



- (51) International Patent Classification:
B63J 3/04 (2006.01)
- (21) International Application Number:
PCT/DK2024/050306
- (22) International Filing Date:
16 December 2024 (16.12.2024)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
PA202330423 20 December 2023 (20.12.2023) DK
- (71) Applicant: STILLSTROM A/S [DK/DK]; Esplanaden 50, 1263 Copenhagen K (DK).
- (72) Inventors: BLYDE, Shaun; c/o Esplanaden 50, 1263 Copenhagen K (DK). HARVEY, Richard; c/o Esplanaden 50, 1263 Copenhagen K (DK).
- (74) Agent: A.P. MØLLER - MÆRSK A/S; Esplanaden 50, 1263 Copenhagen K (DK).
- (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: CHARGING CABLE HANDLING MECHANISM, VESSEL AND SYSTEM AND METHODS

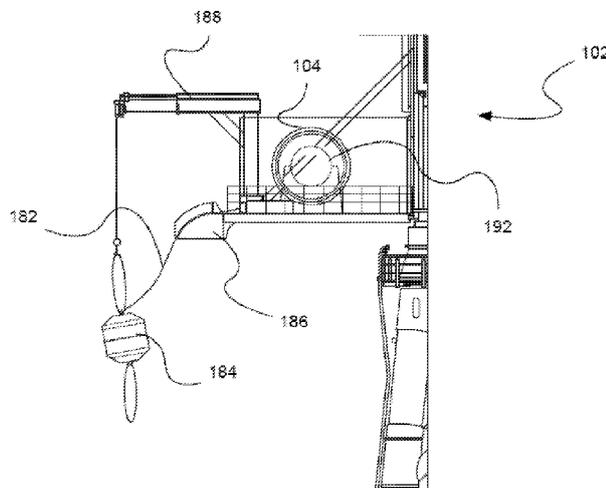


Fig. 1

(57) Abstract: A system includes a vessel (100) with a cable handling mechanism (114) and an electrical circuit (110), a charging cable (104) with a connector end configured to electrically connect to the electrical circuit (110) of the vessel (100), and an offshore charging installation (102) electrically connected to the charging cable (104) and configured to provide power to the vessel (100) through the charging cable (104). The cable handling mechanism (114) comprises a connector mating mechanism (134) configured to move the connector end with respect to a vessel connector (108) between a disconnected position and an engaged position.



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).

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*

Charging cable handling mechanism, vessel and system and methods

Field

5 The technology relates to the field of offshore vessel charging systems, specifically focusing on the handling, and mating of charging cables between vessels and offshore charging installations. This technology aims to improve the speed, efficiency, safety, durability, and reliability of charging processes for vessels operating in offshore environments, such as marine vessels generally, vessels supporting offshore wind
10 farms, and in other offshore installations.

Background

The present invention relates generally to the field of marine vessel charging systems,
15 and more specifically to the handling and connection of heavy electrical cables used for charging vessels from offshore installations, such as mooring buoys or fixed structures.

In recent years, there has been a growing interest in the development of electrically
20 powered vessels, particularly for use in the maritime industry. These vessels require charging systems that can efficiently and safely transfer electrical power from an offshore installation to the vessel's electrical system. One common approach to charging such vessels involves the use of heavy electrical cables that are connected to the vessel's electrical system while the vessel is moored or on dynamic positioning
25 at an offshore installation.

However, the handling and connection of these heavy electrical cables present several challenges and risks. The weight and rigidity of the cables make them difficult and dangerous for the crew to manually handle on the vessel's deck. This can lead to
30 potential injuries and accidents, as well as damage to the vessel and its components due to excessive tension on the cable or wear and damage of the cable from coming in contact with the vessel's surfaces, should an unplanned event or incident occur.

Moreover, the process of connecting and disconnecting the electrical cable to the vessel's electrical system can be inefficient and time-consuming, further increasing the risk of accidents and injuries during manual handling. Additionally, improper
5 connection or disconnection can result in excessive tension on the cable, causing damage to the vessel and its components.

