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(71) Applicant: **Komatsu Ltd.**
Minato-ku
Tokyo 107-8414 (JP)

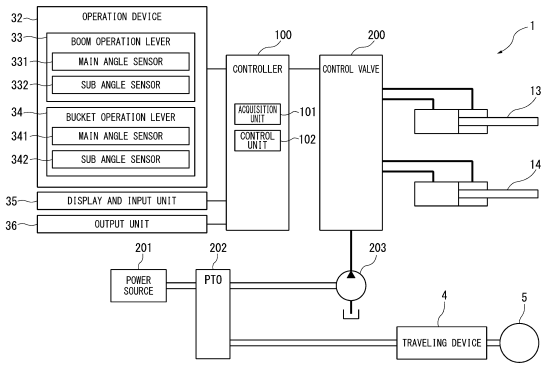
(72) Inventors:
- **KAWAMATA, Rie**
Tokyo 107-8414 (JP)
- **ENOMOTO, Ryota**
Tokyo 107-8414 (JP)
- **FUKUDA, Yuji**
Tokyo 107-8414 (JP)
- **SAITOU, Masaru**
Tokyo 107-8414 (JP)
- **TERANISHI, Yuichi**
Tokyo 107-8414 (JP)
- **TAKAGI, Daisuke**
Tokyo 107-8414 (JP)

(74) Representative: **Global IP Europe**
Patentanwaltskanzlei
Pfarrstraße 14
80538 München (DE)

(54) CONTROL DEVICE, CONTROL METHOD, AND WORKING MACHINE

(57) The control device includes an acquisition unit configured to repeatedly acquire a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount, and a control unit configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time, output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

FIG. 2



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a control device, a control method, and a work machine.

[0002] Priority is claimed on Japanese Patent Application No. 2022-134218, filed August 25, 2022, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] Patent Document 1 discloses a control device that detects a tilt angle of an operation lever of work equipment (a movable body) by two detection units, compares the detected tilt angles, determines whether or not there is an abnormality on the basis of a comparison result, and controls the work equipment on the basis of a detection result of a tilt angle that is smaller in a case where there is the abnormality. The two detection units disclosed in Patent Document 1 have characteristics in which one detection unit decreases a voltage of a detection signal as an angle increases and the other detection unit increases the voltage of the detection signal as the angle increases. The control device determines whether or not there is an abnormality by comparing a total value of the two detection signals with a normal value.

Citation List

Patent Document

[0004] Patent Document 1: Japanese Unexamined Patent Application, First Publication

SUMMARY OF INVENTION

Technical Problem

[0005] The control device disclosed in Patent Document 1 operates the work equipment at a faster speed as the tilt angle from the neutral position of the operation lever is larger. Therefore, for example, in a case where an abnormality occurs in which only a signal indicating that the tilt angle from the neutral position is large can be output to the two detection units, there is a problem that the control of the work equipment may be inappropriate.

[0006] The present disclosure has been made in view of the above circumstances, and an object of the present disclosure is to provide a control device, a control method, and a work machine capable of appropriately dealing with a case where an abnormality occurs in the detection of a tilt amount of an operation lever of the work equipment.

Solution to Problem

[0007] According to an aspect of the present disclosure, there is provided a control device of a work machine including work equipment, the control device including: an acquisition unit configured to repeatedly acquire a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and a control unit configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time, output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

[0008] According to an aspect of the present disclosure, there is provided a control method of a work machine including work equipment, the control method including: a step of repeatedly acquiring a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and a step of repeatedly determining whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time, outputting an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and stopping the output of the alarm and generating and outputting a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

[0009] According to an aspect of the present disclosure, there is provided a work machine including: work equipment; an acquisition unit configured to repeatedly acquire a first detection signal output according to a tilt

amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and a control unit configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time, output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses. Advantageous Effects of Invention

[0010] According to the control device, the control method, and the work machine of the present disclosure, it is possible to appropriately cope with a case where an abnormality occurs in detection of a tilt amount of an operation lever of work equipment.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

[FIG. 1] A side view showing a work machine according to an embodiment of the present disclosure.

[FIG. 2] A block diagram showing a configuration example of a control system of the work machine according to the embodiment of the present disclosure.

[FIG. 3] A cross-sectional view showing an operation lever according to the embodiment of the present disclosure.

[FIG. 4] A cross-sectional view showing the operation lever according to the embodiment of the present disclosure.

[FIG. 5] An output characteristic diagram of an angle sensor according to the embodiment of the present disclosure.

[FIG. 6] A state transition diagram showing an operation example of the controller according to the embodiment of the present disclosure.

[FIG. 7] A schematic diagram for describing an operation example of the controller according to the embodiment of the present disclosure.

[FIG. 8] A schematic diagram for describing an operation example of the controller according to the embodiment of the present disclosure.

[FIG. 9] A schematic diagram for describing an operation example of the controller according to the embodiment of the present disclosure.

[FIG. 10] A schematic diagram for describing an operation example of the controller according to the embodiment of the present disclosure.

DESCRIPTION OF EMBODIMENTS

[0012] Embodiments of the present disclosure will be described below with reference to the drawings. In addition, in each drawing, the same reference numerals are used for the same or corresponding components, and the description thereof will be omitted as appropriate.

[0013] In the present embodiment, a local coordinate system is set in a work machine 1, and a positional relationship of each of units will be described with reference to the local coordinate system. In the local coordinate system, a first axis extending in a right-left direction (vehicle width direction) of the work machine 1 will be defined as an X-axis, a second axis extending in a front-rear direction of the work machine 1 will be defined as a Y-axis, and a third axis extending in an up-down direction of the work machine 1 will be defined as a Z-axis. The X-axis and the Y-axis are orthogonal to each other. The Y-axis and the Z-axis are orthogonal to each other. The Z-axis and the X-axis are orthogonal to each other. A +X-direction is the right direction, and a -X-direction is the left direction. A +Y-direction is the front direction, and a -Y-direction is the rear direction. A +Z-direction is the up direction, and a -Z-direction is the down direction.

[Overview of Work Machine]

[0014] FIG. 1 is a side view showing the work machine 1 according to the present embodiment. For example, the work machine 1 according to the present embodiment is a wheel loader. Hereinafter, the work machine 1 will be referred to as a wheel loader 1 as appropriate.

[0015] As shown in FIG. 1, the wheel loader 1 has a vehicle body 2, a cab 3, a traveling device 4, and work equipment 10. The wheel loader 1 travels on a work place by using the traveling device 4. In the work place, the wheel loader 1 carries out work by using the work equipment 10. The wheel loader 1 can use the work equipment 10 to carry out the work, such as excavation work, loading work, transport work, and snow removal work.

[0016] The cab 3 is supported by the vehicle body 2. Inside the cab 3, a driver's seat 31 on which an operator sits, an operation device 32 to be described later, a display and input unit 35, and an output unit 36 are disposed.

[0017] The traveling device 4 has rotatable wheels 5. The wheels 5 support the vehicle body 2. The wheel loader 1 can travel on a road surface (or ground) RS by the traveling device 4. It should be noted that FIG. 1 shows only a front wheel 5F and a rear wheel 5R on a left side.

[0018] The work equipment 10 is supported by vehicle

body 2. The work equipment 10 is configured by a bucket 12 as an example of a work tool, and a movable support section 17 that changes a position and a posture of the bucket 12. In the example shown in FIG. 1, the movable support section 17 includes a boom 11, a boom cylinder 13, a bucket cylinder 14, a bell crank 15, and a link 16.

[0019] The boom 11 is rotatably supported with respect to the vehicle body 2, and moves in the up-down direction according to expansion and contraction of the boom cylinder 13. The boom cylinder 13 is an actuator that generates power for moving the boom 11, and has one end portion connected to the vehicle body 2 and the other end portion connected to the boom 11. In a case where the operator operates the boom operation lever 33 (FIG. 2) included in the operation device 32, the boom cylinder 13 contracts and extends. As a result, the boom 11 moves in the up-down direction. The boom cylinder 13 is, for example, a hydraulic cylinder.

