(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
12 December 2024 (12.12.2024)

WIPO | PCT

(10) International Publication Number
WO 2024/251337 A1

(51) International Patent Classification:
B66C 13/08 (2006.01)

(21) International Application Number:
PCT/DK2024/050136

(22) International Filing Date:
04 June 2024 (04.06.2024)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PA 2023 70271 06 June 2023 (06.06.2023) DK

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT,

(54) Title: A SYSTEM AND A METHOD FOR HANDLING A LOAD IN AN ELEVATED POSITION

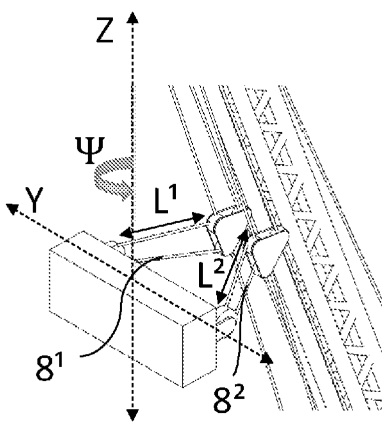

Fig. 5a

(57) Abstract: The present invention relates to a crane system for handling a load (3, 4), and a method for controlling the load (3, 4) during hoisting operation. The method present acts for controlling the orientation of a load (3, 4) during hoisting operation using a speed controlling method. A winch (5) control system controls a winch (5) arrangement, wherein the winch (5) arrangement is arranged relative to a crane system. The method comprising the following steps, placing the load (3, 4) in a first load (3, 4) position, and attaching the first tagline (8) and the second tagline (8, L2) to a first and a second attachment point on the load (3, 4), determining a predicted virtual axis for a next load (3, 4) position relative to the previous virtual axis, moving the load (3, 4) to the next load (3, 4) position relative to the predicted virtual axis while controlling each of the first and second winch (9), such that each of the first and second tagline length (8) are adjusted separately relative to the predicted virtual axis, retrieving at least one first tagline length (LI) information from a first measuring device and at least one second tagline length (8) information from a second measuring device in the next load (3, 4) position, analysing the first and second tagline length (8) information relative to each other to determine an offset value for each of the first and second tagline length (8), and comparing the offset values to the predicted virtual axis related to a current load (3, 4) position, calculating an offset correction of the first and second tagline length (8) compared to each of the offset value based on the predicted virtual axis. When the load (3, 4) is moving towards a further load (3, 4) position having a further predicted virtual axis, each length of the respective taglines (8) is adjusted relative to the predicted virtual axis, such that the load (3, 4) is moved by controlling each length of the respective taglines (8) in advance.

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LU, LV, MC, ME, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:
— *with international search report (Art. 21(3))*

A system and a method for handling a load in an elevated position

Field of invention

The present invention relates to a crane system for handling a load, and a method for controlling the load during hoisting operation.

Background of the invention

Handling heavy load using cranes can be a challenging and complex task. Loads may be wind turbine components, prefabricated building elements, ships, vehicle, etc. The need for controlling the orientation of a load relative to a crane is very important during hoisting operation to avoid hazardous situations. For example, a strong wind complicated the operation, when lifting and lowering a load, because the load may have heavy weight and large dimension, easy for the wind to provide a hazardous activity, which may be difficult to stop. Even the crane’s movements during operation must be taken into consideration. If the crane's stability is threatened, the crane has to stop the lifting work and lock the crane.

When rigging a load, taglines may be added. Taglines may simply be ropes or lines that are in one end connected to the load and the opposite end of the line is connected to an arrangement on the ground or crane base, or controlled by a rigger. The taglines are attached to the load during a lifting operation, to allow the swinging and/or rotation of a suspended load to be reduced, in order to ensure stability. This ensures a load stability during operation, even at high wind speed.

A winch arrangement may be provided to automatically control the taglines during an operation being based on torque measurements. The winch arrangement controls the motor, which drives the winch using a torque controlling method. When using such arrangement, using a torque controlling method, it is necessary to provide information related to the loads weight, before handling the load. If the following load has a different weight than the previous load, the information must be added before hoisting the load. This is very time consuming, and also costly, due to the man hours needed and the man hours on standby.

The document, EP2526042 A1, discloses a winch arrangement for controlling the orientation of a load suspended from a bearing wire in relation to said bearing wire. The winch arrangement comprising a master winch, at least one slave winch and a winch control system. Each of the winches has a winch motor, and a bidirectional rotational spool with a tagline. The master winch and slave winch are arranged, such that they apply opposite directed torque to the load. For example, the master winch applies a clockwise torque, and the slave winch applies a counter clockwise torque, the master winch applies a counter clockwise torque and the slave winch applies a clockwise torque. When the sum of torque applied by the winches equal zero the load will maintain its orientation about the bearing wire. The control system is controllably connected to each winch motor for controlling spool rotation. The control system comprises tension sensor means for determining tagline tension, and spool rotation sensor means for determining spool rotation. The master winch is set to maintain a pre-set tension in the respective tagline and the slave winch is set to follow the master winch. The disadvantage is that the motor, gearboxes, drums etc, affect the overall inertia of the system, and because the control system is torque controlled the result is a slow-acting system, which may become unstable during operation.

The document, WO2021/047745Al, discloses a system and a method relating to a load guiding arrangement arranged for mounting to a crane, which comprises a crane boom and crane counterweight of which load guiding arrangement is arranged for controlling the orientation of a load suspended in a crane boom from a bearing wire about said bearing wire. The load guiding arrangement comprises two winches, each of said winches has a bi-directional rotational spool, wherein the winches are placed on the crane, and two taglines with a first end of the tagline attached to the spool. Each tagline is connected to the load for applying a controlled torque to the load through the bearing wire. The document describes a winch arrangement comprising a control system, and that the winches are controlled by the control system similar to the system disclosed in EP2526042 A1, having the same disadvantage.

The document, US7367464 B1, discloses a control system for controlling a rotating pedestal crane equipped with a Rider Block Tagline System, wherein the control system is capable of controlling a position of a rider block using a winch system. The system has the disadvantage that the position of the payload, which is hanging in a wire, is not controlled, and therefore exposed to ambient forces. Hoisting the payload is therefore affected by the ambient condition, which increases the operation time for lifting and lowering a payload to avoid any hazardous situations.

Summary of the invention

It is an object of the present invention to overcome these disadvantageous, and to provide a method for controlling the orientation of a load relative to a hoist line of a crane with the use of taglines, such that the operation time for lifting and lowering a load is reduced, and thereby perform a more quick and still safe operation.

The object of the invention is furthermore to provide a control system for controlling the orientation of a load during operation, such that a load is handled quickly relative to a crane in a precise and secure position during operation.

The present invention addresses this by providing a method for controlling the orientation of a load during hoisting operation, wherein a control system is configured to control a winch arrangement, wherein the winch arrangement is arranged relative to a crane system, wherein the winch arrangement comprises a first winch arranged in a first position relative to the crane and the first winch is configured to vary a length of a first tagline, and a second winch arranged in a second position relative to the crane configured to vary a length of a second tagline, wherein the method comprises the following steps:

a) placing the load in a first load position,

b) attaching the first tagline and the second tagline to a first and a second attachment point on the load, such that each of the first and second tagline has respective first and second tagline length relative to the load in the first load position, and determining a first virtual axis relative to the load and to the first tagline and the second tagline,

c) determine a predicted virtual axis for a next load position relative to the previous virtual axis,

d) moving the load to the next load position relative to the predicted virtual axis while controlling each of the first and second winch, such that each of the first and second tagline length are adjusted separately relative to the predicted virtual axis,

e) retrieving at least one first tagline length information from a first measuring device and at least one second tagline length information from a second measuring device in the next load position,

f) analysing the first tagline length information and second tagline length information relative to each other to determine an offset value for each of the first and second tagline length, and comparing the offset values to the predicted virtual axis related to a current load position,

g) calculating an offset correction of the first and second tagline length compared to each of the offset value based on the predicted virtual axis, such that when the load is moving towards a further load position having a further predicted virtual axis, each length of the respective taglines is adjusted relative to the predicted virtual axis,

such that the load is moved by controlling each length of the respective taglines in advance.

