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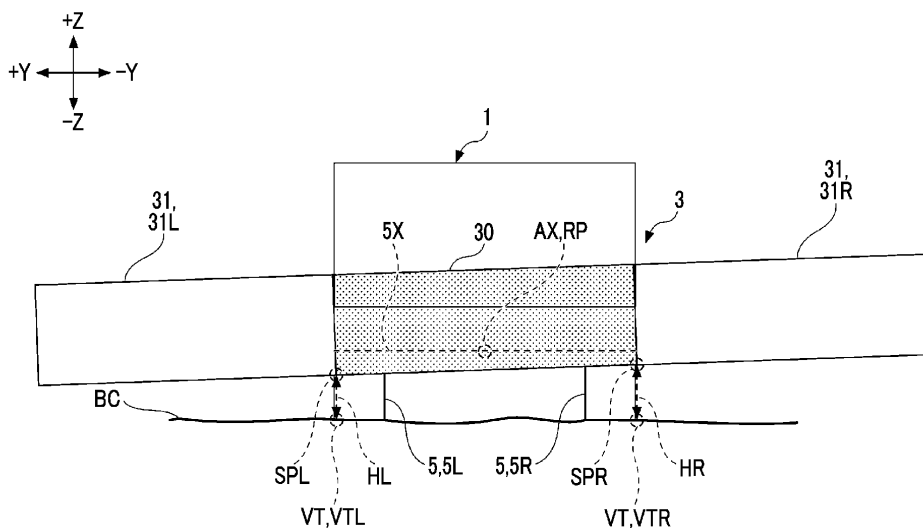
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(54) **ROAD PAVING MACHINE**

(57) Provided is a road machine (100) that can level a paving material (PV) such that a thickness of the paving material (PV) differs in a vehicle width direction. An asphalt finisher (100) that is an example of the road machine (100) includes a tractor (1) that travels on a roadbed (BC), a hopper (2) that receives the paving material (PV), a conveyor (CV) that feeds the paving material (PV) in the hopper (2) to a rear of the tractor (1), a screw (SC) that spreads the paving material (PV) fed by the conveyor (CV) at the rear of the tractor (1), a screed (3) that levels

the paving material (PV) spread by the screw (SC) at a rear of the screw (SC), and a controller (50) that derives a first height (HL) and a second height (HR) of the screed (3) with respect to the roadbed (BC). The first height (HL) is a height of a first point (SPL) in the screed (3), the second height (HR) is a height of a second point (SPR) in the screed (3), and the first point (SPL) is at a position different from a position of the second point (SPR) in a vehicle width direction.

FIG. 5



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present disclosure relates to a road machine and a support system of a road machine.

Description of Related Art

[0002] In the related art, an asphalt finisher that measures the thickness of a paving material leveled by a screed is known (see Japanese Examined Patent Publication No. H2-052042).

SUMMARY OF THE INVENTION

[0003] However, the asphalt finisher described above can only respond to a case where the paving material is leveled such that the thickness of the paving material is uniform in the vehicle width direction, but cannot respond to a case where the paving material is leveled such that the thickness of the paving material differs in the vehicle width direction.

[0004] Thus, it is desirable to provide a road machine that can level a paving material such that the thickness of the paving material differs in a vehicle width direction.

[0005] According to an embodiment of the present disclosure, there is provided a road machine including a tractor that travels on a roadbed, a hopper that is provided in front of the tractor and that receives a paving material, a conveyor that feeds the paving material in the hopper to a rear of the tractor, a screw that spreads the paving material fed by the conveyor at the rear of the tractor, a screed that levels the paving material spread by the screw at a rear of the screw, and a calculation device that derives a first height and a second height of the screed with respect to the roadbed, in which the first height is a height of a first point in the screed, the second height is a height of a second point in the screed, and the first point is at a position different from a position of the second point in a vehicle width direction.

[0006] The road machine described above can level the paving material such that the thickness of the paving material differs in the vehicle width direction.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]

Fig. 1 is a left side view of an asphalt finisher.

Fig. 2 is a top view of the asphalt finisher.

Fig. 3 is a functional block diagram of a controller.

Fig. 4 is a schematic view of a left surface of the asphalt finisher.

Fig. 5 is a schematic view of a back surface of the asphalt finisher.

Fig. 6 is a schematic view of the left surface of the asphalt finisher.

DETAILED DESCRIPTION OF THE INVENTION

[0008] Figs. 1 and 2 are schematic views of an asphalt finisher 100 that is an example of a road machine according to an embodiment of the present disclosure. Specifically, Fig. 1 is a left side view of the asphalt finisher 100, and Fig. 2 is a top view.

[0009] The asphalt finisher 100 is mainly configured by a tractor 1, a hopper 2, and a screed 3. In the example shown in Figs. 1 and 2, the asphalt finisher 100 is disposed such that a vehicle length direction thereof corresponds to an X-axis direction and a vehicle width direction thereof corresponds to a Y-axis direction. In addition, a Z-axis is disposed to be perpendicular to each of an X-axis and a Y-axis. Specifically, a front side in the vehicle length direction corresponds to a +X side, a rear side in the vehicle length direction corresponds to a -X side, a left side in the vehicle width direction corresponds to a +Y side, a right side in the vehicle width direction corresponds to a -Y side, an upper side in a vertical direction corresponds to a +Z side, and a lower side in the vertical direction corresponds to a -Z side.

[0010] The tractor 1 is a mechanism for causing the asphalt finisher 100 to travel. In the example shown in Figs. 1 and 2, the tractor 1 rotates a rear wheel 5 using a rear wheel traveling motor and moves the asphalt finisher 100 by rotating a front wheel 6 using a front wheel traveling motor. Both of the rear wheel traveling motor and the front wheel traveling motor are hydraulic motors that rotate by receiving supply of a hydraulic oil from a hydraulic pump. The tractor 1 may include a crawler instead of the wheels.

[0011] A controller 50 is an example of a calculation device. In the example shown in Figs. 1 and 2, the controller 50 is a computer including a CPU, a volatile storage device, and a non-volatile storage device and is configured to be mounted on the tractor 1 and to control the asphalt finisher 100 by operating various types of functions. Various types of functions of the controller 50 are realized, for example, as the CPU executes a program stored in the non-volatile storage device. The various types of functions realized by the controller 50 include, for example, a function of controlling a discharge amount of the hydraulic pump that discharges a hydraulic oil for driving a hydraulic actuator and a function of controlling a flow of the hydraulic oil between the hydraulic actuator and the hydraulic pump. The hydraulic actuator includes a hydraulic cylinder and a hydraulic motor.

[0012] The hopper 2 is a mechanism for receiving a paving material PV. The paving material PV is, for example, an asphalt mixture. In the example shown in Figs. 1 and 2, the hopper 2 is provided on the front side (+X side) of the tractor 1 and is configured to be opened and closed in the Y-axis direction (vehicle width direction) by a hopper cylinder 24. The asphalt finisher 100 usually brings

the hopper 2 into a fully open state so that the paving material PV is received from a loading platform of a dump truck. The dump truck is an example of a vehicle (transport vehicle) that transports the paving material PV supplied to the asphalt finisher 100. In addition, the asphalt finisher 100 can continue to travel while pushing the dump truck forward via a push roller 2b even when receiving the paving material PV from the loading platform of the dump truck. Figs. 1 and 2 show that the hopper 2 is in a fully open state. For the sake of clarity, Figs. 1 and 2 omit showing the paving material PV received in the hopper 2.

[0013] An operator of the asphalt finisher 100 manually closes the hopper 2 when the paving material PV in the hopper 2 decreases and collects the paving material PV near an inner wall of the hopper 2 at a central portion of the hopper 2. This is to enable a conveyor CV which is at the central portion of a bottom surface of the hopper 2 to transport the paving material PV to the rear of the tractor 1. The paving material PV transported to the rear of the tractor 1 is spread in the vehicle width direction behind the tractor 1 and before the screed 3 by a screw SC.

