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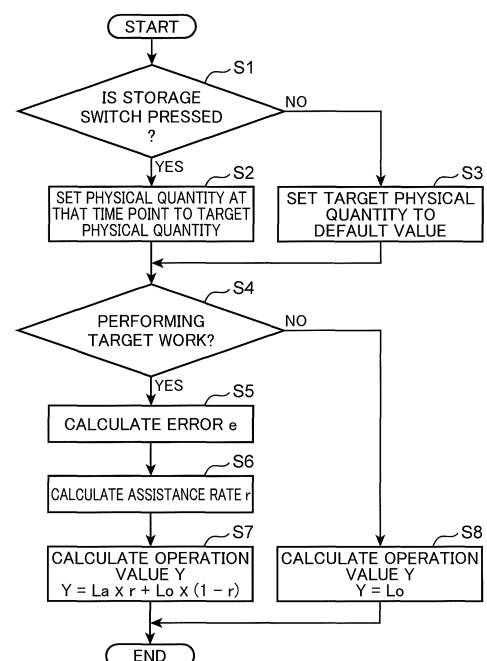
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(54) **CONSTRUCTION MACHINE DRIVING DEVICE, AND CONSTRUCTION MACHINE AND CONSTRUCTION MACHINE SYSTEM PROVIDED WITH SAME**

(57) A controller (50) of a driving device sets a target physical quantity relating to an orientation of a work device, calculates a current physical quantity relating to the actual orientation of the work device, calculates a physical quantity error between the target physical quantity and the current physical quantity, calculates an assistance operation value for assisting operation of an operator, corrects an operator operation value to an operator correction value so as to attain a small value when the physical quantity error is small as compared with when the physical quantity error is large, corrects the assistance operation value to an assistance correction value so as to attain a large value when the physical quantity error is small as compared with when the physical quantity error is large, and controls the orientation of the work device using a total value obtained by adding the operator correction value and the assistance correction value.

FIG.5



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**Description****Technical Field**

5 **[0001]** The present disclosure relates to a construction machine driving device, and a construction machine and a construction machine system including the construction machine driving device.

**Background Art**

10 **[0002]** A construction machine includes a machine body and a work device capable of changing an orientation with respect to the machine body. In a case where the construction machine is, for example, a hydraulic excavator, the machine body is constituted by a lower travelling body, and the work device includes an upper slewing body, a boom, an arm, and a bucket. The construction machine performs various pieces of work at a work site. An operator frequently performs a lever operation for adjusting an orientation of a work device to a desired orientation according to content of work. However, it is not easy for an unskilled person to efficiently perform such an operation. Therefore, a technique in which a controller of a construction machine assists an operation by an operator has been proposed.

15 **[0003]** Patent Literature 1 discloses a construction machine for assisting an operator so that a work element can reliably reach a target value in an individual piece of work. In this construction machine, in a case where pilot pressure is less than a maximum value at a time point when a work element moves to a second predetermined position before moving to a first predetermined position, a control device changes a value of the pilot pressure output from operation device to the maximum value, and accelerates the work element based on the changed maximum value. Further, the control device decelerates and stops a work element using one deceleration pattern selected from a plurality of deceleration patterns based on a speed of the work element detected by a speed detector.

20 **[0004]** In the assist technique of Patent Literature 1 described above, pilot pressure is changed to a maximum value regardless of a lever operation quantity that is the magnitude of operation by an operator when a work element is accelerated, and a work element is decelerated and stopped according to a preset deceleration pattern when a work element is stopped. That is, in the assistance control of Patent Literature 1, since an intention of an operator does not intervene in either acceleration or stop of a work element, there is a problem that an operation technique of the operator is hardly improved.

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**Citation List****Patent Literature**

35 **[0005]** Patent Literature 1: JP 2011-157789 A

**Summary of Invention**

40 **[0006]** An object of the present disclosure is to provide a construction machine driving device capable of assisting operation by an operator for adjusting an orientation of a work device to a desired orientation while allowing intervention of an operator's intention, and a construction machine and a construction machine system including the construction machine driving device.

45 **[0007]** A construction machine driving device to be provided includes an operation device to which an operation by an operator for moving a work device with respect to a machine body is given, and a controller, in which the controller sets a target physical quantity that is a target of a physical quantity related to an orientation of the work device, calculates a current physical quantity that is a physical quantity related to an actual orientation of the work device, calculates a physical quantity error that is an error between the target physical quantity and the current physical quantity, calculates an assistance operation value for assisting the operation of the operator, corrects an operator operation value corresponding to the operation to an operator correction value such that the operator correction value becomes smaller when the physical quantity error is small as compared with when the physical quantity error is large, corrects the assistance operation value to an assistance correction value such that the assistance correction value becomes larger when the physical quantity error is small as compared with when the physical quantity error is large, and controls the orientation of the work device by using a total value obtained by adding the operator correction value and the assistance correction value.

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**Brief Description of Drawings**

**[0008]**

FIG. 1 is a side view illustrating an example of a construction machine including a driving device according to an embodiment of the present disclosure.

FIG. 2 is a diagram illustrating a hydraulic circuit and a controller of the construction machine.

FIG. 3 is an example of a map illustrating a relationship between a physical quantity error and an assistance rate, the physical quantity error being an error between a target physical quantity of a work device of the construction machine and a current physical quantity of the work device.

FIG. 4 is an example of a block diagram illustrating a process of control by the controller.

FIG. 5 is a flowchart illustrating an example of arithmetic processing by the controller.

FIG. 6 is a side view for explaining operation of a work device in earth removal work as an example of work performed by the construction machine.

FIG. 7 is a graph illustrating an example of a temporal change in a tip height of a bucket and an assistance rate.

FIG. 8 is another example of a block diagram illustrating a process of control by the controller.

FIG. 9 is still another example of a block diagram illustrating a process of control by the controller.

FIG. 10 is a diagram illustrating an example of a display device of the driving device.

FIG. 11 is a diagram illustrating another example of the display device.

## Description of Embodiments

**[0009]** Hereinafter, a construction machine driving device according to an embodiment of the present disclosure and a construction machine including the construction machine driving device will be described with reference to the drawings.

[First embodiment]

**[0010]** As illustrated in FIGS. 1 and 2, a construction machine 100 includes a lower travelling body 1, an upper slewing body 2 supported by the lower travelling body 1 so as to be slewable with respect to the lower travelling body 1 about a Z axis extending vertically, an attachment 3 supported by the upper slewing body 2, a plurality of hydraulic actuators, a plurality of hydraulic pumps, an orientation information acquisition unit, a plurality of operation devices, a plurality of control valves, a plurality of proportional valves, and a controller 50. The construction machine 100 according to the present embodiment illustrated in FIG. 1 is a hydraulic excavator. The attachment 3 includes a boom 4, an arm 5, and a tip attachment. The tip attachment is a bucket 6 in the specific example illustrated in FIG. 1, but may be another tip attachment such as a fork, a grapple, a breaker, a grinder (crusher), or the like. The driving device includes the plurality of operation devices and the controller 50.

**[0011]** The lower travelling body 1 is an example of a machine body, and each of the upper slewing body 2, the boom 4, the arm 5, and a tip attachment (for example, the bucket 6) is an example of a work device. Each of these work devices is a device operable to change a relative orientation with respect to the lower travelling body 1.

**[0012]** The construction machine 100 can perform various pieces of work at a work site. The various pieces of work include, for example, excavation work, earth and sand holding and slewing work, earth removal work, and returning slewing work. The excavation work is work of moving the bucket 6 along an excavation target such as the ground or banking to excavate the excavation target and hold earth and sand in the bucket 6. The earth and sand holding and slewing work is work of slewing the upper slewing body 2 while holding excavated earth and sand in the bucket 6 to move the bucket 6 to the vicinity of a cargo bed of a dump truck. The earth removal work is work of releasing earth and sand held by the bucket 6 moved near a cargo bed from the bucket 6, and dropping the earth and sand on the cargo bed of a dump truck to load the earth and sand on the cargo bed. The returning slewing work is work of slewing the upper slewing body 2 and adjusting an orientation of the attachment 3 after earth removal work to move the bucket 6 to the excavation target.

**[0013]** The lower travelling body 1 includes a pair of left and right travelling devices for causing the construction machine 100 to travel, and a lower frame coupling these travelling devices. The upper slewing body 2 includes an upper frame supported by a lower frame so as to be slewable with respect to the lower frame, and a cabin and a machine room supported by the upper frame. A driver's seat or the like on which an operator sits is arranged in the cabin, and various devices constituting a hydraulic circuit are arranged in the machine room.

**[0014]** The boom 4 has a base end portion supported by a front portion of an upper frame of the upper slewing body 2 so that the boom 4 can rotate about a horizontal axis (boom rotation axis) with respect to the upper slewing body 2, and a tip portion on the opposite side of the base end portion. The arm 5 has a base end portion attached to a tip portion of the boom 4 so that the arm 5 is rotatable about a horizontal axis (arm rotation axis) with respect to the boom 4, and a tip portion on the opposite side of the base end portion. The bucket 6 includes a base end portion attached to a tip portion of the arm 5 so that the bucket 6 is rotatable about a horizontal axis (bucket rotation axis) with respect to the arm 5, a housing portion which is a portion capable of housing and holding earth and sand, and a tip of the bucket 6. In the present embodiment, the tip of the bucket 6 is constituted by at least a part of a tooth for excavation.

**[0015]** A plurality of hydraulic pumps include a main pump 21 and a pilot pump 22. The main pump 21 and the pilot pump 22 are driven by, for example, an engine (not illustrated). Each of the main pump 21 and the pilot pump 22 is driven by an engine to discharge hydraulic oil. The pilot pump 22 is driven by an engine to supply pilot pressure to each of a plurality of control valves.

**[0016]** A plurality of hydraulic actuators include a plurality of hydraulic cylinders and a slewing motor 11. The plurality of hydraulic cylinders include at least one boom cylinder 7 for moving the boom 4, an arm cylinder 8 for moving the arm 5, and a bucket cylinder 9 for moving the bucket 6. Although only one of the main pump 21 is illustrated in FIG. 2, the construction machine 100 may include a plurality of main pumps 21.

**[0017]** At least one of the boom cylinder 7 has one end portion connected to the upper slewing body 2 and the other end connected to the boom 4. At least one of the boom cylinder 7 extends or contracts by receiving supply of hydraulic oil discharged from the main pump 21, so as to rotate the boom 4 in a boom raising direction or a boom lowering direction. The boom raising direction is a direction in which a tip portion of the boom 4 moves away from the ground, and the boom lowering direction is a direction in which the tip portion of the boom 4 approaches the ground.

**[0018]** The arm cylinder 8 has one end portion connected to the boom 4 and the other end portion connected to the arm 5. The arm cylinder 8 extends or contracts by receiving supply of hydraulic oil discharged from the main pump 21, so as to rotate the arm 5 in an arm pulling direction or an arm pushing direction. The arm pushing direction is a direction in which a tip portion of the arm 5 moves away from the boom 4, and the arm pulling direction is a direction in which the tip portion of the arm 5 approaches the boom 4.

**[0019]** The bucket cylinder 9 has one end portion connected to the arm 5 and the other end portion connected to the bucket 6 via a link member. The bucket cylinder 9 expands or contracts by receiving supply of hydraulic oil discharged from the main pump 21, so as to rotate the bucket 6 in a bucket pulling direction or a bucket pushing direction. The bucket pulling direction is a direction in which a tip of the bucket 6 approaches the lower travelling body 1, and the bucket pushing direction is a direction in which the tip of the bucket 6 moves away from the lower travelling body 1.

**[0020]** The slewing motor 11 is a hydraulic motor that operates to slew the upper slewing body 2 in a right direction or in a left direction with respect to the lower travelling body 1 by receiving supply of hydraulic oil discharged from the main pump 21. The slewing motor 11 includes an output part (not illustrated) that receives supply of the hydraulic oil and rotates, and the output part transmits a driving force to the upper slewing body 2 so as to slew the upper slewing body 2 in both left and right directions. Specifically, the slewing motor 11 has a pair of ports, and by receiving supply of hydraulic oil to one of the ports, the output part rotates in a direction corresponding to the one of the ports and discharges hydraulic oil from the other port.

**[0021]** The orientation information acquisition unit acquires orientation information that is information on an orientation of a plurality of work devices including the upper slewing body 2, the boom 4, the arm 5, and the bucket 6. The orientation information acquisition unit inputs the acquired orientation information to the controller 50. In the present embodiment, the orientation information acquisition unit includes a boom orientation detector 31, an arm orientation detector 32, a bucket orientation detector 33, and a slewing body orientation detector 34.

**[0022]** The boom orientation detector 31 detects boom orientation information that is information on an orientation of the boom 4. The boom orientation detector 31 inputs a detection signal corresponding to the detected boom orientation information to the controller 50. Specifically, the boom orientation detector 31 may be a boom angle sensor that detects an angle (an example of boom orientation information) of the boom 4 with respect to a preset reference. In this case, the reference may be, for example, the upper slewing body 2, may be a horizontal plane, or may be a straight line or a plane perpendicular to a slewing center axis (Z axis in FIG. 1). Further, the boom orientation detector 31 may be a cylinder stroke sensor that detects a cylinder length of the boom cylinder 7. The cylinder length of the boom cylinder 7 corresponds to an orientation of the boom 4 with respect to the upper slewing body 2. The cylinder length of the boom cylinder 7 is an example of boom orientation information.

**[0023]** The arm orientation detector 32 detects arm orientation information that is information on an orientation of the arm 5. The arm orientation detector 32 inputs a detection signal corresponding to the detected arm orientation information to the controller 50. Specifically, the arm orientation detector 32 may be an arm angle sensor that detects an angle (an example of arm orientation information) of the arm 5 with respect to a preset reference. In this case, the reference may be, for example, the boom 4, may be a horizontal plane, or may be a straight line or a plane perpendicular to a slewing center axis (Z axis in FIG. 1). Further, the arm orientation detector 32 may be a cylinder stroke sensor that detects a cylinder length of the arm cylinder 8. The cylinder length of the arm cylinder 8 corresponds to an orientation of the arm 5 with respect to the boom 4. The cylinder length of the arm cylinder 8 is an example of arm orientation information.

**[0024]** The bucket orientation detector 33 detects bucket orientation information that is information on an orientation of the bucket 6. The bucket orientation detector 33 inputs a detection signal corresponding to the detected bucket orientation information to the controller 50. Specifically, the bucket orientation detector 33 may be a bucket angle sensor that detects an angle (an example of bucket orientation information) of the bucket 6 with respect to a preset reference. In this case, the reference may be, for example, the arm 5, may be a horizontal plane, or may be a straight line or a plane perpendicular to a slewing center axis (Z axis in FIG. 1). Further, the bucket orientation detector 33 may be a

cylinder stroke sensor that detects a cylinder length of the bucket cylinder 9. The cylinder length of the bucket cylinder 9 corresponds to an orientation of the bucket 6 with respect to the arm 5. The cylinder length of the bucket cylinder 9 is an example of bucket orientation information.

**[0025]** The slewing body orientation detector 34 detects slewing body orientation information that is information on an orientation of the upper slewing body 2. The slewing body orientation detector 34 inputs a detection signal corresponding to the detected slewing body orientation information to the controller 50. Specifically, the slewing body orientation detector 34 may be, for example, an inclination angle sensor that detects an inclination angle (an example of slewing body orientation information) of the upper slewing body 2 with respect to a horizontal plane, or may be a rotation angle sensor that detects a rotation angle (an example of slewing body orientation information) of the upper slewing body 2 with respect to the lower travelling body 1. Further, the slewing body orientation detector 34 may include both the inclination angle sensor and the rotation angle sensor.

**[0026]** Each of the boom angle sensor, the arm angle sensor, the bucket angle sensor, and the rotation angle sensor may be, for example, a resolver, a rotary encoder, a potentiometer, an inertial measurement unit (IMU), or another sensor. The inclination angle sensor may be, for example, an IMU.

**[0027]** The controller 50 stores in advance size of each of a plurality of work devices according to a model of the construction machine 100. Further, the controller 50 may store in advance, for example, a relative positional relationship between a slewing center axis and a boom rotation axis, a relative positional relationship between a boom rotation axis, an arm rotation axis, a bucket rotation axis, and a corresponding work device, and the like. By the above, the controller 50 can geometrically calculate an orientation of each of a plurality of work devices including the upper slewing body 2, the boom 4, the arm 5, and the bucket 6 based on a detection signal input from each of the detectors 31 to 34, and can calculate coordinates of a specific part SP that is a part set in advance in any of a plurality of work devices. The specific part SP may be set at a tip of the bucket 6, for example, as illustrated in FIG. 1.

**[0028]** As illustrated in FIG. 2, a plurality of operation devices include a boom operation device 61, an arm operation device 62, a bucket operation device 63, and a slewing operation device 64. Each of the operation devices 61 to 64 includes operation levers 61A to 64A that receive operation of an operator. Each of the operation devices 61 to 64 may include an electric operation device that inputs an operator operation value (electric signal), which is an operation value corresponding to operation applied to an operation lever by an operator, to the controller 50. FIG. 2 illustrates a circuit configuration in a case where the operation devices 61 to 64 include an electric operation device. Further, each of the operation devices 61 to 64 may include an operation device (not illustrated) including a remote control valve.