[0020] The bucket 12 has bucket teeth 12T and is a work tool for performing excavation of the object to be excavated such as earth or loading thereof. The bucket 12 is rotatably connected to the boom 11, and is rotatably connected to one end portion of the link 16. The other end portion of the link 16 is rotatably connected to one end portion of the bell crank 15. The bell crank 15 has a central portion connected to the boom 11 to be rotationally movable, and the other end portion rotatably connected to one end portion of the bucket cylinder 14. The other end portion of the bucket cylinder 14 is rotatably connected to the vehicle body 2. The bucket 12 is operated by power generated by the bucket cylinder 14. The bucket cylinder 14 is an actuator that generates power for moving the bucket 12. In a case where the operator operates the bucket operation lever 34 (FIG. 2), the bucket cylinder 14 is contracted and extended. As a result, the bucket 12 swings. The bucket cylinder 14 is, for example, a hydraulic cylinder. The bucket teeth 12T has a shape of chevron teeth, flat teeth, or the like, and is attached to an end portion of the bucket 12 to be replaceable.

[Configuration of Control System]

[0021] FIG. 2 is a block diagram showing a configuration example of the control system of the wheel loader 1 according to the present embodiment. As shown in FIG. 2, the wheel loader 1 includes a power source 201, a power take off (PTO) 202, a hydraulic pump 203, a control valve 200, an operation device 32, a display and input unit 35, an output unit 36, and a controller 100.

[0022] The power source 201 generates a driving force for operating the work machine. An internal combustion engine and an electric motor are exemplary examples of the power source.

[0023] The PTO 202 transmits at least a part of the driving force of the power source 201 to the hydraulic pump 203. The PTO 202 distributes the driving force of the power source 201 to the traveling device 4 and the hydraulic pump 203.

[0024] The hydraulic pump 203 is driven by the power source 201, and discharges a hydraulic oil. At least a part of the hydraulic oil discharged from the hydraulic pump 203 is supplied to each of the boom cylinder 13 and the bucket cylinder 14 via the control valve 200. The control valve 200 receives a predetermined control signal from the controller 100 and controls the flow rate, the pressure, and the direction of the hydraulic oil supplied to each of the boom cylinder 13 and the bucket cylinder 14 from the hydraulic pump 203. The work equipment 10 is operated by the hydraulic oil from the hydraulic pump 203.

[0025] The operation device 32 is disposed inside the cab 3. The operation device 32 is operated by the operator. The operator operates the operation device 32 to adjust a traveling direction and a traveling speed of the wheel loader 1, switches between forward and rearward movement, and operates the work equipment 10. The operation device 32 includes, for example, a steering, a shift lever, an accelerator pedal, a brake pedal, a boom operation lever 33, and a bucket operation lever 34. The boom operation lever 33 is an operation lever for operating the posture of the boom 11. The boom operation lever 33 includes a main angle sensor 331 and a sub angle sensor 332, and outputs two detection signals indicating the tilt amount of the operation lever. The bucket operation lever 34 is an operation lever for operating the posture of the bucket 12. The bucket operation lever 34 includes a main angle sensor 341 and a sub angle sensor 342, and outputs two detection signals indicating the tilt amount of the operation lever.

[0026] In a case where the boom operation lever 33 and the bucket operation lever 34 are collectively referred to, the boom operation lever 33 and the bucket operation lever 34 are referred to as operation levers. In a case of collectively referring to the main angle sensor 331, the sub angle sensor 332, the main angle sensor 341, and the sub angle sensor 342, the main angle sensor 331, the sub angle sensor 332, the main angle sensor 341, and the sub angle sensor 342 are referred to as an angle sensor. In addition, in a case where the main angle sensor 331 and the main angle sensor 341 are collectively referred to, the main angle sensor 331 and the main angle sensor 341 are referred to as a main angle sensor. In addition, in a case where the sub angle sensor 332 and the sub angle sensor 342 are collectively referred to, the sub angle sensor 332 and the sub angle sensor 342 are referred to as a sub angle sensor. The angle sensor detects a tilt amount of the operation lever and outputs a detection signal indicating a detection result by an analog voltage value. The tilt amount can be represented by a value corresponding to, for example, the tilt angle, a movement amount of a grip portion, and the like. The angle sensor can be configured by, for example, a combination of a variable resistor (potentiometer) and a signal processing circuit, a combination of a hall element and a signal processing circuit, or the like. In addition, each detection signal is set such that a total value of a voltage value of the detection signal of the main angle

sensor and a voltage value of the detection signal of the sub angle sensor is a constant value. In addition, in the following, the main angle sensor may be simply referred to as a main, and the sub angle sensor may be simply referred to as a sub.

[0027] The display and input unit 35 is configured by a combination of an input device and a display device, an input display device, such as a touch panel, and the like. The operator inputs, for example, a set value or the like in the control of the work equipment 10 using the display and input unit 35. The output unit 36 includes a display device, an output device for a synthetic voice, an alarm sound, or a notification sound, a display lamp such as a warning lamp, or the like, and outputs predetermined information.

[0028] The main angle sensor is an example of a first tilt amount sensor according to the present disclosure. In addition, the sub angle sensor is an example of a second tilt amount sensor according to the present disclosure.

[0029] FIGS. 3 and 4 are cross-sectional views showing the boom operation lever 33 and the bucket operation lever 34 according to the present embodiment. The boom operation lever 33 and the bucket operation lever 34 may have the same configuration, and hereinafter, the boom operation lever 33 will be described as an example. FIG. 3 shows a case where a tilt position of the boom operation lever 33 is a neutral position, and FIG. 4 shows a case where the tilt position of the boom operation lever 33 is a position reaching a stroke end in a rear direction. The boom operation lever 33 is also tilted in the front direction in the same manner. The boom operation lever 33 has a mechanism that automatically returns the position of the operation lever to the neutral position in a state where a certain or more operation force is not applied to the operation lever. In the present embodiment, the angle sensor is provided below the operation lever and detects the tilt amount of the operation lever. A spring 301 is provided at a tilting center of the operation lever. The spring 301 has a function of automatically returning the position of the operation lever to the neutral position. A detent solenoid 302 is provided below the operation lever. The detent solenoid 302 has a function of holding the operation lever at a position where the operation lever is most tilted even in a case where the hand is released from the operation lever when the operation lever is most tilted in a case where the current flows to the detent solenoid 302. The operation lever according to the present embodiment is the operation lever of the work equipment 10 that is tilted from the neutral position in the first direction (for example, the front direction) or the second direction (for example, the rear direction) opposite to the first direction.

[0030] FIG. 5 is an output characteristic diagram of the angle sensor according to the embodiment of the present disclosure. A horizontal axis is the output voltage, and a vertical axis is the operation lever stroke. In this case, the operation lever stroke is represented by a percentage in a case where the stroke end is set to "1". In addition, the neutral position is set to "0%", and for example, a case where the operation lever is tilted forward is represented by a negative value, and a case where the operation lever is tilted backward is represented by a positive value. Here, the positive and negative directions may be reversed. A voltage value V1 is, for example, "0 V", and a voltage value V5 is, for example, "5 V". In the present embodiment, a range of a signal voltage in the controller 100 is a direct current of 0 to 5 V. A voltage value V2 is a determination voltage for a ground failure, and a voltage value V4 is a determination voltage for a power supply failure. In a case where the voltage of the detection signal output by the angle sensor is V2 or less, it can be determined that the ground failure occurs. In a case where the voltage of the detection signal output by the angle sensor is V4 or more, it can be determined that the power supply failure occurs. A range of the detection signal of the angle sensor is smaller than a range of the voltage value V2 to the voltage value V4. In addition, the voltage value V3 is a voltage corresponding to the neutral position, and is, for example, "2.5 V". In this example, the total value of the voltage value Vm of the detection signal of the main angle sensor and the voltage value Vs of the detection signal of the sub angle sensor is constant, for example, "5 V". In FIG. 5, a solid line indicates a voltage value Vm of the detection signal of the main angle sensor, and a one-dot chain line indicates a voltage value Vs of the detection signal of the sub angle sensor. Output characteristics indicated by a two-dot chain line are an example in a case where the output characteristics indicated by the solid line fall due to some kind of problem. For example, in a case where the voltage value of the detection signal of the main angle sensor is decreased to Vm', the sum of Vm' and Vs is less than 5 V

[0031] The controller 100 is configured by using, for example, a field programmable gate array (FPGA) or a microcomputer having a processor, a main storage device, an auxiliary storage device, an input/output device, and the like. The controller 100 includes an acquisition unit 101 and a control unit 102 as a functional configuration composed of a combination of hardware, software such as a program, and the like. The controller 100 according to the present embodiment drives and controls the boom cylinder 13 and the bucket cylinder 14 by controlling the control valve 200 according to an operation of the operation device 32 and the like. The controller 100 is an example of a control device according to the present disclosure.