The invention presents a method which controls the orientation of a load relative to a hoist line of a crane with the use of taglines, such that the operation of lifting and lowering a load is done more quick and in a still safe manner. The method may be a speed controlling method. It shall be understood that by a speed controlling method, the method relies on feedback information retrieved from the winch arrangement. The winch arrangement provides safe and precise control during lifting operations.

The control system is configured to control a winch arrangement. The winch arrangement is arranged relative to a crane system. The control system controls the position of a load during the lifting and lowering operation, based on prediction of information related to a predicted load position, relative to a virtual axis. When predicting the position of the load based on the position of the load relative to a virtual axis, the taglines are continuously varied in relation to the movement of the load during operation. The winch arrangement may control the motor, which drives the winch using a speed controlling method. The virtual axis may be substantially similar to a horizontal axis. The load may be controlled, such that the load may be in a predetermined load position relative to the virtual axis during operation, by controlling the taglines relative to each other. The lifting and lowering operation in a speed mode are performed such that the length of the taglines is corrected more rapidly, and thereby preventing the load to turn around the vertical axis in an uncontrolled manner. This provides a more agile manner, which at the same time prevents hazardous situations.

The winch arrangement is arranged relative to a crane system. The winch arrangement comprises a first winch, which is arranged in a first position relative to the crane system. The first winch may be arranged on or at the crane system. The first winch is configured to vary a length of the first tagline. The first winch may vary the first tagline, such that the first tagline extends from the first winch to a load. An extended end of the first tagline is attached to a first attachment point on the load. The winch arrangement also comprises a second winch, which is arranged in a second position relative to the crane system. The second winch is configured to vary a length of the second tagline. The second winch is configured to vary the second tagline, such that the second tagline extends from the second winch to the load, wherein the second tagline is attached to a second attachment point on a load. The second attachment point is different that the first attachment point.

A hoist line is attached to the load by hooking means configured to carry the load during operation. Each of the first and second taglines may be attached to each side of the load using attachment means for attachment to the respective attachment points during operation. The load is arranged in a first load position. The longitudinal direction of the hoist line may be substantially perpendicular to the virtual axis during operation or during part of the operation. The virtual axis may be recalculated during the operation.

The control system controls the winch arrangement using a speed controlling method. When using a speed controlling method instead of torque controlling method, it is not necessary to provide information related to the loads weight before handling the load. This reduces the entire operation time and thereby reduces the operation costs.

The control system may receive load movement information related to the loads predicted performance. The control system controls the position of a load during the lifting and lowering operation based on prediction of information related to a predicted load movement information relative to a virtual axis. When predicting the position of the load based on the position of the load relative to a virtual axis, the taglines are continuously varied in relation to the movement of the load during operation. The load may be controlled, such that the load may be in a predetermined load position relative to the virtual axis, and to the load movement information during operation, by controlling the taglines relative to each other. The lifting and lowering operation in a speed mode are performed, such that the length of the taglines is corrected more rapidly with the use of speed control.

The load movement information is provided to the control system and further, if present, information related to the crane system is provided to the control system and winch parameters may be defined. Parameters, such as the length of each of the taglines from the winch to the load, the drums diameter, the rope length when rolling the rope in or out etc. The load movement information may comprise information related to a loads shape, size and/or weight of the load. The load movement information may comprise information related to aerodynamic properties of the load. The load movement information may also comprise information related to the movement of the load when affected by external influences, such as weather condition and/or the movement of the crane system. The load movement may be calculated using a load prediction algorithm, or a load model based on a load prediction algorithm. The load model may be based on a machine learning model. Alternatively, the prediction of load movement may be based on at least one previous movement. The movement of the load may be predicted during operation, and may therefore be controlled based on the predicted movement based one the previous movements. The tagline may be varied in advance, and thereby adjusting the load’s position based on the load’s predicted position relative to the virtual axis. This may reduce operation time for lifting and lowering a load, when the load can be kept stable during the operation.

When predicting the load movements relative to a next load position, the present first tagline information is received from the first measuring device, and present second tagline information is received from said second measuring device. The measuring devices may each comprise an encoder, wherein the information regarding the drum rotation and length of the tagline may be derived. The first tagline information and second tagline information are analysed relative to a next load position of the load. The first tagline information and the second tagline information may be analysed relative to the load movement information, based on an offset value retrieved from each of the first and second tagline information. The control of each of the first and second winch is performed, such that each of the first and second tagline length are adjusted separately relative to the load movement information. The tagline lengths are prepared to reach the corrected length fitted for the load in a next load position, while moving the load toward the next load position. The first tagline length information and second tagline length information are analysed relative to each other to determine the offset value, and comparing the offset value to the load movement information related to a current load position. The load is kept in an optimal load position relative to the virtual axis by controlling each length of the respective taglines relative to the next load position, while moving the load along the vertical axis, thereby ensure stability during operation.

A first and a second corrected tagline length of the respective first and second tagline may be calculated based on the first and second tagline information relative to the load movement information related to the next load position. When determening an offset value and comparing the offset value to the load movement information related to a current load position, the next load position is predicted. The offset value may be determined relative to the first and second tagline length. If the first and second tagline length have the same length the offset value may be zero. If the first and second tagline length is different from each other, the offset value may be different from zero. The control system may calculate at least one offset correction of the first and second tagline length. The correction relates to each of the offset value based on the current virtual axis, such that when the load is moved towards a predicted load position having a predicted virtual axis, each length of the respective taglines is adjusted relative to the load movement information and to the predicted virtual axis. The load may be moved relative to the predicted virtual axis based on a predicted load movement information, by controlling each length of the respective taglines in advance. The offset value may be included in the load movement information. The offset value may define an offset angle between the load axis and the virtual axis. Each length of the respective taglines is controlled relative to the load movement information, such that the load is moving relative to the predicted virtual axis. Each load position is determined, such that the load is lifted or lowered substantially stepless during operation. Each step calculation is performed in real time or in steps of predetermined time intervals.

The stability of moving the load to the next load position may also be predicted and considered when providing an auxiliary information to the load movement information. The auxiliary information may comprise further adaptive information regarding the movement of the load, which may be useful during operation to avoid any hazardous situation. The auxiliary information may form part of a damping feedback loop. The auxiliary information may also be included in the load movement information.

In a further advantageous method of the invention, the method comprises a further act of repeating d) to h), while moving the load continuously relative to the predicted virtual axis and the correction based on the offset value.

Each of the first and second tagline has respective first and second tagline length relative to the load in the first load position. The predicted virtual axis may be calculated based on an algorithm, which is configured to continuously adapt the virtual axis to the position of the load during operation. The virtual axis, and thereby the position of the load may depend on the movement of the crane, and if needed the weather conditions during operation. The interval between each calculation may be predetermined. The interval between each calculation may depend on the lifting and lowering speed. The act of d) to h) may be repeated at least one time. The act of d) to h) may be repeated at least one time, preferably at least a plurality of times.

The winch system may be based on a position control using a virtual axis. The position control is performed using the speed controlling method. With a continuously predicted position of the load, it is possible to reduce the inertia in the system, which creates a more precise and faster positioning of the load, without the load and crane system being brought into oscillations and becoming unstable. The control system handles the load position of a load during lifting and lowering operation with reference to the position of the load in the horizontal axis. If the load is affected either by the crane itself or by external influences, the load position of the load is maintained more easily.

In a further advantageous method of the invention, the method comprises a further step of determining the next load position relative to an elevated position, such that each of the first and second tagline length are adjusted separately relative to the elevated position and the virtual axis.

