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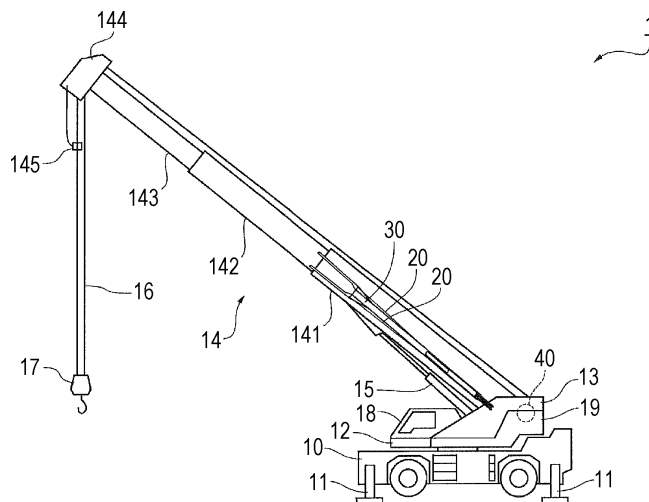
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(54) **DEVICE FOR ESTIMATING NUMBER OF WOUND LAYERS, AND CRANE**

(57) Provided is an estimation apparatus for estimating a number of wound layers of a wire rope in a crane including a boom, a winch drum, and the wire rope wound around the winch drum, the estimation apparatus being mounted on the crane, the estimation apparatus including: a calculation unit that calculates a delivery length of

the wire rope; a detection unit that detects a rotational amount of the winch drum; and a control unit that estimates the number of wound layers, based on a difference in the delivery length of the wire rope and a difference in the rotational amount of the winch drum between a first orientation and a second orientation of the boom.

FIG. 1



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Description

Technical Field

5 **[0001]** The present invention relates to an estimation apparatus for estimating the number of wound layers of a wire rope wound around a winch drum and a crane including the estimation apparatus.

Background Art

10 **[0002]** There is a conventionally known apparatus that applies, to control in a mobile crane, the difference in the length of winding of a wire rope to the rotation of a winch drum, due to a change in the number of wound layers of the wire rope wound around the winch drum.

15 **[0003]** As such an apparatus, for example, Patent Literature 1 discloses a rope irregular-winding prevention apparatus that acquires accurately the position of winding of a rope in the axial direction of rotation of a winch barrel and moves a guide sheave to prevent occurrence of irregular winding of the rope.

Citation List

Patent Literature

20 **[0004]** Patent Literature 1: JP 2020-33114 A

Summary of the Invention

25 Problems to be Solved by the Invention

[0005] According to the invention disclosed in Patent Literature 1, with a known length of rope, the length of the rope delivered from a winch drum in accordance with the orientation of a working machine (hereinafter, referred to as "delivery rope length") is found. Then, according to the invention disclosed in Patent Literature 1, based on the delivery rope length, the number of wound layers of the rope wound around the winch drum is estimated.

30 **[0006]** However, according to the invention disclosed in Patent Literature 1, if the rope is shortened by cutting or an unprescribed length of rope is used, the number of wound layers is likely to be estimated incorrectly.

[0007] Thus, an object of the present invention is to provide an estimation apparatus capable of estimating accurately the number of wound layers of a rope wound around a winch drum.

35 Solutions to Problems

[0008] According to an aspect of the present invention, provided is an estimation apparatus for estimating a number of wound layers of a wire rope in a crane including a boom, a winch drum, and the wire rope wound around the winch drum, the estimation apparatus being mounted on the crane, the estimation apparatus including:

- a calculation unit that calculates a delivery length of the wire rope;
- a detection unit that detects a rotational amount of the winch drum; and
- 45 a control unit that estimates the number of wound layers, based on a difference in the delivery length of the wire rope and a difference in the rotational amount of the winch drum between a first orientation and a second orientation of the boom.

[0009] According to an aspect of the present invention, provided is a crane including the estimation apparatus described above.

50 Effects of the Invention

[0010] According to the present invention, provided can be an estimation apparatus capable of estimating accurately the number of wound layers of a rope wound around a winch drum.

55 Brief Description of Drawings

[0011]

Fig. 1 is a side view of a rough terrain crane according to an embodiment of the present invention.
 Fig. 2 is an explanatory view for the number of wound layers (layer position) and the delivery position on a winch drum.
 Fig. 3 is a block diagram of an estimation apparatus.
 Fig. 4 is a flowchart of control with the estimation apparatus.
 Fig. 5 is a graph indicating the relationship between rotational amount and delivery length.
 Figs. 6(a) and 6(b) are explanatory graphs for search processing.

Description of Embodiments

[0012] An embodiment of the present invention will be described below with reference to the drawings. Note that the constituent elements in the following embodiment are exemplary and thus the technical scope of the present invention is not limited to the constituent elements. A rough terrain crane 1 will be exemplarily given in the following embodiment, but this is not limiting. Thus, the present invention can be widely applied to any other mobile cranes.

(Entire Configuration of Crane)

[0013] As illustrated in Fig. 1, a rough terrain crane 1 according to the present embodiment includes a vehicle body 10 as the main body of a vehicle having a traveling function, outriggers 11 provided one-to-one at the four corners of the vehicle body 10, a swivel 12 attached to the vehicle body 10 so as to swivel horizontally, and a boom 14 attached to a bracket 13 (upper portion of a swivel frame) provided vertically on the swivel 12.

[0014] The outriggers 11 are each capable of slideprotrusion/slide-retraction outside in the width direction of the vehicle body 10, due to extension/contraction of a slide cylinder. In addition, the outriggers 11 are each capable of jack-protrusion/jack-retraction in the up-down direction of the vehicle body 10, due to extension/contraction of a jack cylinder.