[0014] The conveyor CV is driven by a hydraulic motor that rotates by receiving supply of a hydraulic oil from the hydraulic pump. In the example shown in Figs. 1 and 2, the conveyor CV is configured to transport the paving material PV in the hopper 2 to the rear of the tractor 1 via a transport passage CP. The transport passage CP is a substantially rectangular parallelepiped space formed inside the tractor 1. Specifically, the conveyor CV includes a left conveyor CVL and a right conveyor CVR that operate separately from each other.

[0015] The screw SC is driven by a hydraulic motor that rotates by receiving supply of a hydraulic oil from the hydraulic pump. Specifically, the screw SC includes a left screw SCL and a right screw SCR that operate separately from each other. In the shown example, the left screw SCL is provided to protrude to the left side from the width of the tractor 1. The right screw SCR is provided to protrude to the right side from the width of the tractor 1.

[0016] The screed 3 is a mechanism for leveling the paving material PV. In the example shown in Figs. 1 and 2, the screed 3 mainly includes a front screed 30 and a rear screed 31. The rear screed 31 includes a left rear screed 31L and a right rear screed 31R. The front screed 30, the left rear screed 31L, and the right rear screed 31R are disposed to be deviated from each other on the front and rear sides. Specifically, the left rear screed 31L is disposed behind the front screed 30, and the right rear screed 31R is disposed behind the left rear screed 31L. The screed 3 is a floating screed pulled by the tractor 1 and is connected to the tractor 1 via a leveling arm AM. The screed 3 is moved up and down together with the leveling arm AM in response to expansion and contraction of a screed lift cylinder 25.

[0017] The rear screed 31 is configured to expand and contract in the vehicle width direction by an expanding

and contracting cylinder 60. The expanding and contracting cylinder 60 is supported by a support portion fixed to a casing of the front screed 30 and is configured to expand and contract the rear screed 31 in the vehicle width direction. Specifically, the expanding and contracting cylinder 60 includes a left expanding and contracting cylinder 60L and a right expanding and contracting cylinder 60R. The left expanding and contracting cylinder 60L expands and contracts the left rear screed 31L in a space behind the front screed 30 to the left. The right expanding and contracting cylinder 60R expands and contracts the right rear screed 31R in a space behind the front screed 30 to the right. In Figs. 1 and 2, for the sake of clarity, a coarse dot pattern is attached to the paving material PV spread before the rear screed 31, and a fine dot pattern is attached to the paving material PV (newly constructed pavement body NP) leveled by the screed 3.

[0018] The leveling arm AM is configured to connect the screed 3 to the tractor 1. Specifically, the leveling arm AM includes a left leveling arm AML and a right leveling arm AMR. Each of the left leveling arm AML and the right leveling arm AMR has one end (rear end) connected to the screed 3 and the other end (front end) connected to the tractor 1 (leveling cylinder 23).

[0019] The leveling cylinder 23 is a hydraulic cylinder that moves a front end of the leveling arm AM up and down in order to adjust a leveling thickness of the paving material PV. In the example shown in Figs. 1 and 2, a cylinder portion of the leveling cylinder 23 is connected to the tractor 1, and a rod portion thereof is connected to the front end of the leveling arm AM. The front end of the leveling arm AM is attached to the tractor 1 to be slidable up and down. 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 front end of the leveling arm AM. In addition, 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 front end of the leveling arm AM.

[0020] Specifically, the leveling cylinder 23 includes a left leveling cylinder 23L that moves a front connection point (left front connection point) of the left leveling arm AML up and down and a right leveling cylinder 23R that moves a front connection point (right front connection point) of the right leveling arm AMR up and down. The controller 50 can separately expand and contract the left leveling cylinder 23L and the right leveling cylinder 23R.

[0021] The screed lift cylinder 25 is a hydraulic cylinder for lifting the screed 3. In the example shown in Figs. 1 and 2, the screed lift cylinder 25 includes a left screed lift cylinder 25L and a right screed lift cylinder 25R. The left screed lift cylinder 25L has a cylinder portion connected to a left rear end portion of the tractor 1 and a rod portion connected to a rear connection portion (left rear connection portion) of the left leveling arm AML. In addition, the

right screed lift cylinder 25R has a cylinder portion connected to a right rear end portion of the tractor 1 and a rod portion connected to a rear connection portion (right rear connection portion) of the right leveling arm AMR. 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 25. As a result, the screed lift cylinder 25 contracts, a rear end portion of the leveling arm AM is lifted, and the screed 3 is lifted. In addition, 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 25 to flow out. As a result, the screed lift cylinder 25 is expanded by the weight of the screed 3, the rear end portion of the leveling arm AM is lowered, and the screed 3 is lowered. During construction, the screed lift cylinder 25 is in a state that can expand and contract in response to an up-and-down movement of the screed 3.

[0022] A side plate 40 is attached to a distal end of the rear screed 31. The side plate 40 is a plate-shaped member extending in the vehicle length direction and includes a left side plate 40L and a right side plate 40R. Specifically, the left side plate 40L is attached to a distal end (left end) of the left rear screed 31L, and the right side plate 40R is attached to a distal end (right end) of the right rear screed 31R.

[0023] In the shown example, the side plate 40 is also attached to a distal end of a mold board 41. The mold board 41 is a member for adjusting the amount of the paving material PV staying in front of the rear screed 31, out of the paving material PV spread by the screw SC, and may be configured to expand and contract in the vehicle width direction together with the rear screed 31.

[0024] Specifically, the mold board 41 is a plate-shaped member extending in the vehicle width direction and includes a left mold board 41L and a right mold board 41R. In the shown example, the left side plate 40L is attached to a distal end (left end) of the left mold board 41L, and the right side plate 40R is attached to a distal end (right end) of the right mold board 41R.

[0025] The mold board 41 is configured to adjust a height in a Z-axis direction regardless of the rear screed 31 and the side plate 40. By moving the mold board 41 up and down, the operator of the asphalt finisher 100 can adjust the size of a gap between a lower end of the mold board 41 and a roadbed BC and adjust the amount of the paving material PV passing through the gap. For this reason, by moving the mold board 41 up and down, the operator of the asphalt finisher 100 can adjust the amount (height) of the paving material PV staying on the rear side (-X side) of the mold board 41 and the front side (+X side) of the rear screed 31 and can adjust the amount of the paving material PV taken into the lower side of the rear screed 31.

[0026] A screed step 42 is a member configuring a scaffold when a worker works behind the screed 3. Specifically, the screed step 42 includes a left screed step 42L, a central screed step 42C, and a right screed step

42R.

[0027] A retaining plate 43 is a plate-shaped member for preventing the paving material PV spread in the vehicle width direction by the screw SC from being scattered in front of the screw SC in order to appropriately spread the paving material PV in the vehicle width direction by the screw SC. In the example shown in Figs. 1 and 2, the retaining plate 43 includes a left retaining plate 43L and a right retaining plate 43R.

[0028] Next, an example of a support function that is one function of the controller 50 will be described with reference to Fig. 3. Fig. 3 is a functional block diagram of the controller 50. The support function is a function for supporting an operation of the asphalt finisher 100 by the operator of the asphalt finisher 100. The support function is mainly realized by cooperation of a cylinder stroke sensor S1, a distance sensor S2, an inclination sensor S3, the controller 50, and a leveling thickness control device 55. The distance sensor S2 and the inclination sensor S3 may be omitted. In Fig. 3, blocks representing the distance sensor S2 and the inclination sensor S3 that can be omitted are drawn with broken lines.

