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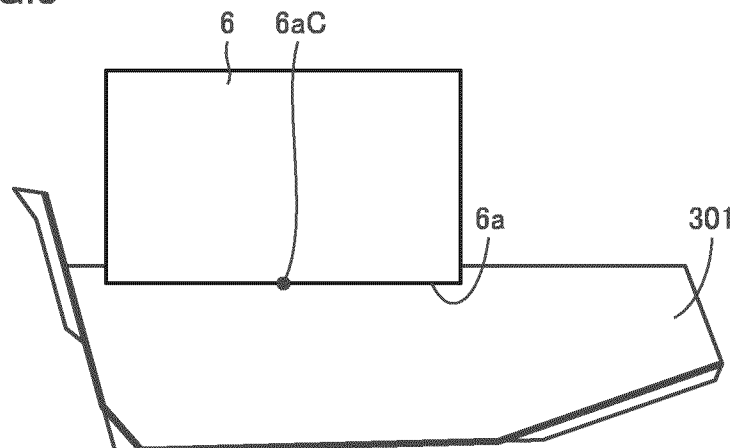
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(54) **SYSTEM INCLUDING WORK MACHINE AND METHOD OF CONTROLLING WORK MACHINE**

(57) A system that allows increase in amount of loading of loads in a container is provided. A work machine includes a bucket (6). The system including the work machine includes an information obtaining unit that obtains information on a vessel (301) of a dump truck into which loads carried in the bucket (6) are to be loaded and

a controller. The controller determines a loading position which is a position of the bucket (6) relative to the vessel (301) in loading the loads into the vessel (301), based on dimension information on a dimension in a width direction of the bucket (6) and the information on the vessel (301).

FIG.8



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a system including a work machine and a method of controlling a work machine.

BACKGROUND ART

[0002] Japanese Patent Laying-Open No. 2017-43887 (PTL 1) discloses a control system that divides a vessel of a dump truck into a central region, a left region, and a right region and shows loading guidance so as to sequentially load in each region, an object to be loaded.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: Japanese Patent Laying-Open No. 2017-43887

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] A work machine loads loads into a container such as a vessel of a dump truck. The vessel of the dump truck often has the entire length longer than a width of a bucket of the work machine. In order to increase an amount of loading of loads in the dump truck, a loading position in a fore/aft direction in the vessel should be managed for loading.

[0005] The present disclosure proposes a system including a work machine and a method of controlling a work machine that allow increase in amount of loading of loads in a container.

SOLUTION TO PROBLEM

[0006] According to one aspect of the present disclosure, a system including a work machine is proposed. The work machine includes a work implement. The system includes an information obtaining unit that obtains information on a container into which loads carried in the work implement are to be loaded and a controller. The controller determines a loading position which is a position of the work implement relative to the container in loading the loads into the container, based on dimension information on a dimension in a width direction of the work implement and the information on the container.

[0007] According to one aspect of the present disclosure, a method of controlling a work machine is proposed. The method includes obtaining dimension information on a dimension in a width direction of a work implement, obtaining information on a container into which loads carried in the work implement are to be loaded, and

determining as a loading position, a position to which the work implement is to be moved with respect to the container in loading of the loads into the container, based on the dimension information of the work implement and the information on the container.

[0008] According to one aspect of the present disclosure, a system including a work machine is proposed. The work machine includes a work implement. The system includes an information obtaining unit that obtains information on a container into which loads carried in the work implement are to be loaded and a controller. The controller determines a target position to which the work implement from which the loads are loaded into the container is headed, based on dimension information on a dimension in a width direction of the work implement and dimension information on a dimension in a fore/aft direction of the container.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009] According to the system including the work machine and the method of controlling the work machine in the present disclosure, the amount of loading of loads in the container can be increased.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 is a side view of a wheel loader as an exemplary work machine.

Fig. 2 is a block diagram showing an overall configuration of a control system that controls the wheel loader.

Fig. 3 is a plan view of the wheel loader that performs excavation and loading works.

Fig. 4 is a block diagram showing a configuration of an automatic control system that controls the wheel loader.

Fig. 5 is a schematic diagram of a vessel of a dump truck viewed from a lateral side.

Fig. 6 is a flowchart showing a flow of operations to load loads carried in a bucket into a container under automatic control.

Fig. 7 is a schematic diagram showing progress of a loading work for loading loads into the vessel in four-time loading.

Fig. 8 is a schematic diagram showing a first exemplary loading position.

Fig. 9 is a schematic diagram showing a second exemplary loading position.

Fig. 10 is a schematic diagram showing a third exemplary loading position.

Fig. 11 is a schematic diagram showing a second example of the loading work for loading loads into the vessel in four-time loading.

Fig. 12 is a schematic diagram showing a third example of the loading work for loading loads into the

vessel in four-time loading.

DESCRIPTION OF EMBODIMENTS

[0011] An embodiment will be described below with reference to the drawings. The same components and constituent elements in the description below have the same reference characters allotted and their labels and functions are also the same. Therefore, detailed description thereof will not be repeated. Extraction of any features from the embodiment and any combination thereof are also originally intended.

<Overall Construction of Wheel Loader 1>

[0012] In an embodiment, a wheel loader 1 as an exemplary work machine will be described. Fig. 1 is a side view of wheel loader 1 as an exemplary work machine.

[0013] As shown in Fig. 1, wheel loader 1 includes a vehicular body frame 2, a work implement 3, a travel apparatus 4, and a cab 5. A vehicular body of wheel loader 1 is composed of vehicular body frame 2, cab 5, and the like. Work implement 3 and travel apparatus 4 are attached to the vehicular body of wheel loader 1. A main body of wheel loader 1 includes the vehicular body and travel apparatus 4.

[0014] Travel apparatus 4 serves for travel of the vehicular body of wheel loader 1 and includes running wheels 4a and 4b. Wheel loader 1 is a wheeled vehicle provided with running wheels 4a and 4b as rotational bodies for travel, on opposing sides in a lateral direction of the vehicular body. Wheel loader 1 is self-propelled as running wheels 4a and 4b are rotationally driven and can perform desired works with work implement 3. Travel apparatus 4 corresponds to an exemplary travel unit.

[0015] A direction in which wheel loader 1 travels straight is herein referred to as a fore/aft direction of wheel loader 1. In the fore/aft direction of wheel loader 1, a side where work implement 3 is arranged with respect to vehicular body frame 2 is defined as the fore direction and a side opposite to the fore direction is defined as the aft direction. The lateral direction of wheel loader 1 refers to a direction orthogonal to the fore/aft direction when wheel loader 1 on a flat ground is viewed in a plan view. A right side and a left side in the lateral direction when one faces the fore direction are defined as a right direction and a left direction, respectively. An upward/downward direction of wheel loader 1 is a direction orthogonal to the plane defined by the fore/aft direction and the lateral direction. A side where the ground is located and a side where the sky is located in the upward/downward direction are defined as a lower side and an upper side, respectively.

[0016] Vehicular body frame 2 includes a front frame 2a and a rear frame 2b. Front frame 2a is arranged in front of rear frame 2b. Front frame 2a and rear frame 2b are attached to each other as being laterally operable.

[0017] A pair of steering cylinders 11 is attached across front frame 2a and rear frame 2b. Steering cylinder 11 is a hydraulic cylinder. As steering cylinder 11 extends and contracts with hydraulic oil from a steering pump, a direction of travel of wheel loader 1 laterally changes. Vehicular body frame 2 in an articulated structure is composed of front frame 2a and rear frame 2b. Wheel loader 1 is an articulated work machine in which front frame 2a and rear frame 2b are coupled to allow a flexion operation.

[0018] Work implement 3 and a pair of running wheels (front wheels) 4a are attached to front frame 2a. Work implement 3 is attached in front of the main body of wheel loader 1. Work implement 3 is supported by the vehicular body of wheel loader 1. Work implement 3 includes a boom 14 and a bucket 6. Bucket 6 is arranged at a tip end of work implement 3. Bucket 6 is a work tool for excavation and loading. A cutting edge 6a is a tip end portion of bucket 6. A rear surface 6b is a part of an outer surface of bucket 6. Rear surface 6b is formed from a plane. Rear surface 6b extends rearward from cutting edge 6a.

[0019] Boom 14 has a base end portion rotatably attached to front frame 2a by a boom pin 9. Bucket 6 is rotatably attached to boom 14 by a bucket pin 17 located at a tip end of boom 14. Boom pin 9 and bucket pin 17 correspond to a plurality of articulations of work implement 3.

[0020] Work implement 3 further includes a bell crank 18 and a link 15. Bell crank 18 is rotatably supported on boom 14 by a support pin 18a located substantially in a center of boom 14. Link 15 is coupled to a coupling pin 18c provided at a tip end portion of bell crank 18. Link 15 couples bell crank 18 and bucket 6 to each other.

[0021] Front frame 2a and boom 14 are coupled to each other by a pair of boom cylinders 16. Boom cylinder 16 is a hydraulic cylinder. Boom cylinder 16 rotationally drives boom 14 upward and downward around boom pin 9. Boom cylinder 16 has a base end attached to front frame 2a. Boom cylinder 16 has a tip end attached to boom 14. Boom cylinder 16 is a hydraulic actuator that operates boom 14 upward and downward with respect to front frame 2a. With movement upward and downward of boom 14, bucket 6 attached at the tip end of boom 14 also moves upward and downward.

[0022] A bucket cylinder 19 couples bell crank 18 and front frame 2a to each other. Bucket cylinder 19 has a base end attached to front frame 2a. Bucket cylinder 19 has a tip end attached to a coupling pin 18b provided at a base end portion of bell crank 18. Bucket cylinder 19 is a hydraulic actuator to cause bucket 6 to pivot upward and downward with respect to boom 14. Bucket cylinder 19 is a work tool cylinder that drives bucket 6. Bucket cylinder 19 rotationally drives bucket 6 around bucket pin 17. Bucket 6 is constructed as being operable with respect to boom 14. Bucket 6 is constructed as being operable with respect to front frame 2a.

[0023] Boom cylinder 16 and bucket cylinder 19 correspond to an exemplary work implement actuator that

drives work implement 3. Travel apparatus 4 as well as boom cylinder 16 and bucket cylinder 19 correspond to an exemplary "movement operation portion" that moves work implement 3.

