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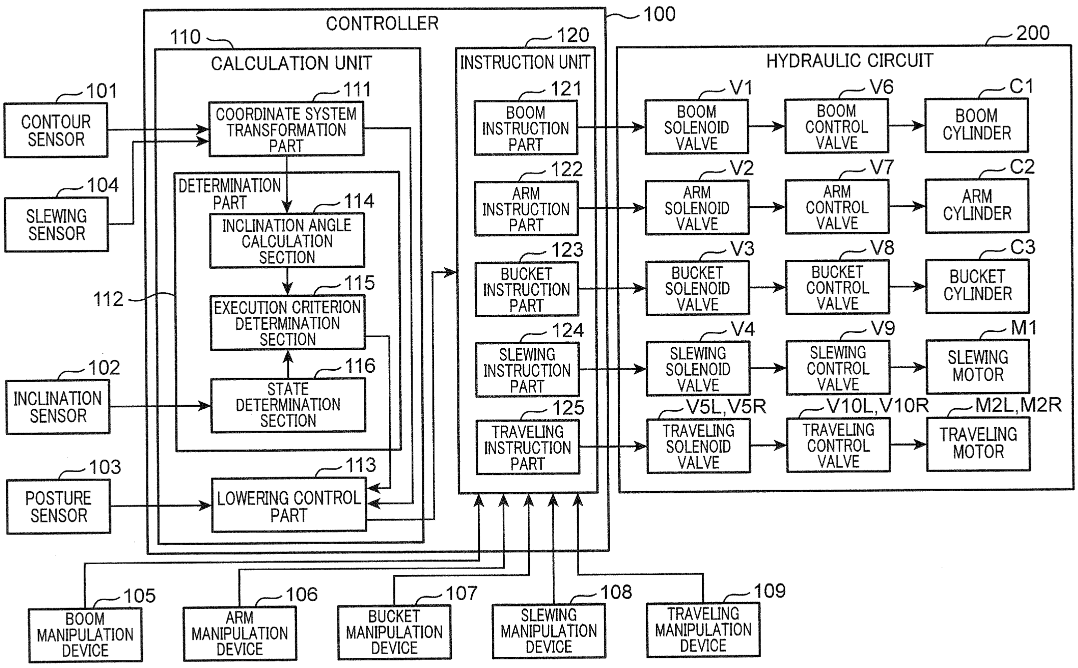
(54) SAFETY DEVICE AND CONSTRUCTION MACHINE

(57) A safety device includes: a contour sensor (101) which acquires contour data representing a contour of a landform around a hydraulic excavator (1); a determination part (112) which determines, based on the contour data, whether the landform satisfies an execution criterion of executing a turning-over prevention control for preventing the hydraulic excavator (1) from being turned over to a slope extending in a specific direction thereabout; and a lowering control part (113) which lowers a leading end of a working device to the slope when the determination part (112) determines that the execution criterion is satisfied.

FIG. 2



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Description

Technical Field

[0001] The disclosure relates to a safety device and a construction machine for ensuring a safety of the construction machine.

Background Art

[0002] Construction machines, such as hydraulic excavators, have been conventionally provided with a region restriction control system. The region restriction control system permits an operator to set a specific restricted region in advance and controls a front working device not to enter the restricted region by comparing a position of the front working device with the set restricted region, and suspending the front working device or causing the front working device to operate along the boundary of the restricted region when the front working device attempts to enter the restricted region. The operator can release a region restriction function on the operator's will when determining that execution of the region restriction control may impair the workability.

[0003] However, the operator is required to perform a manipulation of releasing the region restriction function to release the region restriction function. This results in difficulty in rapidly releasing the region restriction function in terms of the workability.

[0004] For instance, Patent Literature 1 discloses a region restriction control system for determining, based on a state amount of a vehicle body, whether the vehicle body is likely to lift, and releasing a region restriction control to allow manual evacuation when determining that the vehicle body is likely to lift.

[0005] The conventional technology merely discloses releasing the region restriction control of the front working device when the vehicle body is determined to be likely to lift, and relies on the operator for the subsequent manipulations after the releasing.

[0006] For example, the region restriction control of the front working device is released when a footing portion for the construction machine decay and the vehicle body is determined to be likely to lift during a specific work. However, the operator is relied on for the subsequent manipulations after the releasing. In this case, the operator needs to rapidly perform a manipulation for preventing turning-over to ensure a safety.

[0007] However, it is difficult for the operator to abruptly perform the manipulation for preventing the turning-over. Therefore, a safety measure is desired to be adopted for preventing the turning-over.

Citation List

Patent Literature

[0008] Patent Literature 1: Japanese Unexamined Patent Publication No H 8-269998

Summary of Invention

[0009] The disclosure has been made to solve the above-described drawbacks, and an object of the disclosure is to provide a safety device and a construction machine each capable of automatically preventing the construction machine from being turned over and firmly ensure a safety of the construction machine.

[0010] A safety device according to one aspect of the disclosure is a safety device for ensuring a safety of a construction machine including a machine body and a working device attached to the machine body. The safety device includes: an acquisition part which acquires contour data representing a contour of a landform around the construction machine; a determination part which determines, based on the contour data, whether the landform satisfies an execution criterion of executing a turning-over prevention control for preventing the construction machine from being turned over to a slope extending in a specific direction around the construction machine; and a lowering control part which lowers a leading end of the working device to the slope when the determination part determines that the execution criterion is satisfied.

[0011] According to the disclosure, it is possible to automatically prevent the construction machine from being turned over and firmly ensure a safety of the construction machine.

Brief Description of Drawings

[0012]

Fig. 1 shows an exemplary hydraulic excavator serving as a construction machine on which a safety device according to an embodiment of the disclosure is mounted.

Fig. 2 is a block diagram showing a configuration of the hydraulic excavator shown in Fig. 1.

Fig. 3 shows an exemplary case where the hydraulic excavator works around a land surface joined to a slope in the embodiment.

Fig. 4 shows an exemplary case where a footing portion for the hydraulic excavator decays.

Fig. 5 shows an exemplary case where a leading end of a working device included in the hydraulic excavator is lowered to the slope.

Fig. 6 is a flowchart showing an operation of the hydraulic excavator shown in Fig. 2.

Description of Embodiments

[0013] Hereinafter, a preferable embodiment of the disclosure will be described with reference to the accompanying drawings. It should be noted that the following embodiment illustrates one example of the disclosure, and does not delimit the protection scope of the present invention.

[0014] Fig. 1 shows an exemplary hydraulic excavator serving as a construction machine on which a safety device according to an embodiment of the disclosure is mounted. The hydraulic excavator 1 includes a lower traveling body 10 which can travel on a ground G, an upper slewing body 12 mounted on the lower traveling body 10, and a working device 14 mounted on the upper slewing body 12. Hereinafter, an exemplary configuration where the safety device is applied to the hydraulic excavator 1 is described, but the disclosure should not be limited to this configuration. For instance, the safety device is applicable to a wide variety of construction machines, e.g., hydraulic cranes, as long as such a construction machine includes a lower traveling body, an upper slewing body, and a working device.

[0015] In the embodiment, a direction perpendicularly intersecting the ground G and extending upward therefrom is called an "up-direction", and a direction extending downward thereto is called a "down-direction". The up-direction and the down-direction are collectively called an "up-down direction". A forward direction in which the lower traveling body 10 travels forward is called a "front-direction", and a rearward direction in which the lower traveling body 10 travels rearward is called a "rear-direction". The front-direction and the rear-direction are collectively called a "front-rear direction". A direction perpendicularly intersecting the up-down direction and the front-rear direction is called a "left-right direction". A left side of a line extending from the rear-direction to the front-direction with respect to the left-right direction is called a "left-direction", and a right side thereof is called a "right-direction". The lower traveling body 10 has a dimension longer in the front-rear direction than a dimension in the left-right direction. Thus, the lower traveling body 10 has a longitudinal direction agreeing with the front-rear direction.

[0016] The lower traveling body 10 and the upper slewing body 12 constitute a machine body which supports the working device 14. The upper slewing body 12 has a slewing frame 16 and a plurality of elements mounted thereon. The elements include an engine room 17 for accommodating an engine, and a cab 18 serving as an operator compartment. The lower traveling body 10 includes a pair of crawlers. The upper slewing body 12 is mounted on the lower traveling body 10 slewably with respect thereto.

[0017] The working device 14 can perform operations required for an excavation work and other necessary works, and includes a boom 21, an arm 22, and a bucket 23. The boom 21 has a proximal end supported at a front end of a slewing frame 16 rotatably about a horizontal axis, and a distal end opposite to the proximal end. The arm 22 has a proximal end supported at the distal of the boom 21 tiltably, i.e., rotatably about the horizontal axis, and a distal end opposite to the proximal end. The bucket 23 is attached to the distal end of the arm 22 rotatably thereabout.

[0018] The boom 21, the arm 22, and the bucket 23 are attached with a boom cylinder C1, an arm cylinder C2, and a bucket cylinder C3 configured by a plurality of extendable and retractable hydraulic cylinders.

