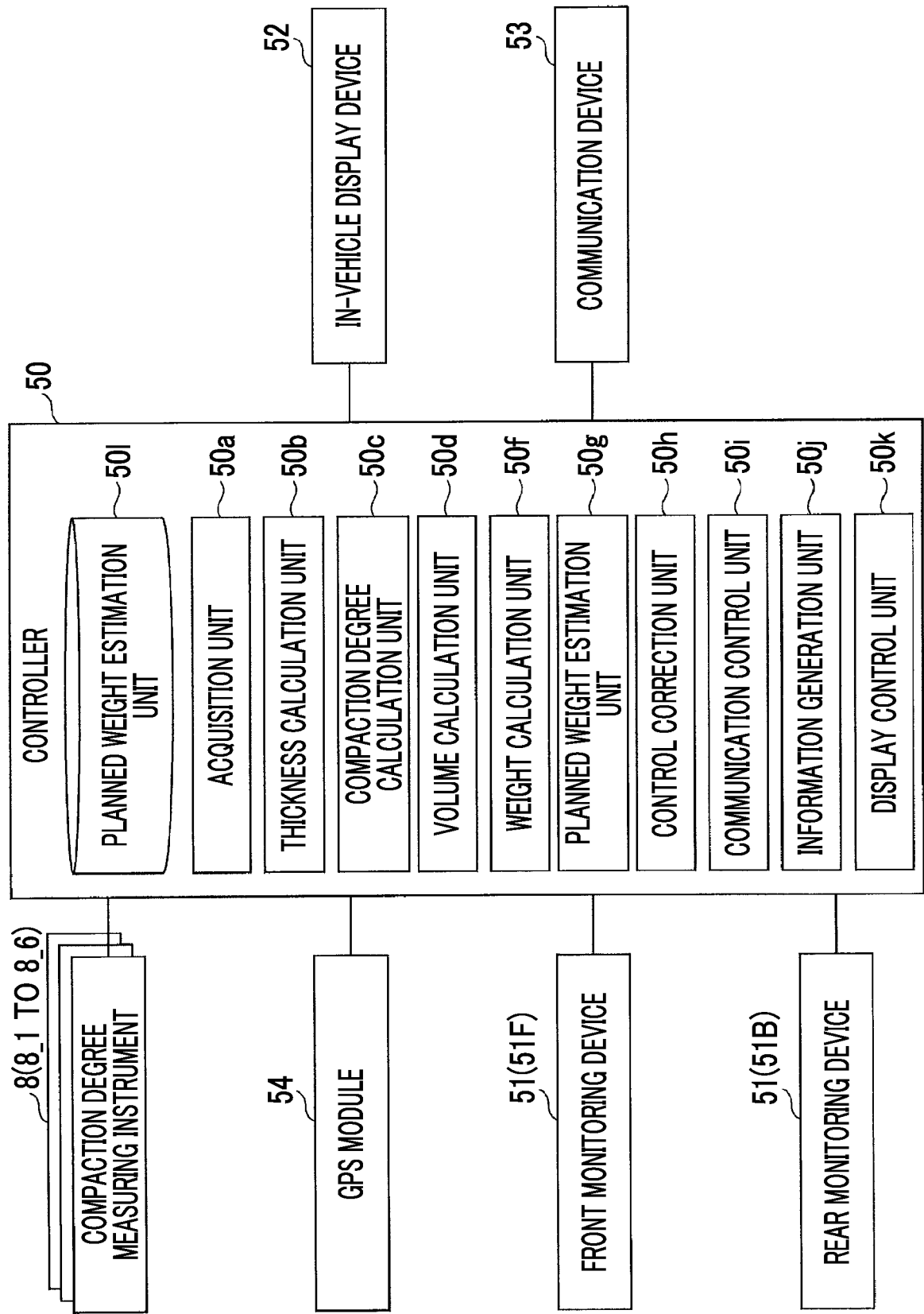


FIG. 4

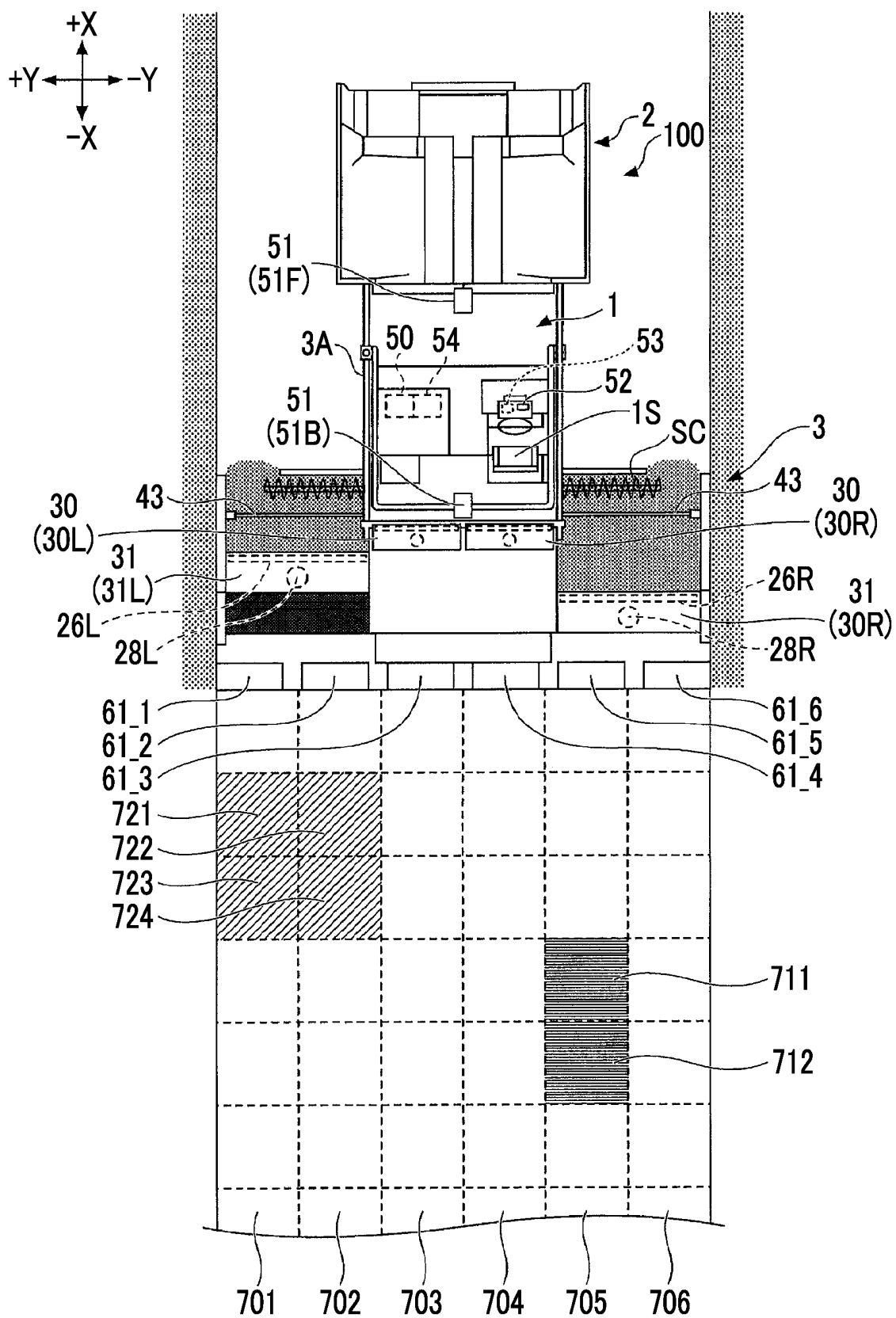