[0015] The swivel 12 includes a pinion gear for transmission of the power of a swivel motor. The pinion gear engages with a circular gear provided in the vehicle body 10 and moves rotationally around the axis of swiveling. The swivel 12 includes a cab 18 disposed on the right in its front, the bracket 13 disposed at the center in its rear, and a counter weight 19 disposed at a lower portion in its rear.

[0016] The boom 14 includes a base boom 141, one or a plurality of intermediate booms 142, and a front boom 143 in telescopic combination. The boom 14 extends/contracts due to an extension cylinder disposed its inside.

[0017] The outermost base boom 141 has a base portion attached pivotably to a support shaft horizontally provided at the bracket 13. The base boom 141 moves upward or downward around the support shaft. Furthermore, a derricking cylinder 15 is provided ranging from the bracket 13 to the lower face of the base boom 141. The entire boom 14 rises/falls due to extension/contraction of the derricking cylinder 15. A boom-length detector 511 and a boom derricking-angle detector 512 measure the boom length LB and derricking angle θ_B of the boom 14, respectively. The measured boom length LB and derricking angle θ_B are transmitted to a controller 60 as a control unit.

[0018] A sheave is disposed at a boom head 144 that the front boom 143 has at its front end. A wire rope 16 passes over the sheave. The wire rope 16 has a front end from which a hook block 17 is hung. Meanwhile, the wire rope 16 has a base end wound around a winch 40. Thus, the wire rope 16 and the hook block 17 can be reeled in or out due to rotation of the winch 40.

[0019] In order to prevent the hook block 17 from striking against/being caught in the boom head 144, an over-hoisting detection switch 145 is attached to the boom head 144. The over-hoisting detection switch 145 is hung at a predetermined distance from the boom head 144. Then, an over-hoisting position detector 52 monitors the over-hoisting detection switch 145. The over-hoisting position detector 52 transmits, to the controller 60, the ON/OFF state of the over-hoisting detection switch 145.

[0020] Furthermore, a jib 30 and tension rods 20 and 20 can be attached to the boom head 144. Note that, referring to Fig. 1, the jib 30 having been held laterally is stored. The jib 30 can be detachably attached so as to extend from the boom head 144 (an increase is made in working radius).

[0021] The jib 30 is foldable with respect to the boom 14 due to extension/contraction of a tilt cylinder (not illustrated) and is extendable/contractable due to an extension cylinder (not illustrated). The tension rods 20 and 20 are each provided ranging from the boom head 144 to the intermediate position of the jib 30 and pull the jib 30 upward. The jib length LJ and derricking angle θ_J of the jib 30 are measured by a jib-length detector 513 and a jib tilt-angle detector 514, respectively, and then are transmitted to the controller 60.

[0022] As illustrated in Fig. 2, the winch 40 includes a winch drum 41 (winch barrel) cylindrical in shape, and a hydraulic motor and reduction gear (not illustrated) that serve as a drive unit that rotates the winch drum 41. The wire rope 16 is wound around the winch drum 41. That is, the wire rope 16 is wound systematically in layers around the winch drum 41. Then, the number of layers of the wire rope 16 is defined as M (M is a natural number) and the position in the lateral direction of the wire rope 16 (the ratio of the distance from the flange portion on the winching start side to the current position in each layer to the drum full width that is defined as 1) is defined as the rope delivery position N (N is a decimal).

(Configuration of Control System)

[0023] Next, the configuration of a control system of an estimation apparatus S mounted on the rough terrain crane 1 will be described with the block diagram of Fig. 3. As illustrated in Fig. 3, the estimation apparatus S according to the present embodiment includes mainly a controller 60 as a control unit. The controller 60 corresponds to a (micro-) computer including a CPU, a memory, a ROM, and an SSD. Then, the controller 60 as a control unit has, as input devices, an orientation detector 51, an over-hoisting position detector 52, and a drum rotational-amount detector 53 connected thereto.

[0024] The orientation detector 51 corresponds to an exemplary orientation detection unit and includes, for example, a boom-length detector 511, a boom derricking-angle detector 512, a jib-length detector 513, and a jib tilt-angle detector 514. Then, the boom length LB, boom derricking angle θ_B , jib length LJ, and jib tilt angle θ_J detected by the orientation detector 51 are transmitted to the controller 60.

[0025] The controller 60 includes, as functional units, a rope delivery-length computing unit 61, a computing event generator 62, a gradient computing unit 63, an adjustment-amount computing unit 64, a drum-rotational-amount to delivery-length table 65, and a delivery-length against over-hoisting-position computing unit 66. The function of each functional unit will be specifically described with the flowchart of Fig. 4 to be described next.

(Control Flow)

[0026] Next, a control flow of the estimation apparatus S will be described with the flowchart of Fig. 4.

[0027] First, the over-hoisting position detector 52 monitors the state of the over-hoisting detection switch, and the computing event generator 62 outputs a change in the switch (ON-OFF) as an event (Et) (step S1).

[0028] The orientation detector 51 detects the orientation (LB, θ_B , LJ, θ_J) of the crane. Then, the rope delivery-length computing unit 61 finds, from the geometric relationship with the rope route based on the orientation detected values, the rope length (X) between the drum-side criterial position and the over-hoisting detection position (step S2). The rope delivery-length computing unit 61 corresponds to an exemplary calculation unit that calculates the delivery length of the wire rope (rope length (X)). Note that the rope length (X) may be retrieved from a table with the orientation detected values as indices.

[0029] The drum rotational-amount detector 53 corresponds to an exemplary detection unit and outputs a rotational amount ϕ of which the output value is 0 when the hook block 17 is located at the position of over-hoisting with a prescribed orientation (boom not extended at a derricking angle of 0) (step S3).