[0029] The cylinder stroke sensor S1 is a sensor that detects an expansion and contraction amount (stroke amount) of the hydraulic cylinder. The cylinder stroke sensor S1 may be any type of sensor. In the shown example, the cylinder stroke sensor S1 is a sensor using ultrasound and is configured to separately detect a stroke amount of each of the left leveling cylinder 23L, the right leveling cylinder 23R, the left screed lift cylinder 25L, and the right screed lift cylinder 25R. Specifically, the cylinder stroke sensor S1 includes four independent cylinder stroke sensors.

[0030] The distance sensor S2 is a sensor for detecting a distance between the tractor 1 and the roadbed BC. The distance sensor S2 may be any type of sensor. In the shown example, the distance sensor S2 includes a left distance sensor S2L that detects a distance between a left end portion of the tractor 1 and the roadbed BC in the Z-axis direction using laser light and a right distance sensor S2R that detects a distance between a right end portion of the tractor 1 and the roadbed BC in the Z-axis direction using laser light. Specifically, the left distance sensor S2L is attached to a front end portion of a left surface of a frame of the tractor 1, and the right distance sensor S2R is attached to a front end portion of a right surface of the frame of the tractor 1.

[0031] The inclination sensor S3 is a sensor for detecting the inclination of the tractor 1. The inclination sensor S3 may be any type of sensor. In the shown example, the inclination sensor S3 is a capacitance type inclination sensor and is configured to detect the inclination of the tractor 1 with respect to a horizontal plane. Specifically, the inclination sensor S3 is configured to detect a pitch angle and a yaw angle of the tractor 1.

[0032] The leveling thickness control device 55 is configured to control a leveling thickness. In the shown example, the leveling thickness control device 55 is an elec-

tromagnetic valve for controlling the flow rate of a hydraulic oil flowing into the leveling cylinder 23 or flowing out from the leveling cylinder 23. Specifically, the leveling thickness control device 55 increases and decreases a flow path area which is a sectional area of a pipeline that connects the leveling cylinder 23 and the hydraulic pump to each other in accordance with a control command from the controller 50.

[0033] More specifically, the leveling thickness control device 55 can increase the leveling thickness (left leveling thickness) of the paving material PV (newly constructed pavement body NP) on the left side (+Y side) of a front-rear axis AX of the asphalt finisher 100 by flowing a hydraulic oil discharged by the hydraulic pump into a rod-side oil chamber of the left leveling cylinder 23L and contracting the left leveling cylinder 23L to raise the front end of the left leveling arm AML. In addition, the leveling thickness control device 55 can decrease the left leveling thickness by flowing out the hydraulic oil in the rod-side oil chamber of the left leveling cylinder 23L and expanding the left leveling cylinder 23L to lower the front end of the left leveling arm AML. Similarly, the leveling thickness control device 55 can increase the leveling thickness (right leveling thickness) of the paving material PV (newly constructed pavement body NP) on the right side (-Y side) of the front-rear axis AX of the asphalt finisher 100 by flowing the hydraulic oil discharged by the hydraulic pump into a rod-side oil chamber of the right leveling cylinder 23R and contracting the right leveling cylinder 23R to raise the front end of the right leveling arm AMR. In addition, the leveling thickness control device 55 can decrease the right leveling thickness by flowing out the hydraulic oil in the rod-side oil chamber of the right leveling cylinder 23R and expanding the right leveling cylinder 23R to lower the front end of the right leveling arm AMR.

[0034] In the shown example, the front-rear axis AX of the asphalt finisher 100 is an axis that extends along the vehicle length direction perpendicularly intersecting an axle 5X of the rear wheel 5 and forms a center line of the tractor 1.

[0035] After acquiring information from the cylinder stroke sensor S1 or the like and executing various types of calculation, the controller 50 outputs a control command to the leveling thickness control device 55 or the like in accordance with the calculation result. Specifically, the controller 50 determines whether or not a predetermined condition is satisfied based on the information acquired from the cylinder stroke sensor S1 or the like, and when it is determined that the predetermined condition is satisfied, the controller 50 outputs a control command to the leveling thickness control device 55 or the like.

[0036] More specifically, the controller 50 includes a calculation unit 50A and a leveling thickness control unit 50B as functional blocks configured by software, hardware, or a combination thereof.

[0037] The calculation unit 50A is configured to calculate information necessary for controlling the leveling

thickness. In the shown example, the calculation unit 50A is configured to calculate the height of the screed 3 with respect to the roadbed BC.

[0038] Herein, an example of a method in which the controller 50 calculates the height of the screed 3 with respect to the roadbed BC will be described with reference to Figs. 4 and 5. Fig. 4 is a schematic view of a left surface of the asphalt finisher 100, and Fig. 5 is a schematic view of a back surface of the asphalt finisher 100. For the sake of clarity, in Figs. 4 and 5, a dot pattern is attached to the front screed 30. The same applies to Fig. 6 to be described later.

[0039] The calculation unit 50A of the controller 50 is configured to calculate a first height HL and a second height HR of the screed 3 with respect to the roadbed BC. The first height HL is the height of a first point SPL in the screed 3, and the second height HR is the height of a second point SPR in the screed 3. The first point SPL is at a position different from the position of the second point SPR in the vehicle width direction. In the shown example, the first point SPL is a left rear end point of a screed plate of the front screed 30, and the second point SPR is a right rear end point of the screed plate of the front screed 30. However, the first point SPL and the second point SPR may be points corresponding to other points in the front screed 30.

[0040] Specifically, the calculation unit 50A derives a left imaginary line VTL that passes through a grounding point of a left rear wheel 5L and a grounding point of a left front wheel 6L based on a radius RD1 of the left front wheel 6L and a radius RD2 of a left rear wheel 5L. Similarly, the calculation unit 50A derives a right imaginary line VTR that passes through a grounding point of a right rear wheel 5R and a grounding point of a right front wheel (not shown) based on the radius RD1 of the right front wheel and the radius RD2 of the right rear wheel 5R. The radius RD1 is the length of a line segment that connects an axle 6X of the front wheel 6 and a grounding point of the front wheel 6 to each other, and the radius RD2 is the length of a line segment that connects the axle 5X of the rear wheel 5 and a grounding point of the rear wheel 5 to each other. In addition, the radius RD1 and the radius RD2 are values registered in advance in the non-volatile storage device of the controller 50 or the like.

[0041] In the shown example, the calculation unit 50A is configured to derive the position of the left imaginary line VTL by calculating coordinates of the grounding point of each of the left rear wheel 5L and the left front wheel 6L in a three dimensional orthogonal coordinate system of which the origin is a reference point RP. Similarly, the calculation unit 50A is configured to derive the position of the right imaginary line VTR by calculating coordinates of the grounding point of each of the right rear wheel 5R and the right front wheel in the three dimensional orthogonal coordinate system of which the origin is the reference point RP.

[0042] In the shown example, the reference point RP is an intersection point of the center line (front-rear axis

AX) of the tractor 1 extending along the vehicle length direction (X-axis direction) and the axle 5X of the rear wheel 5.

[0043] In addition, the calculation unit 50A is configured to derive a relative position of the first point SPL with respect to the reference point RP. In the shown example, the calculation unit 50A is configured to derive coordinates of the first point SPL in the three dimensional orthogonal coordinate system of which the origin is the reference point RP.

[0044] More specifically, the calculation unit 50A derives a length ST1 of the left leveling cylinder 23L based on the stroke amount of the left leveling cylinder 23L detected by the cylinder stroke sensor S1 and further calculates coordinates of a left front connection point P1L of the left leveling arm AML based on the length ST1. In addition, the calculation unit 50A derives a length ST2 of the left screed lift cylinder 25L based on the stroke amount of the left screed lift cylinder 25L detected by the cylinder stroke sensor S1 and further calculates coordinates of a left rear connection portion P2L of the left leveling arm AML based on the length ST2. Then, the calculation unit 50A calculates coordinates of the first point SPL based on the coordinates of the left front connection point P1L and the coordinates of the left rear connection portion P2L.