[0032] The acquisition unit 101 repeatedly acquires each detection signal (first detection signal) output by the main angle sensor according to the tilt amount of the operation lever and each detection signal (second detection signal) output by the sub angle sensor according to the tilt amount of the operation lever, for example, at a predetermined cycle (for example, a cycle of several milliseconds to several hundreds of milliseconds).

[0033] For example, the control unit 102 determines whether or not each detection signal is normal or abnor-

mal based on the detection signal of the main angle sensor and the detection signal of the sub angle sensor, and selects which detection signal of the angle sensor is to be used to control the control valve 200 when the detection signal is abnormal. There are the following two types of determination of whether or not there is an abnormality performed by the control unit 102. One is determination of whether or not each detection signal is a value indicating that the operation lever is in the neutral position, on the premise that the operation lever is not operated at the time of turning on the key (at the time of starting the wheel loader 1) of the wheel loader 1. This determination is referred to as a neutral determination. The time when the key is turned on is a time shorter than a time normally required from turning on the key to starting the operation of the operation lever, and is, for example, a time of several seconds to several tens of seconds from turning on the key. Another determination is whether or not the total value of the voltage values of the main and sub detection signals is a predetermined constant value. This determination is referred to as a sum determination or an error determination. The sum determination is not limited to the start, and can be performed even during the operation of the operation lever.

[0034] For example, at the time of turning on the key of (at the time of starting) the wheel loader 1, the control unit 102 determines whether or not the detection signal (first detection signal) of the main angle sensor and the detection signal (second detection signal) of the sub angle sensor are a value corresponding to the neutral position, and in a case where both of the first detection signal and the second detection signal are values corresponding to the neutral position, the control unit 102 generates and outputs a predetermined control signal for controlling the work equipment 10 based on the first detection signal. In addition, for example, in a case where any one of the first detection signal or the second detection signal does not have the value corresponding to the neutral position, the control unit 102 generates and outputs the control signal based on the other of the first detection signal or the second detection signal, and outputs predetermined information corresponding to a case where one of the first detection signal or the second detection signal from the output unit 36 does not have the value corresponding to the neutral position. In the example shown in FIG. 5, the value corresponding to the neutral position is a voltage value within V3 $\pm$ α. Here, α is a voltage value in an allowable range of the determination. In addition, the output of the predetermined information is, for example, display of an error code representing a case where the value does not correspond to the neutral position, notification that the abnormality is detected by a synthetic voice or an electronic sound, lighting or blinking of a predetermined display lamp, and the like. The output of the predetermined information is also referred to as error report.

[0035] In addition, for example, in a case where any one of the first detection signal or the second detection signal does not have a value corresponding to the neutral position, the control unit 102 generates and outputs the control signal on the basis of the other of the first detection signal or the second detection signal after limiting the function of the work equipment 10. The restriction of the function of the work equipment 10 is a restriction of an action or an operation of the work equipment 10, and is, for example, a restriction of an operation speed of the work equipment 10 to a value lower than a normal value (for example, a normal value of several to several tens of %).

[0036] In addition, for example, in a case where the control unit 102 determines that both of the first detection signal and the second detection signal are the value corresponding to the neutral position, the control unit 102 determines whether or not the total value of the first detection signal and the second detection signal is a certain value, and in a case where the total value is not the certain value, the control unit 102 generates and outputs a control signal to stop the operation of the predetermined actuator of the work equipment 10. Here, the certain value is a voltage value within a range of 2 times the voltage value V3 $\pm$ β described with reference to FIG. 5. In addition, β is a voltage value in an allowable range of the determination.

[0037] In addition, for example, at the time of turning on the key of (at the time of starting) the wheel loader 1, the control unit 102 repeatedly determines whether or not the detection signal (first detection signal) of the main angle sensor and the detection signal (second detection signal) of the sub angle sensor correspond to the neutral position from a time of the key-on for a predetermined time. The predetermined time can be, for example, about several seconds to several tens of seconds. In a case where both of the first detection signal and the second detection signal are not values corresponding to the neutral position, the control unit 102 outputs an alarm of that fact from the output unit 36. In addition, when both of the first detection signal and the second detection signal have the value corresponding to the neutral position before the predetermined time elapses, the control unit 102 stops the output of the alarm, and generates and outputs a control signal for controlling the work equipment 10 based on the first detection signal. In addition, the output of the alarm is, for example, display of an error code indicating that the operation lever is not in the neutral position, notification that the operation lever is not in the neutral position by synthetic voice or electronic sound, lighting or blinking of a predetermined display lamp indicating that the operation lever is not in the neutral position, or the like.

[Operation Example of Controller]

[0038] FIG. 6 is a state transition diagram showing an operation example of the controller according to the embodiment of the present disclosure. FIGS. 7 to 10 are schematic diagrams for describing operation exam-

ples of the controller according to the embodiment of the present disclosure. FIG. 6 shows a transition of a determination state (states S0 to S8) of whether or not there is an abnormality based on the detection signal of the main angle sensor and the detection signal of the sub angle sensor by the control unit 102. The state transition shown in FIG. 6 is started in a case where the key is turned on. The initial state is the state S0.

[0039] In the state S0, the initial check is executed by the control unit 102 in order to determine which of the states S 1 to S4 the transition is made to next. The state transitions to any one of the states S 1 to S4 from the state S0 on the basis of the result of the initial check. The main angle sensor and the sub angle sensor are selected in the state S0. FIG. 7 shows the contents of the initial check. The control unit 102 performs the neutral determination in the state S0. The control unit 102 performs the neutral determination of the main and sub at a T5 time (for example, 0.3 seconds) from the start and at a T6 time (for example, 0.5 seconds) after the elapse of the T5 time. The control unit 102 determines that the state is neutral as long as the state is always within the neutral range for the T6 time. In addition, the control unit 102 determines that the state is non-neutral in a case where the state is out of the neutral range even once for the T6 time.

[0040] When the condition 1 is established in the state S0, the state transitions to the state S1. When the condition 2 is established in the state S0, the state transitions to the state S2. When the condition 3 is established in the state S0, the state transitions to the state S3. When the condition 4 is established in the state S0, the state transitions to the state S4. FIG. 8 shows a list of the conditions 1 to 7.

[0041] The condition 1 is established when the condition 2 is not established, the condition 3 is not established, and the condition 4 is not established.

[0042] The condition 2 is established when the main is neutral, the sub is non-neutral, and both of the main and the sub are out of an error detection range of disconnection, ground fault, or power supply fault. The disconnection can be determined by whether or not an output signal line of each sensor is in a high impedance state.

[0043] The condition 3 is established when the main is non-neutral, the sub is neutral, and both of the main and the sub are out of the error detection range of the disconnection, ground fault, or power supply fault.

[0044] The condition 4 is established when the main is non-neutral, the sub is non-neutral, and both of the main and the sub are out of the error detection range of the disconnection, the ground fault, or power supply fault.

[0045] The state S 1 is a state in which both of the main and the sub are normal (usually). The selection of the main and the sub is the main. The output of the error is in a state in which there is no error (a state in which there is no error report or alarm). When the condition 7 is established for the T1 time (for example, 0.05 seconds) in the state S 1, the state transitions from the state S1 to a state S6.

[0046] The state S2 is a state in which the sub is abnormal. The selection of the main and the sub is the main. The output of the error is error report. The function of the work equipment 10 is limited. The state S2 is maintained until the key is turned off.

[0047] The state S3 is a state in which the main is abnormal. The selection of the main and the sub is the sub. The output of the error is error report. The function of the work equipment 10 is limited. The state S3 is maintained until the key is turned off.

[0048] The state S4 is a state in which both of the main and the sub are abnormal. The output of the error is an alarm. In the state S4, when the condition 5 is established, the state transitions to the state S0, and when the condition 6 is established, the state transitions to the state S5.

[0049] The condition 5 is established when both of the main and the sub are neutral for the T3 time (for example, 0.5 seconds) or more. In a case of performing the transition, the control unit 102 changes the initial check result to neutral for both of the main and sub.