**[0029]** A lever structure in which one operation lever functions as a plurality of operation levers may be included. For example, a right operation lever arranged on the right front side of a driver's seat on which an operator sits may function as the boom operation lever 61A in a case of being operated in a front-rear direction, and may function as the bucket operation lever 63A in a case of being operated in a left-right direction. Further, a left operation lever arranged on the left front side of the driver's seat may function as an arm operation lever 62A in a case of being operated in the front-rear direction, and may function as a slewing operation lever 64A in a case of being operated in the left-right direction. The lever structure may be configured such that a combination functioning as a plurality of operation levers can be optionally changed by an operator's instruction.

**[0030]** The operation lever 61A of the boom operation device 61 is configured to be able to receive a boom raising operation that is an operation by an operator for moving the boom 4 in the boom raising direction and a boom lowering operation that is an operation by an operator for moving the boom 4 in the boom lowering direction. When the boom raising operation or the boom lowering operation is given to the operation lever 61A, the boom operation device 61 inputs an operator operation value (Lo) corresponding to magnitude of the operation and a direction of the operation to the controller 50.

**[0031]** The operation lever 62A of the arm operation device 62 is configured to be able to receive an arm pushing operation that is an operation by an operator for moving the arm 5 in the arm pushing direction and an arm pulling operation that is an operation by an operator for moving the arm 5 in the arm pulling direction. When the arm pushing operation or the arm pulling operation is given to the operation lever 62A, the arm operation device 62 inputs an operator operation value (Lo) corresponding to magnitude of the operation and a direction of the operation to the controller 50.

**[0032]** The operation lever 63A of the bucket operation device 63 is configured to be able to receive a bucket pulling operation that is an operation by an operator for moving the bucket 6 in the bucket pulling direction and a bucket pushing operation that is an operation by an operator for moving the bucket 6 in the bucket pushing direction. When the bucket pulling operation or the bucket pushing operation is given to the operation lever 63A, the bucket operation device 63 inputs an operator operation value (Lo) corresponding to magnitude of the operation and a direction of the operation to the controller 50.

**[0033]** The operation lever 64A of the slewing operation device 64 is configured to be able to receive a right slewing operation which is an operation by an operator for slewing the upper slewing body 2 in the right direction and a left slewing operation which is an operation by an operator for slewing the upper slewing body 2 in the left direction. When the right slewing operation or the left slewing operation is given to the operation lever 64A, the slewing operation device

64 inputs an operator operation value (Lo) corresponding to magnitude of the operation and a direction of the operation to the controller 50.

**[0034]** A plurality of control valves include a boom control valve 41, an arm control valve 42, a bucket control valve 43, and a slewing control valve 44. Each of the plurality of control valves has a pair of pilot ports.

**[0035]** The boom control valve 41 is interposed between the main pump 21 and the boom cylinder 7, and opens and closes to change a direction and a flow rate of hydraulic oil supplied to the boom cylinder 7 according to pilot pressure supplied to a pilot port corresponding to one of the boom raising operation and the boom lowering operation.

**[0036]** The arm control valve 42 is interposed between the main pump 21 and the arm cylinder 8, and opens and closes to change a direction and a flow rate of hydraulic oil supplied to the arm cylinder 8 according to pilot pressure supplied to a pilot port corresponding to one of the arm pushing operation and the arm pulling operation.

**[0037]** The bucket control valve 43 is interposed between the main pump 21 and the bucket cylinder 9, and opens and closes to change a direction and a flow rate of hydraulic oil supplied to the bucket cylinder 9 according to pilot pressure supplied to a pilot port corresponding to one of the bucket pulling operation and the bucket pushing operation.

**[0038]** The slewing control valve 44 is interposed between the main pump 21 and the slewing motor 11, and opens and closes to change a direction and a flow rate of hydraulic oil supplied to the slewing motor 11 according to pilot pressure supplied to a pilot port corresponding to one of the right slewing operation and the left slewing operation.

**[0039]** A plurality of proportional valves include a pair of boom electromagnetic proportional valves 45 and 45, a pair of arm electromagnetic proportional valves 46 and 46, a pair of bucket electromagnetic proportional valves 47 and 47, and a pair of slewing electromagnetic proportional valves 48 and 48. Each of the plurality of proportional valves reduces pressure of pilot oil (hydraulic oil) discharged from the pilot pump 22 in accordance with a control command input from the controller 50, and opens and closes such that pilot pressure that is the reduced pressure is supplied to a pilot port of a control valve corresponding to the proportional valve. By the above, the control valve opens, in a direction corresponding to a pilot port to which pilot pressure is supplied, with a stroke corresponding to magnitude of the pilot pressure. As a result, hydraulic oil from the main pump 21 is supplied to a hydraulic actuator corresponding to the control valve at a flow rate corresponding to the stroke.

**[0040]** The controller 50 includes, for example, a computer including an arithmetic processing device such as an MPU and a memory. The controller 50 includes an operation command unit 51, a target physical quantity setting unit 52, a current physical quantity arithmetic unit 53, a physical quantity error arithmetic unit 54, an assistance rate setting unit 55, an assistance operation value arithmetic unit 56, an operator operation value correction unit 57, an assistance operation value correction unit 58, and a work determination unit 59. Each of the operation command unit 51, the target physical quantity setting unit 52, the current physical quantity arithmetic unit 53, the physical quantity error arithmetic unit 54, the assistance rate setting unit 55, the assistance operation value arithmetic unit 56, the operator operation value correction unit 57, the assistance operation value correction unit 58, and the work determination unit 59 is realized by the arithmetic processing device executing a program.

**[0041]** The operation command unit 51 inputs the control command to each of a plurality of proportional valves. Specifically, when the boom raising operation or the boom lowering operation is given to the operation lever 61A of the boom operation device 61, the operation command unit 51 inputs a control command to the boom electromagnetic proportional valve 45 corresponding to the operation between the pair of the boom electromagnetic proportional valves 45 and 45. When the arm pushing operation or the arm pulling operation is given to the operation lever 62A of the arm operation device 62, the operation command unit 51 inputs a control command to the arm electromagnetic proportional valve 46 corresponding to the operation between the pair of the arm electromagnetic proportional valves 46 and 46. When the bucket pulling operation or the bucket pushing operation is given to the operation lever 63A of the bucket operation device 63, the operation command unit 51 inputs a control command to the bucket electromagnetic proportional valve 47 corresponding to the operation between the pair of the bucket electromagnetic proportional valves 47 and 47. When the right slewing operation or the left slewing operation is given to the operation lever 64A of the slewing operation device 64, the operation command unit 51 inputs a control command to the slewing electromagnetic proportional valve 48 corresponding to the operation between the pair of the slewing electromagnetic proportional valves 48 and 48.

**[0042]** More specifically, in a case where predetermined target work among a plurality of pieces of work that can be performed by the construction machine 100 is performed, as will be described later, the operation command unit 51 inputs a control command calculated using an operator correction value (Lo') and an assistance correction value (La') to a proportional valve corresponding to an operation performed in the target work. The target work is work set in advance as a target of assistance by the controller 50 for an operation of an operator.

**[0043]** On the other hand, in a case where the target work is not performed among a plurality of pieces of work, that is, in a case where non-target work that is work other than the target work is performed, the operation command unit 51 inputs a command corresponding to an operator operation value (Lo) input to the controller 50 from an operation device operated in the non-target work among the plurality of operation devices 61 to 64 to a proportional valve corresponding to the operation as the control command.

**[0044]** The target physical quantity setting unit 52 sets a target physical quantity which is a target of a physical quantity

related to an orientation of at least one work device. In the present embodiment, the physical quantity related to an orientation of a work device is coordinates of a specific part, and the target physical quantity is target coordinates of the specific part. In the present embodiment, the specific part is a tip of the bucket 6. The target physical quantity setting unit 52 may set target coordinates as described below, for example.

**[0045]** In the present embodiment, the construction machine 100 further includes a storage switch 80 that can be operated by an operator. The storage switch 80 is arranged at a position (for example, a position near a driver's seat) at which an operator can operate in a cabin, for example. The storage switch 80 may be a button that can be operated by an operator. Further, the storage switch 80 may be formed on a screen of a display and may be a region that can be operated by an operator. An operator arranges a tip of the bucket 6 at a desired position by operating at least one of the operation levers 61A to 64A of the plurality of operation devices 61 to 64. In a state where a tip of the bucket 6 is arranged at a desired position, an operator performs an input operation (for example, button operation) on the storage switch 80. The target physical quantity setting unit 52 sets, as target coordinates, coordinates at which a tip (specific part) of the bucket 6 is arranged at a time point when an input operation is performed on the storage switch 80. A coordinate system serving as a reference of target coordinates may be, for example, a coordinate system having a preset position at a work site as the origin, a coordinate system having a preset part in the construction machine 100 as the origin, or a coordinate system having another position as the origin. Further, the coordinate system may be a three-dimensional coordinate system or a two-dimensional coordinate system.

**[0046]** Note that the method of setting target coordinates is not limited to the above specific example. For example, in a case where the construction machine 100 includes a camera that acquires an image of a work site and a display that can display an image of the work site (for example, a three-dimensional image) based on image data input from the camera to the controller 50, when an operator designates a desired part in an image displayed on the display (specifically, for example, when the operator touches the desired part on a screen), the target physical quantity setting unit 52 may set coordinates corresponding to the designated part as target coordinates. Further, the target physical quantity setting unit 52 may set coordinates (a plurality of numerical values) input by an operator as target coordinates.

**[0047]** The current physical quantity arithmetic unit 53 calculates a current physical quantity which is a physical quantity related to an actual orientation of at least one work device. In the present embodiment, the current physical quantity is actual coordinates of a tip of the bucket 6, that is, current coordinates which are coordinates at that time point. Therefore, the current physical quantity arithmetic unit 53 calculates current coordinates which are coordinates of a tip (specific part) of the bucket 6. The current physical quantity arithmetic unit 53 calculates current coordinates of a tip of the bucket 6 based on orientation information input from the orientation information acquisition unit. Specifically, the current physical quantity arithmetic unit 53 may calculate an orientation of the boom 4, an orientation of the arm 5, and an orientation of the bucket 6 based on, for example, boom orientation information, arm orientation information, and bucket orientation information detected by the detectors 31 to 33, and calculate current coordinates of a tip of the bucket 6 based on these orientations. Further, the current physical quantity arithmetic unit 53 may calculate current coordinates of a tip of the bucket 6 in further consideration of slewing body orientation information detected by the detector 34.

**[0048]** As illustrated in FIG. 1, an orientation of the boom 4 may be represented by a boom angle  $\theta_1$  which is an angle of the boom 4, an orientation of the arm 5 may be represented by an arm angle  $\theta_2$  which is an angle of the arm 5, and an orientation of the bucket 6 may be represented by a bucket angle  $\theta_3$  which is an angle of the bucket 6. The boom angle  $\theta_1$  may be, for example, an angle formed by a reference plane and a straight line connecting a rotation center of the boom 4 at a base end portion of the boom 4 and a rotation center of the arm 5 at a base end portion of the arm 5.

**[0049]** The reference plane may be a horizontal plane or a plane orthogonal to a slewing center axis (Z axis in FIG. 1). The arm angle  $\theta_2$  may be an angle formed by a straight line connecting the rotation center of the boom 4 and the rotation center of the arm 5 and a straight line connecting the rotation center of the arm 5 and a rotation center of the bucket 6. The bucket angle  $\theta_3$  may be an angle formed by a straight line connecting the rotation center of the arm 5 and the rotation center of the bucket 6 and a straight line connecting the rotation center of the bucket 6 and a tip of the bucket 6.

**[0050]** The physical quantity error arithmetic unit 54 calculates a physical quantity error that is an error between the target physical quantity and the current physical quantity. In the present embodiment, the physical quantity error arithmetic unit 54 calculates a coordinate error (e) that is an error between the target coordinates and the current coordinates. Specifically, the physical quantity error arithmetic unit 54 calculates the coordinate error (e) by using, for example, an equation "coordinate error (e) = target coordinates - current coordinates". The coordinate error (e) calculated by the above equation indicates a direction from current coordinates to target coordinates and a distance from the current coordinates to the target coordinates.

**[0051]** The assistance rate setting unit 55 sets an assistance rate such that the assistance rate has a larger value when the physical quantity error is small as compared with when the physical quantity error is large. In the present embodiment, the assistance rate setting unit 55 sets an assistance rate (r) such that the assistance rate (r) has a larger value when the coordinate error (e) is small as compared with when the coordinate error (e) is large. Specifically, the assistance rate setting unit 55 sets the assistance rate (r) based on the coordinate error (e) calculated by the physical

quantity error arithmetic unit 54 and a map (graph) in which a relationship between the coordinate error (e) and the assistance rate (r) is set in advance as illustrated in FIG. 3, for example.

**[0052]** In the graph illustrated in FIG. 3, the horizontal axis represents magnitude of the coordinate error (e), that is, a distance from current coordinates to target coordinates, and the vertical axis represents the assistance rate (r). As illustrated in FIG. 3, the assistance rate (r) is set to a maximum value ("1" in the specific example of FIG. 3) in a small region where the coordinate error (e) is small, the assistance rate (r) is set to a minimum value ("0" in the specific example of FIG. 3) in a large region where the coordinate error (e) is large, and the assistance rate (r) is set such that the assistance rate (r) becomes larger as the coordinate error (e) is smaller in a middle region which is an intermediate region between the small region and the large region. However, the map illustrated in FIG. 3 is an example of a map created in advance for setting the assistance rate (r) such that the assistance rate (r) has a larger value when the coordinate error (e) is small as compared with when the coordinate error (e) is large, and the map representing a relationship between the coordinate error (e) and the assistance rate (r) is not limited to the specific example illustrated in FIG. 3. In the map, for example, at least a part of the middle region may be represented by a curve, and at least one of the small region and the large region may be omitted. Further, the maximum value of the assistance rate (r) may be a value larger than "1" or a value smaller than "1", and the minimum value of the assistance rate (r) may be a value larger than "0" or a value smaller than "0".

**[0053]** The assistance operation value arithmetic unit 56 calculates an assistance operation value (La) which is an operation value for assisting operation of the operator. In the present embodiment, the assistance operation value arithmetic unit 56 calculates the assistance operation value (La) for assisting operation of the operator based on the coordinate error (e). Specifically, the controller 50 stores in advance, for example, Formula (1) described below for performing feedback control. For example, as illustrated in FIG. 4, the assistance operation value arithmetic unit 56 (PID controller) calculates the assistance operation value (La) by using Formula (1) described below and the coordinate error (e). Note that, in Formula (1) described below, "u" is the assistance operation value (La), "Kp", "Ki", and "Kd" are PID gains (a proportional gain, an integral gain, and a derivative gain), and "e" is a coordinate error.

[Mathematical formula 1]

$$u(t) = K_p e(t) + K_i \int_0^t e(\tau) d\tau + K_d \frac{de(t)}{dt} \quad (1)$$

**[0054]** The assistance operation value (La) is an operation value for bringing the coordinate error (e) close to zero, that is, an operation value for bringing a tip (specific part) of the bucket 6 close to target coordinates. The controller 50 performs feedback control using an assistance operation value (La) for bringing the coordinate error (e) close to zero. For example, the assistance operation value (La) may be an operation value that realizes at least one of bringing a direction in which a tip of the bucket 6 moves closer to target coordinates and decreasing a speed at which a tip of the bucket 6 moves as magnitude (distance) of the coordinate error (e) is lowered. The assistance operation value (La) may be an operation value that assists operation of an operator so that a tip of the bucket 6 moves toward target coordinates. Further, the assistance operation value (La) may be an operation value that makes a speed at which a tip of the bucket 6 moves toward target coordinates large when the coordinate error (e) is large, and makes a speed at which the tip of the bucket 6 moves toward the target coordinates small when the coordinate error (e) is small.

**[0055]** The operator operation value correction unit 57 corrects the operator operation value (Lo) to the operator correction value (Lo') such that the operator correction value (Lo') becomes smaller when the physical quantity error is small as compared with when the physical quantity error is large. In the present embodiment, the operator operation value correction unit 57 corrects the operator operation value (Lo) to the operator correction value (Lo') such that the operator correction value (Lo') becomes smaller as the assistance rate (r) is larger. For example, the operator operation value correction unit 57 may calculate the operator correction value (Lo') by multiplying the operator operation value (Lo) by a value obtained by subtracting the assistance rate (r) from a preset setting value (for example, "1"). Specifically, for example, the operator operation value correction unit 57 calculates the operator correction value (Lo') by using Formula (2) "Lo' = Lo × (1 - r)". In Formula (2), the assistance rate (r) is a value (0 ≤ r ≤ 1) of zero or more and one or less.

**[0056]** Therefore, the operator correction value (Lo') decreases as the assistance rate (r) increases.

**[0057]** The assistance operation value correction unit 58 corrects the assistance operation value (La) to the assistance correction value (La') such that the assistance correction value (La') becomes larger when the physical quantity error is small as compared with when the physical quantity error is large. In the present embodiment, the assistance operation value correction unit 58 corrects the assistance operation value (La) to the assistance correction value (La') such that the assistance correction value (La') becomes larger as the assistance rate (r) is larger. The assistance operation value correction unit 58 calculates the assistance correction value (La') by, for example, multiplying the assistance operation



value (La) by the assistance rate (r). Specifically, for example, the assistance operation value correction unit 58 calculates the assistance correction value (La') by using Formula (3) " $La' = La \times r$ ". In Formula (3), the assistance rate (r) is a value ( $0 \leq r \leq 1$ ) equal to or more than zero and equal to or less than one like the one described above. Therefore, the assistance correction value (La') becomes larger as the assistance rate (r) is larger.