[0030] Next, the gradient computing unit 63 stores at least a set (X1, ϕ_1) in which the rope length (X) at the time of event occurrence has a minimum value and a set (X2, ϕ_2) in which the rope length (X) at the time of event occurrence has a maximum value (step S4). Note that, although at least two points of the minimum and the maximum are stored, a plurality of points therebetween may be stored (Fig. 6(a)).

[0031] Next, the adjustment-amount computing unit 64 determines an adjustment amount ($\Delta\phi_{adj}$) such that the stored points at the time of event occurrence coincide with the curve of the drum-rotational-amount to delivery-length table 65 (step S5, Fig. 6(b)). A procedure of finding an adjustment amount for two points of the maximum and the minimum by binary search will be described later.

[0032] Next, the delivery-length against over-hoisting-position computing unit 66 outputs, as the current number of layers on the drum (M), the number of layers on the drum at a rotational amount ($\phi_{det} + \Delta\phi_{adj}$) resulting from adjustment of a drum rotational detected amount (ϕ_{det}) by $\Delta\phi_{adj}$ (right vertical axis of Fig. 5) (step S6).

[0033] Simultaneously, the delivery-length against over-hoisting-position computing unit 66 determines the ratio at the same layer in the table determined as M (the ratio between the encoder width of a flat portion and the distance from the left edge portion to the current position at the same number of layers) as the rope delivery position (N) at the same layer (step S6).

[0034] In a case where the rope length between the drum-side criterial position and the over-hoisting detection position with the prescribed orientation (boom not extended at a derricking angle of 0) is defined as X0, the wire rope full length Y (wire rope delivery amount Y) with respect to the over-hoisting detection position can be expressed as follows (step S7).

[Mathematical Formula 1]

$$Y = X_0 - X(L_B, \theta_B, L_J, \theta_J) + Tbl(\phi_{det} + \Delta\phi_{adj}) - Tbl(\Delta\phi_{adj})$$

(Procedure of Finding Adjustment Amount by Binary Search)

[0035] Next, a specific procedure of calculation for finding an adjustment amount by binary search in the controller 60 of the estimation apparatus S will be described (step S5 in Fig. 4). A procedure of estimation will be described at power-on, in detection, and in use in order.

(At Power-On)

[0036]

(1) The relationship of the delivery length (left vertical axis) and the number of layers (right vertical axis) with drum rotation (horizontal axis) is stored as ROM data (refer to Fig. 5). In this case, the number of layers on the drum ranges to the maximum number of layers reelable physically. At the point in time maximum reeling is conducted, the encoder value of drum rotation is 0.

(2) The drum rotational amount φ , of which the detected amount is 0 with the hook located at an over-hoisting prevention weight included in the over-hoisting detection switch 145 and with the prescribed orientation (boom not extended at a derricking angle of 0), corresponds to the encoder value positive on the side of delivery.

(In Detection)

[0037] (3) A drum rotational amount φ_1 and a rope delivery length X1 are recorded at the timing at which a change is made in a signal for detecting over-hoisting (over-hoisting/non-over-hoisting) with the rope length (X) that is minimum (first orientation). The rope delivery length X1 is calculated in accordance with the orientation of the working machine, such as the derricking angle, the boom length, or the position at which the over-hoisting weight is provided. In a case where multiple slinging is adopted, the number of lines is taken account of.

[0038] (4) A drum rotational amount φ_2 and a rope delivery length X2 are recorded at the timing of detection of over-hoisting (over-hoisting/non-over-hoisting) with the rope length (X) that is maximum (second orientation).

[0039] (5) The difference in delivery length ($\Delta X = X_2 - X_1$) and the difference in rotational amount ($\Delta\varphi = \varphi_2 - \varphi_1$) are calculated.

[0040] (6) A method of finding an adjustment amount by binary search will be now described with Fig. 6(b). As initial values for search, the minimum position ($\varphi = 0$) of the rotational amount registered in the ROM and the maximum position (maximum value of φ) of the rotational amount registered in the ROM are P1 and P2, respectively. The position resulting from subtraction of the difference ($\Delta\varphi$) in rotational amount from the position P2 is P3.

[0041] (7) The intermediate point between P1 and P3 is P4. From the drum-rotational-amount to delivery-length table 65 in the ROM, an increase ΔX_4 in delivery length responsive to an increase $\Delta\varphi$ from the position P4 is calculated.

[0042] (8) ΔX_4 and the difference ($\Delta X = X_1 - X_2$) in delivery length are compared.

a) In a case where the following condition is satisfied: $\Delta X_4 > \Delta X$, the value of P3 is updated with P4.

b) In a case where the following condition is satisfied: $\Delta X_4 < \Delta X$, the value of P1 is updated with P4. Until the following condition is satisfied: ($\Delta X_4 \approx \Delta X$), a) and b) are repeated.

$$\varphi_{det} + \Delta\varphi_{adj} = \varphi_{rom}$$

[0043] The adjustment amount $\Delta\varphi_{adj}$ is determined such that the above relationship is obtained, that is, the drum rotational detected amount φ_{det} is equivalent to the rotational amount φ_{rom} in the drum-rotational-amount to delivery-length table 65 registered in the ROM.

(In Use)

[0044] (10) For the rope absolute delivery length having taken account of the accurate number of layers, the wire rope full length Y (wire rope delivery amount Y) with respect to the over-hoisting detection position, the position M of the layer in use on the drum, and the ratio N of the rope delivery position in the layer in use are calculated.

(Effects)

[0045] Next, effects of the estimation apparatus S described in the embodiment will be described in sequence.

