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(54) METHOD FOR OPERATING WINCH AND ELECTRIC DRIVE FOR WINCH

(57) A method for operating a winch of a vessel and an electric drive for a winch, the winch comprising a rotatable winch drum (20) for spooling a spoolable medium (10), and an electric motor (30) to rotate the winch drum, wherein the electric drive (40) is configured to be operably coupled to the electric motor (30), and is configured to control, in response to a detected changing of a vertical position of the vessel (100), a length of the spoolable medium (10) between the winch drum (20) and a winched object (200) such that a magnitude of a change of a vertical position of the object (200) with respect to the reference vertical position resulting from the change of the vertical position of the vessel (100) with respect to the reference vertical position is reduced, thus providing active heave control.

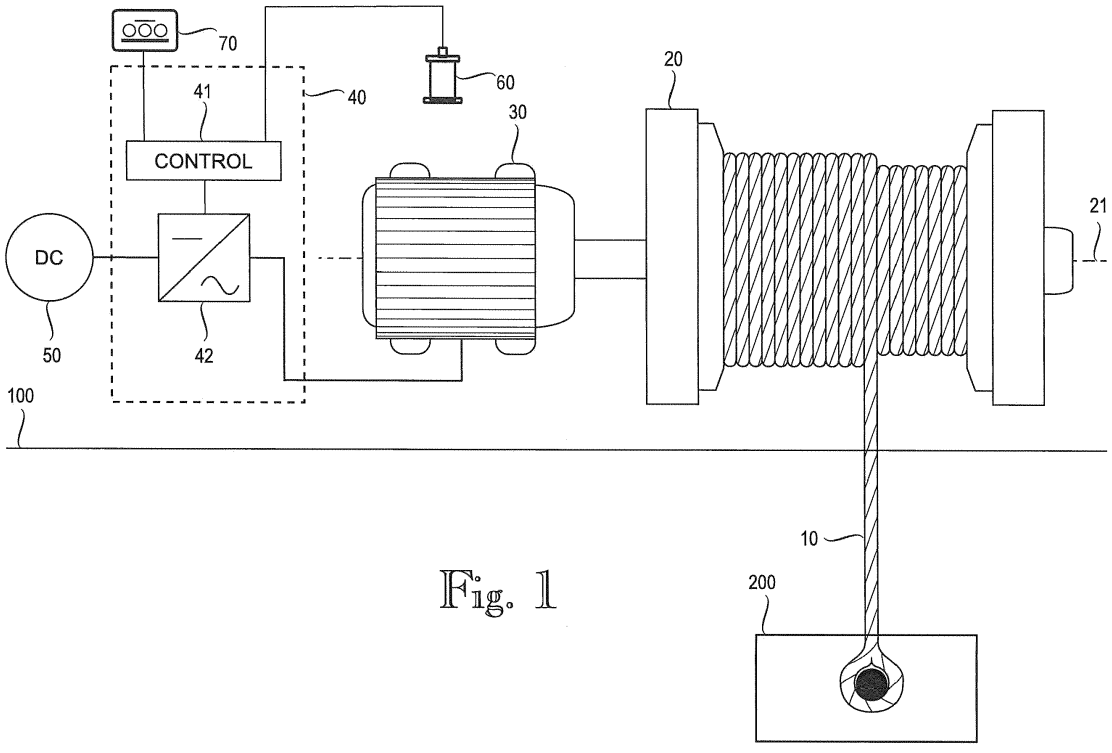

Fig. 1

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Description

FIELD OF THE INVENTION

[0001] The invention relates to operating a winch of a vessel, and to an electric drive for a winch of a vessel.

BACKGROUND OF THE INVENTION

[0002] Winches may be used in connection with many applications. An example is a winch of a vessel which can be used for lifting various objects, such as cargo or other kind of load, and/or keeping such objects in a steady position, for example. A winch of a vessel may comprise a winch drum rotatable about an axis and used for spooling a spoolable medium such as a cable, a rope, a wire or a chain, for example. An object to be winched is then connected to the spoolable medium. Such a winch may further comprise an electric drive and an electric motor, which is configured to rotate the winch drum about the axis of rotation thereof during spooling in or spooling out of the spoolable medium. The electric drive can be an AC drive or a DC drive and the electric motor can be an AC motor, such as an asynchronous motor or a synchronous motor, or a DC motor, respectively, for example.