**[0058]** As described above, in a case where target work is performed among a plurality of pieces of work, the operation command unit 51 inputs a control command calculated using the operator correction value (Lo') and the assistance correction value (La') to a proportional valve corresponding to an operation performed in the target work. Specifically, in a case where target work is performed, the operation command unit 51 outputs a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as a control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value. The output control command Y is input to a proportional valve corresponding to at least one operation device among operation devices operated in the target work.

**[0059]** The work determination unit 59 determines work performed by the construction machine 100. The work determination unit 59 can acquire a boom orientation, an arm orientation, a bucket orientation, and a slewing body orientation based on a detection signal input from the plurality of detectors 31 to 34 to the controller 50. For example, since at least one of an orientation of the boom 4, an orientation of the arm 5, an orientation of the bucket 6, and an orientation of the upper slewing body 2 is characteristically changed temporally in each of excavation work, earth and sand holding and slewing work, earth removal work, and returning slewing work, the work determination unit 59 can determine work of the construction machine 100 based on data of the temporal change of at least one of the orientation of the boom 4, the orientation of the arm 5, the orientation of the bucket 6, and the orientation of the upper slewing body 2.

**[0060]** Specifically, for example, in a case where data of the temporal change satisfies a predetermined condition related to excavation work, the work determination unit 59 determines that the construction machine 100 is performing the excavation work. Similarly, the work determination unit 59 determines that the construction machine 100 is performing earth and sand holding and slewing work in a case where data of the temporal change satisfies a predetermined condition related to the earth and sand holding and slewing work, the work determination unit 59 determines that the construction machine 100 is performing earth removal work in a case where data of the temporal change satisfies a predetermined condition related to the earth removal work, and the work determination unit 59 determines that the construction machine 100 is performing returning slewing work in a case where data of the temporal change satisfies a predetermined condition related to the returning slewing work.

**[0061]** The work determination unit 59 may determine work by the construction machine 100 based on the operator operation value (Lo) instead of or together with data of a temporal change of at least one of an orientation of the boom 4, an orientation of the arm 5, an orientation of the bucket 6, and an orientation of the upper slewing body 2. Further, the work determination unit 59 may determine work by the construction machine 100 based on a load applied to a work device instead of or together with data of a temporal change of at least one of an orientation of the boom 4, an orientation of the arm 5, an orientation of the bucket 6, and an orientation of the upper slewing body 2. In this case, the work determination unit 59 may use, for example, a detection result (detection signal) of a load sensor capable of detecting a load applied to a work device or a load sensor attached to at least one of a plurality of movable portions constituting a work device for determination of work of the construction machine 100.

**[0062]** When the driving device of the construction machine 100 includes an input device 90 (see FIG. 2) that allows an operator to input a type of work, the work determination unit 59 may determine work performed by the construction machine 100 based on work content input by the operator.

**[0063]** Hereinafter, an example of arithmetic processing by the controller 50 will be described with reference to a flowchart illustrated in FIG. 5. In a specific example below, earth and sand loading work including a series of pieces of work is repeatedly performed at a work site, the pieces of work including excavation work, earth and sand holding and slewing work, earth removal work, and returning slewing work. Among these pieces of work, the earth removal work is set as the target work described above, and the excavation work, the earth and sand holding and slewing work, and the returning slewing work are set as non-target work. The specific part is set to a tip of the bucket 6.

**[0064]** The target physical quantity setting unit 52 of the controller 50 determines whether or not an input operation to the storage switch 80 (coordinate storage switch in the present embodiment) is performed (Step S 1).

**[0065]** At a time point of starting earth and sand loading work, for example, as illustrated in an upper diagram (A) in FIG. 6, an operator operates at least one of the operation levers 61A to 64A of the operation devices 61 to 64 to move a tip of the bucket 6 to a desired position TP (position of a star). The position TP of the star is a target position suitable for causing earth and sand held by the bucket 6 to fall from the bucket 6 to a cargo bed of a dump truck in earth removal work. The operator presses the storage switch 80 after stopping the tip of the bucket 6 at the desired position TP (the position of the star).

**[0066]** When a signal indicating that the storage switch 80 is pressed is input to the controller 50, the target physical quantity setting unit 52 determines that an input operation to the storage switch 80 is performed (YES in Step S1), and sets coordinates at which the tip of the bucket 6 is located at that time as target coordinates (target physical quantity) (Step S2). On the other hand, when determining that an input operation to the storage switch 80 is not performed (NO

in Step S1), the target physical quantity setting unit 52 sets target coordinates (target physical quantity) to a default value (Step S3). The default value may be coordinates previously set as target coordinates and stored in a memory, or may be target coordinates set last time.

**[0067]** Next, the work determination unit 59 of the controller 50 determines whether or not the earth removal work set as the target work is performed (Step S4). Based on a detection signal input from the plurality of detectors 31 to 34 to the controller 50, for example, in a case where data of a temporal change of an orientation of the arm 5 and an orientation of the bucket 6 satisfies a predetermined condition related to the earth removal work, the work determination unit 59 determines that the construction machine 100 is performing the earth removal work (YES in Step S4). Specifically, this will be described below.

**[0068]** A work device at a time point at which earth and sand holding and slewing work performed before the earth removal work is finished and the earth removal work is started is arranged in, for example, an orientation (earth removal work starting orientation) as illustrated in a second diagram (B) in FIG. 6. A third diagram (C) in FIG. 6 illustrates an orientation of the work device at an intermediate stage of the earth removal work, and a lower diagram (D) in FIG. 6 illustrates an orientation of the work device at a time point at which the earth removal work is finished. As illustrated in the diagrams (B) to (D), in the earth removal work, the arm pushing operation is given to the operation lever 62A of the arm operation device 62 so that the arm 5 moves in the arm pushing direction, and the bucket pushing operation is given to the operation lever 63A of the bucket operation device 63 so that the bucket 6 moves in the bucket pushing direction. That is, in the earth removal work, an orientation of the arm 5 and an orientation of the bucket 6 characteristically change temporally as described above. Therefore, a condition related to the earth removal work is set in advance to a condition for which a characteristic temporal change in an orientation of the arm 5 and an orientation of the bucket 6 as described above can be determined.

**[0069]** When the work determination unit 59 determines that the earth removal work is being performed (YES in Step S4), the current physical quantity arithmetic unit 53 calculates current coordinates which are coordinates of the tip of the bucket 6 at that time point based on orientation information input from the orientation information acquisition unit (detectors 31 to 34), and the physical quantity error arithmetic unit 54 calculates the coordinate error (e) by using, for example, the above formula (coordinate error (e) = target coordinates - current coordinates) (Step S5).

**[0070]** Next, the assistance rate setting unit 55 sets the assistance rate (r) based on, for example, the map illustrated in FIG. 3 and the coordinate error (e) calculated by the physical quantity error arithmetic unit 54 (Step S6).

**[0071]** Next, the operator operation value (Lo) at that time point is input to the controller 50. Specifically, when the arm pushing operation is given to the operation lever 62A, the arm operation device 62 inputs the operator operation value (Lo), which is an electric signal corresponding to magnitude of the arm pushing operation, to the controller 50, and when the bucket pushing operation is given to the operation lever 63A, the bucket operation device 63 inputs the operator operation value (Lo), which is an electric signal corresponding to magnitude of the bucket pushing operation, to the controller 50.

**[0072]** Further, the assistance operation value arithmetic unit 56 (PID controller) calculates the assistance operation value (La) for assisting the bucket pushing operation by using Formula (1) described above and the coordinate error (e).

**[0073]** The operator operation value correction unit 57 calculates the operator correction value (Lo') by using Formula (2) described above, the operator operation value (Lo) in the bucket pushing operation, and the assistance rate (r).

**[0074]** The assistance operation value correction unit 58 calculates the assistance correction value (La') by using Formula (3) described above, the assistance operation value (La) in the bucket pushing operation, and the assistance rate (r).

**[0075]** Regarding the bucket pushing operation, the operation command unit 51 outputs a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as the control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value (Step S7). The output control command Y is input to the proportional valve 47 corresponding to the bucket pushing operation.

**[0076]** On the other hand, when the work determination unit 59 determines that the earth removal work is not being performed (NO in Step S4), the operation command unit 51 outputs the operator operation value (Lo) corresponding to an operation input from at least one of the plurality of operation devices 61 to 64 as a control command which is a final operation value (Step S8).

**[0077]** As described above, in this construction machine, the controller 50 controls an orientation of at least one work device by using a total value obtained by adding the operator correction value (Lo'), which is corrected to become a small value when the coordinate error (e) is small as compared with when the coordinate error (e) is large, and the assistance correction value (La'), which is corrected to become a large value when the coordinate error (e) is small as compared with when the coordinate error (e) is large. That is, the controller 50 performs feedback control using the assistance operation value (La) for bringing the coordinate error (e) close to zero as illustrated in FIG. 4, and repeatedly performs arithmetic processing as illustrated in Steps S1 to S8 of the flowchart of FIG. 5. This makes it possible to assist operator's operation for adjusting an orientation of at least one work device to a desired orientation while allowing intervention of an operator's intention.

**[0078]** The controller 50 sets the assistance rate (r) that is large when the coordinate error (e) is small as compared with when the coordinate error (e) is large, calculates the assistance correction value (La') by multiplying the assistance operation value (La) by the assistance rate (r), and calculates the operator correction value (Lo') by multiplying the operator operation value (Lo) by a value obtained by subtracting the assistance rate (r) from "1" that is a preset setting value. Therefore, as the coordinate error (e) becomes smaller, that is, as a tip of the bucket 6 approaches target coordinates, the operator correction value (Lo') can be continuously decreased and the assistance correction value (La') can be continuously increased. This enables smooth transition from a state in which operation by an operator is mainly performed to a state in which assist by the controller 50 is mainly performed in a process in which a tip of the bucket 6 approaches target coordinates.

[Second embodiment]

**[0079]** In the first embodiment, a physical quantity related to an orientation of a work device is coordinates of a tip (specific portion) of the bucket 6, but in a second embodiment, the physical quantity is a cylinder length detected by the stroke sensor (an example of the orientation information acquisition unit). In the second embodiment, a target physical quantity is a target cylinder length, and a current physical quantity is an actual cylinder length (current cylinder length) detected by the stroke sensor. A physical quantity error is a length error that is an error between a target cylinder length and a current cylinder length.

**[0080]** In the second embodiment, the boom orientation detector 31 is a cylinder stroke sensor that detects a cylinder length of the boom cylinder 7, the arm orientation detector 32 is a cylinder stroke sensor that detects a cylinder length of the arm cylinder 8, and the bucket orientation detector 33 is a cylinder stroke sensor that detects a cylinder length of the bucket cylinder 9.

**[0081]** In the second embodiment, an operator arranges the boom 4, the arm 5, and the bucket 6 in a desired orientation by operating at least one of the operation levers 61A to 64A of the plurality of operation devices 61 to 64. The desired orientation varies depending on target work.

**[0082]** Similarly to the first embodiment, the controller 50 of the driving device according to the second embodiment may perform arithmetic processing along the flowchart illustrated in FIG. 5, for example. Hereinafter, an example of arithmetic processing by the controller 50 according to the second embodiment will be described with reference to the flowchart illustrated in FIG. 5. Also in a specific example below, target work is set to earth removal work, and excavation work, earth and sand holding and slewing work, and returning slewing work are set to non-target work.

**[0083]** The target physical quantity setting unit 52 of the controller 50 determines whether or not an input operation to the storage switch 80 is performed (Step S1).

**[0084]** At a time point of starting earth and sand loading work, an operator operates at least one of the operation levers 61A to 64A of the operation devices 61 to 64 to arrange the arm 5 and the bucket 6 in a desired orientation as illustrated in an upper diagram (A) in FIG. 6, for example, and, in this state, presses the storage switch 80.

**[0085]** When a signal indicating that the storage switch 80 is pressed is input to the controller 50, the target physical quantity setting unit 52 determines that input operation to the storage switch 80 is performed (YES in Step S1), sets a cylinder length of the arm cylinder 8 at that time point to a target cylinder length (first target cylinder length), and sets a cylinder length of the bucket cylinder 9 at that time point to a target cylinder length (second target cylinder length) (Step S2). On the other hand, when determining that an input operation to the storage switch 80 is not performed (NO in Step S1), the target physical quantity setting unit 52 sets a target cylinder length to a default value (Step S3). The default value may be a value set in advance as the first target cylinder length and the second target cylinder length and stored in a memory, or may be the first target cylinder length and the second target cylinder length set last time.

**[0086]** Next, the work determination unit 59 of the controller 50 determines whether earth removal work is being performed (Step S4). Based on a detection signal input from the plurality of detectors 31 to 34 to the controller 50, for example, in a case where data of a temporal change of an orientation of the arm 5 and an orientation of the bucket 6 satisfies a predetermined condition related to the earth removal work, the work determination unit 59 determines that the construction machine 100 is performing the earth removal work (YES in Step S4).

**[0087]** When the work determination unit 59 determines that the earth removal work is being performed (YES in Step S4), the current physical quantity arithmetic unit 53 calculates a current cylinder length (first current cylinder length) which is a cylinder length of the arm cylinder 8 at that time point based on a detection signal input from the arm orientation detector 32, and calculates a current cylinder length (second current cylinder length) which is a cylinder length of the bucket cylinder 9 at that time point based on a detection signal input from the bucket orientation detector 33. Then, the physical quantity error arithmetic unit 54 calculates the first length error (e) related to an orientation of the arm 5 by using, for example, a formula (first length error = first target cylinder length - first current cylinder length), and calculates the second length error (e) related to an orientation of the bucket 6 by using, for example, a formula (second length error = second target cylinder length - second current cylinder length) (Step S5).

**[0088]** The controller 50 stores in advance a map (arm map), for example, as illustrated in FIG. 3, set in advance to

control an orientation of the arm 5, and stores in advance a map (bucket map), for example, as illustrated in FIG. 3, set in advance to control an orientation of the bucket 6. These two maps are individually set in advance so that each of the arm 5 and the bucket 6 performs appropriate operation in the earth removal work. In the second embodiment, in the graph illustrated in FIG. 3, the horizontal axis represents a length error (first length error or second length error), and the vertical axis represents the assistance rate (r).

**[0089]** Next, the assistance rate setting unit 55 sets the first assistance rate (r) which is an assistance rate for the arm 5 based on the arm map and the first length error (e) calculated by the physical quantity error arithmetic unit 54, and sets the second assistance rate (r) which is an assistance rate for the bucket 6 based on the bucket map and the second length error (e) calculated by the physical quantity error arithmetic unit 54 (Step S6).

**[0090]** Next, the operator operation value (Lo) at that time point is input to the controller 50. Specifically, when the arm pushing operation is given to the operation lever 62A, the arm operation device 62 inputs an operator operation value (first operator operation value (Lo)), which is an electric signal corresponding to magnitude of the arm pushing operation, to the controller 50. When the bucket pushing operation is given to the operation lever 63A, the bucket operation device 63 inputs an operator operation value (second operator operation value (Lo)), which is an electric signal corresponding to magnitude of the bucket pushing operation, to the controller 50.

**[0091]** The controller 50 stores in advance, for example, a formula (arm arithmetic expression) as shown in Formula (1) described above, which is set in advance for feedback control of an orientation of the arm 5, and stores in advance, for example, a formula (bucket arithmetic expression) as shown in Formula (1) described above, which is set in advance for feedback control of an orientation of the bucket 6. These two formulas are individually set in advance so that each of the arm 5 and the bucket 6 performs appropriate operation in the earth removal work.

**[0092]** The assistance operation value arithmetic unit 56 (PID controller) calculates the first assistance operation value (La), which is an assistance operation value for assisting the arm pushing operation, by using the arm arithmetic expression and the first length error (e). Similarly, the assistance operation value arithmetic unit 56 (PID controller) calculates the second assistance operation value (La), which is an assistance operation value for assisting the bucket pushing operation, by using the bucket arithmetic expression and the second length error (e).

**[0093]** The operator operation value correction unit 57 calculates the first operator correction value (Lo') by using Formula (2) described above, the first operator operation value (Lo) in the arm pushing operation, and the first assistance rate (r), and calculates the second operator correction value (Lo') by using Formula (2) described above, the second operator operation value (Lo) in the bucket pushing operation, and the second assistance rate (r).

**[0094]** The assistance operation value correction unit 58 calculates the first assistance correction value (La') by using Formula (3) described above, the first assistance operation value (La) in the arm pushing operation, and the first assistance rate (r), and calculates the second assistance correction value (La') by using Formula (3) described above, the second assistance operation value (La) in the bucket pushing operation, and the second assistance rate (r).

**[0095]** Regarding the arm pushing operation, the operation command unit 51 outputs a first total value that is a total value obtained by adding the first operator correction value (Lo') and the first assistance correction value (La') as the first control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) that is a final operation value. Further, regarding the bucket pushing operation, the operation command unit 51 outputs a second total value that is a total value obtained by adding the second operator correction value (Lo') and the second assistance correction value (La') as the second control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value (Step S7). The output first control command Y is input to the proportional valve 46 corresponding to the arm pushing operation, and the output second control command Y is input to the proportional valve 47 corresponding to the bucket pushing operation.

**[0096]** On the other hand, when the work determination unit 59 determines that the earth removal work is not being performed (NO in Step S4), the operation command unit 51 outputs the operator operation value (Lo) corresponding to an operation input from at least one of the plurality of operation devices 61 to 64 as a control command which is a final operation value (Step S8).