[0019] The boom cylinder C1 is located between the upper slewing body 12 and the boom 21, and extends and retracts to cause the boom 21 to tilt. The arm cylinder C2 is located between the boom 21 and the arm 22, and extends and retracts to rotate the arm 22. The bucket cylinder C3 is located between the arm 22 and the bucket 23, and extends and retracts to rotate the bucket 23.

[0020] Fig. 2 is a block diagram showing a configuration of the hydraulic excavator shown in Fig. 1. The hydraulic excavator 1 includes a controller 100, a contour sensor 101, an inclination sensor 102, a posture sensor 103, a slewing sensor 104, a boom manipulation device 105, an arm manipulation device 106, a bucket manipulation device 107, a slewing manipulation device 108, a traveling manipulation device 109, and a hydraulic circuit 200.

[0021] In addition to the boom cylinder C1, the arm cylinder C2, and the bucket cylinder C3 shown in Fig. 1, the hydraulic circuit 200 includes a slewing motor M1, a pair of left and right traveling motors M2L, M2R, a pair of boom solenoid valves V1, a pair of arm solenoid valves V2, a pair of bucket solenoid valves V3, a pair of slewing solenoid valves V4, a pair of left traveling solenoid valves V5L, a pair of right traveling solenoid valves V5R, a boom control valve V6, an arm control valve V7, a bucket control valve V8, a slewing control valve V9, and a pair of left and right traveling control valves V10L, V10R. The hydraulic circuit 200 is driven with a drive force of an unillustrated engine, and further includes a hydraulic pump for supplying a hydraulic fluid to each of the actuators and a pilot pump for sending a pilot pressure to a pilot port of each of the switch valves via a corresponding pilot line.

[0022] The boom cylinder C1 extends and retracts in response to the supply of the hydraulic fluid from the hydraulic pump, thereby performing a boom raising operation and a boom lowering operation.

[0023] The arm cylinder C2 extends and retracts in response to the supply of the hydraulic fluid from the hydraulic pump, thereby performing an arm pulling operation and an arm pushing operation.

[0024] The bucket cylinder C3 extends and retracts in response to the supply of the hydraulic fluid from the hydraulic pump, thereby performing a bucket scooping operation and a bucket opening operation.

[0025] The slewing motor M1 has a motor output shaft which bidirectionally rotates in response to the supply of the hydraulic fluid from the hydraulic pump, and causes the upper slewing body 12 coupled to the motor output shaft to slew leftward or rightward.

[0026] Each of the traveling motor M2L and the traveling motor M2R has a motor output shaft bidirectionally rotatable in response to the supply of the hydraulic fluid from the hydraulic pump, and causes the lower traveling body 10 coupled to their motor output shafts to travel forward or rearward. The traveling motor M2L and the traveling motor M2R rotate at the same speed to thereby allow the lower traveling body 10 to travel forward or rearward. In contrast, the traveling motor M2L and the traveling motor M2R rotate at different speeds to thereby allow the lower traveling body 10 to turn.

[0027] The boom control valve V6 is composed of a hydraulic pilot switch valve having a pair of boom pilot ports. One of the pair of boom pilot ports receives an input of a boom pilot pressure. The boom control valve V6 accordingly opens in a direction corresponding to the boom pilot port at a stroke corresponding to the input boom pilot pressure. In this manner, the boom control valve V6 changes a supply direction and a flow rate of the hydraulic fluid with respect to the boom cylinder C1.

[0028] The arm control valve V7 is composed of a hydraulic pilot switch valve having a pair of arm pilot ports. One of the pair of arm pilot ports receives an input of an arm pilot pressure. The arm control valve V7 accordingly opens in a direction corresponding to the arm pilot port at a stroke corresponding to the input arm pilot pressure. In this manner, the arm control valve V7 changes a supply direction and a flow rate of the hydraulic fluid with respect to the arm cylinder C2.

[0029] The bucket control valve V8 is composed of a hydraulic pilot switch valve having a pair of bucket pilot ports. One of the pair of bucket pilot ports receives an input of a bucket pilot pressure. The bucket control valve V8 accordingly opens in a direction corresponding to the bucket pilot port at a stroke corresponding to the input bucket pilot pressure. In this manner, the bucket control valve V8 changes a flow direction and a flow rate of the hydraulic fluid with respect to the bucket cylinder C3.

[0030] The slewing control valve V9 is composed of a hydraulic pilot switch valve having a pair of slewing pilot ports. One of the pair of slewing pilot ports receives an input of a slewing pilot pressure. The slewing control valve V9 accordingly opens in a direction corresponding to the slewing pilot port at a stroke corresponding to the input slewing pilot pressure. In this manner, the slewing control valve V9 changes a supply direction and a flow rate of the hydraulic fluid with respect to the slewing motor M1.

[0031] Each of the traveling control valves V10L, V10R is composed of a hydraulic pilot switch valve having a pair of traveling pilot ports. One of the pair of traveling pilot ports receives an input of a traveling pilot pressure. Each of the traveling control valves V10L, V10R accordingly opens in a direction corresponding to the traveling pilot port at a stroke corresponding to the input traveling pilot pressure. In this manner, each of the traveling control valves V10L, V10R changes a supply direction and a flow rate of the hydraulic fluid with respect to each of the traveling motors M2L, M2R.

[0032] Each of the pair of boom solenoid valves V1 is located between the pilot pump and a corresponding one of the pair of boom pilot ports of the boom control valve V6, and opens or closes in response to an input of a boom instructive signal representing an electric signal. Each of the pair of boom solenoid valves V1 having received the input of the boom instructive signal adjusts the boom pilot pressure at a degree corresponding to the boom instructive signal.

[0033] Each of the pair of arm solenoid valves V2 is located between the pilot pump and a corresponding one of the pair of arm pilot ports of the arm control valve V7, and opens or closes in response to an input of an arm instructive signal representing an electric signal. Each of the pair of arm solenoid valves V2 having received the input of the arm instructive signal adjusts the arm pilot pressure at a degree corresponding to the arm instructive signal.

[0034] Each of the pair of bucket solenoid valves V3 located between the pilot pump and a corresponding one of the pair of arm pilot ports of the bucket control valve V8, and opens or closes in response to an input of a bucket instructive signal representing an electric signal. Each of the pair of bucket solenoid valves V3 having received the input of the bucket instructive signal adjusts the bucket pilot pressure at a degree corresponding to the bucket instructive signal.

[0035] Each of the pair of slewing solenoid valves V4 is located between the pilot pump and a corresponding one of the pair of slewing pilot ports of the slewing control valve V9, and opens or closes in response to an input of a slewing instructive signal representing an electric signal. The slewing solenoid valve V4 having received the input of the slewing instructive signal adjusts the slewing pilot pressure at a degree corresponding to the slewing instructive signal.

[0036] Each of the pair of traveling solenoid valves V5L is located between the pilot pump and a corresponding one of the pair of traveling pilot ports of the traveling control valve 10L, and opens or closes in response to an input of a slewing instructive signal representing an electric signal. Each of the pair of traveling solenoid valves V5L having received the input of the traveling instructive signal adjusts the traveling pilot pressure at a degree corresponding to the traveling instructive signal.

[0037] Each of the pair of traveling solenoid valves V5R is located between the pilot pump and a corresponding one of the pair of traveling pilot ports of the traveling control valve 10R, and opens or closes in response to an input of a slewing instructive signal representing an electric signal. Each of the pair of traveling solenoid valves V5L having received the input of the traveling instructive signal adjusts the traveling pilot pressure at a degree corresponding to the traveling instructive signal.

[0038] The contour sensor 101 acquires contour data representing a contour of a landform of the hydraulic excavator 1. The contour sensor 101 detects contour data representing a distance distribution of the landform around the hydraulic excavator 1. The contour sensor 101 includes a three-dimensional distance measurement sensor, such as a light detection and ranging (LIDAR).

The contour sensor 101 may include any sensor, e.g., a distance measurement sensor using infrared light and a distance measurement sensor using an ultrasonic wave, which can measure the distance distribution, as well as the LIDAR. In the embodiment, the contour sensor 101 is attached to, for example, the upper slewing body 12, the working device 14, or the lower traveling body 10 so that a central line at an angle of view therein extends diagonally downward in the front-direction. Hereinafter, the contour sensor 101 will be described as being attached to an upper portion of the upper slewing body 12. The contour data represents, for example, distance image data where depth data each indicating a depth from the contour sensor 101 to the landform is arranged in a matrix form. The contour sensor 101 inputs the detected contour data to the controller 100.

[0039] The inclination sensor 102 detects a ground surface angle representing an inclination angle of a bottom surface of the lower traveling body 10 to a ground surface (horizontal plane). The inclination sensor 102 includes an inertial sensor serving as, for example, an acceleration sensor and an angular velocity sensor. The inclination sensor 102 detects, based on a detection signal from the inertial sensor, the ground surface angle by using a strapped-down method or other method. The inclination sensor 102 converts the detected ground surface angle to a detection signal representing an electric signal corresponding to the angle, and inputs the detection signal to the controller 100.