[0003] The winch can control the length of the spoolable medium between the winch drum and the object to be winched by means of the electric drive. The electric motor can be controlled by the electric drive such that the length of the spoolable medium between the winch drum and the winched object connected to the spoolable medium is shortened (spooled in) or lengthened (spooled out) towards the desired length. And when the desired length of the spoolable medium between the winch drum and the winched object is reached, the spooling in or spooling out may be stopped. The electric motor of the winch may be controlled by the electric drive in a stepless way down to zero speed. The electrical motor may then stand still at zero speed of rotation and may hold essentially constant torque to keep the tension of the spoolable medium stable and thus support the winched object if desired. Thus, the winch may also be used for supporting the winched object in the air and/or in the water during the winching.

[0004] A problem related to the above solution is that a heave motion of the vessel caused by waves, for example, also affects the winch of the vessel and the winched object connected to the spoolable medium of the winch causing an up and down (vertical) movement to the winched object during the winching thereof. Such an additional movement of the winched object may impede the winching operation and cause a potential safety risk.

BRIEF DESCRIPTION OF THE INVENTION

[0005] The object of the invention is thus to provide a method and an apparatus for implementing the method so as to solve or at least alleviate the above problem. The object of the invention is achieved with a method, a computer program product, and an electric drive that are characterized by what is stated in the independent claims. Preferred embodiments of the invention are described in the dependent claims.

[0006] The invention is based on the idea of detecting by the electric drive a changing of a vertical position of the vessel with respect to a reference vertical position, and controlling by the electric drive, in response to the detected changing of the vertical position of the vessel, a length of the spoolable medium between the winch drum and the winched object such that a magnitude of a change of a vertical position of the object with respect to the reference vertical position resulting from the change of the vertical position of the vessel with respect to the reference vertical position is reduced.

[0007] An advantage of the invention is that the electric drive of the winch can compensate for the heave motion of the vessel, i.e. provide an active heave control, and thus increase the stability and safety of the winch.

BRIEF DESCRIPTION OF THE FIGURES

[0008] In the following, the invention will be described in more detail in connection with preferred embodiments with reference to the accompanying drawings, in which

Figure 1 illustrates a winch arrangement according to an embodiment; and
Figure 2 illustrates a diagram according to an embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0009] Figure 1 illustrates a simplified diagram of a winch arrangement of a vessel 100 according to an embodiment. Herein the term vessel refers to a ship, a boat, a raft or generally a craft designed for water transportation in a sea, an ocean, a lake, a river, a channel, a canal, or any parts thereof, for example. The vessel may be a floating vessel or an at least partly submersible vessel, for instance. The exemplary winch arrangement of Figure 1 can be used for winching one or more objects 200 connected to the spoolable medium 10, for example. The one or more objects 200 may include one or more lifting hooks or corresponding devices for lifting loads or other objects with the winch. The winching of the at least one object 200 may include moving and/or holding stationary the at least one object 200 to be winched. The figure only shows components necessary for understanding the various embodiments.

[0010] The exemplary winch arrangement comprises a winch drum 20 for spooling a spoolable medium 10, which winch drum is rotatable about an axis of rotation 21. The spoolable medium 10 may comprise a cable, a rope, a wire, a chain or a combination thereof, for example. In the example of Figure 1, the winch arrangement