FIG. 5

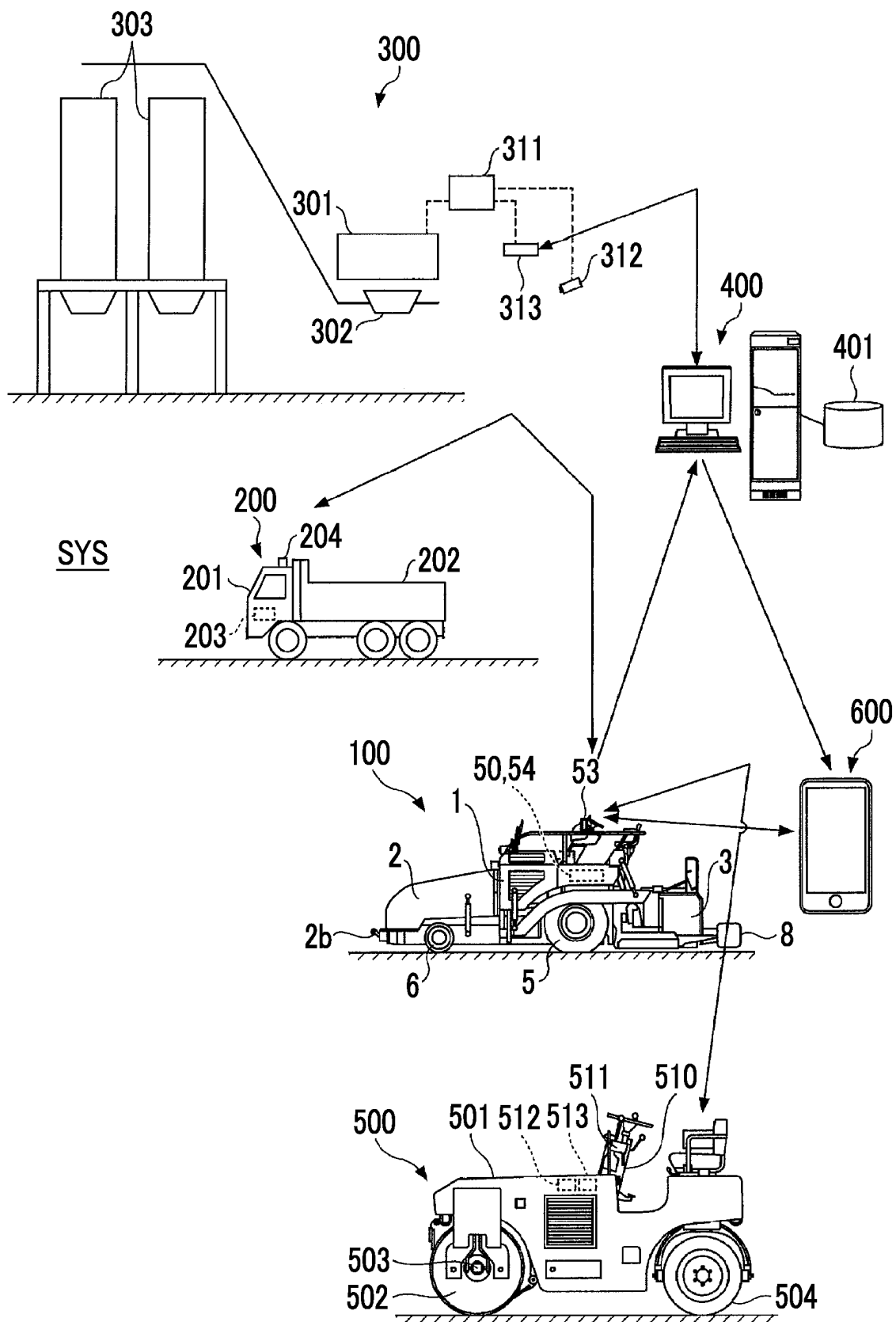


FIG. 6

