(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 276 048 A1

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

(43) Date of publication:
15.11.2023 Bulletin 2023/46

(21) Application number: **21918878.6**

(22) Date of filing: **14.07.2021**

(51) International Patent Classification (IPC):
B66C 13/48 (2006.01) ***B66C 13/16*** (2006.01)

(86) International application number:
PCT/CN2021/106256

(87) International publication number:
WO 2022/151683 (21.07.2022 Gazette 2022/29)

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

(30) Priority: **14.01.2021 CN 202110050727**

(71) Applicant: **Zhejiang Sany Equipment Co., LTD**
Huzhou, Zhejiang 313028 (CN)

(72) Inventors:
- **GUO, Song**
  Huzhou, Zhejiang 313028 (CN)
- **XIE, Jun**
  Huzhou, Zhejiang 313028 (CN)
- **SUN, Hao**
  Huzhou, Zhejiang 313028 (CN)
- **DING, Ping**
  Huzhou, Zhejiang 313028 (CN)
- **GUO, Yi**
  Huzhou, Zhejiang 313028 (CN)

(74) Representative: **Canzler & Bergmeier Patentanwälte Partnerschaft mbB**
Despag-Straße 6
85055 Ingolstadt (DE)

(54) CRANE SUPER-LIFTING RADIUS CONTROL METHOD, APPARATUS, AND CRANE

(57) A crane super-lifting radius control method and system, and a crane. The crane super-lifting radius control method comprises: obtaining physical state information of a boom frame and a super-lifting boom (11); receiving first input of a user; in response to the first input, determining a target super-lifting radius; and adjusting a super-lifting radius on the basis of the targe super-lifting radius and the physical state information when the physical state information of the boom frame and the super-lifting boom (11) is suitable for an adjustment to the super-lifting radius. According to the crane super-lifting radius control method and system, and the crane, upon determining that the boom frame and the super-lifting boom (11) are suitable for an adjustment to the super-lifting radius, an angle of the super-lifting boom (11) is automatically adjusted by combining the physical state information of the boom frame and the super-lifting boom (11) with the target super-lifting radius inputted by the user, and thus, the auto-adjustment to the super-lifting boom (11) can be implemented, the adjustment to the super-lifting radius is more accurate, and the efficiency is improved.

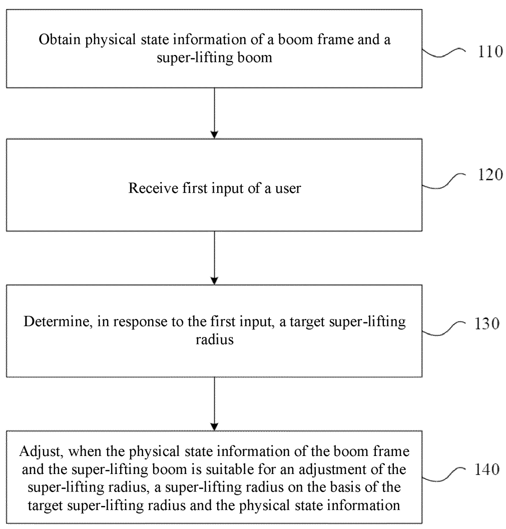

FIG. 1

EP 4 276 048 A1

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the priority of Chinese patent application No. 202110050727.0, filed on January 14, 2021, and entitled "CRANE SUPER-LIFTING RADIUS CONTROL METHOD, APPARATUS, AND CRANE", which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This application relates to the technical field of working machinery, and in particular to a crane super-lifting radius control method, an apparatus, and a crane.

BACKGROUND

[0003] For a crane with a super-lifting apparatus, if the rated load of the crane is to be changed, it is required to adjust the super-lifting radius in order to ensure the balance of the crane. For example, to lift a heavier article, it is required to increase the super-lifting radius.

[0004] At present, the typical way of adjusting the super-lifting radius is to manually operate the handles of the main luffing winch and the super-lift luffing winch at the same time, or to switch between the handles of the main luffing winch and the super-lift luffing winch. This requires a high operating level of the operator, which leads to inaccurate adjustment of the super-lifting radius and low efficiency of manual operation.

SUMMARY

[0005] This application provides a crane super-lifting radius control method, an apparatus, and a crane, in order to overcome the defects of inaccurate adjustment of super-lifting radius and low efficiency of manual operation in the prior art, so that the auto-adjustment of the super-lifting boom can be implemented, the adjustment of the super-lifting radius is more accurate, and the efficiency is improved.

[0006] This application provides a crane super-lifting radius control method. The crane super-lifting radius control method includes: obtaining physical state information of a boom frame and a super-lifting boom; receiving first input of a user; determining, in response to the first input, a target super-lifting radius; and adjusting, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0007] According to the crane super-lifting radius control method provided by this application, the physical state information includes a boom frame angle and a super-lifting boom angle, and the adjusting the super-lifting radius on the basis of the target super-lifting radius and the physical state information includes: controlling speeds of a main luffing winch and a super-lift luffing winch on the basis of the target super-lifting radius, the boom frame angle and the super-lifting boom angle to adjust the super-lifting radius.

[0008] According to the crane super-lifting radius control method provided by this application, the controlling the speeds of the main luffing winch and the super-lift luffing winch on the basis of the target super-lifting radius, the boom frame angle and the super-lifting boom angle to adjust the super-lifting radius includes: carrying out a PID adjustment on the speeds of the main luffing winch and the super-lift luffing winch of the crane while ensuring that the boom frame angle remains constant to adjust the super-lifting radius.

[0009] According to the crane super-lifting radius control method provided by this application, the crane further includes: a safety limit component, and the super-lifting radius control method further includes: confirming that the safety limit component detects a limit signal, and controlling the main luffing winch and the super-lift luffing winch to stop working.

[0010] This application further provides a crane super-lifting radius control system. The crane super-lifting radius control system includes: an obtaining module, configured to obtain physical state information of a boom frame and a super-lifting boom; a receiving module, configured to receive first input of a user; a determination module, configured to determine, in response to the first input, a target super-lifting radius; and an adjustment module, configured to adjust, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0011] This application further provides an electronic device, including a memory, a processor and a computer program stored in the memory and runnable in the processor. The processor, when executing the computer program, implements steps of the crane super-lifting radius control method according to any of the descriptions above.

[0012] This application further provides a non-transitory computer-readable storage medium, storing a computer program therein. The computer program, when executed by a processor, implements steps of the crane super-lifting radius control method according to any of the descriptions above.

