



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
10.11.2021 Bulletin 2021/45

(51) Int Cl.:
E02F 9/24 ^(2006.01) **E02F 9/26** ^(2006.01)

(21) Application number: **20755521.0**

(86) International application number:
PCT/JP2020/000570

(22) Date of filing: **10.01.2020**

(87) International publication number:
WO 2020/166241 (20.08.2020 Gazette 2020/34)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(72) Inventors:
• **DOI, Takayuki**
Hiroshima-shi, Hiroshima 731-5161 (JP)
• **YAMAZAKI, Yoichiro**
Hiroshima-shi, Hiroshima 731-5161 (JP)

(74) Representative: **TBK**
Bavariaring 4-6
80336 München (DE)

(30) Priority: **14.02.2019 JP 2019024436**

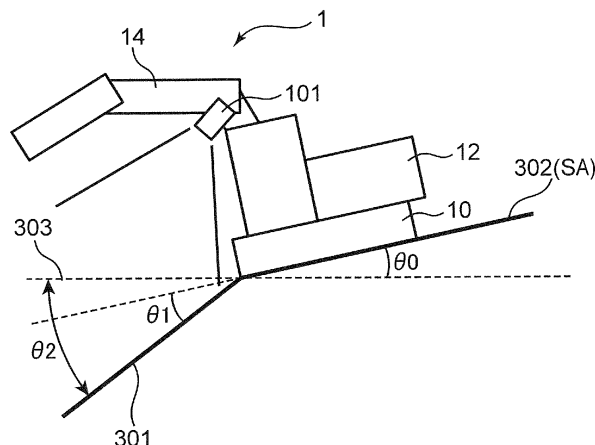
(71) Applicant: **KOBELCO CONSTRUCTION MACHINERY CO., LTD.**
Hiroshima-shi
Hiroshima 731-5161 (JP)

(54) **MONITORING DEVICE AND CONSTRUCTION MACHINE**

(57) A monitoring system calculates, based on a contour data, a first slope angle representing an inclination angle of a slope to a ground surface on which a construction machine stands, detects a ground surface angle representing an inclination angle of the ground surface to a horizontal plane, calculates a second slope angle representing an inclination angle of the slope to the horizontal

plane by adding the first slope angle to the ground surface angle, calculates a relative angle of a longitudinal direction of a lower traveling body to an inclination direction of the slope, and determines that the construction machine is in an unstable state when the second slope angle is larger than a first threshold and the relative angle is larger than a second threshold.

FIG. 3



Description

Technical Field

[0001] The present invention relates to a monitoring system and a construction machine for monitoring a state of the construction machine.

Background Art

[0002] In recent years, construction machines, such as hydraulic excavators, have been known for detecting a contour of a ground around such a construction machine, determining a stability of the construction machine based on the detected contour, and preventing the construction machine from being turned over in advance.

[0003] For instance, Patent Literature 1 discloses an excavator for estimating a posture of the excavator at a predetermined future time, based on: information concerning a current position and orientation of the excavator; a current posture of an excavating attachment; information concerning a current contour of a working target ground; and manipulation contents of an operator, and calculating a stability of the excavator.

[0004] A slope is unstable. Hence, the slope may decay due to an operation of a construction machine, e.g., traveling turn, during a work of the construction machine on a land surface joined to the slope, and accordingly the construction machine may be turned over. Particularly, a land surface joined to a steep slope and inclined thereto is more likely to decay. This results in increasing the possibility that the construction machine is turned over. Therefore, it is necessary to monitor a stability of the construction machine and prevent the construction machine from being turned over in advance during the work of the construction machine on the land surface.

[0005] Patent Literature 1 fails to predict such a work of the construction machine on the inclined land surface joined to the slope, much less give consideration to the drawbacks.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Publication No. 2016-172963

Summary of Invention

[0007] The present invention has been achieved to solve the drawbacks, and has an object of providing a monitoring system and a construction machine each capable of accurately determining whether a construction machine working on an inclined land surface joined to a slope is in an unstable state.

[0008] The present inventors have obtained the knowledge described below as a result of their studies con-

cerning a stability of a construction machine working on or around a slope. A construction machine working on an inclined land surface joined to a slope becomes more unstable as an angle between an inclination direction of the slope and a longitudinal direction of a lower traveling body approaches 90°. This is because an overload is applied to the ground around a fulcrum edge of a crawler composing the lower traveling body, resulting in increasing the possibility that the slope decays.

[0009] Even when the slope has a relatively gentle inclination angle to the inclined land surface, an inclination angle of the land surface to a horizontal plane may be steep. In this case, the inclination angle of the slope to the horizontal plane is steep as well. Accordingly, the slope is highly likely to decay.

[0010] For the construction machine working on the land surface joined to the slope, a contour sensor attached to the construction machine detects a contour data measured not on the basis of the horizontal plane but on the basis of a ground surface on which the construction machine stands. Hence, the inclination angle of the slope represented by the contour data detected by the contour sensor is shown as a gentle inclination angle. This leads to an inaccurate determination concerning an unstable state of the construction machine. The present inventors have focused on the obtained knowledge and conceived of the present invention.

[0011] A monitoring system according to one aspect of the present invention monitors a state of a construction machine includes: a lower traveling body which has a longitudinal direction and travels in the longitudinal direction; an upper slewing body configured to be slewable with respect to the lower traveling body; and a working device mounted on the upper slewing body. The monitoring system includes: an acquisition part which acquires contour data representing a contour of a landform around the construction machine; a first slope angle calculation part which calculates, based on the contour data, a first slope angle representing an inclination angle of the slope to a ground surface on which the construction machine stands; an inclination sensor which detects a ground surface angle representing an inclination angle of the ground surface to a horizontal plane; a second slope angle calculation part which calculates a second slope angle representing an inclination angle of the slope to the horizontal plane by adding the first slope angle to the ground surface angle; a relative angle calculation part which calculates a relative angle of the longitudinal direction of the lower traveling body to an inclination direction of the slope; and a state determination part which determines that the construction machine is in an unstable state when the second slope angle is larger than a first threshold and the relative angle is larger than a second threshold, and outputs a determination signal indicating a determination result.

Brief Description of Drawings

[0012]

Fig. 1 shows an exemplary hydraulic excavator serving as a construction machine on which a monitoring system according to an embodiment of the present invention is mounted.

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

Fig. 3 shows an exemplary case where a determination is made as to whether the hydraulic excavator is in an unstable state in the embodiment.

Fig. 4 shows another exemplary case where a determination is made as to whether the hydraulic excavator is in an unstable state in the embodiment.

Fig. 5 is a view of the hydraulic excavator located on a land surface and seen downward from above.

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

Description of Embodiments

[0013] Hereinafter, preferable embodiments of the present invention will be described with reference to the accompanying drawings.

