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(71) Applicant: **Sumitomo Construction Machinery Co., Ltd.**
Tokyo 141-6025 (JP)

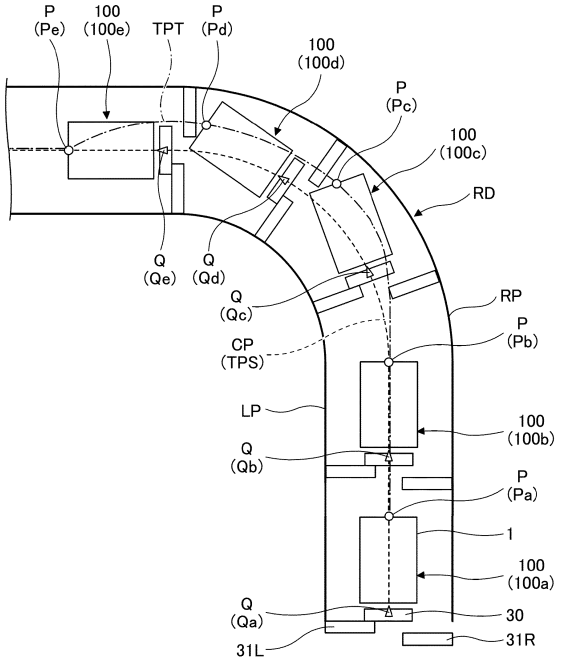
(72) Inventor: **TERAMOTO, Tota**
Chiba-shi, Chiba 263-0001 (JP)

(74) Representative: **Louis Pöhlau Lohrentz Patentanwälte**
Postfach 30 55
90014 Nürnberg (DE)

(54) ASPHALT FINISHER

(57) The asphalt finisher (100) of claim 1 includes: a tractor (1); a hopper (2) installed in front of the tractor (1) and configured to receive pavement material; a conveyor (CV) configured to feed the pavement material in the hopper (2) to the rear of the tractor (1); a screw (SC) configured to spread, behind the tractor (1), the pavement material fed by the conveyor (CV) ; a screed (3) configured to flatten, behind the screw (SC), the pavement material spread by the screw (SC); an information acquiring device (51) configured to acquire information related to a road targeted for application; and a control device (50) configured to control the movement of the tractor (1) based on a target trajectory (TPT) or a target position (Pf) that is determined by information related to the road targeted for application acquired by the information acquiring device (51).

FIG.4



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Description

TECHNICAL FIELD

[0001] This disclosure relates to an asphalt finisher.

BACKGROUND ART

[0002] Conventionally, there is an asphalt finisher, known as having: a tractor; a hopper installed in front of the tractor for receiving pavement material; a conveyor for feeding the pavement material in the hopper to the rear of the tractor; a screw for spreading, behind the tractor, the pavement material fed by the conveyor; and a screed for flattening, behind the screw, the pavement material spread by the screw (see, for example, Patent Document 1).

[0003] The driver of the asphalt finisher usually maneuvers a guiding rod (pointer rod) that is attached to the tractor, to drive the asphalt finisher such that the widthwise end surface of the pavement that is laid stretches along the steps on the road targeted for application. That is, the driver drives the asphalt finisher while maintaining the widthwise end surface of the screed and the bumpy surfaces of the steps in the road targeted for application substantially level. Note that the steps in the road targeted for application include, for example, the step between the curb and the roadbed, the step between existing pavement and the roadbed, the step between the formwork for the pavement and the roadbed, the step that is created when cutting the old pavement, and so on.

RELATED-ART DOCUMENT

PATENT DOCUMENT

[0004] Patent Document 1: Unexamined Japanese Patent Application Publication No. 2017-160636

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0005] However, when the road to be constructed is curved, the driver is unable to make the widthwise end surface of the pavement stick to and be laid along the steps by maneuvering the guiding rod alone. This is because the trajectory that a predetermined point in the center part of the screed positioned in the rear of the tractor draws does not always trace the trajectory that a predetermined point in the center part of the tractor draws, and drifts outward along the curves.

[0006] In view of the above-mentioned problem, it is desirable to provide an asphalt finisher that can appropriately lay pavement along the road to be constructed.

MEANS FOR SOLVING PROBLEM

[0007] An asphalt finisher according to an embodiment of the present invention has: a tractor; a hopper installed in front of the tractor and configured to receive pavement material; a conveyor configured to feed the pavement material in the hopper to the rear of the tractor; a screw configured to spread, behind the tractor, the pavement material fed by the conveyor; a screed configured to flatten, behind the screw, the pavement material spread by the screw; an information acquiring device configured to acquire information related to a road targeted for application; and a control device configured to control the movement of the tractor based on a target trajectory or a target position that is determined by information related to the road targeted for application by the information acquiring device.

ADVANTAGEOUS EFFECTS OF THE INVENTION

[0008] The above-described means provides an asphalt finisher that can appropriately lay pavement along the road to be constructed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

FIG. 1 is a side view of an asphalt finisher according to an embodiment of the present invention;
FIG. 2 is a top view of the asphalt finisher of FIG. 1;
FIG. 3 is a diagram showing an example configuration of an automatic steering system;
FIG. 4 is a top view of a construction site;
FIG. 5 is a top view of a construction site;
FIG. 6A is a top view of a construction site; and
FIG. 6B is a top view of a construction site.

EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0010] FIG. 1 is a side view of an asphalt finisher 100 according to an embodiment of the present invention. FIG. 2 is a top view of the asphalt finisher 100. In this embodiment, the asphalt finisher 100 is a wheel-type asphalt finisher, and composed mainly of a tractor 1, a hopper 2, and a screed 3. Hereinafter, the direction of the hopper 2 viewed from the tractor 1 (+X direction) will be defined as the front, and the direction of the screed 3 viewed from the tractor 1 (-X direction) will be defined as the rear.

[0011] The tractor 1 is a mechanism that allows the asphalt finisher 100 to move. In this embodiment, the tractor 1 rotates a rear wheel 5 by using a rear wheel traveling hydraulic motor, and rotates a front wheel 6 by using a front wheel traveling hydraulic motor, thereby moving the asphalt finisher 100. The rear wheel traveling hydraulic motor and the front wheel traveling hydraulic

motor are supplied with hydraulic oil from a hydraulic pump and rotate. However, the front wheel 6 may be a non-driving wheel.

[0012] The asphalt finisher 100 may also be a crawler-type asphalt finisher. In this case, the combination of the rear wheel 5 and the front wheel 6 is replaced by the combination of a left crawler and right crawler.

[0013] The controller 50 is a control device that controls the asphalt finisher 100. In this embodiment, the controller 50 is composed of a microcomputer including a CPU, a volatile memory device, a non-volatile memory device, and so forth, and is mounted on the tractor 1. The functions of the controller 50 are implemented as the CPU executes programs stored in the nonvolatile storage device. However, the functions of the controller 50 may be implemented not only by software, but may also be implemented by hardware or by any combinations of hardware and software.

[0014] The hopper 2 is a mechanism for receiving pavement material. In this embodiment, the hopper 2 is installed in front of the tractor 1 and configured to be opened and closed in the vehicle's width direction (Y-axis direction) by means of a hopper cylinder. The asphalt finisher 100 normally receives pavement material (for example, an asphalt mixture) from the bed of a dump truck when the hopper 2 is fully open. A dump truck is an example of a transport vehicle that transports pavement material. FIG. 1 and FIG. 2 show the hopper 2 as being fully open. When the pavement material in the hopper 2 is reduced, the hopper 2 is closed, and the pavement material around the inner walls of the hopper 2 is collected in the center part of the hopper 2, so that the conveyor CV provided in the center part of the hopper 2 can feed the pavement material to the rear of the tractor 1. The pavement material fed to the rear of the tractor 1 is spread in the vehicle's width direction by means of a screw SC, behind the tractor 1, and in front of the screed 3. In this embodiment, the screw SC assumes a state in which extension screws are connected to the left and right. FIG. 1 and FIG. 2 omit the illustration of the pavement material in the hopper 2. In FIG. 1 and FIG. 2, the coarse dot pattern represents the pavement material PV that is spread by the screw SC, and the fine dot pattern represents the new pavement NP that is flattened by the screed 3.

[0015] The screed 3 is a mechanism for flattening the pavement material PV. In this embodiment, the screed 3 includes a front screed 30 and a rear screed 31. The front screed 30 includes a left front screed 30L and a right front screed 30R. The rear screed 31 can extend and contract in the vehicle's width direction, and includes a left rear screed 31L and a right rear screed 31R. However, the rear screed 31 may be a screed of a fixed width that is connected to the left and right of the front screed 30. Also, the screed 3 is a free floating screed towed by the tractor 1, and connected to the tractor 1 via leveling arms 3A. The leveling arms 3A include a left leveling arm 3AL provided to the left of the tractor 1, and a right leveling arm 3AR provided to the right of the tractor 1.

[0016] A mold board 43 is attached to the front part of the screed 3. the mold board 43 is configured such that the amount of pavement material PV to be deposited in front of the screed 3 can be adjusted. The pavement material PV reaches under the screed 3 through the gap between the lower end of the moldboard 43 and the roadbed BS.

[0017] The tractor 1 has an information acquiring device 51, an on-vehicle display device 52, and a steering device 53 attached thereto.