[0013] According to the crane super-lifting radius control method provided by this application, upon determining that the boom frame and the super-lifting boom are suitable for an adjustment of the super-lifting radius, an angle of the super-lifting boom is automatically adjusted by combining the physical state information of the boom frame and the super-lifting boom with the target super-lifting radius inputted by the user, and thus, the auto-adjustment of the super-lifting boom can be implemented, the adjustment of the super-lifting radius is more accurate, and the efficiency is improved.

BRIEF DESCRIPTION OF DRAWINGS

[0014] In order to more clearly illustrate the technical solutions in this application or in the prior art, the accompanying drawings required to be used in the description of the embodiments or the prior art will be briefly described below. It is apparent that the accompanying drawings in the following description are only some embodiments of this application, and those of ordinary skill in the art can obtain other drawings according to these drawings without any creative work.

FIG. 1 is a schematic flowchart of a crane super-lifting radius control method according to this application;
FIG. 2 is a program block diagram of the crane super-lifting radius control method according to this application;
FIG. 3 is a schematic structural diagram I of a crane super-lifting radius control system according to this application;
FIG. 4 is a schematic structural view of a crane according to this application;
FIG. 5 is a schematic structural diagram II of the crane super-lifting radius control system according to this application; and
FIG. 6 is a schematic structural diagram of an electronic device according to this application.

[0015] Reference signs:

10: boom; 11: super-lifting boom; 12: luffing jib; 20: super-lift luffing winch; 21: main luffing winch; 30: boom angle sensor; 31: super-lifting boom angle sensor; 32: luffing jib angle sensor; 40: boom tension sensor; 41: luffing jib tension sensor;
42: boom back-stop pressure sensor; 43: super-lift back-stop pressure sensor; 50: boom upper limit position detection apparatus; 51: super-lifting boom lower limit position detection apparatus; 60: height limit apparatus; 61: off-ground detection apparatus; 70: super-lift counterweight; R1: super-lifting radius; R2: hook working radius.

DETAILED DESCRIPTION OF EMBODIMENTS

[0016] In order to make the objects, technical solutions and advantages of this application more clear, the technical solutions in this application will be clearly and completely described below with reference to the accompanying drawings in this application. It is apparent that the described embodiments are a part, rather than all of the embodiments of this application. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of this application without making creative efforts shall fall within the protection scope of this application.

[0017] A crane super-lifting radius control method, an apparatus, and a crane of this application will be described below in conjunction with FIG. 1 to FIG. 6.

[0018] As shown in FIG. 1 and FIG. 2, an embodiment of this application provides a crane super-lifting radius control method. The crane super-lifting radius control method includes: step 110 to step 140 as follows.

[0019] Step 110: Obtain physical state information of a boom frame and a super-lifting boom 11.

[0020] It can be understood that the crane may include a boom frame and a super-lifting boom 11. The boom frame may include a boom 10 and a luffing jib 12. A top of the boom 10 is provided with a hook. An article may be hung up by the hook. The super-lifting boom 11 is an apparatus that is arranged opposite to the boom 10 and functions as a balance. The super-lifting boom 11 is also known as a super-lifting mast. A counterweight is suspended at a top of the super-lifting boom 11. The counterweight, the super-lifting boom 11, the boom 10, the lifted article and other apparatuses of the crane can form a force balance.

[0021] The super-lifting radius is the length of the projection of the super-lifting boom 11 on the horizontal plane. The hook working radius R2 is the projection of the boom 10 and the luffing jib 12 (under the working condition that there exists a jib) on the horizontal plane, or the distance between the hook and the center of gyration of the crane. When the hook working radius R2 remains constant, if the weight of the article lifted by the hook is to be adjusted, the size of the super-lifting radius may be adjusted.

[0022] The luffing jib 12 may be selected according to the working condition of the crane.

[0023] Here, the physical state information of the boom frame and the super-lifting boom 11 may be obtained by means of a detection apparatus mounted on the boom frame and the super-lifting boom 11. The physical state information may include: a boom angle, a super-lifting boom angle, a luffing jib angle, a boom tension, a luffing jib tension, a boom back-stop pressure and a super-lift back-stop pressure. Particularly, the boom angle is an included angle between the boom 10 and the horizontal line. The super-lifting boom angle is an included angle between the boom 10 and the horizontal line. The luffing jib angle is an included angle between the luffing jib 12 and the horizontal line.

[0024] Step 120: Receive first input of a user.

[0025] It can be understood that the crane may receive the first input of the user. For example, the crane may have a display screen, and the user may give the first input by means of keys or a touch module according to a query window displayed on the display screen. For example, the query window displayed on the display screen may include: Please input a target super-lifting radius. The user may input the target super-lifting radius according to a prompt message of the query window.

[0026] Step 130: Determine, in response to the first input, a target super-lifting radius.

[0027] It can be understood that the target super-lifting radius can be obtained according to the first input of the user. The target super-lifting radius is the target value to which the user wants to adjust the super-lifting radius.

[0028] Step 140: Adjust, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0029] It can be understood that whether the boom frame and the super-lifting boom 11 are suitable for an adjustment of the super-lifting radius may be determined according to the physical state information of the boom frame and the super-lifting boom 11. For example, if the angle of the super-lifting boom 11 has reached the minimum value, the angle of the super-lifting boom 11 can no longer be reduced, so it is not suitable to increase the super-lifting radius. For another example, if the pressures of the boom frame and the super-lifting boom 11 have exceeded the limit values, it is also not suitable for an adjustment of the super-lifting radius. Only when the physical state information of the boom frame and the super-lifting boom 11 is suitable for an adjustment of the super-lifting radius, can the super-lifting radius be adjusted.

[0030] The physical state information of the super-lifting boom 11 may include the angle of the super-lifting boom 11. According to the angle of the super-lifting boom 11, an actual super-lifting radius of the super-lifting boom 11 can be calculated. According to a difference between the actual super-lifting radius of the super-lifting boom 11 and the target super-lifting radius, the super-lifting boom 11 can be adjusted to make the difference between the actual super-lifting radius and the target super-lifting radius smaller and smaller, that is, to make the actual super-lifting radius closer and closer to the target super-lifting radius.

[0031] Here, there is no need to manually adjust the angle of the super-lifting boom 11. Instead, by comparing the actual angle of the super-lifting boom 11 with the target angle of the super-lifting boom 11 corresponding to the target super-lifting radius, the super-lifting boom 11 is controlled to adjust the angle, so that the actual angle gradually approaches the target angle value, thereby implementing the auto-adjustment of the super-lifting radius.