Some prior art solutions have attempted to address these challenges by providing adaptive tension compensating systems and docking mechanisms for the cable as
10 shown in EP4151514 and WO2023/161637. However, these solutions often do not adequately address misalignment and incorrect orientation of the cable connector during the connection process, which can be dangerous for the crew especially if they try to manually adjust the position of the cable connector. Furthermore, these solutions may require the vessel to be positioned in a way that is unsuitable for some vessels
15 and offshore installations, and the cable connector can move with respect to the vessel during the connection process, increasing the risk of accidents and injuries.

Therefore, there is a need for an improved vessel charging system that can safely and efficiently handle and connect heavy electrical cables to the vessel's electrical system,
20 while minimising the risks associated with manual handling, cable tension, and connector orientation. This is relevant for environments in the open sea which are exposed to waves and wind.

Summary

25 According to a first aspect of the disclosure, a vessel is provided that includes a vessel electrical circuit, a vessel connector electrically connected to the vessel electrical circuit, and a cable handling mechanism mounted on a vessel. The cable handling mechanism comprises a cable securing mechanism configured to secure a charging
30 cable having a cable connector with respect to the vessel. The charging cable is electrically connected to an offshore charging installation. The cable handling mechanism also includes a cable mating mechanism configured to move the vessel

connector with respect to the cable connector between a disconnected position and an engaged position. This configuration allows for the cable connector to interface with a vessel in an efficient, safe, and secure connection of the vessel to an offshore charging installation, facilitating the transfer of power from the offshore installation to the vessel.

5 This means that the crew do not have to manually intervene with connecting the cable connector to the vessel connector. Accordingly, the cable and cable connector can be handled remotely which is less strenuous and reduces the risk of electrical hazards.

10 Optionally in some examples, the cable mating mechanism is configured to move the vessel connector in a plane parallel with the vessel deck. This feature simplifies the connection process by allowing the vessel connector to move in a plane parallel with the vessel deck, reducing the risk of misalignment between the cable connector and vessel connector during mating.

15 Optionally in some examples, the vessel further comprises a cable guide arrangement configured to orientate the vessel connector with respect to the cable connector. This feature further ensures proper alignment between the vessel connector and the cable connector, minimising the chances of damaging and stressing the cable and its components during connection.

20 Optionally in some examples, the cable mating mechanism is configured to actively align the vessel connector and the cable connector by movement of one of the vessel connector and the cable connector with respect to the other of the vessel connector and the cable connector. In some examples, the vessel connector is configured to
25 rotate with respect to the cable connector in order to rotationally align the vessel connector and the cable connector before they are connected together.

30 Optionally in some examples, the cable securing mechanism comprises a gripping mechanism moveable between open and closed positions. This feature enables secure cable handling and easy release when needed, reducing the need for manual handling of the heavy charging cable. In some other examples the cable securing mechanism comprises a restraining mechanism such as a collar or a locking dog.

Optionally in some examples, the vessel further comprises a locking mechanism configured to mechanically lock the gripping mechanism in the closed position. The locking mechanism comprises a locking lever moveable between a locked position and a release position. This feature prevents accidental opening of the gripping mechanism when the vessel connector is energised and connected to the cable connector, providing an additional layer of safety.

Optionally in some examples, the vessel further comprises a cable tension detection system having a tension sensor configured to detect the tension in the charging cable. This feature prevents damage to the vessel and components by triggering emergency release if the tension in the charging cable exceeds a safe threshold.

Optionally in some examples, the vessel further comprises a vessel controller configured to control the cable handling mechanism. This feature allows for centralised control and monitoring of the cable handling mechanism, enhancing the efficiency and safety of the connection process.

Optionally in some examples, the vessel controller is configured to control the cable securing mechanism and the cable mating mechanism. This feature allows for precise control over the connection process, ensuring a secure and efficient connection between the vessel and the offshore charging installation.

Optionally in some examples, the vessel controller is configured to receive a signal from the tension sensor and trigger an emergency release event in response to the detected tension exceeding a safe tension threshold. This feature provides an automatic safety mechanism that can quickly respond to potentially dangerous situations, enhancing the overall safety of the system.