(1) As described above, the estimation apparatus S estimates the number of wound layers M of the wire rope 16 wound around the winch drum 41 of the mobile crane. The estimation apparatus S includes the orientation detector 51 that detects the orientation of the boom 14 of the mobile crane, the drum rotational-amount detector 53 that detects the rotational amount of the winch drum 41, and the controller 60 as a control unit that controls the boom 14 and the winch drum 41. The controller 60 stores the delivery length X1 of the wire rope 16 calculated based on the detected first orientation of the boom 14, the detected rotational amount φ_1 of the winch drum 41, the delivery length X2 of the wire rope 16 calculated based on the detected second orientation of the boom 14, and the detected rotational amount φ_2 of the winch drum 41, and estimates the number of wound layers M, based on the difference ΔX in delivery length and the difference $\Delta\varphi$ in rotational amount between the first orientation and the second orientation. According to such a configuration, even in a case where the wire rope 16 is cut or an unprescribed length of wire rope 16 is used, based on the detected orientation of the boom 14 and the detected rotational amount φ of the winch drum 41, the number of wound layers M can be accurately estimated to find the full length Y accurately.

[0046] That is, according to the estimation apparatus S, the number of wound layers M can be accurately detected, so that the rope full length Y can be found accurately from the drum rotational amount φ . Furthermore, in a case where the original wire rope 16 is shortened by cutting, an abnormal operation in which all the wire rope 16 is delivered from the winch drum 41 or usage with the number of wound layers M not less than the expected number of wound layers that causes a winch torque shortage can be inhibited.

[0047] Then, the estimation apparatus S has an effect varying depending on the level of $\Delta\varphi$ at the time of computing of the adjustment amount as follows:

1) $\Delta\varphi$ larger than the rotational amount at the same layer

Since M and N can be calculated correctly, the full length Y can be found correctly based on the layer (M) in use and the rope delivery position (N).

2) $\Delta\varphi$ smaller than the rotational amount at the same layer

a)

$$N = 0 (\%)$$

The found delivery length is the upper limit of the actual delivery amount and thus can be used as the limit at the time of working range restriction on the side of reeling-out (as a safety that prevents contact with the target at the time of reeling-out operation).

b)

$$N = 100 (\%)$$

The found delivery length is the lower limit of the actual delivery amount and thus can be used as the limit at the time of working range restriction on the side of reeling-in (as a safety that prevents contact with the target at the time of reeling-in operation).

(2) In addition, preferably, the controller 60 as a control unit further includes the data recording unit ROM in which the relationship between the rotational amount φ of the winch drum 41 and the delivery length X of the wire rope 16 (drum-rotational-amount to delivery-length table 65) is recorded, and estimates, based on the recorded relationship between the rotational amount φ and the delivery length X and the difference $\Delta\varphi$ in rotational amount and the difference ΔX in delivery length between the first orientation and the second orientation, the number of wound layers M at a coincidence in the rate of change ($\Delta X/\Delta\varphi$) therebetween. As above, from the relationship between the rotation amount φ and the delivery length X, having an upward convex curve, the number of wound layers M at a coincidence in the rate of change (gradient) $\Delta X/\Delta\varphi$ can be retrieved.

(3) Furthermore, preferably, the estimation apparatus S further includes the over-hoisting position detector 52 that detects the position of over-hoisting of the hook block 17, and the controller 60 as a control unit detects a state where the hook block 17 is at the position of over-hoisting as the first orientation or second orientation of the boom 14, and calculates the delivery length of the wire rope 16, based on the detected first orientation or second orientation of the boom 14. Prescription of the first orientation or second orientation with the over-hoisting position detector 52 as above enables accurate calculation of the delivery length X of the wire rope 16 in the first orientation or second orientation by geometric calculation.

(4) In addition, preferably, the controller 60 as a control unit selects, as the first orientation of the boom 14, a state of non-extension where the length of the boom 14 is minimum and a state of non-elevation where the derricking angle of the boom 14 is minimum. Such selection as above enables a larger difference $\Delta\phi$ in rotational amount and a larger difference ΔX in delivery length between the first orientation and the second orientation. Therefore, an improvement is made in the accuracy of estimating the number of wound layers M.

(5) Then, the rough terrain crane 1 serving as the mobile crane according to the present embodiment includes such an estimation apparatus S as described above, so that the full length Y can be accurately found with accurate estimation of the number of wound layers M. Thus, liftoff control or unloading control can be conducted accurately and safely.

[0048] The embodiment of the present invention has been described in detail above with reference to the drawings. However, the specific configurations in the embodiment are not limiting, and thus any changes in design without departing from the gist of the present invention are to be included in the present invention.

[0049] For example, the winch 40 described in the embodiment may be a main winch or an auxiliary winch. For such a main winch, the relationship between the rotational amount ϕ and the delivery length X can be modified in accordance with the number of wire-rope lines of the wire rope 16.

[0050] In the embodiment, the case where the delivery lengths X1 and X2 of the wire rope 16 are found by geometric calculation based on orientation has been given, but this is not limiting. For example, the delivery lengths X1 and X2 of the wire rope 16 can be manually input after being measured in practice with a measuring tape.

[0051] Furthermore, in the embodiment, the number of wound layers M and the delivery position N are estimated such that the rate of change based on the minimum and maximum delivery lengths X coincides with the stored rate of change, but this is not limiting. For example, the number of wound layers M and the delivery position N can be estimated every time over-hoisting is detected, leading to an improvement in the accuracy of estimation with the estimated values (M, N).

[0052] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2021-070805, filed on April 20, 2021, the entire contents of which are incorporated herein by reference.

Industrial Applicability

[0053] The present invention can be applied to various cranes.