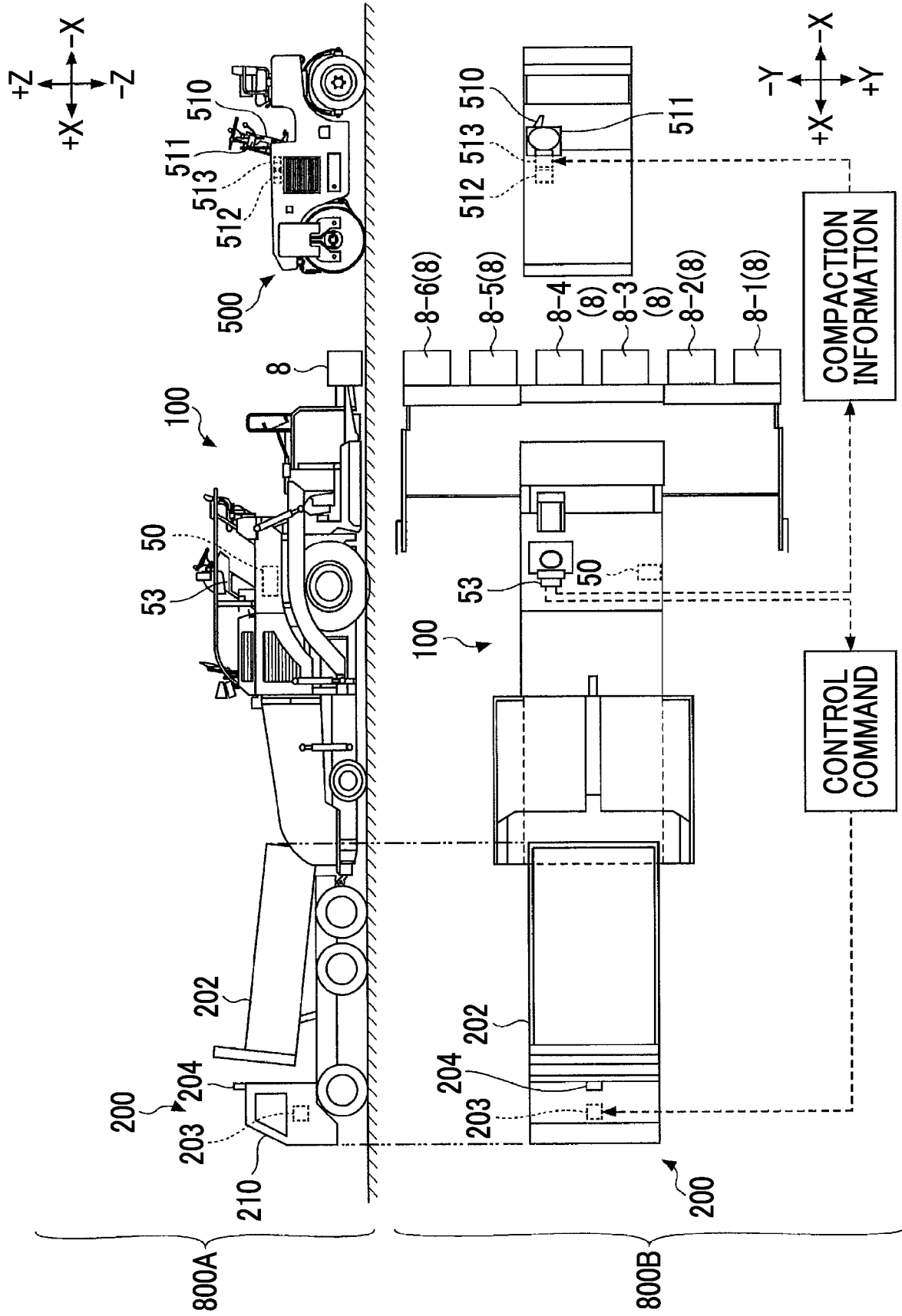


FIG. 7

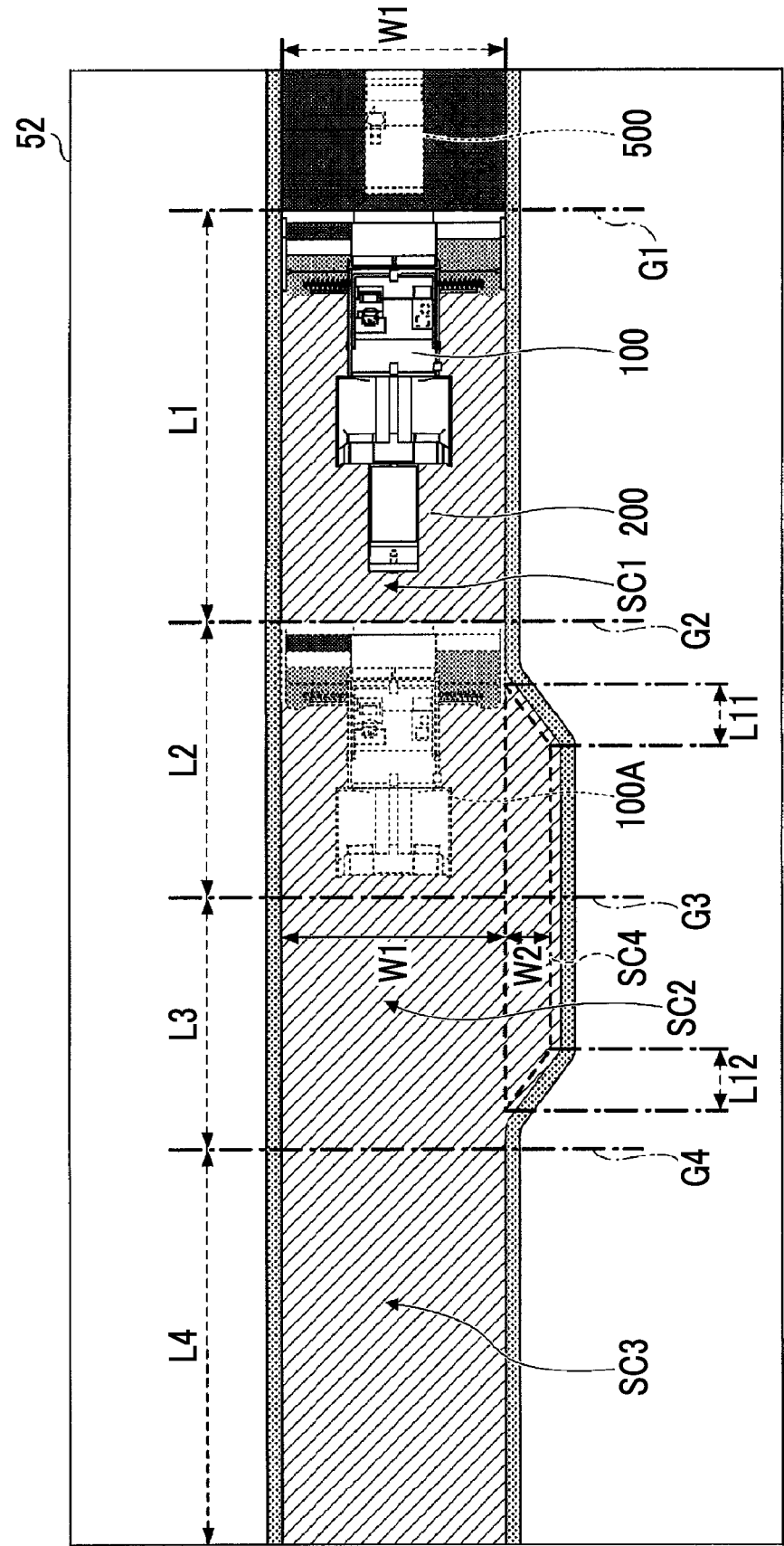
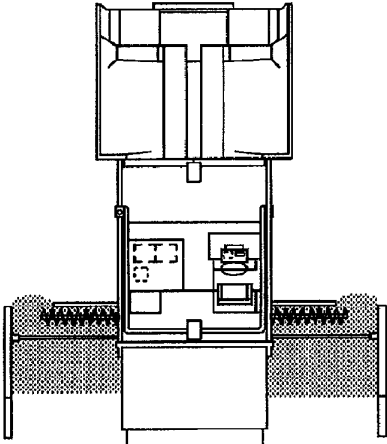
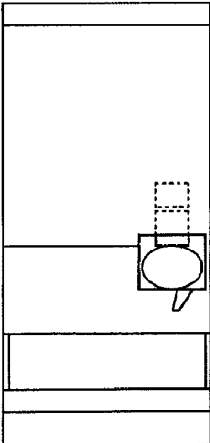
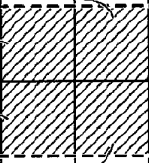
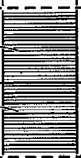