further comprises an electric motor 30, which is operably coupled to the winch drum 20 such that the winch drum can be rotated with the electric motor 30. The electric motor 30 may be connected to the winch drum 20 directly or via one or more other components or devices, such as a gearbox (not shown in the figure). While the exemplary winch arrangement of Figure 1 comprises one electric motor 30 operably coupled to the winch drum 20, there could be more than one electric motors 30 operably coupled to the same winch drum 20 and configured to rotate the winch drum 20. In such a case, the two or more electric motors 30 may be configured to work together in a suitable manner for load sharing purposes, for example. The electric motor 30 driving the winch drum 20 can be of any type. Possible examples include an asynchronous AC motor, such as an induction motor, a synchronous AC motor, and a DC motor, for instance. Possible examples of the synchronous AC motor include non-excited motors, such as a reluctance motor, a hysteresis motor and a permanent magnet motor, and DC-excited motors, for example. It should be noted that the use of the embodiments described herein is not limited to systems employing any specific fundamental frequency or any specific voltage level, for example. The exemplary winch arrangement further comprises an electric drive 40, which in the example of Figure 1 comprises an inverter 42, for feeding the electric motor 30 from a DC power supply 50. An inverter is a device used, for instance, for controlling a motor. Herein 'inverter' generally refers to an electronic device or circuitry that is able to convert direct current to alternating current. An example of the inverter is a semiconductor bridge implemented by means of controllable semiconductor switches, such as IGBTs (Insulated-Gate Bipolar Transistor) or FETs (Field-Effect Transistor), which are controlled according to a modulation or control scheme used. The control of the electric motor 30 may be implemented reliably by means of the inverter 42 in such a manner that the motor 30 accurately implements a desired speed and/or torque instruction, for example. Examples of control methods for electric drives include frequency control, flux vector control and direct torque control, for example. The inverter 42 could also be a part of a frequency converter, for instance, and the electric drive 40 could then include a rectifier. In the exemplary embodiment of Figure 1, the electric drive 40 further comprises a control arrangement 41 of the electric drive 40, which may be used to control the inverter 42 and, thus, the electric motor 30 and to operate the winch. At least part of the functionality according to the various embodiments can be implemented by the control arrangement 41. The control arrangement 41 may be a separate unit or a part of the inverter 42 or some other unit, for example. The winch arrangement may comprise suitable I/O (Input-Output) means 70, such as a keyboard and display unit or another separate terminal unit, which may be connected to the control arrangement 41 of the electric drive 40 in a wired or wireless manner. Thus, an operator or a user of the winch arrangement can operate the winch through such I/O means 70, for instance. The I/O means 70 could be included in the electric drive 40 either alternatively or additionally. According to an embodiment, the electric drive 40, including at least the control arrangement 41 and the inverter 42, is realized as a single enclosure unit. Thus, the parts of the electric drive 40 may be integrated in a single enclosure, such as a cabinet. Figure 1 also illustrates a motion reference device 60 connected to the control arrangement 41 of the electric drive 40. According to an embodiment, such a motion reference device 60 may be included in the electric drive 40. According to an embodiment, the motion reference device may be any kind of device, which is preferably capable of determining at least a heave position (heave amplitude) of a heave motion of the vessel 100 where it is located, or a quantity indicative thereof. The heave position of the heave motion of the vessel 100 could be determined from roll angle and pitch angle information of the vessel 100, for instance. An example of such a motion reference device is a Motion Reference Unit (MRU), which is a solid-state device with single- or multi-axis motion sensors. The term roll angle generally refers to a rotational angle of a vessel about its longitudinal (front-back) axis. The term pitch angle in turn generally refers to a rotational angle of a vessel about its transverse (side-to-side) axis. An MRU may readily have an option to output a heave position signal (heave amplitude signal), which can then be used in connection with the various embodiments described herein. The heave position (amplitude) may be a value expressed in any unit of length (e.g. mm), for example.

[0011] Figure 2 illustrates an example of winching operation according to an embodiment. In the figure an object 200 connected to the spoolable medium 10 is being winched by the winch of the vessel 100 on the surface 310 of a body of water. The body of water can be a sea, an ocean, a lake, a river, a channel, a canal, or any parts thereof, for example. While in the figure the winched object 200 is shown fully submerged, it might be only partly submerged or fully above the surface 310 of the water. The example further shows a bottom 300 of a body of water below the vessel 100, such as seabed. The distance between the vessel and the bottom 300 of the body of water is d1 and the distance between the winched object 200 and the bottom 300 of the body of water is d2.

[0012] According to an embodiment, the winch of the vessel 100 can be operated as follows. During a winching of at least one object 200 connected to the spoolable medium 10, a length of the spoolable medium 10 between the winch drum 20 and the at least one object 200 to be winched, i.e. a pay-out length of the spoolable medium 10, may be controlled by using the electric drive 40 to suitably control the electric motor 30. Such winch control may be performed by a user or operator of the winch and/or automatically by the winch system depending on the winch operation being performed, for example. According to an embodiment, the control according to the various embodiments may be performed continuously by

the electric drive 40 during the winching of the object 200. It is also possible that the control according to the various embodiments may be deactivated and/or activated by a user or an operator of the winch system.