**[0097]** As described above, the controller 50 performs the feedback control using the assistance operation value (La) for bringing the length error (e) close to zero as illustrated in FIG. 4 for each of the arm 5 and the bucket 6, and repeatedly performs the arithmetic processing as illustrated in Steps S1 to S8 of the flowchart of FIG. 5 for each of the arm 5 and the bucket 6. This makes it possible to assist operator's operation for adjusting an orientation of the arm 5 and an orientation of the bucket 6 to a desired orientation while allowing intervention of an operator's intention.

[Third embodiment]

**[0098]** In the driving device according to the above embodiment, the target work is the earth removal work, but the driving device according to the present disclosure is not limited to that in the above embodiment. The target work may be, for example, the returning slewing work. In this case, the specific part is, for example, a tip of the bucket 6, the physical quantity related to an orientation of a work device is a height of the tip of the bucket 6, the target physical quantity is, for example, a target height (excavation start height) of the tip of the bucket 6, the current physical quantity is, for

example, a current height that is an actual height of the tip of the bucket 6, and the physical quantity error is a height error that is an error between the target height (excavation start height) and the current height (for example, a distance between the tip of the bucket 6 and a working surface). The excavation start height and the current height may have, for example, a value based on the ground, or may have a value based on a position below or above the ground. FIG. 7 is a graph illustrating an example of a temporal change in a tip height of a bucket and an assistance rate in this third embodiment, and FIG. 8 is an example of a block diagram illustrating a process of control by the controller 50 in the third embodiment.

**[0099]** In the third embodiment, an operator arranges a tip of the bucket 6 at a desired position by operating at least one of the operation levers 61A to 64A of the plurality of operation devices 61 to 64. The desired position is, for example, a position of the tip of the bucket 6 when excavation is started. When an operator performs an input operation on the storage switch 80 in a state where the tip of the bucket 6 is arranged at the desired position, the target physical quantity setting unit 52 sets a height at which the tip of the bucket 6 is arranged at that time point as an excavation start height (target height).

**[0100]** The current physical quantity arithmetic unit 53 calculates a current height (attachment tip height) of the tip of the bucket 6 based on orientation information input from the orientation information acquisition unit. For example, the current physical quantity arithmetic unit 53 may calculate the current height based on the boom angle 01, the arm angle 02, and the bucket angle 03 detected by the detectors 31 to 33, and an inclination angle of the upper slewing body 2 with respect to the horizontal plane detected by the slewing body orientation detector 34. Specifically, for example, when the ground on which the lower travelling body 1 is arranged and the ground located below the bucket 6 are assumed to be included in the same plane, the current physical quantity arithmetic unit 53 can geometrically calculate a height of the tip of the bucket 6 from the ground based on a detection signal input from the detectors 31 to 34.

**[0101]** The physical quantity error arithmetic unit 54 calculates the height error, which is an error between the excavation start height and the current height, by using, for example, a formula "height error = excavation start height - current height".

**[0102]** The assistance rate setting unit 55 sets the assistance rate (r) such that the assistance rate (r) has a larger value when the height error is small as compared with when the height error is large. Specifically, the assistance rate setting unit 55 sets the assistance rate (r) based on a height error calculated by the physical quantity error arithmetic unit 54 and a map in which a relationship between the height error (e) and the assistance rate (r) is set in advance as illustrated in FIG. 8, for example.

**[0103]** The assistance operation value arithmetic unit 56 calculates the assistance operation value (La) which is for assisting operation of the operator. Specifically, in the third embodiment, the assistance operation value arithmetic unit 56 calculates the assistance operation value (La) which is an operation value for bringing an angular error, which is an error between a target bucket angle and the actual bucket angle 03, close to zero.

**[0104]** In FIG. 1, an angle 04 is an arm to ground angle that is an angle of the arm 5 with respect to the ground, and an angle 05 is a bucket to ground angle that is an angle of the bucket 6 with respect to the ground. For example, as illustrated in FIG. 1, the arm to ground angle 04 may be an angle between a straight line connecting a rotation center of the arm 5 with respect to the boom 4 and a rotation center of the bucket 6 with respect to the arm 5 and the ground. For example, as illustrated in FIG. 1, the bucket to ground angle 05 may be an angle between a straight line connecting a rotation center of the bucket 6 with respect to the arm 5 and a tip of the bucket 6 and the ground.

**[0105]** The assistance operation value arithmetic unit 56 sets a target bucket angle based on, for example, a map in which a relationship between the arm to ground angle 04 and a target angle (target bucket angle) of the bucket 6 is set in advance as in the graph drawn at the left end of FIG. 8 and the actual arm to ground angle 04 at that time. Next, the assistance operation value arithmetic unit 56 (PID controller) calculates the assistance operation value (La) by using, for example, Formula (1) described above and the angular error.

**[0106]** The operator operation value correction unit 57 calculates the operator correction value (Lo') by using Formula (2) " $Lo' = Lo \times (1 - r)$ " similar to the one described above. The calculated operator correction value (Lo') becomes smaller as the assistance rate (r) is larger.

**[0107]** The assistance operation value correction unit 58 calculates the assistance correction value (La') by using Formula (3) " $La' = La \times r$ " similar to the one described above. The calculated assistance correction value (La') becomes larger as the assistance rate (r) is larger.

**[0108]** In a case where target work (returning slewing work in the third embodiment) is performed, the operation command unit 51 outputs a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as the control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value. The output control command Y is input to a proportional valve corresponding to at least one operation device among operation devices operated in the returning slewing work.

**[0109]** In the third embodiment, an assistance rate is set using a height error that is an error between an excavation start height of the bucket 6 and a current height of a tip of the bucket 6. Therefore, when a height error is large, it is possible to allow significant intervention of an operator's intention. On the other hand, when the height error is small, that is, when a tip of the bucket 6 approaches an excavation start height (target height) and fine adjustment of an

orientation of a work device is performed, intervention of an operator's intention can be made less than that when the height error is large, and the tip of the bucket 6 can be easily adjusted to the excavation start height with assistance of the controller 50. By the above, it is possible to achieve both intervention of an operator's intention and easy adjustment of an orientation of a work device.

**[0110]** Further, in the third embodiment, the assistance operation value ( $L_a$ ) is calculated using an angular error that is an error between a target bucket angle and the actual bucket angle  $\Theta_3$ . The assistance operation value ( $L_a$ ) is an operation value calculated using, for example, Formula (1) described above in order to bring the angular error close to zero. Therefore, in the third embodiment, the controller 50 performs feedback control using the assistance operation value ( $L_a$ ) for bringing the angular error close to zero as illustrated in FIG. 8, and repeatedly performs the arithmetic processing as illustrated in Steps S1 to S8 of the flowchart of FIG. 5, for example, so that the bucket to ground angle  $\Theta_5$  at start of excavation can be brought close to a desired angle while intervention of an operator's intention is allowed. The desired angle is preferably an angle (for example, an angle of about 90 degrees) at which a tip of the bucket 6 is positioned directly below a rotation center of the bucket 6 with respect to the arm 5.

**[Fourth embodiment]**

**[0111]** FIG. 9 is an example of a block diagram illustrating a process of control by the controller 50 according to a fourth embodiment. In the fourth embodiment, a physical quantity related to an orientation of a work device is an angle detected by an angle sensor, a target physical quantity is a target angle that is a target of an angle of the work device, and a current physical quantity is a current angle that is an actual angle detected by the angle sensor. Specifically, in the fourth embodiment, an orientation of the boom 4, an orientation of the arm 5, and an orientation of the bucket 6 are controlled using an angle of the boom 4, an angle of the arm 5, and an angle of the bucket 6. In the fourth embodiment, the boom orientation detector 31 is a boom angle sensor, the arm orientation detector 32 is an arm angle sensor, and the bucket orientation detector 33 is a bucket angle sensor.

**[0112]** In the fourth embodiment, a target physical quantity includes first to third target physical quantities, a current physical quantity includes first to third current physical quantities, and a physical quantity error includes first to third physical quantity errors. Specifically, the first target physical quantity is a first target angle (boom target angle) that is a target of an angle of the boom 4, the second target physical quantity is a second target angle (arm target angle) that is a target of an angle of the arm 5, and the third target physical quantity is a third target angle (bucket target angle) that is a target of an angle of the bucket 6. The first current physical quantity is a first current angle which is an actual angle of the boom 4 detected by the boom orientation detector 31, the second current physical quantity is a second current angle which is an actual angle of the arm 5 detected by the arm orientation detector 32, and the third current physical quantity is a third current angle which is an actual angle of the bucket 6 detected by the bucket orientation detector 33. The first physical quantity error is a first angular error that is an error between the first target angle and the first current angle, the second physical quantity error is a second angular error that is an error between the second target angle and the second current angle, and the third physical quantity error is a third angular error that is an error between the third target angle and the third current angle.

**[0113]** Similarly to the first embodiment, the controller 50 of the driving device according to the fourth embodiment may perform arithmetic processing along the flowchart illustrated in FIG. 5, for example. Hereinafter, an example of arithmetic processing by the controller 50 according to the fourth embodiment will be described with reference to the flowchart illustrated in FIG. 5. In the fourth embodiment, target work is set to earth removal work, and excavation work, earth and sand holding and slewing work, and returning slewing work are set to non-target work.

**[0114]** At a time point of starting earth and sand loading work, an operator operates at least one of the operation levers 61A to 64A of the operation devices 61 to 64 to arrange the boom 4, the arm 5, and the bucket 6 in a desired orientation as illustrated in the upper diagram (A) in FIG. 6, for example, and, in this state, presses the storage switch 80.

**[0115]** When a signal indicating that the storage switch 80 is pressed is input to the controller 50, the target physical quantity setting unit 52 (target orientation setting device in FIG. 9) determines that input operation to the storage switch 80 is performed (YES in Step S1), sets an angle of the boom 4 at that time point as the first target angle, sets an angle of the arm 5 at that time point as the second target angle, and sets an angle of the bucket 6 at that time point as the third target angle (Step S2). On the other hand, when determining that input operation to the storage switch 80 is not performed (NO in Step S1), the target physical quantity setting unit 52 sets the first to third target angles to a default value (Step S3). The default value may be a value preset as the first to third target angles and stored in a memory, or may be the first to third target angles set last time.

**[0116]** Next, the work determination unit 59 of the controller 50 determines whether the earth removal work is being performed as described above (Step S4). When the work determination unit 59 determines that the earth removal work is being performed (YES in Step S4), the current physical quantity arithmetic unit 53 calculates the first current angle which is an angle of the boom 4 at that time point based on a detection signal input from the boom orientation detector 31, calculates the second current angle which is an angle of the arm 5 at that time point based on a detection signal

input from the arm orientation detector 32, and calculates the third current angle which is an angle of the bucket 6 at that time point based on a detection signal input from the bucket orientation detector 33. Then, the physical quantity error arithmetic unit 54 calculates the first angular error that is an error relating to the boom 4 by using, for example, a formula (first angular error = first target angle - first current angle), calculates the second angular error that is an error relating to the arm 5 by using, for example, a formula (second angular error = second target angle - second current angle), and calculates the third angular error that is an error relating to the bucket 6 by using, for example, a formula (third angular error = third target angle - third current angle) (Step S5).

[0117] The controller 50 stores in advance a map (boom map), for example, as illustrated in FIG. 3, set in advance to control an orientation of the boom 4, stores in advance a map (arm map), for example, as illustrated in FIG. 3, set in advance to control an orientation of the arm 5, and stores in advance a map (bucket map), for example, as illustrated in FIG. 3, set in advance to control an orientation of the bucket 6. These three maps are individually set in advance so that each of the boom 4, the arm 5, and the bucket 6 performs appropriate operation in the earth removal work. In the fourth embodiment, in the graph illustrated in FIG. 3, the horizontal axis represents an angular error (first angular error, second angular error, or third angular error), and the vertical axis represents the assistance rate (r).

[0118] Next, the assistance rate setting unit 55 sets the first assistance rate (r) which is an assistance rate for the boom 4 based on the boom map and the first angular error (e) calculated by the physical quantity error arithmetic unit 54. Similarly, the assistance rate setting unit 55 sets the second assistance rate (r) which is an assistance rate for the arm 5 based on the arm map and the second angular error (e) calculated by the physical quantity error arithmetic unit 54, and sets the third assistance rate (r) which is an assistance rate for the bucket 6 based on the bucket map and the third angular error (e) calculated by the physical quantity error arithmetic unit 54 (Step S6).

[0119] Next, the operator operation value (Lo) at that time point is input to the controller 50. Specifically, when boom operation (the boom lowering operation or the boom raising operation) is given to the operation lever 61A, the boom operation device 61 inputs an operator operation value (the first operator operation value (Lo)), which is an electric signal corresponding to a direction and magnitude of the boom operation, to the controller 50. Specifically, when the arm pushing operation is given to the operation lever 62A, the arm operation device 62 inputs an operator operation value (the second operator operation value (Lo)), which is an electric signal corresponding to magnitude of the arm pushing operation, to the controller 50. When the bucket pushing operation is given to the operation lever 63A, the bucket operation device 63 inputs an operator operation value (the third operator operation value (Lo)), which is an electric signal corresponding to magnitude of the bucket pushing operation, to the controller 50.

[0120] The controller 50 stores in advance, for example, a formula (boom arithmetic expression) as shown in Formula (1) described above, which is set in advance for feedback control of an orientation of the boom 4, stores in advance, for example, a formula (arm arithmetic expression) as shown in Formula (1) described above, which is set in advance for feedback control of an orientation of the arm 5, and stores in advance, for example, a formula (bucket arithmetic expression) as shown in Formula (1) described above, which is set in advance for feedback control of an orientation of the bucket 6. These three formulas are individually set in advance so that each of the boom 4, the arm 5, and the bucket 6 performs appropriate operation in the earth removal work.

[0121] The assistance operation value arithmetic unit 56 (PID controller) calculates the first assistance operation value (La), which is an assistance operation value for assisting the boom operation, by using the boom arithmetic expression and the first angular error (e). Similarly, the assistance operation value arithmetic unit 56 (PID controller) calculates the second assistance operation value (La), which is an assistance operation value for assisting the arm pushing operation, by using the arm arithmetic expression and the second angular error (e), and calculates the third assistance operation value (La), which is an assistance operation value for assisting the bucket pushing operation, by using the bucket arithmetic expression and the third angular error (e).

[0122] The operator operation value correction unit 57 calculates the first operator correction value (Lo') by using Formula (2) described above, the first operator operation value (Lo) in the boom operation, and the first assistance rate (r). Similarly, the operator operation value correction unit 57 calculates the second operator correction value (Lo') by using Formula (2) described above, the second operator operation value (Lo) in the arm pushing operation, and the second assistance rate (r), and calculates the third operator correction value (Lo') by using Formula (2) described above, the third operator operation value (Lo) in the bucket pushing operation, and the third assistance rate (r).

[0123] The assistance operation value correction unit 58 calculates the first assistance correction value (La') by using Formula (3) described above, the first assistance operation value (La) in the boom operation, and the first assistance rate (r). Similarly, the assistance operation value correction unit 58 calculates the second assistance correction value (La') by using Formula (3) described above, the second assistance operation value (La) in the arm pushing operation, and the second assistance rate (r), and calculates the third assistance correction value (La') by using Formula (3) described above, the third assistance operation value (La) in the bucket pushing operation, and the third assistance rate (r).

[0124] Regarding the boom operation, the operation command unit 51 outputs a first total value that is a total value obtained by adding the first operator correction value (Lo') and the first assistance correction value (La') as the first control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) that is a final operation value. Further, regarding the arm pushing operation,

the operation command unit 51 outputs a second total value that is a total value obtained by adding the second operator correction value ( $Lo'$ ) and the second assistance correction value ( $La'$ ) as the second control command  $Y$  ( $Y = Lo \times (1 - r) + La \times r$ ) that is a final operation value. Further, regarding the bucket pushing operation, the operation command unit 51 outputs a third total value that is a total value obtained by adding the third operator correction value ( $Lo'$ ) and the third assistance correction value ( $La'$ ) as the third control command  $Y$  ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value (Step S7). The output first control command  $Y$  is input to the proportional valve 45 corresponding to the boom operation (boom lowering operation or boom raising operation), the output second control command  $Y$  is input to the proportional valve 46 corresponding to the arm pushing operation, and the output third control command  $Y$  is input to the proportional valve 47 corresponding to the bucket pushing operation.

**[0125]** On the other hand, when the work determination unit 59 determines that the earth removal work is not being performed (NO in Step S4), the operation command unit 51 outputs the operator operation value ( $Lo$ ) corresponding to an operation input from at least one of the plurality of operation devices 61 to 64 as a control command which is a final operation value (Step S8).

**[0126]** As described above, the controller 50 performs the feedback control using the assistance operation value ( $La$ ) for bringing the angular error ( $e$ ) close to zero as illustrated in FIG. 4 for each of the boom 4, the arm 5, and the bucket 6, and repeatedly performs the arithmetic processing as illustrated in Steps S1 to S8 of the flowchart of FIG. 5 for each of the boom 4, the arm 5, and the bucket 6. This makes it possible to assist operator's operation for adjusting an orientation of the boom 4, an orientation of the arm 5, and an orientation of the bucket 6 to a desired orientation while allowing intervention of an operator's intention.

[Variation]

**[0127]** The construction machine driving device according to the embodiment of the present disclosure is described above, but the present disclosure is not limited to the embodiment, and includes a variation below, for example.