[0045] Similarly, the calculation unit 50A derives the length of the right leveling cylinder 23R based on the stroke amount of the right leveling cylinder 23R detected by the cylinder stroke sensor S1 and further calculates coordinates of the right front connection point (not shown) of the right leveling arm AMR based on the length. In addition, the calculation unit 50A derives the length of the right screed lift cylinder 25R based on the stroke amount of the right screed lift cylinder 25R detected by the cylinder stroke sensor S1 and further calculates coordinates of the right rear connection portion (not shown) of the right leveling arm AMR based on the length. Then, the calculation unit 50A calculates coordinates of the second point SPR based on the coordinates of the left front connection point and the coordinates of the left rear connection portion.

[0046] The dimension of each member such as the leveling cylinder 23, the screed lift cylinder 25, the leveling arm AM, and the front screed 30 and the position (coordinates) of a connection point of each of the leveling cylinder 23 and the screed lift cylinder 25 with respect to the tractor 1, and the like are registered in the non-volatile storage device of the controller 50 or the like in advance. For this reason, the calculation unit 50A calculates the coordinates of the first point SPL and the second point SPR based on a value registered in advance in the non-volatile storage device or the like and the detection value of the cylinder stroke sensor S1. This is because the leveling arm AM and the screed 3 are rigidly connected to each other in the shown example.

[0047] In addition, the calculation unit 50A derives a distance between the left imaginary line VTL and the first

point SPL as the first height HL (left leveling thickness) based on the left imaginary line VTL and the coordinates of the first point SPL calculated through the method described above. Similarly, the calculation unit 50A derives a distance between the right imaginary line VTR and the second point SPR as the second height HR (right leveling thickness) based on the right imaginary line VTR and the coordinates of the second point SPR calculated through the method described above.

[0048] The leveling thickness control unit 50B is configured to control the leveling thickness of the paving material PV. In the shown example, the leveling thickness control unit 50B is configured to adjust the leveling thickness such that a target leveling thickness set in advance and an actual leveling thickness match each other. The target leveling thickness is, for example, a distance between a design surface set in design data and the road-bed BC. Specifically, the target leveling thickness set in advance includes a left target leveling thickness that is a target value of the thickness of the paving material PV to be leveled in a region on the left side of the front-rear axis AX of the asphalt finisher 100 and a right target leveling thickness that is a target value of the thickness of the paving material PV to be leveled in a region on the right side of the front-rear axis AX of the asphalt finisher 100. For example, the left target leveling thickness is a target value of the thickness of the paving material PV immediately below a left end portion of the screed plate of the front screed 30, and the right target leveling thickness is a target value of the thickness of the paving material PV immediately below a right end portion of the screed plate of the front screed 30.

[0049] More specifically, the leveling thickness control unit 50B generates a control command with respect to the leveling thickness control device 55 such that the first height HL (left leveling thickness) calculated by the calculation unit 50A and the left target leveling thickness match each other.

[0050] Similarly, the leveling thickness control unit 50B generates a control command with respect to the leveling thickness control device 55 such that the second height HR (right leveling thickness) calculated by the calculation unit 50A and the right target leveling thickness match each other.

[0051] For example, in a case where the first height HL (left leveling thickness) calculated this time is larger than the left target leveling thickness, the leveling thickness control unit 50B generates a control command for lowering the front end of the left leveling arm AML by expanding the left leveling cylinder 23L to decrease the left leveling thickness and outputs the control command toward the leveling thickness control device 55. On the contrary, in a case where the first height HL (left leveling thickness) calculated this time is smaller than the left target leveling thickness, the leveling thickness control unit 50B generates a control command for raising the front end of the left leveling arm AML by contracting the left leveling cylinder 23L to increase the left leveling thick-

ness and outputs the control command toward the leveling thickness control device 55.

[0052] With such a configuration, the controller 50 can level the paving material PV such that the thickness of the paving material PV in the vehicle width direction (Y-axis direction) differs.

[0053] Next, another example of the method in which the controller 50 calculates the height of the screed 3 with respect to the roadbed BC will be described with reference to Fig. 6. Fig. 6 is a schematic view showing the left surface of the asphalt finisher 100 and corresponds to Fig. 4.

[0054] The method to be described with reference to Fig. 6 is mainly different from the method described with reference to Fig. 4 in that the left imaginary line VTL and the right imaginary line VTR are derived using an output of at least one of the distance sensor S2 and the inclination sensor S3, but is the same as the method described with reference to Fig. 4 in terms of the other points.

[0055] Specifically, the calculation unit 50A derives a left locus BCL that is a line which represents the surface shape of the roadbed BC through which the left front wheel 6L and the left rear wheel 5L pass based on an output of the left distance sensor S2L, which is acquired each time the asphalt finisher 100 advances by a predetermined distance (for example, several centimeters). The calculation unit 50A may use an output of the inclination sensor S3 in order to derive the left locus BCL.

[0056] The left locus BCL is a line that connects points hit by laser light emitted by the left distance sensor S2L (measurement points) each time the asphalt finisher 100 advances by the predetermined distance (a line on an imaginary plane parallel to an XZ plane). The calculation unit 50A calculates coordinates of each measurement point on the left locus BCL in the three dimensional orthogonal coordinate system of which the origin is the reference point RP.

[0057] Similarly, the calculation unit 50A derives a right locus that is a line which represents the surface shape of the roadbed BC through which the right front wheel (not shown) and the right rear wheel 5R pass based on an output of the right distance sensor S2R, which is acquired each time the asphalt finisher 100 advances by a predetermined distance (for example, several centimeters). The calculation unit 50A may use an output of the inclination sensor S3 in order to derive the right locus.

[0058] The right locus is a line that connects points hit by laser light emitted by the right distance sensor S2R (measurement points) each time the asphalt finisher 100 advances by the predetermined distance (a line on an imaginary plane parallel to the XZ plane). The calculation unit 50A calculates coordinates of each measurement point on the right locus in the three dimensional orthogonal coordinate system of which the origin is the reference point RP.

[0059] After then, the calculation unit 50A derives a single straight line representing the left locus BCL as the left imaginary line VTL. In the shown example, the left

imaginary line VTL is an approximate straight line of the left locus BCL, which is derived using the least square method.

[0060] Similarly, the calculation unit 50A derives a single straight line representing the right locus as the right imaginary line VTR. In the shown example, the right imaginary line VTR is an approximate straight line of the right locus, which is derived using the least square method.

[0061] The calculation unit 50A may derive straight lines that represent the left locus BCL and the right locus respectively using another method other than the least square method as the left imaginary line VTL and the right imaginary line VTR.

[0062] Then, the calculation unit 50A derives a distance between the left imaginary line VTL and the first point SPL as the first height HL (left leveling thickness) based on the left imaginary line VTL and the coordinates of the first point SPL calculated through the same method described with reference to Fig. 4. Similarly, the calculation unit 50A derives a distance between the right imaginary line VTR and the second point SPR as the second height HR (right leveling thickness) based on the right imaginary line VTR and the coordinates of the second point SPR.

[0063] In addition, the leveling thickness control unit 50B generates a control command with respect to the leveling thickness control device 55 such that the first height HL (left leveling thickness) calculated by the calculation unit 50A and the left target leveling thickness match each other. In addition, the leveling thickness control unit 50B generates a control command with respect to the leveling thickness control device 55 such that the second height HR (right leveling thickness) calculated by the calculation unit 50A and the right target leveling thickness match each other.

[0064] With such a configuration, the controller 50 can level the paving material PV such that the thickness of the paving material PV in the vehicle width direction (Y-axis direction) differs.