[0050] The condition 6 is established when the T4 time (for example, 10 seconds) elapses after the state transitions to the state S4.

[0051] The condition 7 is that the total value of the main and sub voltage values is out of the range of $2 \times V3 \pm \beta$ and both of the main and sub are out of the error detection range of the disconnection, the ground fault, or power supply fault.

[0052] The state S5 is a state in which both of the sub and the main are abnormal. The selection of the main and the sub is the main. The output of the error is error report. The function of the work equipment 10 is limited. The state S5 transitions to the state S7 in a case where the condition 7 is established for the T1 time.

[0053] The state S6 is a state in which one or both of the sub or the main are abnormal. The selection of the main and the sub is the main. There is no error output. The operation of a predetermined actuator of the work equipment 10 is stopped. The state S6 transitions to the state S1 when the condition 7 is not established, and transitions to the state S8 when the condition 7 is established for the T2 time (for example, 1 second).

[0054] The state S7 is a state in which both of the sub state and the main state are abnormal. The selection of the main and the sub is the main. The output of the error is error report. The operation of a predetermined actuator of the work equipment 10 is stopped. The state S7 transitions to the state S6 when the condition 7 is not established, and transitions to the state S8 in a case where the condition 7 is further established for the T2 time.

[0055] The state S8 is a state in which one or both of the sub or the main are abnormal. The selection of the main and the sub is the main. The output of the error is error report. The operation of a predetermined actuator of the work equipment 10 is stopped. The state S8 is maintained until the key is turned off.

[0056] In the state transition shown in FIG. 6, in the state S2 and the state S3, since the work equipment 10

can be moved when one of the main or the sub is non-neutral and the other is normal, the emergency operation can be performed. In addition, since the error report is performed, the repair is prompted, and it is possible to reduce the possibility that the other angle sensor is also failed (double failure). The emergency operation in the present embodiment means the operation of the work machine 1 in a state where the minimum function is maintained in an emergency such as a failure, and is, for example, the operation in a state where the function necessary for driving the work equipment 10 to a state where the work machine 1 can travel and for moving the work machine 1 to a repairable place or the like is maintained.

[0057] In addition, in the state S4, an alarm (for example, an erroneous operation alarm (not a failure)) is activated in a case of an erroneous operation when the key is turned on, and the failure is determined in a case where the abnormality is determined to be the T4 time or more.

[0058] In state S8, in a case of the sum error, safety is secured by the forced stop of the work equipment 10. In a case where the emergency operation is required, turning the key from OFF to ON will cause a transition to state S2, for example, and when one of the sensors is not failed, the work equipment 10 can be operated.

[0059] FIG. 9 is a table summarizing the operation of the controller 100 described with reference to FIG. 6. In the neutral determination or the error determination, "o" represents normality and "×" represents abnormality. For the emergency operation, "o" represents that the posture of the work equipment 10 is driven to a state where the work equipment 10 can travel and the emergency operation is possible, and "Δ" represents that the emergency operation is possible in some cases.

[0060] FIG. 10 is a diagram summarizing the operation in a case where the failure progresses from the normal state (No. 1) shown in FIG. 9. In a case where the voltage of one or both of the detection signals of the angle sensors is dropped, the error determination is abnormal in any case, and the work equipment 10 is stopped. Therefore, even in a case where the neutral determination is in a state of being abnormal, the work equipment 10 is stopped, and thus, the work equipment 10 is not moved in a state where the hand is released from the operation lever. Therefore, safety can be secured ("◦").

(Actions and Effects)

[0061] According to the present embodiment, it is possible to appropriately handle a case where the abnormality occurs in the detection of the tilt amount of the operation lever of the work equipment.

<Modification Example or Other Embodiments of Present Embodiment>

[0062] Although the embodiments of the present invention have been described above in detail with reference to the drawings, the specific configuration is not limited to the above embodiments, and design modifications and the like are included within the scope of the gist of the present invention. Furthermore, some or all of the programs executed by the computer in the above embodiments can be distributed via a computer-readable recording medium or a communication line.

[0063] For example, the wheel loader 1 may be remotely operable. In this case, a part or all of the controller 100 and the operation device 32 can be provided, for example, at a place in which the remote operation is performed.

[0064] In addition, for example, the work machine (or the work vehicle) is not limited to the wheel loader, and may be a work machine including work equipment driven according to an operation of an operation lever. For example, another work machine such as a hydraulic excavator can be used. In addition, the work tool is not limited to the bucket. The work tool may be, for example, a fork, a bale grab, or the like that is attached to the wheel loader to be replaceable, as an attachment.

<Additional Notes>

[0065] The controller 100 (control device) described in the above embodiment is understood as follows, for example.

[0066]

(1) A controller 100 (control device) is a control device of a work machine 1 including work equipment 10, the control device includes: an acquisition unit 101 configured to repeatedly acquire a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor (main stroke sensor) configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor (sub stroke sensor) configured to detect the tilt amount; and a control unit 102 configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time, output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit 36 in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corre-

sponding to the neutral position before the predetermined time elapses.

(2) The control device according to (1), in which in a case where any one of the first detection signal or the second detection signal is not the value corresponding to the neutral position, the control unit 102 generates and outputs the control signal based on the other of the first detection signal or the second detection signal, and outputs predetermined information corresponding to a case where the one is not the value corresponding to the neutral position, from the predetermined output unit.

(3) The control device according to (2), in which in a case where any one of the first detection signal or the second detection signal is not the value corresponding to the neutral position, the control unit 102 generates and outputs the control signal based on the other of the first detection signal or the second detection signal after limiting a function of the work equipment.

INDUSTRIAL APPLICABILITY

[0067] According to the control device, the control method, and the work machine of the present disclosure, it is possible to appropriately cope with a case where an abnormality occurs in detection of a tilt amount of an operation lever of work equipment.

REFERENCE SIGNS LIST

[0068]

1 Wheel loader (work machine)
2 Vehicle body
3 Cab
4 Traveling device
5 Wheel
6 Tire
10 Work equipment
11 Boom
12 Bucket (work tool)
12T Bucket teeth
13 Boom cylinder
14 Bucket cylinder
15 Bell crank
16 Link
17 Movable support section
32 Operation device
33 Boom operation lever
34 Bucket operation lever
341 Main stroke sensor
342 Sub stroke sensor
100 Controller (control device)
101 Acquisition unit
102 Control unit

Claims

1. A control device of a work machine including work equipment, the control device comprising:

an acquisition unit configured to repeatedly acquire a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and

a control unit configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time,

output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and

stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

2. The control device according to Claim 1, wherein, in a case where any one of the first detection signal or the second detection signal is not the value corresponding to the neutral position, the control unit generates and outputs the control signal based on the other of the first detection signal or the second detection signal, and outputs predetermined information corresponding to a case where the one is not the value corresponding to the neutral position, from the predetermined output unit.

3. The control device according to Claim 2, wherein, in a case where any one of the first detection signal or the second detection signal is not the value corresponding to the neutral position, the control unit generates and outputs the control signal based on the other of the first detection signal or the second detection signal after limiting a function of the work equipment.

4. A control method of a work machine including work

equipment, the control method comprising:

a step of repeatedly acquiring a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and
a step of repeatedly determining whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time,
outputting an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and
stopping the output of the alarm and generating and outputting a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

5. A work machine comprising:

work equipment;
an acquisition unit configured to repeatedly acquire a first detection signal output according to a tilt amount of an operation lever by a first tilt amount sensor configured to detect the tilt amount of the operation lever of the work equipment tilted from a neutral position in a first direction or a second direction opposite to the first direction, and a second detection signal output according to the tilt amount by a second tilt amount sensor configured to detect the tilt amount; and
a control unit configured to repeatedly determine whether or not the first detection signal and the second detection signal are a value corresponding to the neutral position at a time of start of the work machine, for a predetermined time,
output an alarm indicating that both of the first detection signal and the second detection signal are not the value corresponding to the neutral position from a predetermined output unit in a case where both of the first detection signal and the second detection signal are not the value corresponding to the neutral position, and
stop the output of the alarm and generate and output a predetermined control signal for controlling the work equipment based on the first detection signal when both of the first detection signal and the second detection signal are the value corresponding to the neutral position before the predetermined time elapses.