(A) In the first embodiment, a physical quantity related to an orientation of a work device is coordinates of a tip of the bucket 6, and an orientation of the bucket 6 is controlled using coordinates of the tip of the bucket 6. However, the first embodiment is not limited to such a specific example. For example, an orientation of a work device may be controlled using at least one of coordinates of a specific part (for example, a tip of the boom 4) in the boom 4, coordinates of a specific part (for example, a tip of the arm 5) in the arm 5, and coordinates of a specific part (for example, a tip of the bucket 6) in the bucket 6. Specifically, for example, an orientation of the arm 5 may be controlled using coordinates of a tip of the arm 5, and an orientation of the bucket 6 may be controlled using coordinates of a tip of the bucket 6. Further, an orientation of the boom 4 may be controlled using coordinates of a tip of the boom 4, an orientation of the arm 5 may be controlled using coordinates of a tip of the arm 5, and an orientation of the bucket 6 may be controlled using coordinates of a tip of the bucket 6. Specifically, in a case where a tip of the arm 5 is set as the specific part and a tip of the bucket 6 is set as the specific part in the first embodiment, the controller 50 preferably controls an orientation of the arm 5 by using a current physical quantity that is actual coordinates of the tip of the arm 5, a target physical quantity that is a target of coordinates of the tip of the arm 5, a physical quantity error that is an error between these, an operator operation value, an assistance operation value, an operator correction value, and an assistance correction value, and preferably controls an orientation of the bucket 6 by using a current physical quantity that is actual coordinates of the tip of the bucket 6, a target physical quantity that is a target of coordinates of the tip of the bucket 6, a physical quantity error that is an error between these, an operator operation value, an assistance operation value, an operator correction value, and an assistance correction value.

(B) In the second embodiment, a physical quantity related to an orientation of a work device is a cylinder length, an orientation of the arm 5 is controlled using a cylinder length of the arm cylinder 8, and an orientation of the bucket 6 is controlled using a cylinder length of the bucket cylinder 9. However, the second embodiment is not limited to such a specific example. For example, an orientation of a work device may be controlled using at least one of a cylinder length of the boom cylinder 7, a cylinder length of the arm cylinder 8, and a cylinder length of the bucket cylinder 9.

(C) In the third embodiment, a physical quantity related to an orientation of a work device is a height of a tip of the bucket 6, and an orientation of the work device is controlled using a height of the tip of the bucket 6, but the present invention is not limited to such a specific example. For example, an orientation of a work device may be controlled using at least one of a height of a specific part (for example, a tip of the boom 4) in the boom 4, a height of a specific part (for example, a tip of the arm 5) in the arm 5, and a height of a specific part (for example, a tip of the bucket 6) in the bucket 6.

(D) A physical quantity related to an orientation of a work device may include, for example, at least one of the boom angle  $\theta 1$ , the arm angle  $\theta 2$ , the bucket angle  $\theta 3$ , and an inclination angle of the upper slewing body 2.

(E) Regarding construction machine system



**[0128]** The driving device according to the present disclosure can also be applied to a construction machine system. The construction machine system includes the construction machine 100, and the remote operation devices 61 to 64 which are the operation device 61 to 64 arranged at a position away from the construction machine 100. The construction machine 100 may include a part or whole of the controller 50, and a part or whole of the controller 50 may be arranged at a remote location. The construction machine 100 is configured to operate based on operation by an operator given to the remote operation devices 61 to 64. The operator operation value (Lo) output from the remote operation devices 61 to 64 is transmitted to the construction machine 100 by wireless communication or wired communication. Further, an image of a work site where the construction machine 100 performs work is captured by a camera (not illustrated), captured data is transmitted to a remote place by wireless communication or wired communication, and a display device arranged at the remote place displays an image of the work site in real time by using the transmitted data. An operator operates the remote operation devices 61 to 64 while viewing the display device at a remote place. In a case where the remote operation devices 61 to 64 are operated at a remote place in the above manner, it is difficult for an operator to grasp a situation of a work site such as a sense of perspective of a work site as compared with a case where the operator gets on the construction machine 100 (actual machine) and operates an operation device. Therefore, as the driving device according to the present disclosure is applied to a system for such remote control, an effect of reducing burden on an operator by assistance of the driving device becomes more remarkable in work of adjusting a work device to a predetermined orientation.

(F) Regarding operation device

**[0129]** In a case where each of the operation devices 61 to 64 is constituted by an operation device including a remote control valve, the construction machine 100 includes a plurality of pilot pressure sensors (not illustrated) that detect pressure of pilot oil output from the remote control valve according to a lever operation quantity that is magnitude of an operation given to an operation lever of each of the operation devices 61 to 64. Each of the plurality of pilot pressure sensors inputs an operation value, which is a signal corresponding to detected pressure of pilot oil, to the controller 50 as an operator operation value. Further, an electromagnetic proportional valve is arranged between each remote control valve and a control valve corresponding to each remote control valve, and the electromagnetic proportional valve reduces pressure of pilot oil based on a control command from the controller 50 and supplies the reduced pilot pressure to a pilot port of a corresponding control valve. In a case where pressure larger than pressure of pilot oil output from the remote control valve is supplied to a pilot port of a control valve according to a lever operation quantity, the controller 50 may control a second electromagnetic proportional valve different from the electromagnetic proportional valve so that secondary pressure of the second electromagnetic proportional valve is selected to a high level in a shuttle valve (not illustrated) to be supplied to the pilot port of the control valve.

(G) Regarding input device

**[0130]** The driving device may further include the input device 90 (see FIG. 2) that receives input by an operator for correcting the assistance rate (r), and the controller 50 may be configured to correct the assistance rate (r) based on input by the operator to the input device 90. In this configuration, since an operator can correct the assistance rate (r), degree of intervention of an operator's intention can be adjusted according to the preference of the operator.

**[0131]** Specifically, for example, an operator inputs an input value (r') for correcting the assistance rate (r) to the input device 90. The operator operation value correction unit 57 of the controller 50 may calculate the operator correction value (Lo') by using, for example, a formula " $Lo \times (1 - \min(r, r'))$ ", and the assistance operation value correction unit 58 may calculate the assistance correction value (La') by using, for example, a formula " $La \times \min(r, r')$ ". Then, the operation command unit 51 may output a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as the control command Y ( $Y = Lo \times (1 - \min(r, r')) + La \times \min(r, r')$ ) which is a final operation value. Note that " $\min(r, r')$ " in the above formula means that a smaller one of the assistance rate (r) and the input value (r') is employed for calculation.

**[0132]** Further, the operator operation value correction unit 57 of the controller 50 may calculate the operator correction value (Lo') by using, for example, a formula " $Lo \times (1 - r) \times (1 - r')$ ", and the assistance operation value correction unit 58 may calculate the assistance correction value (La') by using, for example, a formula " $La \times r \times r'$ ". Then, the operation command unit 51 may output a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as the control command Y ( $Y = Lo \times (1 - r) \times (1 - r') + La \times r \times r'$ ) which is a final operation value.

(H) Regarding notification device

**[0133]** As illustrated in FIG. 2, the driving device may further include a notification device 70 (an example of a teaching device) for notifying an operator of a situation of control by the controller 50, and the controller 50 may be configured to

control operation of the notification device so that output from the notification device 70 changes according to the assistance rate (r). The notification device 70 outputs, for example, sound, an image, vibration (for example, vibration of an operation lever), and the like. With this configuration, an operator can perform work for adjusting an orientation of a work device to a desired orientation while roughly grasping a situation of control by the controller 50 based on the assistance rate (r). By the above, since the operator can recognize that assistance control by the controller 50 is being performed, a sense of security of the operator at the time of operation is improved. In this case, the controller 50 is preferably configured to control operation of the notification device so that output from the notification device 70 changes according to magnitude of the assistance rate (r). By the above, the operator can perform work for adjusting an orientation of a work device to a desired orientation while more accurately grasping a situation of control by the controller 50 based on the assistance rate (r).

**[0134]** Further, the controller 50 may be configured to control operation of the notification device 70 so that output from the notification device 70 changes according to the physical quantity error (e). With this configuration, an operator can perform work for adjusting an orientation of a work device to a desired orientation while roughly grasping a situation of control by a controller based on the physical quantity error (e). By the above, the operator can operate an operation device while grasping a sense of distance until a work device reaches a desired orientation (target orientation), and thus a sense of security of the operator at the time of operation is improved. In particular, in a case where the operator is an unskilled person, improvement of an ability to grasp a sense of distance of the unskilled person can be expected.

**[0135]** Further, in this case, the controller 50 is preferably configured to control operation of the notification device so that output from the notification device 70 changes according to magnitude of the physical quantity error (for example, a coordinate error, a height error, a distance error, a length error, an angular error, or the like). By the above, an operator can perform work for adjusting an orientation of a work device to a desired orientation while more accurately grasping the physical quantity error (e), that is, the sense of distance.

**[0136]** In the specific example illustrated in FIG. 9, the controller 50 controls operation of the notification device 70 so that an alarm sound from an alarm sound generation device as the notification device 70 changes according to an angular error. The controller 50 may be configured to change a type of sound according to the error (e). By the above, an operator can recognize a distance until a work device reaches a desired orientation (target orientation) through a change in a type of sound, so that a sense of security is improved. Further, the controller 50 may be configured to change a type of sound according to the assistance rate (r). By the above, since the operator can recognize that assistance control by the controller 50 is being performed, a sense of security of the operator at the time of operation is improved.

#### (I) Regarding target physical quantity

**[0137]** The controller 50 may be configured to set a plurality of target physical quantities, determine work being performed by the construction machine 100, and select a target physical quantity corresponding to the determined work among the plurality of target physical quantities. In this configuration, for example, in a case where a plurality of different pieces of work are continuously performed, an operator does not need to select a target physical quantity for each piece of work, so that burden on the operator is reduced. A specific example is as described below.

**[0138]** In a case where earth and sand loading work, which is a series of pieces of work including excavation work, earth and sand holding and slewing work, earth removal work, and returning slewing work, is repeatedly performed at a work site, the earth removal work and the returning slewing work may be set to the target work described above, and the excavation work and the earth and sand holding and slewing work may be set to non-target work. In this case, before the series of pieces of work is started, the controller 50 sets and stores a target physical quantity for the earth removal work and a target physical quantity for the returning slewing work. Then, in the series of pieces of work, the work determination unit 59 of the controller 50 determines work performed by the construction machine 100, and the operation command unit 51 outputs a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La') as the control command Y ( $Y = Lo \times (1 - r) + La \times r$ ) which is a final operation value in a case where the earth removal work or the returning slewing work is performed. On the other hand, in a case where neither the earth removal work nor the returning slewing work is performed, the operation command unit 51 outputs the operator operation value (Lo) corresponding to an operation input from at least one of the plurality of operation devices 61 to 64 as a control command which is a final operation value.

**[0139]** (J) In the embodiment described above, the controller 50 calculates the assistance correction value (La') by multiplying the assistance operation value (La) by the assistance rate (r), and calculates the operator correction value (Lo') by multiplying the operator operation value (Lo) by a value obtained by subtracting the assistance rate (r) from a preset setting value (for example, "1"), but the embodiment is not limited to such a mode. The controller 50 may calculate the assistance correction value (La') and the operator correction value (Lo') without using an assistance rate. That is, the controller 50 may correct the operator operation value (Lo) corresponding to an operation by an operator to the operator correction value (Lo') based on a map set in advance such that the operator correction value (Lo') becomes smaller when the physical quantity error (e) is small as compared with when the physical quantity error (e) is large.

Further, the controller 50 may correct the assistance operation value (La) to the assistance correction value (La') based on a map set in advance such that the assistance correction value (La') becomes a larger value when the physical quantity error (e) is small as compared with when the physical quantity error (e) is large.

5 (K) Regarding assistance by image

10 [0140] The driving device of the construction machine 100 according to each of the embodiments described above may further include a display device (an example of a teaching device), and the controller 50 may be configured to cause the display device to display an actual orientation image which is an image relating to an actual orientation of at least one work device of the plurality of work devices and a target orientation image which is an image relating to a target orientation of the at least one work device. The display device may be, for example, a display arranged at a position that can be viewed by an operator in a cabin of the upper slewing body 2, or may be a head mounted display that can be worn by the operator. Further, the display device may be, for example, a device capable of displaying an image on front glass of the cabin. Further, in a case where the driving device according to the present disclosure is applied to the construction machine system as described above, the display device may be arranged at a remote place. That is, the display device may be a device that can be viewed by an operator who operates the remote operation devices 61 to 64 arranged at a position away from the construction machine 100.

15 [0141] FIG. 10 is a diagram illustrating an example of a display device 92. In the specific example illustrated in FIG. 10, the controller 50 displays an image in which the entire construction machine 100 including a plurality of work devices is viewed from the side. The image drawn by a solid line in FIG. 10 includes an actual orientation image which is an image relating to an actual orientation of each of the lower travelling body 1, the upper slewing body 2, the boom 4, the arm 5, and the bucket 6 at that time point. The actual orientation image may be, for example, an actual image of at least one work device captured by a camera, or may be an image created by the controller 50 based on the orientation information input from the orientation information acquisition unit to the controller 50.

20 [0142] The image depicted by a broken line in FIG. 10 includes a boom target orientation image related to a target orientation of the boom 4, an arm target orientation image related to a target orientation of the arm 5, and a bucket target orientation image related to a target orientation of the bucket 6. The boom target orientation image is an image corresponding to the target physical quantity (boom target physical quantity) related to an orientation of the boom 4 set by the target physical quantity setting unit 52. The arm target orientation image is an image corresponding to a target physical quantity (arm target physical quantity) related to an orientation of the arm 5 set by the target physical quantity setting unit 52. The bucket target orientation image is an image corresponding to a target physical quantity (bucket target physical quantity) related to an orientation of the bucket 6 set by the target physical quantity setting unit 52.

25 [0143] The controller 50 causes the display device 92 to display a boom target orientation image, an arm target orientation image, and a bucket target orientation image superimposed on an actual orientation image of the boom 4, the arm 5, and the bucket 6. By the above, an operator can recognize, through the image displayed on the display device 92, a gap between a target orientation of the boom 4, the arm 5, and the bucket 6 and an actual orientation of these. In particular, in a case where an operator is an unskilled person, the unskilled person is expected to effectively improve an operation technique by operating an operation device while recognizing the gap through an image displayed on the display device 92.

30 [0144] FIG. 11 is a diagram illustrating another example of the display device 92. In the specific example illustrate in FIG. 11, the controller 50 displays an image assuming a viewpoint from an operator sitting on a driver's seat in a cabin. A left image drawn by a solid line in FIG. 11 is an image (actual orientation image) related to an actual orientation of each of the arm 5 and the bucket 6 at that time point. The actual orientation image may be, for example, an actual image of at least one work device captured by a camera, or may be an image created by the controller 50 based on the orientation information. Further, in a case where the display device is a device capable of displaying an image on front glass of a cabin, the actual orientation image may be an image created by the controller 50 based on the orientation information, or may be an actual image of the arm 5 and the bucket 6 visible through the front glass.

35 [0145] A right image drawn by a broken line in FIG. 11 is a bucket target orientation image related to a target orientation of the bucket 6. The bucket target orientation image is an image corresponding to a target physical quantity related to an orientation of the bucket 6 set by the target physical quantity setting unit 52. A central image drawn by a two-dot chain line in FIG. 11 is an intermediate orientation image (bucket intermediate orientation image) related to an intermediate orientation between an actual orientation of the bucket 6 and a target orientation of the bucket 6. The controller 50 causes the display device 92 to display an actual orientation image of the arm 5 and the bucket 6, a bucket target orientation image, and a bucket intermediate orientation image. By the above, an operator can recognize, through the image displayed on the display device 92, a gap between a target orientation of the bucket 6 and an actual orientation of the bucket 6. Moreover, an operator can recognize, through the bucket intermediate orientation image displayed on the display device 92, what kind of intermediate orientation the bucket 6 takes until reaching a target orientation from an actual orientation.

**[0146]** Further, the controller 50 may cause the display device 92 to further display an image of an object present around the bucket 6 in addition to an actual orientation image of the bucket 6, a bucket target orientation image, and a bucket intermediate orientation image. In this case, an operator can determine whether the bucket 6 collides with an object present around the bucket 6 while the bucket 6 reaches a target orientation from an actual orientation through an intermediate orientation.

**[0147]** For example, the controller 50 may calculate the intermediate orientation based on information related to an operation speed of the bucket 6. By the above, the controller 50 can relatively accurately predict the intermediate orientation. Specifically, an operation speed of the bucket 6 includes a direction in which the bucket 6 operates and a speed at which the bucket 6 operates. The controller 50 may use information related to an operation speed of the bucket 6 at that time point and, for example, a set time set in advance or a set time set based on input by an operator to calculate, as the intermediate orientation, an orientation of the bucket 6 after lapse of the set time from that time point. However, calculation of the intermediate orientation by the controller 50 is not limited to the above specific example. For example, the controller 50 may calculate an orientation at a central point between an actual orientation of the bucket 6 and a target orientation of the bucket 6 by using, for example, a method such as linear interpolation.

**[0148]** The information related to an operation speed of the bucket 6 may be an operator operation value corresponding to an operation given to at least one of the plurality of operation devices 61 to 64. Further, the information related to an operation speed of the bucket 6 may be a total value obtained by adding the operator correction value (Lo') and the assistance correction value (La'). Further, the information related to an operation speed of the bucket 6 may be an operation speed of the bucket 6 actually detected by a speed sensor (not illustrated).