[0018] The information acquiring device 51 is configured to acquire information related to the road targeted for application and output the acquired information to a controller 50. The information related to the road targeted for application includes, for example, the width of the road, changes in curvature in transition sections (clothoid sections), the curvature in arched sections, and so forth. In this embodiment, the information acquiring device 51 includes a front monitoring device 51F, a rear monitoring device 51B, a driving speed sensor 51S, a positioning device 51P, and a communication device 51T.

[0019] The front monitoring device 51F is configured to monitor the front of the asphalt finisher 100. With this embodiment, the front monitoring device 51F is a LIDAR that monitors a monitoring range RF situated in front of the tractor 1, and attached to the center part of the tractor 1. The center part of the tractor 1 refers to, for example, the front center part of the cover that covers the engine compartment that is situated behind the hopper 2. However, the front monitoring device 51F may be attached to another part of the asphalt finisher 100, and composed of a plurality of LIDARs. When composed of multiple LIDARs, the front monitoring device 51F can monitor multiple non-overlapping monitoring ranges all simultaneously. In this case, the LIDARs may include a right front LIDAR that is attached to the front-end right-side part of the tractor 1 and a left front LIDAR that is attached to the front-end left-side part of the tractor 1. Also, the LIDARs may be attached to the tractor 1 via brackets, poles and the like.

[0020] The rear monitoring device 51B is configured to monitor the rear of the asphalt finisher 100. In this embodiment, the rear monitoring device 51B is a LIDAR for monitoring a monitoring range RB situated behind the screed 3, and attached to a guide rail 1G that functions as a handrail. However, the rear monitoring device 51B may be attached to a lower part of the driver's seat 1S as well, or may be attached to another part of the asphalt finisher 100. Also, the rear monitoring device 51B may be composed of a plurality of LIDARs. When composed of multiple LIDARs, the rear monitoring device 51B can monitor multiple non-overlapping monitoring ranges all simultaneously. In this case, the LIDARs may include a right rear LIDAR that is attached to the rear-end right-side part of the tractor 1, and a left rear LIDAR that is attached to the rear-end left-side part of the tractor 1. Also, the LIDARs may be attached to the tractor 1 via

brackets, poles, and the like.

[0021] The information acquiring device 51 may include side monitoring devices configured to monitor the sides of the asphalt finisher 100. In this case, the side monitoring devices may include a left monitoring device and a right monitoring device. The left monitoring device may, for example, serve as a LIDAR for monitoring a monitoring range situated to the left of the tractor 1, and be placed closer to the front than the rear wheel 5, in the top left-end part of the tractor 1. The right monitoring device may, for example, serve as a LIDAR for monitoring a monitoring range situated to the right of the tractor 1, and be placed closer to the front than the rear wheel 5, in the top right-end part of the tractor 1.

[0022] A LIDAR is configured, for example, to measure the distances between a number of points within its 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 range image camera, a laser range finder, and so forth. The same is true for the side monitoring devices.

[0023] The monitoring range RF of the front monitoring device 51F preferably includes the roadbed BS and an anchor point AP that is present outside the roadbed BS, so that information about the width of the road targeted for application can be acquired. The same is true for the monitoring range of the side monitoring devices. With this embodiment, the monitoring range RF has a width greater than the width of the roadbed BS. The anchor point AP is an L-shaped gutter block. The anchor point AP may be the formwork for pavement, the curb block, existing pavement, and so forth.

[0024] The monitoring range RB of the rear monitoring device 51B preferably includes new pavement NP and an anchor point AP that is present outside the new pavement NP, so that information about the width of new pavement NP can be acquired. In this embodiment, the monitoring range RB has a width greater than the width of new pavement NP.

[0025] The driving speed sensor 51S is configured to detect the driving speed of the asphalt finisher 100. In this embodiment, the driving speed sensor 51S is a wheel speed sensor, and configured to detect the rotational angular velocity and rotational angle of the rear wheel 5, and, furthermore, the driving speed and the driving distance of the asphalt finisher 100.

[0026] The positioning device 51P is configured to estimate the position of the asphalt finisher 100. In this embodiment, the positioning device 51P is a GNSS compass, and configured to estimate the position and orientation of the asphalt finisher 100. As shown in FIG. 1 and FIG. 2, the GNSS compass that serves as the positioning device 51P includes a left GNSS receiver 51PL, attached to the upper end of a pole PL extending vertically upward from a rear end part of the left leveling arm 3AL, and a right GNSS receiver 51PR, attached to the upper end of a pole PL (not shown) extending vertically upward from a rear end part of the right leveling arm 3AR.

[0027] However, the positioning device 51P may be a total station. In this case, a reflecting prism to serve as the total station's target is attached to the tip of the pole PL. The main body of the total station, installed around the asphalt finisher 100, is connected to the controller 50 via wireless communication. That is, the main body of the total station transmits information that is derived with regard to the target position, to the controller 50.

[0028] The communication device 51T is configured to control communication between the asphalt finisher 100 and devices that are present apart from the asphalt finisher 100. In this embodiment, the communication device 51T is installed in front of the driver's seat 1S, and configured to control communication via a mobile communication network, a short-range wireless communication network, a satellite communication network, and so forth.

[0029] The information acquiring device 51 may include a steering angle sensor that is configured to detect the steering angle of the asphalt finisher 100, and a pavement width sensor that is configured to detect the amount of expansion and contraction of the rear screed 31 to calculate the pavement width.

[0030] Also, the information acquiring device 51 may include a monitoring device that is installed at the construction site or a monitoring device that is attached to an aircraft flying over the asphalt finisher 100. The monitoring device to be installed at the construction site is, for example, a LIDAR or a monocular camera that is attached to the tip of a pole installed along the road targeted for application. The monitoring device to be attached to an aircraft is, for example, a LIDAR or a monocular camera that is attached to a multi-copter (drone) or an airship.

[0031] The on-vehicle display device 52 is configured to display information related to the asphalt finisher 100. With this embodiment, the on-vehicle display device 52 is a liquid crystal display that is installed in front of the driver's seat 1S. However, the on-vehicle display device 52 may also be installed in at least one of the left end part and the right end part of the screed 3.

[0032] The steering device 53 is configured to control the steering of the asphalt finisher 100. In this embodiment, the steering device 53 is configured to extend and contract a front wheel steering cylinder that is provided near the front axle. To be more specific, the steering device 53 includes a steering electromagnetic control valve for controlling the amount of hydraulic fluid that flows into the front wheel steering cylinder from a hydraulic pump, and the amount of hydraulic fluid that is discharged from the front wheel steering cylinder. The steering electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the front wheel steering cylinder in accordance with the rotation of the steering wheel SH (handle) as the operating device. Also, the steering electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the front wheel steering cylinder in accordance with control commands from the controller 50, regardless of the rotation

of the steering wheel SH. That is, the controller 50 can control the steering of the asphalt finisher 100 regardless of whether the steering wheel SH is operated by the driver or not.

[0033] When the asphalt finisher 100 is a crawler-type asphalt finisher, the steering device 53 is configured to control a pair of left and right crawlers. To be more specific, the steering device 53 includes a left electromagnetic control valve for controlling the amount of hydraulic oil that flows from the hydraulic pump to the left traveling hydraulic motor for rotating the left crawler, and a right electromagnetic control valve for controlling the amount of hydraulic oil that flows from the hydraulic pump to the right traveling hydraulic motor for rotating the right crawler. The left electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the left traveling hydraulic motor in accordance with the amount of operation (inclination angle) of the left operating lever, which is the operating device for operating the left crawler. Also, the left electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the left travelling hydraulic motor in accordance with control commands from the controller 50, regardless of whether the left operating lever is operated by the driver. the right electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the right traveling hydraulic motor in accordance with the amount of operation (inclination angle) of the right operating lever, which is the operating device for operating the right crawler. Also, the right electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the right travelling hydraulic motor in accordance with control commands from the controller 50, regardless of whether the right operating lever is operated by the driver.

[0034] Next, an example configuration of an automatic steering system DS mounted on the asphalt finisher 100 will be described with reference to FIG. 3. FIG. 3 is a block diagram showing an example configuration of the automatic steering system DS.

[0035] The automatic steering system DS is composed mainly of a controller 50, a front monitoring device 51F, a rear monitoring device 51B, a driving speed sensor 51S, a positioning device 51P, a communication device 51T, an on-vehicle display device 52, a steering device 53, and so forth.

[0036] In the example shown in FIG. 3, the controller 50 includes a target calculation part 50a, a steering control part 50b, and a display control part 50c as functional blocks.

[0037] The target calculation part 50a is configured to calculate the target for use by the steering control part 50b. The target for use by the steering control part 50b is, for example, a target trajectory, which is the trajectory that a predetermined point on the asphalt finisher 100 should draw. The predetermined point is a point that is associated with a predetermined part of the asphalt finisher 100 in advance, and also referred to as a "steering reference point" or a "control reference point." However, the predetermined point may be a point that is associated with a predetermined part of the asphalt finisher 100 on a dynamic basis. Strictly speaking, the target trajectory is a one-dimensional array of a number of target positions. A target position is a point in location that a predetermined point on the asphalt finisher 100 should reach. Alternatively, a target for use by the steering control part 50b may be a target position that serves as a point in location that a predetermined point on the asphalt finisher 100 should reach a predetermined time later. The predetermined time is, for example, several milliseconds, several tens of milliseconds, several hundreds of milliseconds, or several seconds.