FIG. 1

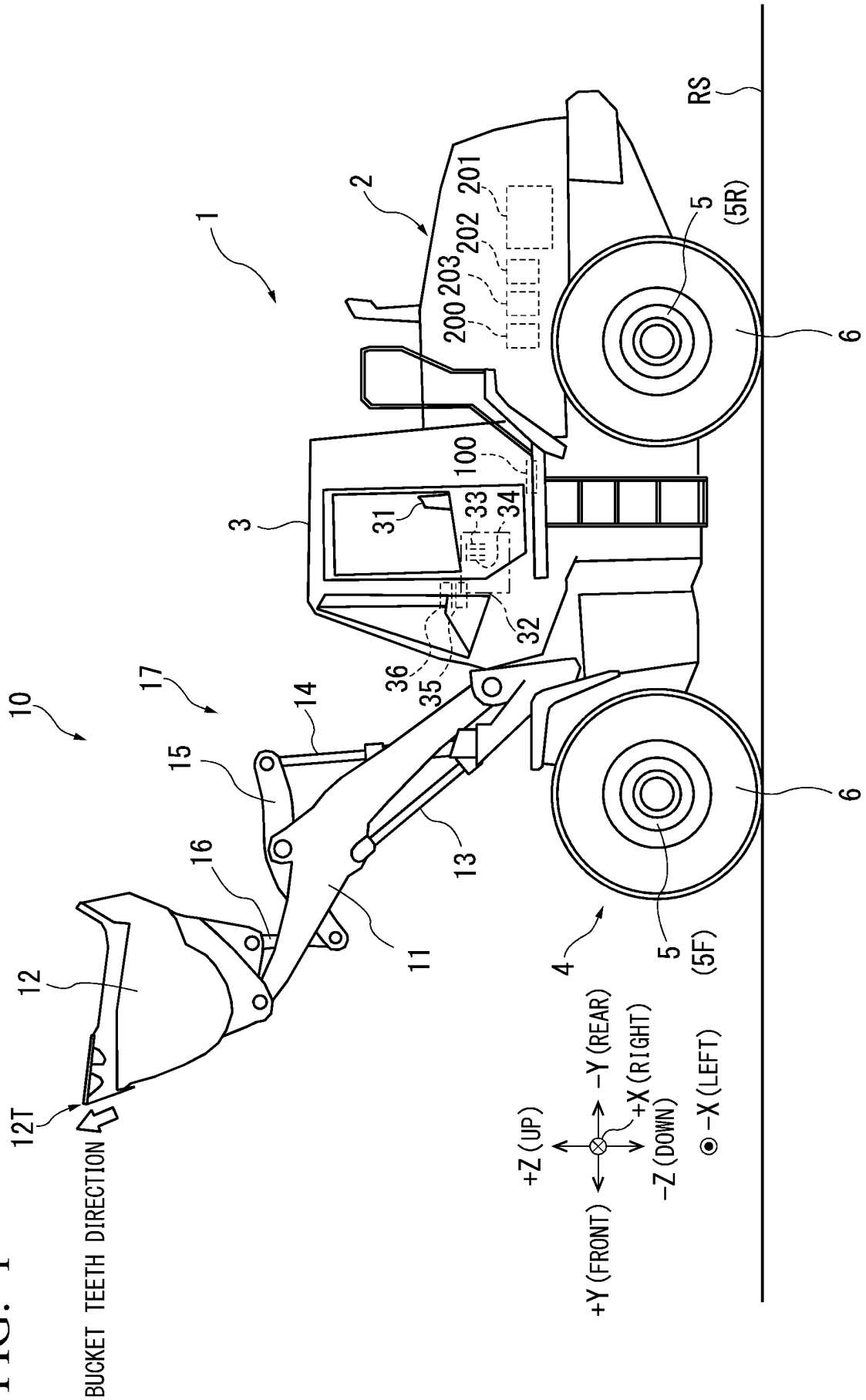
BUCKET TEETH DIRECTION
12T
12
10
17
14
15
16
11
13
1
2
3
4
5
(5F)
5
(5R)
6
6
RS
200
201
202
203
100
31
33
34
32
36
35
+Z (UP)
-Z (DOWN)
+Y (FRONT)
-Y (REAR)
+X (RIGHT)
-X (LEFT)

FIG. 2

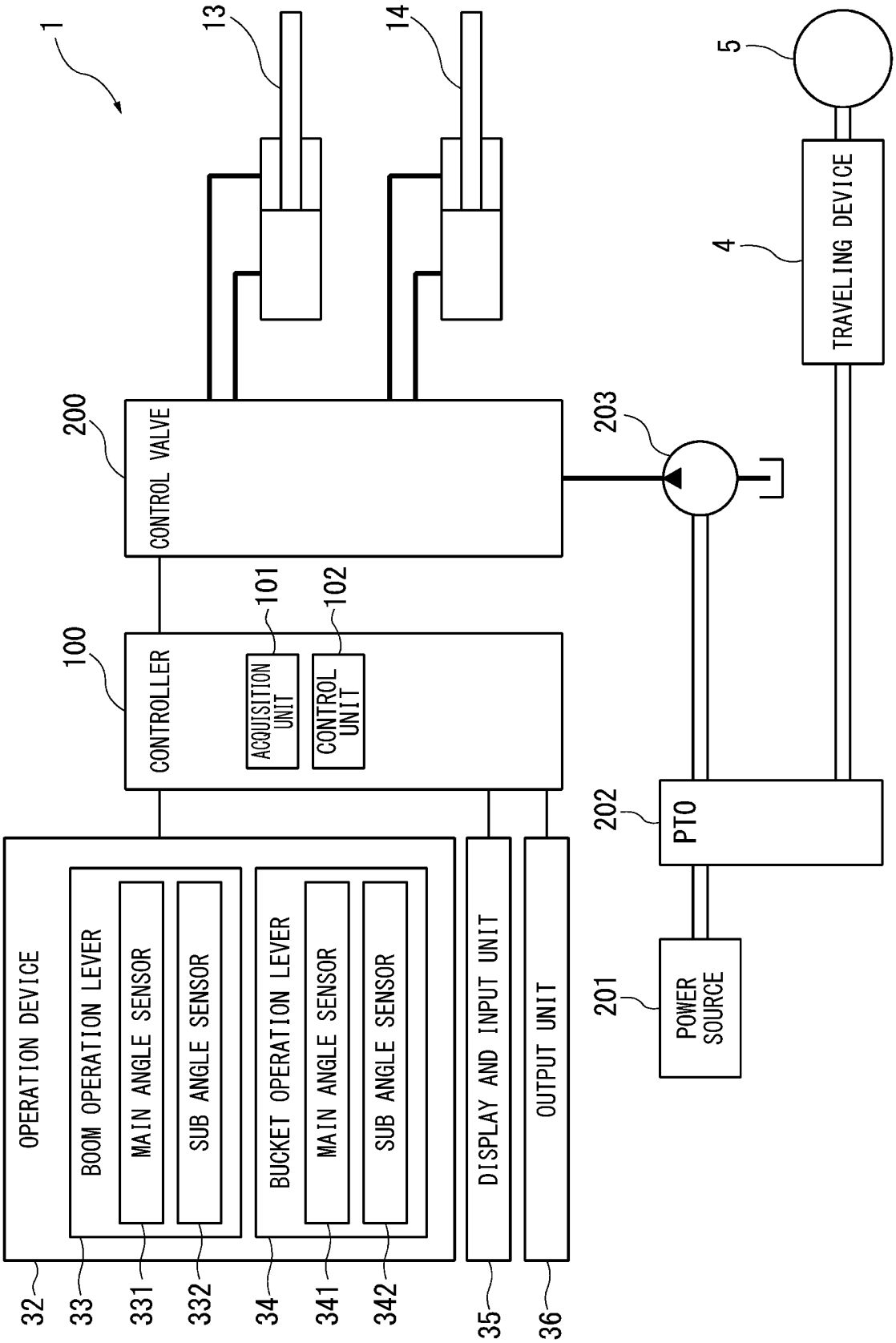
1
13
14
5
TRAVELING DEVICE
4
200
CONTROL VALVE
203
101
102
100
CONTROLLER
ACQUISITION UNIT
CONTROL UNIT
202
PTO
201
POWER SOURCE
OPERATION DEVICE
BOOM OPERATION LEVER
MAIN ANGLE SENSOR
SUB ANGLE SENSOR
BUCKET OPERATION LEVER
MAIN ANGLE SENSOR
SUB ANGLE SENSOR
DISPLAY AND INPUT UNIT
OUTPUT UNIT
32
33
331
332
34
341
342
35
36