[0014] Fig. 1 shows an exemplary hydraulic excavator 1 serving as a construction machine on which a monitoring system according to an embodiment of the present invention 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 monitoring system is applied to the hydraulic excavator 1 is described, but the present invention should not be limited to the configuration. For instance, the monitoring system 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 has the longitudinal direction and travels in the longitudinal direction. 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. The working device 14 includes a boom 21, an arm 22, and a bucket 23. The boom 21 has a proximal end and a distal end opposite to the proximal end. The proximal end of the boom 21 is tiltably supported at a front end of the slewing frame 16. Specifically, the proximal end of the boom 21 is supported at the front end of the slewing frame 16 rotatably about a horizontal axis. The arm 22 has a proximal end and a distal end opposite to the proximal end. The proximal end of the arm 22 is supported at the distal end of the boom 21 rotatably about the horizontal axis. 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, respectively. The boom cylinder C1, the arm cylinder C2, and the bucket cylinder C3 are 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. The boom cylinder C1 extends and retracts to cause the boom 21 to tilt. The arm cylinder C2 is located between the boom 21 and the arm 22. The arm cylinder C2 extends and retracts to rotate the arm 22. The bucket cylinder C3 is located between the arm 22 and the bucket 23. The bucket cylinder C3 extends and retracts to rotate the bucket 23.

[0020] Fig. 2 is a block diagram of the hydraulic excavator 1 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, an alarming device 130, 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 for the boom 21.

[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 for the arm 22.

[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 for the bucket 23.

[0025] The slewing motor M1 has a motor output shaft bidirectionally rotatable in response to the supply of the hydraulic fluid from the hydraulic pump. The slewing motor M1 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. The traveling motor M2L and the traveling motor M2R cause 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 of the boom control valve V6 receives an input of a boom pilot pressure. The boom control valve V6 opens in a direction corresponding to the boom pilot port having received the input of the boom pilot pressure 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 of the arm control valve V7 receives an input of an arm pilot pressure. The arm control valve V7 opens in a direction corresponding to the arm pilot port having received the input of the arm

pilot pressure 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 of the bucket control valve V8 receives an input of a bucket pilot pressure. The bucket control valve V8 opens in a direction corresponding to the bucket pilot port having received the input of the bucket pilot pressure at a stroke corresponding to input the 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 of the slewing control valve V9 receives an input of a slewing pilot pressure. The slewing control valve V9 opens in a direction corresponding to the slewing pilot port having received the input of the slewing pilot pressure 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 of each of the traveling control valves V10L, V10R receives an input of a traveling pilot pressure. Each of the traveling control valves V10L, V10R opens in a direction corresponding to the traveling pilot port having received the input of the traveling pilot pressure 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. Each of the pair of boom solenoid valves V1 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. Each of the pair of arm solenoid valves V2 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 is located between the pilot pump and a corresponding one of the pair of arm pilot ports of the bucket control valve V8. Each of the pair of bucket solenoid valves V3 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. Each of the pair of slewing solenoid valves V4 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 VIOL. Each of the pair of traveling solenoid valves V5L 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 V10R. Each of the pair of traveling solenoid valves V5R 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 V5R 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 (an exemplary acquisition part) acquires contour data representing a distance distribution of a 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 a lower surface of the working device 14 as shown in Fig. 3. 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.

[0039] The inclination sensor 102 detects a ground surface angle representing an inclination angle of the ground surface with which the lower traveling body 10 is in contact to a 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, a ground surface angle by using a strapped-down method, or other method.

[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 rotational angle of the boom 21 with respect to the upper slewing body 12. The arm angle sensor 62 detects a rotational angle of the arm 22 with respect to the boom 21. The bucket angle sensor 63 detects 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.

[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.

[0042] The boom manipulation device 105 is composed of an electric lever device. The electric lever device includes 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 manipulation amount of the boom manipulation lever to the controller 100.

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

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

[0046] The traveling manipulation device 109 is com-

posed of an electric lever device. The electric lever device includes 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 manipulation amount of the traveling manipulation lever to the controller 100.

[0047] The controller 100 is composed of, for example, a microcomputer. The controller 100 includes a calculation unit 110 and an instruction unit 120. The calculation unit 110 determines whether the hydraulic excavator 1 is in the unstable state. The instruction unit 120 controls an operation of each of elements included in the hydraulic circuit.

[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. 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. Thus, an opening degree of the boom solenoid valve V1 is set to a value corresponding to the manipulation amount of the boom manipulation device 105.

[0049] 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. Thus, an opening degree of the arm solenoid valve V2 is set to a value corresponding to the manipulation amount of the arm manipulation device 106.

[0050] 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. Thus, an opening degree of the bucket solenoid valve V3 is set to a value corresponding to the manipulation amount of the bucket manipulation device 107.

[0051] 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. Thus, an opening degree of the slewing solenoid valve V4 is set to a value corresponding to the manipulation amount of the slewing manipulation device 108.

[0052] 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. Thus, an opening degree of each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R is set to a value corresponding to the manipulation amount of the traveling manipulation device 109.

[0053] The calculation unit 110 includes a first slope angle calculation part 111, a second slope angle calculation part 112, a state determination part 113, a relative

angle calculation part 114, and a restriction part 115. The first slope angle calculation part 111 calculates, based on the contour data detected by the contour sensor 101, a first slope angle.

[0054] Fig. 3 shows an exemplary case where a determination is made as to whether the hydraulic excavator 1 is in an unstable state in the embodiment. Hereinafter, the process executed by the first slope angle calculation part 111 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 includes a slope having 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 inclined to the slope 301 with respect to a horizontal plane 303. A first slope 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 is located on the land surface 302, and thus the ground surface SA serves as the land surface 302.

[0055] Fig. 5 is a view of the hydraulic excavator 1 located on the land surface 302 and seen downward from above. In Fig. 5, the reference sign "L0" denotes the longitudinal direction of the lower traveling body 10. The reference sign "L1" denotes an inclination direction of the slope 301. The reference sign "L2" denotes a longitudinal direction of the working device 14, that is, a longitudinal direction of the upper slewing body 12. The reference sign " α " denotes a relative angle of the longitudinal direction L0 of the lower traveling body 10 to the inclination direction L1 of the slope 301. The reference sign " β " denotes a slewing angle of the upper slewing body 12 to the longitudinal direction L0 of the lower traveling body 10. Here, the relative angle α is defined as being positive in a clockwise direction with respect to the inclination direction L1 of the slope 301. The slewing angle β is defined as being positive in a clockwise direction with respect to the longitudinal direction L0 of the lower traveling body 10.

[0056] First, the first slope angle calculation part 111 transforms the contour data detected by the contour sensor 101 to a coordinate system 500 of the hydraulic excavator 1. The coordinate system 500 is, for example, a three-dimensional rectangular coordinate system defined by an X-axis extending in the longitudinal direction L0 (front-rear direction), a Y-axis extending in the left-right direction, and a Z-axis extending in the up-down direction. The position of the contour sensor 101 attached to the working device 14 in the coordinate system 500 shifts in accordance with the posture and the slewing angle β of the working device 14.