[0038] In this embodiment, the target calculation part 50a calculates the target trajectory that a predetermined point in the center part of the tractor 1 should trace, based on information related to the road targeted for application such as construction design data. In this case, the target trajectory is typically calculated before the asphalt finisher 100 starts running. Consequently, the target trajectory may be calculated by a server or the like installed in a management center that is located outside the asphalt finisher 100, and then transmitted to the controller 50 via communication. Note that the predetermined point may be a point set in the center part of the front end part of the hopper 2, not a point set in the center part of the tractor 1. Also, in the event the asphalt finisher 100 is a wheel-type asphalt finisher, the predetermined point may be a point set at the position of the left front wheel, a point set at the position of the right front wheel, or a point set in the center part of the front wheel shaft.

[0039] The target calculation part 50a may calculate a target position as a point in location that a predetermined point in the center part of the tractor 1 should reach a predetermined time later. In this case, the target position is repeatedly calculated in a predetermined control cycle while the asphalt finisher 100 is running. For example, the target calculation part 50a may calculate, as a target position, the widthwise center point of the road targeted for application located a predetermined distance ahead of the current position of the predetermined point in the center part of the tractor 1, based on information acquired by the front monitoring device 51F. The predetermined distance is, for example, several centimeters or several tens of centimeters. In this case, the target calculation part 50a can calculate the target position without acquiring construction design data. However, the target calculation part 50a may calculate the target position based on construction design data and information acquired by the front monitoring device 51F. For example, the target calculation part 50a may correct the target position calculated based on construction design data, based on information acquired by the front monitoring device 51F. Also, the target calculation part 50a may utilize information obtained by the rear monitoring device 51B.

[0040] The steering control part 50b is configured to control the steering of the asphalt finisher 100 automat-

ically, regardless of the operation of the operating device.

[0041] In this embodiment, the steering control part 50b outputs control commands to the steering device 53 such that a predetermined point in the center part of the tractor 1 traces the target trajectory calculated by the target calculation part 50a. To be more specific, the steering control part 50b determines the current position of the predetermined point in the center part of the tractor 1, based on output of the positioning device 51P. Then, if it is determined that the predetermined point deviates to the right from the target trajectory, the steering control part 50b outputs a control command to the steering device 53 such that the asphalt finisher 100 moves to the left. Similarly, if it is determined that the predetermined point deviates to the left from the target trajectory, the steering control part 50b outputs a control command to the steering device 53 such that the asphalt finisher 100 moves to the right.

[0042] Alternatively, the steering control part 50b may output a control command to the steering device 53 so as to position a predetermined point in the center part of the tractor 1 at the target position calculated by the target calculation part 50a. In this case, the steering control part 50b may determine the current position of the predetermined point in the center part of the tractor 1 based on output of the positioning device 51P, or the steering control part 50b may determine the current position of the predetermined point in the center part of the tractor 1 based on output of at least one of the rear monitoring device 51B and the front monitoring device 51F. In the latter case, the positioning device 51P may be omitted.

[0043] Next, the function of moving the asphalt finisher 100 along the target trajectory will be described with reference to FIG. 4. FIG. 4 is a top view of a construction site showing the asphalt finisher 100 passing a curved section (left curve) of the road RD where construction is taking place. Referring to FIG. 4, the asphalt finisher 100a is the asphalt finisher 100 at a first point in time, which is when the construction starts. Similarly, the asphalt finisher 100b is the asphalt finisher 100 at a second point in time, which is a predetermined time after the first time point. The asphalt finisher 100c is the asphalt finisher 100 at a third point in time, which is a predetermined time after the second time point. The asphalt finisher 100d is the asphalt finisher 100 at a fourth point in time, which is a predetermined time after the third time point. The asphalt finisher 100e is the asphalt finisher 100 at a fifth point in time, which is a predetermined time after the fourth time point. Note that, for clarity, FIG. 4 shows the tractor 1, the front screed 30, the left rear screed 31L, and the right rear screed 31R of the asphalt finisher 100, in a simplified manner, and omits the illustration of the hopper 2.

[0044] The target calculation part 50a of the controller 50 calculates a target trajectory TPT that a predetermined point P in the center part of the tractor 1 should trace at the first time point, which is when the construction starts. In the example shown in FIG. 4, the predetermined point P is represented by the symbol "o," and the target trajectory TPT is represented by the dashed line. Referencing the construction design data, the target calculation part 50a determines the center line CP of the road targeted for application RD based on the left boundary line LP and the right boundary line RP of the road targeted for application RD. Then, the target calculation part 50a sets the center line CP as a target trajectory TPS that the predetermined point Q in the center part of the front screed 30 should trace. In the example shown in FIG. 4, the predetermined point Q is represented by the symbol "△, " and the target trajectory TPS is represented by the dashed line. Then, the target calculation part 50a calculates the target trajectory TPT that the predetermined point P should trace, based on known information such as the distance between the rear wheel 5 and the front wheel 6 of the asphalt finisher 100, and the target trajectory TPS.

[0045] In the example shown in FIG. 4, the left boundary line LP, the right boundary line RP, the center line CP, the target trajectory TPT that the predetermined point P should trace, and the target trajectory TPS that the predetermined point Q should trace are all derived as a one-dimensional array of multiple position coordinates. The position coordinates are, for example, coordinates in a reference coordinate system.

[0046] The reference coordinate system is, for example, the world geodetic system. The world geodetic system is a three-dimensional orthogonal XYZ coordinate system, which has its origin at the center of gravity of the earth, and in which the axis to pass through the intersection of the Greenwich meridian and the equator, and the origin is the X axis, the axis to pass through the intersection of the meridian of 90 degrees east longitude and the equator, and the origin is the Y axis, and the axis to pass through the north pole and the origin is the Z axis.

[0047] Subsequently, the steering control part 50b of the controller 50 operates the asphalt finisher 100 such that the actual position coordinates of the predetermined point P match one of the position coordinates forming the target trajectory TPT. To be more specific, the steering control part 50b determines the current position of the predetermined point P in the center part of the tractor 1 based on output of the positioning device 51P. Then, when the predetermined point P is positioned to the right of the target trajectory TPT, the steering control part 50b outputs a control command to the steering electromagnetic control valve that constitutes the steering device 53, and a predetermined amount of hydraulic oil is introduced into the bottom-side oil chamber of the front wheel steering cylinder. As a result of this, the asphalt finisher 100 moves to the left while moving forward, and the predetermined point P is positioned closer to the target trajectory TPT. On the other hand, when the predetermined point P is positioned to the left of the target trajectory TPT, the steering control part 50b outputs a control command to the steering electromagnetic control valve that constitutes the steering device 53, and a predetermined

amount of hydraulic oil is introduced into the rod-side oil chamber of the front wheel steering cylinder. As a result of this, the asphalt finisher 100 moves to the right while moving forward, and the predetermined point P is positioned closer to the target trajectory TPT. Note that, with this example, the front wheel steering cylinder is configured such that the left steering angle increases when the front wheel steering cylinder extends beyond a predetermined length, and the right steering angle increases when the front wheel steering cylinder contracts below a predetermined length.

[0048] In this manner, the controller 50 can position the predetermined point P, which is at the position of a point Pa at the first time point, at a point Pb at the second time point, at a point Pc at the third time point, at a point Pd at the fourth time point, and at a point Pe at the fifth time point. As a result, the controller 50 can position a predetermined point Q, which is at the position of a point Qa at the first time point, at a point Qb at the second time point, at a point Qc at the third time point, at a point Qd at the fourth time point, and at a point Qe at the fifth time point.

[0049] In the example shown in FIG. 4, the left rear screed 31L is extended leftward such that its left end surface meets the left boundary line LP of the road RD, the right rear screed 31R is extended rightward such that its right end surface meets the right boundary line RP of the road RD. Then, the left end surface of the left rear screed 31L moves tracing the left boundary line LP, and the right end surface of the right rear screed 31R moves tracing the right boundary line RP. Consequently, the controller 50 can make the width of the road RD and the width of the new pavement NP match, by moving the tractor 1 forward such that the predetermined point P in the center part of the tractor 1 traces the target trajectory TPT.

[0050] The controller 50 may extend and contract the rear screed 31 while the asphalt finisher 100 is running. For example, when there is a risk that the left end surface of the left rear screed 31L will deviate from the left boundary line LP into the road RD, the controller 50 may extend the left rear screed 31L leftward. Alternatively, if there is a risk that the right end surface of the right rear screed 31R will deviate from the right boundary line RP into the road RD, the controller 50 may extend the right rear screed 31R rightward.

[0051] Also, although, in the example illustrated in FIG. 4, the steering control part 50b controls the steering of the asphalt finisher 100 while the asphalt finisher 100 is running in the curved section of the road RD, the steering control part 50b may control the steering of the asphalt finisher 100 while the asphalt finisher 100 is running in the straight section of the road RD.

[0052] Next, the function of moving the asphalt finisher 100 while determining the target position first-hand will be described with reference to FIG. 5. FIG. 5 is a top view of a construction site showing the asphalt finisher 100 passing a curved section of the road targeted for application RD. Similar to FIG. 4, for clarity, FIG. 5 shows the tractor 1, the front screed 30, the left rear screed 31L, and the right rear screed 31R of the asphalt finisher 100, in a simplified manner, and omits the illustration of the hopper 2.