[0040] The posture sensor 103 detects a posture of the working device 14. The posture sensor 103 includes a boom angle sensor 61, an arm angle sensor 62, and a bucket angle sensor 63 each shown in Fig. 1. The boom angle sensor 61 detects a boom angle representing a rotational angle of the boom 21 with respect to the upper slewing body 12. The arm angle sensor 62 detects an arm angle representing a rotational angle of the arm 22 with respect to the boom 21. The bucket angle sensor 63 detects a bucket angle representing a rotational angle of the bucket 23 with respect to the arm 22. Each of the boom angle sensor 61, the arm angle sensor 62, and the bucket angle sensor 63 is composed of a resolver or a rotary encoder. The posture sensor 103 converts each of the detected boom angle, arm angle, and bucket angle to a detection signal representing an electric signal corresponding to each of the angles, and inputs the detection signal to the controller 100.

[0041] The slewing sensor 104 detects a slewing angle of the upper slewing body 12 with respect to the lower traveling body 10. The slewing sensor 104 is composed of, for example, a resolver or a rotary encoder. The slewing sensor 104 converts the detected slewing angle to a detection signal representing an electric signal corresponding to the angle, and inputs the detection signal to the controller 100.

[0042] The boom manipulation device 105 is composed of an electric lever device including a boom manipulation lever which receives a manipulation of an operator for the boom raising operation or the boom lowering operation, and a manipulation signal generation part which inputs a boom manipulation signal corresponding to a manipulation amount of the boom manipulation lever to the controller 100.

[0043] The arm manipulation device 106 is composed of an electric lever device including an arm manipulation lever which receives a manipulation of an operator for the arm pulling operation or the arm pushing operation, and a manipulation signal generation part which inputs an arm manipulation signal corresponding to a manipulation amount of the arm manipulation lever to the controller 100.

[0044] The bucket manipulation device 107 is composed of an electric lever device including a bucket manipulation lever which receives a manipulation of the operator for the bucket scooping operation or the bucket opening operation, and a manipulation signal generation part which inputs a bucket manipulation signal corresponding to a manipulation amount of the bucket manipulation lever to the controller 100.

[0045] The slewing manipulation device 108 is composed of an electric lever device including a slewing manipulation lever which receives a manipulation of the operator for causing the upper slewing body 12 to slew leftward or rightward, and a manipulation signal generation part which inputs a slewing manipulation signal corresponding to a manipulation amount of the slewing manipulation lever to the controller 100.

[0046] The traveling manipulation device 109 is composed of an electric lever device including a traveling manipulation lever which receives a manipulation of the operator for causing the lower traveling body 10 to travel forward or rearward, and a manipulation signal generation part which inputs a traveling manipulation signal corresponding to a manipulation amount of the traveling manipulation lever to the controller 100.

[0047] The controller 100 is composed of, for example, a microcomputer, and includes a calculation unit 110 and an instruction unit 120. The calculation unit 110 executes, when the landform satisfies an execution criterion of executing a turning-over prevention control for preventing the hydraulic excavator 1 from being turned over to the slope extending in a specific direction around the hydraulic excavator, the turning-over prevention control of lowering a leading end of the working device 14 to the slope. The instruction unit 120 controls an operation of each of the elements included in the hydraulic circuit 200.

[0048] The instruction unit 120 includes a boom instruction part 121, an arm instruction part 122, a bucket instruction part 123, a slewing instruction part 124, and a traveling instruction part 125.

[0049] The boom instruction part 121 inputs, to each of the pair of boom solenoid valves V1, a boom instructive signal indicating a value corresponding to the manipulation amount of the boom manipulation device 105, thereby setting an opening degree of the boom solenoid valve V1 to a degree corresponding to the manipulation amount of the boom manipulation device 105. A flow rate of the hydraulic fluid supplied to the boom cylinder C1 increases in accordance with an increase in the set opening degree.

[0050] The arm instruction part 122 inputs, to each of the pair of arm solenoid valves V2, an arm instructive signal indicating a value corresponding to the manipulation amount of the arm manipulation device 106, thereby setting an opening degree of the arm solenoid valve V2 to a value corresponding to the manipulation amount of the arm manipulation device 106.

[0051] The bucket instruction part 123 inputs, to each of the pair of bucket solenoid valves V3, a bucket instructive signal indicating a value corresponding to the manipulation amount of the bucket manipulation device 107, thereby setting an opening degree of the bucket solenoid valve V3 to a value corresponding to the manipulation amount of the bucket manipulation device 107.

[0052] The slewing instruction part 124 inputs, to the slewing solenoid valve V4, a slewing instructive signal indicating a value corresponding to the manipulation amount of the slewing manipulation device 108, thereby setting an opening degree of the slewing solenoid valve V4 to a value corresponding to the manipulation amount of the slewing manipulation device 108.

[0053] The traveling instruction part 125 inputs, to each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R, a traveling instructive signal indicating a value corresponding to the manipulation amount of the traveling manipulation device 109, thereby setting an opening degree of each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R to a value corresponding to the manipulation amount of the traveling manipulation device 109.

[0054] The calculation unit 110 includes a coordinate system transformation part 111, a determination part 112, and a lowering control part 113.

[0055] The coordinate system transformation part 111 transforms the contour data detected by the contour sensor 101 to the data of the machine coordinate system based on the hydraulic excavator 1. The machine coordinate system is, for example, a three-dimensional rectangular coordinate system having an X-axis extending in the longitudinal direction (front-rear direction), a Y-axis extending in the left-right direction, a Z-axis extending in the up-down direction, and an origin at a connection portion between the upper slewing body 12 and the lower traveling body 10 on a slewing axis of the upper slewing body 12. The X-axis, the Y-axis, the Z-axis, and the origin in the machine coordinate system are not limited to the aforementioned definition. The origin of the machine coordinate system may be, for example, a base part (corresponding to the proximal end of the boom 21) of the working device 14.

[0056] The contour sensor 101 is attached to the upper slewing body 12. Thus, the position of the contour sensor 101 in the machine coordinate system shifts in accordance with a slewing angle of the upper slewing body 12. The coordinate system transformation part 111 calculates, by using the slewing angle detected by the slewing sensor 104, the position of the contour sensor 101 in the machine coordinate system, and specifies a relative positional relation between the coordinate system of the contour sensor 101 and the machine coordinate system from the calculated position, and transforms, based on the specified relative positional relation, the contour data to the contour data of the machine coordinate system. The contour sensor 101 displays the landform based on depth data at a plurality of detection points in the matrix form. The coordinate system transformation part 111 calculates, from a depth (distance) to each of the detection points, a coordinate of each of the detection points in the machine coordinate system.

[0057] Meanwhile, a configuration where the contour sensor 101 is arranged at the working device 14 requires a detection signal from the posture sensor 103 and the slewing angle when transforming the contour data to the data of the machine coordinate system. Another configuration where the contour sensor 101 is arranged at the lower traveling body 10 maintains the position of the contour sensor 101 in the machine coordinate system. Thus, the detection signal from the posture sensor 103 and the slewing angle are unnecessary for transforming the contour data to the machine coordinate system.

[0058] The determination part 112 determines, based on the contour data, whether the landform satisfies the execution criterion of executing the turning-over prevention control for preventing the hydraulic excavator 1 from being turned over to the slope extending in a specific direction around the hydraulic excavator. The turning-over prevention control in the embodiment represents a control of lowering the leading end of the working device 14 to the slope. The determination part 112 includes an inclination angle calculation section 114, an execution criterion determination section 115, and a state determination section 116.

[0059] The inclination angle calculation section 114 calculates, based on the contour data, an inclination angle of the slope to the ground surface on which the hydraulic excavator 1 stands.

[0060] Fig. 3 shows an exemplary case where the hydraulic excavator works around a land surface joined to a slope in the embodiment. Hereinafter, the process executed by the inclination angle calculation section 114 will be described with reference to Fig. 3. The hydraulic excavator 1 works on a land surface 302 joined to a slope 301. The slope 301 covers, for example, a slope including an artificial inclined surface made by removing or adding soil. The land surface 302 is connected to an upper end of the slope 301. The land surface 302 is horizontal. An inclination angle $\theta 1$ represents an inclination angle of the slope 301 to a ground surface SA on which the hydraulic excavator 1 stands. Here, the hydraulic excavator 1 is located on the land surface 302, and thus the ground surface SA serves as the land surface 302. The slope 301 includes a target surface from or to which the hydraulic excavator 1 causes the working device 14 to remove or add soil.

[0061] The inclination angle calculation section 114 calculates the inclination angle θ1 from the contour data transformed to the machine coordinate system. In this case, the inclination angle calculation section 114 detects, from the contour data, a boundary between the ground surface SA with which the lower traveling body 10 is in contact and the slope 301, and extracts, as a slope candidate region, a region falling within a predetermined range opposite to the ground surface SA across the boundary. Next, the inclination angle calculation section 114 sets a direction perpendicularly intersecting the boundary as the inclination direction of the slope 301, extracts, from the slope candidate region, a coordinate data group on a line parallel to the inclination direction, and obtains a regression line of the extracted data group. The inclination angle calculation section 114 then calculates, as the inclination angle, an angle of the regression line to an X-Y plane, that is, an angle to the ground surface SA. Here, the inclination angle calculation section 114 may determine that the contour data does not contain the slope 301 when a coefficient of determination of the regression line is equal to or smaller than a predetermined value, and determine that the contour data contains the slope 301 when the coefficient of determination is larger than the predetermined value.