FIG. 8

CONSTRUCTION INFORMATION MANAGEMENT SHEET WRITER: 000									
<BASIC INFORMATION> · CONSTRUCTION DATE AND TIME: 000 · CONSTRUCTION LOCATION: 000 · CONSTRUCTION MACHINE NUMBER: 000 <CONSTRUCTION CONDITION> · CONSTRUCTION DISTANCE: 000					<SETTING INFORMATION AND MEASUREMENT INFORMATION> · AVERAGE SETTING THICKNESS: 000 · AVERAGE ASSUMED THICKNESS: 000 · AVERAGE SETTING VOID RATIO: 000 · AVERAGE MEASURED VOID RATIO: 000 · SETTING MIXTURE AMOUNT: 000 · ACTUAL MIXTURE AMOUNT: 000				
AF MEASUREMENT RESULT					ROAD ROLLER MEASUREMENT RESULT				
									
END TIME 12:30 12:00									
813									831
811									833
812									834
814									832
821									851
822									852
START TIME 10:30									
861					862				

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/016304

A. CLASSIFICATION OF SUBJECT MATTER <i>E01C 19/48</i> (2006.01)i FI: E01C19/48 A 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) E01C19/48 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 1971-2022 Registered utility model specifications of Japan 1996-2022 Published registered utility model applications of Japan 1994-2022 Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>JP 2012-225153 A (JOSEPH VOEGELE AG) 15 November 2012 (2012-11-15) paragraphs [0026]-[0044], fig. 1-5</td> <td>1, 5-13, 15</td> </tr> <tr> <td>A</td> <td>entire text, all drawings</td> <td>2-4, 14</td> </tr> <tr> <td>A</td> <td>CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 018063/1993 (Laid-open No. 031908/1995) (DIRECTOR GENERAL OF TOHOKU REGIONAL CONSTRUCTION BUREAU, MINISTRY OF CONSTRUCTION et al.) 16 June 1995 (1995-06-16), entire text, all drawings</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 153138/1987 (Laid-open No. 057110/1989) (NIIGATA ENGINEERING CO., LTD.) 10 April 1989 (1989-04-10), entire text, all drawings</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>JP 2018-190228 A (KAJIMA ROAD CO., LTD.) 29 November 2018 (2018-11-29) entire text, all drawings</td> <td>1-15</td> </tr> <tr> <td>A</td> <td>WO 2020/196540 A1 (SUMITOMO CONSTRUCTION MACHINERY CO., LTD.) 01 October 2020 (2020-10-01) entire text, all drawings</td> <td>1-15</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	JP 2012-225153 A (JOSEPH VOEGELE AG) 15 November 2012 (2012-11-15) paragraphs [0026]-[0044], fig. 1-5	1, 5-13, 15	A	entire text, all drawings	2-4, 14	A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 018063/1993 (Laid-open No. 031908/1995) (DIRECTOR GENERAL OF TOHOKU REGIONAL CONSTRUCTION BUREAU, MINISTRY OF CONSTRUCTION et al.) 16 June 1995 (1995-06-16), entire text, all drawings	1-15	A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 153138/1987 (Laid-open No. 057110/1989) (NIIGATA ENGINEERING CO., LTD.) 10 April 1989 (1989-04-10), entire text, all drawings	1-15	A	JP 2018-190228 A (KAJIMA ROAD CO., LTD.) 29 November 2018 (2018-11-29) entire text, all drawings	1-15	A	WO 2020/196540 A1 (SUMITOMO CONSTRUCTION MACHINERY CO., LTD.) 01 October 2020 (2020-10-01) entire text, all drawings	1-15	☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.
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X	JP 2012-225153 A (JOSEPH VOEGELE AG) 15 November 2012 (2012-11-15) paragraphs [0026]-[0044], fig. 1-5	1, 5-13, 15																				
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Date of the actual completion of the international search 01 June 2022	Date of mailing of the international search report 14 June 2022																					
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.																					

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2022/016304

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2012-225153 A	15 November 2012	US 2012/0263531 A1 paragraphs [0030]-[0048], fig. 1-5	
		EP 2514871 A1	
		CN 102747673 A	
JP 7-031908 U1	16 June 1995	(Family: none)	
JP 64-057110 U1	10 April 1989	(Family: none)	
JP 2018-190228 A	29 November 2018	(Family: none)	
WO 2020/196540 A1	01 October 2020	(Family: none)	

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Patent documents cited in the description

- WO 2020196540 A [0004]