The next load position may be based on the next elevated position when the load may be lifted or lowered. The first and second tagline length may be adjusted separately relative to the elevated position and the virtual axis.

In a still further advantageous method of the invention, the method comprises a further step of measuring a tension load using a first and a second tension load measuring device, wherein the first and second tagline information comprise a tension load value related to each of respective first and second tagline.

A tagline tension information for each of the first and second tagline may be retrieved, when measuring a tension load using a respective first and second tension load measuring device. Each of the tension load measuring device may be a tension load cell sensor or similar. The first and second load cell sensor measuring the tension load related to the first and second tagline during operation. The measurement may cause an alternative correction of the tagline length based on at least one tagline tension information. The tagline tension information may be comprised in the load movement information. Comparing the tagline tension information from the first and second tagline may provide at least one torque value for each of the first and second tagline. The torque value may be directly related to the movement of the load during operation. The torque value may indicate whether the load is moving as predicted, or the load is moving differently than predicted. If the load is moving differently than predicted, the torque value may be different than the value predicted, and load movement information may be recalculated to provide a more accurate prediction based on the load movement information. The reason why the load is moving differently than predicted may be caused by external influences, such as weather condition and/or the movement of the crane system. By measuring the tension load on each of the winches, the method may perform a more agile, quick, and steady operation.

In a still further advantageous method of the invention, the method comprises further acts of comparing each of the tagline's tagline tension information with a tagline tension limit value.

The tension load related to the each of the first and second tagline may be measured using operation. Each of the tagline tension information may comprise a tagline tension limit, which indicate a limitation for the maximum tension of the tagline. The tagline tension limit value may be comprised in the load movement information. If the tension load of the taglines reaches a predefined tension limit, the tagline or taglines will be loosed. The first and second tagline length may be recalculated based on new information or measurements. The updated load movement information may predict a need for damping of the load's movement, for example to reduce for pendulum movement of hanging loads, and thereby ensure stability during operation. A damping ratio, a stability level and/or a moving load velocity value may be comprised in the load movement information. The load's movement during operation may for example by calculated based on a damping ratio, a stability level and/or a moving load velocity value.

In a further advantageous method of the invention, the first and the second tagline length are determined based on crane system movement.

The method present controlling acts of handling the load with the use of taglines, wherein the load may hang from hoist line from a crane boom in a crane system. The load may be controlled, such that the load may be in a predetermined load position relative to the crane boom, by controlling the taglines relative to each other. The virtual axis may be in a predefined position to the crane boom. The operation hazard for lifting and lowering the load may be reduced, when controlling the operation based on prediction of the virtual axis related to the movement of the crane boom. Based on controlling the taglines relative to the predicted virtual axis, the crane system may perform a more quick and still safe lifting and lowering operation.

The first and second tagline length may be determined, or partly determined by and controlled relative to the length of the hoist line. The dependency between the taglines and the hoist line may be defined by a ratio. For example, the first and second winch are arranged on or near the crane base or the ground, and the hoist line's length is reduced, when lifting the load, the length of the respective first and second tagline may increase. If the hoist line's length is increased, when lowering the load, the length of the respective first and second tagline is reduced. The next position of the load may be defined by a predicted length of the hoist line from at least one previous length of the hoist line. The length of the respective first and second tagline may be increased or reduced based on the arrangement of the respective winches.

In a further advantageous method of the invention, wherein a load movement information is provided before lifting and lowering the load and if present, the load movement information comprises at least one ambient weather condition information

The load movement information may comprise at least one ambient weather condition information. The ambient whether condition information may comprise information related to wind speed. In addition to wind speed, it is crucial to account for the size and weight of the load and how high the load needs to be lifted. As wind speeds increase with height, it is also important to ensure that the crane may have a wind speed measuring device fitted on for example the tip of the boom to determine the wind speed. The measuring device may be an anemometer or similar. The measurement may alternatively be received from the external measurement devices. The crane system's movement may be measured in real time. The load movement may be affected by the external influences, such as the movement of the crane system, for example the crane boom. The predicted load movement information comprises at least one previous crane system movement. The predicted load movement information comprises a current crane system movement. The crane boom may move the load sideways. The crane system may by moving the load sideways causing the load to perform a pendulum movement while hanging from the hoist line. The predicted load movement information may predict the load's movement, and thereby predict the damping of the pendulum movement of hanging load. The load's movement caused by the crane system's movement may for example be damped by using a damping algorithm. The damping algorithm may reduce or preferably eliminate the oscillating swing of the load suspended from the hoist line on the crane boom with the use of the winch arrangement.

In a second aspect of the invention, a control system for controlling the orientation of a load during operation is provided, wherein the control system comprises a processing unit and at least one communication unit, and a retrieving unit, wherein the control system is configured to be in communication with a winch arrangement, wherein the control system is configured to receive at least one first tagline length information, and at least one second tagline length information related to the first and second tagline length, wherein the control system is configured to control the first and second tagline length based on a load movement information and an adaptive virtual axis, such that the load during operation is moving relative to an adaptive virtual axis, by controlling each length of the respective taglines with the use of a load movement information.

The control system is configured to perform a method for controlling the orientation of a load during operation. The control system comprises a processing unit, at least one communication unit, and a retrieving unit. The control system may be configured to be in communication with a crane system. The control system may comprise a full control system monitoring system. The control system may comprise or be comprised in a crane system. The control system may be configured to be in communication with a weather information system. The control system is configured to be in communication with a winch arrangement. The control system is configured to control the winch arrangement. The control system is configured to receive at least one first tagline length information, and at least one second tagline length information related to the first and second tagline length. The control system is configured to control the first and second tagline length based on a load movement information and an adaptive virtual axis, such that the load during operation is moving relative to an adaptive virtual axis, by controlling each length of the respective taglines with the use of a load movement information. The load is handled quickly relative to a crane in a precise and secure position during operation.

In an advantageous embodiment of the invention, the winch arrangement comprises at least one auxiliary line.

The winch arrangement may comprise at least one auxiliary line. The auxiliary may be controlled using an auxiliary winch. The first and second winch may be used as an auxiliary winch. The auxiliary winch or winches may be arranged on or at the crane system. The auxiliary winch is configured to vary a length of the auxiliary tagline. The auxiliary winch may vary the auxiliary tagline, such that the auxiliary tagline extends from the auxiliary winch to a load. An extended end of the auxiliary tagline is attached to an auxiliary attachment point on the load.

The first tagline, the second tagline and if present, the auxiliary tagline or taglines may be attached to the respective attachment points on the load. Each of the first, second and auxiliary taglines have respective first, second and auxiliary tagline length relative to the load in the first load position. A virtual axis is defined from the first, second and the auxiliary tagline lengths compared to each other relative to the load in the first load position. The second virtual axis for a next load position is relative to the load movement information. The load is moved to the next load position, such that a load axis is parallel to the virtual axis while controlling each of the first, second and auxiliary winch. Each of the first, second and auxiliary tagline lengths are adjusted separately relative to the load movement information and the second virtual axis.

At least one first, second and auxiliary tagline length information is retrieved from the respective first, second and auxiliary measuring devices. The first and second auxiliary tagline length information are analysed relative to each other to determine an offset value. The offset value is compared to the load movement information related to a current load position. An offset correction of the first, second and auxiliary tagline lengths is calculated. The control system is configured to move the load relative to an adaptive virtual axis, by controlling each length of the respective taglines based on the load movement information.

In a further advantageous embodiment of the invention, the winch arrangement comprises a first and a second tension load measurement device.

The winch arrangement comprises a first, a second and if present, an auxiliary tension load measurement device. The tension load measurement device may be a load cell sensor or similar.

This invention has now been explained with reference to a few embodiments and methods, which have only been discussed to illustrate the many varying possibilities achievable related to the winch control system, for handling a load related to a crane system, and a method for controlling the load during hoisting operation according to the present invention.