[0062] Alternatively, the inclination angle calculation section 114 may extract, from the slope candidate region, coordinate data groups on a plurality of lines parallel to the inclination direction, obtain regression lines for the lines, respectively, calculate an angle of each of the regression lines to the ground surface SA, and determine that the contour data contains the slope 301 when each of the angles is within a predetermined angle range and each of the regression lines has a coefficient of determination larger than a predetermined threshold. In this case, the inclination angle calculation section 114 may calculate, as the inclination angle θ1, an average value of the angles of the regression lines to the ground surface SA.

[0063] The state determination section 116 determines whether the hydraulic excavator 1 is in a stable sate or in an unstable state. The hydraulic excavator 1 is determined to be in the stable state when the whole of the bottom surface of the lower traveling body 10 is in contact with the ground surface SA. In contrast, the hydraulic excavator 1 is determined to lean forward and thus be in the unstable state when a footing portion 303 for the hydraulic excavator 1 decays to the slope 301 and accordingly only a part of the bottom surface of the lower traveling body 10 is in contact with the ground surface SA in Fig. 3.

[0064] Fig. 4 shows an exemplary case where the footing portion for the hydraulic excavator decays.

[0065] As shown in Fig. 4, the hydraulic excavator 1 leans forward when the footing portion 303 for the hydraulic excavator 1 decays to the slope 301. The inclination sensor 102 detects a ground surface angle θ2 representing an inclination angle to the ground surface (horizontal plane) SA with which the lower traveling body 10 is in contact. An acceleration rate in the vertical direction of the hydraulic excavator 1 increases as the hydraulic excavator 1 leans forward. Here, the state determination section 116 acquires an acceleration rate of the hydraulic excavator 1, and determines that the hydraulic excavator 1 is in the unstable state when the acquired acceleration rate is higher than a threshold. The state determination section 116 calculates the acceleration rate of the hydraulic excavator 1 by differentiating the ground surface angle θ2 detected by the inclination sensor 102. The state determination section 116 determines whether the calculated acceleration rate is higher than the threshold. The state determination section 116 then determines that the hydraulic excavator 1 is in the unstable state when determining that the calculated acceleration rate is higher than the threshold.

[0066] The acceleration rate is calculated from the ground surface angle θ2 detected by the inclination sensor 102 in the embodiment. However, the disclosure should not be particularly limited thereto. The hydraulic excavator 1 may be provided with an acceleration sensor so that the acceleration sensor can detect an acceleration rate of the hydraulic excavator 1.

[0067] The execution criterion determination section 115 determines that the landform satisfies the execution criterion of executing the turning-over prevention control for preventing the hydraulic excavator 1 from being tuned over to the slope in the front-direction when the inclination angle calculated by the inclination angle calculation section 114 is larger than the threshold and the state determination section 116 determines that the hydraulic excavator 1 is in the unstable state.

[0068] The lowering control part 113 executes the turning-over prevention control of lowering the leading end of the working device 14 to the slope when the determination part 112 determines that the execution criterion is satisfied. The lowering control part 113 lowers the leading end of the working device 14 to the slope along a route having a shortest distance between the leading end of the working device 14 and the slope.

[0069] Specifically, the lowering control part 113 calculates a coordinate of the leading end of the working device 14 in the machine coordinate system, based on the boom angle, the arm angle, and the bucket angle each detected by the posture sensor 103, and based on the length from the proximal end to the distal end of each of the boom 21, the arm 22, and the bucket 23. The leading end of the working device 14 corresponds to a distal or leading end 231 of the bucket 23. The length from the proximal end to the distal end of each of the boom 21, the arm 22, and the bucket 23 is stored in an unillustrated memory in advance. The lowering control part 113 specifies, from the coordinate data group in the slope candidate region, a coordinate of a point 304 on the slope where the distance from the coordinate of the leading end 231 of the bucket 23 is the shortest. Furthermore, the lowering control part 113 calculates, as a route 401 along which the leading end 231 of the bucket 23 moves, a line connecting the coordinate of the leading end 231 of the bucket 23 and the coordinate of the point 304 on the slope where the distance from the coordinate of the leading end 231 of the bucket 23 is the shortest with each other. The lowering control part 113 generates a boom control signal, an arm control signal, and a bucket control signal for moving the leading end 231 of the bucket 23 along the calculated route 401, and outputs the generated boom control signal, arm control signal, and bucket control signal to the instruction unit 120.

[0070] The boom instruction part 121 inputs, to each of the pair of boom solenoid valves V1, a boom instructive signal indicating a value corresponding to the control amount of the lowering control part 113. The arm instruction part 122 inputs, to each of the pair of arm solenoid valves V2, an arm instructive signal indicating a value corresponding to the control amount of the lowering control part 113. The bucket instruction part 123 inputs, to each of the pair of bucket solenoid valves V3, a bucket instructive signal indicating a value corresponding to the control amount of the lowering control part 113.

[0071] Fig. 5 shows an exemplary case where the leading end of the working device included in the hydraulic excavator is lowered to the slope.

[0072] The lowering control part 113 lowers the leading end of the working device 14 to a target position which makes the distance between the position of the leading end 231 of the working device 14 and a specific position of the slope be within a predetermined range. The target position is at a position where the leading end 231 of the working device 14 is below the surface of the slope 301. The lowering control part 113 lowers the leading end 231 of the working device 14 to a position where the leading end 231 of the working device 14 reaches below the surface of the slope 301. In this manner, the leading end 231 of the working device 14 jabs into slope 301, and thus the stability of the hydraulic excavator 1 can be more firmly ensured.

[0073] The target position may be a position above the slope 301. The lowering control part 113 may lower the leading end 231 of the working device 14 to the position above the slope 301. This configuration can shorten the time required for the leading end 231 of the working device 14 to reach the target position and thus can more rapidly stabilize the hydraulic excavator 1.

[0074] The hydraulic excavator 1 may additionally include a boom cylinder pressure sensor for detecting a pressure value of the boom cylinder C1, and an arm cylinder pressure sensor for detecting a pressure value of the arm cylinder C2. The lowering control part 113 may lower the leading end of the working device 14 until the boom cylinder pressure sensor or the arm cylinder pressure sensor detects a pressure value which is equal to or higher than a predetermined value. The pressure value of the boom cylinder C1 or the arm cylinder C2 rises when the leading end of the working device 14 is pressed to the ground. Therefore, lowering the leading end of the working device 14 until the pressure value detected by the boom cylinder pressure sensor or the arm cylinder pressure sensor reaches a value equal to or higher than the predetermined value succeeds in sufficiently pressing the leading end of the working device 14 to the ground, and further reliably stabilizing the hydraulic excavator 1.

[0075] Besides, when the determination part 112 determines that the execution criterion is satisfied, the lowering control part 113 automatically lowers the leading end of the working device 14 to the slope while hindering a manipulation of the operator, and allows the manipulation of the operator after finishing the lowering of the leading end of the working device 14 to the target position. In other words, the lowering control part 113 avoids receiving a manipulation signal from each of the boom manipulation device 105, the arm manipulation device 106, the bucket manipulation device 107, the slewing manipulation device 108, and the traveling manipulation device 109 when the determination part 112 determines that the execution criterion is satisfied. The lowering control part 113 then receives the manipulation signal from each of the boom manipulation device 105, the arm manipulation device 106, the bucket manipulation device 107, the slewing manipulation device 108, and the traveling manipulation device 109 after finishing the lowering of the leading end of the working device 14 to the target position. The manipulation of the operator is thus allowed after the leading end of the working device 14 reaches the slope. The operator can consequently perform a turning-over avoidance manipulation of such as, for example, causing the hydraulic excavator 1 to travel rearward, in a state where the leading end of the bucket 23 is pressed to the slope after the hydraulic excavator 1 is stabilized.

[0076] Fig. 6 is a flowchart showing an operation of the hydraulic excavator shown in Fig. 2. The flow shown in Fig. 6 is repeated at a predetermined cycle during a drive of the hydraulic excavator 1.

[0077] First, in step S1, the contour sensor 101 acquires contour data representing a distance distribution of a landform around the hydraulic excavator 1.

[0078] Next, in step S2, the slewing sensor 104 acquires a slewing angle of the upper slewing body 12 with respect to the lower traveling body 10.

[0079] Subsequently, in step S3, the coordinate system transformation part 111 transforms, by using the acquired slewing angle, the acquired contour data represented by the coordinate system based on the contour sensor 101 to the contour data represented by the machine coordinate system based on the hydraulic excavator 1.

[0080] Subsequently, in step S4, the inclination angle calculation section 114 calculates, based on the contour data of the machine coordinate system transformed by the coordinate system transformation part 111, an inclination angle of the slope in the front-direction to the ground surface on which the hydraulic excavator 1 stands.