[0024] Cab 5 on which an operator rides and a pair of running wheels (rear wheels) 4b are attached to rear frame 2b. Cab 5 in a box shape is arranged in the rear of boom 14. Cab 5 is carried on vehicular body frame 2. In cab 5, a seat where the operator of wheel loader 1 is seated, an operation apparatus 8 which will be described later, and the like are arranged.

[0025] Cab 5 is provided with a perception device 111. Perception device 111 is arranged, for example, in a ceiling portion of cab 5. Perception device 111 is mounted, for example, on an upper surface of cab 5. Perception device 111 is arranged, for example, in a front portion of cab 5. Perception device 111 is attached to cab 5, for example, as facing forward, and it can obtain information on the front of cab 5. Details of perception device 111 will be described later.

<System Configuration>

[0026] Fig. 2 is a block diagram showing an overall configuration of a control system that controls wheel loader 1.

[0027] An engine 21 is a drive source that generates drive force to drive work implement 3 and travel apparatus 4, and it is, for example, a diesel engine. A motor driven by a power storage, instead of engine 21, may be employed as the drive source, or both of the engine and the motor may be employed. Output from engine 21 is controlled by adjustment of an amount of fuel to be injected into a cylinder of engine 21.

[0028] Drive force generated by engine 21 is transmitted to a transmission 23. Transmission 23 converts drive force into appropriate torque and a rotation speed. An axle 25 is connected to an output shaft of transmission 23. Drive force converted by transmission 23 is transmitted to axle 25. Drive force is transmitted from axle 25 to running wheels 4a and 4b (Fig. 1). Wheel loader 1 thus travels. In wheel loader 1 in the embodiment, both of running wheel 4a and running wheel 4b implement drive wheels for travel of wheel loader 1 upon receiving drive force.

[0029] Some of drive force from engine 21 is transmitted to a work implement pump 13. Work implement pump 13 is a hydraulic pump driven by engine 21 to activate work implement 3 with hydraulic oil it delivers. Work implement 3 is driven by hydraulic oil from work implement pump 13. Hydraulic oil delivered by work implement pump 13 is supplied to boom cylinder 16 and bucket cylinder 19 through a main valve 32. As boom cylinder 16 extends and contracts upon receiving supply of hydraulic oil, boom 14 moves upward and downward. As bucket cylinder 19 extends and contracts upon receiving supply of hydraulic oil, bucket 6 pivots upward and downward.

[0030] Wheel loader 1 includes a vehicular body controller 50. Vehicular body controller 50 includes an engine controller 60, a transmission controller 70, and a work implement controller 80.

[0031] Vehicular body controller 50 is generally implemented by reading of various programs by a central processing unit (CPU). Vehicular body controller 50 includes a not-shown memory. The memory functions as a work memory, and various programs for performing functions of wheel loader 1 are stored in the memory.

[0032] Operation apparatus 8 is provided in cab 5. Operation apparatus 8 is operated by an operator. Operation apparatus 8 includes a plurality of types of operation members operated by the operator to operate wheel loader 1. Operation apparatus 8 includes an accelerator pedal 41 and a work implement control lever 42. Operation apparatus 8 may include a steering wheel, a shift lever, and the like which are not shown.

[0033] Accelerator pedal 41 is operated to set the target number of rotations of engine 21. Engine controller 60 controls output from engine 21 based on an amount of operation onto accelerator pedal 41. With increase in amount of operation (amount of pressing) onto accelerator pedal 41, output from engine 21 increases. With decrease in amount of operation onto accelerator pedal 41, output from engine 21 decreases. Transmission controller 70 controls transmission 23 based on the amount of operation onto accelerator pedal 41.

[0034] Work implement control lever 42 is operated to operate work implement 3. Work implement controller 80 controls electromagnetic proportional control valves 35 and 36 based on the amount of operation onto work implement control lever 42.

[0035] Electromagnetic proportional control valve 35 switches main valve 32 such that bucket cylinder 19 contracts to move bucket 6 in a dump direction (a direction in which the cutting edge of bucket 6 is lowered). Electromagnetic proportional control valve 35 switches main valve 32 such that bucket cylinder 19 extends to move bucket 6 in a tilt direction (a direction in which the cutting edge of bucket 6 is raised). Electromagnetic proportional control valve 36 switches main valve 32 such that boom cylinder 16 contracts to lower boom 14. Electromagnetic proportional control valve 36 switches main valve 32 such that boom cylinder 16 extends to raise boom 14.

[0036] A machine monitor 51 shows various types of information upon receiving input of a command signal from vehicular body controller 50. The various types of information shown on machine monitor 51 may be, for example, information on works performed by wheel loader 1, vehicular body information such as an amount of remaining fuel, a temperature of coolant, and a temperature of hydraulic oil, an image of surroundings obtained by image pick-up of the surroundings of wheel loader 1, and the like. Machine monitor 51 may be implemented by a touch panel, and in this case, a signal generated by touching by the operator onto a part of machine monitor

51 is outputted from machine monitor 51 to vehicular body controller 50.

<Excavation and Loading Works>

[0037] Wheel loader 1 in the present embodiment performs excavation and loading works to scoop an excavation target such as soil and to load the excavation target onto a loading target such as a dump truck. Fig. 3 is a plan view of wheel loader 1 that performs excavation and loading works. Fig. 3 illustrates wheel loader 1 that performs what is called a V shape work.

[0038] Fig. 3 (A) illustrates wheel loader 1 that performs what is called unloaded forward travel. Wheel loader 1 travels forward along an excavation path R1 toward an excavation target 310 such as soil. Wheel loader 1 plunges bucket 6 into excavation target 310 and stops forward travel. By raising bucket 6 with cutting edge 6a of bucket 6 dug into excavation target 310, the excavation work to scoop excavation target 310 in bucket 6 is performed.

[0039] Fig. 3 (B) illustrates wheel loader 1 that performs what is called loaded rearward travel. Excavation target 310 has been loaded in bucket 6. Wheel loader 1 travels rearward along excavation path R1 to a position from which it started forward travel in Fig. 3 (A).

[0040] Fig. 3 (C) illustrates wheel loader 1 that performs what is called loaded forward travel. With excavation target 310 having been loaded in bucket 6, wheel loader 1 travels forward toward a vessel 301 of a dump truck 300. Wheel loader 1 travels forward along a loading path R2 from the position where it started forward travel in Fig. 3 (A) toward dump truck 300. When wheel loader 1 approaches dump truck 300 and reaches a prescribed position, it loads excavation target 310 in bucket 6 into vessel 301. Vessel 301 corresponds to an exemplary "container" into which loads carried in work implement 3 are to be loaded.

[0041] Fig. 3 (D) illustrates wheel loader 1 that performs what is called unloaded rearward travel. While bucket 6 is empty as a result of full ejection of excavation target 310 in bucket 6 into vessel 301 of dump truck 300, wheel loader 1 travels rearward along loading path R2 to the position where it started forward travel in Fig. 3 (C).

[0042] Wheel loader 1 can thus repeatedly perform a series of works including excavation, rearward travel, dump approach, soil ejection, and rearward travel.

<Automatic Control System that Controls Wheel loader 1>

[0043] In automating a loading work for loading onto dump truck 300 by wheel loader 1, in order to more quickly perform the loading work while an amount of works is ensured without contact of bucket 6 with vessel 301, reproduction of operations of work implement 3 by a skilled operator under automatic control has been desired. Fig. 4 is a block diagram showing a configuration of

an automatic control system that controls wheel loader 1.

[0044] An automation controller 100 is configured to transmit and receive a signal to and from vehicular body controller 50 described with reference to Fig. 2. Automation controller 100 is configured to transmit and receive a signal to and from an external information obtaining unit 110. External information obtaining unit 110 includes perception device 111 and a positional information obtaining device 112. Perception device 111 and positional information obtaining device 112 are mounted on wheel loader 1.

[0045] Perception device 111 obtains information on surroundings of wheel loader 1. Perception device 111 is attached, for example, to a front portion of the upper surface of cab 5. Perception device 111 corresponds to an exemplary object sensor that detects an object around the main body of wheel loader 1.

[0046] Perception device 111 contactlessly detects a direction of an object outside wheel loader 1 and a distance to the object. Perception device 111 is implemented, for example, by light detection and ranging (LiDAR) that obtains information on an object by emission of laser beams. Perception device 111 may be implemented by a visual sensor including a camera. Perception device 111 may be implemented by radio detection and ranging (Radar) that obtains information on an object by emission of radio waves. Perception device 111 may be implemented by an infrared sensor.

[0047] Positional information obtaining device 112 obtains information on a current position of wheel loader 1. Positional information obtaining device 112 obtains, for example, positional information of wheel loader 1 in a global coordinate system with the Earth being defined as a reference, with the use of a satellite positioning system. Positional information obtaining device 112 uses, for example, global navigation satellite systems (GNSS) and includes a GNSS receiver. The satellite positioning system calculates a position of wheel loader 1 by computing a position of an antenna of the GNSS receiver based on a positioning signal received from a satellite by the GNSS receiver.

[0048] External information on the outside of wheel loader 1 obtained by perception device 111 and positional information of wheel loader 1 obtained by positional information obtaining device 112 are inputted to automation controller 100.

[0049] Vehicular body controller 50 is configured to transmit and receive a signal to and from a vehicle information obtaining unit 120, and receives input of information on wheel loader 1 obtained by vehicle information obtaining unit 120. Vehicle information obtaining unit 120 is composed of various sensors mounted on wheel loader 1. Vehicle information obtaining unit 120 includes an articulation angle sensor 121, a vehicle speed sensor 122, a boom angle sensor 123, a bucket angle sensor 124, and a boom cylinder pressure sensor 125.

[0050] Articulation angle sensor 121 detects an articu-

lation angle which is an angle formed between front frame 2a and rear frame 2b, and generates a signal indicating the detected articulation angle. Articulation angle sensor 121 outputs a signal indicating the articulation angle to vehicular body controller 50.

[0051] Vehicle speed sensor 122 detects a speed of movement of wheel loader 1 by travel apparatus 4, for example, by detection of a rotation speed of an output shaft of transmission 23 and generates a signal indicating the detected vehicle speed. Vehicle speed sensor 122 outputs the signal indicating the vehicle speed to vehicular body controller 50. Vehicle speed sensor 122 corresponds to an exemplary travel sensor that detects a status of travel of travel apparatus 4 (travel unit).