Brief description of the drawings

The embodiments of the invention are described in the following with reference to:

Fig. 1a,b:	Illustrating a first embodiment of a crane system.
Fig. 2a,b:	Illustrating a second embodiment of a crane system.
Fig. 3a,b,c:	Illustrating a third embodiment of a crane system carrying a load in a first position.
Fig. 4a,b,c:	Illustrating a fourth embodiment of a crane system carrying a load in an elevated position.
Fig. 5a,b:	Illustrating a load position in a crane system.
Fig. 6:	Showing a schematic diagram of a control system configured to control a winch arrangement.
Fig. 7:	Showing a detailed schematic diagram of a control system.

Fig. 8: Showing a workflow of controlling orientation of a load during operation.

In the explanations of the figures, identical or corresponding elements will be provided with the same designations in different figures. Therefore, no explanation of all details will be given in connection with each single figure/embodiment.

Detailed description

Embodiments of the invention are explained in the following detailed description. It is to be understood that the invention is not limited to its scope to the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or carried out in various ways.

Fig. 1a,b illustrates a first embodiment of a crane system. The crane system 1 comprise a crane boom 2, a hoist line 4, a crane boom top 10 and a crane base 11. The load 3 is hooked to a hoist line 4 with the use of a hooking device having hooking means for hooking on to the load 3. The crane system uses a winch arrangement. The winch arrangement comprises at least one first winch 9^1 with a first tagline 8^1 attached to a first side of the load 3, and at least one second winch 9^2 with a second tagline 8^2 attached to a second side of the load 3, wherein the second side is opposite the first side. The winch arrangement is fastened to the crane base 11 in front of the crane boom 2.

In fig. 1a, the load 3 is hanging from the hoist line 4 in a first load position. In fig. 1b, the load 3 is hanging from the hoist line 4 in a next load position. The first and second winch 9^1, 9^2 are arranged on the crane base 11. The hoist line's length has a predetermined length at the first load position. The hoist line extends from the crane boom top to the load 3. When lifting the load 3, the length of the respective first and second tagline 8^1, 8^2 increases, while the hoist line 4 is reduced. When the load 3 is lowered, the hoist line's 4 length is increased, while the length of the respective first and second tagline 8^1, 8^2 is reduced. The load 3 may be stabilised and supported with the use of the taglines 8^1, 8^2. The next position of the load may be defined by predicting the next length of respective first and second tagline 8^1, 8^2, from at least one previous length of the respective first and second tagline 8^1, 8^2 to a next length of respective first and second tagline 8^1, 8^2. Furthermore, the next position of the load may be defined by predicting the next length of the hoist line 4 from at least one previous length of the hoist line to a next length of the hoist line 4. The length of the respective first and second tagline 8^1, 8^2 may be increased or reduced based on the arrangement of the respective winches. The length of the respective first and second tagline 8^1, 8^2 may be increased or reduced, based on the position of the load 3 relative to the crane boom 10. The length of the first tagline 8^1 and the length of the second tagline 8^2 are analysed relative to each other to determine an offset value. By comparing the offset value to the load movement information related to a current load position, the position of the load 3 relative to the virtual axis can be determined. An offset correction of the length of the first and second tagline 8^1, 8^2 can be calculated, when compared to the offset value. The load 3 can be adjusted relative to the virtual axis, by controlling each length of the respective taglines 8^1, 8^2 relative to the load movement information. The first and second tagline length may be determined by and controlled relative to the length of the hoist line 4 as an alternative. The dependency between the taglines and the hoist line 4 may be defined by a ratio.

Fig. 2a,b illustrates a second embodiment of a crane system 1. In fig. 2a the load 3 is hanging from the hoist line 4 in a first load position. In fig. 2b, the load 3 is hanging from the hoist line 4 in a next load position. The second embodiment of the crane system 1 is substantially equal to fig. 1, wherein the second embodiment of the crane system 1 differs from the first embodiment in that, the first and second winch 9^1, 9^2 are arranged in a predetermined distance on opposite sides of the crane base 11. The hoist line's length has a predetermined length at the first load position. The hoist line 4 extends from the crane boom 10 top to the load 3.

Fig. 3a,b,c illustrates a third embodiment of a crane system 1 viewed from three different viewing angles. The load 3 is hanging from the hoist line 4 in a first load position d_1. The first and second winch 9^1, 9^2 are arranged on the crane base 11 in front of the crane boom 2. The hoist line's 4 length has a predetermined length, when the load is arranged in the first load position d_1. The hoist line 4 extends from the crane boom top 10 to the load 3. The length of the hoist line 4 is controlled by a winch 5. The hoist line winch 5 is arranged on the crane base 11 on the opposite side of the crane boom 2 relative to first and second winch 9^1, 9^2. Auxiliary lines 6,7 extend from the respective first and second winch 9^1, 9^2 to the crane boom top 10. The first and second winch may be used as an auxiliary winch. The taglines 8^1, 8^2 are used as auxiliary line 6,7, arranged such that the taglines 8^1, 8^2 via connecting means is adjustable wired relative to the auxiliary line 6,7. The lines used as taglines 8^1, 8^2 are arranged in a substantially horizontal position in an angle to the auxiliary line 6,7. The first and second winch 9^1, 9^2 handles the length of the respective first and second tagline 8^1, 8^2 via the auxiliary line 6,7.

Fig. 4a,b,c illustrates the third embodiment of a crane system carrying a load 4 in an elevated position. The elevated position of the load may be in a next position d_2. The crane system is explained in fig. 3a,b,c.

The hoist line 4 defines a vertical axis Z. The first and second tagline 8^1, 8^2 forms an axis X extending from the load 3 to a point between the connecting means, wherein the axis X is substantially perpendicular to the vertical axis Z. The axis Y is substantially perpendicular to the vertical axis Z, wherein the axis Y may be equal to the virtual axis. The axis Y may also be substantially perpendicular to the axis X.

Fig. 5a,b illustrates a load position in a crane system 1. The axis Y and the vertical axis Z may define a centre of rotation of the load, where the load may rotate relative to the vertical axis Z. L is related to the length of the first and second taglines. The first tagline length L_1 and the second tagline L_2 may be adjustable relative to each other, such that when the load lifted and lowered the length of the first tagline length L_1 and the second tagline L_2 is known in advance based on the load movement information. The first tagline length L_1 and the second tagline L_2 may be adjustable relative the load's 3 position relative to the virtual axis, such that the virtual axis is kept in an offset position substantially perpendicular to the axis X. The load may rotate Ψ relative to the vertical axis Z virtual axis. The load may move away from the offset position define by an offset point. The movement of the load may be predicted, such that the first tagline length L_1 and the second tagline L_2 can control the load and thereby ensuring a stabile movement.

Fig. 6 shows a schematic diagram of a control system comprising a control unit 21 configured to control a winch arrangement. The winch arrangement comprises a first winch 9^1, which is illustrated as a right winch, configured to vary a length of a first tagline 8^1, and a second winch 9^2, which is illustrated as a left winch, configured to vary a length of a second tagline 8^2.

A first motor 24^1 and a second motor 24^2 are configured to drive the respective first and second drum 23^1, 23^2 clockwise and counterclockwise, winding and unwinding the first and second tagline 8^1, 8^2. The control system 20 may use measuring devices 25^1,25^2, such as sensor or sensors, to retrieve information related to the respective first and second drum 23^1, 23^2. The sensors may both be of the type of encoder or similar. The first and second motor 24^1, 24^2 may each be driven by a driver unit 22^1, 22^2, in this example a type of frequency driver. The driver units 22^1, 22^2 receives each a respective signal a^1, b^1 from the sensor 25^1, 25^2. The driver units 22^1, 22^2 the drives the motors 24^1, 24^2 using a driving signal a^2, b^2. At least one further measuring device 26^1, 26^2, e.g., a sensor device, wherein an encoder may be a part of the sensor device, may be provided to measure the respective length of each of the taglines or as an alternative to the first and second measuring devices 25^1, 25^2.