Optionally in some examples, the vessel further comprises a hydraulic control system, an electric control system, or a pneumatic control system connected to the cable handling mechanism. This feature allows for precise and efficient control of the cable

handling mechanism, enhancing the overall performance and reliability of the system. In some other examples, the hydraulic system can be replaced with alternative options such as an electric control system, a pneumatic control system or any other suitable control system for operating and moving the components of the cable handling system.

5 For example, pneumatic actuators, mechanical actuators, electric actuators, or any other suitable actuator can be used as an alternative.

Optionally in some examples, the cable handling mechanism further comprises a cable guide arrangement configured to guide and direct the charging cable into the correct position and orientation for connection. This feature simplifies the connection process by guiding the cable into the correct position on the vessel deck, making it easier for the crew to handle and manipulate the cable during the connection process.

Optionally in some examples, the cable guide comprises a funnel narrowing towards the vessel connector. This feature further simplifies the connection process by guiding the cable into the correct position on the vessel deck, reducing the risk of misalignment between the cable connector and vessel connector during mating.

Optionally in some examples, the cable guide comprises a guiding slot configured to engage with a self-aligning keyway projecting from the cable connector. This feature ensures proper alignment between the vessel connector and the cable connector, minimising the chances of damaging and stressing the cable and its components during connection.

25 According to a second aspect of the disclosure, a vessel charging system is provided that includes a vessel as described above, an offshore charging installation having an offshore charging circuit which is electrically connected to the charging cable and a power source. This system allows charging of the vessel from e.g. an offshore power source such as a wind turbine generator, facilitating the use of renewable energy sources in maritime applications.

Optionally in some examples, the vessel charging system further comprises a mooring line configured to tether the vessel to the offshore charging installation.

5 Optionally in some examples, the offshore charging installation is floating. This feature allows for flexible positioning of the offshore charging installation, making it suitable for use in a variety of offshore environments. In some examples, when the offshore charging installation is a floating offshore charging installation, the offshore charging installation comprises a mooring buoy which is anchored to the seabed. This means existing offshore structures can be utilised for retrofitting the offshore charging
10 installation.

Optionally in some examples, the offshore charging installation is fixed with respect to the seabed. In some examples, the offshore charging installation can be mounted on the transition piece of an offshore wind turbine or mounted on a monopile foundation
15 embedded in the seabed.

According to a third aspect of the disclosure, a cable handling mechanism for a vessel is provided. The cable handling mechanism includes a cable securing mechanism configured to secure a charging cable having a cable connector with respect to the
20 vessel. The charging cable is electrically connected to an offshore charging installation. The cable handling mechanism also includes a cable mating mechanism configured to move a vessel connector electrically connected to a vessel electrical circuit with respect to the cable connector between a disconnected position and an engaged position. This configuration allows for efficient and secure connection of the vessel to
25 an offshore charging installation, facilitating the transfer of power from the offshore installation to the vessel. The cable handling mechanism can be retrofitted onto existing vessels, if required. As mentioned above, this means that the crew do not have to manually intervene with connecting the cable connector to the vessel connector. Accordingly, the cable and cable connector can be handled remotely which
30 is less strenuous and reduces the risk of electrical hazards.

According to a fourth aspect of the disclosure, a method of handling and mating a charging cable on a vessel is provided. The method includes the steps of raising the charging cable onto the vessel, securing the charging cable with a cable securing mechanism of a cable handling mechanism, orientating a vessel connector with respect to a cable connector, and moving the vessel connector towards the cable connector. This method allows for efficient and secure connection of the vessel to an offshore charging installation, facilitating the transfer of power from the offshore installation to the vessel.

According to a fifth aspect of the disclosure, a method of handling and disconnecting a charging cable on a vessel is provided. The method includes the steps of monitoring tension in the charging cable, determining tension of the charging cable above a tension threshold, triggering an emergency event based on detected tension, deenergising the charging cable, disengaging a cable securing mechanism, and disconnecting the charging cable. This method provides a safe and efficient way to disconnect the charging cable from the vessel, ensuring the safety of the vessel and its crew. Optionally, the messenger line is also disengaged, if still connected between the vessel and the offshore charging installation.