[0032] According to the crane super-lifting radius control method provided by this application, upon determining that the boom frame and the super-lifting boom 11 are suitable for an adjustment of the super-lifting radius, an angle of the super-lifting boom 11 is automatically adjusted by combining the physical state information of the boom frame and the super-lifting boom 11 with the target super-lifting radius inputted by the user, and thus, the auto-adjustment of the super-lifting boom 11 can be implemented, the adjustment of the super-lifting radius is more accurate, and the efficiency is improved.

[0033] As shown in FIG. 2, in some embodiments, the physical state information includes a boom frame angle. The adjusting the super-lifting radius on the basis of the target super-lifting radius and the physical state information includes in step 140: controlling speeds of a main luffing winch 21 and a super-lift luffing winch 20 on the basis of the target super-lifting radius, the boom frame angle and the super-lifting boom angle to adjust the super-lifting radius.

[0034] It can be understood that the actual super-lifting radius can be calculated according to the super-lifting boom angle. The actual super-lifting radius is the product of the length of the super-lifting boom 11 and the cosine of the super-lifting boom angle. The actual super-lifting radius is compared with the target super-lifting radius. If the actual super-lifting radius is less than the target super-lifting radius, it is determined that the super-lifting boom 11 should move toward a direction in which the super-lifting radius increases, and at this time, the main luffing winch 21 may be controlled to wind and the super-lift luffing winch 20 may be controlled to unwind. If the actual super-lifting radius is greater than the target super-lifting radius, it is determined that the super-lifting boom 11 should move toward a direction in which the super-lifting radius decreases, and at this time, the main luffing winch 21 may be controlled to unwind and the super-lift luffing winch 20 may be controlled to wind.

[0035] Of course, the actual hook working radius R2 may also be calculated according to the boom frame angle. The actual hook working radius R2 is the product of the length of the boom frame and the cosine of the boom frame angle. When adjusting the super-lifting radius R1, it is required to ensure that the product of the actual hook working radius R2 and the gravity of the article on the hook is balanced with the product of the actual super-lifting radius and the gravity of the counterweight, thereby avoiding the risk of crane overturning in the process of adjusting the super-lifting radius.

[0036] As shown in FIG. 2, in some embodiments, the controlling the wind/unwind speeds of the main luffing winch 21 and the super-lift luffing winch 20 on the basis of the target super-lifting radius and the boom frame angle to adjust the super-lifting radius includes:

carrying out a PID adjustment on the speeds of the main luffing winch 21 and the super-lift luffing winch 20 of the crane while ensuring that the boom frame angle remains constant to adjust the super-lifting radius.

[0037] Here, the PID adjustment may be carried out on the speeds of the main luffing winch 21 and the super-lift luffing winch 20 of the crane while ensuring that the angle of the boom 10 in the boom frame remains constant to adjust the super-lifting radius.

[0038] Of course, there may be errors in actual operation. For example, in a case that the boom frame angle is 75 degrees, there may be an error of 0.1 degrees or even less. Here, the boom frame angle is allowed to change slightly within a certain error range.

[0039] It can be understood that when controlling the speeds of the main luffing winch 21 and the super-lift luffing winch 20, the boom frame angle can be kept constant, that is, while ensuring that the working radius of the hook remains constant. The PID adjustment is carried out on the speeds of the main luffing winch 21 and the super-lift luffing winch 20 of the crane, that is, only the super-lifting radius R1 is adjusted, while the hook working radius R2 is not adjusted.

[0040] For example, as shown in FIG. 2, upon determining that the physical state information is suitable for an adjustment of the super-lifting radius, an operating handle of the main luffing winch is controlled without considering the direction and amplitude of the operating handle. When the driver pushes the operating handle, it is equivalent to giving the PID system a signal to start adjustment. At this time, with the boom angle at the moment the auto-adjustment is activated, the PID adjustment is carried out on the speeds of the main luffing winch 21 and the super-lift luffing winch 20 of the crane. The main luffing handle can control the speed of the main luffing winch 21. The speed of the super-lift luffing winch 20 is controlled by the PID adjustment result. When the super-lifting radius is adjusted to the target super-lifting radius, the PID adjustment ends. The system stops the output of a proportional valve or a proportional pump. The display shows that auto-adjustment of the super-lifting radius has been completed. At this time, the operating handle returns to its neutral position.

[0041] As shown in FIG. 2 and FIG. 3, in some embodiments, the crane further includes: a safety limit component. The safety limit component is electrically connected to a controller. The safety limit component is configured to feed back a limit signal to the controller when recognizing the limit signal.

[0042] The super-lifting radius control method further includes: confirming that a limit signal is detected, and controlling the main luffing winch 21 and the super-lift luffing winch 20 to stop working.

[0043] It can be understood that the safety limit component may be connected to the boom 10, the super-lifting boom 11 or other apparatus of the crane, and can detect whether the boom 10, the super-lifting boom 11 or other apparatus has reached the limit position. When the boom 10, the super-lifting boom 11 or other apparatus has reached the limit position, the safety limit component detects the limit signal. At this time, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0044] As shown in FIG. 3 and FIG. 4, an embodiment of this application further provides a crane. The crane includes: a boom frame, a super-lifting boom 11, a super-lift luffing winch 20 and a main luffing winch 21.

[0045] Particularly, the boom frame and the super-lifting boom 11 are connected to the detection apparatus, and the detection apparatus is configured to detect physical state information of the boom frame and the super-lifting boom 11.

[0046] Here, the physical state information of the boom frame and the super-lifting boom 11 may be obtained by means of a detection apparatus mounted on the boom frame and the super-lifting boom 11. The physical state information may include: a boom angle, a super-lifting boom angle, a luffing jib angle, a boom tension, a luffing jib tension, a boom back-stop pressure and a super-lift back-stop pressure. Particularly, the boom angle is an included angle between the boom 10 and the horizontal line. The super-lifting boom angle is an included angle between the boom 10 and the horizontal line. The luffing jib angle is an included angle between the luffing jib 12 and the horizontal line.

[0047] The receiving apparatus is configured to receive first input of a user.

[0048] The crane may receive the first input of the user. For example, the crane may have a display screen, and the user may give the first input by means of keys or a touch module according to a query window displayed on the display screen. For example, the query window displayed on the display screen may include: Please input a target super-lifting radius. The user may input the target super-lifting radius according to a prompt message of the query window.

[0049] The controller, the detection apparatus, the receiving apparatus, the main luffing winch 21 and the super-lift luffing winch 20 are electrically connected to the controller.