The first and second winches 9^1, 9^2 may comprise a first and a second tension load measuring device, each having a sensor 27^1, 27^2. A tension load may be measured such that the first and second tagline information comprise a tension load value related to each of respective first and second tagline 8^1, 8^2. Each of the tagline's 8^1, 8^2 tagline tension information may be compared with a tagline tension limit value to ensure that the tension limit value is not exceeded.

Fig. 7 shows a detailed schematic diagram of a control system's 20 control unit 21 is configured to control a winch arrangement. Following explanation is a continuation of the explanation of the control system 20 in fig. 6.

Each of the driver units 22^1, 22^2 returns measured information a^8, b^8 related to the respective winches 9^1, 9^2. A processing unit 28 calculates a position for the predicted virtual axis, e.g., based on offset value for each of the first and second winch 9^1, 9^2. The offset value a^5, b^5 for each of the first and second winch 9^1, 9^2, and a position related to the predicted virtual axis c is then forwarded to the position regulating unit 29. The position regulating unit 29 compares the signals a^5, b^5, c, and calculates offset correction of the first and second tagline length 8^1, 8^2, compared to each of the offset value based on the current virtual axis, such that the load may move towards a predicted load position provided with a predicted virtual axis. Each of the offset correction a^6, b^6 are forwarded to the respective winch position regulation units 30^1, 30^2, which sends a speed command a^7, b^7 to the respective driver units 22^1, 22^2. The driver units 22^1, 22^2 then drives the winch motors 24^1, 24^2 using a driving signal a^2, b^2 adjusting the length of the first and second tagline length 8^1, 8^2.

Each length of the respective taglines is adjusted relative to the load movement information and to the predicted virtual axis. The load 3 may be moved substantially stepless relative to a predicted virtual axis and to the load movement information, by controlling each length of the respective taglines in advance 8^1, 8^2.

If the first and second winches 9^1, 9^2 comprises a first and a second tension load measuring device, a tension load may be measured and the signals a^4, b^4 are sent to the processing unit 28. Each of the tagline's 8^1, 8^2 tagline tension information may be compared with a tagline tension limit value to ensure that the tension limit value is not exceeded. If the tension limit value is exceeded, the tagline may be loosened to avoid any hazardous situations. The first and second measuring devices 26^1, 26^2 may be used for tagline length measurement, wherein the signals a^3, b^3 are sent to the processing unit 28 for calculation of each of the taglines respective length. The length of the taglines 8^1, 8^2 may then be adjusted accordingly to a predetermined adjustment sequence controlled by the control unit 21.

Fig 8 shows a workflow of controlling orientation of a load during operation based on speed control. The steps may be carried out in a different sequence, than described in this example.

a) A load in a first load position relative to the crane system. The load 3 is hooked to a hoist line 4, which is explained in fig. 1 to fig. 5.

b) The first tagline 8^1 and the second tagline 8^2 are attached to a first and a second attachment point on the load 3. Preferable in each side end of the load 3. Each of the first and second tagline 8^1, 8^2 has respective first and second tagline length relative to the load 3 in the first load position. The predicted virtual axis Y may be defined from the first and second tagline length, which may be compared to each other having substantially the same length in a first load position. Furthermore, the predicted virtual axis Y may be defined, and from the previous virtual axis related to the load in the previous load position.

c) The load movement information is provided, and the predicted virtual axis defined. The predicted virtual axis may be the next virtual axis of the next load position.

d) A predicted virtual axis may be determined based on predicted load movement information, the previous load movement information and the previous virtual axis.

e) The load is moved to the predicted load position by lifting or lowering the load 3 using a hoist line 4. The load axis is moved into a position substantially parallel to the predicted virtual axis, while controlling each of the first and second winch, such that each of the first and second tagline length are adjusted separately relative to the load movement information and the predicted virtual axis.

f) At least one first tagline length information is retrieved from a first measuring device 25^1, and at least one second tagline length information is retrieved from a second measuring device 25^2, while the load is arranged in the current load position.

g) The control system 20 analyses the first tagline length information and second tagline length information relative to each other to determine an offset value for each of the first and second tagline length. The control system 20 compares the offset values to the current virtual axis related to a current load position.

h) The control system 20 calculates an offset correction of the first and second tagline length compared to each of the offset value based on the current virtual axis, such that when the load 3 is moving towards a predicted load position having a predicted virtual axis, each length of the respective taglines is adjusted relative to the load movement information and to the third virtual axis. The load 3 is moved relative to a predicted virtual axis based on a predicted load movement information, by controlling each length of the respective taglines in advance. The control system may repeat act d) to h) at least one time. The control system may repeat act d) to h) at least a plurality of times.

PATENT CLAIMS

1. A method for controlling the orientation of a load (3) during operation, wherein a control system (20) is configured to control a winch arrangement to a crane system, wherein the winch arrangement comprises a first winch (9^1) configured to vary a length of a first tagline (8^1), and a second winch (9^2) configured to vary a length of a second tagline (8^2), characterized in that the method comprises the following acts:

a) placing the load (3) in a first load position (d_1),

b) attaching the first tagline (8^1) and the second tagline (8^2) to a first and a second attachment point on the load (3), such that each of the first and second tagline (8^1, 8^2) has respective first and second tagline length relative to the load (3) in the first load position (d_1), and determining a first virtual axis (Y) relative to the load (3) and to the first tagline (8^1) and the second tagline (8^2),

c) determine a predicted virtual axis for a next load position relative to the first virtual axis (Y),

d) moving the load (3) to the next load position (d_2) relative to the predicted virtual axis while controlling each of the first and second winch (9^1, 9^2), such that each of the first and second tagline length are adjusted separately relative to the predicted virtual axis,

e) retrieving at least one first tagline length information (a^1) from a first measuring device (25^1) and at least one second tagline length information (b^1) from a second measuring device (25^2) in the next load position,

f) analysing the first tagline length information (a^1) and second tagline length information (b^1) relative to each other to determine an offset value for each of the first and second tagline length, and comparing the offset values to the predicted virtual axis related to a current load position,

g) calculating an offset correction of the first and second tagline length compared to each of the offset value based on the predicted virtual axis, such that when the load (3) is moving towards a further load position having a further predicted virtual axis, each length of the respective taglines is adjusted relative to the predicted virtual axis,

such that the load is moved by controlling each length of the respective taglines in advance.

2. Method according to claim 1, wherein the method comprises a further act of repeating d) to h), while moving the load (3) continuously relative to the predicted virtual axis and the offset correction based on the respective offset values, when hoisting the load (3).

3. Method according to claim 1 or 2, wherein the method comprises a further step of determining the next load position relative to an elevated position, such that each of the first and second tagline length are adjusted separately relative to the elevated position and the predicted virtual axis.

4. Method according to claim 1, wherein the method comprises a further step of measuring a tension load using a first and a second tension load measuring device (27^1, 27^2), wherein the first and second tagline information comprise a tension load value related to each of respective first and second tagline (8^1, 8^2).

5. Method according to claim 3, wherein the method comprises further acts of comparing each of the tagline's tagline tension information with a tagline tension limit value.

6. Method according to any one of the preceding claims, wherein the first and the second tagline length are determined based on crane system movement.

7. Method according to any one of the preceding claims, wherein a load movement information is provided before lifting and lowering the load and if present the load movement information comprises at least one ambient weather condition information.

8. A control system for controlling the orientation of a load during operation, characterized in that the control system (20) is configured to perform the method acts according to claim 1-7, wherein the control system (20) comprises a processing unit

(28) and at least one communication unit, and a retrieving unit, wherein the control system (20) is configured to be in communication with a winch arrangement, wherein the control system (20) is configured to receive at least one first tagline length information and at least one second tagline length information related to the first and second tagline length, wherein the control system (20) is configured to control the first and second tagline length based on a load movement information and a predicted virtual axis, such that the load during operation is moving relative to the predicted virtual axis, by controlling each length of the respective taglines (8^1, 8^2) with the use of a load movement information.