[0013] According to an embodiment, the operation of the winch of the vessel 100 comprises detecting by the electric drive 40 a changing of a vertical position of the vessel 100 with respect to a reference vertical position, and controlling by the electric drive 40, in response to the detected changing of the vertical position of the vessel 100, a length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 such that a magnitude of a change of a vertical position of the object 200 with respect to the reference vertical position resulting from the change of the vertical position of the vessel 100 with respect to the reference vertical position is reduced. As a result, an active heave compensation (AHC) can be provided by the electric drive 40. According to an embodiment, such controlling by the electric drive 40 may include spooling the spoolable medium 10 to such a direction, i.e. in or out, that a direction of a vertical movement of the object 200 caused by the spooling is opposite to a direction of a vertical movement of the object 200 caused by the changing of the vertical position of the vessel 100. Thus, when the spooling of the spoolable medium 10 causes the object 200 to move to an opposite direction to that caused by the vertical movement of the vessel, the magnitude of the resulting, i.e. total, change of the vertical position of the object 200 can be reduced. In addition, according to an embodiment, such spooling in or out of the spoolable medium 10 may be performed at a speed corresponding (e.g. as closely as possible) to a speed of the vertical movement of the object 200 caused by the respective changing of the vertical position of the vessel 100.

[0014] According to an embodiment, the length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 is controlled by the electric drive 40, in response to the detected changing of the vertical position of the vessel 100, such that the magnitude of the change of the vertical position of the object 200 with respect to the reference vertical position is reduced smaller than a magnitude of the respective change of the vertical position of the vessel 100 with respect to the reference vertical position. According to an embodiment, the length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 is controlled by the electric drive 40, in response to the detected changing of the vertical position of the vessel 100, such that the magnitude of the change of the vertical position of the object 200 with respect to the reference vertical position is reduced smaller than a predetermined fraction of a magnitude of the respective change of the vertical position of the vessel 100 with respect to the reference vertical position. The predetermined fraction of the magnitude of the changing of the vertical position of the vessel 100 may depend on the characteristics of the winch system and/or operating conditions, for instance. For example, system and measurement speed and accuracy may limit the ability of the winch system to compensate for the vertical displacement of the object 200 due to the heave motion of the vessel 100.

[0015] According to an embodiment, the reference vertical position may be defined by the bottom 300 of the body of water below the vessel 100 or by another vessel, for example. In the example of Figure 2, when using the bottom 300 of the body of water below the vessel 100 as the reference vertical position, distance d1 can be used to indicate the vertical position of the vessel 100 and distance d2 can be used to indicate the vertical position of the winched object 200. As an example, a magnitude of a change of the vertical position of the vessel 100 with respect to the reference vertical position observed during a time period may be indicated by a magnitude of a change in distance d1, $|\Delta d1|$, and the magnitude of a respective change of the vertical position of the object 200 with respect to the same reference vertical position observed during the same time period may be indicated by a magnitude of a change in distance d2, $|\Delta d2|$. Then, according to an embodiment, the length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 is controlled by the electric drive 40 during said time period such that $|\Delta d2| < |\Delta d1|$. According to an embodiment, the length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 is controlled by the electric drive 40 such that $|\Delta d2| < a|\Delta d1|$, where $0<a<1$.

[0016] According to an embodiment, the electric drive 40 is connected to a motion reference device 60 and the detecting of the changing of the vertical position of the vessel 100 with respect to the reference vertical position may be based on a signal received from the motion reference device by the electric drive 40. According to an embodiment, the signal indicates a heave position (amplitude) of the heave of the vessel 100. According to another embodiment, the electric drive 40 comprises a motion reference device 60 for detecting the changing of the vertical position of the vessel 100 with respect to the reference vertical position. Also in this case the motion reference device 60 within the electric drive 40 may produce a signal indicating the heave position (amplitude) of the heave of the vessel 100. According to an embodiment, the electric drive 40 is configured to control the length of the spoolable medium 10 between the winch drum 20 and the object 200 connected to the spoolable medium 10 by essentially following the heave position provided by the motion reference device 60. As a result, an active heave compensation based on heave position can be provided by the electric drive 40.