(L) Regarding release of assistance control

**[0149]** In a case where a non-assistance condition, which is a predetermined condition, is satisfied while the controller 50 performs assistance control for controlling the orientation of the work device by using the total value, the controller 50 may be configured to switch from the assistance control to control based on an operation given to an operation device (normal control). In this variation, in a case where the non-assistance condition is satisfied while the controller 50 performs assistance control, the controller 50 switches from the assistance control to the normal control. By the above, assist by the controller 50 is released, and the work device performs operation corresponding to the operation given to an operation device by an operator. This makes it possible to release assistance and appropriately operate a work device according to an operator's intention in a case where a situation in which it is not preferable to continue assistance control as it is occurs.

**[0150]** Examples of the situation in which it is not preferable to continue assistance control as it is include a situation in which a work device needs to avoid an obstacle, a situation in which earth removal from a bucket is completed before an orientation of a work device reaches a target orientation when earth removal work is being performed, and the like.

**[0151]** The non-assistance condition may include switching from the operation given to the operation device in the assistance control to another operation set in advance. In a case where the above situation occurs, an operator often switches from an operation given to an operation device in assistance control to another operation. Specifically, for example, when a situation in which a work device needs to avoid an obstacle occurs, an operator tries to avoid contact between the work device and the obstacle by switching to an operation in a direction different from (for example, a direction opposite to) a direction of a lever operation given to the work device until then. When assist by the controller 50 is released under such a situation, contact between the work device and the obstacle is more effectively avoided. Further, when a situation in which earth removal from a bucket is completed occurs during earth removal work, an operator switches to the arm pulling operation in a direction opposite to the arm pushing operation which is given to a work device until then, in order to perform a next piece of work (for example, returning slewing work). When assist by the controller 50 is released under such a situation, continuity of a plurality of pieces of work is more effectively ensured. As described above, switching from the operation given to the operation device in the assistance control to another operation set in advance is an indication for determining that a situation in which it is not preferable to continue assistance control as it is occurs.

**[0152]** However, the non-assistance condition is not limited to the above specific example, and may include, for example, switching from a state in which the physical quantity error decreases to a state in which the physical quantity error increases, and elapsed time from the switching exceeding a time threshold which is a preset threshold.

**[0153]** As described above, according to the present disclosure, the construction machine driving device capable of assisting an operation by an operator for adjusting an orientation of a work device to a desired orientation while allowing intervention of an operator's intention, and a construction machine and a construction machine system including the construction machine driving device are provided.

**[0154]** A construction machine driving device to be provided includes an operation device to which an operation by an operator for moving a work device with respect to a machine body is given, and a controller, in which the controller sets a target physical quantity that is a target of a physical quantity related to an orientation of the work device, calculates

a current physical quantity that is a physical quantity related to an actual orientation of the work device, calculates a physical quantity error that is an error between the target physical quantity and the current physical quantity, calculates an assistance operation value for assisting the operation of the operator, corrects an operator operation value corresponding to the operation to an operator correction value such that the operator correction value becomes smaller when

the physical quantity error is small as compared with when the physical quantity error is large, corrects the assistance operation value to an assistance correction value such that the assistance correction value becomes larger when the physical quantity error is small as compared with when the physical quantity error is large, and controls the orientation of the work device by using a total value obtained by adding the operator correction value and the assistance correction value.

**[0155]** The controller of the construction machine controls an orientation of a work device by using a total value obtained by adding an operator correction value corrected to become a small value when a physical quantity error is small as compared with when the physical quantity error is large and an assistance correction value corrected to become a large value when the physical quantity error is small as compared with when the physical quantity error is large. Therefore, the controller of the construction machine can assist operation by an operator for adjusting an orientation of a work device to a desired orientation while allowing intervention of an operator's intention. Specifically, when a physical quantity error is large, a proportion of contribution of an operator operation value to the total value can be made large, and when the physical quantity error is small, a proportion of contribution of an assistance operation value to the total value can be made large. Therefore, when a physical quantity error is large, significant intervention of an operator's intention is allowed, and when the physical quantity error is small, that is, when an orientation of a work device approaches a target orientation and the orientation of the work device is finely adjusted, intervention of an operator's intention can be made less as compared with when the physical quantity error is large, and an orientation of the work device can be easily adjusted to a target orientation by assistance of the controller. By the above, it is possible to achieve both intervention of an operator's intention and easy adjustment of an orientation of a work device.

**[0156]** The controller preferably sets an assistance rate such that the assistance rate becomes a larger value when the physical quantity error is small as compared with when the physical quantity error is large, calculates the assistance correction value by multiplying the assistance operation value by the assistance rate, and calculates the operator correction value by multiplying the operator operation value by a value obtained by subtracting the assistance rate from a preset setting value. In this configuration, as a physical quantity error becomes smaller, that is, as an orientation of a work device approaches a target orientation, an operator correction value can be continuously made smaller and an assistance correction value can be continuously made larger. This enables smooth transition from a state in which operation by an operator is mainly performed to a state in which assist by the controller is mainly performed in a process in which an orientation of a work device approaches a target orientation.

**[0157]** The driving device may further include an input device that receives input by the operator for correcting the assistance rate, in which the controller may correct the assistance rate based on the input by the operator. In this configuration, since an operator can correct an assistance rate, degree of intervention of an operator's intention can be adjusted according to the preference of the operator.

**[0158]** The driving device preferably further includes a notification device for notifying the operator of a situation of control by the controller, and the controller preferably controls operation of the notification device such that output from the notification device changes according to the assistance rate. With this configuration, an operator can perform work for adjusting an orientation of a work device to a desired orientation while roughly grasping a situation of control by the controller based on an assistance rate.

**[0159]** The driving device preferably further includes a notification device for notifying the operator of a situation of control by the controller, in which the controller preferably controls operation of the notification device such that output from the notification device changes according to the physical quantity error. With this configuration, an operator can perform work for adjusting an orientation of a work device to a desired orientation while roughly grasping a situation of control by a controller based on the physical quantity error.

**[0160]** The controller may calculate the assistance operation value based on the physical quantity error such that the physical quantity error approaches zero. In this configuration, the controller can effectively perform assistance to bring an orientation of a work device close to a target orientation.

**[0161]** The controller may set a plurality of target physical quantities including the target physical quantity, determine work being performed by the construction machine, and select a target physical quantity corresponding to the determined work from the plurality of target physical quantities. In this configuration, the controller can select an appropriate target physical quantity for each piece of work. Therefore, in this configuration, for example, in a case where a plurality of different pieces of work are continuously performed, an operator does not need to select a target physical quantity for each piece of work, so that burden on the operator is reduced.

**[0162]** The controller preferably determines whether or not target work that is work set in advance as a target of assistance by the controller is performed, controls the orientation of the work device by using the total value in a case where the target work is performed, and controls the orientation of the work device by using the operator operation value

in a case where the target work is not performed. In this configuration, the controller can perform control according to a determination result as to whether or not target work is being performed. By the above, an operator can smoothly perform a plurality of series of pieces of work including target work and other pieces of work.

**[0163]** The work device may include a bucket, and the physical quantity error may be a value corresponding to a distance between a tip of the bucket and a working surface. In this configuration, for example, in a case of performing excavation work, an operator can easily arrange a tip of a bucket at a desired position that is an excavation start position of a working surface while receiving assistance from the controller.

**[0164]** The driving device may further include a display device, in which the controller may cause the display device to display an actual orientation image which is an image related to an actual orientation of the work device and a target orientation image which is an image related to a target orientation of the work device. By the above, an operator can recognize, through an image displayed on the display device, a gap between a target orientation and an actual orientation of a work device. In particular, in a case where an operator is an unskilled person, the unskilled person is expected to effectively improve an operation technique by operating an operation device while recognizing the gap through an image displayed on the display device.

**[0165]** The controller may cause the display device to further display an intermediate orientation image which is an image related to an intermediate orientation between the actual orientation and the target orientation. By the above, an operator can recognize, through an image displayed on the display device, what kind of intermediate orientation a work device takes until reaching a target orientation from an actual orientation.

**[0166]** The controller may calculate the intermediate orientation based on information related to an operation speed of the work device. By the above, the controller can relatively accurately predict the intermediate orientation.

**[0167]** In a case where a non-assistance condition, which is a predetermined condition, is satisfied while the controller performs assistance control for controlling the orientation of the work device by using the total value, the controller preferably switches from the assistance control to control based on an operation given to the operation device (normal control). In this configuration, in a case where the non-assistance condition is satisfied while assistance control is performed, the controller switches from the assistance control to the normal control, so that assistance by the controller is released, and the work device performs an operation corresponding to the operation given to the operation device by an operator. This makes it possible to release assistance and appropriately operate a work device according to an operator's intention in a case where a situation in which it is not preferable to continue assistance control as it is occurs.

**[0168]** The non-assistance condition preferably includes switching from the operation given to the operation device in the assistance control to another operation set in advance. In a case where the above situation occurs, an operator often switches from an operation given to an operation device in assistance control to another operation. Therefore, switching from the operation given to the operation device in the assistance control to another operation set in advance is an indication for determining that a situation in which it is not preferable to continue assistance control as it is occurs.

**[0169]** A construction machine to be provided includes the machine body, the work device, and the driving device described above. The construction machine can assistance operation by an operator for adjusting an orientation of a work device to a desired orientation while allowing intervention of an operator's intention.

**[0170]** A construction machine system to be provided includes the driving device described above, in which the operation device is a remote operation device arranged at a place away from the construction machine. In this construction machine system, in a case where an operator operates a remote operation device at a remote place to cause a construction machine to perform work at a work site, the controller can assistance operation by an operator while allowing intervention of an operator's intention. Specifically, in a case where a remote operation device is operated at a remote place, it is difficult for an operator to grasp a situation of a work site such as a sense of perspective of a work site as compared with a case where the operator gets on a construction machine (actual machine) and operates an operation device. Therefore, as the driving device according to the present disclosure is applied to a system for such remote control, an effect of reducing burden on an operator by assistance of the driving device becomes more remarkable in work of adjusting a work device to a predetermined orientation.

## Claims

1. A construction machine driving device comprising:

an operation device to which an operation by an operator for moving a work device with respect to a machine body is given; and  
a controller,  
wherein the controller:

sets a target physical quantity that is a target of a physical quantity related to an orientation of the work device;

calculates a current physical quantity that is a physical quantity related to an actual orientation of the work device;

calculates a physical quantity error that is an error between the target physical quantity and the current physical quantity;

calculates an assistance operation value for assisting the operation of the operator;

corrects an operator operation value corresponding to the operation to an operator correction value such that the operator correction value becomes smaller when the physical quantity error is small as compared with when the physical quantity error is large;

corrects the assistance operation value to an assistance correction value such that the assistance correction value becomes larger when the physical quantity error is small as compared with when the physical quantity error is large; and

controls the orientation of the work device by using a total value obtained by adding the operator correction value and the assistance correction value.

2. The construction machine driving device according to claim 1, wherein the controller:

sets an assistance rate such that the assistance rate becomes a larger value when the physical quantity error is small as compared with when the physical quantity error is large;

calculates the assistance correction value by multiplying the assistance operation value by the assistance rate; and

calculates the operator correction value by multiplying the operator operation value by a value obtained by subtracting the assistance rate from a preset setting value.

3. The construction machine driving device according to claim 2, further comprising an input device that receives input by the operator for correcting the assistance rate, wherein the controller corrects the assistance rate based on the input by the operator.

4. The construction machine driving device according to claim 2 or 3, further comprising a notification device for notifying the operator of a situation of control by the controller, wherein the controller controls operation of the notification device such that output from the notification device changes according to the assistance rate.

5. The construction machine driving device according to any one of claims 1 to 3, further comprising a notification device for notifying the operator of a situation of control by the controller, wherein the controller controls operation of the notification device such that output from the notification device changes according to the physical quantity error.

6. The construction machine driving device according to any one of claims 1 to 5, wherein the controller calculates the assistance operation value based on the physical quantity error such that the physical quantity error approaches zero.

7. The construction machine driving device according to any one of claims 1 to 6, wherein the controller:

sets a plurality of target physical quantities including the target physical quantity;

determines work being performed by the construction machine; and

selects a target physical quantity corresponding to the determined work from the plurality of target physical quantities.

8. The construction machine driving device according to any one of claims 1 to 6, wherein the controller:

determines whether or not target work that is work set in advance as a target of assistance by the controller is performed;

controls the orientation of the work device by using the total value in a case where the target work is performed; and

controls the orientation of the work device by using the operator operation value in a case where the target work is not performed.

9. The construction machine driving device according to any one of claims 1 to 8, wherein

the work device includes a bucket, and  
the physical quantity error is a value corresponding to a distance between a tip of the bucket and a working  
surface.

10. The construction machine driving device according to any one of claims 1 to 9, further comprising a display device,  
wherein the controller causes the display device to display an actual orientation image which is an image related to  
an actual orientation of the work device and a target orientation image which is an image related to a target orientation  
of the work device.

11. The construction machine driving device according to claim 10, wherein the controller causes the display device to  
further display an intermediate orientation image which is an image related to an intermediate orientation between  
the actual orientation and the target orientation.

12. The construction machine driving device according to claim 11, wherein the controller calculates the intermediate  
orientation based on information related to an operation speed of the work device.

13. The construction machine driving device according to any one of claims 1 to 12, wherein in a case where a non-  
assistance condition, which is a predetermined condition, is satisfied while the controller performs assistance control  
for controlling the orientation of the work device by using the total value, the controller switches from the assistance  
control to control based on an operation given to the operation device.

14. The construction machine driving device according to claim 13, wherein the non-assistance condition includes  
switching from the operation given to the operation device in the assistance control to another operation set in  
advance.

15. A construction machine comprising:

the machine body;  
the work device; and  
the driving device according to any one of claims 1 to 14.

16. A construction machine system comprising:

the driving device according to any one of claims 1 to 14,  
wherein the operation device is a remote operation device arranged at a place away from the construction  
machine.