9. Control system according to claim 8, wherein the winch arrangement comprises at least one auxiliary line (6,7).

10. Control system according to claim 8 or 9, wherein the winch arrangement comprises a first and a second tension load measurement device (27^1, 27^2).

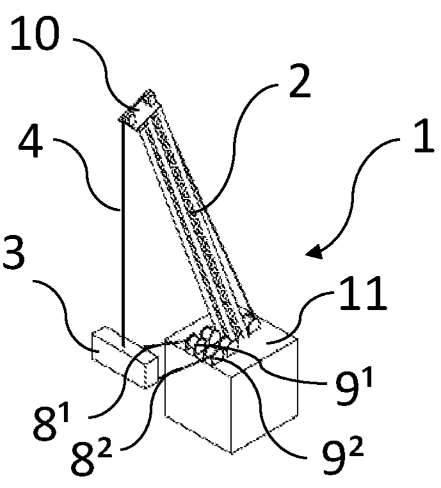

Fig. 1a

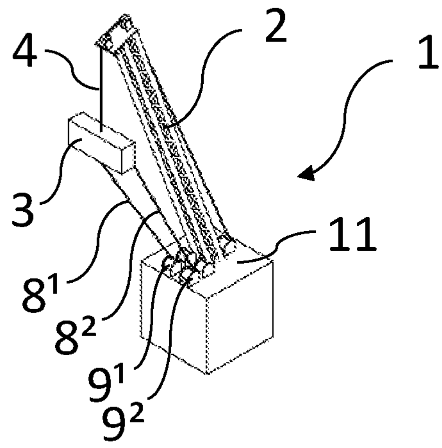

Fig. 1b

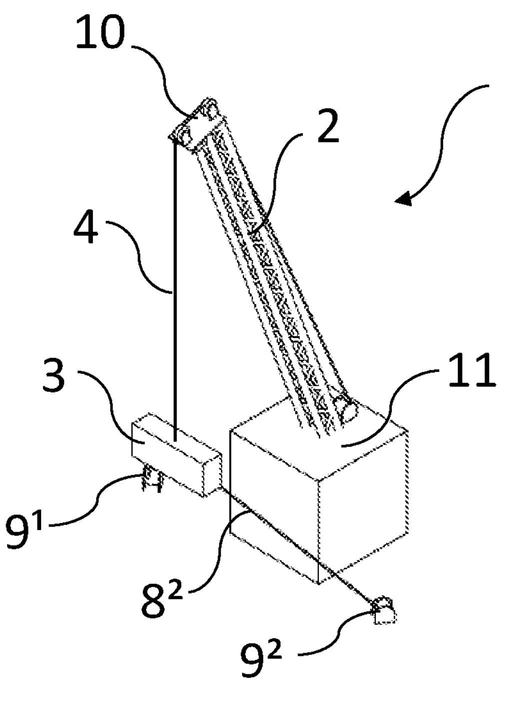

Fig. 2a

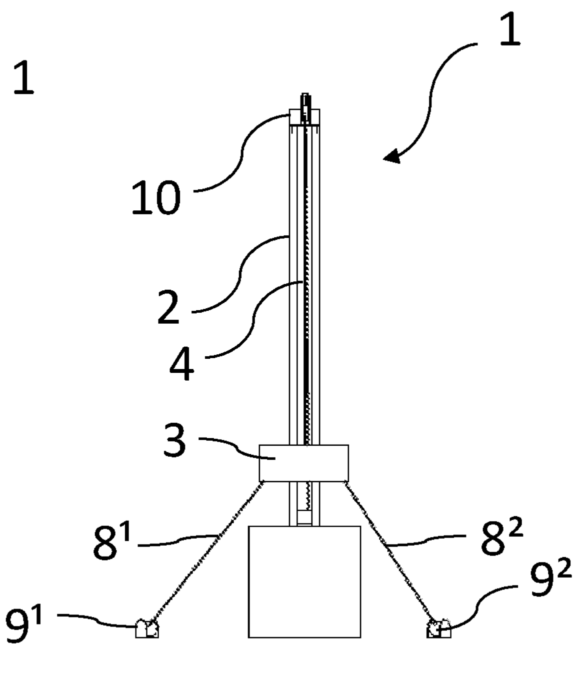

Fig. 2b

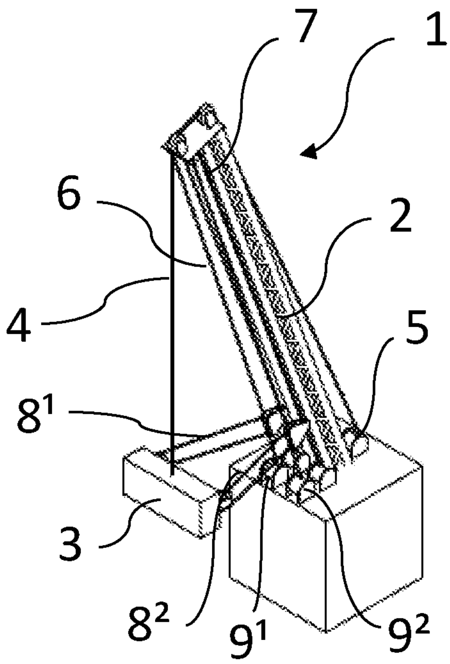

Fig. 3a

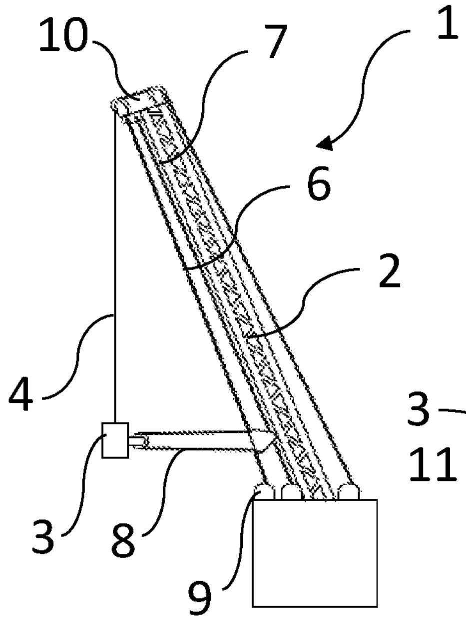

Fig. 3b

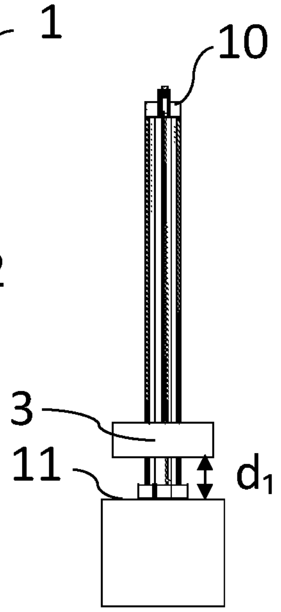