[0017] According to an embodiment, the electric drive may be further configured to control the tension of the spoolable medium between the winch drum 20 and the object 200 connected to the spoolable medium 10. Such

tension control may include a set tension limit value, which represents a maximum allowed tension for the spoolable medium between the winch drum 20 and the object 200 connected to the spoolable medium 10 such that the tension should be kept equal to or lower than the tension limit value. According to an embodiment, the tension of the spoolable medium 10 may be controlled by controlling a torque of the electric motor 30 or a quantity indicative of the torque of the electric motor 30. According to an embodiment, the torque of the electric motor 30 can be monitored or controlled by monitoring or controlling a current of the electric motor. According to an embodiment, the tension limit value, e.g. when settable by a user or an operator of the winch arrangement, may be represented by a motor torque % or a true force in kgs/lbs, for instance.

[0018] According to an embodiment, the winch arrangement of the tug 100 may be provided with an automatic overload protection system (AOPS) and/or manual overload protection system (MOPS). Such functionality may be provided by the electric drive 40. AOPS generally refers to a system that automatically safeguards and protects the winch against overload and over-moment during operation by allowing the hook of the winch to be pulled away from the winch in order to avoid significant damage. MOPS generally refers to a system, activated by the winch operator, protecting the winch against overload and over-moment by reducing the load-carrying capacity and allowing the hook to be pulled away from the winch. Term over-moment generally refers to a load moment which exceeds a maximum load moment (safe working load (SWL) multiplied by radius).

[0019] An apparatus implementing the control functions according to any one of the above embodiments, or a combination thereof, may be implemented as one unit or as two or more separate units that are configured to implement the functionality of the various embodiments. Here the term 'unit' refers generally to a physical or logical entity, such as a physical device or a part thereof or a software routine. One or more of these units, such as the control arrangement 41, may reside in the electric drive 40 or a component thereof, such as the inverter 42, for example.

[0020] An apparatus, such as the control arrangement 41, according to any one of the embodiments may be implemented at least partly by means of one or more computers or corresponding digital signal processing (DSP) equipment provided with suitable software, for example. Such a computer or digital signal processing equipment preferably comprises at least a working memory (RAM) providing storage area for arithmetical operations and a central processing unit (CPU), such as a general-purpose digital signal processor. The CPU may comprise a set of registers, an arithmetic logic unit, and a CPU control unit. The CPU control unit is controlled by a sequence of program instructions transferred to the CPU from the RAM. The CPU control unit may contain a number of microinstructions for basic operations. The implementation of microinstructions may vary depending on the CPU design. The program instructions may be coded by a programming language, which may be a high-level programming language, such as C, Java, etc., or a low-level programming language, such as a machine language, or an assembler. The computer may also have an operating system, which may provide system services to a computer program written with the program instructions. The computer or other apparatus implementing the invention, or a part thereof, may further comprise suitable input means for receiving e.g. measurement and/or control data, and output means for outputting e.g. control data. It is also possible to use a specific integrated circuit or circuits, or discrete electric components and devices for implementing the functionality according to any one of the embodiments.

[0021] The invention according to any one of the embodiments, or any combination thereof, can be implemented in existing system elements, such as electric drives or components thereof, such as inverters or frequency converters, or similar devices, or by using separate dedicated elements or devices in a centralized or distributed manner. Present devices for electric drives, such as inverters and frequency converters, typically comprise processors and memory that can be utilized in the functions according to embodiments of the invention. Thus, all modifications and configurations required for implementing an embodiment of the invention e.g. in existing devices may be performed as software routines, which may be implemented as added or updated software routines. If the functionality of the invention is implemented by software, such software can be provided as a computer program product comprising computer program code which, when run on a computer, causes the computer or corresponding arrangement to perform the functionality according to the invention as described above. Such a computer program code may be stored or generally embodied on a computer readable medium, such as suitable memory, e.g. a flash memory or a disc memory from which it is loadable to the unit or units executing the program code. In addition, such a computer program code implementing the invention may be loaded to the unit or units executing the computer program code via a suitable data network, for example, and it may replace or update a possibly existing program code.