[0057] The first slope angle calculation part 111 then calculates the position of the contour sensor 101 in the coordinate system 500 by using the detection signal from the posture sensor 103 and the slewing angle β detected by the slewing sensor 104. The first slope angle calculation part 111 specifies, from the calculated position of the contour sensor 101, a relative positional relation be-

tween a coordinate system of the contour sensor 101 and the coordinate system 500, and transforms, based on the specified relative positional relation, the contour data detected by the contour sensor 101 to contour data of the coordinate system 500.

[0058] Meanwhile, a configuration where the contour sensor 101 is arranged at the upper slewing body 12 requires the slewing angle β , but does not require the detection signal from the posture sensor 103 when transforming the contour data detected by the contour sensor 101 to the contour data of the coordinate system 500. 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 coordinate system 500. Thus, the detection signal from the posture sensor 103 and the slewing angle β are unnecessary for transforming the contour data to the contour data of the coordinate system 500.

[0059] Subsequently, the first slope angle calculation part 111 calculates the first slope angle θ_1 from the contour data transformed to the coordinate system 500. In this case, the first slope angle calculation part 111 detects, from the contour data, a boundary L3 of the ground surface SA with which the lower traveling body 10 is in contact, and extracts, as a slope candidate region, a region falling within a predetermined range opposite to the ground surface SA across the boundary L3. Next, the first slope angle calculation part 111 sets a direction perpendicularly intersecting the boundary L3 as the inclination direction L1 of the slope 301, extracts, from the slope candidate region, a data group on a line parallel to the inclination direction L1, and obtains a regression line of the extracted data group. The first slope angle calculation part 111 then calculates, as the first slope angle θ_1 , an angle of the regression line to an X-Y plane, that is, an angle to the ground surface SA. Here, the first slope angle calculation part 111 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.

[0060] Alternatively, the first slope angle calculation part 111 extracts, from the slope candidate region, data groups on a plurality of lines parallel to the inclination direction L1, obtains regression lines respectively for the lines, and calculates a plurality of angles to the ground surface SA for the regression lines respectively. The first slope angle calculation part 111 may 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 first slope angle calculation part 111 may calculate, as the first slope angle θ_1 , an average value of the angles of the regression lines to the ground surface SA.

[0061] Referring back to Fig. 2, the second slope angle calculation part 112 calculates a second slope angle θ_2

by adding the first slope angle θ_1 calculated by the first slope angle calculation part 111 to a ground surface angle θ_0 detected by the inclination sensor 102. Referring to Fig. 3, the second slope angle θ_2 represents an inclination angle of the slope 301 to the horizontal plane 303. The ground surface angle θ_0 represents an inclination angle of the ground surface SA (land surface 302) to the horizontal plane 303. The first slope angle θ_1 represents a slope angle to the ground surface SA. Therefore, the second slope angle θ_2 representing the inclination angle of the slope 301 to the horizontal plane 303 can be calculated by adding the first slope angle θ_1 to the ground surface angle θ_0 .

[0062] The relative angle calculation part 114 calculates, based on the contour data detected by the contour sensor 101, a relative angle α of the longitudinal direction L0 of the lower traveling body 10 to the inclination direction L1 of the slope 301 with reference to Fig. 5. Here, the relative angle calculation part 114 transforms the contour data to contour data of the coordinate system 500 of the hydraulic excavator 1, and calculates, based on the transformed contour data, the inclination direction L1 of the slope 301 in the same manner as the first slope angle calculation part 111. Further, the relative angle calculation part 114 may calculate the relative angle α by calculating an angle between an inclination direction L1' obtained by projecting the inclination direction L1 of the slope 301 onto the X-Y plane and the longitudinal direction L0 of the lower traveling body 10. Alternatively, the relative angle calculation part 114 may calculate the relative angle α by using the contour data transformed by the first slope angle calculation part 111.

[0063] The state determination part 113 determines whether the second slope angle θ_2 is larger than a first threshold and whether the relative angle α calculated by the relative angle calculation part 114 is larger than a second threshold. The state determination part 113 further determines that the hydraulic excavator 1 is in the unstable state when the second slope angle θ_2 is larger than the first threshold and the relative angle α is larger than the second threshold. Conversely, the state determination part 113 determines that the hydraulic excavator 1 is in a stable state when the second slope angle θ_2 is equal to or smaller than the first threshold, or the relative angle α is equal to or smaller than the second threshold, and outputs a determination signal indicating a determination result.

[0064] Referring to Fig. 5, the lower traveling body 10 has the dimension long in the front-rear direction, and thus the hydraulic excavator 1 becomes more unstable as the relative angle α approaches 90° . In this respect, an angle of 80° , 75° , 60° , or other angle each smaller than 90° is, for example, adoptable as the second threshold. Moreover, the hydraulic excavator 1 becomes more unstable as the second slope angle θ_2 approaches 90° . In this respect, an angle of 80° , 75° , 60° , or other angle each smaller than 90° is, for example, adoptable as the first threshold.

[0065] Fig. 4 shows another exemplary case where a determination is made as to whether the hydraulic excavator 1 is in an unstable state in the embodiment. In Fig. 3, the lower traveling body 10 has a relative angle α of 0° and the upper slewing body 12 has a slewing angle β of 0° . In contrast, in Fig. 4, the lower traveling body 10 has a relative angle α of 90° and the upper slewing body has a slewing angle β of 90° . Here, a counterclockwise moment of causing the hydraulic excavator 1 to be turned over is larger in the case shown in Fig. 4 than in the case shown in Fig. 3. From these perspectives, the hydraulic excavator 1 is more highly likely to be turned over as the slewing angle of the longitudinal direction L2 of the upper slewing body 12 to the inclination direction L1 of the slope 301 approaches 0° .

[0066] In the embodiment, referring to Fig. 5, the state determination part 113 calculates, based on the slewing angle β (an exemplary first slewing angle) and the relative angle α , a slewing angle γ (an exemplary second slewing angle) of the longitudinal direction L2 of the upper slewing body 12 to the inclination direction L1 of the slope 301. The state determination part 113 sets at least one of the first threshold and the second threshold to a smaller value. This is because the hydraulic excavator 1 is more highly likely to be turned over as the slewing angle γ approaches 0° .

[0067] Moreover, the moment of causing the hydraulic excavator 1 to be turned over increases as the position of a leading end of the working device 14 shifts farther away from the upper slewing body 12.

[0068] Hence, the state determination part 113 may set at least one of the first threshold and the second threshold to a smaller value as the position of the leading end of the working device 14 shifts farther away from the upper slewing body 12.

[0069] Besides, the hydraulic excavator 1 becomes more unstable as the second slope angle θ_2 approaches 90° , and becomes much more unstable as the relative angle α increases. Thus, while one of the first threshold and the second threshold is set to a relatively larger value, the other may be set to a relatively smaller value.

[0070] Referring to Fig. 3, the slope 301 is less likely to decay as long as a distance from the hydraulic excavator 1 to the slope 301 is equal to or longer than a predetermined. Here, the state determination part 113 may calculate, based on the contour data, the distance from the hydraulic excavator 1 to the slope 301, and determine whether the hydraulic excavator is in the unstable state only when the distance is equal to or shorter than the predetermined distance.