[0081] In step S5, the inclination sensor 102 further acquires a ground surface angle representing an inclination angle of a bottom surface of the lower traveling body 10 to a ground surface (horizontal plane).

[0082] Subsequently, the state determination section 116 calculates, in step S6, an acceleration rate from the ground surface angle detected by the inclination sensor 102.

[0083] Next, in steps S7, the state determination section 116 determines, based on the calculated acceleration rate, whether the hydraulic excavator 1 is in a stable sate or in an unstable state. The state determination section 116 here determines whether the calculated acceleration rate is higher than a threshold. The state determination section 116 then determines that the hydraulic excavator 1 is in the stable sate when determining that the calculated acceleration rate is equal to or lower than the threshold. Conversely, the state determination section 116 determines that the hydraulic excavator 1 is in the unstable state when determining that the calculated acceleration rate is higher than the threshold.

[0084] Subsequently, in steps S8, the execution criterion determination section 115 determines whether the inclination angle calculated by the inclination angle calculation section 114 is larger than a threshold and whether the state of the hydraulic excavator 1 determined by the state determination section 116 indicates the unstable state.

[0085] When the inclination angle is determined to be equal to or smaller than the threshold, or the state of the hydraulic excavator 1 is determined to indicate the stable state ("NO" in step S8), the flow finishes there.

[0086] In contrast, when the inclination angle is determined to be larger than the threshold and the state of the hydraulic excavator 1 is determined to indicate the unstable state ("YES" in step S8), the lowering control part 113 suspends a manipulation of the operator in step S9. Specifically, the lowering control part 113 abandons a manipulation signal, without receiving the same, from each of the boom manipulation device 105, the arm manipulation device 106, the bucket manipulation device 107, the slewing manipulation device 108, and the traveling manipulation device 109.

[0087] Subsequently, in step S10, the posture sensor 103 detects a posture of the working device 14. The posture sensor 103 detects a boom angle, an arm angle, and a bucket angle as representing the posture of the working device 14.

[0088] Next, in step S11, the lowering control part 113 calculates a coordinate of the leading end of the working device 14 in the machine coordinate system, based on the boom angle, the arm angle, and the bucket angle each detected by the posture sensor 103, and based on the length from the proximal end to the distal end of each of the boom 21, the arm 22, and the bucket 23.

[0089] In step S12, the lowering control part 113 further specifies, from the coordinate data group in the slope candidate region, a coordinate of a point on the slope where the distance from the coordinate of the leading end of the working device 14 is the shortest.

[0090] In steep S13, the lowering control part 113 then calculates a movement route of the leading end of the working device 14. Specifically, the lowering control part 113 calculates, as the movement route of the leading end of the working device 14, a line connecting the coordinate of the leading end of the working device 14 and the coordinate of the point on the slope where the distance from the coordinate of the leading end of the working device 14 is the shortest with each other.

[0091] Subsequently, in step S14, the lowering control part 113 controls the instruction unit 120 that outputs respective instructive signals for lowering the leading end of the working device 14 to the slope along the calculated movement route. That is, the lowering control part 113 generates a boom control signal, an arm control signal, and a bucket control signal for lowering the leading end of the working device 14 to the slope along the calculated movement route, and outputs the generated boom control signal, arm control signal, and bucket control signal to the instruction unit 120. The boom instruction part 121 inputs, to each of the pair of boom solenoid valves V1, a boom instructive signal indicating a value corresponding to the boom control signal input from the lowering control part 113. The arm instruction part 122 inputs, to each of the pair of arm solenoid valves V2, an arm instructive signal indicating a value corresponding to the arm control signal input from the lowering control part 113. The bucket instruction part 123 inputs, to each of the pair of bucket solenoid valves V3, a bucket instructive signal indicating a value corresponding to the bucket control signal input from the lowering control part 113. In this manner, the boom cylinder C1, the arm cylinder C2, and the bucket cylinder C3 are driven to lower the leading end of the working device 14 to the slope.

[0092] Next, in step S15, the lowering control part 113 allows the manipulation of the operator. Specifically, the lowering control part 113 receives the manipulation signal from each of the boom manipulation device 105, the arm manipulation device 106, the bucket manipulation device 107, the slewing manipulation device 108, and the traveling manipulation device 109.

[0093] As described above, it is determined whether the landform satisfies the execution criterion of executing the turning-over prevention control for preventing the hydraulic excavator 1 from being turned over to the slope in the front-direction. When the execution criterion is determined to be satisfied, the leading end of the working device 14 is lowered to the slope, and thus the leading end of the working device 14 is pressed to the slope, and the hydraulic excavator 1 is consequently supported via the leading end of the working device 14. This configuration makes it possible to automatically prevent the hydraulic excavator 1 from being turned over and firmly ensure the safety of the hydraulic excavator 1.

[0094] Moreover, the embodiment discloses the execution of the turning-over prevention control in the state where the front of the lower traveling body 10 faces the slope 301. However, the disclosure should not be limited thereto. The turning-over prevention control may be executed in a state where the front of the lower traveling body 10 does not face the slope 301. In this case, a relative direction of the hydraulic excavator 1 to the slope 301 where the hydraulic excavator 1 causes the working device 14 to perform a work of removing or adding soil as shown in Fig. 3 may be stored as a specific direction. With this configuration, the turning-over prevention control is executable when the hydraulic excavator 1 is likely to be turned over to the slope 301 during the work of the working device 14 on the slope 301 with the upper slewing body 12 slewing with respect to the lower traveling body 10 in a state where the front of the lower traveling body 10 does not face the slope 301.

[0095] In the embodiment, the slope 301 is detected by using the contour data detected by the contour sensor 101. However, the disclosure should not be limited thereto. The slope 301 may be detected from the memory by acquiring the contour data measured in advance, or acquiring the contour data from an external server via a communication therewith. In this case, the inclination angle calculation section 114 may acquire a current position of the hydraulic excavator 1 from an unillustrated GPS sensor, plot the current position of the hydraulic excavator 1 onto the acquired contour data, and then detect, from the contour data, the slope 301 around the hydraulic excavator 1.

[0096] Additionally, the hydraulic excavator 1 may further include an information presentation device which presents information for notifying the operator of the automatic lowering of the leading end of the working device 14 to prevent the hydraulic excavator 1 from being turned over. The information presentation device is, for example, a display or a speaker.

[0097] In the embodiment, the determination part 112 includes the inclination angle calculation section 114, the execution criterion determination section 115, and the state determination section 116. However, the disclosure should not be particularly limited thereto. The determination part 112 may include the inclination angle calculation section 114 and the execution criterion determination section 115 without the state determination section 116. In this case, the execution criterion determination section 115 may determine whether the inclination angle calculated by the inclination angle calculation section 114 is larger than the threshold. The execution criterion determination section 115 may determine that the execution criterion is satisfied when the inclination angle is larger than the threshold.

Summary of embodiments

[0098] The technical features of the embodiments will be summarized below.

[0099] A safety device according to one aspect of the disclosure is a safety device for ensuring a safety of a construction machine including a machine body and a working device attached to the machine body. The safety device includes: an acquisition part which acquires contour data representing a contour of a landform around the construction machine; a determination part which determines, based on the contour data, whether the landform satisfies an execution criterion of executing a turning-over prevention control for preventing the construction machine from being turned over to a slope extending in a specific direction around the construction machine; and a lowering control part which lowers a leading end of the working device to the slope when the determination part determines that the execution criterion is satisfied.

[0100] According to this configuration, it is determined whether the landform satisfies the execution criterion of executing the turning-over prevention control for preventing the construction machine from being turned over to the slope extending in the specific direction. When the execution criterion is determined to be satisfied, the leading end of the working device is lowered to the slope, and thus the leading end of the working device is pressed to the slope, and the construction machine is consequently supported via the leading end of the working device. This configuration makes it possible to automatically prevent the construction machine from being turned over and firmly ensure the safety of the construction machine.

[0101] In the safety device, the determination part may calculate, based on the contour data, an inclination angle of the slope to a ground surface on which the construction machine stands, and determine that the execution criterion is satisfied when the inclination angle is larger than a threshold.

[0102] According to this configuration, when the inclination angle of the slope extending in the specific direction of the construction machine is larger than the threshold, the execution criterion is determined to be satisfied, and the leading end of the working device is lowered to the slope. This can prevent the construction machine from being turned over even when the construction machine is highly likely to be turned over.

[0103] In the safety device, the determination part may calculate, based on the contour data, an inclination angle of the slope to a ground surface on which the construction machine stands, determine whether the construction machine is in an unstable state, and determine that the execution criterion is satisfied when the inclination angle is larger than a threshold and determining that the construction machine is in the unstable state.

[0104] This configuration can automatically prevent the construction machine from being turned over when the inclination angle of the slope to the ground surface on which the construction machine stands is larger than the threshold and the construction machine is in the unstable state.

[0105] In the safety device, the determination part may acquire an acceleration rate of the construction machine, and determine that the construction machine is in the unstable state when the acquired acceleration rate is higher than a threshold.