Reference Signs List

[0054]

- 1 Rough terrain crane
- 10 Vehicle body
- 11 Outrigger
- 12 Swivel
- 13 Bracket
- 14 Boom
- 141 Base boom
- 142 Intermediate boom
- 143 Front boom
- 144 Boom head
- 15 Derricking cylinder
- 16 Wire
- 17 Hook
- 18 Cab
- 19 Counter weight
- 20 Tension rod
- 30 Jib
- 40 Winch
- 51 Orientation detector
- 511 Boom-length detector
- 512 Boom derricking-angle detector
- 513 Jib-length detector
- 514 Jib tilt-angle detector
- 52 Over-hoisting position detector

53	Drum rotational-amount detector
60	Controller
61	Rope delivery-length computing unit
62	Computing event generator
5	63 Gradient computing unit
64	Adjustment-amount computing unit
65	Drum-rotational-amount to delivery-length table
66	Delivery-length against over-hoisting-position computing unit
S	Estimation apparatus
10	X Rope length between drum-side criterial position and over-hoisting detection position
Φ	Drum rotational amount

Claims

- 15
1. An estimation apparatus for estimating a number of wound layers of a wire rope in a crane including a boom, a winch drum, and the wire rope wound around the winch drum, the estimation apparatus being mounted on the crane, the estimation apparatus comprising:
- 20
- a calculation unit that calculates a delivery length of the wire rope;
a detection unit that detects a rotational amount of the winch drum; and
a control unit that estimates the number of wound layers, based on a difference in the delivery length of the wire rope and a difference in the rotational amount of the winch drum between a first orientation and a second orientation of the boom.
- 25
2. The estimation apparatus according to claim 1, wherein the control unit
- 30
- further includes a data recording unit in which a drum-rotational-amount to delivery-length table is recorded, the drum-rotational-amount to delivery-length table including the rotational amount of the winch drum and the delivery length of the wire rope in one-to-one correspondence, and estimates the number of wound layers, based on the drum-rotational-amount to delivery-length table, the difference in the delivery length of the wire rope, and the difference in the rotational amount of the winch drum.
- 35
3. The estimation apparatus according to claim 1, further comprising an over-hoisting position detector that detects a position of over-hoisting of a hook, wherein the first orientation and the second orientation of the boom are different from each other and correspond to a state where the hook fixed to the wire rope is at the position of over-hoisting.
- 40
4. The estimation apparatus according to claim 1, wherein the first orientation corresponds to a state of non-extension of the boom and a state of non-elevation of the boom.
5. A crane comprising the estimation apparatus according to claim 1.