[0053] In the example shown in FIG. 5, the target calculation part 50a of the controller 50 determines the center line CP of the road targeted for application RD based on information acquired by the front monitoring device 51F. In the example shown in FIG. 5, the center line CP is represented by the dotted line. To be more specific, the target calculation part 50a determines the left boundary line LP and the right boundary line RP of the road RD based on information acquired by the front monitoring device 51F, determines the center line CP of the road RD based on the left boundary line LP and the right boundary line RP. The information acquired by the front monitoring device 51F is, for example, the position and orientation of the step between the curb block and the roadbed BS. Also, the target calculation part 50a determines the current position Pn of the predetermined point P in the center part of the tractor 1 and the current position Qn of the predetermined point Q in the center part of the front screed 30. To be more specific, the target calculation part 50a determines the current position Pn of the predetermined point P and the current position Qn of the predetermined point Q based on output of the positioning device 51P. In the example shown in FIG. 5, the predetermined point P is represented by the symbol "o," and the predetermined point Q is represented by the symbol "△."

[0054] That provided, the target calculation part 50a calculates a target position Pf as a point in location that the predetermined point P should reach a predetermined time later. To be more specific, the target calculation part 50a calculates a target position Qf as a point in location that the predetermined point Q should reach a predetermined time later, based on construction design data and the current position Pn of the predetermined point P, calculates a target position Pf based on known information such as the distance between the rear wheel 5 and the front wheel 6, and the target position Qf. The target position Pf and the target position Qf are both derived as position coordinates. The position coordinates are, for example, coordinates in a reference coordinate system. In the example shown in FIG. 5, the target position Pf is represented the symbol "o" drawn by a dotted line, and the target position Qf is represented by the symbol "△" drawn by a dotted line.

[0055] Subsequently, the steering control part 50b of the controller 50 operates the asphalt finisher 100 such that the position coordinates of the predetermined point P match the position coordinates of the target position Pf. For example, the steering control part 50b determines the central axis AX of the asphalt finisher 100 based on output of the positioning device 51P. Then, when the target position Pf is positioned to the left of the center axis AX, the steering control part 50b outputs a control com-

mand to the steering electromagnetic control valve that constitutes the steering device 53, and a predetermined amount of hydraulic oil is introduced into the bottom-side oil chamber of the front wheel steering cylinder. As a result of this, the asphalt finisher 100 moves to the left while moving forward, and the predetermined point P is positioned closer to the target position Pf. On the other hand, when the target position Pf is positioned to the right of the center axis AX, the steering control part 50b outputs a control command to the steering electromagnetic control valve that constitutes the steering device 53, and a predetermined amount of hydraulic oil is introduced into the rod-side oil chamber of the front wheel steering cylinder. As a result of this, the asphalt finisher 100 moves to the right while moving forward, and the predetermined point P is positioned closer to the target position Pf. Note that, with this example, the front wheel steering cylinder is configured such that the left steering angle increases when the front wheel steering cylinder extends beyond a predetermined length, and the right steering angle increases when the front wheel steering cylinder contracts below a predetermined length. Thus, the controller 50 can position the predetermined point P at the target position Pf. As a result of this, the controller 50 can position the predetermined point Q at the target position Qf.

[0056] The steering control part 50b may operate the asphalt finisher 100 such that the position coordinates of the predetermined point Q match the position coordinates of the target position Qf. Alternatively, the steering control part 50b may operate the asphalt finisher 100 such that the predetermined point Q approaches the center line CP of the road RD. In this case, the steering control part 50b determines, in a predetermined control cycle, whether the predetermined point Q is positioned on the center line CP of the road RD, positioned to the right of the center line CP, or positioned to the left of the center line CP. Then, the steering control part 50b shifts the asphalt finisher 100 to the left when the predetermined point Q is determined to be positioned to the right of the center line CP, and shifts the asphalt finisher 100 to the right when the predetermined point Q is determined to be positioned to the left of the center line CP.

[0057] Then, in the example shown in FIG. 5, the left rear screed 31L is extended to the left such that its left end surface meets the left boundary line LP of the road RD, and the right rear screed 31R is extended to the right such that its right end surface meets the right boundary line RP of the road RD. Then, the left end surface of the left rear screed 31L moves tracing the left boundary line LP, and the right end surface of the right rear screed 31R moves tracing the right boundary line RP. Consequently, the controller 50 can make the width of the road RD and the width of the new pavement NP match, by moving the tractor 1 forward such that the predetermined point P in the center part of the tractor 1 follows the target position Pf calculated in a predetermined control cycle.

[0058] The controller 50 may extend and contract the rear screed 31 while the asphalt finisher 100 is running. For example, when there is a risk that the left end surface of the left rear screed 31L will deviate from the left boundary line LP into the road RD, the controller 50 may extend the left rear screed 31L leftward. Alternatively, if there is a risk that the right end surface of the right rear screed 31R will deviate from the right boundary line RP into the road RD, the controller 50 may extend the right rear screed 31R rightward.

[0059] Also, although, in the example illustrated in FIG. 5, the steering control part 50b controls the steering of the asphalt finisher 100 while the asphalt finisher 100 is running in the curved section of the road RD, the steering control part 50b may control the steering of the asphalt finisher 100 while the asphalt finisher 100 is running in the straight section of the road RD.

[0060] Next, the effect of controlling the movement of the asphalt finisher 100 automatically by means of the steering device 53 will be described with reference to FIG. 6A and FIG. 6B. FIG. 6A and FIG. 6B are each a top view of a construction site showing the asphalt finisher 100 passing a curved section of the road targeted for application RD. To be more specific, FIG. 6A shows the movement of the asphalt finisher 100 when automatic steering by the steering device 53 is at work. FIG. 6B shows the movement of the asphalt finisher 100 when manual steering is at work such that the predetermined point P in the center part of the tractor 1 traces the center line CP of the road RD. In the example shown in FIG. 6A and FIG. 6B, the predetermined point P in the center part of the tractor 1 is represented by the symbol "o," and the predetermined point Q in the center part of the front screed 30 is represented by the symbol "△."

[0061] As shown in FIG. 6B, when steering is performed manually such that the predetermined point P traces the center line CP of the road RD, the predetermined point Q in the center part of the front screed 30 traces the trajectory PS represented by the two-dot chain line. That is, when the asphalt finisher 100 passes the curved section of the road RD, the distance between the front end of the right-side surface of the tractor 1 and the right boundary line RP of the road RD changes while remaining substantially equal to the distance between the front end of the left-side surface of the tractor 1 and the left boundary line LP of the road RD. On the other hand, the distance between the front end of the right-side surface of the front screed 30 and the right boundary line RP of the road RD changes while remaining smaller than the distance between the front end of the left-side surface of the front screed 30 and the left boundary line LP of the road RD. Consequently, pavement material is not laid in the area inside the curved section of the road RD represented by the dot pattern, whereas, in the area outside the curved section of the road RD represented by the cross pattern, the pavement material overflows and is laid beyond the right boundary line RP of the road RD.

[0062] In this way, assuming that the driver of the asphalt finisher 100 moves the asphalt finisher 100 such that the tractor 1 is positioned at the widthwise center of

the road RD when the asphalt finisher 100 passes the curved section of the road RD, the screed 3 still cannot be positioned at the widthwise center of the road RD.

[0063] In contrast with this, if, as shown in FIG. 4 and FIG. 6A, the movement of the asphalt finisher 100 is automatically controlled by the steering device 53 such that the predetermined point P traces the target trajectory TPT, the predetermined point Q in the center part of the front screed 30 traces the center line CP of the road RD represented by the dashed line. That is, when the asphalt finisher 100 passes the curved section of the road RD, the distance between the front end of the right-side surface of the tractor 1 and the right boundary line RP of the road RD changes while remaining smaller than the distance between the front end of the left-side surface of the tractor 1 and the left boundary line LP of the road RD. On the other hand, the distance between the front end of the right-side surface of the front screed 30 and the right boundary line RP of the road RD changes while remaining substantially equal to the distance between the front end of the left-side surface of the front screed 30 and the left boundary line LP of the road RD. As a result of this, the pavement material is laid reliably, even in areas inside the curved section of the road RD, and no pavement material overflows or and is laid beyond the right boundary line RP of the road RD. That is, the asphalt finisher 100 can make the width of the road targeted for application RD and the width of new pavement NP match even in curved sections of the road RD.

[0064] Thus, when the asphalt finisher 100 passes a curved section of the road RD, the controller 50 moves the asphalt finisher 100 so as to allow the tractor 1 to approach the widthwise end parts of the road RD, thereby positioning the screed 3 at the widthwise center of the road RD.

[0065] As described above, the asphalt finisher 100 according to the embodiment of the present invention has: a tractor 1; a hopper 2 installed in front of the tractor 1 and configured to receive pavement material; a conveyor CV configured to feed the pavement material in the hopper 2 to the rear of the tractor 1; a screw SC configured to spread, behind the tractor 1, the pavement material fed by the conveyor CV; a screed 3 configured to flatten, behind the screw SC, the pavement material spread by the screw SC; an information acquiring device 51 configured to acquire information related to a road targeted for application; and a control device 50 configured to control the movement of the tractor 1 based on a target trajectory TPT or a target position Pf that is determined by information related to the road targeted for application acquired by the information acquiring device 51.

[0066] Configured thus, the asphalt finisher 100 can appropriately lay pavement along the road targeted for application RD.

[0067] As shown in FIG. 4 or FIG. 5, the controller 50 may be configured such that, when the road targeted for application RD curves to the left, the controller 50 moves the target trajectory TPT or the target position Pf, in the curved section of the road targeted for application RD, to the outside (to the right) with respect to the center (center line CP) of the road RD. Note that the target trajectory TPT is, for example, a target trajectory that the predetermined point P in the center part of the tractor 1 should trace, and the target position Pf is a point in location that the predetermined point P should reach a predetermined time later.