[0052] Boom angle sensor 123 is implemented, for example, by a rotary encoder provided in boom pin 9 which is a portion of attachment of boom 14 to vehicular body frame 2. Boom angle sensor 123 detects an angle of boom 14 with respect to a horizontal direction and generates a signal indicating the detected angle of boom 14. Boom angle sensor 123 outputs the signal indicating the angle of boom 14 to vehicular body controller 50.

[0053] Bucket angle sensor 124 is implemented, for example, by a rotary encoder provided in support pin 18a which is a rotation shaft of bell crank 18. Bucket angle sensor 124 detects an angle of bucket 6 with respect to boom 14 and generates a signal indicating the detected angle of bucket 6. Bucket angle sensor 124 outputs the signal indicating the angle of bucket 6 to vehicular body controller 50.

[0054] Boom angle sensor 123 and bucket angle sensor 124 correspond to an exemplary work implement posture sensor that detects a posture of work implement 3.

[0055] Boom cylinder pressure sensor 125 detects a pressure on a bottom side (boom bottom pressure) of boom cylinder 16 and generates a signal indicating the detected boom bottom pressure. The boom bottom pressure becomes higher while bucket 6 is loaded and becomes lower while the bucket is unloaded. Boom cylinder pressure sensor 125 outputs a signal indicating the boom bottom pressure to vehicular body controller 50.

[0056] Vehicular body controller 50 outputs information inputted from vehicle information obtaining unit 120 to automation controller 100. Automation controller 100 receives detection values from vehicle speed sensor 122, boom angle sensor 123, and bucket angle sensor 124 through vehicular body controller 50.

[0057] An actuator 140 is configured to transmit and receive a signal to and from vehicular body controller 50. Upon receiving a command signal from vehicular body controller 50, actuator 140 is driven. Actuator 140 includes a brake EPC (electromagnetic proportional control valve) 141 for activation of a brake of travel apparatus 4, a steering EPC 142 for adjustment of a travel direction of wheel loader 1, a work implement EPC 143 for operations of work implement 3, and a hydraulic mechanical transmission (HMT) 144.

[0058] Electromagnetic proportional control valves 35 and 36 shown in Fig. 2 implement work implement EPC 143. Transmission 23 shown in Fig. 2 is implemented as HMT 144 that utilizes electronic control. Transmission 23 may be a hydro-static transmission (HST). A power transmission apparatus that transmits motive power from engine 21 to running wheels 4a and 4b may include an electric drive apparatus such as a diesel electric drive apparatus, and may include any combination of the HMT, the HST, and the electric drive apparatus.

[0059] Transmission controller 70 includes a brake control unit 71 and an accelerator control unit 72. Brake control unit 71 outputs a command signal for control of activation of the brake to brake EPC 141. Accelerator control unit 72 outputs a command signal for control of the vehicle speed to HMT 144.

[0060] Work implement controller 80 includes a steering control unit 81 and a work implement control unit 82. Steering control unit 81 outputs a command signal for control of the travel direction of wheel loader 1 to steering EPC 142. Work implement control unit 82 outputs a command signal for control of operations of work implement 3 to work implement EPC 143.

[0061] Automation controller 100 includes a position estimator 101, a path planning unit 102, and a path tracking control unit 103.

[0062] Position estimator 101 estimates an own position of wheel loader 1 based on the positional information obtained by positional information obtaining device 112. Position estimator 101 recognizes a target position based on the external information obtained by perception device 111. The target position is, for example, a position of excavation target 310 or dump truck 300 shown in Fig. 3. Position estimator 101 can obtain a prescribed reference point of dump truck 300, such as a position of an upper end of a side surface of vessel 301. Perception device 111 may recognize the target position and input the target position to automation controller 100, or position estimator 101 may recognize the target position based on a result of detection by perception device 111.

[0063] Path planning unit 102 generates an optimal path of wheel loader 1 in automatic control of wheel loader 1. The optimal path includes a path for travel by travel apparatus 4 and a path for operations of work implement 3. For example, path planning unit 102 generates an optimal path of wheel loader 1 that performs loaded forward travel toward dump truck 300 and an optimal path of wheel loader 1 that moves away from dump truck 300 in unloaded rearward travel, in the loading work for loading onto dump truck 300. Path planning unit 102 generates an optimal path that connects a current own position of wheel loader 1 to a target position to which wheel loader 1 is headed from now, while the loading work for loading onto dump truck 300 is performed.

[0064] Path tracking control unit 103 controls the accelerator, the brake, and steering such that wheel loader 1 travels as following the optimal path generated by path

planning unit 102. Path tracking control unit 103 outputs a command signal for travel of wheel loader 1 along the optimal path to brake control unit 71, accelerator control unit 72, and steering control unit 81. Path tracking control unit 103 controls boom cylinder 16 and bucket cylinder 19 such that work implement 3 operates along the optimal path generated by path planning unit 102. Path tracking control unit 103 outputs a command signal for movement of work implement 3 along the optimal path to work implement control unit 82.

[0065] An interface 130 is configured to transmit and receive a signal to and from vehicular body controller 50. Interface 130 includes an automation switch 131, an engine emergency stop switch 132, and a mode indicator 133.

[0066] Automation switch 131 is operated by the operator. The operator operates automation switch 131 to switch between a manual operation of wheel loader 1 and automatic control of wheel loader 1. Engine emergency stop switch 132 is operated by the operator. When an event that requires emergency stop of engine 21 occurs, the operator operates engine emergency stop switch 132. A signal resulting from an operation onto automation switch 131 and engine emergency stop switch 132 is inputted to vehicular body controller 50.

[0067] Mode indicator 133 indicates whether wheel loader 1 is currently in a mode of the manual operation by the operator or an automatic control mode. Vehicular body controller 50 outputs a command signal for control of turn-on of the indicator to mode indicator 133.

<Vessel 301>

[0068] Fig. 5 is a schematic diagram of vessel 301 of dump truck 300 viewed from a lateral side, as an exemplary container into which loads carried in work implement 3 (bucket 6) are to be loaded. Fig. 5 and subsequent Figs. 7 to 12 illustrate a general shape of vessel 301 viewed from the left side of dump truck 300. A bold line in the figures represent the general shape when a surface defining an internal geometry of vessel 301 is viewed from the left of dump truck 300.

[0069] In Figs. 5 and 7 to 12, the lateral direction in the figures corresponds to the fore/aft direction of dump truck 300 (the fore/aft direction of vessel 301). In Figs. 5 and 7 to 12, the left direction in the figures corresponds to the fore direction of dump truck 300 (vessel 301) and the right direction in the figures corresponds to the aft direction of dump truck 300 (vessel 301). In Figs. 5 and 7 to 12, a direction perpendicular to the sheet plane corresponds to the lateral direction of dump truck 300 (the lateral direction of vessel 301). In Figs. 5 and 7 to 12, the upward/downward direction in the figures corresponds to the upward/downward direction of dump truck 300 (the upward/downward direction of vessel 301).

[0070] Vessel 301 is provided in a rear portion of dump truck 300. A cab is provided in a front portion of dump truck 300, and vessel 301 is arranged in the rear of the

cab. Vessel 301 is structured such that an object to be loaded which has a weight, such as soil and crushed stone, can be carried therein.

[0071] As shown in Fig. 5, vessel 301 includes a bottom surface 302, a front wall surface 303, and a rear inclined surface 305. Bottom surface 302 is in a flat shape. Bottom surface 302 is in a planar shape extending in the fore/aft direction and the lateral direction of dump truck 300 (vessel 301).

[0072] Front wall surface 303 is in a flat shape. Front wall surface 303 extends forward and upward from a front end of bottom surface 302. Front wall surface 303 extends as being inclined forward, toward the upward direction. Front wall surface 303 forms a front wall surface of vessel 301. The front wall surface of vessel 301 is inclined upward, toward the front. Front wall surface 303 is provided with a front upper edge 304. Front upper edge 304 extends in the lateral direction. Front upper edge 304 forms a front edge portion of vessel 301.

[0073] Rear inclined surface 305 is in a flat shape. Rear inclined surface 305 extends rearward and upward from a rear end of bottom surface 302. Rear inclined surface 305 extends as being inclined rearward, toward the upward direction. Rear inclined surface 305 is inclined upward, toward the rear. Rear inclined surface 305 is provided with a rear upper edge 306. Rear upper edge 306 extends in the lateral direction. Rear upper edge 306 forms a rear edge portion of vessel 301. Rear upper edge 306 is located at a position lower than front upper edge 304.

[0074] Fig. 5 illustrates the shape of vessel 301 without a tail gate. In an example where vessel 301 includes the tail gate, the tail gate is arranged to extend upward from the rear end of rear inclined surface 305. An upper edge of the tail gate forms rear upper edge 306.

<Flow of Automatic Loading on Dump>

[0075] Fig. 6 is a flowchart showing a flow of operations to load loads carried in bucket 6 into the container under automatic control of wheel loader 1. Vessel 301 of dump truck 300 is an exemplary container into which loads carried in work implement 3 (bucket 6) are to be loaded. The container is not limited to vessel 301 of dump truck 300, and for example, a hopper may be applicable.

[0076] In step S1, the number of times of loading indicating how many times wheel loader 1 should perform works for loading loads into vessel 301 of one dump truck 300 to achieve a condition of full load in vessel 301 is calculated.

[0077] For example, the shape of dump truck 300 is obtained by LiDAR which is perception device 111. Point group data indicating three-dimensional coordinate values of measurement points on dump truck 300 is obtained by irradiating dump truck 300 with laser beams from LiDAR. Dump truck 300 is sensed from four directions of the fore direction, the aft direction, the right direction, and the left direction, and the shape of vessel

301 can be recognized based on information on a point group. The recognized shape of vessel 301 is inputted to automation controller 100. Automation controller 100 calculates a maximum loading capacity of vessel 301 and calculates a dimension of vessel 301, based on the shape of vessel 301. Perception device 111 corresponds to an exemplary "information obtaining unit" that obtains information on vessel 301.