FIG.1

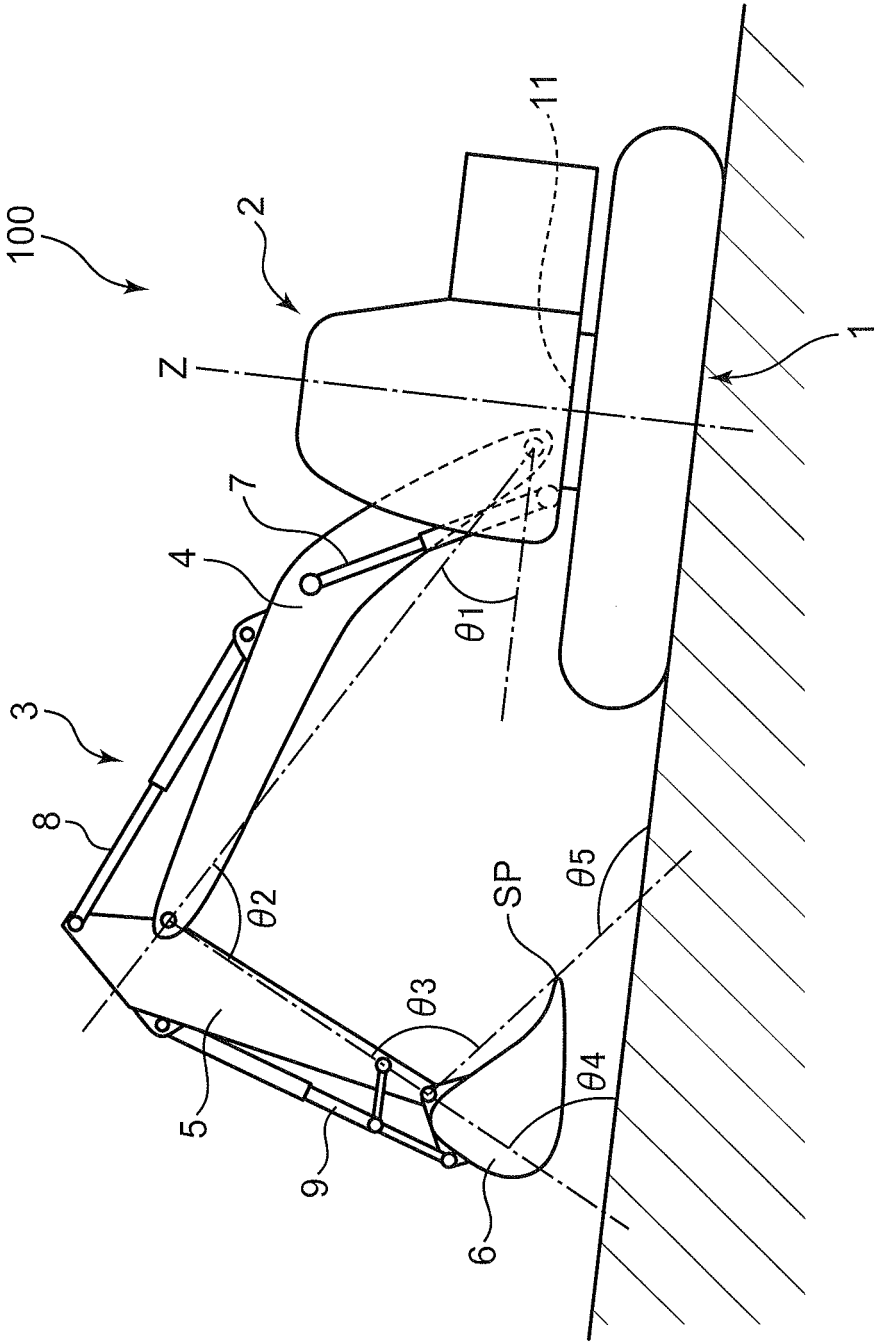


FIG.2

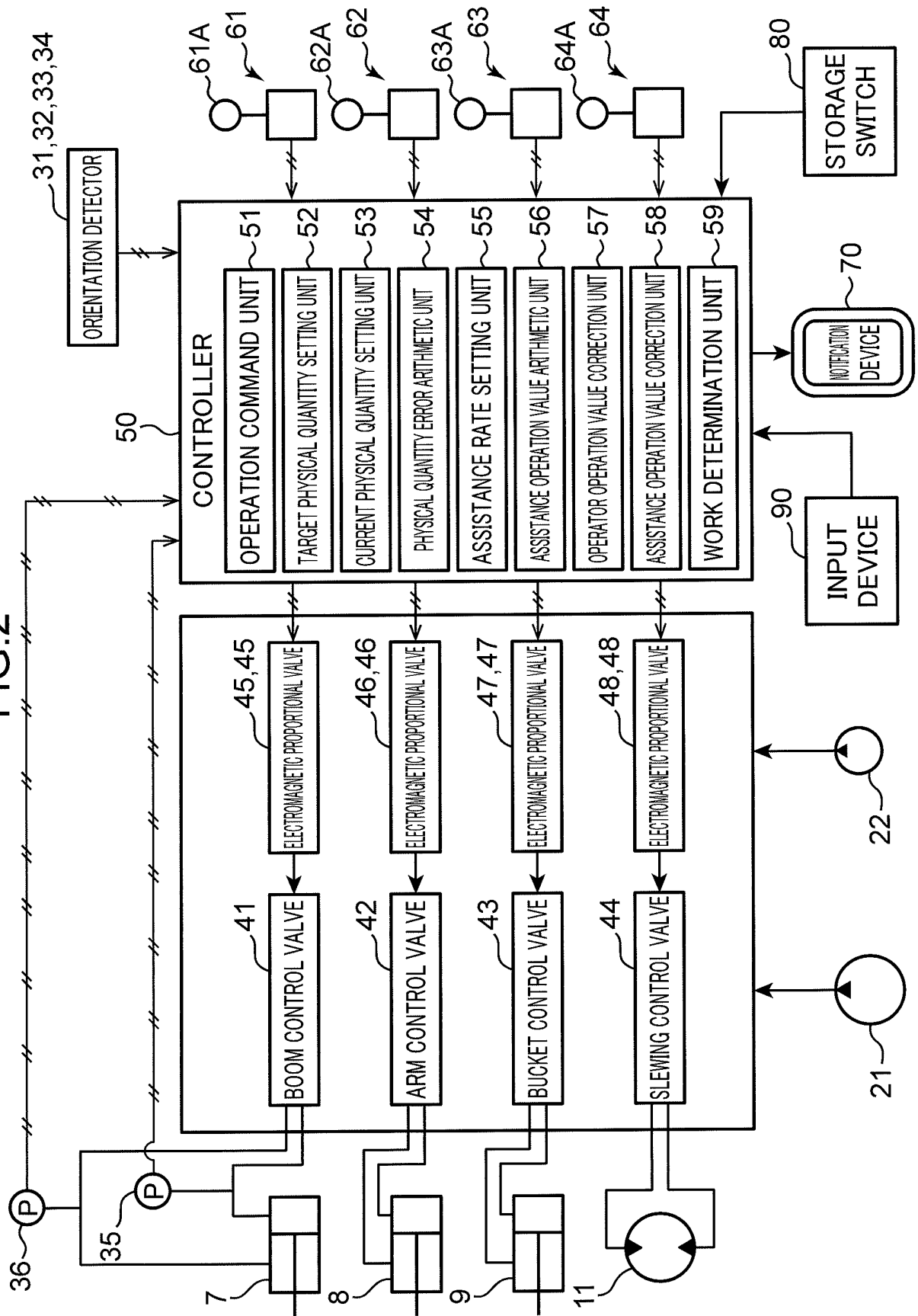


FIG.3

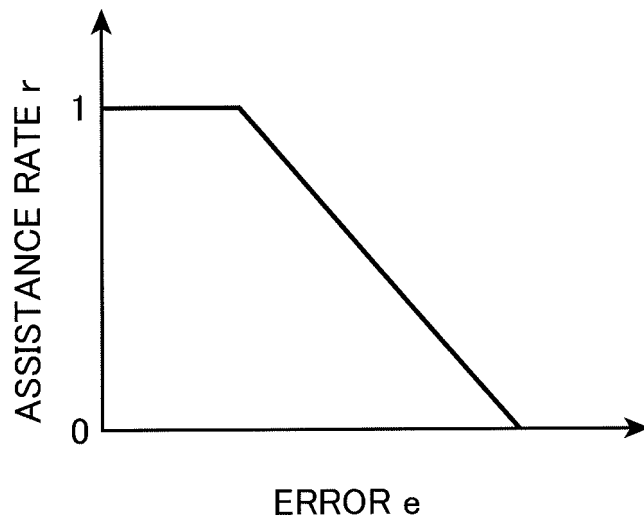


FIG.4

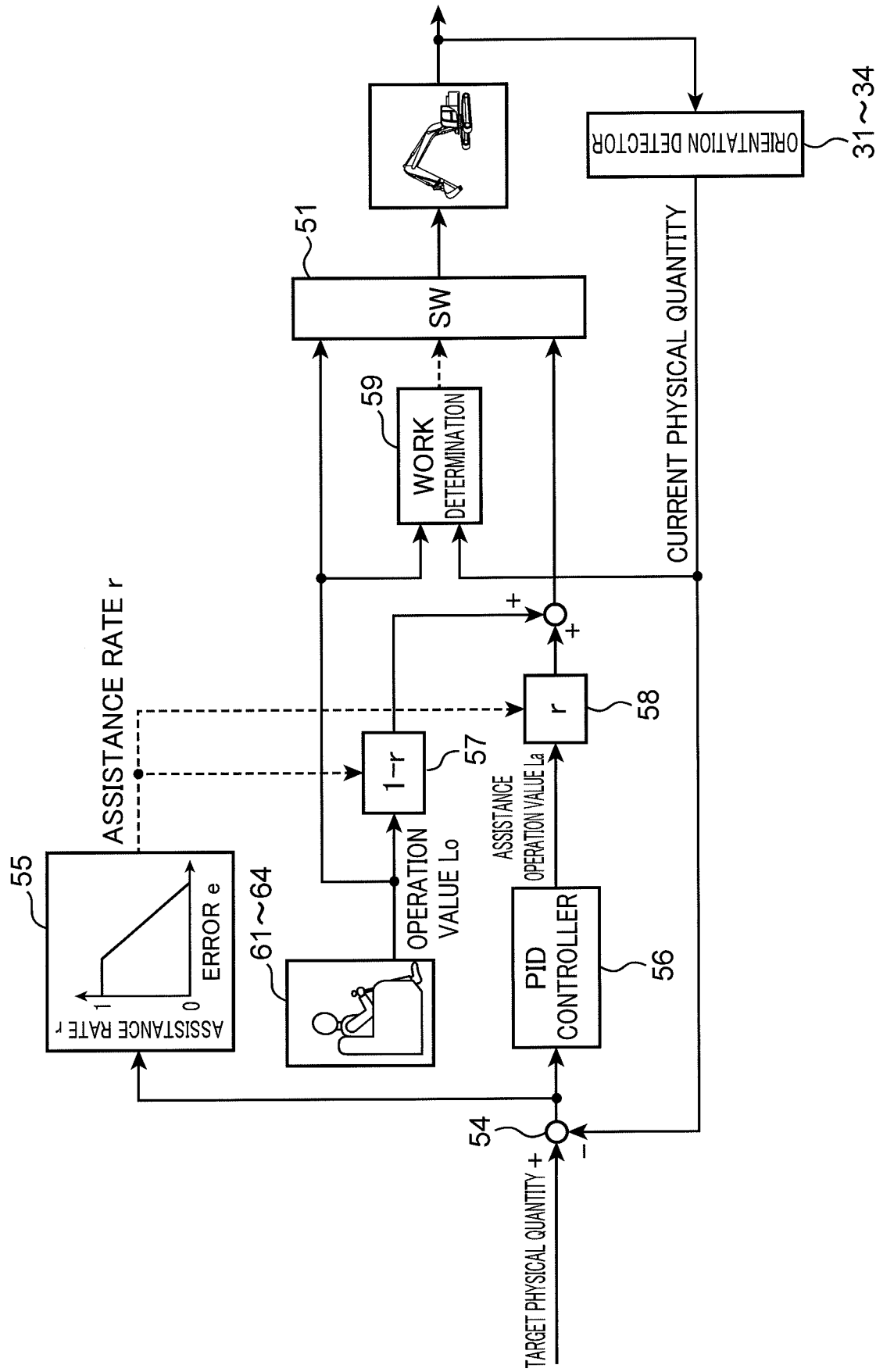


FIG.5

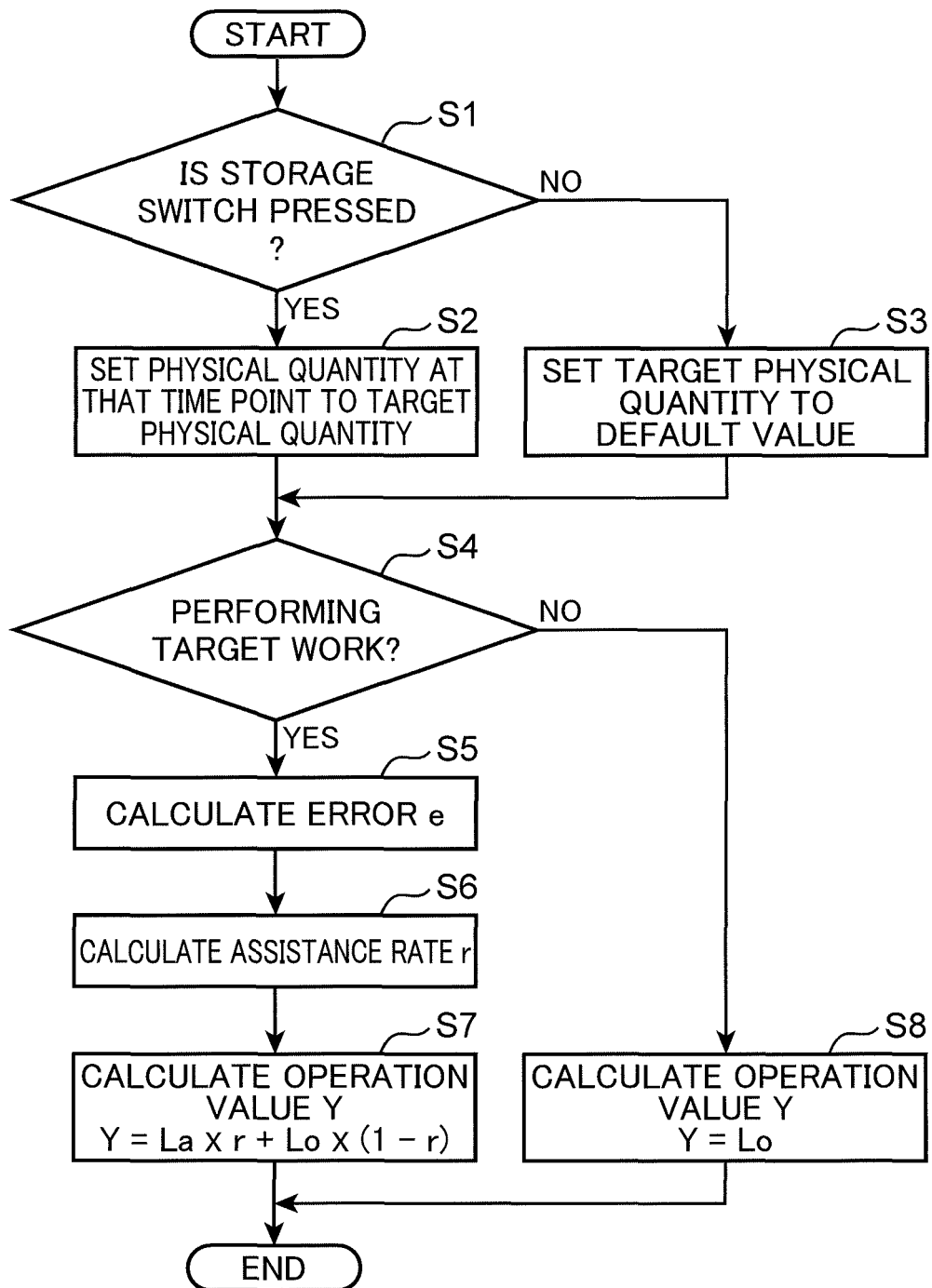


FIG.6

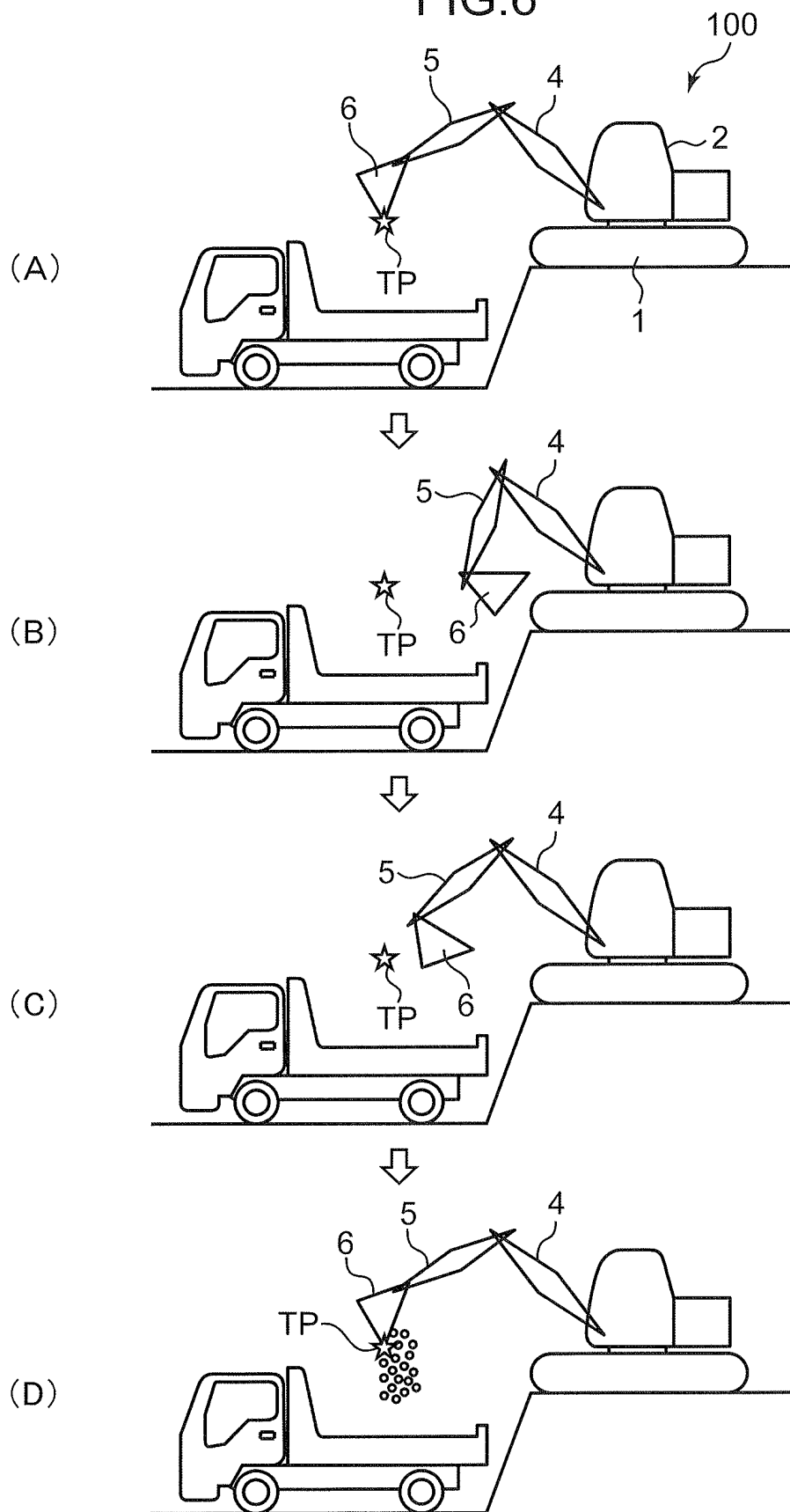


FIG.7

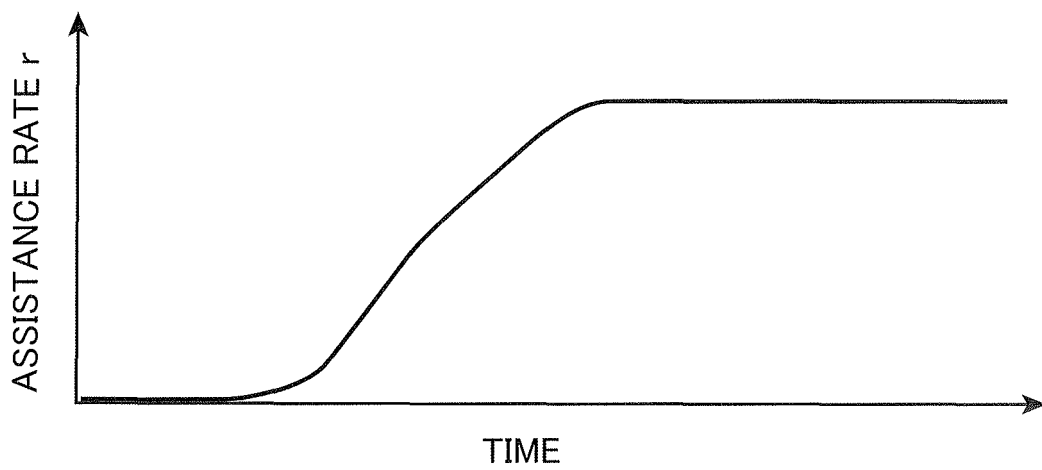
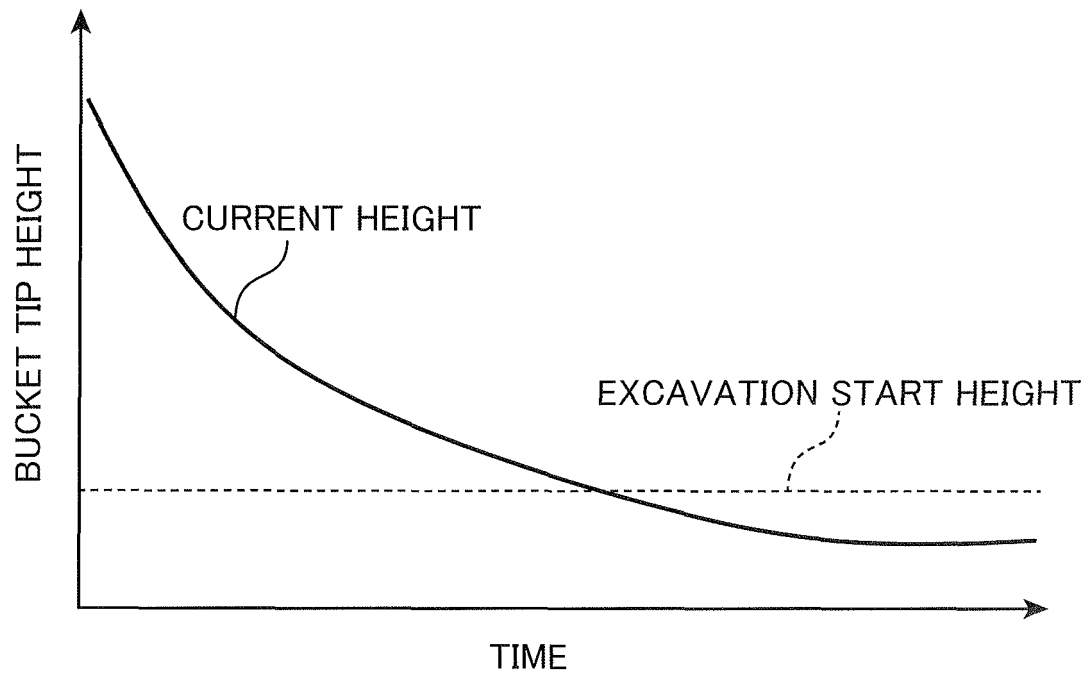


FIG.8

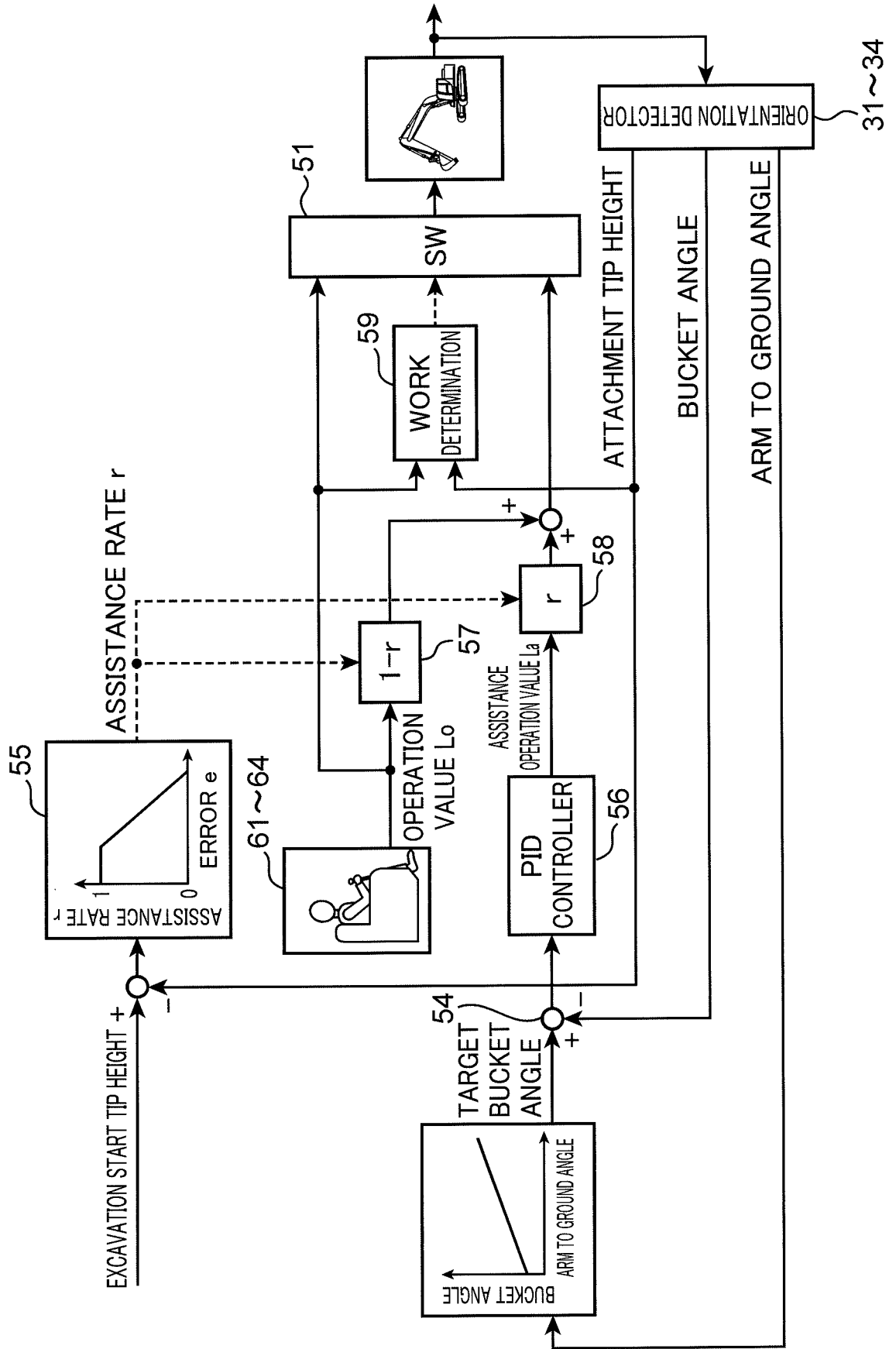




FIG.9

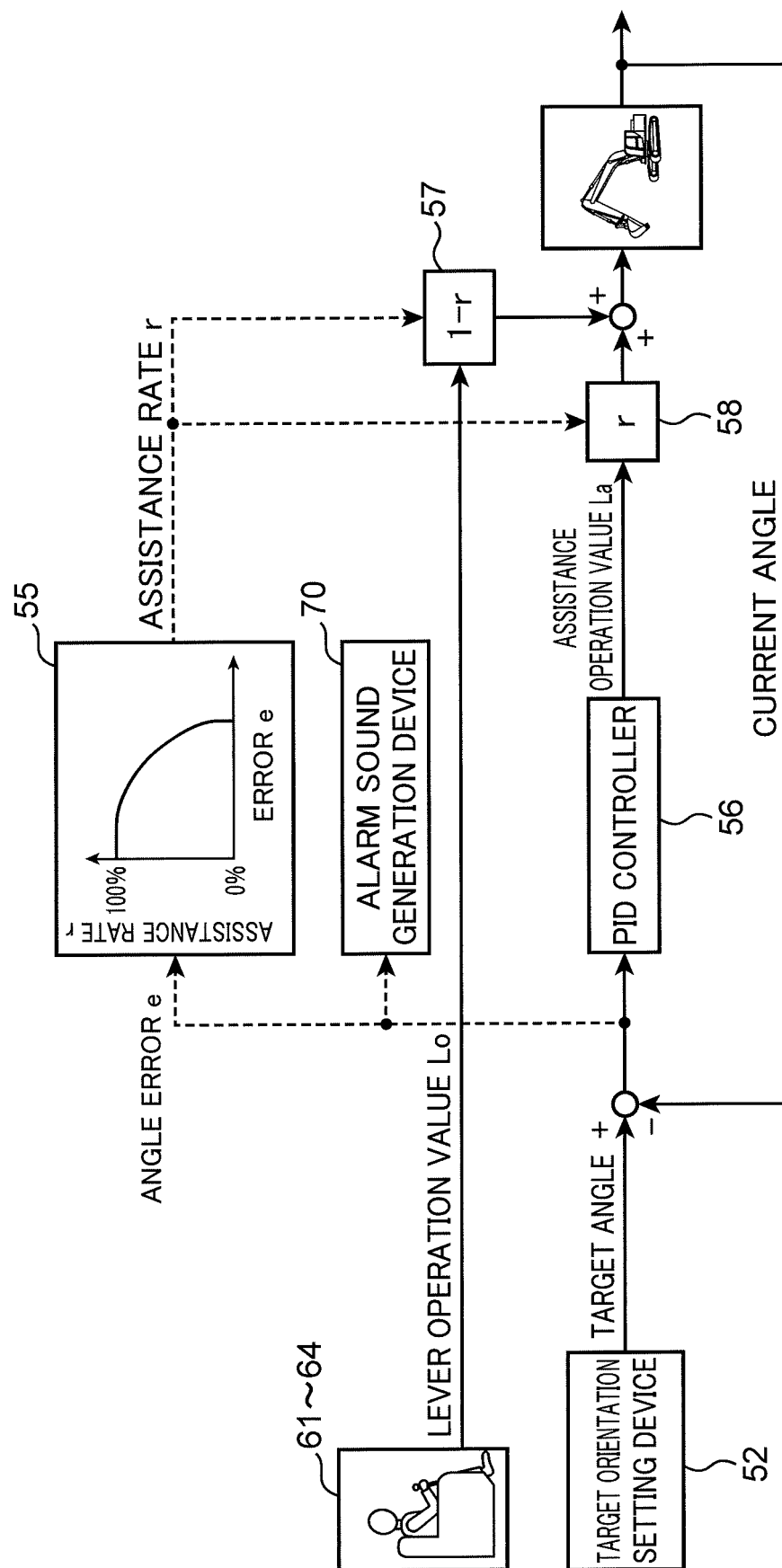


FIG.10

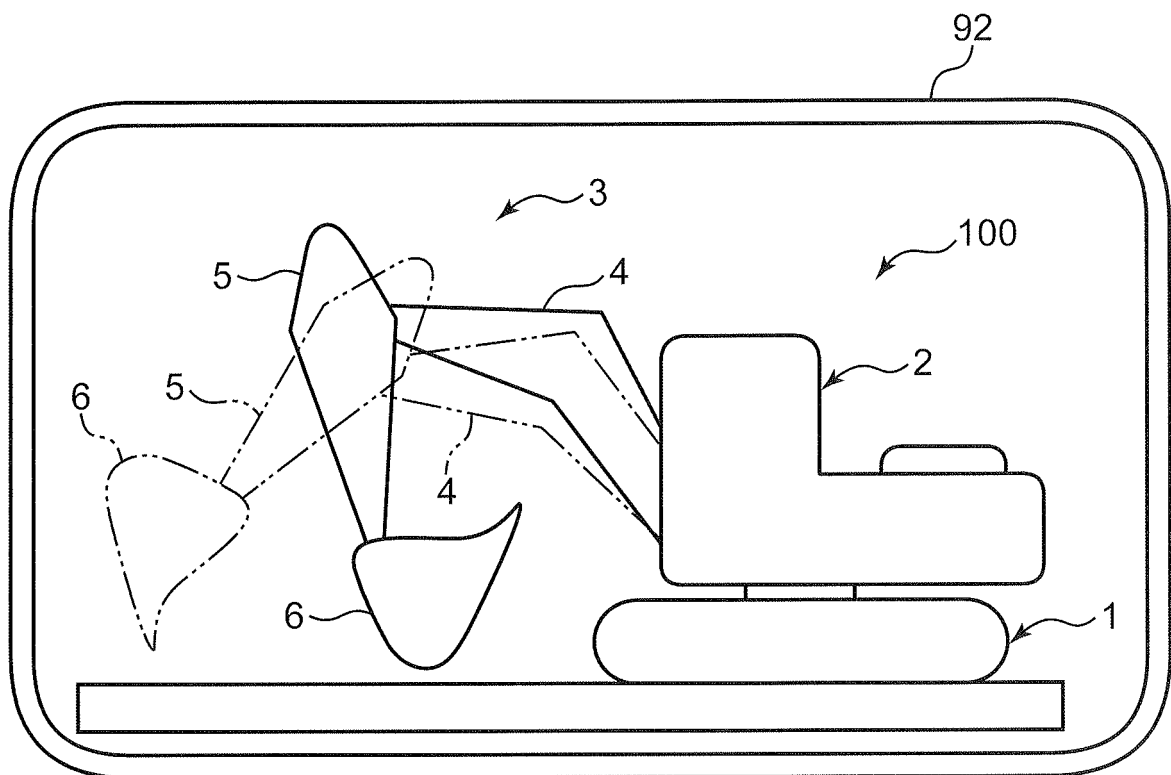
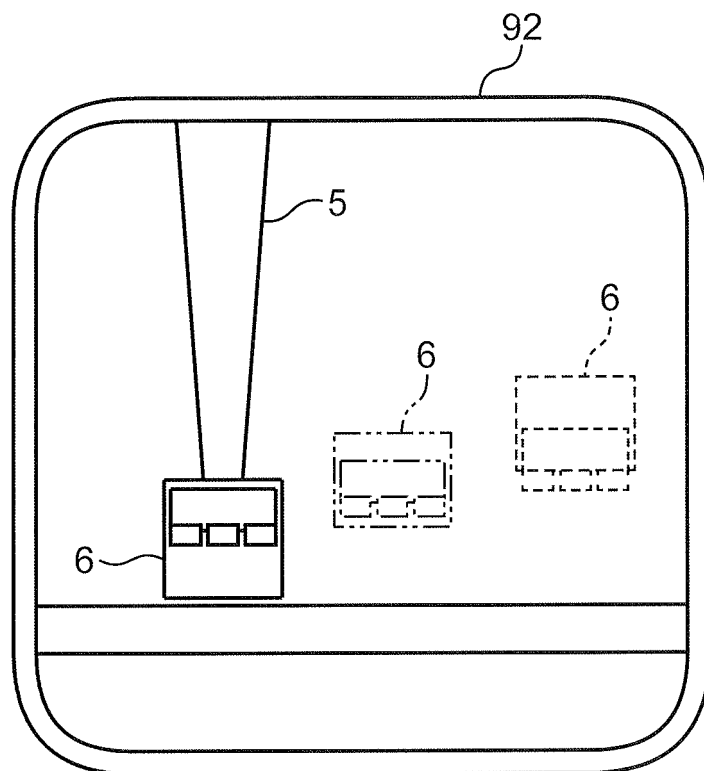


FIG.11



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/042839

## A. CLASSIFICATION OF SUBJECT MATTER

*E02F 9/20*(2006.01)i; *E02F 3/43*(2006.01)i; *E02F 9/26*(2006.01)i  
 FI: E02F9/20 Q; E02F3/43 C; E02F9/26 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)

E02F9/20; E02F3/43; E02F9/26

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

Published examined utility model applications of Japan 1922-1996  
 Published unexamined utility model applications of Japan 1971-2022  
 Registered utility model specifications of Japan 1996-2022  
 Published registered utility model applications of Japan 1994-2022

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

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                                         | Relevant to claim No. |
|-----------|----------------------------------------------------------------------------------------------------------------------------|-----------------------|
| A         | JP 2021-050584 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 01 April 2021<br>(2021-04-01)<br>entire text, all drawings     | 1-16                  |
| A         | JP 2021-085179 A (KOBELCO CONSTRUCTION MACHINERY CO., LTD.) 03 June 2021<br>(2021-06-03)<br>entire text, all drawings      | 1-16                  |
| A         | JP 2011-157789 A (SUMITOMO HEAVY INDUSTRIES, LTD.) 18 August 2011<br>(2011-08-18)<br>entire text, all drawings             | 1-16                  |
| A         | JP 2021-152307 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 30 September<br>2021 (2021-09-30)<br>entire text, all drawings | 1-16                  |

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

\* Special categories of cited documents:

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 “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

26 December 2022

Date of mailing of the international search report

17 January 2023

Name and mailing address of the ISA/JP

Japan Patent Office (ISA/JP)  
 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915  
 Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT  
Information on patent family members

International application No.  
**PCT/JP2022/042839**

| Patent document<br>cited in search report |             |   | Publication date<br>(day/month/year) | Patent family member(s)                    | Publication date<br>(day/month/year) |
|-------------------------------------------|-------------|---|--------------------------------------|--------------------------------------------|--------------------------------------|
| JP                                        | 2021-050584 | A | 01 April 2021                        | (Family: none)                             |                                      |
| JP                                        | 2021-085179 | A | 03 June 2021                         | EP 4047139 A1<br>entire text, all drawings |                                      |
|                                           |             |   |                                      | CN 114651161 A                             |                                      |
| JP                                        | 2011-157789 | A | 18 August 2011                       | (Family: none)                             |                                      |
| JP                                        | 2021-152307 | A | 30 September 2021                    | (Family: none)                             |                                      |

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

- JP 2011157789 A [0005]