[0065] As described above, as shown in Figs. 1 and 2, the asphalt finisher 100 includes the tractor 1 that travels on the roadbed BC, the hopper 2 that is provided in front of the tractor 1 and that receives the paving material PV, the conveyor CV that feeds the paving material PV in the hopper 2 to the rear of the tractor 1, the screw SC that spreads the paving material PV fed by the conveyor CV at the rear of the tractor 1, the screed 3 that levels the paving material PV spread by the screw SC at the rear of the screw SC, and the controller 50 that is the calculation device which derives the first height HL (see Fig. 5) and the second height HR (see Fig. 5) of the screed 3 with respect to the roadbed BC. In addition, as shown in Fig. 5, the first height HL is the height of the first point SPL in the screed 3, and the second height HR is the height of the second point SPR in the screed 3. The first point SPL is at a position different from the position of the second point SPR in the vehicle width direction (Y-

axis direction).

[0066] As shown in Fig. 5, the controller 50 may derive an imaginary line VT (the left imaginary line VTL and the right imaginary line VTR) that represents the roadbed BC based on the dimension of a traveling member, calculate a distance between the left imaginary line VTL and the first point SPL as the first height HL (left leveling thickness), and calculate a distance between the right imaginary line VTR and the second point SPR as the second height HR (right leveling thickness).

[0067] The dimension of the traveling member is, for example, the radius RD1 of the front wheel 6, the radius RD2 of the rear wheel 5, and the like. In a case where the tractor 1 is a crawler type instead of a wheel type, the dimension of the traveling member is, for example, a distance between a rotation axis of a traveling hydraulic motor that rotates a crawler and an outer surface of a crawler link vertically below the rotation axis.

[0068] At least one of the distance sensor S2 that detects a distance to the roadbed BC and the inclination sensor S3 that detects the inclination of the tractor 1 may be attached to the tractor 1. In this case, as shown in Fig. 6, the controller 50 may derive the imaginary line VT (the left imaginary line VTL and the right imaginary line VTR) that represents the roadbed BC based on an output of at least one of the distance sensor S2 and the inclination sensor S3, calculate a distance between the left imaginary line VTL and the first point SPL as the first height HL, and calculate a distance between the right imaginary line VTR and the second point SPR as the second height HR.

[0069] The asphalt finisher 100 may include an actuator that adjusts the leveling thickness. In the example shown in Figs. 1 and 2, the asphalt finisher 100 includes the leveling cylinder 23 as the actuator that adjusts the leveling thickness. In this case, the controller 50 may control an expansion and contraction amount (stroke amount) of the leveling cylinder 23 such that each of the first height HL and the second height HR and the height of the design surface match each other.

[0070] The controller 50 may recognize the position of each of the first point SPL and the second point SPR using coordinates in a predetermined coordinate system. In the example shown in Figs. 4 to 6, the controller 50 may recognize the position of each of the first point SPL and the second point SPR using coordinates in the three dimensional orthogonal coordinate system of which the origin is the reference point RP. The reference point RP is the intersection point of the center line of the tractor 1 extending along the vehicle length direction (X-axis direction) of the asphalt finisher 100 and the axle 5X of the rear wheel 5.

[0071] The screed 3 may include the front screed 30 and the left rear screed 31L and the right rear screed 31R that are capable of expanding and contracting in the vehicle width direction (Y-axis direction). In this case, as shown in Fig. 5, the first point SPL may be the left rear end point of the screed plate of the front screed 30, and

the second point SPR may be the right rear end point of the screed plate of the front screed 30.

[0072] As shown in Figs. 5 and 6, the controller 50 may detect unevenness of the roadbed BC based on an output of at least one of the distance sensor S2 and the inclination sensor S3, derive the straight line (the left imaginary line VTL and the right imaginary line VTR) that represents the roadbed BC including such unevenness, calculate a distance between the straight line (left imaginary line VTL) and the first point SPL as the first height HL, and calculate a distance between the straight line (right imaginary line VTR) and the second point SPR as the second height HR.

[0073] The straight line (the left imaginary line VTL and the right imaginary line VTR) derived by the controller 50 may be an approximate straight line. In the example shown in Fig. 6, the left imaginary line VTL is an approximate straight line of the left locus BCL derived based on an output of the distance sensor S2. In addition, the straight line (the left imaginary line VTL and the right imaginary line VTR) derived by the controller 50 may be an approximate straight line derived using the least square method.

[0074] The preferable embodiment of the present invention has been described in detail hereinbefore. However, the present invention is not limited to the embodiment described above. Various modifications, substitutions, or the like can be applied to the embodiment described above without departing from the scope of the present invention. In addition, characteristics described separately can be combined insofar as technical inconsistencies do not occur.

[0075] For example, the controller 50 is mounted on an edge side (the tractor 1 of the asphalt finisher 100) in the embodiment described above, but may be mounted on a cloud side (outside the asphalt finisher 100). In this case, the controller 50 may be configured to acquire information output by various types of devices attached to the asphalt finisher 100 through a communication device mounted on the tractor 1 and to transmit a control command to the leveling thickness control device 55 or the like through the communication device mounted on the tractor 1. For example, the communication device is configured to control communication with an external device via a communication network.

[0076] The communication network is configured to mainly connect the asphalt finisher 100, a management device, and a supporting device to each other. The communication network includes, for example, at least one of a satellite communication network, a mobile phone communication network, an Internet network, and the like.

[0077] The supporting device is, for example, a computer including a CPU, a ROM, a RAM, an input and output interface, an input device, a display, and the like. Specifically, the supporting device includes a mobile communication terminal, a fixed communication terminal, and the like. The mobile communication terminal is

a laptop, a tablet PC, a mobile phone, a smartphone, a smart watch, smart glasses, or the like.

[0078] The management device is a device provided in an external facility such as a management center and stores and manages information transmitted by the asphalt finisher 100. The management device is, for example, a computer including a CPU, a ROM, a RAM, an input and output interface, an input device, a display, and the like. Specifically, the management device acquires and stores information received through the communication network and manages the information such that the operator (administrator) can refer to the stored information as necessary.

[0079] The asphalt finisher 100, the management device, and the supporting device are connected to each other, for example, using a communication protocol such as the Internet protocol. Each of the asphalt finisher 100, the management device, and the supporting device, which are connected to each other via the communication network, may be one or more.

[0080] The controller 50 may be provided at the management device or may be provided at the supporting device. In addition, the calculation unit 50A and the leveling thickness control unit 50B of the controller 50 may be distributed and disposed at the management device and the supporting device.

[0081] As described above, at least one of the asphalt finisher 100, the management device, and the supporting device may configure a support system that supports the movement of the asphalt finisher 100.

Brief Description of the Reference Symbols

[0082]

1 tractor
2 hopper
2b push roller
3 screed
5 rear wheel
6 front wheel
23 leveling cylinder
24 hopper cylinder
25 screed lift cylinder
30 front screed
31 rear screed
40 side plate
41 mold board
42 screed step
43 retaining plate
50 controller
50A calculation unit
50B leveling thickness control unit
55 leveling thickness control device
60 expanding and contracting cylinder
100 asphalt finisher
AM leveling arm
CP transport passage

CV conveyor
PV paving material
SC screw

Claims

1. A road machine (100) comprising:

a tractor (1) that travels on a roadbed (BC);
a hopper (2) that is provided in front of the tractor (1) and that receives a paving material (PV);
a conveyor (CV) that feeds the paving material (PV) in the hopper (2) to a rear of the tractor (1);
a screw (SC) that spreads the paving material (PV) fed by the conveyor (CV) at the rear of the tractor (1);
a screed (3) that levels the paving material (PV) spread by the screw (SC) at a rear of the screw (SC); and
a calculation device (50) that derives a first height (HL) and a second height (HR) of the screed (3) with respect to the roadbed (BC), wherein the first height (HL) is a height of a first point (SPL) in the screed (3), the second height (HR) is a height of a second point (SPR) in the screed (3), and the first point (SPL) is at a position different from a position of the second point (SPR) in a vehicle width direction.