[0022] It is obvious to a person skilled in the art that as technology advances, the basic idea of the invention can be implemented in a variety of ways. Consequently, the invention and its embodiments are not restricted to the above examples, but can vary within the scope of the claims.

Claims

1. A method for operating a winch of a vessel, the winch comprising a rotatable winch drum (20) for spooling a spoolable medium (10), an electric motor (30) op-

erably coupled to the winch drum to rotate the winch drum, and an electric drive (40) operably coupled to the electric motor (30) to control the electric motor, wherein an object (200) is connected to and supported by the spoolable medium (10), the method comprising:

detecting by the electric drive (40) a changing of a vertical position of the vessel (100) with respect to a reference vertical position; and
controlling by the electric drive (40), in response to the detected changing of the vertical position of the vessel (100), a length of the spoolable medium (10) between the winch drum (20) and the object (200) connected to the spoolable medium (10) such that a magnitude of a change of a vertical position of the object (200) with respect to the reference vertical position resulting from the change of the vertical position of the vessel (100) with respect to the reference vertical position is reduced.

2. A method as claimed in claim 1, wherein the length of the spoolable medium (10) between the winch drum (20) and the object (200) connected to the spoolable medium (10) is controlled by the electric drive (40), in response to the detected changing of the vertical position of the vessel (100), such that the magnitude of the change of the vertical position of the object (200) with respect to the reference vertical position is reduced smaller than a magnitude of the respective change of the vertical position of the vessel (100) with respect to the reference vertical position.

3. A method as claimed in claim 1 or 2, wherein the reference vertical position is defined by a bottom (300) of a body of water below the vessel (100) or by another vessel.

4. A method as claimed in claim 1, 2 or 3, wherein the electric drive (40) is connected to a motion reference device (60), wherein the detecting of the changing of the vertical position of the vessel (100) with respect to the reference vertical position is based on a signal received from the motion reference device by the electric drive (40).

5. A method as claimed in claim 1, wherein the signal indicates a heave position of a heave of the vessel (100).

6. A method as claimed in claim 1, 2 or 3, wherein the electric drive (40) comprises a motion reference device (60) for detecting the changing of the vertical position of the vessel (100) with respect to the reference vertical position.

7. A method as claimed in any one of claims 1 to 6, wherein the vessel (100) is a floating vessel or an at least partly submersible vessel.

8. A computer program product comprising computer program code, wherein execution of the program code in a computer causes the computer to carry out the steps of the method according to any one of claims 1 to 7.

9. An electric drive for a winch of a vessel, the winch comprising a rotatable winch drum (20) for spooling a spoolable medium (10), and an electric motor (30) operably coupled to the winch drum to rotate the winch drum, wherein an object (200) is connected to and supported by the spoolable medium (10), and wherein the electric drive (40) is configured to be operably coupled to the electric motor (30), and comprises control means (41) configured to:

detect a changing of a vertical position of the vessel (100) with respect to a reference vertical position; and
control, in response to the detected changing of the vertical position of the vessel (100), a length of the spoolable medium (10) between the winch drum (20) and the object (200) connected to the spoolable medium (10) such that a magnitude of a change of a vertical position of the object (200) with respect to the reference vertical position resulting from the change of the vertical position of the vessel (100) with respect to the reference vertical position is reduced.

10. An electric drive as claimed in claim 9, wherein the control means (41) are configured to control the length of the spoolable medium (10) between the winch drum (20) and the object (200) connected to the spoolable medium (10), in response to the detected changing of the vertical position of the vessel (100), such that the magnitude of the change of the vertical position of the object (200) with respect to the reference vertical position is reduced smaller than a magnitude of the respective change of the vertical position of the vessel (100) with respect to the reference vertical position.

11. An electric drive as claimed in claim 9 or 10, wherein the reference vertical position is defined by a bottom (300) of a body of water below the vessel (100) or by another vessel.