Brief Description of the Drawings

Examples are described in more detail below with reference to the appended drawings. Figure 1 is a partial side view of an offshore charging installation with a charging cable according to some examples;

Figure 2 is a side view of messenger line between an offshore charging installation and a vessel according to some examples;

Figure 3 is a side view of messenger line and charging cable between an offshore charging installation and a vessel according to some examples;

Figure 4 is a side view of charging cable between an offshore charging installation and a vessel according to some examples;

Figure 5 is a side view of a cable handling mechanism on a vessel when the cable connector is disconnected from a vessel connector according to some examples;

Figure 6 is a side view of a cable handling mechanism on a vessel when the cable connector is secured with respect to a vessel connector according to some examples; Figure 7 is a side view of a cable handling mechanism on a vessel when the cable connector is connected to a vessel connector according to some examples;

5 Figure 8 is a flowchart illustrating the method of handling and energising a charging cable on a vessel;

Figure 9 is a flowchart illustrating the method of monitoring the tension in a charging cable and deenergising and disconnecting a charging cable on a vessel; and

10 Figure 10 is a schematic representation of a vessel charging system including a vessel and an offshore charging installation.

Detailed Description

15 The detailed description set forth below provides information and examples of the disclosed technology with sufficient detail to enable those skilled in the art to practise the disclosure.

20 Figure 1 shows a partial side view of an offshore charging installation 102 with a charging cable 104 according to some examples. The offshore charging installation 102 is connected to a power source 118 (best shown in Figure 10) and an offshore installation charging circuit 122 (also best shown in Figure 10). The charging cable 104 is electrically connected to the offshore charging installation 102 and has a cable connector 106 at its end.

25 Turning back to Figure 1, in some examples, the offshore charging installation 102 is a structure or platform located offshore that is used to provide power to the vessel 100. The offshore charging installation 102 includes various components and systems that enable it to perform its intended functions, including a charging circuit controller 124, an offshore communication module 126, a power source 118, and other components
30 as schematically shown in Figure 10.

The offshore charging installation 102 and the charging cable 104 together with a vessel 100 provides a vessel charging system. The vessel 100 is equipped with a cable handling mechanism 114 and a vessel electrical circuit 110 and the vessel 100 will be discussed in more detail below. The charging cable 104, which is electrically connected to the offshore charging installation 102, features a cable connector 106. The cable connector 106 is designed to electrically connect to the vessel connector 108 of a vessel electrical circuit 110 of the vessel 100, thereby enabling the transfer of power from the offshore charging installation 102 to the vessel 100.

10 In some examples, the charging cable 104 is not configured to moor the vessel 100 to the offshore charging installation 102. In this example, the vessel 100 may be moored to the offshore charging installation 102 via a mooring line (not shown) or the vessel 100 may be kept in position with a dynamic positioning system.

15 In the Figures e.g. Figure 1, the offshore charging installation 102 is an “hang-off” charging arrangement mounted to a fixed offshore installation. That is, the offshore charging installation 102 is fixed with respect to the seabed (not shown). This may in some examples be an offshore substation electrically connected to an offshore wind turbine generator or an offshore wind farm. Alternatively, the offshore charging installation 102 may be mounted on other suitable fixed offshore installations. For example, the offshore charging installation 102 can be the transition piece (not shown) of a wind turbine generator. Indeed, the offshore charging installation 102 can be any fixed offshore installation. In some other alternative examples, the offshore charging installation 102 is a floating buoy (not shown). In this case, the vessel 100 can tether to the offshore charging installation 102 e.g. the floating buoy via a mooring buoy and also connect via the charging cable 104.

The offshore charging installation 102 will now be discussed in more detail with respect to Figure 1 and Figure 10. Figure 10 is a schematic representation of a vessel charging system including a vessel 100 and an offshore charging installation 102.