[0106] This configuration can reliably determine that the construction machine is in the unstable state, since the acceleration rate of the construction machine becomes higher than the threshold when, for example, the footing portion for the construction machine decays to the slope and the construction machine leans in the specific direction.

[0107] In the safety device, the lowering control part may lower the leading end of the working device to the slope along a route having a shortest distance between the leading end of the working device and the slope.

[0108] According to this configuration, the leading end of the working device is lowered to the slope along the route having the shortest distance between the leading end of the working device and the slope. This configuration can consequently lower the leading end of the working device to the slope at the shortest distance, and automatically and more rapidly prevent the construction machine from being turned over.

[0109] In the safety device, the lowering control part may lower the leading end of the working device to a target position which makes a distance between a position of the leading end of the working device and a specific position of the slope be within a predetermined range.

[0110] According to this configuration, the leading end of the working device is lowered to the target position which makes the distance between the position of the leading end of the working device and the specific position of the slope be within the predetermine range. This configuration can reliably prevent the construction machine from being turned over by, for example, lowering the leading end of the working device to a position where the construction machine is supportable by the working device.

[0111] In the safety device, the target position may be at a position where the leading end of the working device is below the surface of the slope.

[0112] This configuration can more firmly stabilize the construction machine by lowering the leading end of the construction machine to the position below the surface of the slope to allow the leading end of the working device to jab into the slope.

[0113] In the safety device, when the determination part determines that the execution criterion is satisfied, the lowering control part may lower the leading end of the working device to the slope while hindering a manipulation of an operator, and allow the manipulation of the operator after finishing the lowering of the leading end of the working device to the target position.

[0114] According to this configuration, when the execution criterion is determined to be satisfied, the leading end of the working device is lowered to the slope while the manipulation of the operator is hindered, and the manipulation of the operator is allowed after the finishing of the lowering of the leading end of the working device to the target position. The operator can consequently perform a turning-over avoidance manipulation, such as, for example, causing the construction machine to travel rearward, in a state where the leading end of the working device is pressed to the slope after the construction machine is stabilized.

[0115] A construction machine according to another aspect of the disclosure includes the safety device having any one of the configurations described above, a machine body, and a working device attached to the machine body.

[0116] According to this configuration, it is determined whether the landform satisfies the execution criterion of executing the turning-over prevention control for preventing the construction machine from being turned over to the slope extending in the specific direction. When the execution criterion is determined to be satisfied, the leading end of the working device is lowered to the slope, and thus the leading end of the working device is pressed to the slope, and the construction machine is consequently supported via the leading end of the working device. This configuration makes it possible to automatically prevent the construction machine from being turned over and firmly ensure the safety of the construction machine.

[0117] Here, the aspects or examples described in detail for each of the aspects to implement the invention are intended for simply clarifying the technical contents of the disclosure, and thus should not be construed in a narrow scope limiting to the examples, but can be implemented with various modifications within a scope defined in the claims in accordance with the spirit of the disclosure.

[0118] A safety device and a construction machine according to the disclosure can automatically prevent the construction machine from being turned over and firmly ensure a safety of the construction machine. Conclusively, the safety device and the construction machine are useful as a safety device and a construction machine for ensuring the safety of the construction machine.

Claims

1. A safety device for ensuring a safety of a construction machine including a machine body and a working device attached to the machine body, the safety device comprising:

an acquisition part which acquires contour data representing a contour of a landform around the construction machine;

a determination part which determines, based on the contour data, whether the landform satisfies an execution criterion of executing a turning-over prevention control for preventing the construction machine from being turned over to a slope extending in a specific direction around the construction machine; and a lowering control part which lowers a leading end of the working device to the slope when the determination part determines that the execution criterion is satisfied.

2. The safety device according to claim 1, wherein the determination part calculates, based on the contour data, an inclination angle of the slope to a ground surface on which the construction machine stands, and determines that the execution criterion is satisfied when the inclination angle is larger than a threshold.

3. The safety device according to claim 1, wherein the determination part calculates, based on the contour data, an inclination angle of the slope to a ground surface on which the construction machine stands, determines whether the construction machine is in an unstable state, and determines that the execution criterion is satisfied when the inclination angle is larger than a threshold and determining that the construction machine is in the unstable state.

4. The safety device according to claim 3, wherein the determination part acquires an acceleration rate of the construction machine, and determines that the construction machine is in the unstable state when the acquired acceleration rate is higher than a threshold.

5. A safety device according to any one of claims 1 to 4, wherein the lowering control part lowers the leading end of the working device to the slope along a route having a shortest distance between the leading end of the working device and the slope.

6. The safety device according to any one of claims 1 to 5, wherein the lowering control part lowers the leading end of the working device to a target position which makes a distance between a position of the leading end of the working device and a specific position of the slope be within a predetermined range.

7. The safety device according to claim 6, wherein the target position is at a position where the leading end of the working device is below the surface of the slope.

8. The safety device according to claim 6 or 7, wherein when the determination part determines that the execution criterion is satisfied, the lowering control part lowers the leading end of the working device to the slope while hindering a manipulation of an operator, and allows the manipulation of the operator after finishing the lowering of the leading end of the working device to the target position.

9. A construction machine comprising:

the safety device according to any one of claims 1 to 8;
a machine body; and
a working device attached to the machine body.