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FIG. 1

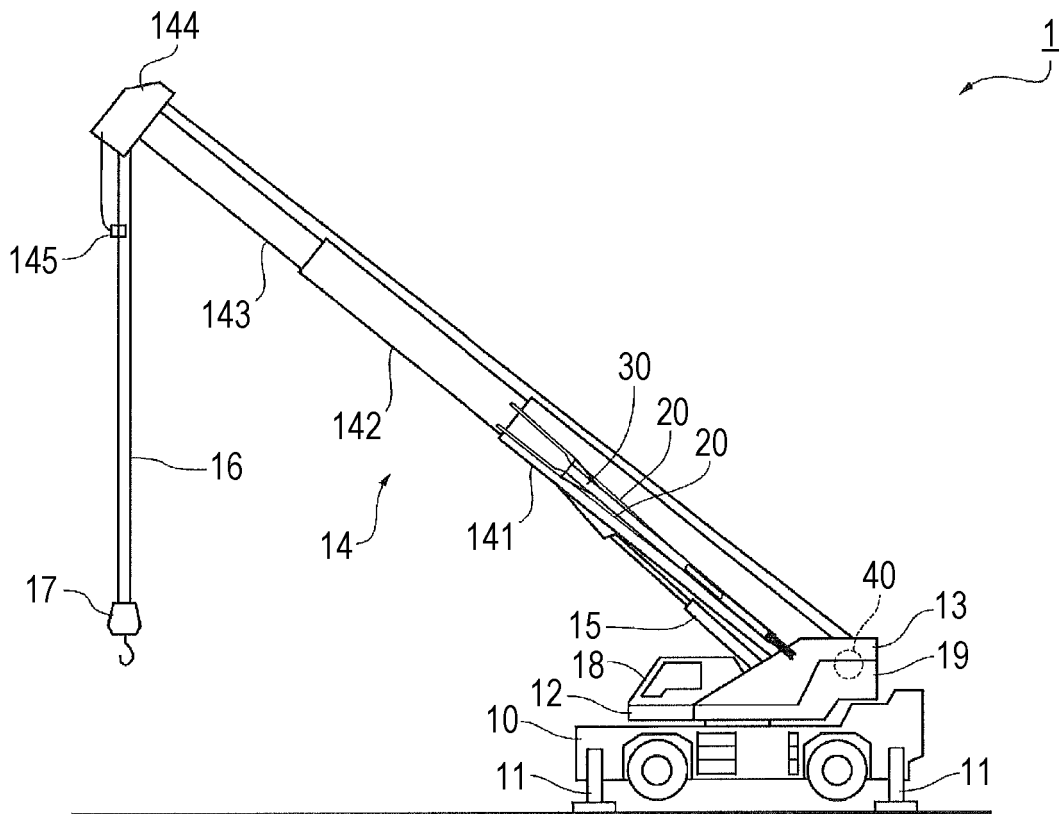


FIG. 2

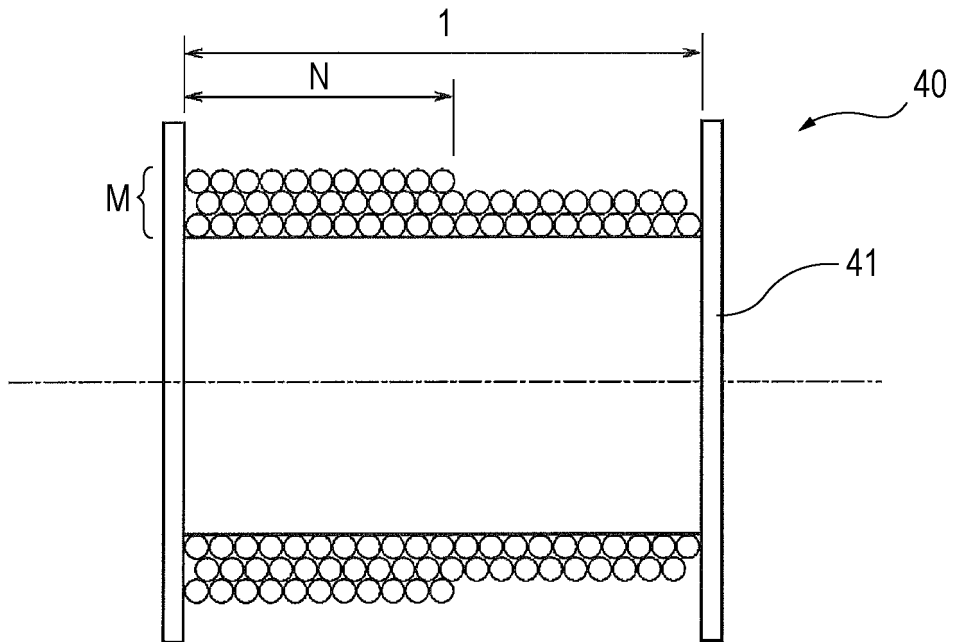


FIG. 3

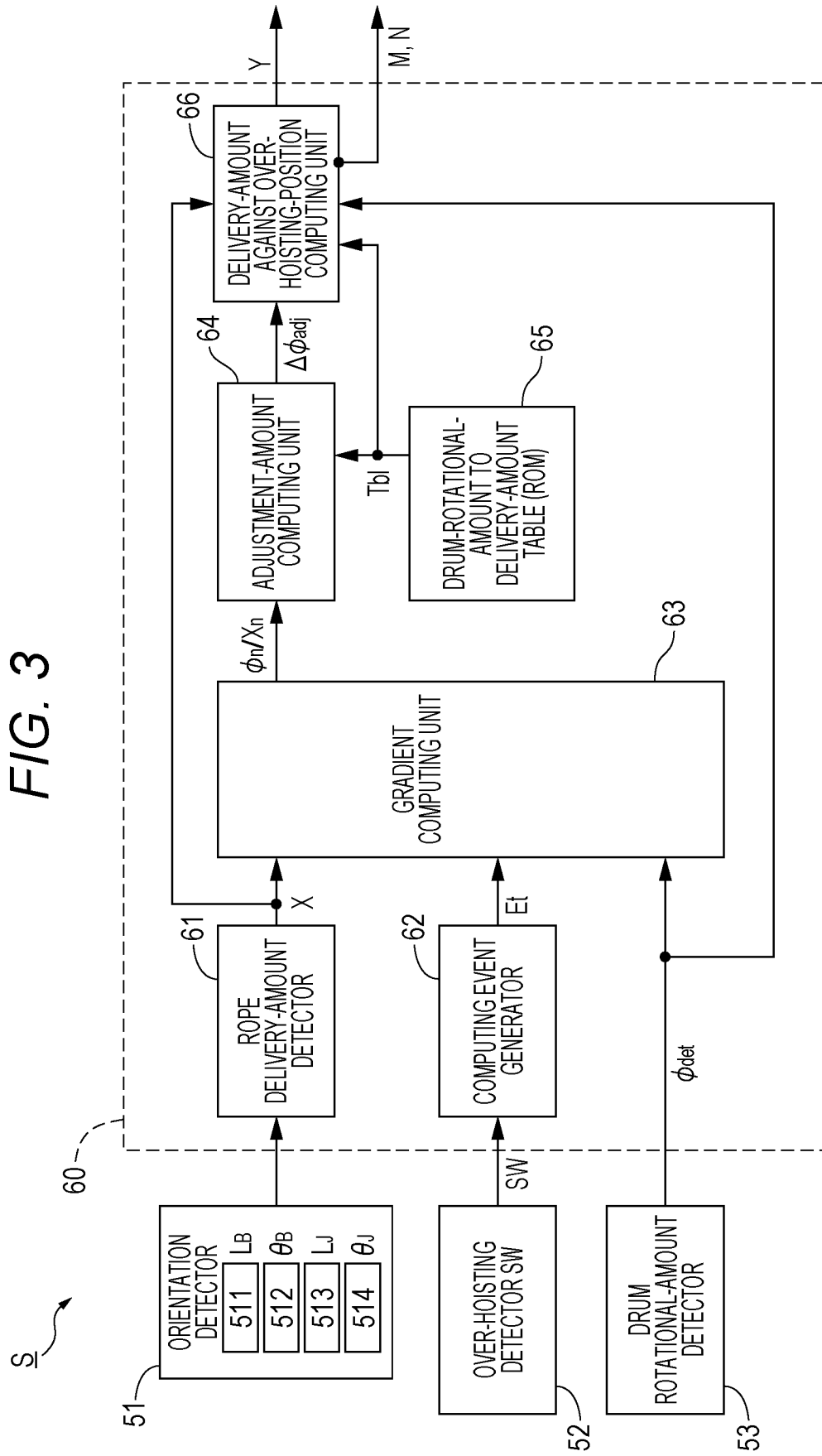


FIG. 4

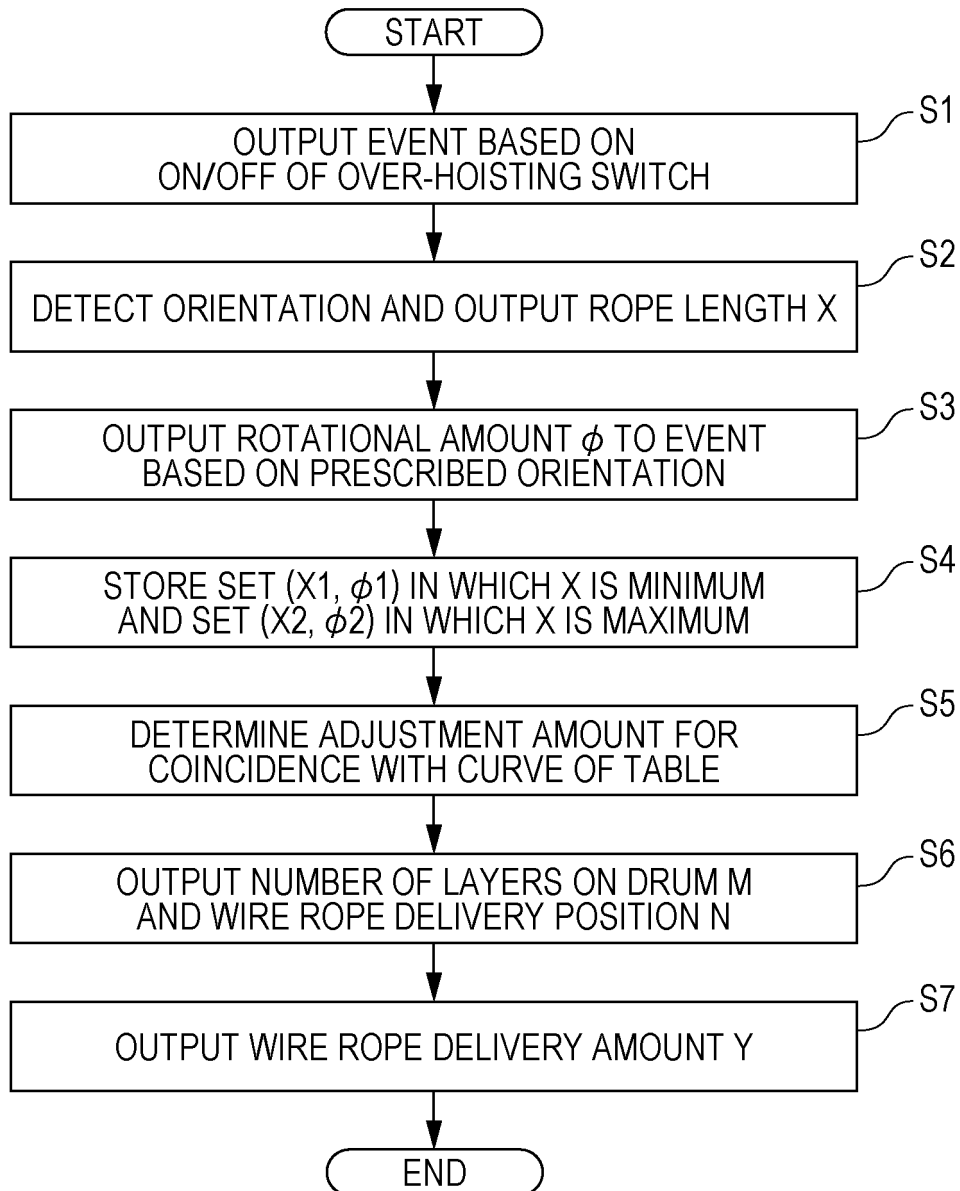


FIG. 5

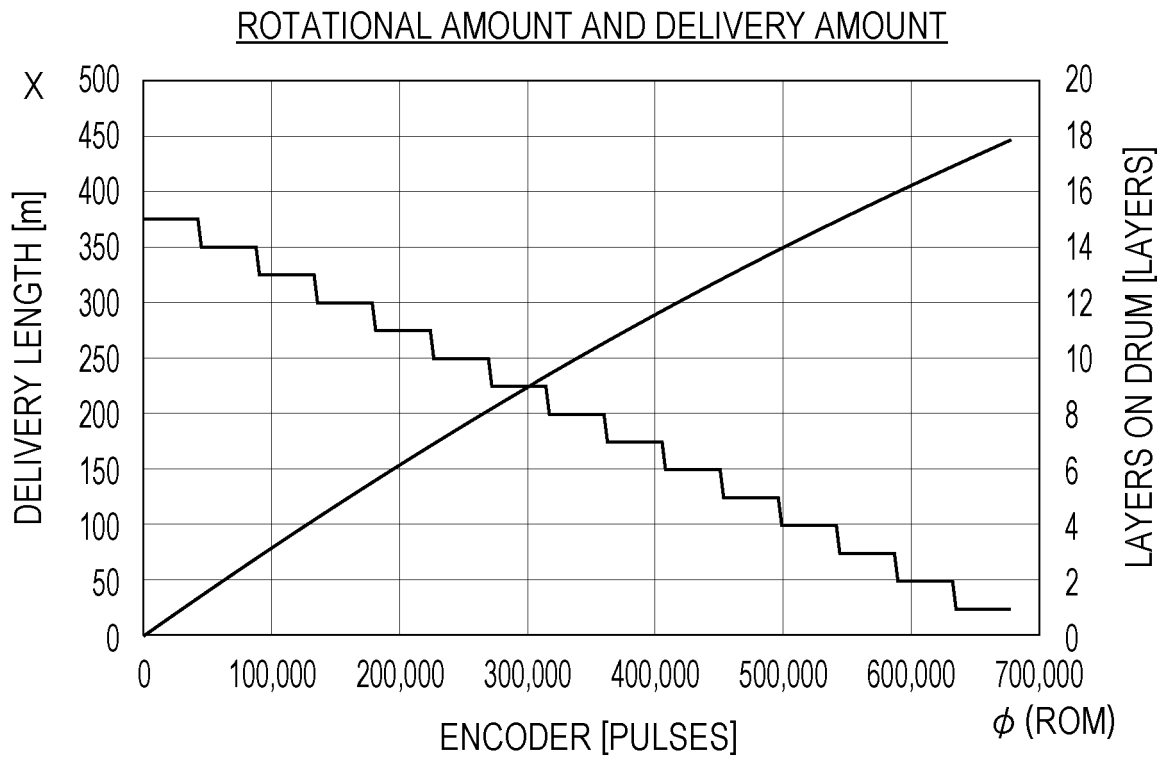
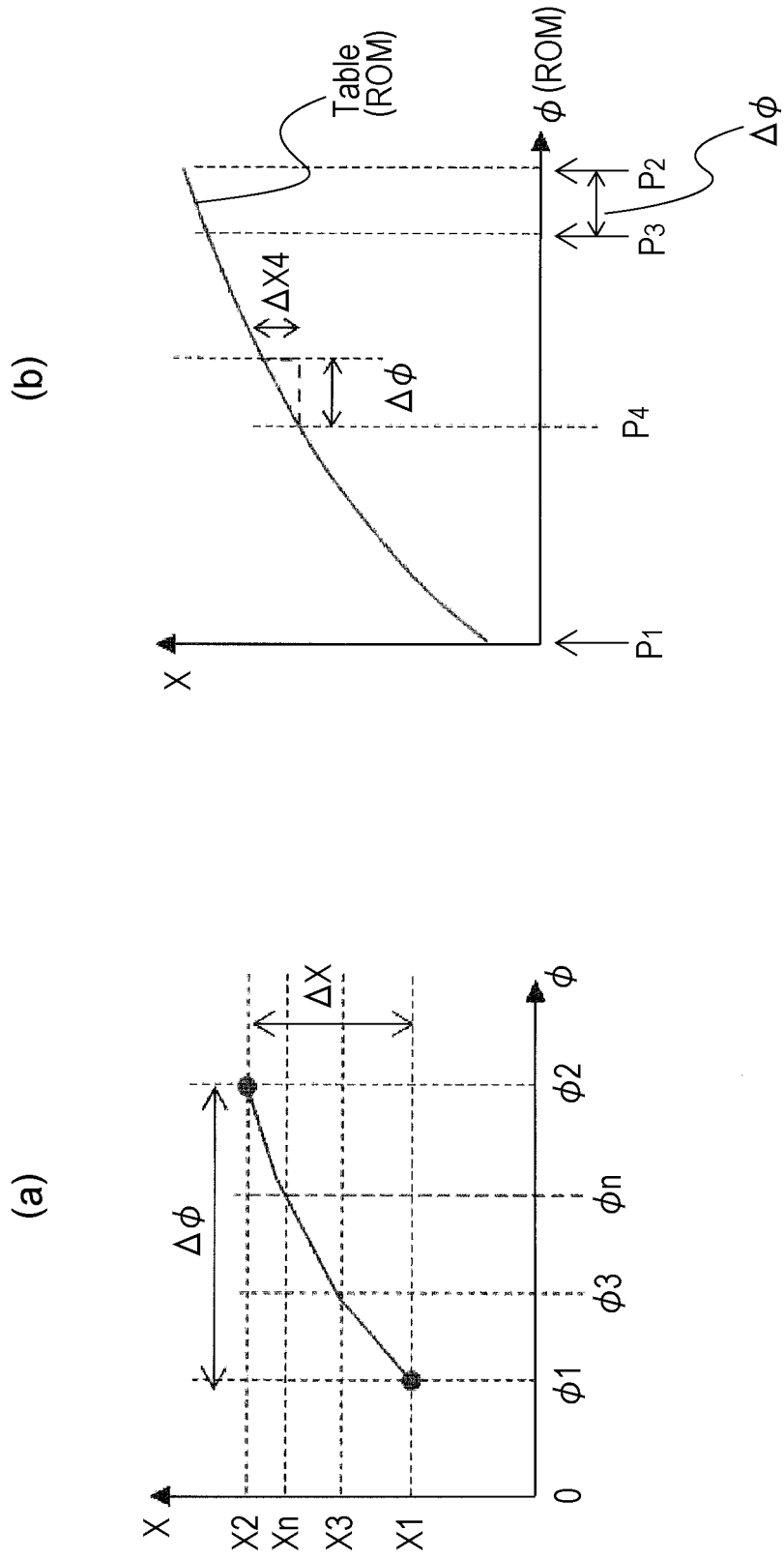


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2022/015651

5	A. CLASSIFICATION OF SUBJECT MATTER	
	<i>B66D 1/30</i> (2006.01)i; <i>B66D 1/54</i> (2006.01)i FI: B66D1/54 G; B66D1/30 B	
	According to International Patent Classification (IPC) or to both national classification and IPC	
10	B. FIELDS SEARCHED	
	Minimum documentation searched (classification system followed by classification symbols) B66D1/30; B66D1/54	
	Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched	
15	Published examined utility model applications of Japan 1922-1996 Published unexamined utility model applications of Japan 1971-2022 Registered utility model specifications of Japan 1996-2022 Published registered utility model applications of Japan 1994-2022	
	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)	
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT	
	Category*	Citation of document, with indication, where appropriate, of the relevant passages
		Relevant to claim No.
25	A	JP 10-59688 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 03 March 1998 (1998-03-03) paragraphs [0011]-[0015], fig. 1-7
	A	JP 10-17277 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 20 January 1998 (1998-01-20)
	A	JP 2018-2426 A (TADANO LTD.) 11 January 2018 (2018-01-11)
30	A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 26563/1991 (Laid-open No. 115880/1992) (TADANO LTD.) 15 October 1992 (1992-10-15)
	A	JP 10-231086 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 02 September 1998 (1998-09-02)
35	<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.	
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