[0071] The restriction part 115 restricts a traveling operation of the lower traveling body 10 when the state determination part 113 outputs a determination signal indicating the unstable state of the hydraulic excavator 1. In this case, the restriction part 115 suspends the lower traveling body 10 from traveling in a direction of increasing a degree of the unstable state and permits the lower traveling body 10 to travel in a direction of decreasing a

degree of the unstable state.

[0072] Referring to Fig. 3, the boundary between the slope 301 and the land surface 302 and therearound is likely to decay. Hence, the slope 301 becomes highly likely to decay as a load around the boundary increases. In this regard, in the case shown in Fig. 3, an overload is applied to the ground around the fulcrum edge of the crawler of the lower traveling body 10 when the lower traveling body 10 travels forward, turns rightward while traveling forward, or turns leftward while traveling forward. As a result, the slope is highly likely to decay, and the degree of the unstable state increases. In contrast, in the case shown in Fig. 3, the load around the boundary reduces when the lower traveling body 10 travels rearward, turns rightward while traveling rearward, or turns leftward while traveling rearward. Thus, the degree of the unstable state on the slope 301 decreases.

[0073] In the case shown in Fig. 4, the load around the boundary increases when the lower traveling body 10 turns leftward or rightward while traveling forward, and turns leftward or rightward while traveling rearward. Thus, the degree of the unstable state increases. In contrast, in the case shown in Fig. 4, the load around the boundary does not increase even when the lower traveling body travels forward or rearward. Thus, the degree of the unstable state does not increase.

[0074] In each of the cases, the degree of the unstable state is estimated to increase when the lower traveling body 10 travels closer to the slope 301.

[0075] Under the circumstances, the restriction part 115 specifies a direction in which the lower traveling body 10 travels closer to the slope 301 as a direction of increasing the degree of the unstable state, and suspends the operation of the lower traveling body 10 when the traveling manipulation device 109 receives an input of a manipulation for moving the lower traveling body 10 in the direction. In contrast, the restriction part 115 may decelerate the operation of the lower traveling body 10 when the traveling manipulation device 109 receives an input of a manipulation for moving the lower traveling body 10 in the direction of decreasing the degree of the unstable state. Furthermore, the restriction part 115 may decelerate the operation of the lower traveling body 10 when the traveling manipulation device 109 receives an input of a manipulation for allowing the lower traveling body 10 to travel in a direction of unchanging the degree of the unstable state. Here, the restriction part 115 sufficiently determines whether to suspend the operation of the lower traveling body 10 by using a table storing in advance a manipulation corresponding to the relative angle α at which the lower traveling body 10 travels in the direction of increasing the degree of the unstable state.

[0076] The restriction part 115 suspends or restricts the operation of the lower traveling body 10, for example, in the manner described below. The restriction part 115 inputs a suspension request to the traveling instruction part 125 when the traveling manipulation device 109 receives an input of a manipulation leading to an increase

in the degree of the unstable state. The traveling instruction part 125 thus inputs, to the traveling instruction part 125, a traveling instruction of closing each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R regardless of a manipulation amount of the traveling manipulation device 109. The traveling operation is consequently suspended. In contrast, the restriction part 115 inputs a deceleration request to the traveling instruction part 125 when the traveling manipulation device 109 receives an input of not increasing the degree of the unstable state. The traveling instruction part 125 attenuates the traveling instruction having a value corresponding to the manipulation amount of the traveling manipulation device 109 at a predetermined attenuation ratio, and inputs the attenuated instruction to each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R. This decreases an opening degree of each of the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R in comparison with an opening degree corresponding to the manipulation amount, and accordingly decelerates the traveling operation.

[0077] The alarming device 130 includes at least one of a speaker for outputting a buzzer sound, an alarming lamp for outputting an alarm by emitting light, and a displayer for displaying an alarming message, each provided in the cab 18. When the state determination part 113 outputs a determination signal indicating an unstable state of the hydraulic excavator 1, the alarming device 130 further notifies the operator of the unstable state of the hydraulic excavator 1 by executing at least one of the ways of: outputting a buzzer sound from the speaker; turning on the alarming lamp; and causing the displayer to display the alarming message.

[0078] Fig. 6 is a flowchart showing an operation of the hydraulic excavator 1 shown in Fig. 2. The flow is repeated at a predetermined cycle during a drive of the hydraulic excavator 1. First, the inclination sensor 102 detects a ground surface angle θ_0 representing an inclination angle of the ground surface SA to the horizontal plane 303 (step S1). Next, the contour sensor 101 acquires contour data representing a distance distribution of a landform around the hydraulic excavator 1 (step S2). Then, the first slope angle calculation part 111 transforms the acquired contour data from the coordinate system of the contour sensor 101 to the coordinate system 500 of the hydraulic excavator 1 (step S3).

[0079] Subsequently, the first slope angle calculation part 111 determines whether a distance from the lower traveling body 10 to the slope 301, that is, a distance from the lower traveling body 10 to the boundary L3 is equal to or shorter than a predetermined distance (step S4). When the distance from the lower traveling body 10 to the slope 301 is equal to or shorter than the predetermined distance ("YES" in step S4), the first slope angle calculation part 111 calculates a first slope angle θ_1 (step 5). Conversely, when the distance from the lower traveling body 10 to the slope 301 is longer than the pre-

determined distance ("NO" in step S4), the flow finishes there.

[0080] Next, the second slope angle calculation part 112 calculates a second slope angle θ_2 by adding the first slope angle θ_1 calculated in step S6 to the ground surface angle θ_0 detected in step S1 (step S6). The relative angle calculation part 114 then calculates a relative angle α of the longitudinal direction L0 of the lower traveling body 10 to the inclination direction L1 of the slope 301 (step S7).

[0081] Subsequently, the state determination part 113 determines whether the second slope angle θ_2 is larger than a first threshold and the relative angle α is larger than a second threshold (step S8). When the second slope angle θ_2 is larger than the first threshold and the relative angle α is larger than the second threshold ("YES" in step S8), the state determination part 113 determines that the hydraulic excavator 1 is in an unstable state (step S9). Conversely, when second slope angle θ_2 is equal to or smaller than the first threshold, or the relative angle α is equal to or smaller than the second threshold ("NO" in step S8), the state determination part 113 determines that the hydraulic excavator 1 is in the stable state, and accordingly, the flow finishes there. The restriction part 115 restricts a traveling operation of the lower traveling body 10 in step S10. In this case, the restriction part 115 sufficiently suspends the lower traveling body 10 from traveling in a direction of increasing a degree of the unstable state, and decelerating an operation of the lower traveling body 10 in any other remaining direction.

[0082] Subsequently, the alarming device 130 outputs an alarm to notify the operator of the unstable state of the hydraulic excavator 1 (step S11).

[0083] As described above, the embodiment includes calculating the second slope angle θ_2 representing the inclination angle of the slope 301 not to the ground surface SA but to the horizontal plane 303, and calculating the relative angle α of the lower traveling body 10 to the inclination direction of the slope 301. The embodiment further includes evaluating a state of the hydraulic excavator 1 based on the second slope angle θ_2 and the relative angle α . According to the embodiment, it is consequently possible to accurately determine whether the hydraulic excavator 1 working on the inclined land surface 302 is in the unstable state, and prevent the hydraulic excavator 1 from being turned over in advance.