[0068] The controller 50 may be configured to set the target trajectory TPT or the target position Pf such that the widthwise center of the road targeted for application RD and the widthwise center of the screed 3 match. For example, as shown in FIG. 4, the target calculation part 50a of the controller 50 may be configured to set the target trajectory TPT or the target position Pf such that the trajectory that the predetermined point Q in the center part of the front screed 30 draws and the center line CP of the road RD match.

[0069] This configuration allows the controller 50 to make the width of the road RD and the width of new pavement NP match not only when the asphalt finisher 100 passes straight sections of the road RD but also when the asphalt finisher 100 passes curved sections.

[0070] The controller 50 may be also configured to set the target trajectory TPT or the target position Pf such that at least one of the two end parts of the screed 3 and an anchor point match. For example, the target calculation part 50a of the controller 50 may set the target trajectory TPT or the target position Pf such that, as shown in FIG. 4, the left end part of the screed 3 and the left boundary line LP of the road RD match, and the right end part of the screed 3 and the right boundary line RP of the road RD match. Alternatively, the target calculation part 50a of the controller 50 may set the target trajectory TPT or the target position Pf such that the left end part of the screed 3 and the left boundary line LP of the road RD match. Alternatively, the target calculation part 50a of the controller 50 may set the target trajectory TPT or the target position Pf such that the right end part of the screed 3 and the right boundary line RP of the road RD match.

[0071] Also, the controller 50 may be configured to set the target trajectory TPT or the target position Pf based on the distance, in the direction of the front and the rear, between the predetermined point P, which serves as a steering reference point, and the screed 3. For example, the controller 50 may be configured to set the target trajectory TPT or the target position Pf based on the distance, in the direction of the front and the rear, between the predetermined point P and the predetermined point Q in the center part of the front screed 30.

[0072] Also, the controller 50 may be configured to set the target trajectory TPS or the target position Qf based on the distance, in the direction of the front and the rear, between the predetermined point P, which serves as a steering reference point, and the screed 3. For example, the controller 50 may be configured to set the target trajectory TPS or the target position Qf based on the dis-

tance, in the direction of the front and the rear, between the predetermined point P and the predetermined point Q in the center part of the front screed 30. Note that the target trajectory TPS is, for example, a target trajectory that the predetermined point Q in the center part of the front screed 30 should trace, and the target position Qf is a point in location that the predetermined point Q should reach a predetermined time later.

[0073] In the event the asphalt finisher 100 is a wheel-type asphalt finisher, the controller 50 may be configured to control the movement of the tractor 1 by controlling the steering angle of the front wheel 6. In the event the asphalt finisher 100 is a crawler-type asphalt finisher, the controller 50 may be configured to control the movement of the tractor 1 by controlling the respective rotation speeds of the left crawler and the right crawler separately.

[0074] Configured thus, the controller 50 can control the movement of the asphalt finisher 100 automatically, thereby properly laying pavement along the road targeted for application RD, whether the asphalt finisher 100 is a wheel-type asphalt finisher or a crawler-type asphalt finisher.

[0075] The controller 50 may be configured to control the movement of the tractor 1 such that the asphalt finisher 100 moves along a target trajectory TPT that is set in advance. To be more specific, the controller 50 may be configured to control the movement of the tractor 1 such that the asphalt finisher 100 moves along a target trajectory TPT that is set before the asphalt finisher 100 starts running. However, the controller 50 may be configured to control the movement of the tractor 1 such that the asphalt finisher 100 moves along a target trajectory TPT that is calculated first-hand.

[0076] Configured thus, the controller 50 can easily and reliably control the movement of the tractor 1 appropriately.

[0077] The information acquiring device 51 may be an imaging device or a communication device 51T. The imaging device may also be a LIDAR, a monocular camera, a stereo camera, a range image camera, and so forth.

[0078] A preferred embodiment of the present invention has been described above. However, the present invention is by no means limited to the embodiment described above. Various modifications or replacements may be applied to the above-described embodiment without departing from the scope of the present invention. Also, all of the features described with reference to the above embodiment may be combined as appropriate as long as no technical inconsistencies arise therefrom.

[0079] For example, according to the embodiment described above, the steering device 53 is configured to extend and contract a front wheel steering cylinder that is provided near the front axle. However, in the event a hydraulic steering motor is employed instead of a front wheel steering cylinder, the steering device 53 may be configured to rotate the hydraulic steering motor. In this case, the steering device 53 may include a steering electromagnetic control valve for controlling the amount of hydraulic oil that flows from the hydraulic pump to the hydraulic steering motor. The steering electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the hydraulic steering motor in accordance with the rotation of a steering wheel SH (handle) that serves as an operating device. Also, the steering electromagnetic control valve is configured to control the inflow and outflow of hydraulic oil in the hydraulic steering motor in accordance with control command from the controller 50, regardless of the rotation of the steering wheel SH. Alternatively, the steering device 53 may be configured to control an electric motor that automatically rotates the steering wheel SH. In this case, the steering device can control the movement of the asphalt finisher 100 automatically by rotating the steering wheel SH automatically in accordance with control commands from the controller 50.

[0080] This application is based on and claims priority to Japanese Patent Application No. 2020-056662, filed on March 26, 2020, and the entire contents of this Japanese patent application are incorporated herein by reference.

LIST OF REFERENCE NUMERALS

[0081]

1	tractor
1G	guide rail
1S	driver's seat
2	hopper
3	screed
3A	leveling arm
3AL	left leveling arm
3AR	right leveling arm
5	rear wheel
6	front wheel
30	front screed
31	rear screed
43	mold board
50	controller
50a	target calculation part
50b	steering control part

51	information acquiring device
51B	rear monitoring device
51F	front monitoring device
51P	positioning device
51PL	left GNSS receiver
51PR	right GNSS receiver
51S	driving speed sensor
51T	communication device
52	on-vehicle display device
53	steering device
100	asphalt finisher
AP	anchor point
BS	roadbed
CV	conveyor
DS	automatic steering system
NP	new pavement
PL	pole
PV	pavement material
SC	screw
SH	steering wheel

Claims

1. An asphalt finisher comprising:

a tractor;
a hopper installed in front of the tractor and configured to receive pavement material;
a conveyor configured to feed the pavement material in the hopper to rear of the tractor;
a screw configured to spread, behind the tractor, the pavement material fed by the conveyor;
a screed configured to flatten, behind the screw, the pavement material spread by the screw;
an information acquiring device configured to acquire information related to a road targeted for application; and
a control device configured to control movement of the tractor based on a target trajectory or a target position that is determined by information related to the road targeted for application acquired by the information acquiring device.

2. The asphalt finisher according to claim 1, wherein, in a curved section of the road targeted for application, the control device sets the target trajectory or the target position on outside with respect to a center of the road targeted for application.

3. The asphalt finisher according to claim 1, wherein the control device sets the target trajectory or the target position such that a widthwise center of the road targeted for application and a widthwise center of the screed match.

4. The asphalt finisher according to claim 1, wherein the control device sets the target trajectory or the target position such that at least one of two end parts of the screed matches an anchor point.

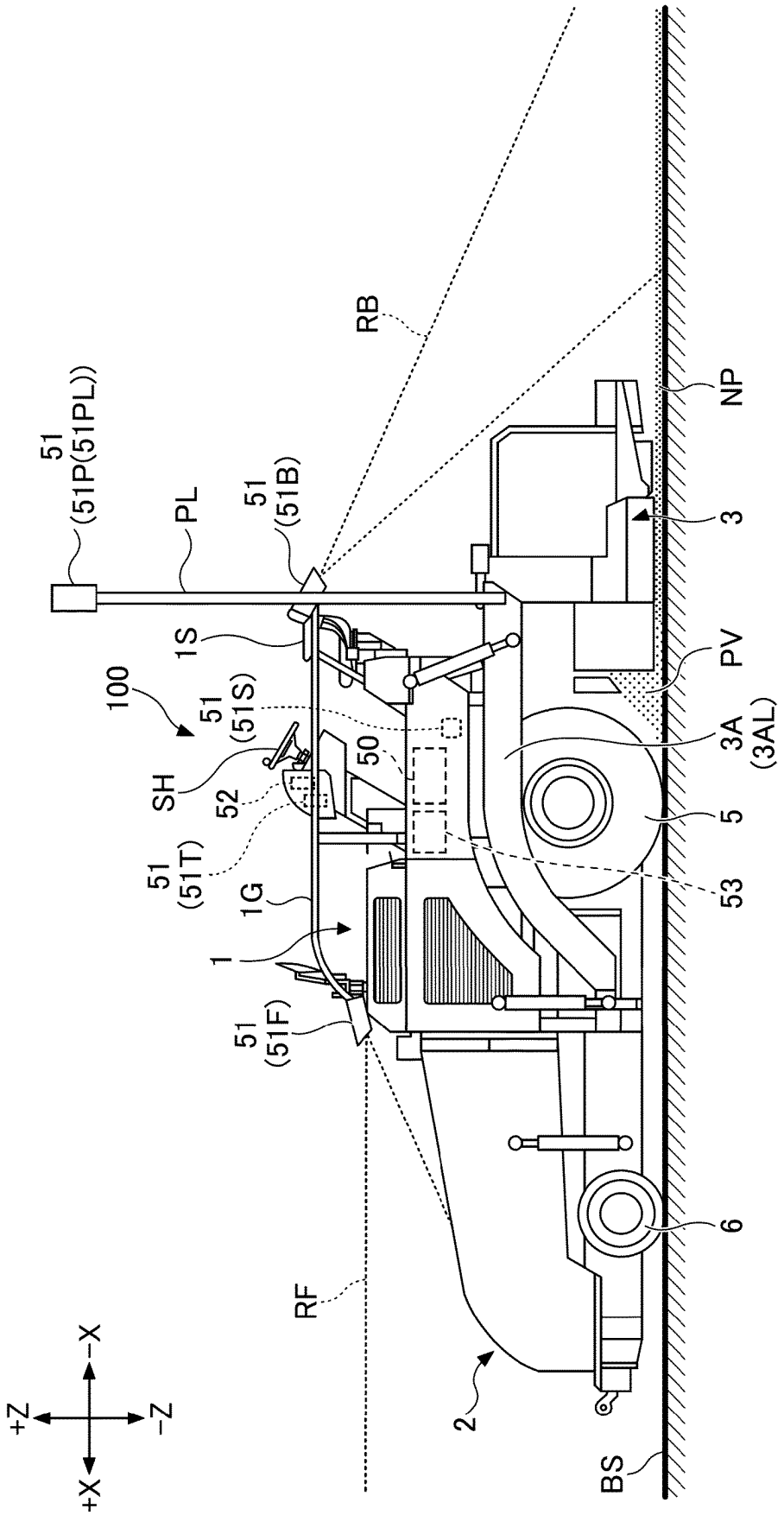
5. The asphalt finisher according to claim 1, wherein the controller controls movement of the tractor by controlling a steering angle of a front wheel when the asphalt finisher is a wheel-type asphalt finisher, and controls the movement of the tractor by controlling respective control speeds of a left crawler and a right crawler individually when the asphalt finisher is a crawler-type asphalt finisher.