Fig. 3c

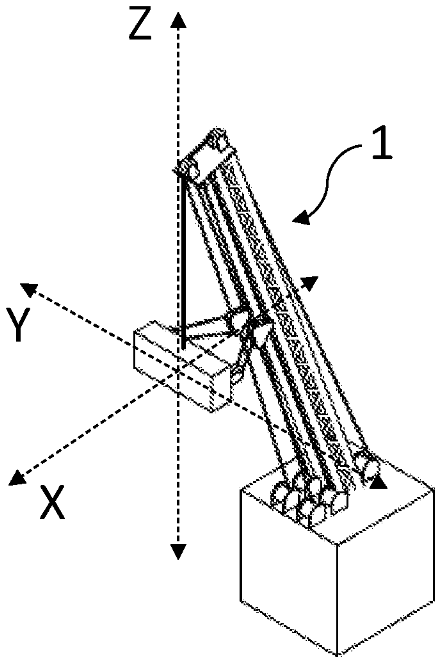

Fig. 4a

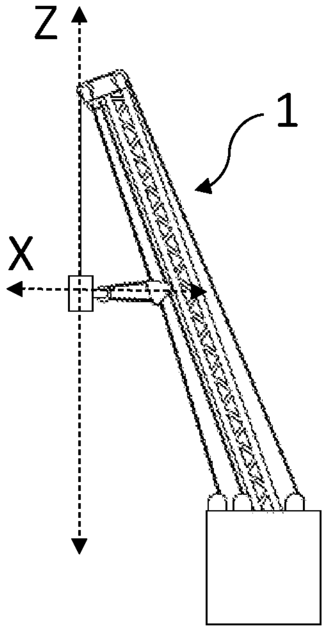

Fig. 4b

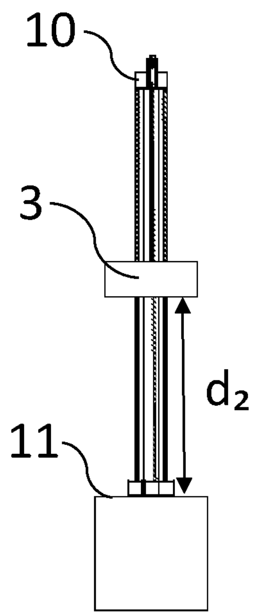

Fig. 4c

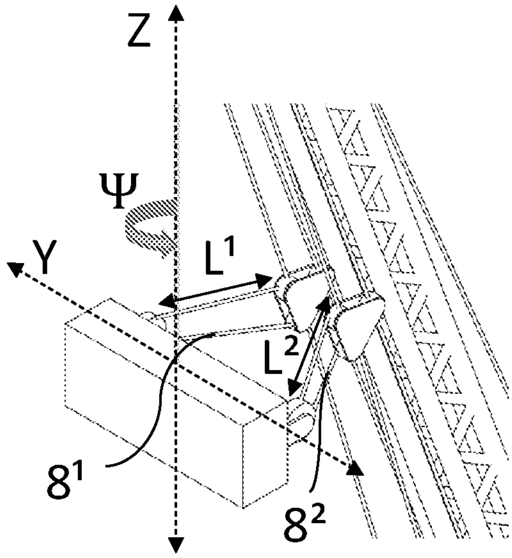

Fig. 5a

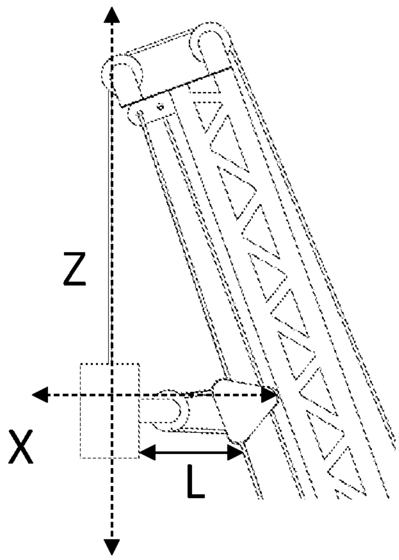

Fig. 5b

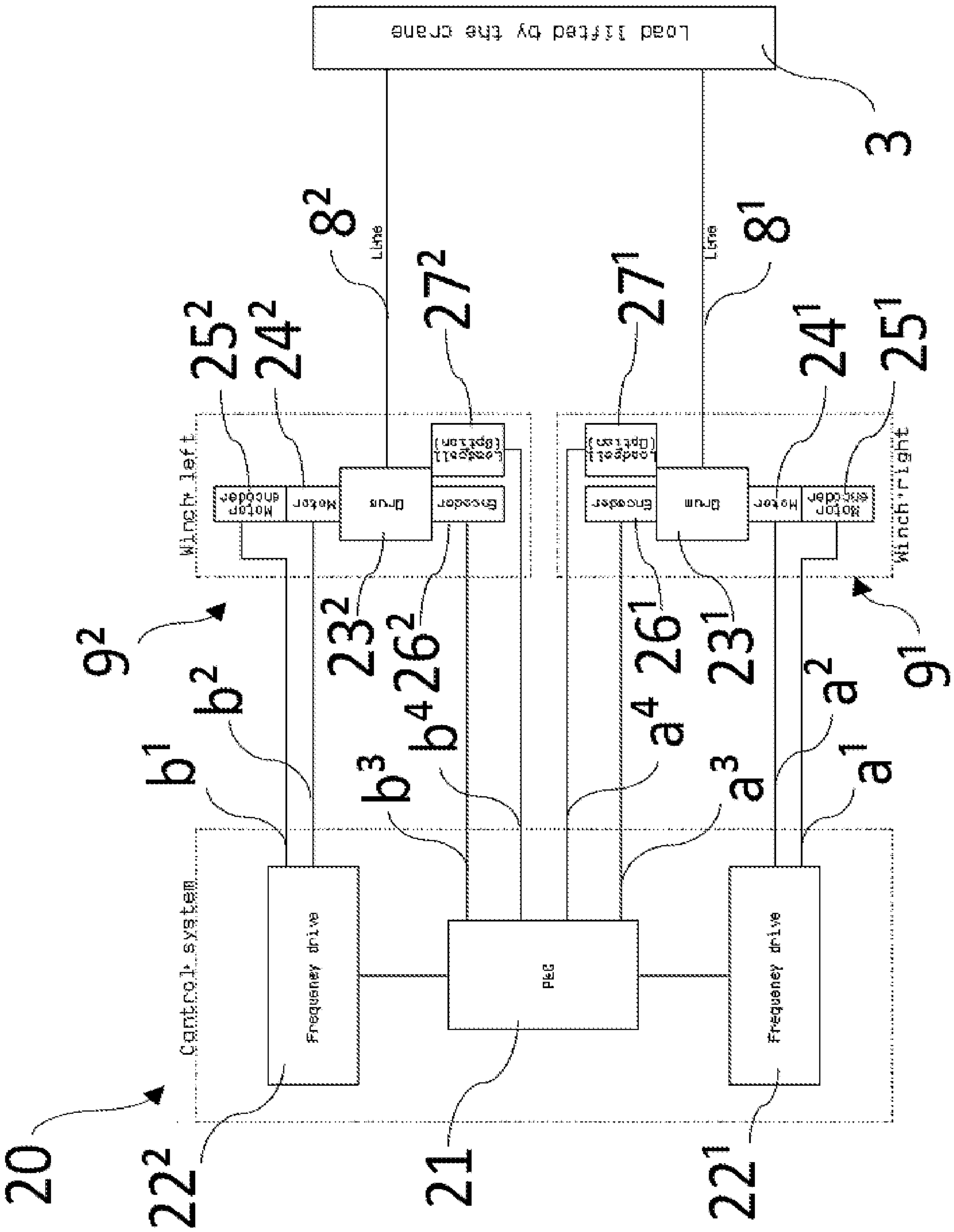
Load lifted by the crane
Line
Line
Winch left
Winch right
Motor encoder
Motor
Drum
Encoder
Loadcell (Option)
Control system
Frequency drive
PLC
Frequency drive
3
8^2
8^1
27^2
27^1
25^2
24^2
24^1
25^1
9^2
9^1
23^2
26^2
26^1
23^1
b^1
b^2
b^3
b^4
a^4
a^3
a^2
a^1
20
22^2
21
22^1