FIG. 3

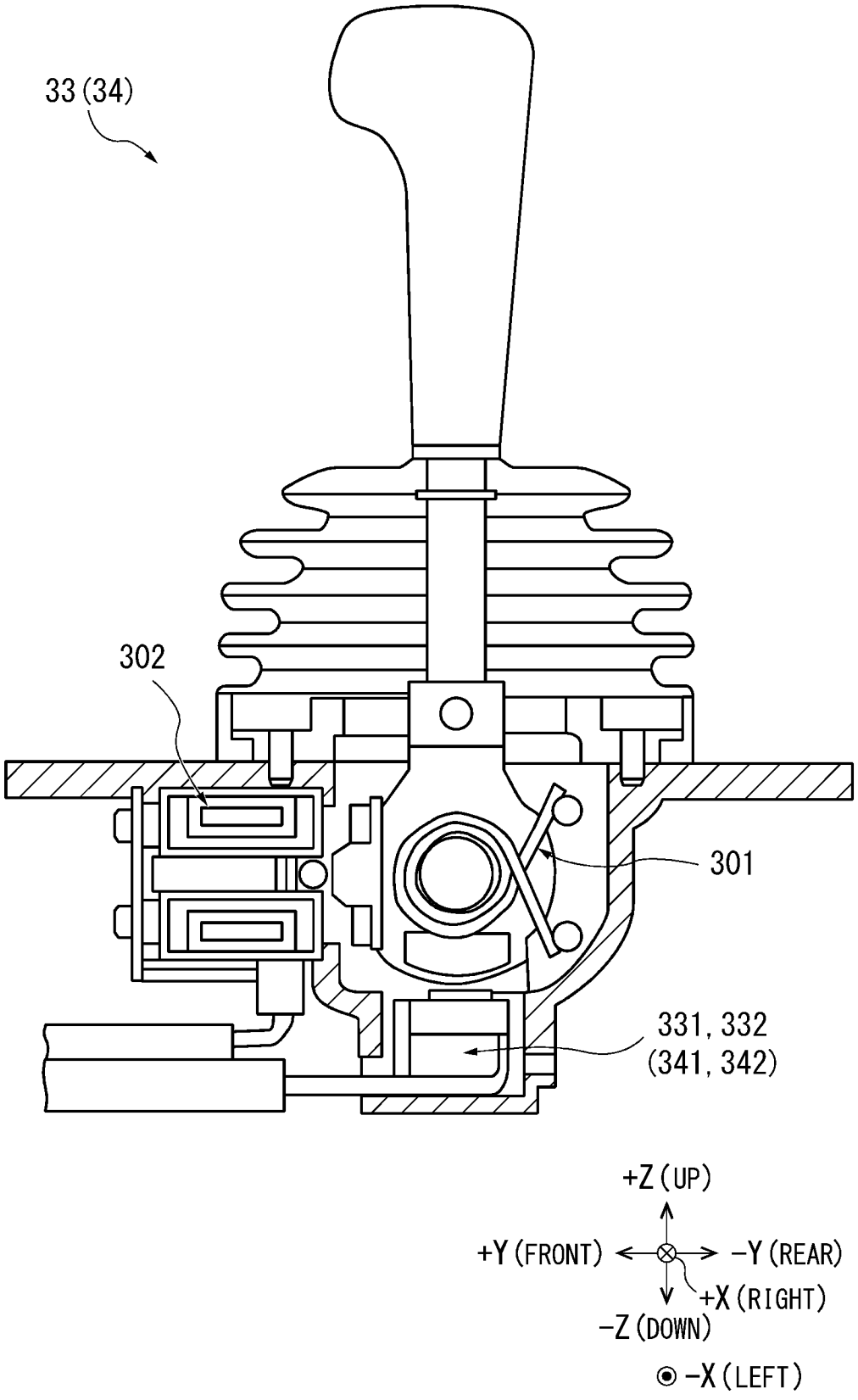
33 (34)
302
301
331, 332
(341, 342)
+Z (UP)
+Y (FRONT)
-Y (REAR)
+X (RIGHT)
-Z (DOWN)
-X (LEFT)

FIG. 4

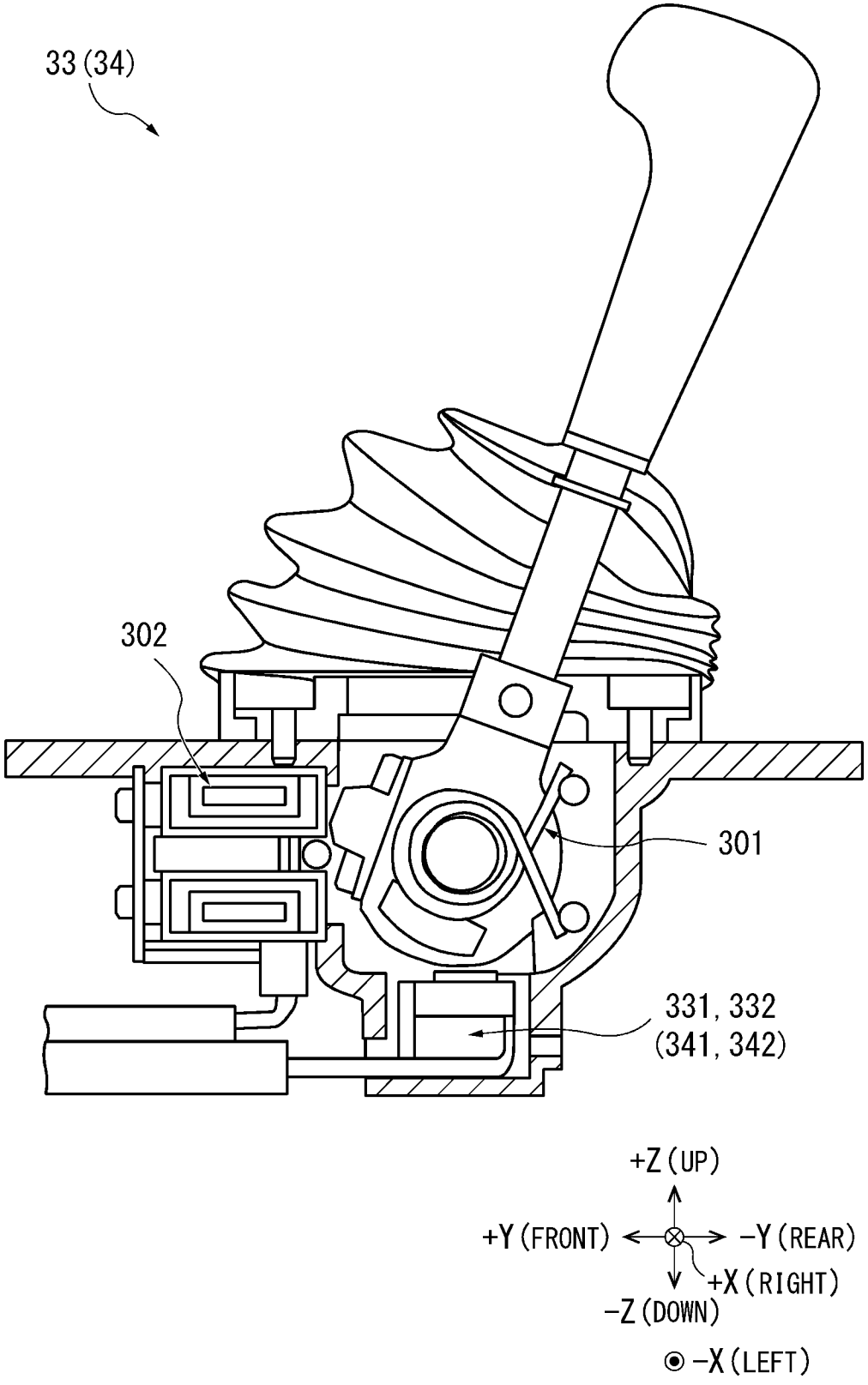
33 (34)
302
301
331, 332
(341, 342)
+Z (UP)
+Y (FRONT)
-Y (REAR)
+X (RIGHT)
-Z (DOWN)
-X (LEFT)