6. The asphalt finisher according to claim 1, wherein the control device controls movement of the tractor such that the asphalt finisher moves along a target trajectory that is set in advance.

7. The asphalt finisher according to claim 1, wherein the information acquiring device is an imaging device or a communication device.

8. The asphalt finisher according to claim 1, wherein the control device sets the target trajectory or the target position based on a distance, in a direction of front and rear, between a steering reference point and the screed.

FIG.1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50
52
5
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(51F)
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BS
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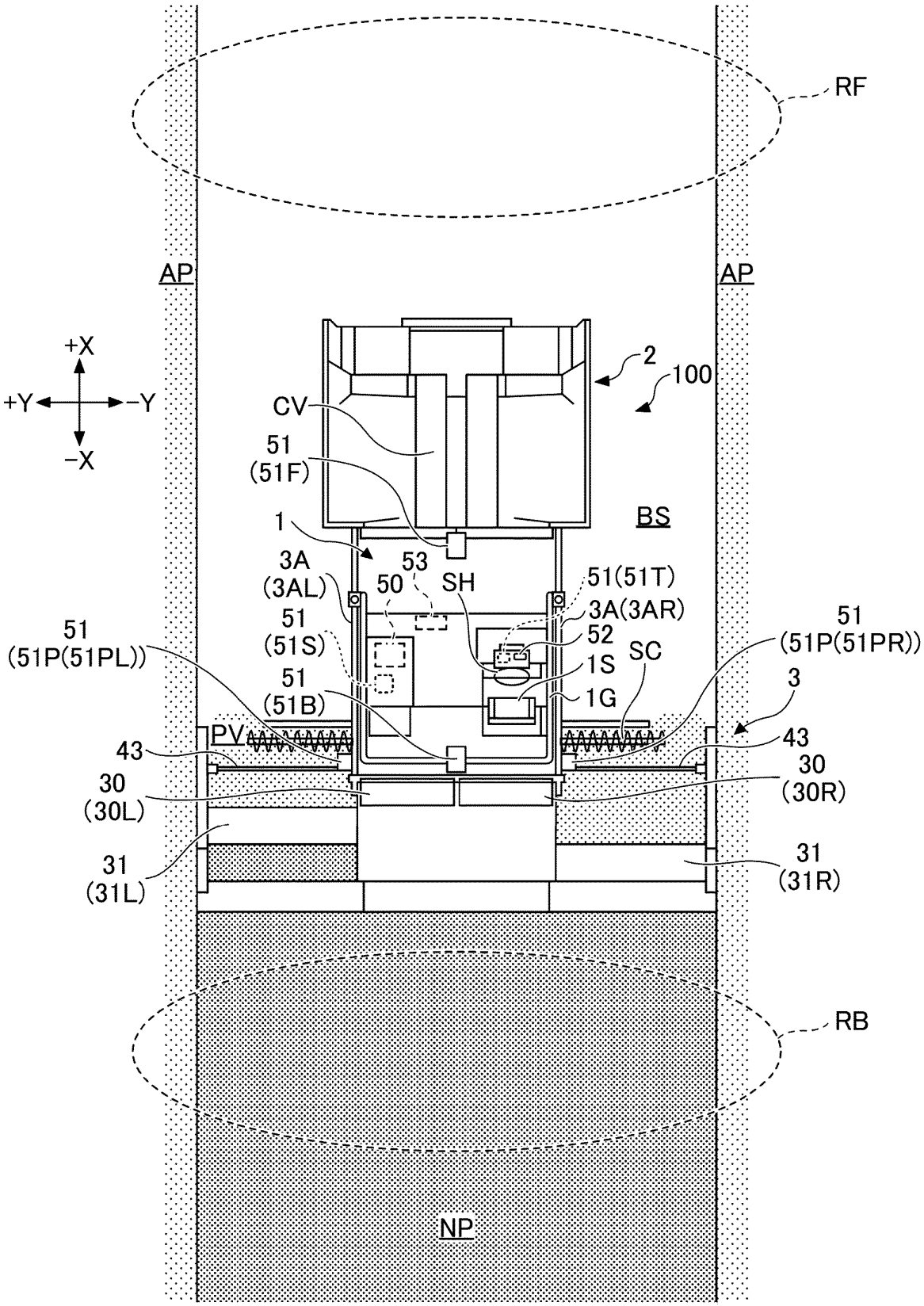
FIG.2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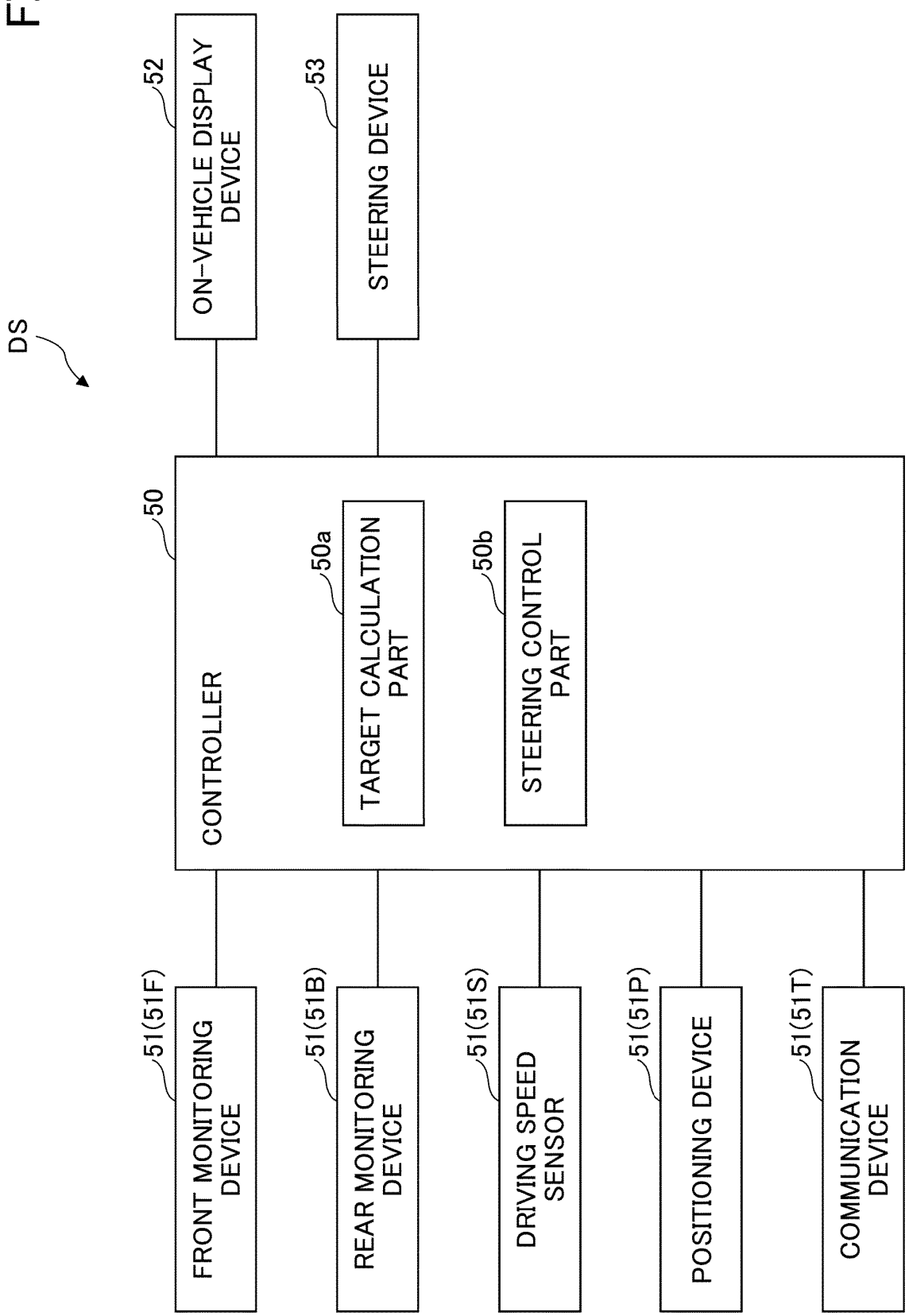
RB
NP