FIG. 1

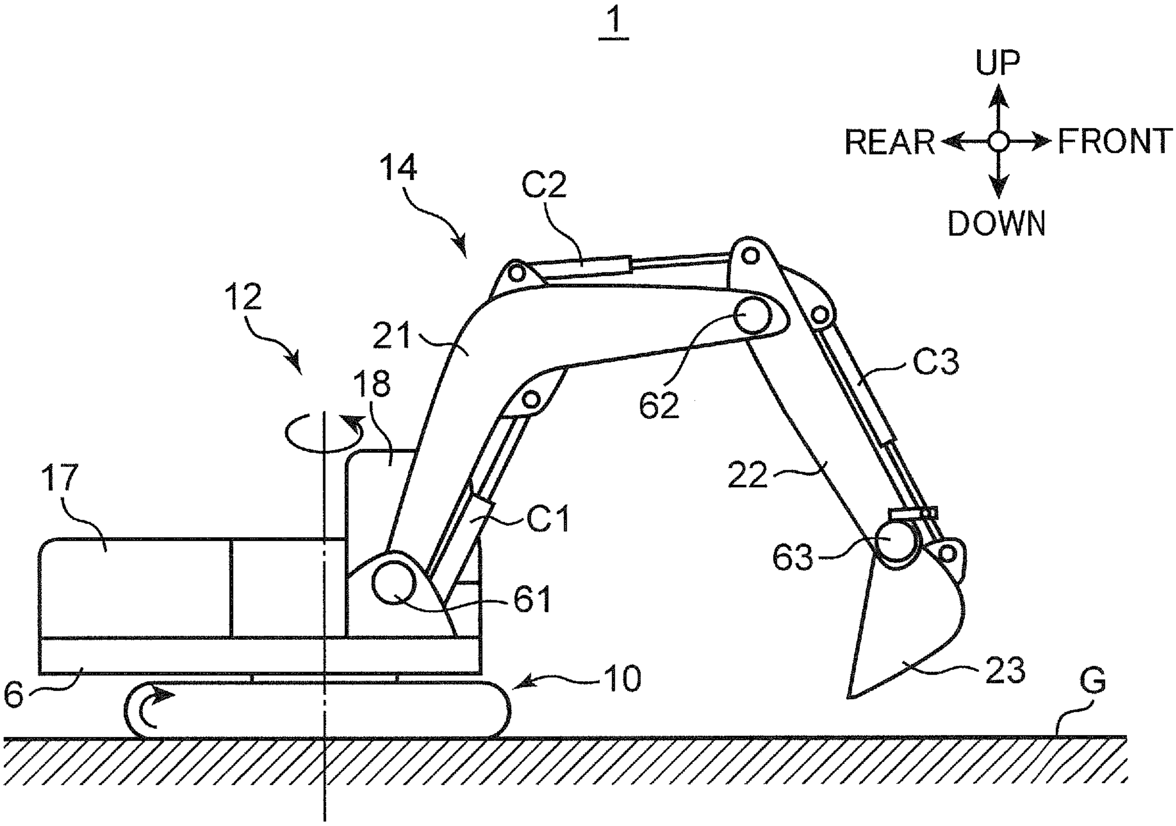


FIG. 2

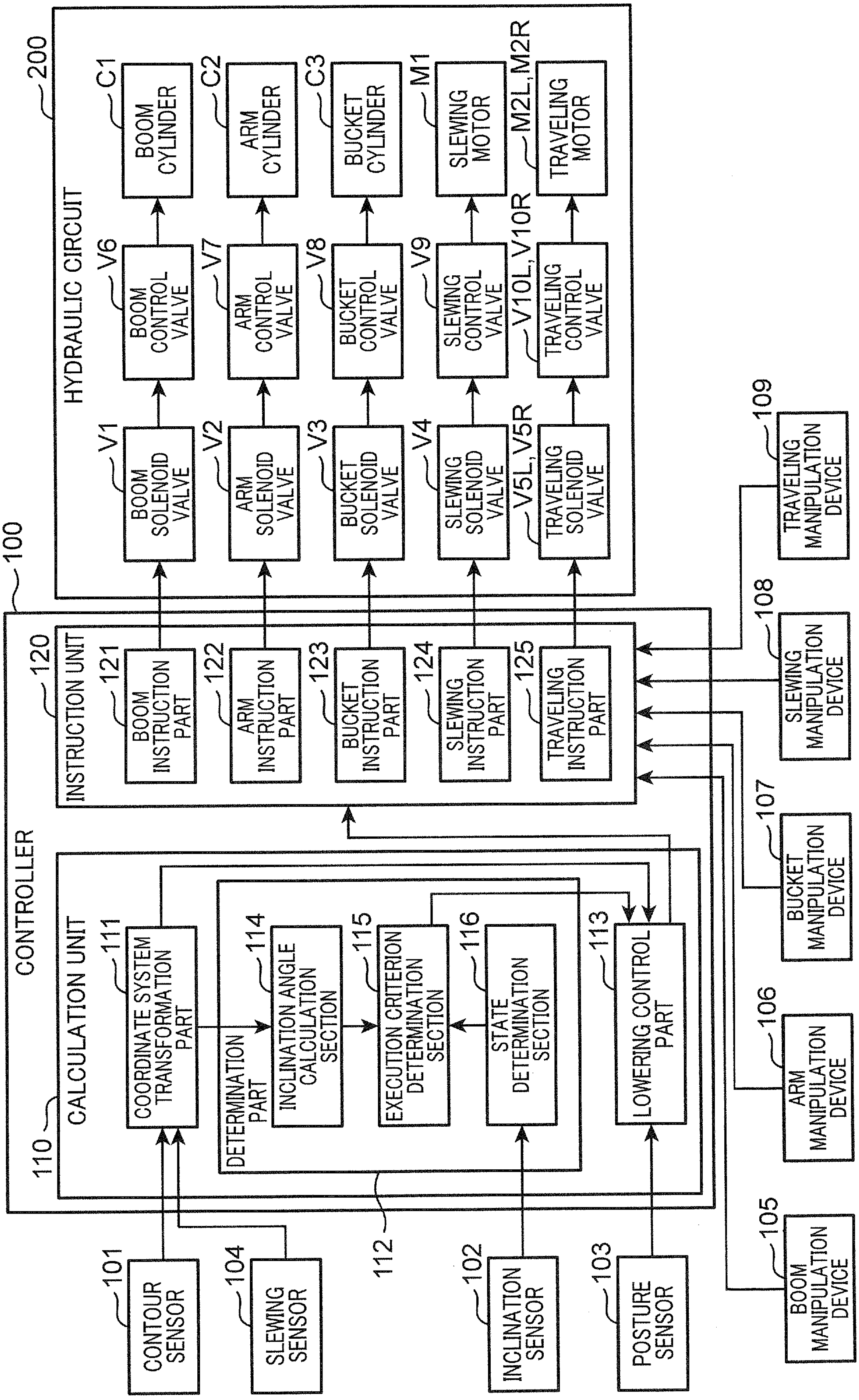

200
HYDRAULIC CIRCUIT
C1
BOOM CYLINDER
C2
ARM CYLINDER
C3
BUCKET CYLINDER
M1
SLEWING MOTOR
M2L, M2R
TRAVELING MOTOR
V6
BOOM CONTROL VALVE
V7
ARM CONTROL VALVE
V8
BUCKET CONTROL VALVE
V9
SLEWING CONTROL VALVE
V10L, V10R
TRAVELING CONTROL VALVE
V1
BOOM SOLENOID VALVE
V2
ARM SOLENOID VALVE
V3
BUCKET SOLENOID VALVE
V4
SLEWING SOLENOID VALVE
V5L, V5R
TRAVELING SOLENOID VALVE
100
CONTROLLER
120
INSTRUCTION UNIT
121
BOOM INSTRUCTION PART
122
ARM INSTRUCTION PART
123
BUCKET INSTRUCTION PART
124
SLEWING INSTRUCTION PART
125
TRAVELING INSTRUCTION PART
110
CALCULATION UNIT
111
COORDINATE SYSTEM TRANSFORMATION PART
112
DETERMINATION PART
114
INCLINATION ANGLE CALCULATION SECTION
115
EXECUTION CRITERION DETERMINATION SECTION
116
STATE DETERMINATION SECTION
113
LOWERING CONTROL PART
101
CONTOUR SENSOR
104
SLEWING SENSOR
102
INCLINATION SENSOR
103
POSTURE SENSOR
105
BOOM MANIPULATION DEVICE
106
ARM MANIPULATION DEVICE
107
BUCKET MANIPULATION DEVICE
108
SLEWING MANIPULATION DEVICE
109
TRAVELING MANIPULATION DEVICE