Modifications

[0084] (1) In the embodiment, the slope 301 is detected by using the contour data detected by the contour sensor 101, but the present invention should not be limited thereto. The hydraulic excavator 1 may detect the slope 301 by acquiring the contour data measured in advance from a memory, or acquiring the contour data from an external server via a communication therewith. In this case, the first slope angle calculation part 111 may acquire a cur-

rent 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.

[0085] (2) In the embodiment, the electric lever device is adopted for 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, but the present invention should not be limited thereto. A hydraulic lever device for outputting a pilot pressure corresponding to a manipulation amount may be adopted instead. Hereinafter, the traveling control valves VIOL and the traveling control valves V10R are collectively called a "traveling control valve", and the pair of traveling solenoid valves V5L and the pair of traveling solenoid valves V5R are collectively called a "traveling solenoid valve".

[0086] In this case, the traveling control valve has a pilot port provided with a solenoid switch valve. The solenoid switch valve inputs a pilot pressure from the hydraulic lever device to the pilot port of the traveling control valve during a normal operation. In contrast, the solenoid switch valve blocks an input of the pilot pressure to the pilot port in response to an input of a suspension signal from the restriction part 115. The traveling operation of the lower traveling body 10 is consequently suspended.

[0087] The solenoid switch valve further inputs a pilot pressure from the traveling solenoid valve to the pilot port in response to an input of a restriction signal from the restriction part 115. At this time, the pilot pressure corresponding to a manipulation amount output from the hydraulic lever device is depressurized by the solenoid switch valve and input to the pilot port. The traveling operation of the lower traveling body 10 is consequently restricted.

Summary of embodiments

[0088] The technical features of the embodiments will be summarized below.

[0089] A monitoring system according to one aspect of the present invention monitors a state of a construction machine includes: a lower traveling body which has a longitudinal direction and travels in the longitudinal direction; an upper slewing body configured to be slewable with respect to the lower traveling body; and a working device mounted on the upper slewing body. The monitoring system includes: an acquisition part which acquires contour data representing a contour of a landform around the construction machine; a first slope angle calculation part which calculates, based on the contour data, a first slope angle representing an inclination angle of the slope to a ground surface on which the construction machine stands; an inclination sensor which detects a ground surface angle representing an inclination angle of the ground surface to a horizontal plane; a second slope angle calculation part which calculates a second

slope angle representing an inclination angle of the slope to the horizontal plane by adding the first slope angle to the ground surface angle; a relative angle calculation part which calculates a relative angle of the longitudinal direction of the lower traveling body to an inclination direction of the slope; and a state determination part which determines that the construction machine is in an unstable state when the second slope angle is larger than a first threshold and the relative angle is larger than a second threshold, and outputs a determination signal indicating a determination result.

[0090] In the configuration, the contour data representing the contour of the landform around the construction machine is acquired. The first slope angle representing the inclination angle of the slope to the ground surface on which the construction machine stands is calculated based on the contour data. The second slope angle representing the inclination angle of the slope to the horizontal plane is calculated by adding the first slope angle to the ground surface angle representing the inclination angle of the construction machine to the horizontal plane. The construction machine is determined to be in the unstable state when the second slope angle is larger than the first threshold and the relative angle of the longitudinal direction of the lower traveling body to the inclination direction of the slope is larger than the second threshold.

[0091] As described above, this configuration includes calculating the second slope angle representing the inclination angle of the slope not to the ground surface but to the horizontal plane, and calculating the relative angle of the lower traveling body to the inclination direction of the slope. The configuration further includes determining, based on the second slope angle and the relative angle, whether the construction machine is in the unstable state. Consequently, the configuration can accurately determine whether the construction machine working on the inclined land surface joined to the slope is in the unstable state.

[0092] In the aspect, it is preferable to further include an alarming device which outputs an alarm when the determination signal output from the state determination part indicates the unstable state.

[0093] This configuration can prevent the construction machine from being turned over in advance by outputting the alarm when the unstable state is determined.

[0094] In the aspect, it is preferable to further include a restriction part which restricts a traveling operation of the lower traveling body when the determination signal output from the state determination part indicates the unstable state.

[0095] This configuration can prevent the construction machine from being turned over in advance by restricting the traveling of the lower traveling body when the unstable state is determined.

[0096] In this aspect, it is preferable to further include a slewing sensor which detects a first slewing angle representing a slewing angle of the upper slewing body to the lower traveling body. The state determination part

preferably calculates, based on the relative angle and the first slewing angle, a second slewing angle representing a slewing angle of the longitudinal direction of the upper slewing body to the inclination direction of the slope, and reduces at least one of the first threshold and the second threshold as the second slewing angle decreases.

[0097] A moment of causing the construction machine to be turned over to the slope increases as the second slewing angle representing the slewing angle of the longitudinal direction of the upper slewing body to the inclination direction of the slope decreases. This configuration can accurately determine whether the construction machine is in the unstable state in consideration of the second slewing angle since at least one of the first threshold and the second threshold is reduced as the second slewing angle decreases.

[0098] In the configuration, the restriction part preferably suspends the lower traveling body from traveling in a direction of increasing a degree of the unstable state and permits the lower traveling body to travel in a direction of decreasing a degree of the unstable state when the state determination part determines the unstable state.

[0099] This configuration can suspend the lower traveling body from traveling in the direction of increasing the non-stability and permitting the lower traveling body to travel in the direction of decreasing the non-stability when the state determination part determines the unstable state. This consequently makes it possible to prevent the construction machine from being turned over in advance and permit the construction machine to evacuate the place where it is and travel to a higher and stabler place.

Claims

1. A monitoring system for monitoring a state of a construction machine including: a lower traveling body which has a longitudinal direction and travels in the longitudinal direction; an upper slewing body configured to be slewable with respect to the lower traveling body; and a working device mounted on the upper slewing body, the monitoring system comprising:

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

a first slope angle calculation part which calculates, based on the contour data, a first slope angle representing an inclination angle of the slope to a ground surface on which the construction machine stands;

an inclination sensor which detects a ground surface angle representing an inclination angle of the ground surface to a horizontal plane;

a second slope angle calculation part which cal-

culates a second slope angle representing an inclination angle of the slope to the horizontal plane by adding the first slope angle to the ground surface angle;

- a relative angle calculation part which calculates a relative angle of the longitudinal direction of the lower traveling body to an inclination direction of the slope; and
- a state determination part which determines that the construction machine is in an unstable state when the second slope angle is larger than a first threshold and the relative angle is larger than a second threshold, and outputs a determination signal indicating a determination result.

2. The monitoring system according to claim 1, further comprising an alarming device which outputs an alarm when the determination signal output from the state determination part indicates the unstable state.

3. The monitoring system according to claim 1 or 2, further comprising a restriction part which restricts a traveling operation of the lower traveling body when the determination signal output from the state determination part indicates the unstable state.