FIG. 5

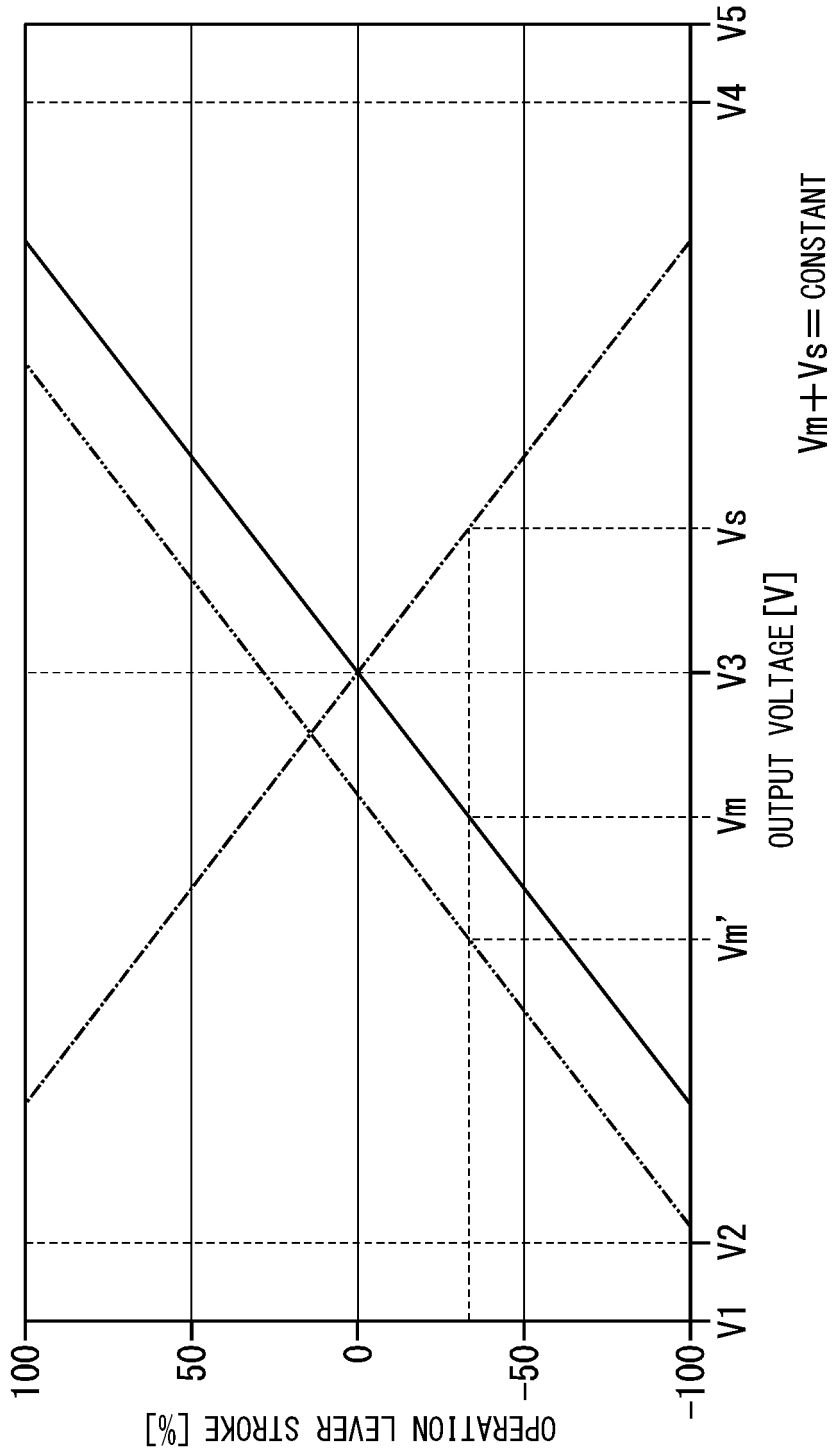
100
50
0
-50
-100
OPERATION LEVER STROKE [%]
V1
V2
Vm'
Vm
V3
Vs
V4
V5
OUTPUT VOLTAGE [V]
Vm+Vs= CONSTANT

FIG. 6

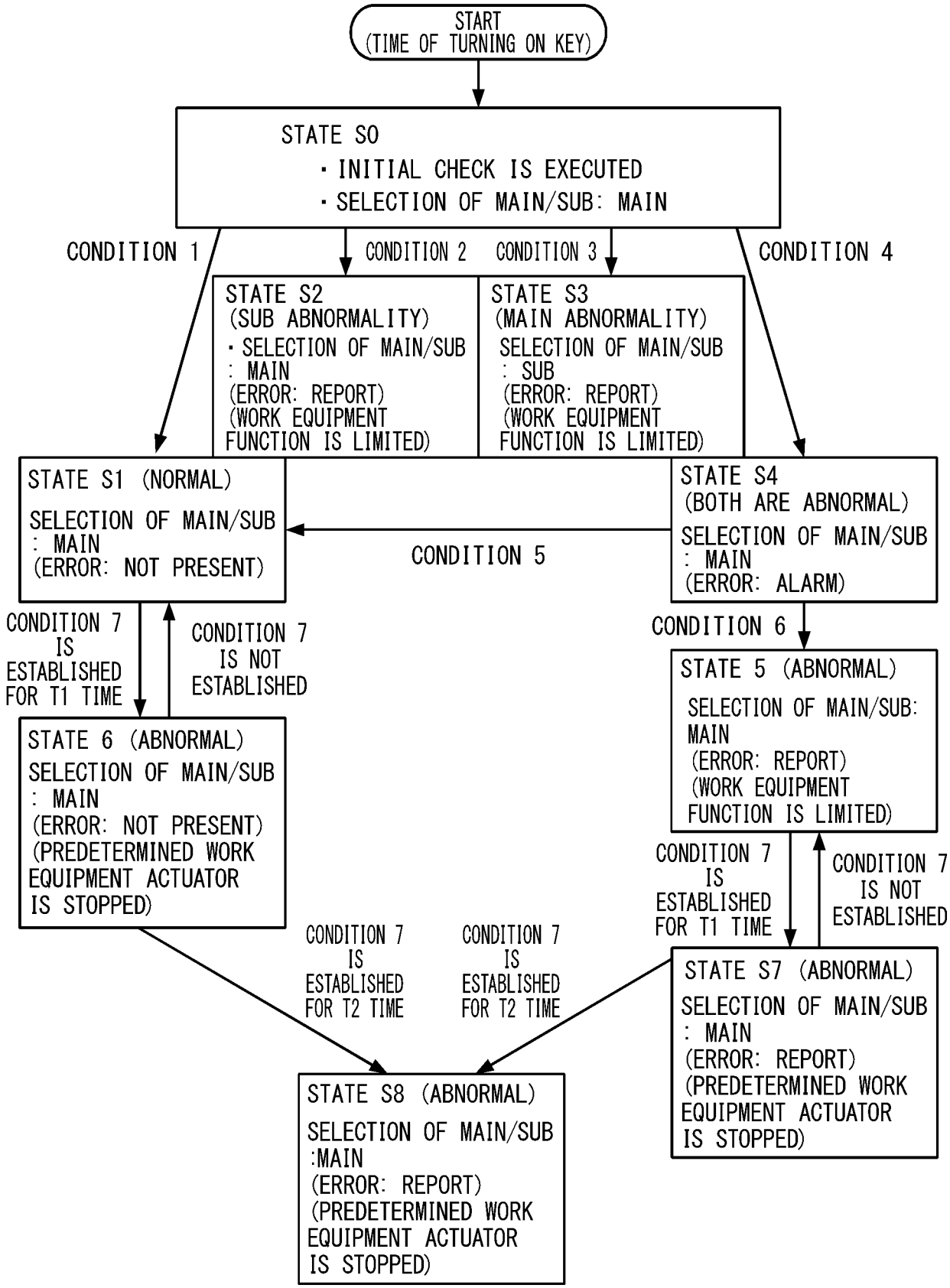
START
(TIME OF TURNING ON KEY)
STATE S0
・INITIAL CHECK IS EXECUTED
・SELECTION OF MAIN/SUB: MAIN
CONDITION 1
CONDITION 2
CONDITION 3
CONDITION 4
STATE S2
(SUB ABNORMALITY)
・SELECTION OF MAIN/SUB : MAIN
(ERROR: REPORT)
(WORK EQUIPMENT FUNCTION IS LIMITED)
STATE S3
(MAIN ABNORMALITY)
SELECTION OF MAIN/SUB : SUB
(ERROR: REPORT)
(WORK EQUIPMENT FUNCTION IS LIMITED)
STATE S1 (NORMAL)
SELECTION OF MAIN/SUB : MAIN
(ERROR: NOT PRESENT)
STATE S4
(BOTH ARE ABNORMAL)
SELECTION OF MAIN/SUB : MAIN
(ERROR: ALARM)
CONDITION 5
CONDITION 7 IS ESTABLISHED FOR T1 TIME
CONDITION 7 IS NOT ESTABLISHED
CONDITION 6
STATE 6 (ABNORMAL)
SELECTION OF MAIN/SUB : MAIN
(ERROR: NOT PRESENT)
(PREDETERMINED WORK EQUIPMENT ACTUATOR IS STOPPED)
STATE 5 (ABNORMAL)
SELECTION OF MAIN/SUB: MAIN
(ERROR: REPORT)
(WORK EQUIPMENT FUNCTION IS LIMITED)
CONDITION 7 IS ESTABLISHED FOR T1 TIME
CONDITION 7 IS NOT ESTABLISHED
CONDITION 7 IS ESTABLISHED FOR T2 TIME
CONDITION 7 IS ESTABLISHED FOR T2 TIME
STATE S7 (ABNORMAL)
SELECTION OF MAIN/SUB : MAIN
(ERROR: REPORT)
(PREDETERMINED WORK EQUIPMENT ACTUATOR IS STOPPED)
STATE S8 (ABNORMAL)
SELECTION OF MAIN/SUB :MAIN
(ERROR: REPORT)
(PREDETERMINED WORK EQUIPMENT ACTUATOR IS STOPPED)