FIG. 3

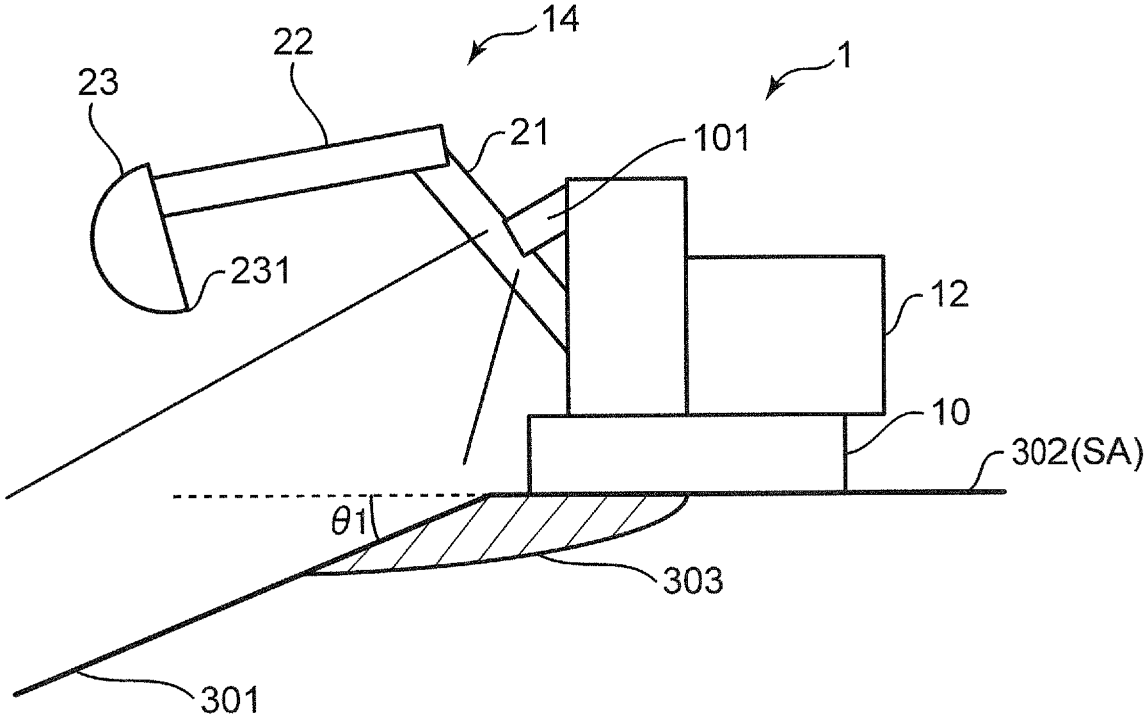


FIG. 4

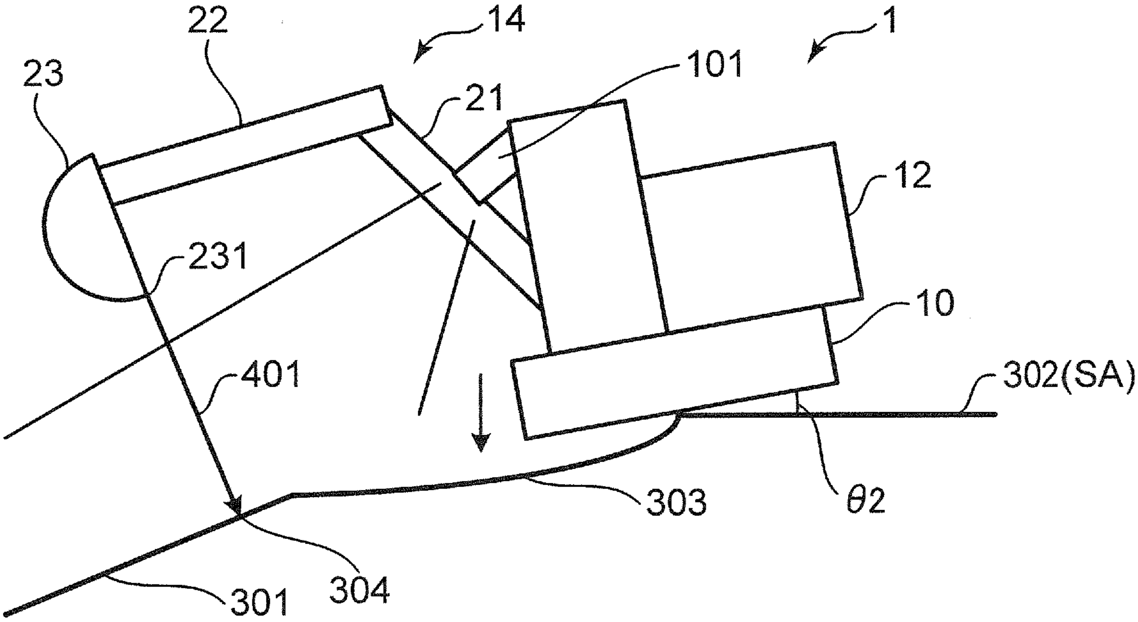


FIG. 5

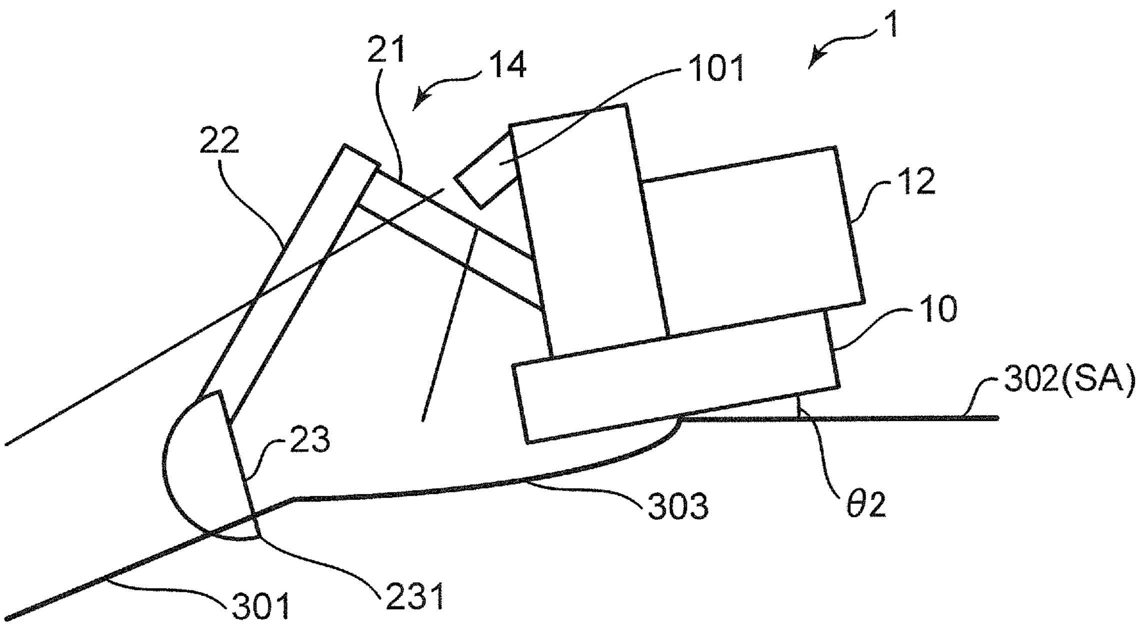
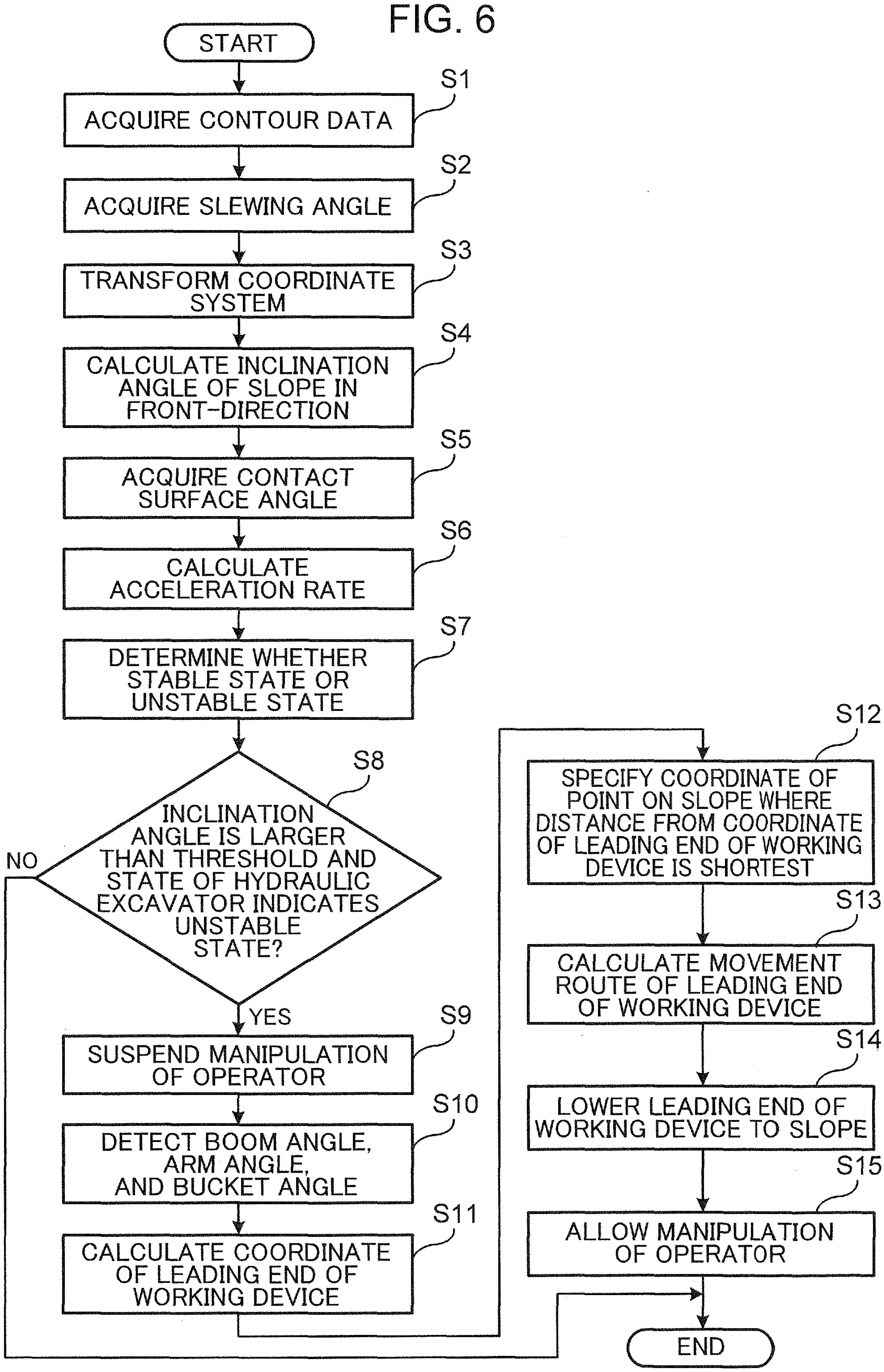


FIG. 6


START
S1
ACQUIRE CONTOUR DATA
S2
ACQUIRE SLEWING ANGLE
S3
TRANSFORM COORDINATE SYSTEM
S4
CALCULATE INCLINATION ANGLE OF SLOPE IN FRONT-DIRECTION
S5
ACQUIRE CONTACT SURFACE ANGLE
S6
CALCULATE ACCELERATION RATE
S7
DETERMINE WHETHER STABLE STATE OR UNSTABLE STATE
S8
INCLINATION ANGLE IS LARGER THAN THRESHOLD AND STATE OF HYDRAULIC EXCAVATOR INDICATES UNSTABLE STATE?
NO
YES
S9
SUSPEND MANIPULATION OF OPERATOR
S10
DETECT BOOM ANGLE, ARM ANGLE, AND BUCKET ANGLE
S11
CALCULATE COORDINATE OF LEADING END OF WORKING DEVICE
S12
SPECIFY COORDINATE OF POINT ON SLOPE WHERE DISTANCE FROM COORDINATE OF LEADING END OF WORKING DEVICE IS SHORTEST
S13
CALCULATE MOVEMENT ROUTE OF LEADING END OF WORKING DEVICE
S14
LOWER LEADING END OF WORKING DEVICE TO SLOPE
S15
ALLOW MANIPULATION OF OPERATOR
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/001805

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. E02F3/43(2006.01)i, E02F9/24(2006.01)i
FI: E02F9/24 B, E02F3/43 A

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. E02F3/43, E02F9/20-9/26

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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 2005-104625 A (KOMATSU LTD.) 21 April 2005, claims, paragraphs [0029]-[0034], [0048], fig. 1-4	1-9
A	JP 2003-90729 A (MITSUBISHI ELECTRIC CORP.) 28 March 2003, claims, paragraph [0017]	1-9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"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
05.03.2020	17.03.2020

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

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/001805

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2005-104625 A	21.04.2005	(Family: none)	
JP 2003-90729 A	28.03.2003	(Family: none)	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H8269998 A **[0008]**