[0078] Wheel loader 1 and dump truck 300 may establish inter-vehicle communication with each other. Wheel loader 1 may include a communication unit that communicates with dump truck 300 in addition to the system configuration shown in Fig. 4. Through inter-vehicle communication between the communication unit of wheel loader 1 and a communication unit of dump truck 300, information on vessel 301 such as the maximum loading capacity of vessel 301 and the dimension of vessel 301 may be transmitted from dump truck 300 to wheel loader 1. In this case, the communication unit of wheel loader 1 corresponds to an exemplary "information obtaining unit" that obtains information on vessel 301.

[0079] Information on bucket 6 is stored in vehicular body controller 50. The information on bucket 6 includes a dimension of bucket 6 and a capacity of bucket 6. The dimension of bucket 6 includes a dimension in a width direction of bucket 6. The width direction of bucket 6 refers to a direction in parallel to a direction of extension of bucket pin 17 that couples bucket 6 and boom 14 to each other and a direction perpendicular to the sheet plane in Fig. 1. When an articulation angle of wheel loader 1 is 0° and wheel loader 1 travels straight, the width direction of bucket 6 coincides with the lateral direction of wheel loader 1. Cutting edge 6a of bucket 6 extends in the width direction of bucket 6. The dimension of bucket 6 includes a length by which cutting edge 6a extends in the width direction of bucket 6.

[0080] In wheel loader 1, bucket 6 is replaceable. Vehicular body controller 50 outputs the information on bucket 6 currently attached to the tip end of work implement 3 to automation controller 100.

[0081] A density of excavation target 310 excavated by wheel loader 1 and loaded into vessel 301 of dump truck 300 is also inputted to automation controller 100. The density of excavation target 310 may be estimated by automation controller 100 based on a result of detection of excavation target 310 by perception device 111 which is a visual sensor such as a camera. The density of excavation target 310 may be inputted by the operator through interface 130.

[0082] The automation controller determines the number of times of loading based on the maximum loading capacity of vessel 301, the capacity of bucket 6, and the density of excavation target 310. When vessel 301 has the maximum loading capacity up to which excavation target 310 (loads) carried in bucket 6 can be loaded a plurality of times, the number of times of loading is set to the plurality of times. Though an example in which the number of times of loading is set to four times will be

described below, the number of times of loading is naturally not limited to four times.

[0083] In step S2, automation controller 100 determines as the loading position, a position to which work implement 3 (bucket 6) is to be moved with respect to vessel 301 in loading of loads carried in work implement 3 (bucket 6) into vessel 301. The loading position is a position of work implement 3 (bucket 6) relative to vessel 301 in loading the loads carried in work implement 3 (bucket 6) into vessel 301.

[0084] Fig. 7 is a schematic diagram showing progress of a loading work for loading loads into vessel 301 in four-time loading. Fig. 7 (A) shows a condition in vessel 301 after first loading of loads. Fig. 7 (B), (C), and (D) shows conditions in vessel 301 after second, third, and fourth loadings of the loads, respectively. Fig. 7 (D) shows a state in which the work for loading into vessel 301 has been completed.

[0085] Fig. 8 is a schematic diagram showing a first exemplary loading position. Fig. 9 is a schematic diagram showing a second exemplary loading position. Fig. 10 is a schematic diagram showing a third exemplary loading position. Figs. 8 to 10 schematically illustrate vessel 301 viewed from the left. Figs. 8 to 10 schematically illustrate bucket 6 viewed from the rear of wheel loader 1 (viewed when one faces front). Bucket 6 is provided with cutting edge 6a that extends in the width direction. A central point 6aC is a central point of cutting edge 6a in the width direction of bucket 6.

[0086] Wheel loader 1 travels forward from the lateral side (left) of dump truck 300 toward vessel 301 and performs the loading work. The width direction of bucket 6 during the loading work coincides with the fore/aft direction (in Figs. 8 to 10, the lateral direction in the figures) of dump truck 300 (vessel 301). As shown in Figs. 8 to 10, the dimension in the fore/aft direction of vessel 301 is larger than the dimension in the width direction of bucket 6.

[0087] Bucket 6 shown in Figs. 8 to 10 is in a full dump posture. Bucket 6 in the posture shown in Figs. 8 to 10 has moved to its maximum in the dump direction. When bucket 6 is in the posture shown in Figs. 8 to 10, a cylinder stroke length of bucket cylinder 19 is minimized.

[0088] Fig. 8 shows a loading position A in first loading. Fig. 8 shows a loading position B in second loading. Fig. 9 shows a loading position C in third loading. Fig. 10 shows a loading position D in fourth loading.

[0089] Fig. 7 (A) shows with a reference A, loads loaded from loading position A in the first loading. Fig. 7 (B) shows with a reference B, loads loaded from loading position B in the second loading, over the loads loaded in the first loading. Fig. 7 (C) shows with a reference C, loads loaded from loading position C in the third loading, over and in the rear of the loads loaded until the second loading. Fig. 7 (D) shows with a reference D, loads loaded from loading position D in the fourth loading, over the loads loaded until the third loading.

[0090] Automation controller 100 determines a posi-

tion where there is no interference by work implement 3 (bucket 6) in loading of loads in vessel 301, as loading position A, loading position B, and loading position D. Loading position A, loading position B, and loading position D are set as positions where a left end of bucket 6 is distant by a prescribed distance from front wall surface 303 of vessel 301 when bucket 6 in the full dump posture is viewed from the rear of wheel loader 1 (viewed when one faces front).

[0091] A position of the left end of bucket 6 relative to central point 6aC of cutting edge 6a is calculated based on the dimension in the width direction of bucket 6. While bucket 6 is located at loading position A, loading position B, and loading position D, the left end of bucket 6 is distant rearward by a prescribed distance from front wall surface 303 in the fore/aft direction of dump truck 300. While bucket 6 is located at loading position A, loading position B, and loading position D, there is a clearance in the fore/aft direction of dump truck 300 between the left end of bucket 6 and front wall surface 303 of dump truck 300.

[0092] Automation controller 100 determines as loading position C, a position where the loads loaded in vessel 301 do not fall from vessel 301. Loading position C is set as a position where a right end of bucket 6 is distant by a prescribed distance from rear upper edge 306 of vessel 301 when bucket 6 in the full dump posture is viewed from the rear of wheel loader 1 (viewed when one faces front).

A position of the right end of bucket 6 relative to central point 6aC of cutting edge 6a is calculated based on the dimension in the width direction of bucket 6. While bucket 6 is located at loading position C, the right end of bucket 6 is distant forward by a prescribed distance from rear upper edge 306 in the fore/aft direction of dump truck 300.

[0093] A height of cutting edge 6a of bucket 6 at each of loading position A, loading position B, loading position C, and loading position D is determined based on the capacity of bucket 6, the capacity of vessel 301, the number of times of loading (four times), and a height of the loads in vessel 301 estimated from records of the loading positions. The records of the loading positions indicate records about how many times loading was performed before present loading and in which order loads were loaded to which position until previous loading. A shape of the load in vessel 301 is estimated from the records of the loading positions. The shape of the load in vessel 301 can also be defined as a fill factor of loads in vessel 301. As loading into vessel 301 is continued, the height of the loads in vessel 301 changes. The height of cutting edge 6a in present loading is determined in accordance with the height of the loads loaded in vessel 301 until previous loading.

[0094] As shown in Figs. 8 and 9, the height of cutting edge 6a at loading position C in the third loading is set to be higher than the height of cutting edge 6a at loading position A in the first loading and loading position B in the second loading. As shown in Figs. 9 and 10, the height of cutting edge 6a at loading position D in the fourth loading is set to be higher than the height of cutting edge 6a at

loading position C in the third loading. With progress of the loading work for loading of loads into vessel 301, the height of cutting edge 6a is set to be higher stepwise so as to avoid interference of operations of bucket 6 with the already loaded loads.

[0095] Front wall surface 303 of vessel 301 is inclined with respect to the fore/aft direction and the lateral direction of dump truck 300. Front wall surface 303 is inclined obliquely forward and upward, so as to be located forward toward the upward direction. The loading position is determined in conformity with an inclination of front wall surface 303 of vessel 301. As shown in Figs. 8 and 10, loading position D is arranged in front of loading position A and loading position B in dump truck 300. The loading position is determined depending on an angle of front wall surface 303.

[0096] Front upper edge 304 and rear upper edge 306 of vessel 301 are not equal to each other in height position, and front upper edge 304 is located at a position higher than rear upper edge 306. More loads are loaded on a front side of vessel 301. As shown in Fig. 7 (D), the loading position is determined such that the loads reach front upper edge 304 along front wall surface 303. The loading position is determined depending on the height of front wall surface 303.

[0097] Loading position C is set to a position where loads at an angle of repose do not fall from vessel 301 in loading of loads into vessel 301. For example, the loading position is determined in such a manner that, in view of an angle of repose of sand which is 30°, the angle of loads formed with respect to the fore/aft direction of dump truck 300 at rear upper edge 306 is not larger than 30°.

[0098] Referring back to Fig. 6, then in step S3, automation controller 100 recognizes an own position of wheel loader 1. Positional information obtaining device 112 obtains the current position of the vehicular body of wheel loader 1 and obtains the posture of the work implement with respect to the vehicular body with boom angle sensor 123 and bucket angle sensor 124, to thereby recognize the current positions of wheel loader 1 and work implement 3 in the global coordinate system. The position of cutting edge 6a of bucket 6 relative to vessel 301 of dump truck 300 can be calculated based on the current positions of wheel loader 1 and work implement 3 and the current position of dump truck 300 in the global coordinate system.

[0099] Alternatively, perception device 111 may be used to obtain the direction and the distance of vessel 301 of dump truck 300 from a position of arrangement of perception device 111, to thereby calculate the current position of cutting edge 6a of bucket 6 relative to vessel 301.

[0100] Automation controller 100 recognizes a target position. For example, in the loading work by four-time loading shown in Fig. 7, the automation controller recognizes how many times loading present loading is. When the present loading is the first loading, the target position is recognized as loading position A. When the present

loading is the second loading, the target position is recognized as loading position B. When the present loading is the third loading, the target position is recognized as loading position C. When the present loading is the fourth loading, the target position is recognized as loading position D.

[0101] Automation controller 100 generates an optimal path that connects the current own position of bucket 6 to the target position to which bucket 6 from which loads are loaded into vessel 301 is headed from now. As described above, the optimal path includes the path for travel by travel apparatus 4 and the path for operations of work implement 3.