[0050] The controller may be electrically connected to a power supply module of the crane, and the power supply module may supply power to the controller.

[0051] The controller is configured to control the speeds of the main luffing winch 21 and the super-lift luffing winch 20 on the basis of the first input and the physical state information to adjust a super-lifting radius.

[0052] It can be understood that the target super-lifting radius can be obtained according to the first input of the user. The target super-lifting radius is the target value to which the user wants to adjust the super-lifting radius.

[0053] Whether the boom frame and the super-lifting boom 11 are suitable for an adjustment of the super-lifting radius may be determined according to the physical state information of the boom 10 and the super-lifting boom 11. For example, if the angle of the super-lifting boom 11 has reached the minimum value, the angle of the super-lifting boom 11 can no longer be reduced, so it is not suitable to increase the super-lifting radius. For another example, if the pressures of the boom frame and the super-lifting boom 11 have exceeded the limit values, it is also not suitable for an adjustment of the super-lifting radius R1. Only when the physical state information of the boom frame and the super-lifting boom 11 is suitable for an adjustment of the super-lifting radius R1, can the super-lifting radius R1 be adjusted.

[0054] The physical state information of the super-lifting boom 11 may include the angle of the super-lifting boom 11. According to the angle of the super-lifting boom

11, an actual super-lifting radius of the super-lifting boom 11 can be calculated. According to a difference between the actual super-lifting radius of the super-lifting boom 11 and the target super-lifting radius, the super-lifting boom 11 can be adjusted to make the difference between the actual super-lifting radius and the target super-lifting radius smaller and smaller, that is, to make the actual super-lifting radius closer and closer to the target super-lifting radius.

[0055] Here, there is no need to manually adjust the angle of the super-lifting boom 11. Instead, by comparing the actual angle of the super-lifting boom 11 with the target angle of the super-lifting boom 11 corresponding to the target super-lifting radius, the super-lifting boom 11 is controlled to adjust the angle, so that the actual angle gradually approaches the target angle value, thereby implementing the auto-adjustment of the super-lifting radius R1.

[0056] According to the crane provided by this application, upon determining that the boom frame and the super-lifting boom 11 are suitable for an adjustment of the super-lifting radius, an angle of the super-lifting boom 11 is automatically adjusted by combining the physical state information of the boom frame and the super-lifting boom 11 with the target super-lifting radius inputted by the user, and thus, the auto-adjustment of the super-lifting boom 11 can be implemented, the adjustment of the super-lifting radius is more accurate, and the efficiency is improved.

[0057] As shown in FIG. 4, in some embodiments, the boom frame includes: a boom 10 and a luffing jib 12.

[0058] A top of the boom 10 is provided with a hook. An article may be hung up by the hook. The boom 10 may bear the gravity of the article. The detection apparatus is connected to the boom 10. The detection apparatus is configured to detect physical state information of the boom 10.

[0059] The luffing jib 12 may be located at a top end of the boom 10. The hook may be arranged on the luffing jib 12. The luffing jib 12 may be arranged according to the specific working condition of the crane. The detection apparatus is connected to the luffing jib 12. The detection apparatus is also configured to detect physical state information of the luffing jib 12.

[0060] As shown in FIG. 4, in some embodiments, the detection apparatus includes: a boom angle sensor 30, a super-lifting boom angle sensor 31 and a luffing jib angle sensor 32.

[0061] Particularly, the boom angle sensor 30 is arranged at the boom 10 and configured to detect an angle of the boom 10. The angle of the boom 10 may be an included angle between the boom 10 and the horizontal plane.

[0062] The super-lifting boom angle sensor 31 is arranged at the super-lifting boom 11 and configured to detect an angle of the super-lifting boom 11. The angle of the super-lifting boom 11 may be an included angle between the super-lifting boom 11 and the horizontal plane.

[0063] The luffing jib angle sensor 32 is arranged at the luffing jib 12 and configured to detect an angle of the luffing jib 12. The angle of the luffing jib 12 may be an included angle between the luffing jib 12 and the horizontal plane.

[0064] In some embodiments, the detection apparatus further includes: a boom tension sensor 40, a boom back-stop pressure sensor 42 and a super-lift back-stop pressure sensor 43.

[0065] Particularly, the boom tension sensor 40 is arranged at the boom 10 and configured to detect a tension borne by the boom 10.

[0066] The detection apparatus further includes a luffing jib tension sensor 41. The luffing jib tension sensor 41 is arranged at the luffing jib 12 and configured to detect a tension borne by the luffing jib 12.

[0067] The boom back-stop pressure sensor 42 is arranged at a boom back-stop cylinder of the crane and configured to measure a pressure of the boom back-stop cylinder.

[0068] The super-lift back-stop pressure sensor 43 is arranged at a super-lift back-stop cylinder of the crane and configured to detect a pressure of the super-lift back-stop cylinder.

[0069] As shown in FIG. 4, in some embodiments, the crane further includes: a safety limit component.

[0070] The safety limit component is electrically connected to the controller. The safety limit component is configured to feed back a limit signal to the controller when recognizing the limit signal. The controller is configured to control the main luffing winch 21 and the super-lift luffing winch 20 to stop working on the basis of the limit signal.

[0071] It can be understood that the safety limit component may be connected to the boom 10, the super-lifting boom 11 or other apparatus of the crane, and can detect whether the boom 10, the super-lifting boom 11 or other apparatus has reached the limit position. When the boom 10, the super-lifting boom 11 or other apparatus has reached the limit position, the safety limit component detects the limit signal. At this time, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0072] As shown in FIG. 4, in some embodiments, the safety limit component includes: a boom upper limit position detection apparatus 50.

[0073] The boom upper limit position detection apparatus 50 is connected to the boom 10 and configured to detect whether the boom 10 has reached an upper limit position. When the boom 10 has reached the upper limit position, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0074] As shown in FIG. 4, in some embodiments, the safety limit component includes: a super-lifting boom lower limit position detection apparatus 51.

[0075] The super-lifting boom lower limit position detection apparatus 51 is connected to the super-lifting boom 11 and configured to detect whether the super-lifting boom 11 has reached a lower limit position. When the super-lifting boom 11 has reached the lower limit position, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0076] In some embodiments, the safety limit component includes: a winch underwind protector.

[0077] Ropes of the main luffing winch 21 and the super-lift luffing winch 20 are connected to the winch underwind protector. The winch underwind protector is configured to detect whether the ropes have reached limit positions. The winch underwind protector is used for the last remaining protection of the winch ropes. When the rope has reached the limit position, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0078] As shown in FIG. 4, in some embodiments, the safety limit component includes: a height limit apparatus 60 and an off-ground detection apparatus 61.