FIG.3


DS
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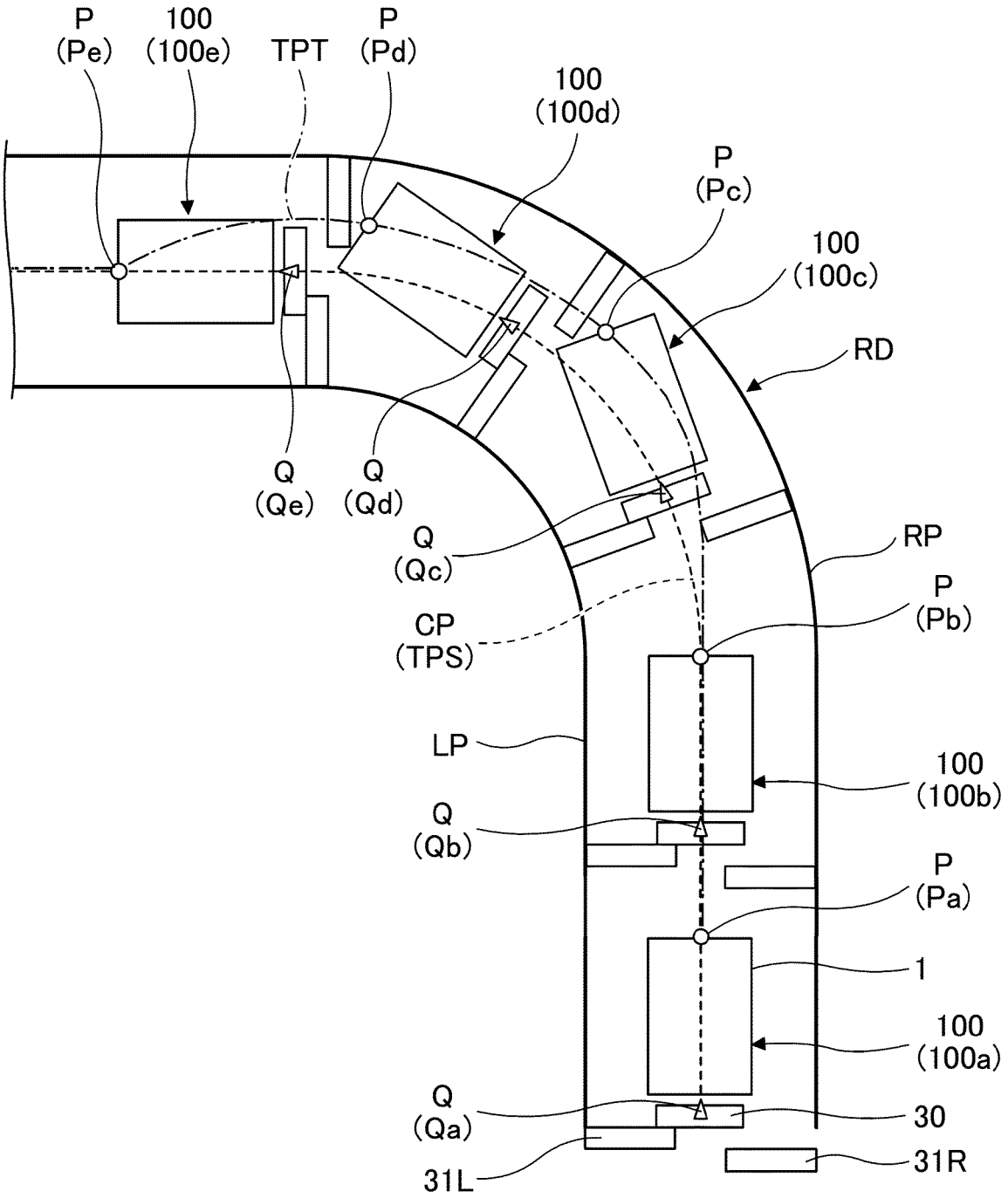
ON-VEHICLE DISPLAY DEVICE
53
STEERING DEVICE
50
CONTROLLER
50a
TARGET CALCULATION PART
50b
STEERING CONTROL PART
51(51F)
FRONT MONITORING DEVICE
51(51B)
REAR MONITORING DEVICE
51(51S)
DRIVING SPEED SENSOR
51(51P)
POSITIONING DEVICE
51(51T)
COMMUNICATION DEVICE