2. The road machine (100) according to claim 1, wherein the calculation device (50) derives an imaginary line (VT) that represents the roadbed (BC) based on a dimension of a traveling member, calculates a distance between the imaginary line (VT) and the first point (SPL) as the first height (HL), and calculates a distance between the imaginary line (VT) and the second point (SPR) as the second height (HR).

3. The road machine (100) according to claim 1,

wherein at least one of a distance sensor (S2) that detects a distance to the roadbed (BC) and an inclination sensor (S3) that detects an inclination of the tractor (1) is attached to the tractor (1), and
the calculation device (50) derives an imaginary line (VT) that represents the roadbed (BC) based on an output of at least one of the distance sensor (S2) and the inclination sensor (S3), calculates a distance between the imaginary line (VT) and the first point (SPL) as the first height (HL), calculates a distance between the imaginary line (VT) and the second point (SPR) as the second height (HR).

4. The road machine (100) according to any one of claims 1 to 3, further comprising:

an actuator (23) that adjusts a leveling thickness,
wherein the calculation device (50) controls the actuator (23) such that each of the first height (HL) and the second height (HR) matches a height of a design surface.

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5. The road machine (100) according to any one of claims 1 to 3,
wherein the calculation device (50) recognizes a position of each of the first point (SPL) and the second point (SPR) using a coordinate in a predetermined coordinate system.

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6. The road machine (100) according to any one of claims 1 to 3,

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wherein the screed (3) includes a front screed (30) and a left rear screed (31L) and a right rear screed (31R) that are capable of expanding and contracting in the vehicle width direction,
the first point (SPL) is a left rear end point of a screed plate of the front screed (30), and
the second point (SPR) is a right rear end point of the screed plate of the front screed (30).

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7. The road machine (100) according to claim 3,
wherein the calculation device (50) detects unevenness of the roadbed (BC) based on the output of at least one of the distance sensor (S2) and the inclination sensor (S3), derives a straight line (VTL, VTR) that represents the roadbed (BC) including the unevenness, calculates a distance between the straight line (VTL) and the first point (SPL) as the first height (HL), and calculates a distance between the straight line (VTR) and the second point (SPR) as the second height (HR).

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8. The road machine (100) according to claim 7,
wherein the straight line (VTL, VTR) is an approximate straight line.

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9. A support system of a road machine (100) including a tractor (1) that travels on a roadbed (BC), a hopper (2) that is provided in front of the tractor (1) and that receives a paving material (PV), a conveyor (CV) that feeds the paving material (PV) in the hopper (2) to a rear of the tractor (1), a screw (SC) that spreads the paving material (PV) fed by the conveyor (CV) at the rear of the tractor (1), and a screed (3) that levels the paving material (PV) spread by the screw (SC) at a rear of the screw (SC), the support system comprising:

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a calculation device (50) that derives a first

height (HL) and a second height (HR) of the screed (3) with respect to the roadbed (BC), wherein the first height (HL) is a height of a first point (SPL) in the screed (3),
the second height (HR) is a height of a second point (SPR) in the screed (3), and
the first point (SPL) is at a position different from a position of the second point (SPR) in a vehicle width direction.