[0079] The height limit apparatus 60 is connected to a rope at the head of the boom 10 and configured to detect whether the hook of the crane has reached a limit position. The height limit apparatus 60 may prevent the hook from being over-retracted. When the hook of the crane has reached the limit position, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0080] The off-ground detection apparatus 61 is connected to a super-lift counterweight 70 of the crane and configured to detect whether the super-lift counterweight 70 has been off the ground. When the super-lift counterweight 70 has not been off the ground, if the main luffing winch 21 and the super-lift luffing winch 20 continue working, a risk may be raised. At this time, the main luffing winch 21 and the super-lift luffing winch 20 are controlled to stop working.

[0081] As shown in FIG. 3, in some embodiments, the receiving apparatus includes: a touch display screen. The touch display screen is electrically connected to the controller. The touch display screen is configured to receive first input of a user.

[0082] It can be understood that the user may perform a click operation on the touch display screen, and the touch display screen may recognize the click operation of the user, thereby receiving the first input of the user. The touch display screen may display virtual keys, and the user may input the target super-lifting radius by means of the virtual keys.

[0083] As shown in FIG. 5, the crane super-lifting radius control system provided by this application will be described below. The crane super-lifting radius control system described below may be cross-referenced to the crane super-lifting radius control method described above.

[0084] This application provides a crane super-lifting radius control system. The crane super-lifting radius control system includes: an obtaining module 510, a receiving module 520, a determination module 530 and an adjustment module 540.

[0085] The obtaining module 510 is configured to obtain physical state information of a boom frame and a super-lifting boom 11.

[0086] The receiving module 520 is configured to receive first input of a user.

[0087] The determination module 530 is configured to determine, in response to the first input, a target super-lifting radius.

[0088] The adjustment module 540 is configured to adjust, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0089] FIG. 6 shows a schematic diagram of the physical structure of an electronic device. As shown in FIG. 6, the electronic device may include: a processor 610, a communication interface 620, a memory 630 and a communication bus 640. Particularly, the processor 610, the communication interface 620 and the memory 630 communicate with each other through the communication bus 640. The processor 610 may invoke logic instructions in the memory 630 to execute the crane super-lifting radius control method. The method includes: obtaining physical state information of a boom frame and a super-lifting boom; receiving first input of a user; determining, in response to the first input, a target super-lifting radius; and adjusting, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0090] In addition, the logic instructions in the memory 630 may be implemented in the form of software functional units, and may be stored in a computer-readable storage medium when they are sold or used as independent products. Based on such an understanding, the technical solutions of this application essentially, or the part contributing to the prior art, or the part of the technical solutions may be implemented in the form of a software product. The computer software product is stored in a storage medium and includes several instructions for enabling a computer device (which may be a personal computer, a server, a network device, or the like) to execute all or part of the steps in the method described in the embodiments of this application. The foregoing storage medium includes: a USB flash disk, a mobile hard disk, a read-only memory (ROM), a random access memory (RAM), a magnetic disk, an optical disk, or any medium that can store program codes.

[0091] In another aspect, this application further provides a computer program product. The computer program product includes a computer program stored in a non-transitory computer-readable storage medium. The computer program includes a program instruction. When the program instruction is executed by a computer, the computer can execute the crane super-lifting radius control method according to the descriptions above. The method includes: obtaining physical state information of a boom frame and a super-lifting boom; receiving first input of a user; determining, in response to the first input, a target super-lifting radius; and adjusting, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0092] In still another aspect, this application further provides a non-transitory computer-readable storage medium, storing a computer program therein. The computer program, when executed by a processor, implements the crane super-lifting radius control method according to the descriptions above. The method includes: obtaining physical state information of a boom frame and a super-lifting boom; receiving first input of a user; determining, in response to the first input, a target super-lifting radius; and adjusting, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

[0093] The apparatus embodiments described above are only illustrative. The units described as separate components may or may not be physically separated, and the components displayed as units may or may not be physical units, that is, they may be located in one place, or may be distributed in a plurality of network units. Some or all of the modules may be selected according to actual needs to achieve the objectives of the solutions of the embodiments. Those of ordinary skill in the art can understand and implement it without creative work.

[0094] Through the description of the above implementations, those skilled in the art can clearly understand that the implementations can be implemented by means of software plus a necessary common hardware platform, and certainly can be implemented by hardware. Based on such an understanding, the above technical solution in essence or the part that contributes to the prior art can be embodied in the form of a software product, and the computer software product may be stored in a computer-readable storage medium such as a ROM/RAM, a magnetic disk or an optical disk, and includes several instructions configured to enable a computer device (which may be a personal computer, a server, a network device or the like) to execute the methods described in various embodiments or some parts of the embodiments.

[0095] Finally, it should be noted that the above embodiments are intended only to illustrate, but not limit the technical solutions of this application. Although this application has been described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that they can still modify the technical solutions described in the foregoing embodiments, or equivalently substitute some of the technical features. These modifications and substitutions do not make the essence of the corresponding technical solutions deviate from the spirit and scope of the technical solutions of the embodiments of this application.

Claims

1. A crane super-lifting radius control method, comprising:

   obtaining physical state information of a boom frame and a super-lifting boom;
   receiving first input of a user;
   determining, in response to the first input, a target super-lifting radius; and
   adjusting, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

2. The crane super-lifting radius control method according to claim 1, wherein the physical state information comprises a boom frame angle and a super-lifting boom angle, and the adjusting the super-lifting radius on the basis of the target super-lifting radius and the physical state information comprises:
   controlling speeds of a main luffing winch and a super-lift luffing winch on the basis of the target super-lifting radius, the boom frame angle and the super-lifting boom angle to adjust the super-lifting radius.

3. The crane super-lifting radius control method according to claim 2, wherein the controlling the speeds of the main luffing winch and the super-lift luffing winch on the basis of the target super-lifting radius, the boom frame angle and the super-lifting boom angle to adjust the super-lifting radius comprises:
   carrying out a PID adjustment on the speeds of the main luffing winch and the super-lift luffing winch of the crane while ensuring that the boom frame angle remains constant to adjust the super-lifting radius.

4. The crane super-lifting radius control method according to any of claims 1 to 3, wherein the crane further comprises: a safety limit component, and
   the super-lifting radius control method further com-

prises: confirming that the safety limit component detects a limit signal, and controlling the main luffing winch and the super-lift luffing winch to stop working.