Fig. 6

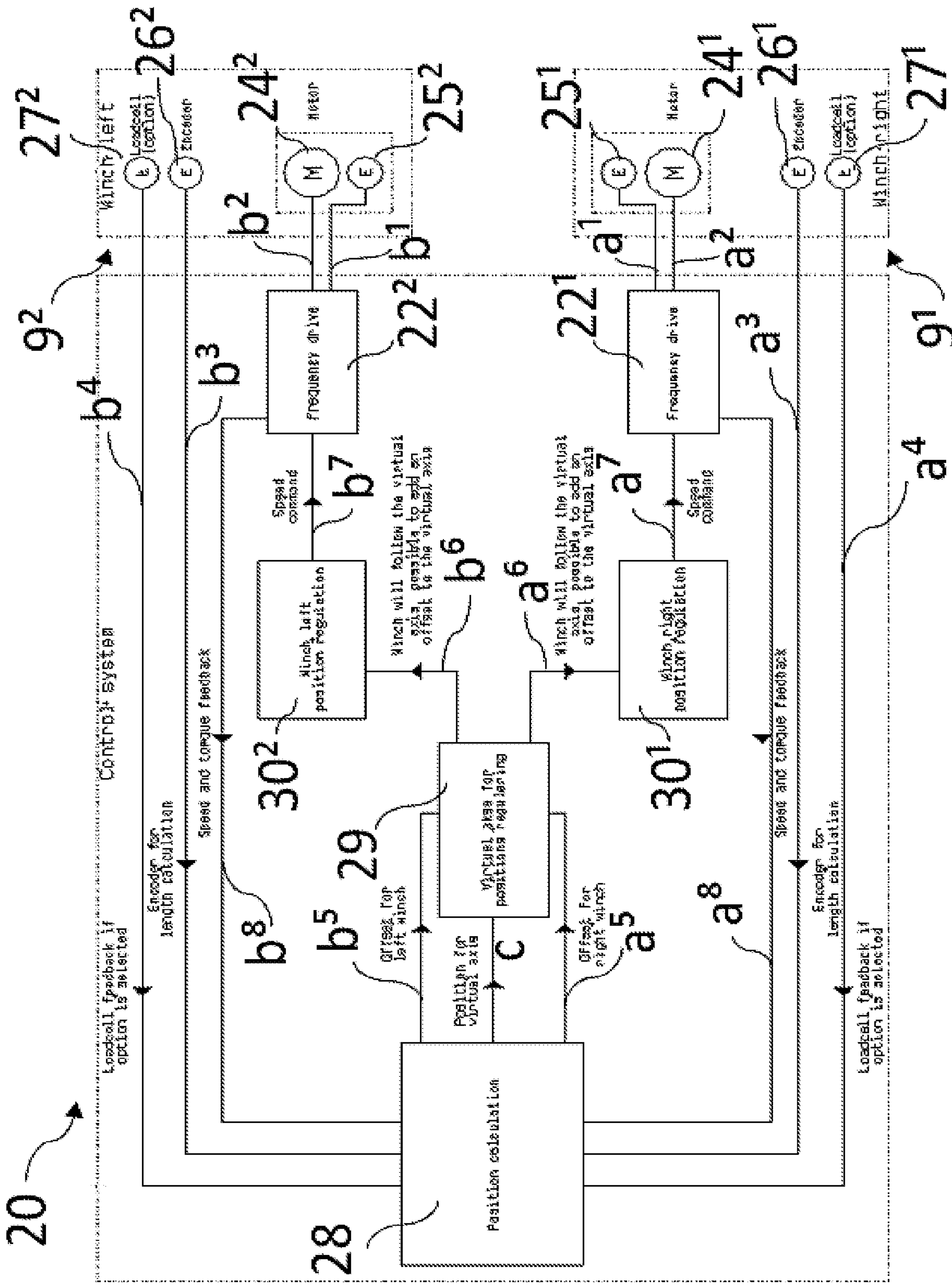
Control system
Position calculation
Virtual axis for positions regulating
Winch left position regulation
Winch right position regulation
Frequency drive
Frequency drive
Motor
Motor
M
E
Winch left
Winch right
Loadcell (option)
Encoder
Speed command
Speed command
Speed and torque feedback
Speed and torque feedback
Encoder for length calculation
Encoder for length calculation
Loadcell feedback if option is selected
Loadcell feedback if option is selected
Offset for left winch
Offset for right winch
Position for virtual axis
Winch will follow the virtual axis possible to add an offset to the virtual axis
Winch will follow the virtual axis possible to add an offset to the virtual axis
20
28
29
30^2
30^1
22^2
22^1
24^2
24^1
25^2
25^1
26^2
26^1
27^2
27^1
9^2
9^1
b^1
b^2
b^3
b^4
b^5
b^6
b^7
b^8
a^1
a^2
a^3
a^4
a^5
a^6
a^7
a^8
c

Fig. 7

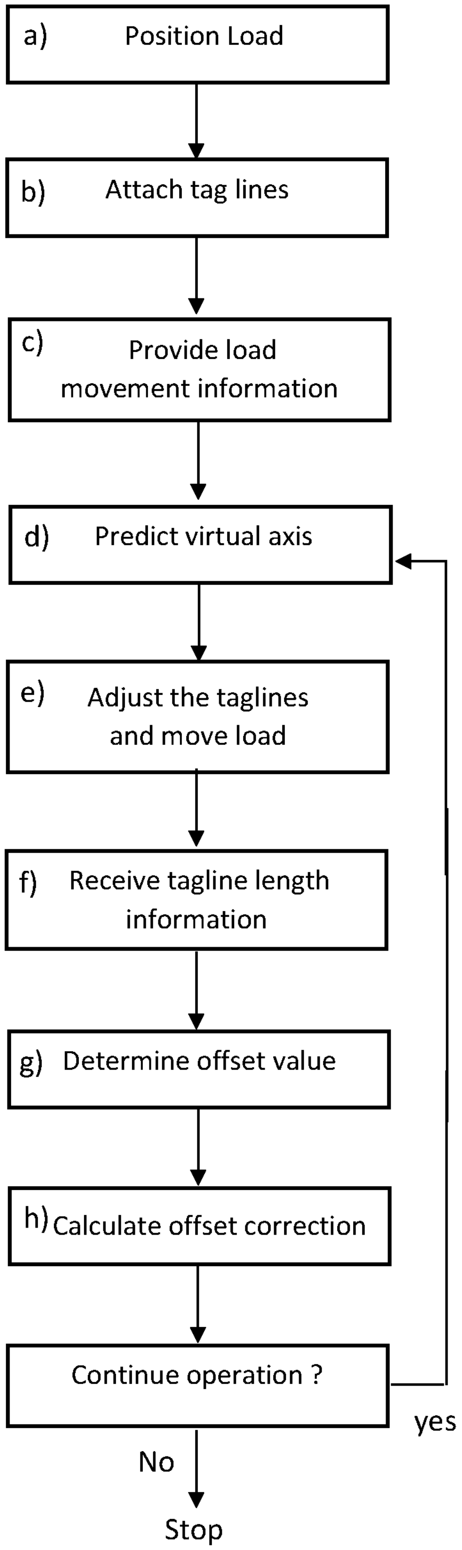
a) Position Load
b) Attach tag lines
c) Provide load movement information
d) Predict virtual axis
e) Adjust the taglines and move load
f) Receive tagline length information
g) Determine offset value
h) Calculate offset correction
Continue operation ?
yes
No
Stop

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/DK2024/050136

A. CLASSIFICATION OF SUBJECT MATTER
INV. B66C13/08
ADD.

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)
B66C

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2017/050824 A1 (FENGER PER E [DK]) 23 February 2017 (2017-02-23) paragraph [0002] paragraph [0011] paragraph [0018] - paragraph [0031] paragraph [0045] - paragraph [0047] paragraph [0049] - paragraph [0064] figures 1-5	1-10

☐ 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	Date of mailing of the international search report
27 August 2024	11/09/2024

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Serafeim, Athanasios

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/DK2024/050136

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2017050824 A1	23-02-2017	DK 201600255 A1	30-05-2016
		EP 3137407 A1	08-03-2017
		US 2017050824 A1	23-02-2017
		WO 2015165463 A1	05-11-2015