[0102] Then in step S4, automation controller 100 has wheel loader 1 travel along the optimal path and has work implement 3 operate to perform loading to a designated portion of vessel 301. Automation controller 100 outputs a command for travel of travel apparatus 4 along the optimal path to brake control unit 71, accelerator control unit 72, and steering control unit 81 of vehicular body controller 50. Upon receiving a command signal, travel apparatus 4 operates. Automation controller 100 outputs a command to extend and contract boom cylinder 16 and bucket cylinder 19 to work implement control unit 82 of work implement controller 80. Upon receiving a command signal, boom cylinder 16 and bucket cylinder 19 operate.

[0103] In step S5, automation controller 100 determines whether or not the number of times of loading has reached a defined number. Since the number of times of loading has been set to four times, at time points of ends of the first, second, and third loadings, the number of times of loading has not reached the defined number. When the number of times of loading is determined as not having reached the defined number (NO in step S5), the process returns to step S3. The optimal path to a next target position is generated and loading of the loads into vessel 301 is repeated.

[0104] When the fourth loading ends and the number of times of loading is determined as having reached the defined number (YES in step S5), the process ends ("end" in Fig. 6).

<Another Example of Loading Work>

[0105] Fig. 11 is a schematic diagram showing a second example of the loading work for loading of loads into vessel 301 in four-time loading. Fig. 11 (A) shows with reference C, loads loaded from loading position C in the first loading. Fig. 11 (B) shows with reference A, loads loaded from loading position A in the second loading, over and in front of the loads loaded in the first loading. Fig. 11 (C) shows with reference B, loads loaded from loading position B in the third loading, over the loads loaded until the second loading. Fig. 11 (D) shows with reference D, loads loaded from loading position D in the fourth loading, over the loads loaded until the third loading.

[0106] In the loading work shown in Fig. 11, positions of loading positions A to D in the fore/aft direction of dump truck 300 are the same as in Figs. 8 to 10. The positions in a height direction of the loading positions, on the other hand, are different from those in Figs. 8 to 10. The height of cutting edge 6a at loading position C in the first loading is changed to the height of cutting edge 6a shown in Fig. 8. The height of cutting edge 6a at loading position B in the third loading is changed to the height of cutting edge 6a shown in Fig. 10.

[0107] Fig. 12 is a schematic diagram showing a third example of the loading work for loading of loads into vessel 301 in four-time loading. Fig. 12 (A) shows with reference A, loads loaded from loading position A in the first loading. Fig. 12 (B) shows with reference C, loads loaded from loading position C in the second loading, over and in the rear of the loads loaded in the first loading. Fig. 12 (C) shows with reference B, loads loaded from loading position B in the third loading, over the loads loaded until the second loading. Fig. 12 (D) shows with reference D, loads loaded from loading position D in the fourth loading, over the loads loaded until the third loading.

[0108] In the loading work shown in Fig. 12, the positions of loading positions A to D in the fore/aft direction of dump truck 300 are the same as in Figs. 8 to 10. The positions in the height direction of the loading positions, on the other hand, are different from those in Figs. 8 to 10. The height of cutting edge 6a at loading position C in the second loading is changed to the height of cutting edge 6a shown in Fig. 8. The height of cutting edge 6a at loading position B in the third loading is changed to the height of cutting edge 6a shown in Fig. 10.

<Functions and Effects>

[0109] Characteristic features and functions and effects of the present embodiment will be summarized as below, although some description may overlap with the description above.

[0110] As shown in Figs. 6 and 8 to 10, automation controller 100 determines the loading position based on the dimension information on the dimension in the width direction of bucket 6 and the information on vessel 301. The loading position is the position of bucket 6 relative to vessel 301 in loading of loads into vessel 301.

[0111] When wheel loader 1 performs loading into vessel 301 with the entire length longer than the width of its own bucket 6, by appropriate management of the loading position in the fore/aft direction of vessel 301, contact of bucket 6 with vessel 301 or fall of loads from vessel 301 during loading can be suppressed. Therefore, the amount of loading of loads in vessel 301 can be increased.

[0112] As shown in Figs. 7 and 11 to 12, vessel 301 has the maximum loading capacity up to which loads can be loaded a plurality of times. Automation controller 100 determines the loading position in each loading. In an

example where loading on one dump truck 300 is performed a plurality of times, the loading position can appropriately be selected and the order of loading to the loading position can be defined. By changing the position of loading into vessel 301 in accordance with the number of times of loading, fall of loads in loading can be suppressed and the amount of loading in vessel 301 can be increased.

[0113] As shown in Figs. 7 and 12, automation controller 100 sets as the loading position in the first loading, the position where the end of bucket 6 in the width direction is distant rearward by the prescribed distance from front wall surface 303 of vessel 301. By thus determining the loading position in the first loading, contact of bucket 6 with front wall surface 303 of vessel 301 can be suppressed.

[0114] As shown in Figs. 7 and 12, automation controller 100 determines the prescribed distance by which the end of bucket 6 in the width direction is distant rearward from front wall surface 303 of vessel 301, as the distance sufficient for bucket 6 not to interfere with vessel 301 in loading of loads in vessel 301. By thus determining the prescribed distance in the first loading, contact of bucket 6 with front wall surface 303 of vessel 301 can be suppressed.

[0115] As shown in Fig. 11, automation controller 100 sets as the loading position in the first loading, the position where the end of bucket 6 in the width direction is distant forward by the prescribed distance from rear upper edge 306 of vessel 301. By thus determining the loading position in the first loading, fall of loads from vessel 301 can be suppressed.

[0116] As shown in Fig. 11, automation controller 100 determines the prescribed distance by which the end of bucket 6 in the width direction is distant forward from rear upper edge 306 of vessel 301, as the distance sufficient for the loads loaded in vessel 301 not to fall from vessel 301. The prescribed distance can be determined, for example, in consideration of the angle of repose of loads loaded in vessel 301. By thus setting the loading position in the first loading, fall of loads from vessel 301 can be suppressed.

[0117] As shown in Fig. 5, rear upper edge 306 of vessel 301 is located at the position lower than front upper edge 304 of vessel 301. Prevention of occurrence of fall of loads from rear upper edge 306 in loading of loads in vessel 301 in such a shape is demanded. By setting as the loading position, the position where the end of bucket 6 in the width direction is distant forward by the prescribed distance from rear upper edge 306 of vessel 301, fall of loads from vessel 301 can be suppressed.

[0118] As shown in Figs. 8 to 10, automation controller 100 determines the position of cutting edge 6a of bucket 6 relative to vessel 301 while bucket 6 is in the full dump posture. By defining the position of bucket 6 while bucket 6 is in the full dump posture at the loading position, contact of bucket 6 with the side surface of vessel 301 can be avoided. By changing the height of cutting edge 6a

depending on the number of times of loading, contact of bucket 6 with already loaded loads can also be avoided.

[0119] As shown in Fig. 1, wheel loader 1 includes travel apparatus 4, boom cylinder 16, and bucket cylinder 19. Travel apparatus 4, boom cylinder 16, and bucket cylinder 19 can move work implement 3 relatively to vessel 301. In loading loads carried in bucket 6 into vessel 301, travel apparatus 4, boom cylinder 16, and bucket cylinder 19 can appropriately operate to reliably move bucket 6 to the loading position.

[0120] Automation controller 100 included in the automatic control system for wheel loader 1 described in the embodiment above does not necessarily have to be mounted on wheel loader 1. Such a system that a controller outside wheel loader 1 implements automation controller 100 may be configured. An external controller may determine loading positions A to D which are positions of bucket 6 relative to vessel 301, based on the dimension information on the dimension in the width direction of bucket 6 and the information on vessel 301.

[0121] The external controller may be arranged at a worksite of wheel loader 1 or at a remote location distant from the worksite of wheel loader 1. The external controller may be a transportable device. The external controller may be a portable device that can be used as being carried by a worker, such as a notebook personal computer, a tablet computer, or a smartphone.

[0122] In the embodiment, an example in which wheel loader 1 is a manned vehicle including cab 5 on which the operator rides is described. Wheel loader 1 may be an unmanned vehicle. Wheel loader 1 does not have to include cab 5 on which the operator rides for performing operations. Wheel loader 1 does not have to be equipped with a function for manipulating by the operator who rides on the cab. Wheel loader 1 may be a work machine dedicated for remote control. Wheel loader 1 may be manipulated through a wireless signal from a remote control device.

[0123] In the embodiment, exemplary machine control in which automation controller 100 automates the loading work onto dump truck 300 by wheel loader 1 is described. A machine guidance function to show a loading position determined by the controller on a display in front of the driver's seat where the operator who controls wheel loader 1 sits to have the operator perform the loading work in accordance with the loading position may be performed.

[0124] In the embodiment, though wheel loader 1 is exemplified as an exemplary work machine, other types of loading machines are also applicable. The loading machine may be a track loader. The loading machine may be an excavator. The excavator may be a hydraulic excavator, a mechanical rope excavator, or a hybrid excavator. The excavator may be a backhoe or a loading excavator. The loading machine may be a bucket crane. In an example where the loading machine includes a work implement, a revolving unit that supports the work implement, and a revolution operation portion that re-

volves the revolving unit, the revolution operation portion is encompassed in the "movement operation portion." The revolution operation portion is, for example, a revolution motor. The revolution motor may be a hydraulic motor or an electric motor.

<Additional Aspects>

[0125] The description above includes features additionally described below.

(Additional Aspect 1)

[0126] A system including a work machine, the work machine including a work implement, includes

an information obtaining unit that obtains information on a container into which loads carried in the work implement are to be loaded, and
a controller that determines a loading position which is a position of the work implement relative to the container in loading the loads into the container, based on dimension information on a dimension in a width direction of the work implement and the information on the container.

(Additional Aspect 2)

[0127] In the system according to Additional Aspect 1, the controller is provided in the work machine.

(Additional Aspect 3)

[0128] In the system according to Additional Aspect 1 or 2,

the container has a maximum loading capacity up to which the loads can be loaded a plurality of times, and
the controller determines the loading position in each loading.

(Additional Aspect 4)

[0129] In the system according to Additional Aspect 3, the controller sets as the loading position in first loading, a position where an end of the work implement in the width direction is distant rearward by a prescribed distance from a front wall surface of the container.