5. A crane super-lifting radius control system, comprising:

an obtaining module, configured to obtain physical state information of a boom frame and a super-lifting boom;
a receiving module, configured to receive first input of a user;
a determination module, configured to determine, in response to the first input, a target super-lifting radius; and
an adjustment module, configured to adjust, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information.

6. An electronic device, comprising a memory, a processor and a computer program stored in the memory and runnable in the processor, wherein the processor, when executing the program, implements steps of the super-lifting radius control method according to any of claims 1 to 4.

7. A non-transitory computer-readable storage medium, storing a computer program therein, wherein the computer program, when executed by a processor, implements steps of the super-lifting radius control method according to any of claims 1 to 4.

8. A crane, comprising:

a boom frame, a super-lifting boom, a super-lift luffing winch and a main luffing winch;
a detection apparatus, the boom frame and the super-lifting boom being connected to the detection apparatus, and the detection apparatus being configured to detect physical state information of the boom frame and the super-lifting boom;
a receiving apparatus, the receiving apparatus being configured to receive first input of a user, and the first input comprising a target super-lifting radius; and
a controller, the detection apparatus, the receiving apparatus, the main luffing winch and the super-lift luffing winch being electrically connected to the controller, and the controller being configured to control speeds of the main luffing winch and the super-lift luffing winch on the basis of the target super-lifting radius and the physical state information to adjust a super-lifting radius.

9. The crane according to claim 8, wherein the boom frame comprises:

a boom, the detection apparatus being connected to the boom, and the detection apparatus being configured to detect physical state information of the boom; and
a luffing jib, the detection apparatus being connected to the luffing jib, and the detection apparatus being configured to detect physical state information of the luffing jib.

10. The crane according to claim 9, wherein the detection apparatus comprises:

a boom angle sensor, the boom angle sensor being arranged at the boom and configured to detect an angle of the boom;
a super-lifting boom angle sensor, the super-lifting boom angle sensor being arranged at the super-lifting boom and configured to detect an angle of the super-lifting boom;
a luffing jib angle sensor, the luffing jib angle sensor being arranged at the luffing jib and configured to detect an angle of the luffing jib;
a boom tension sensor, the boom tension sensor being arranged at the boom and configured to detect a tension borne by the boom;
a luffing jib tension sensor, the luffing jib tension sensor being arranged at the luffing jib and configured to detect a tension borne by the luffing jib;
a boom back-stop pressure sensor, the boom back-stop pressure sensor being arranged at a boom back-stop cylinder of the crane and configured to measure a pressure of the boom back-stop cylinder; and
a super-lift back-stop pressure sensor, the super-lift back-stop pressure sensor being arranged at a super-lift back-stop cylinder of the crane and configured to detect a pressure of the super-lift back-stop cylinder.

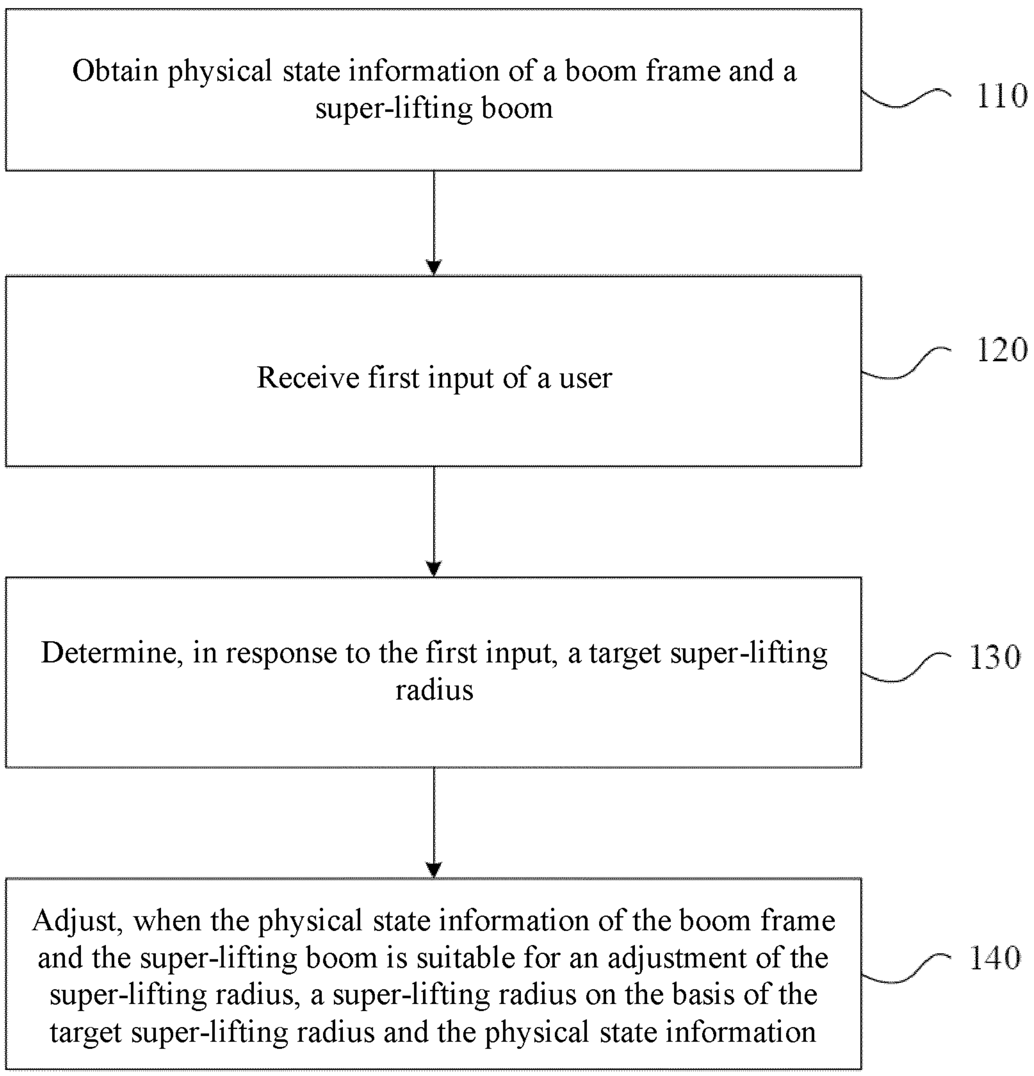
Obtain physical state information of a boom frame and a super-lifting boom
110
Receive first input of a user
120
Determine, in response to the first input, a target super-lifting radius
130
Adjust, when the physical state information of the boom frame and the super-lifting boom is suitable for an adjustment of the super-lifting radius, a super-lifting radius on the basis of the target super-lifting radius and the physical state information
140