4. The monitoring system according to any one of claims 1 to 3, further comprising:

a slewing sensor which detects a first slewing angle representing a slewing angle of the upper slewing body to the lower traveling body, wherein

the state determination part calculates, based on the relative angle and the first slewing angle, a second slewing angle representing a slewing angle of the longitudinal direction of the upper slewing body to the inclination direction of the slope, and reduces at least one of the first threshold and the second threshold as the second slewing angle decreases.

5. The monitoring system according to claim 3, wherein the restriction part suspends the lower traveling body from traveling in a direction of increasing a degree of the unstable state and permits the lower traveling body to travel in a direction of decreasing a degree of the unstable state when the state determination part determines the unstable state.

6. A construction machine comprising:

the monitoring system according to any one of claims 1 to 5;

- a lower traveling body;
- an upper slewing body configured to be slewable with respect to the lower traveling body; and
- a working device mounted on the upper slewing body.

FIG. 1

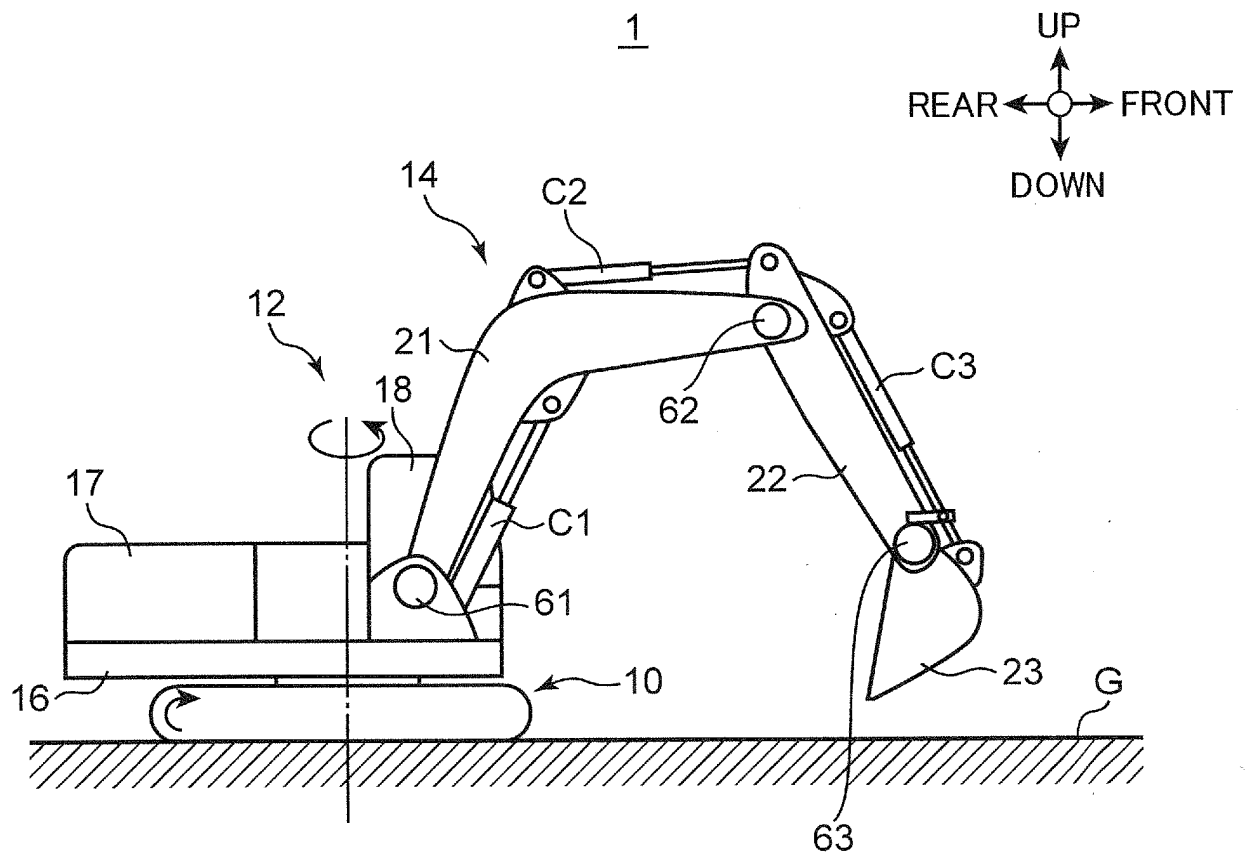