(Additional Aspect 5)

[0130] In the system according to Additional Aspect 4, the controller determines the prescribed distance as a distance for prevention of the work implement from interfering with the container in loading of the loads into the container.

(Additional Aspect 6)

[0131] In the system according to Additional Aspect 3, the controller sets as the loading position in first loading, a position where an end of the work implement in the width direction is distant forward by a prescribed distance from a rear edge of the container.

(Additional Aspect 7)

[0132] In the system according to Additional Aspect 6, the controller determines the prescribed distance as a distance sufficient for the loads loaded in the container not to fall from the container.

(Additional Aspect 8)

[0133] In the system according to Additional Aspect 6 or 7, the rear edge of the container is located at a position lower than a front edge of the container.

(Additional Aspect 9)

[0134] In the system according to any one of Additional Aspects 4 to 8,

the work implement includes a bucket at a tip end, and
the controller determines a position relative to the container, of a tip end of the bucket while the bucket is in a full dump posture.

(Additional Aspect 10)

[0135] The system according to any one of Additional Aspects 1 to 9 further includes a movement operation portion that moves the work implement relatively to the container.

[0136] It should be understood that the embodiment disclosed herein is illustrative and non-restrictive in every respect. The scope of the present invention is defined by the terms of the claims rather than the description above and is intended to include any modifications within the scope and meaning equivalent to the terms of the claims.

REFERENCE SIGNS LIST

[0137] 1 wheel loader; 2 vehicular body frame; 2a front frame; 2b rear frame; 3 work implement; 4 travel apparatus; 4a, 4b running wheel; 5 cab; 6 bucket; 6a cutting edge; 6aC central point; 8 operation apparatus; 9 boom pin; 11 steering cylinder; 13 work implement pump; 14 boom; 15 link; 16 boom cylinder; 17 bucket pin; 18 bell crank; 18a support pin; 18b, 18c coupling pin; 19 bucket cylinder; 21 engine; 23 transmission; 25 axle; 32 main valve; 35, 36 electromagnetic proportional control valve; 41 accelerator pedal; 42 work implement control lever; 50

vehicular body controller; 51 machine monitor; 60 engine controller; 70 transmission controller; 71 brake control unit; 72 accelerator control unit; 80 work implement controller; 81 steering control unit; 82 work implement control unit; 100 automation controller; 101 position estimator; 102 path planning unit; 103 path tracking control unit; 110 external information obtaining unit; 111 perception device; 112 positional information obtaining device; 120 vehicle information obtaining unit; 121 articulation angle sensor; 122 vehicle speed sensor; 123 boom angle sensor; 124 bucket angle sensor; 125 boom cylinder pressure sensor; 130 interface; 131 automation switch; 132 engine emergency stop switch; 133 mode indicator; 140 actuator; 141 brake EPC; 142 steering EPC; 143 work implement EPC; 144 HMT; 300 dump truck; 301 vessel; 302 bottom surface; 303 front wall surface; 304 front upper edge; 305 rear inclined surface; 306 rear upper edge.

Claims

1. A system including a work machine, the work machine including a work implement, the system comprising:

an information obtaining unit that obtains information on a container into which loads carried in the work implement are to be loaded; and
a controller that determines a loading position which is a position of the work implement relative to the container in loading the loads into the container, based on dimension information on a dimension in a width direction of the work implement and the information on the container.

2. The system according to claim 1, wherein the controller is provided in the work machine.

3. The system according to claim 1, wherein

the container has a maximum loading capacity up to which the loads can be loaded a plurality of times, and
the controller determines the loading position in each loading.

4. The system according to claim 3, wherein the controller sets as the loading position in first loading, a position where an end of the work implement in the width direction is distant rearward by a prescribed distance from a front wall surface of the container.

5. The system according to claim 4, wherein the controller determines the prescribed distance as a distance for prevention of the work implement from interfering with the container in loading of the loads

into the container.

6. The system according to claim 3, wherein the controller sets as the loading position in first loading, a position where an end of the work implement in the width direction is distant forward by a prescribed distance from a rear edge of the container.

7. The system according to claim 6, wherein the controller determines the prescribed distance as a distance sufficient for the loads loaded in the container not to fall from the container.

8. The system according to claim 7, wherein the rear edge of the container is located at a position lower than a front edge of the container.

9. The system according to claim 4 or 6, wherein

the work implement includes a bucket at a tip end, and
the controller determines a position relative to the container, of a tip end of the bucket while the bucket is in a full dump posture.

10. The system according to claim 1 or 2, further comprising a movement operation portion that moves the work implement relatively to the container.

11. A method of controlling a work machine, the method comprising:

obtaining dimension information on a dimension in a width direction of a work implement;
obtaining information on a container into which loads carried in the work implement are to be loaded; and
determining as a loading position, a position to which the work implement is to be moved with respect to the container in loading of the loads into the container, based on the dimension information of the work implement and the information on the container.

12. A system including a work machine, the work machine including a work implement, the system comprising:

an information obtaining unit that obtains information on a container into which loads carried in the work implement are to be loaded; and
a controller that determines a target position to which the work implement from which the loads are loaded into the container is headed, based on dimension information on a dimension in a width direction of the work implement and dimension information on a dimension in a fore/aft

direction of the container.