In one configuration, the charging circuit controller 124 is a control unit responsible for controlling and monitoring the charging process between the offshore charging installation 102 and the vessel 100. The charging circuit controller 124 is configured to selectively energise the charging cable 104 in response to signals received from the vessel controller 112. The charging circuit controller 124 is also configured to send signals to an offshore installation charging circuit 122 to control the flow of electricity through the charging cable 104.

In some implementations, the offshore charging installation 102 includes an offshore communication module 126. The offshore communication module 126 is configured to communicate with the vessel communication module 132 of the vessel 100. The offshore communication module 126 may include various types of communication devices, such as a Wi-Fi module, a cellular module (e.g., GSM, LTE), a satellite communication module, or other types of communication devices. The offshore communication module 126 allows the charging circuit controller 124 to communicate with the vessel controller 112, enabling coordinated control of the charging process. In some other examples, the offshore communication module 126 is additionally or alternatively configured to communicate with the vessel communication module 132 of the vessel 100 via an alternative wired connection e.g. by a separate hard wired data connection between the vessel 100 and the offshore charging installation 102. For example, the charging cable 104 may comprise a pilot line, an optical fibre, powerline communications configured to transmit data signals between the vessel 100 and the offshore charging installation 102. In some examples, the data connection is embedded in the charging cable 104, but in this case, the vessel 100 may need multiple methods of data communication in order that the vessel 100 may communicate with the offshore charging installation 102 when the charging cable 104 is not connected.

The offshore charging installation 102 as shown in the Figures is connected to a power source 118. The power source 118 provides electrical power to the offshore charging installation 102, which is then transferred to the vessel 100 via the charging cable 104. The power source 118 can be any suitable source of electrical power, such as an offshore wind turbine, an offshore substation, a subsea electrical cable, an offshore

power grid connection, or other types of power sources. The power source 118 is electrically connected to the offshore installation charging circuit 122 and the charging cable 104, allowing power to be transferred from the power source 118 to the vessel 100 during the charging process.

5

In some configurations as mentioned above, the offshore charging installation 102 optionally includes a mooring line (not shown). The mooring line is configured to tether the vessel 100 to the offshore charging installation 102, helping to maintain the position of the vessel 100 relative to the offshore charging installation 102 during the charging process. The mooring line can be made of any suitable material, such as steel, synthetic fibres, or other types of materials, and can be of any suitable length and diameter to accommodate the size and weight of the vessel 100 and the environmental conditions at the offshore location. In some alternative configurations, the vessel 100 may not be moored to the offshore charging installation 102 and instead, the vessel 100 maintains its position with respect to the offshore charging installation 102 using a dynamic positioning system.

10
15

The offshore installation charging circuit 122 is electrically connected to the charging cable 104 and is configured to selectively energise the charging cable 104 in response to signals received from the charging circuit controller 124. The offshore installation charging circuit 122 includes various components, such as switches, circuit breakers, transformers, HVAC systems, detectors, sensor, cameras, and any other components that control the flow of electricity through the charging cable 104.

20

As shown in Figure 1, the offshore charging installation 102 includes a messenger line 182. The messenger line 182 is connected to the charging cable 104 and is used to facilitate the transfer of the charging cable 104 between the offshore charging installation 102 and the vessel 100. The messenger line 182 is lighter and easier to handle than the charging cable 104, making it easier for the crew of the vessel 100 to winch in the charging cable 104 onto the vessel deck 172.

25

30

In one configuration, the messenger line 182 is connected to a messenger line buoy 184. The messenger line buoy 184 is a floatation device that keeps the end of the messenger line 182 afloat in the water, making it easier for the crew of the vessel 100 to pick up the messenger line 182. The messenger line buoy 184 can be made of any suitable material, such as plastic, foam, or other types of floatation materials, and can be of any suitable size and shape to keep the end of the messenger line 182 afloat in the water.

In some implementations and as shown in Figure 1, the offshore charging installation 102 includes a cable chute 186. The cable chute 186 is mounted on the offshore charging installation 102 and is configured to guide the charging cable 104 as it is reeled out from the offshore charging installation 102. The cable chute 186 helps to prevent overbending of the charging cable 104, which can cause damage to the charging cable 104 and reduce its lifespan.