FIG. 1


Start
Obtain a target super-lifting radius
Is the target super-lifting radius within an allowable range?
N
Y
Record a current boom angle
Is the target super-lifting radius Rs greater than an actual super-lifting radius Rc?
N
Is the target super-lifting radius Rs less than an actual super-lifting radius Rc?
N
Y
Y
Does the current condition allow an increase in the super-lifting radius?
N
Does the current condition allow a decrease in the super-lifting radius?
N
Y
Y
Operate an operating handle of a main luffing winch
Operate an operating handle of a main luffing winch
Carry out PID adjustment while ensuring that the boom angle remains constant
Carry out PID adjustment while ensuring that the boom angle remains constant
The main luffing winch winds and the super-lift luffing winch unwinds collaboratively
The main luffing winch unwinds and the super-lift luffing winch winds collaboratively
Stop and give an alarm indication
Y
Is there a safety protection or fault alarm?
Is there a safety protection or fault alarm?
Y
Stop and give an alarm indication
N
N
The super-lifting radius has reached the target super-lifting radius, and the operating handle of the main luffing winch returns to its neutral position
End

FIG. 2

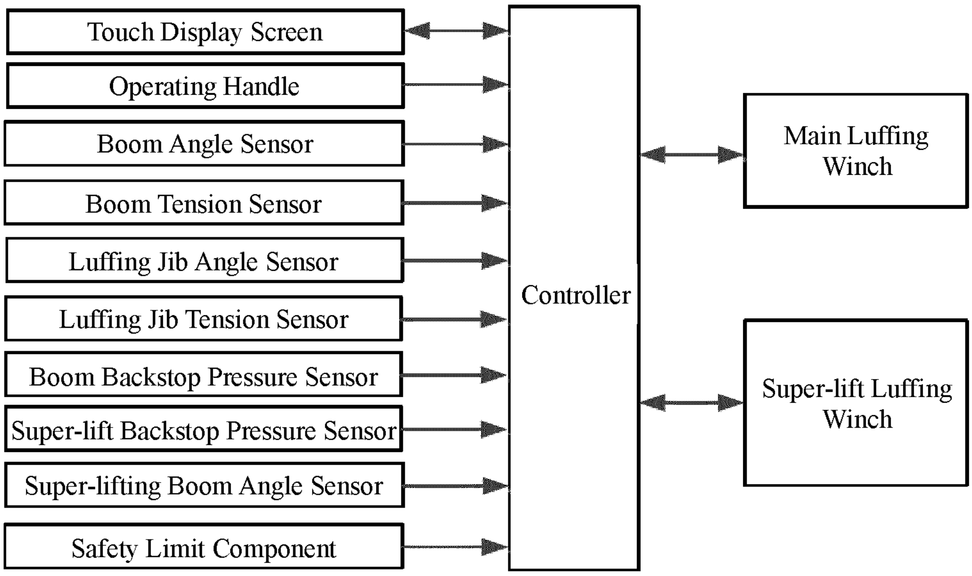
Touch Display Screen
Operating Handle
Boom Angle Sensor
Boom Tension Sensor
Luffing Jib Angle Sensor
Luffing Jib Tension Sensor
Boom Backstop Pressure Sensor
Super-lift Backstop Pressure Sensor
Super-lifting Boom Angle Sensor
Safety Limit Component
Controller
Main Luffing Winch
Super-lift Luffing Winch