13. The system according to claim 12, wherein the controller is provided in the work machine.

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FIG.1

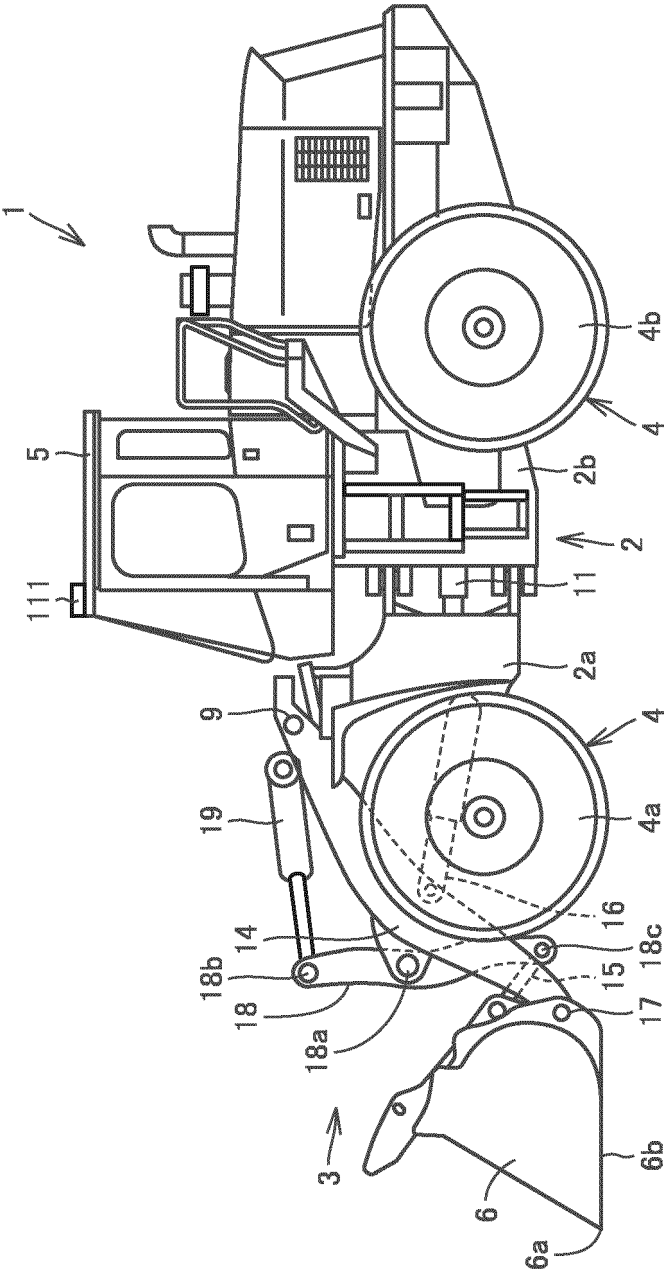


FIG.2

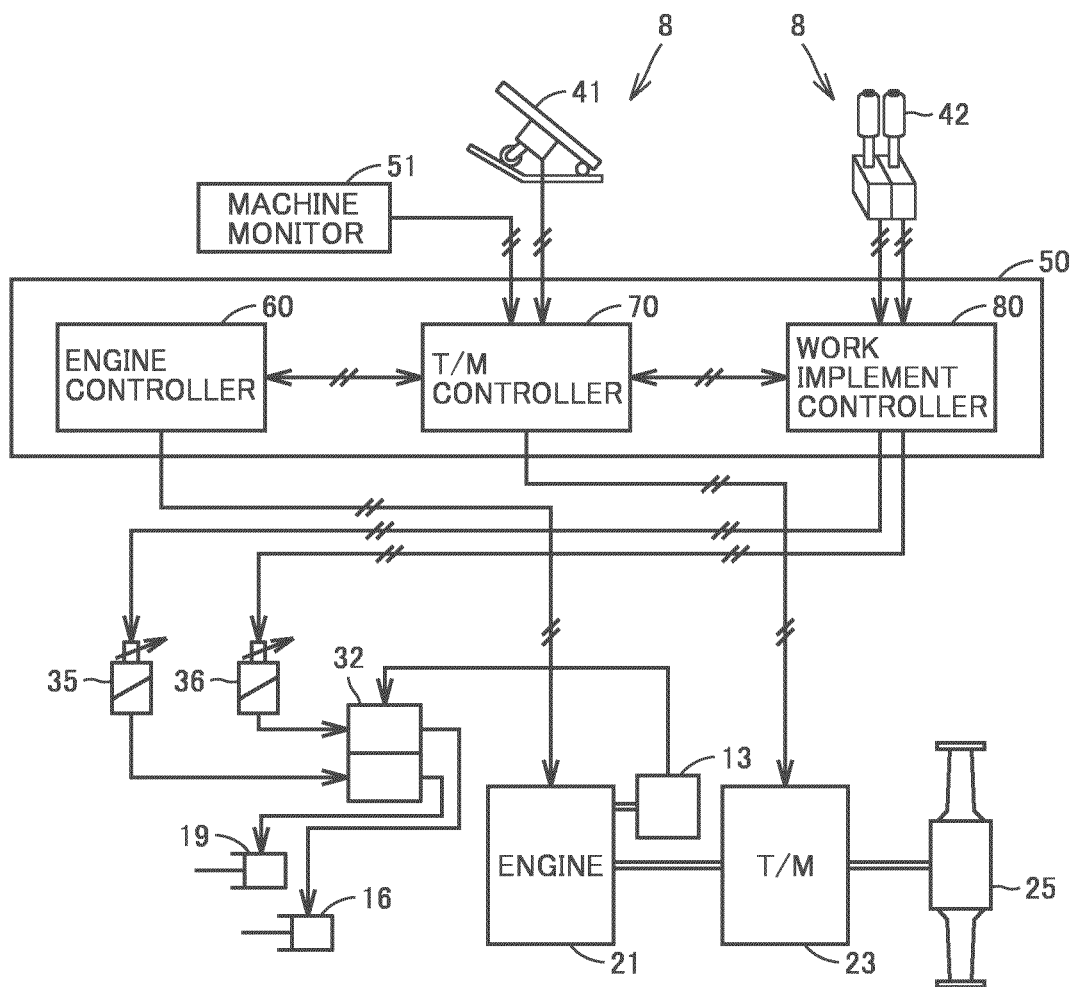


FIG.3

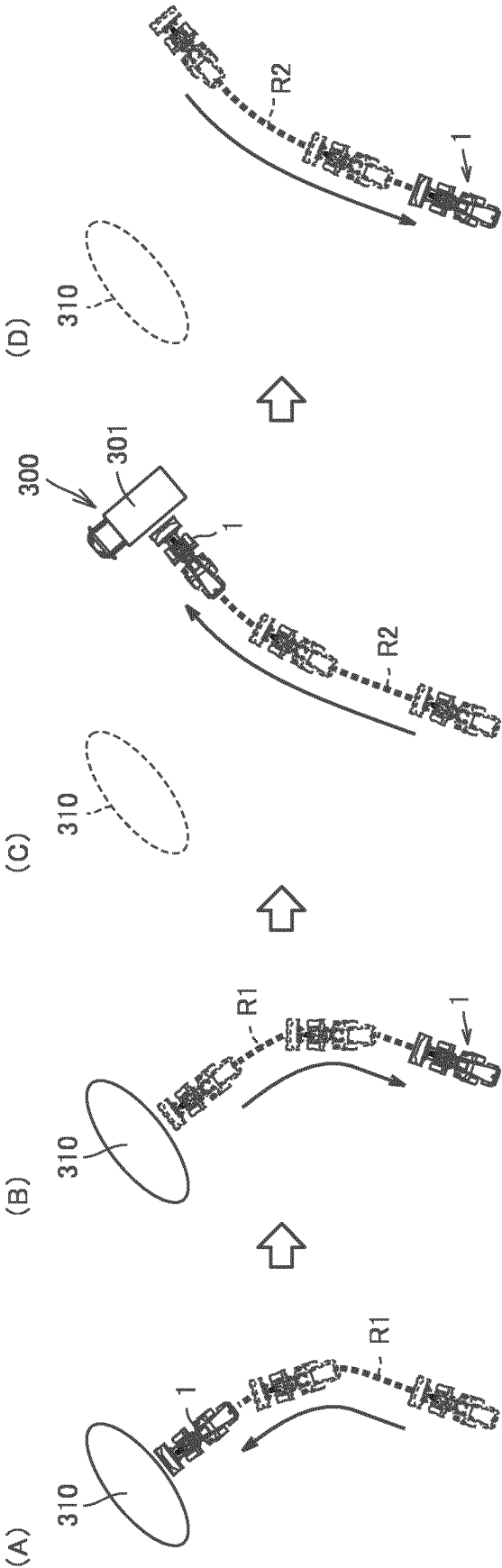


FIG.4

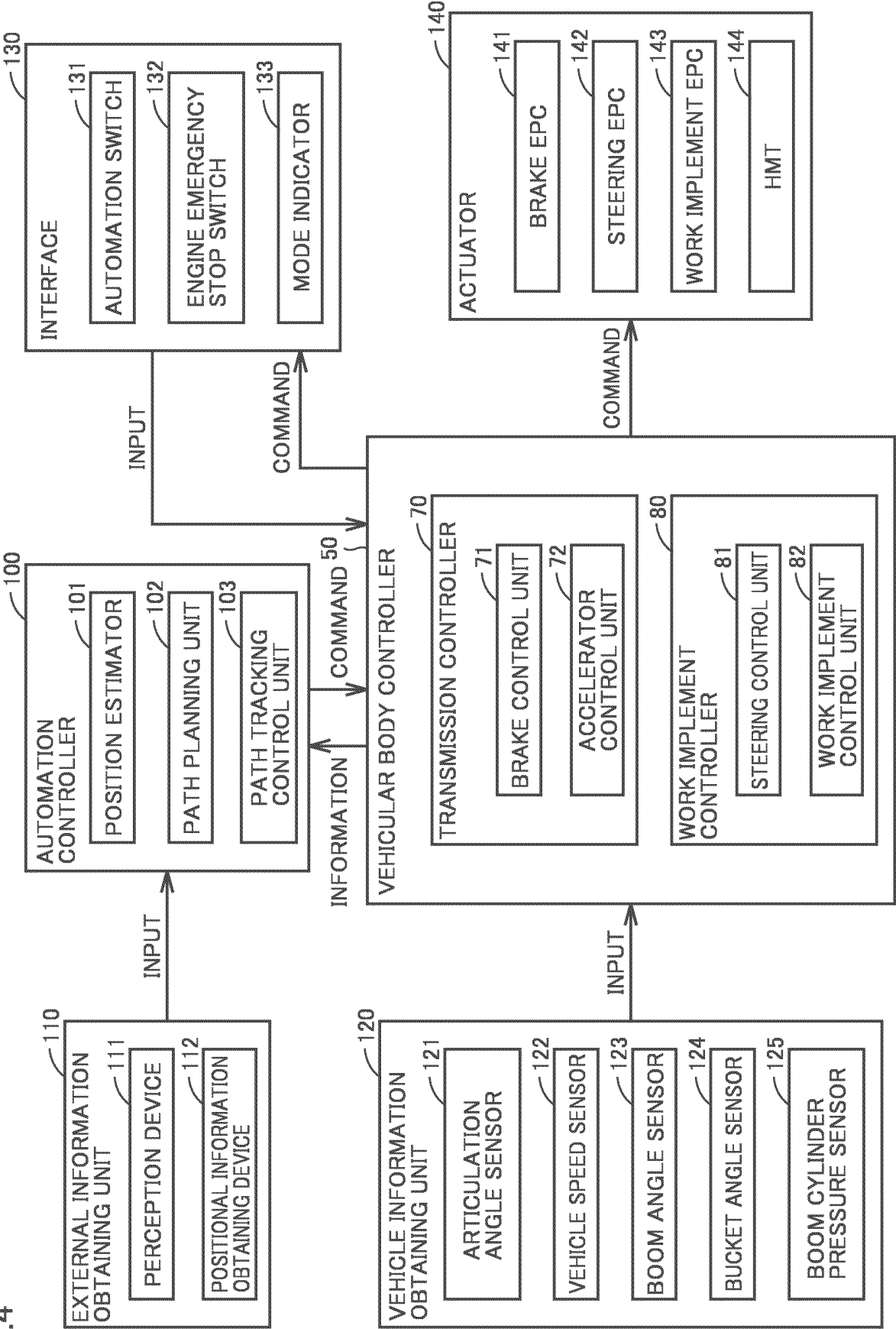


FIG.5

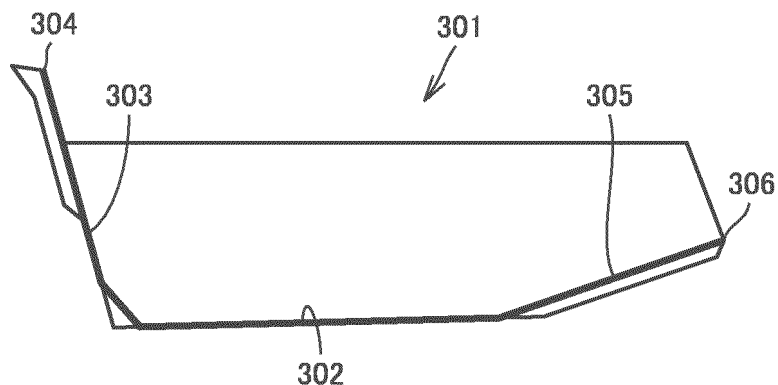


FIG.6

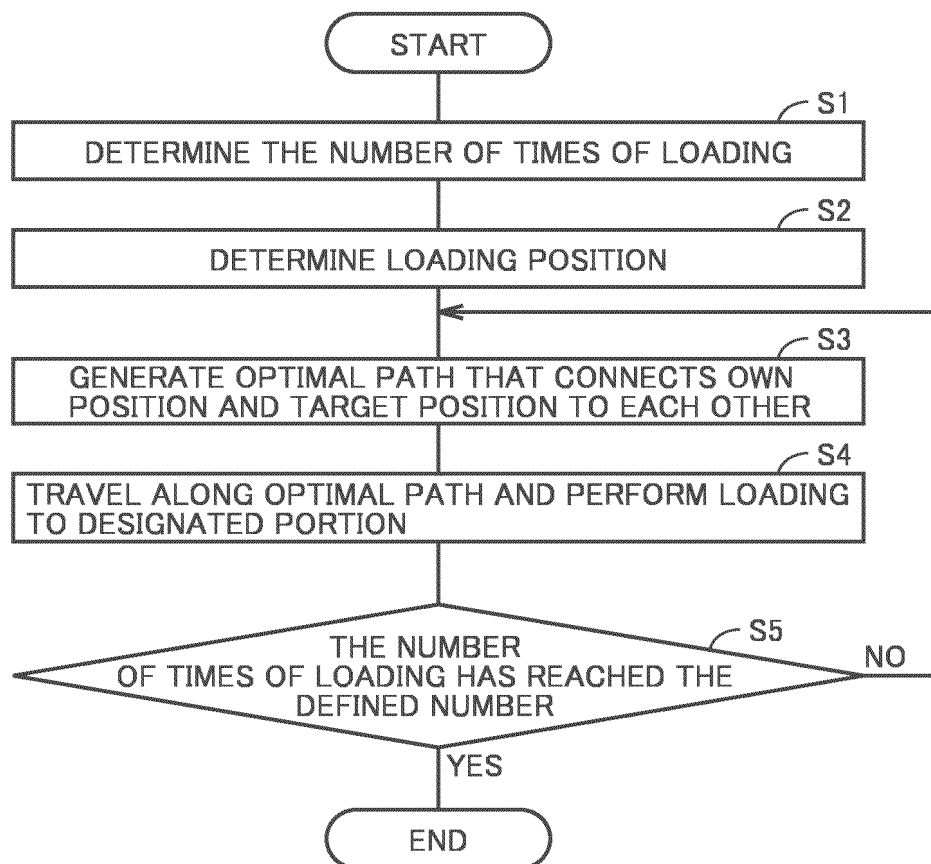


FIG.7

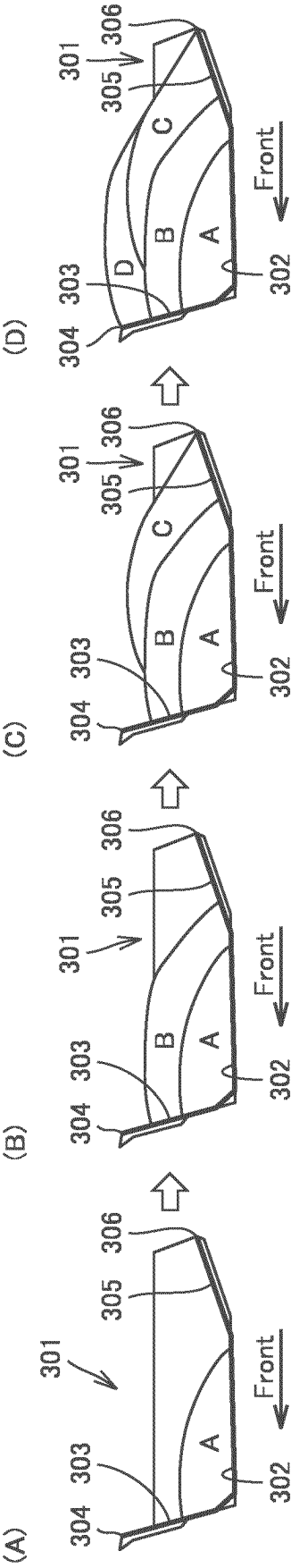


FIG.8

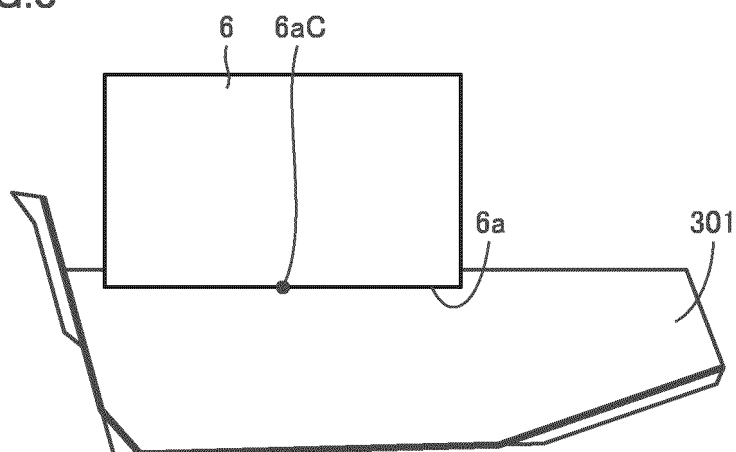


FIG.9

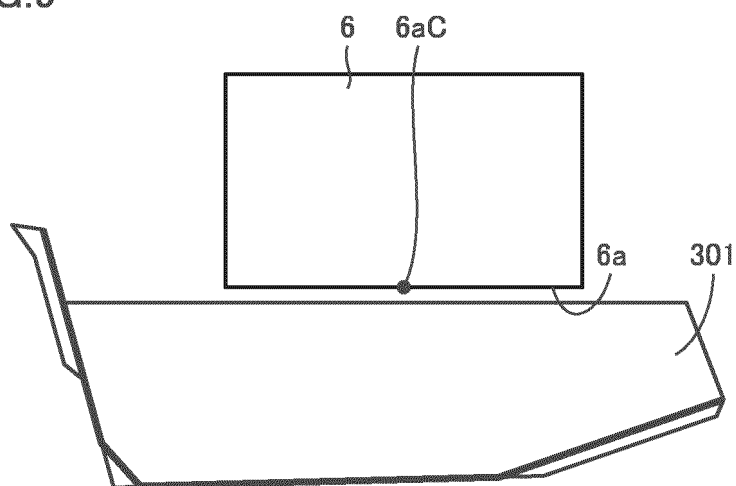


FIG.10

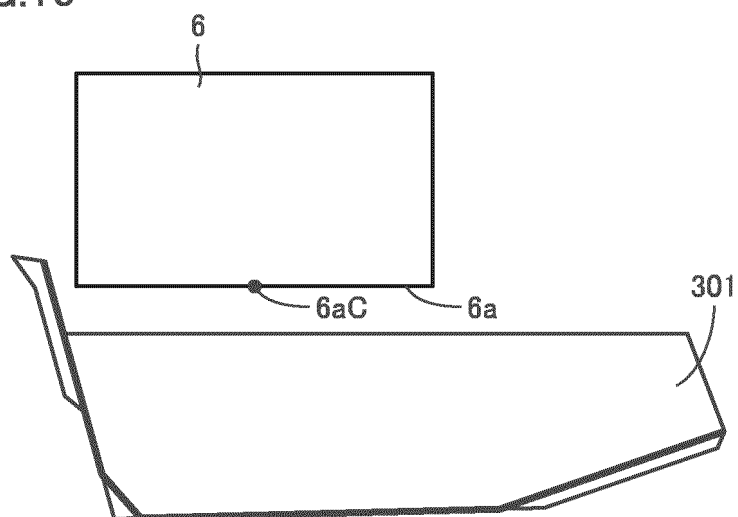


FIG.11

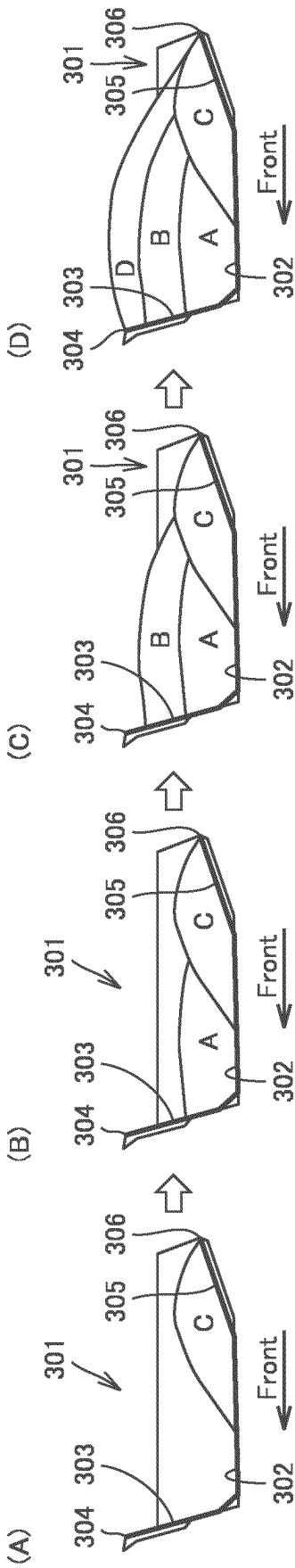
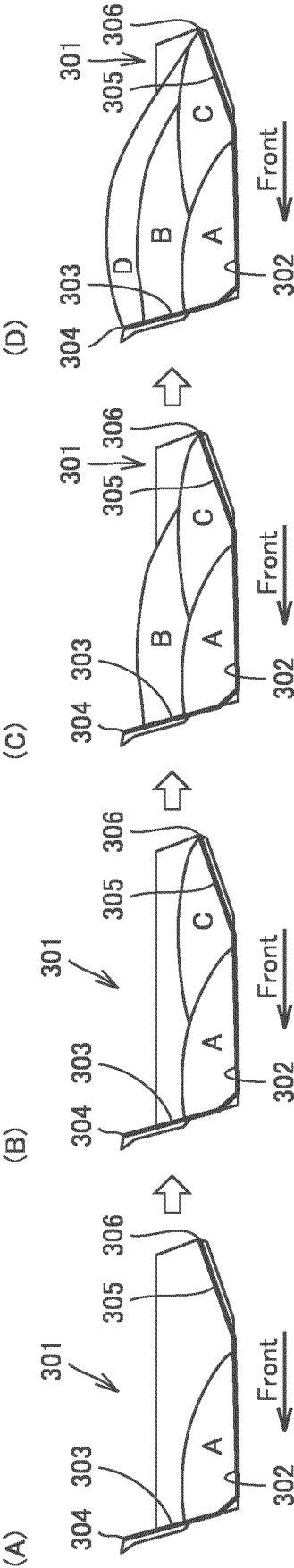


FIG.12



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/031875

A. CLASSIFICATION OF SUBJECT MATTER

E02F 3/43(2006.01)j

FI: E02F3/43 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)

E02F3/43

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 1971-2023

Registered utility model specifications of Japan 1996-2023

Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2022-078605 A (HITACHI LTD) 25 May 2022 (2022-05-25) paragraphs [0001], [0014]-[0119], [0154], fig. 1-14, 19	1-13
X	JP 2022-075200 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 18 May 2022 (2022-05-18) paragraphs [0001], [0011]-[0099], fig. 1-15	1-13
A	JP 2000-136549 A (CARNEGIE MELLON UNIV) 16 May 2000 (2000-05-16) entire text, all drawings	1-13

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

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/031875

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)		Publication date (day/month/year)
JP	2022-078605	A	25 May 2022	CN	116194640 A	
				paragraphs [0001], [0043]- [0165], [0209], fig. 1-14, 19		
				KR	10-2023-0056747	A
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				paragraphs [0001], [0030]- [0124], fig. 1-15		
JP	2000-136549	A	16 May 2000	US	6363632 B1	
				entire text, all drawings		

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2017043887 A [0002] [0003]