FIG. 1

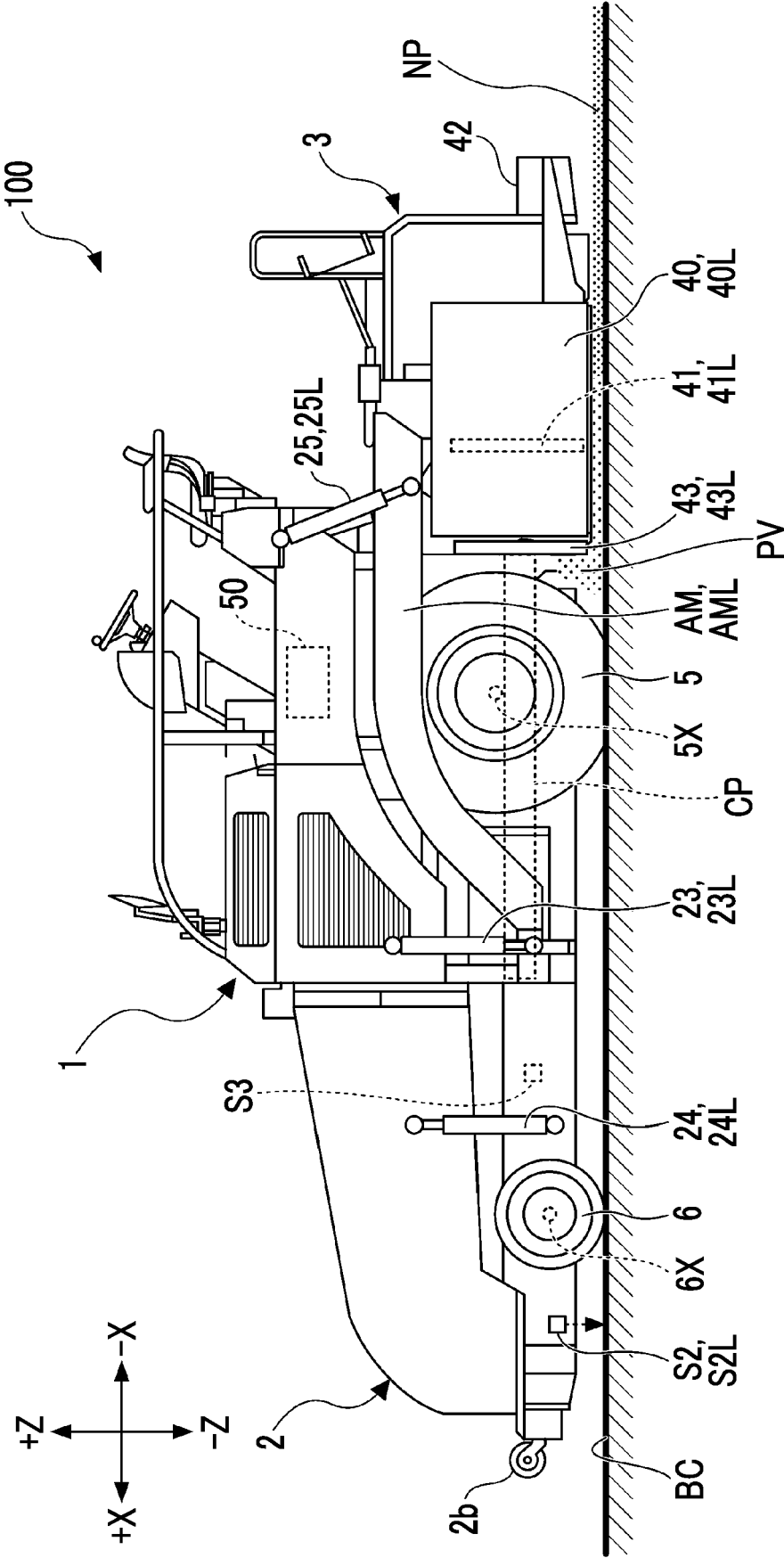


FIG. 2

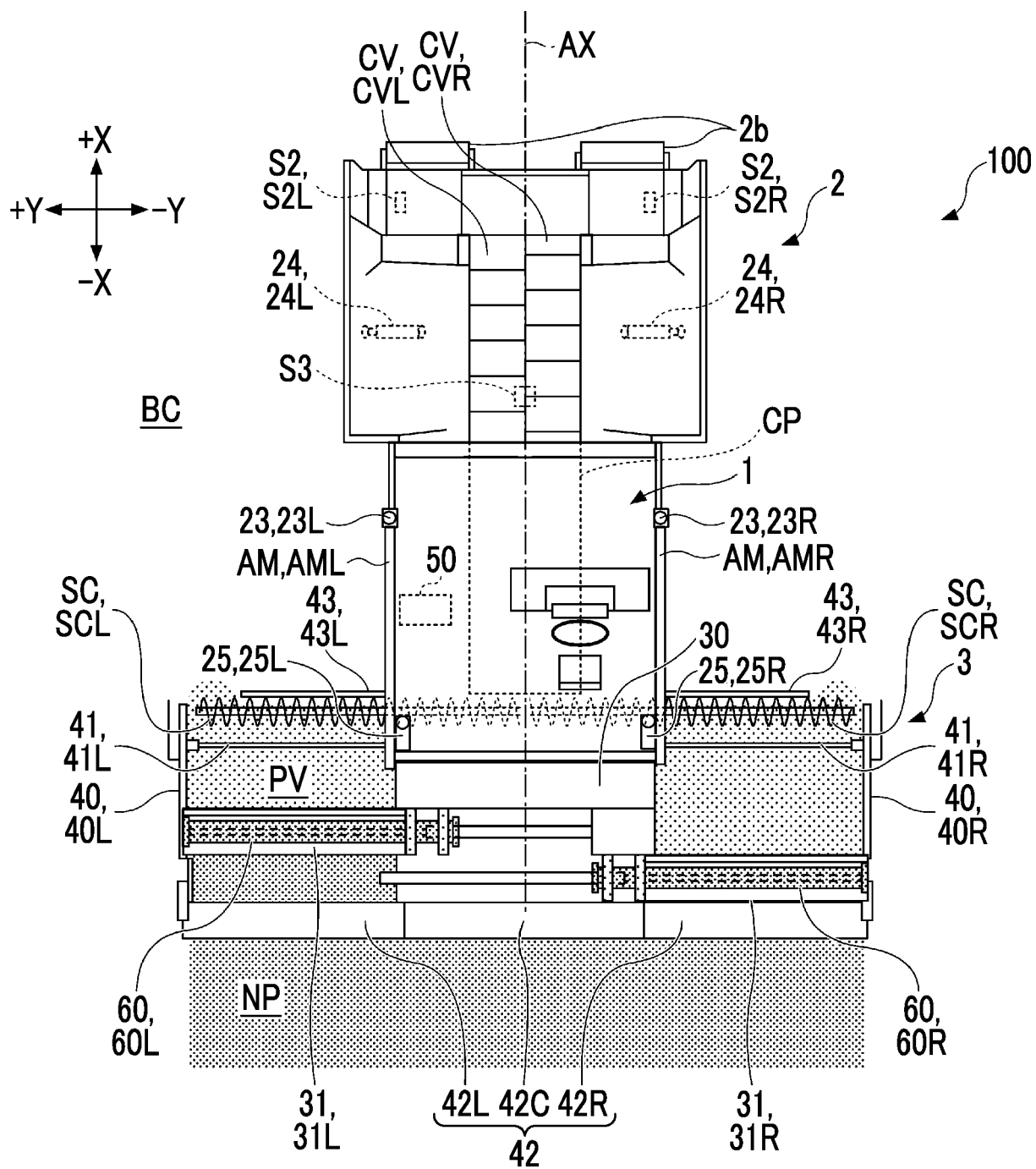


FIG. 3

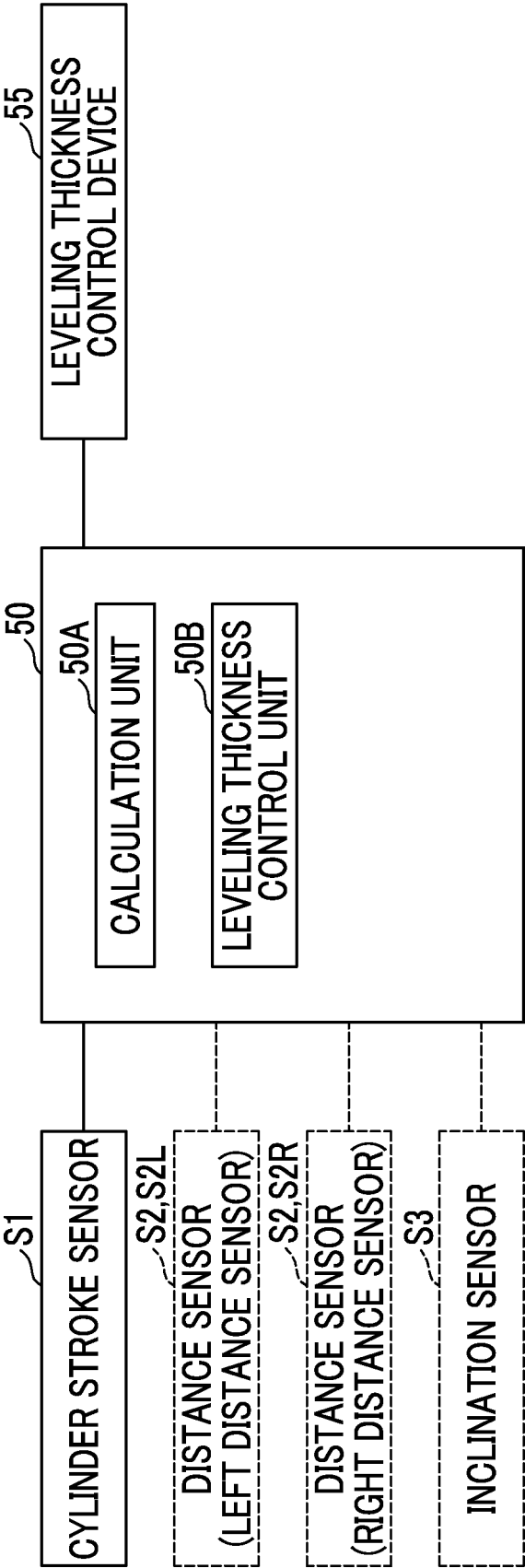


FIG. 4

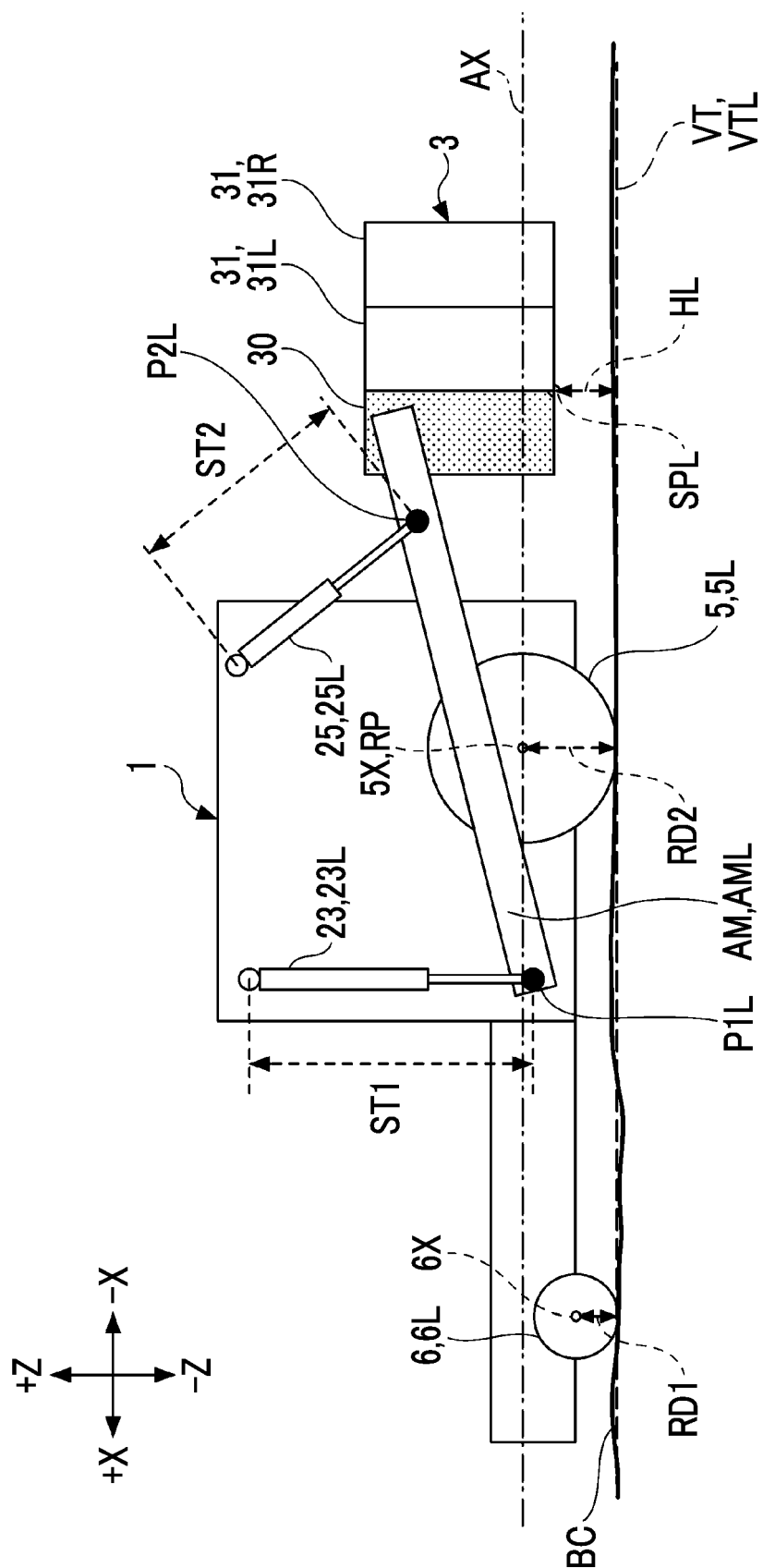
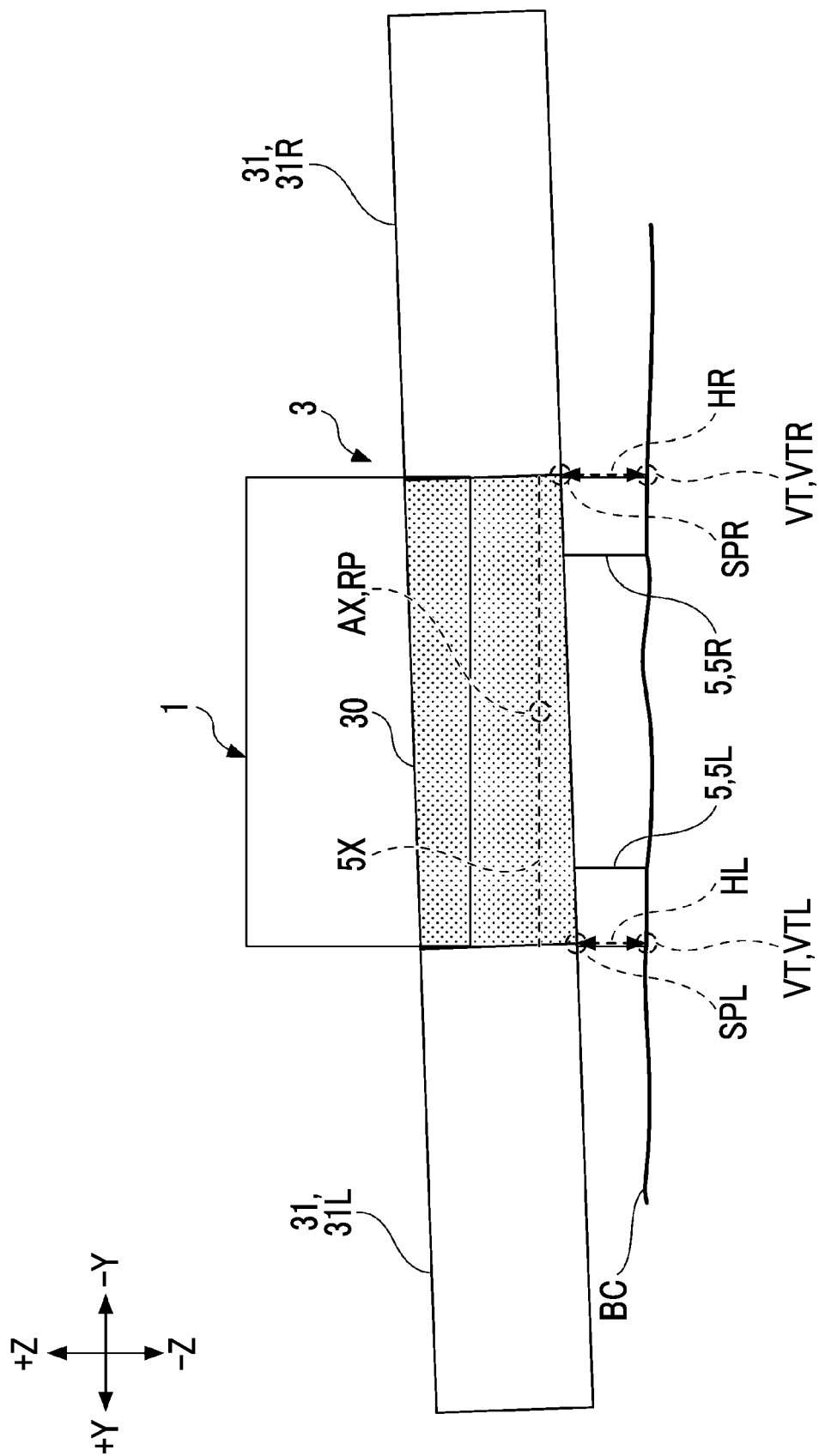


FIG. 5





EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 11 242 658 B2 (VOLVO CONSTR EQUIP AB [SE]) 8 February 2022 (2022-02-08)	1, 4-6, 9	INV.
Y	* the whole document *	3, 7, 8	E01C19/48
A	-----	2	E01C23/07
			E01C19/00
Y	US 5 393 167 A (FUJITA MAKIO [JP] ET AL) 28 February 1995 (1995-02-28)	3, 7, 8	
	* the whole document *		

A	JP 5 602452 B2 (SOOKI KK) 8 October 2014 (2014-10-08)	6	
	* the whole document *		

A	US 9 200 415 B2 (CATERPILLAR PAVING PROD [US]) 1 December 2015 (2015-12-01)	5	
	* the whole document *		

			TECHNICAL FIELDS SEARCHED (IPC)
			E01C
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
Munich		9 October 2023	Kerouach, May
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ON EUROPEAN PATENT APPLICATION NO.**

EP 23 16 8263

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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09-10-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 11242658 B2	08-02-2022	CN 111601929 A	28-08-2020
		EP 3735491 A1	11-11-2020
		US 2021062440 A1	04-03-2021
		WO 2019134744 A1	11-07-2019

US 5393167 A	28-02-1995	DE 69126017 T2	06-11-1997
		EP 0510215 A1	28-10-1992
		KR 920702454 A	04-09-1992
		US 5393167 A	28-02-1995
		WO 9208847 A1	29-05-1992

JP 5602452 B2	08-10-2014	JP 5602452 B2	08-10-2014
		JP 2011169017 A	01-09-2011

US 9200415 B2	01-12-2015	CN 104652235 A	27-05-2015
		DE 102014017010 A1	21-05-2015
		US 2015139729 A1	21-05-2015

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H2052042 B [0002]