FIG. 7

CONTENT OF INITIAL CHECK
NEUTRAL DETERMINATION IS PERFORMED IN STATE S0. NEUTRAL DETERMINATION OF MAIN AND SUB IS PERFORMED AT T5 TIME FROM START AND AT T6 TIME AFTER ELAPSE OF T5 TIME ・STATE IS ALWAYS WITHIN NEUTRAL RANGE FOR T6 TIME: IT IS DETERMINED THAT STATE IS NEUTRAL ・STATE IS OUT OF NEUTRAL RANGE EVEN ONCE FOR T6 TIME: IT IS DETERMINED THAT STATE IS NON-NEUTRAL

FIG. 8

CONDITION NAME	CONTENT
CONDITION 1	CONDITION 2 IS NOT ESTABLISHED, CONDITION 3 IS NOT ESTABLISHED, AND CONDITION 4 IS NOT ESTABLISHED
CONDITION 2	MAIN IS NEUTRAL, SUB IS NON-NEUTRAL, AND BOTH MAIN AND SUB ARE OUT OF ERROR DETECTION RANGE OF DISCONNECTION, GROUND FAULT, OR POWER SUPPLY FAULT
CONDITION 3	MAIN IS NON-NEUTRAL, SUB IS NEUTRAL, AND BOTH MAIN AND SUB ARE OUT OF ERROR DETECTION RANGE OF DISCONNECTION, GROUND FAULT, OR POWER SUPPLY FAULT
CONDITION 4	MAIN IS NON-NEUTRAL, SUB IS NON-NEUTRAL, AND BOTH MAIN AND SUB ARE OUT OF ERROR DETECTION RANGE OF DISCONNECTION, GROUND FAULT,OR POWER SUPPLY FAULT
CONDITION 5	BOTH MAIN AND SUB ARE NEUTRAL FOR T3 TIME OR MORE (IN CASE OF PERFORMING TRANSITION, INITIAL CHECK RESULT IS CHANGED TO NEUTRAL FOR BOTH MAIN AND SUB)
CONDITION 6	T4 TIME ELAPSES AFTER STATE TRANSITIONS TO STATE S4
CONDITION 7	TOTAL VALUE OF MAIN AND SUB VOLTAGE VALUES IS OUT OF RANGE OF $2 \times V3 \pm \beta$ AND BOTH OF MAIN AND SUB ARE OUT OF ERROR DETECTION RANGE OF DISCONNECTION, GROUND FAULT, OR POWER SUPPLY FAULT

FIG. 9

No.	WHEN TURNING ON KEY					
	NEUTRAL DETERMINATION (V3±α)		ERROR DETERMINATION (2×V3±β)	OPERATION STATE	ERROR REPORT	EMERGENCY OPERATION
	MAIN	SUB	TOTAL OF MAIN AND SUB VOLTAGES			
1	○	○	○	OPERATED WITH MAIN	NOT PRESENT	○
2	×	○	○	OPERATED BY SPEED RESTRICTION WITH SUB	PRESENT	○
3	×	○	×	OPERATED BY SPEED RESTRICTION WITH SUB	PRESENT	○
4	○	×	○	OPERATED BY SPEED RESTRICTION WITH MAIN	PRESENT	○
5	○	×	×	OPERATED BY SPEED RESTRICTION WITH MAIN	PRESENT	○
6	×	×	○	OPERATED WITH MAIN	ONLY ALARM AT FIRST AND PRESENT AFTER 10 SECONDS	△
7	×	×	×	STOP	PRESENT	△

FIG. 10

No.	TYPE OF FAILURE	NEUTRAL DETERMINATION (V3 ± α)		ERROR DETERMINATION (2 × V3 ± β)	OPERATION STATE	ERROR REPORT	NOT MOVED IN STATE WHERE HAND IS RELEASED	SAFETY
	CASE WHERE FAILURE PROGRESSES FROM WHEN TURNING ON KEY							
		MAIN	SUB	TOTAL OF MAIN AND SUB VOLTAGES				
11	VOLTAGE OF ONE IS DROPPED	× (DROPPED)	○	×	STOP	PRESENT	STOP	○
12		○	× (DROPPED)	×	STOP	PRESENT	STOP	○
13	VOLTAGES OF BOTH ARE DROPPED	× (DROPPED)	○ (DROPPED)	×	STOP	PRESENT	STOP	○
14		○ (DROPPED)	× (DROPPED)	×	STOP	PRESENT	STOP	○
15		× (DROPPED)	× (DROPPED)	×	STOP	PRESENT	STOP	○

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/024786

A. CLASSIFICATION OF SUBJECT MATTER

E02F 9/20(2006.01)i
FI: E02F9/20 K

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

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-328759 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 07 December 2006 (2006-12-07) abstract, paragraph [0050]	1-5
A	JP 2000-87908 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 28 March 2000 (2000-03-28) fig. 1, 8, paragraphs [0018], [0039]-[0051]	1-5
A	JP 2001-49698 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 20 February 2001 (2001-02-20) abstract	1-5
A	JP 63-142130 A (KOMATSU LTD.) 14 June 1988 (1988-06-14) claims	1-5
A	JP 2019-206878 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 05 December 2019 (2019-12-05) fig. 7, paragraphs [0069], [0070]	1-5

☑ 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	Date of mailing of the international search report
23 August 2023	**05 September 2023**

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/024786

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2019-203282 A (KOBELCO CONSTRUCTION MACHINERY CO., LTD.) 28 November 2019 (2019-11-28) abstract	1-5
A	JP 2018-53448 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 05 April 2018 (2018-04-05) paragraph [0078]	1-5

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/024786

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2006-328759 A	07 December 2006	(Family: none)	
JP 2000-87908 A	28 March 2000	(Family: none)	
JP 2001-49698 A	20 February 2001	(Family: none)	
JP 63-142130 A	14 June 1988	(Family: none)	
JP 2019-206878 A	05 December 2019	(Family: none)	
JP 2019-203282 A	28 November 2019	US 2021/0214918 A1 abstract WO 2019/225324 A1 EP 3779061 A1 CN 112105784 A KR 10-2021-0011389 A	
JP 2018-53448 A	05 April 2018	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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- JP 2022134218 A **[0002]**