FIG.4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31R

FIG.5

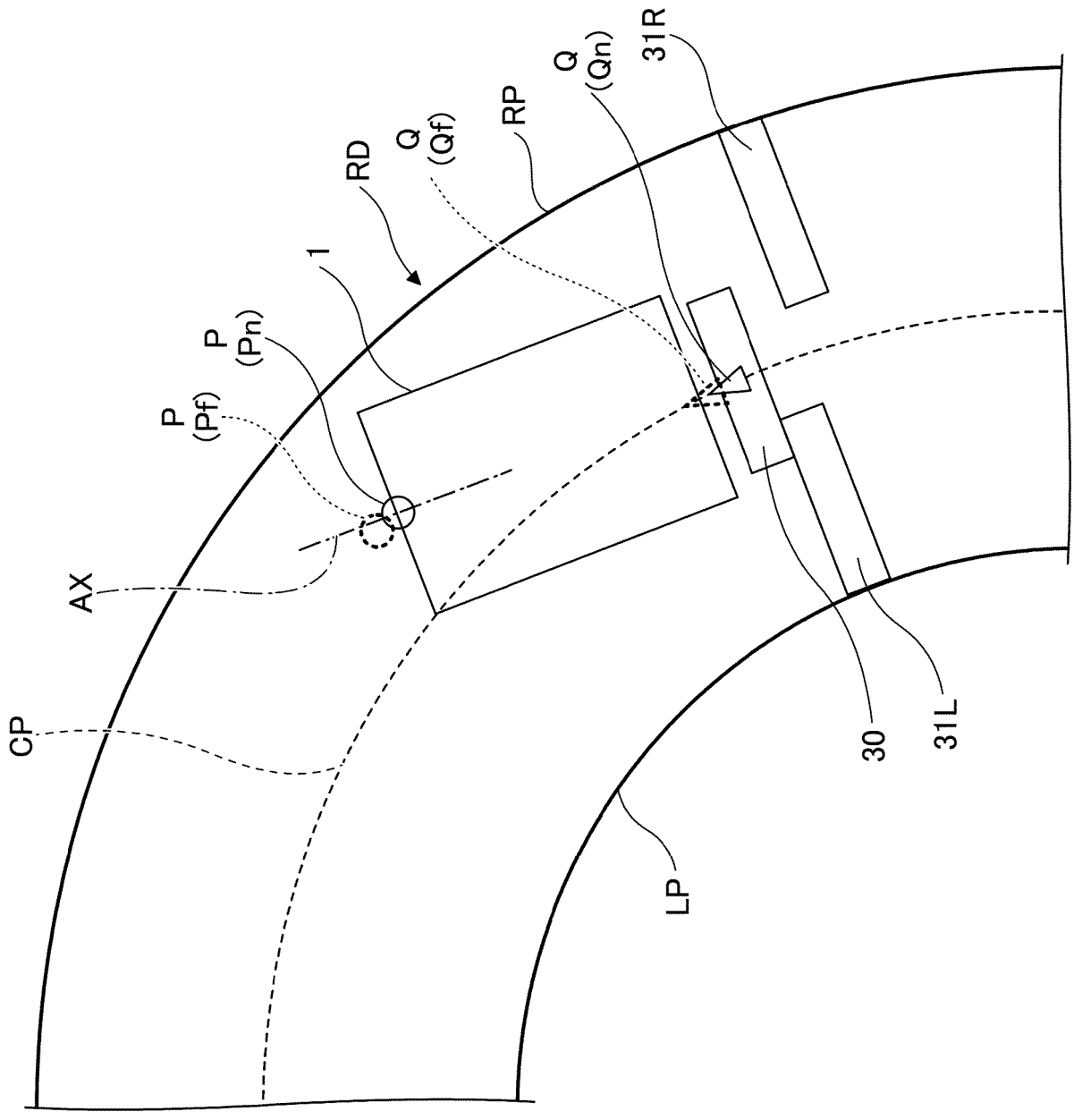


FIG.6A

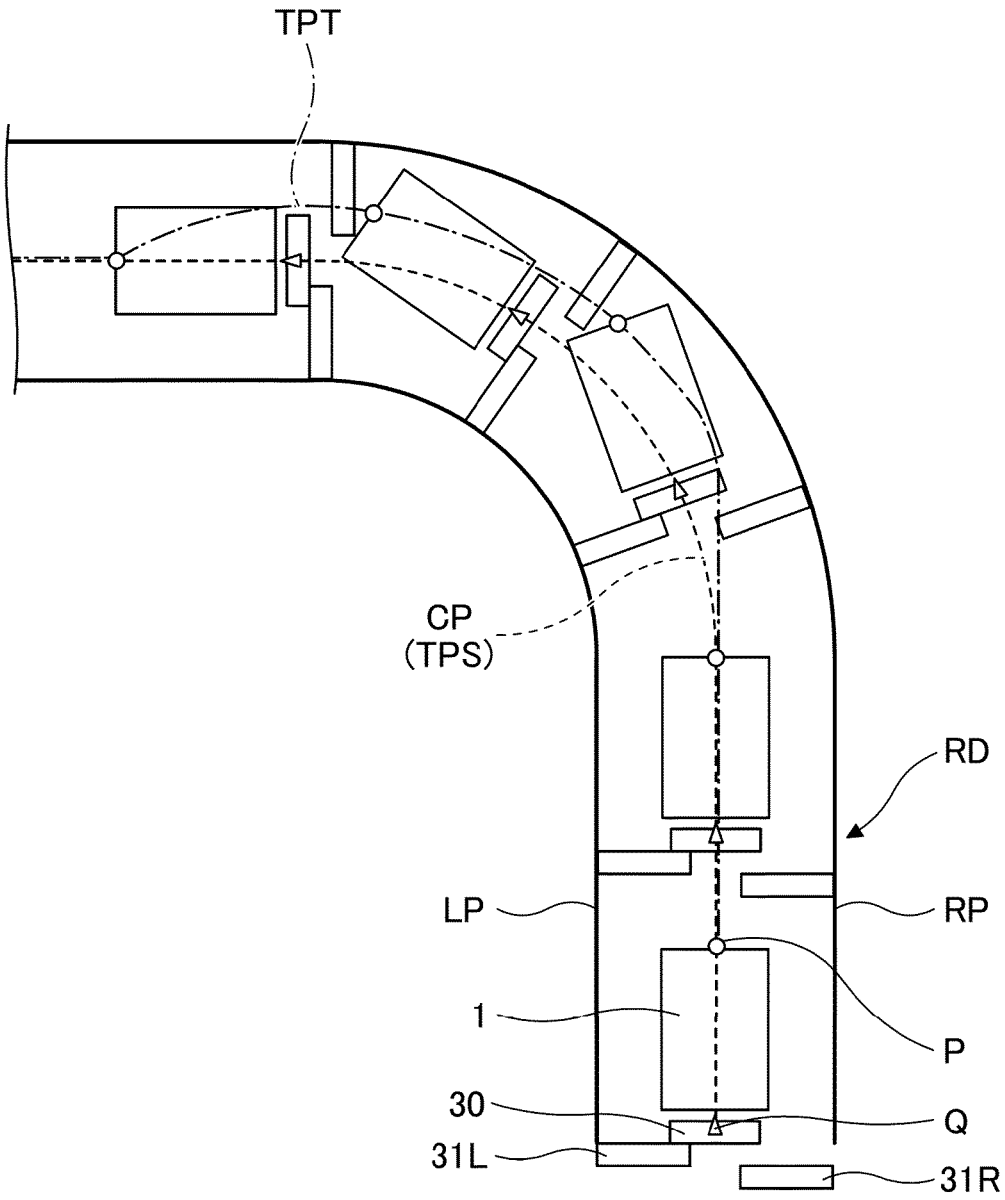
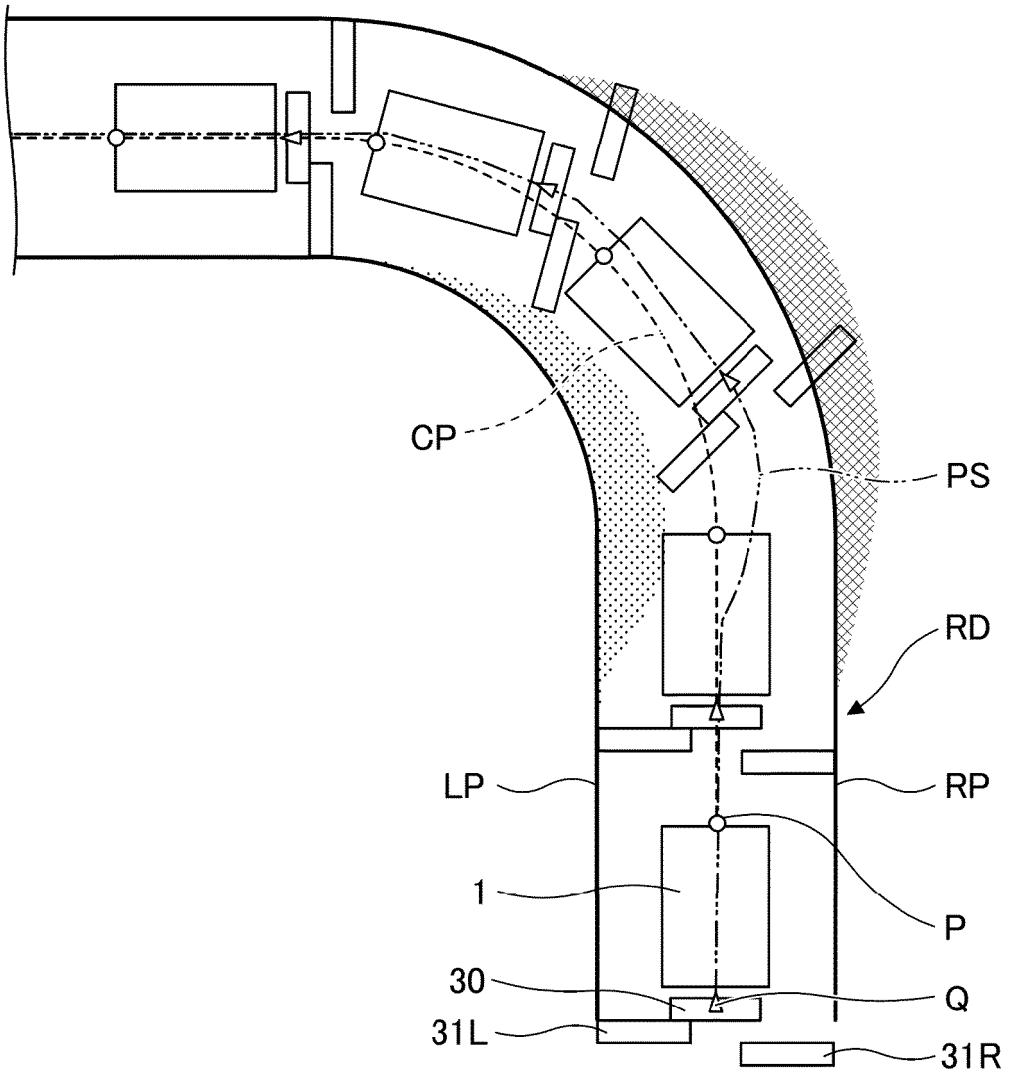


FIG.6B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/011078

A. CLASSIFICATION OF SUBJECT MATTER
E01C 19/48(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	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 018062/1993 (Laid-open No. 031907/1995) (KENSETSUSHO TOHOKU CHIHO KENSETSU KYOKUCHO, ADVANCED CONSTRUCTION TECHNOLOGY CENTER, OBAYASHI ROAD CORPORATION, KAJIMAROAD CO., LTD.) 16 June 1995 (1995-06-16) paragraphs [0001]-[0017], fig. 1-5	1-8
Y	paragraphs [0001]-[0017], fig. 1-5	1-8
X	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 019832/1992 (Laid-open No. 083806/1993) (TOYO UMPANKI CO., LTD.) 12 November 1993 (1993-11-12) paragraphs [0002]-[0031], fig. 1-10	1-8
Y	paragraphs [0002]-[0031], fig. 1-10	1-8

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 May 2021 (11.05.2021)	18 May 2021 (18.05.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/011078

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 49-012631 A (SUMITOMO HEAVY INDUSTRIES, LTD.) 04 February 1974 (1974-02-04) page 2, lower right column, line 1 to page 3, upper left column, line 6, fig. 1, 2	1-8
Y	page 2, lower right column, line 1 to page 3, upper left column, line 6, fig. 1, 2	1-8
X	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 111417/1991 (Laid-open No. 047010/1993) (SHIN CATERPILLAR MITSUBISHI LTD.) 22 June 1993 (1993-06-22) paragraphs [0004]-[0017], fig. 1-8	1-8
Y	paragraphs [0004]-[0017], fig. 1-8	1-8
X	JP 61-097713 A (NIIGATA ENG CO., LTD., NIPPON HOSO KK) 16 May 1986 (1986-05-16) page 2, upper right column, line 9 to page 4, upper right column, line 3, fig. 1-7	1-8
Y	page 2, upper right column, line 9 to page 4, upper right column, line 3, fig. 1-7	1-8
Y	WO 2019/031318 A1 (SUMITOMO (S.H.I.) CONSTRUCTION MACHINERY COMPANY, LIMITED) 14 February 2019 (2019-02-14) paragraphs [0126]-[0134], fig. 1-14	1-8

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/011078

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 07-031907 U1	16 Jun. 1995	US 5546123 A column 2, line 29 to column 4, line 21, fig. 1-5	
JP 05-083806 U1	12 Nov. 1993	(Family: none)	
JP 49-012631 A	04 Feb. 1974	(Family: none)	
JP 05-047010 U1	22 Jun. 1993	(Family: none)	
JP 61-097713 A	16 May 1986	(Family: none)	
WO 2019/031318 A1	14 Feb. 2019	CN 111032958 A	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2017160636 A **[0004]**
- JP 2020056662 A **[0080]**