FIG. 3

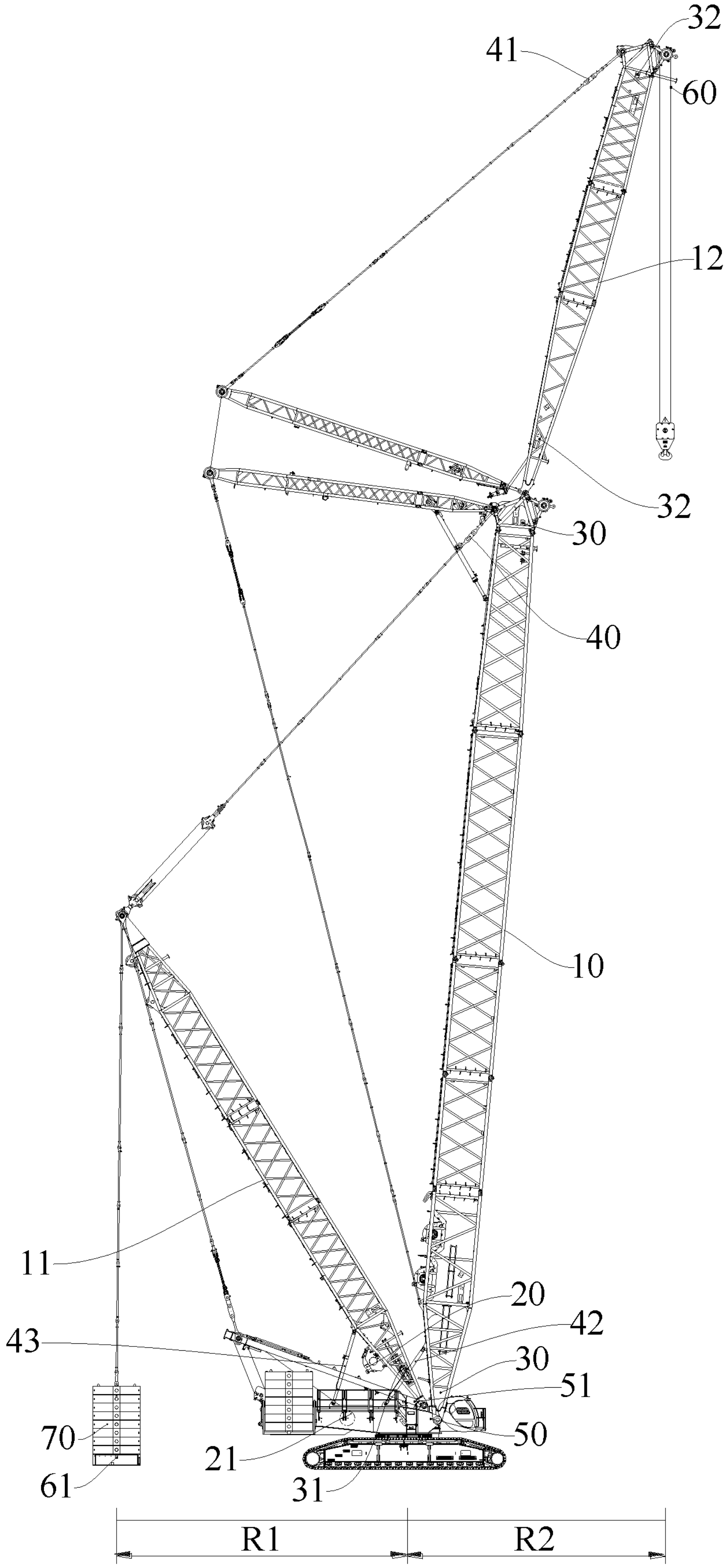

FIG. 4

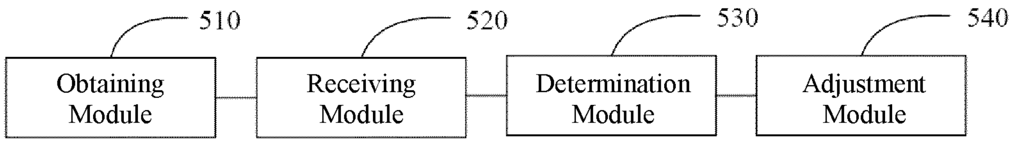
510
520
530
540
Obtaining Module
Receiving Module
Determination Module
Adjustment Module

FIG. 5

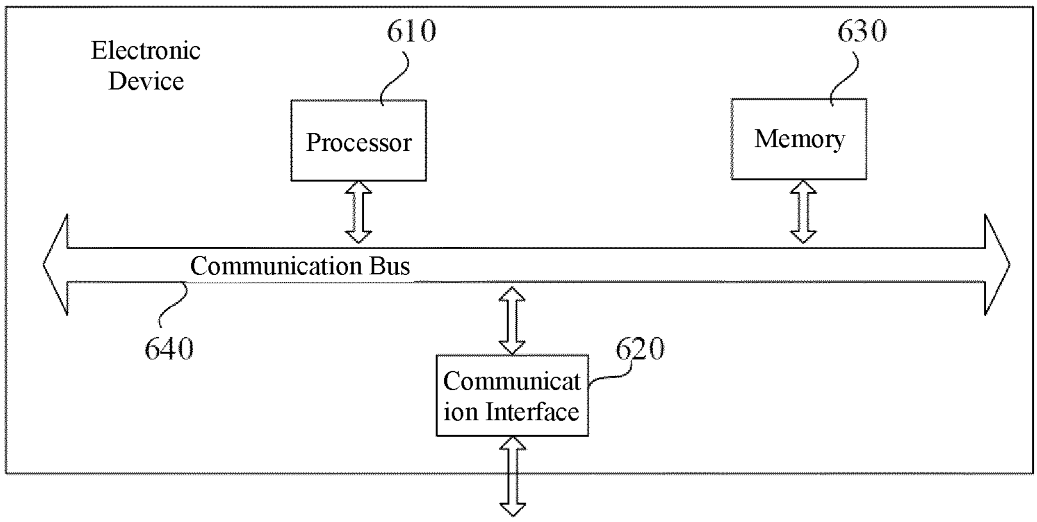
Electronic Device
610
630
Processor
Memory
Communication Bus
640
620
Communication Interface

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2021/106256**

A. CLASSIFICATION OF SUBJECT MATTER

B66C 13/48(2006.01)i； B66C 13/16(2006.01)i

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)

CNABS, CNTXT, VEN, CNKI, DWPI, SIPOABS, 起重机, 超起, 配重, 对重, 平衡重, 臂, 臂架, 控制, 变幅, 幅度, 半径, 工况; crane, superlift, counterweight, arm, mast, control

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 112723172 A (ZHEJIANG SANY EQUIPMENT CO., LTD.) 30 April 2021 (2021-04-30) claims 1-10	1-10
X	CN 103787197 A (XCMG CONSTRUCTION MACHINERY CO., LTD.) 14 May 2014 (2014-05-14) description, specific embodiments, and figures 1-3	1-3, 5-10
Y	CN 103787197 A (XCMG CONSTRUCTION MACHINERY CO., LTD.) 14 May 2014 (2014-05-14) description, specific embodiments, and figures 1-3	4
Y	CN 201598126 U (XUZHOU HEAVY MACHINERY CO., LTD.) 06 October 2010 (2010-10-06) Claims 1-6	4
X	CN 111348568 A (ZHEJIANG SANY EQUIPMENT CO., LTD.) 30 June 2020 (2020-06-30) description, specific embodiments, and figures 3-6	1-3, 5-10
Y	CN 111348568 A (ZHEJIANG SANY EQUIPMENT CO., LTD.) 30 June 2020 (2020-06-30) description, specific embodiments, and figures 3-6	4

☑ 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
23 September 2021	**20 October 2021**
Name and mailing address of the ISA/CN **China National Intellectual Property Administration (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China**	Authorized officer
Facsimile No. **(86-10)62019451**	Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2021/106256**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 211946021 U (ZHEJIANG SANY EQUIPMENT CO., LTD.) 17 November 2020 (2020-11-17) entire document	1-10
A	CN 102275837 A (SHANGHAI SANY TECHNOLOGY CO., LTD.) 14 December 2011 (2011-12-14) entire document	1-10
A	EP 1266861 A1 (DEMAG MOBILE CRANES GMBH & CO) 18 December 2002 (2002-12-18) entire document	1-10
A	WO 9936343 A1 (MANNESMANN AG et al.) 22 July 1999 (1999-07-22) entire document	1-10

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2021/106256

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	112723172	A	30 April 2021	None			
CN	103787197	A	14 May 2014	CN	103787197	B	23 September 2015
CN	201598126	U	06 October 2010	None			
CN	111348568	A	30 June 2020	None			
CN	211946021	U	17 November 2020	None			
CN	102275837	A	14 December 2011	CN	102275837	B	18 March 2015
EP	1266861	A1	18 December 2002	DE	10129022	A1	02 January 2003
				DE	50200134	D1	22 January 2004
				DE	10129022	B4	28 July 2005
				EP	1266861	B1	10 December 2003
				AT	256078	T	15 December 2003
WO	9936343	A1	22 July 1999	AU	3245599	A	02 August 1999
				DE	19802187	A1	22 July 1999
				DE	19802187	C2	25 November 1999

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

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- CN 202110050727 **[0001]**