12. An electric drive as claimed in claim 9, 10 or 11, wherein the electric drive (40) is configured to be connected to a motion reference device (60), and the control means (41) are configured to detect the changing of the vertical position of the vessel (100) with respect to the reference vertical position based

on a signal received from the motion reference device.

13. An electric drive as claimed in claim 12, wherein the signal indicates a heave position of a heave of the vessel (100).

14. An electric drive as claimed in claim 9, 10 or 11, wherein the electric drive (40) comprises a motion reference device (60) for detecting the changing of the vertical position of the vessel (100) with respect to the reference vertical position.

15. An electric drive as claimed in any one of claims 9 to 14, comprising an inverter (42).

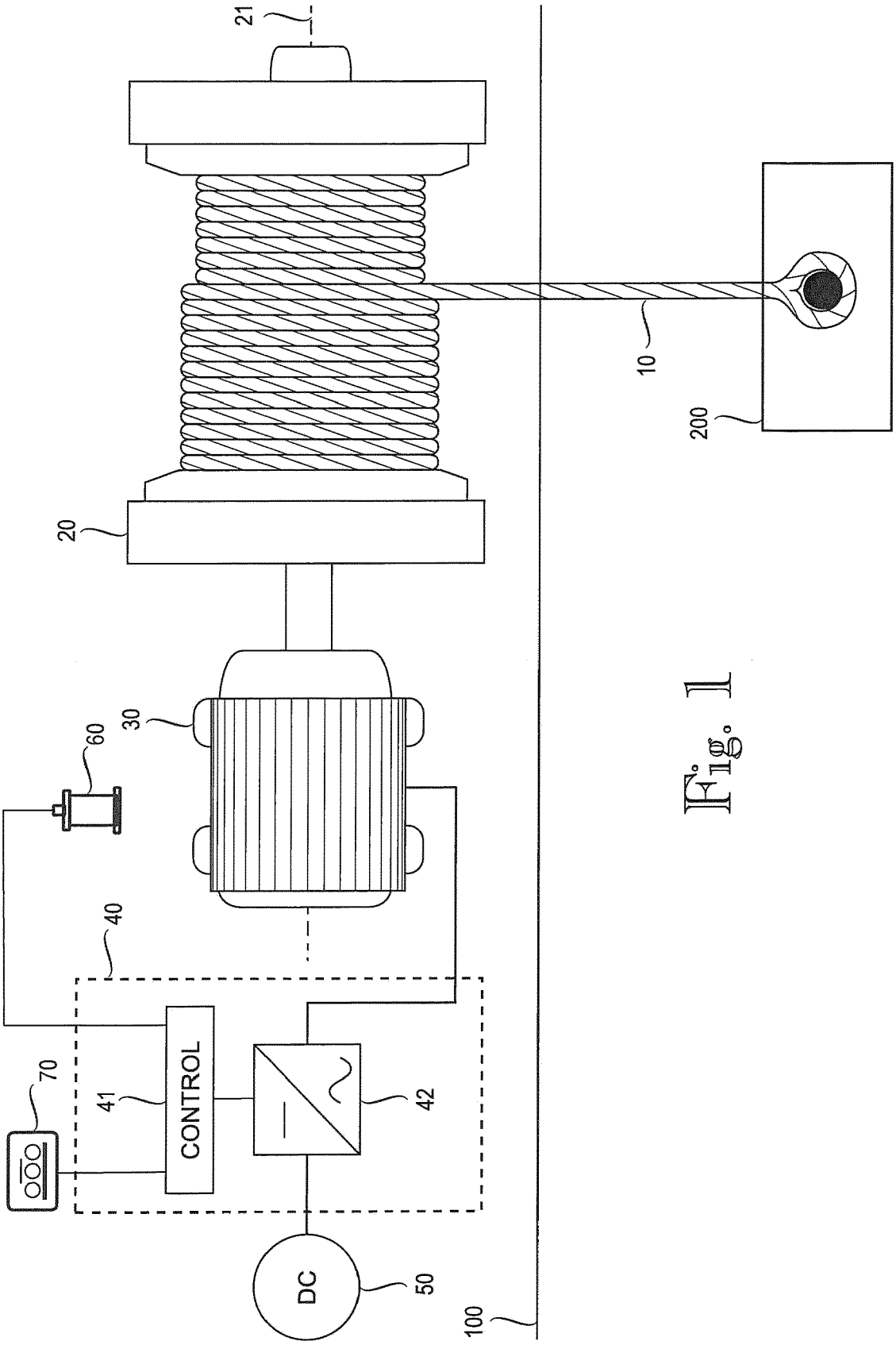

Fig. 1

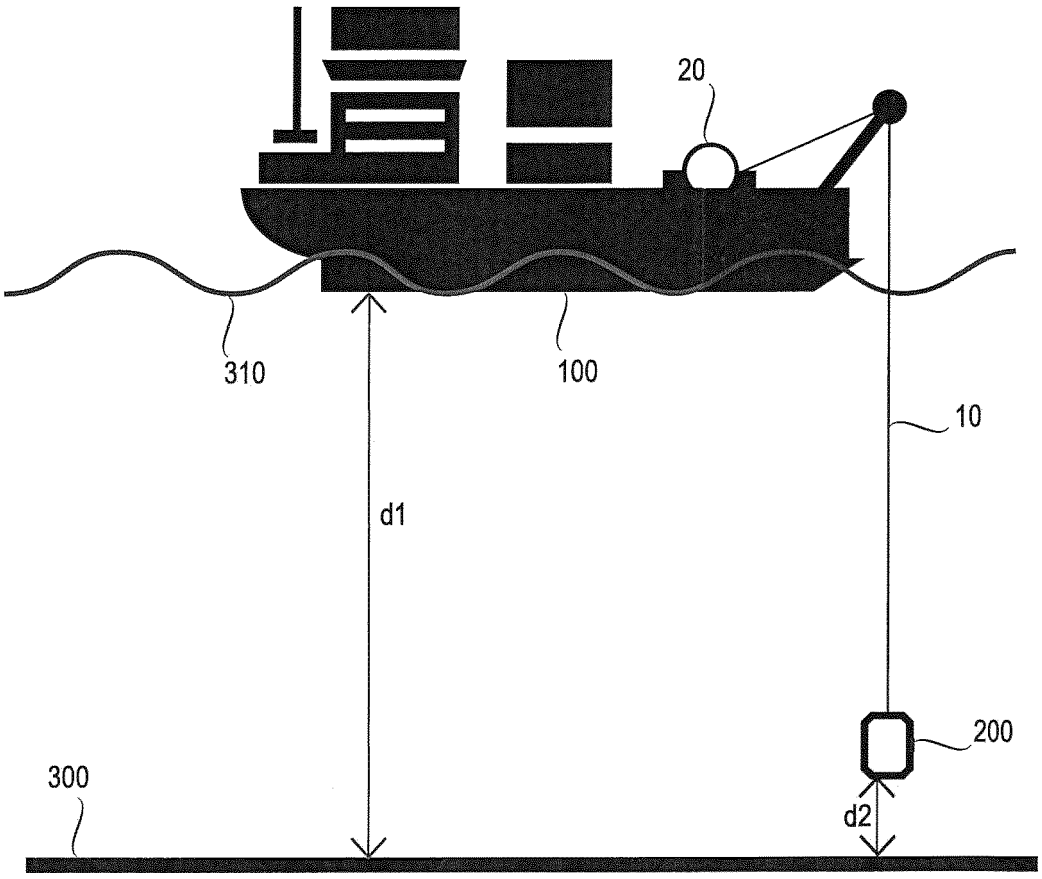

Fig. 2

Europäisches Patentamt
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EUROPEAN SEARCH REPORT

Application Number
EP 18 20 3696

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2015/044898 A1 (ROLLS ROYCE CANADA LTD [CA]) 2 April 2015 (2015-04-02) * abstract * * paragraph [0023] - paragraph [0035] * * figures *	1-14	INV. B66D1/52
X	CN 204 355 998 U (UNIV HUNAN SCI & TECHNOLOGY) 27 May 2015 (2015-05-27) * abstract * * figures *	1-7,9-15	

TECHNICAL FIELDS SEARCHED (IPC)

B66D
B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 April 2019	Sheppard, Bruce

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 20 3696

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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15-04-2019

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2015044898 A1	02-04-2015	NONE	
CN 204355998 U	27-05-2015	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82