FIG. 2

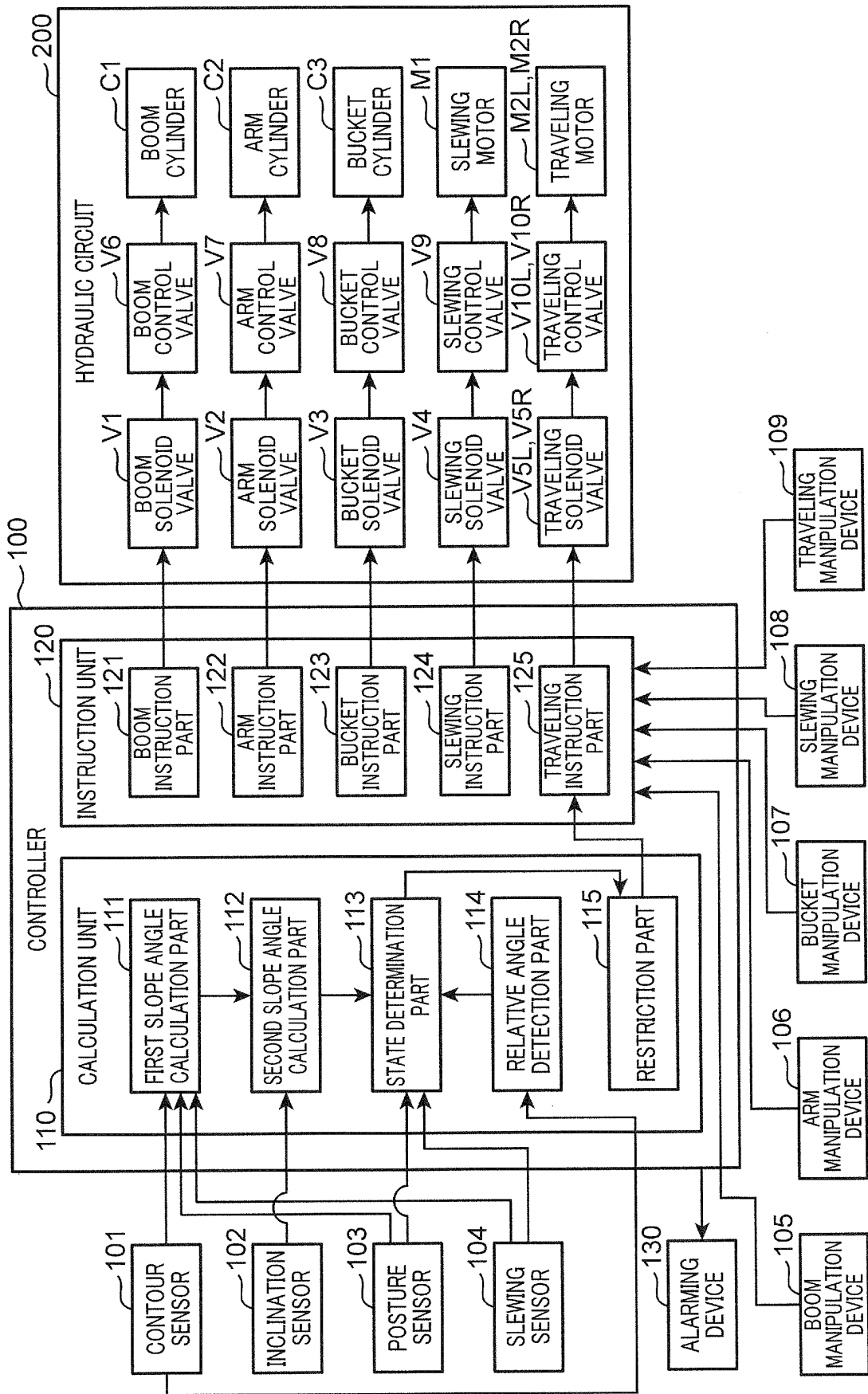


FIG. 3

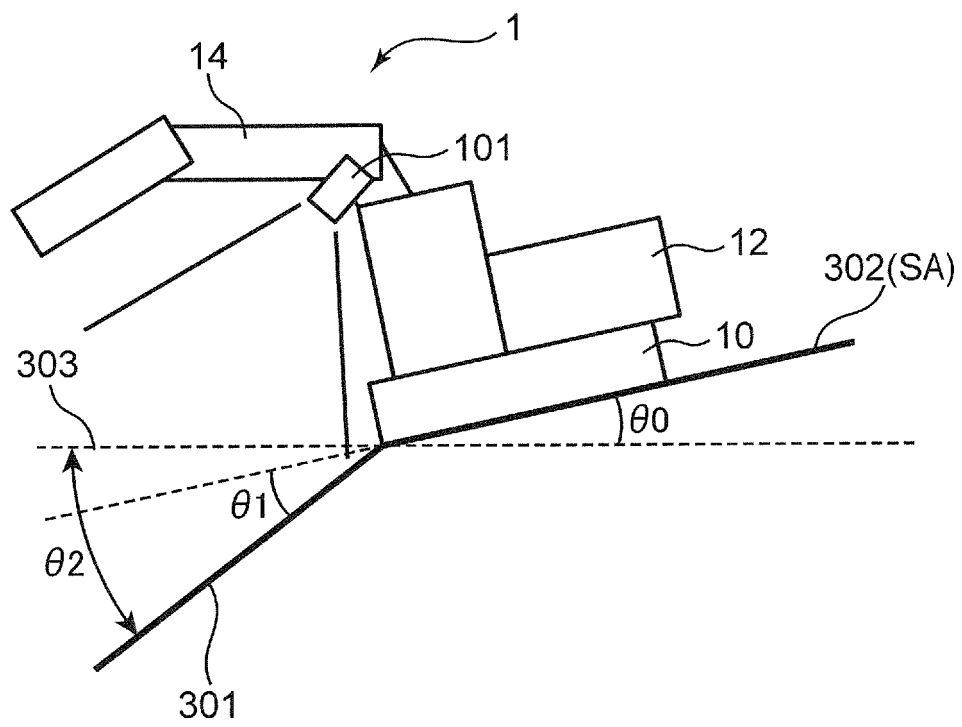


FIG. 4

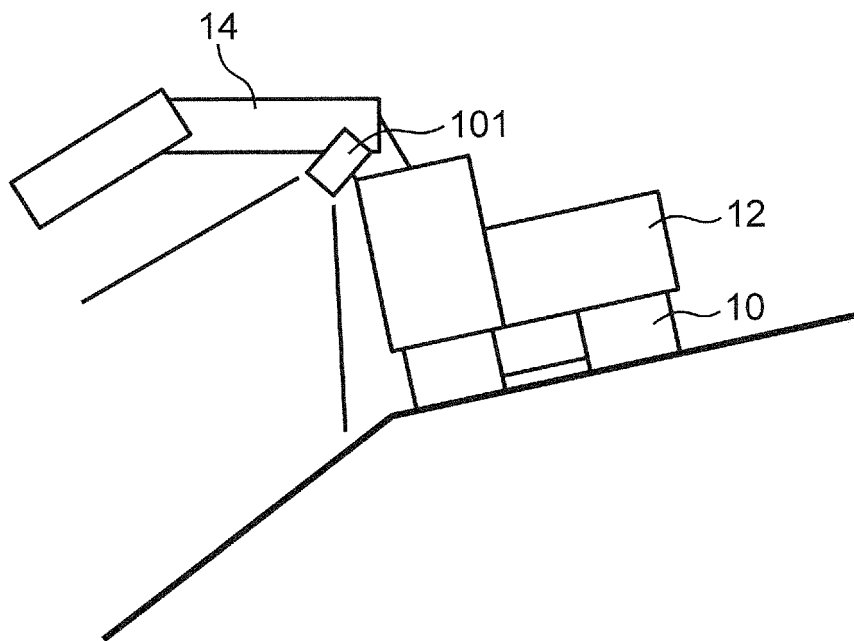


FIG. 5

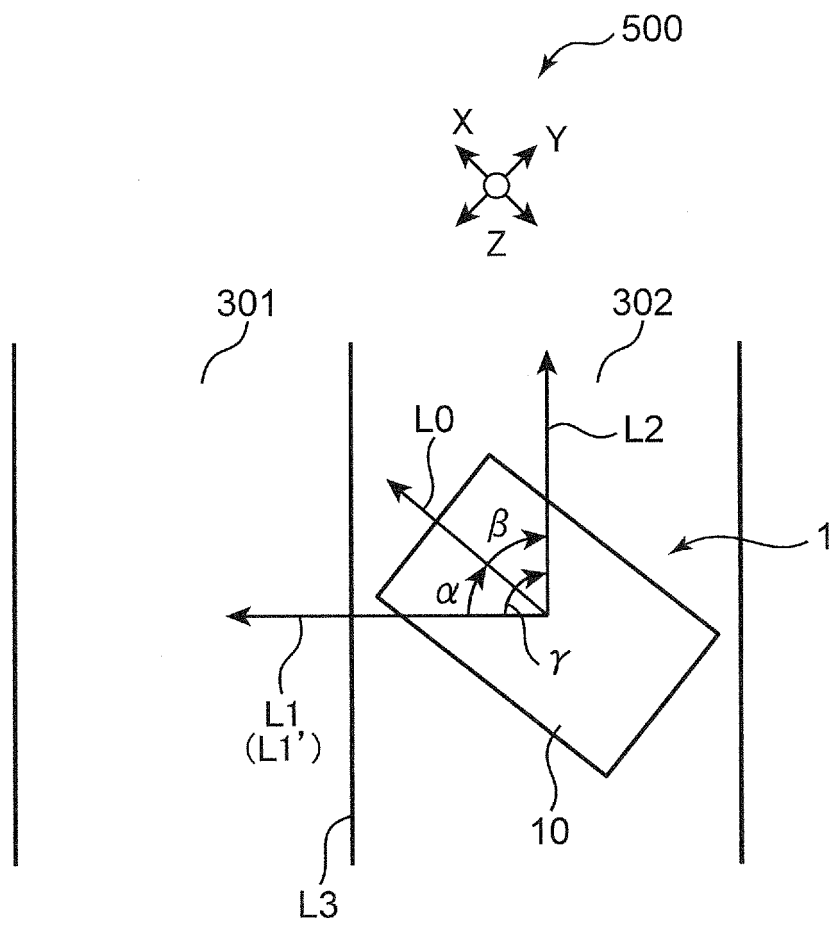
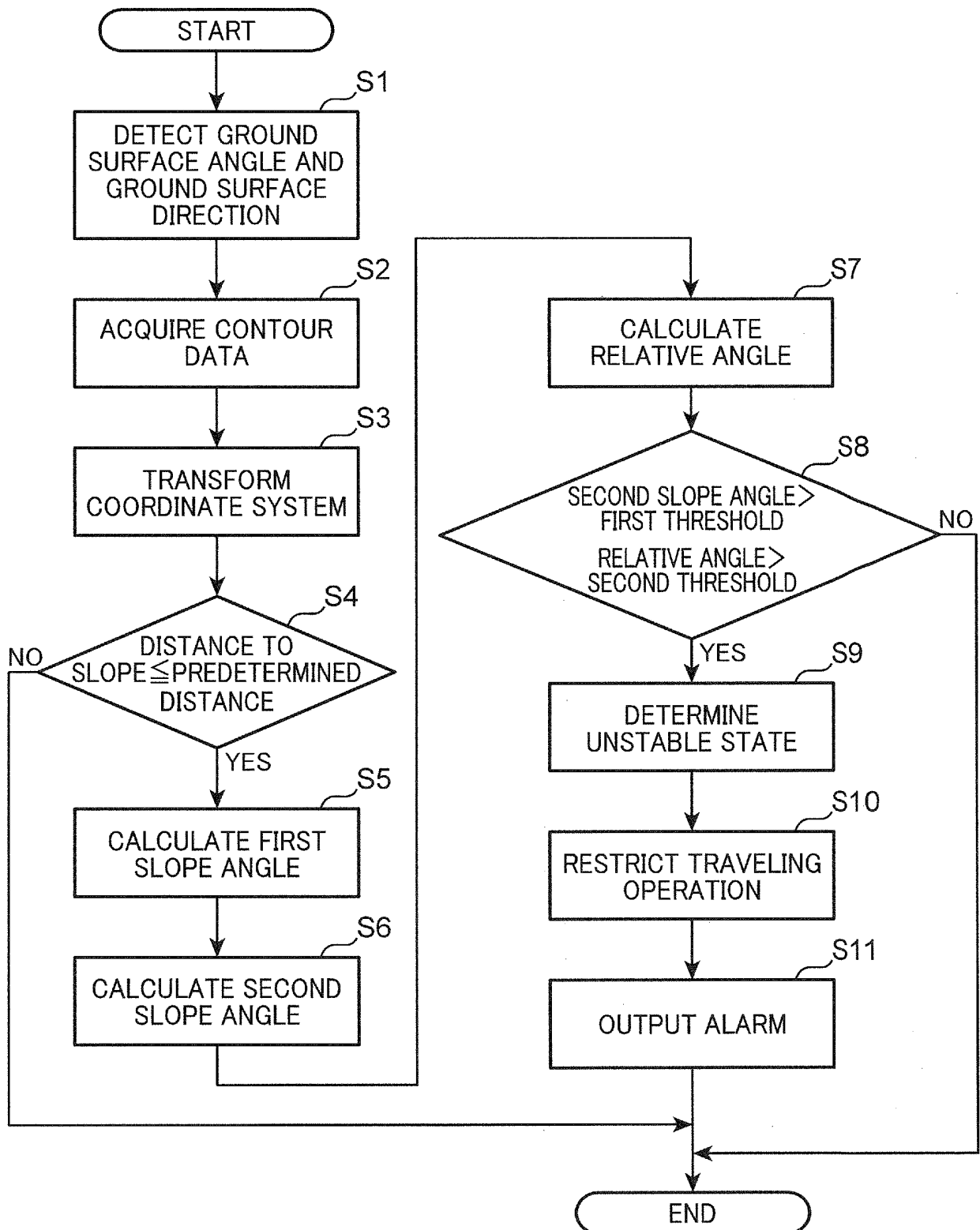


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2020/000570

A. CLASSIFICATION OF SUBJECT MATTER

E02F 9/24 (2006.01) i; E02F 9/26 (2006.01) i

FI: E02F9/24 B; E02F9/26 B

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)

E02F9/24; E02F9/26

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

Published examined utility model applications of Japan 1922-1996

Published unexamined utility model applications of Japan 1971-2020

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.
Y	JP 2013-238097 A (SUMITOMO HEAVY INDUSTRIES, LTD.) 28.11.2013 (2013-11-28) paragraphs [0012]-[0060], fig. 1-8	1-6
Y	WO 2019/026802 A1 (SUMITOMO HEAVY INDUSTRIES, LTD.) 07.02.2019 (2019-02-07) paragraphs [0010]-[0086], fig. 1-3, 5-8	1-6
A	JP 2019-2242 A (KOBE STEEL, LTD.) 10.01.2019 (2019-01-10) entire text, all drawings	1-6
A	JP 2013-189767 A (SUMITOMO HEAVY INDUSTRIES, LTD.) 26.09.2013 (2013-09-26) entire text, all drawings	1-6
A	JP 2013-204260 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 07.10.2013 (2013-10-07) entire text, all drawings	1-6
A	JP 55-138523 A (KOMATSU LTD.) 29.10.1980 (1980-10-29) entire text, all drawings	1-6
A	JP 50-147104 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 26.11.1975 (1975-11-26) entire text, all drawings	1-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T"

later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X"

document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y"

document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"

document member of the same patent family

Date of the actual completion of the international search
09 March 2020 (09.03.2020)Date of mailing of the international search report
24 March 2020 (24.03.2020)Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/JP2020/000570

	Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
5				
	JP 2013-238097 A	28 Nov. 2013	(Family: none)	
	WO 2019/026802 A1	07 Feb. 2019	(Family: none)	
10	JP 2019-2242 A	10 Jan. 2019	(Family: none)	
	JP 2013-189767 A	26 Sep. 2013	(Family: none)	
	JP 2013-204260 A	07 Oct. 2013	(Family: none)	
	JP 55-138523 A	29 Oct. 1980	(Family: none)	
	JP 50-147104 A	26 Nov. 1975	(Family: none)	
15				
20				
25				
30				
35				
40				
45				
50				

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2016172963 A [0006]