In one example as shown in Figures 1 to 4, the offshore charging installation 102 optionally includes a transfer crane 188. The transfer crane 188 is mounted on the offshore charging installation 102 and is configured to transfer the messenger line 182 to the vessel 100. The transfer crane 188 includes a telescopic boom that can extend and retract to reach the vessel 100. The operation of the transfer crane 188 can be remotely controlled via the vessel controller 112, allowing the crew of the vessel 100 to control the transfer of the messenger line 182 from the offshore charging installation 102 to the vessel 100.

In some configurations, the transfer crane 188 optionally includes a telescopic boom. The telescopic boom is a multi-section arm that can extend and retract to reach the vessel 100. In some other implementations, the transfer crane 188 comprises a fixed boom which is not telescopic. The telescopic boom is controlled by a hydraulic or electric actuator, which is controlled by the vessel controller 112 and / or the charging circuit controller 124. In other examples, the transfer crane 188 can be controlled manually by the crew on the vessel 100 or on the offshore charging installation 102.

The telescopic boom allows the transfer crane 188 to reach the vessel 100 even when the vessel 100 is at a distance from the offshore charging installation 102.

5 Whilst the transfer of the messenger line 182 in Figures 1 to 4 is shown with a transfer crane 188, other equipment or methods can be used to transfer the messenger line 182 from the offshore charging installation 102 to the vessel 100. For example, the messenger line 182 can be thrown from the offshore charging installation 102 to the vessel 100. Alternatively, messenger line buoy 184 can be retrieved from the water by crew on the vessel 100. Indeed, any suitable method, or equipment can be used
10 to transfer the messenger line 182 to the vessel 100.

In one implementation, the offshore charging installation 102 includes a charging cable reel 192. The charging cable reel 192 is a carousel or winch that is used to reel in or reel out the charging cable 104. The charging cable reel 192 is mounted on the offshore
15 charging installation 102 and is connected to the charging circuit controller 124. The operation of the charging cable reel 192 is controlled by the charging circuit controller 124, allowing the charging cable 104 to be reeled in or reeled out in a controlled manner during the charging process.

20 In some examples, the charging cable 104 is a high-voltage cable that is used to transfer electrical power from the offshore charging installation 102 to the vessel 100. The charging cable 104 includes a cable connector 106 at one end, which is designed to connect to the vessel connector 108 on the vessel 100. The charging cable 104 is electrically connected to the offshore installation charging circuit 122 and the power
25 source 118, allowing power to be transferred from the offshore charging installation 102 to the vessel 100 during the charging process. In some examples, the charging cable 104 is not configured to withstand the force of the vessel 100 moving away from the offshore charging installation 102. In this case, either the vessel 100 uses a dynamic positioning system or a mooring line. However, in some examples,
30 alternatively, the charging cable 104 can be a combined charging cable 104 and mooring line and perform the function of a charging cable 104 and a mooring line. Furthermore, in some other examples, the vessel 100 may be directly moored to the

offshore charging installation 102. For example, the vessel 100 may be roped up to bollards and there is no free lining on a long hawser rope between the vessel 100 and the offshore charging installation 102.

- 5 In one configuration, the cable connector 106 is part of the charging cable 104 and is designed to electrically and mechanically connect to the vessel connector 108.

10 In some implementations, the cable connector 106 includes a cable connector end cap 166. The cable connector end cap 166 is a protective cover that is designed to mount on the end of the cable connector 106 and cover the cable connector 106 when not in use. The cable connector end cap 166 is removable, allowing it to be removed before the cable connector 106 engages the vessel connector 108 during the connection process. The cable connector end cap 166 may optionally be water tight to prevent the cable connector 106 from getting wet when submerged by accident or as part of the connection process of the charging cable 104 to the vessel 100.

15 In one example, the cable connector 106 includes a self-aligning keyway 168. The self-aligning keyway 168 is a feature that projects from the surface of the cable connector 106 and extends along the surface of the cable connector 106. The self-aligning keyway 168 is designed to align and engage with a reciprocal guiding slot 162 on the vessel 100 as the cable connector 106 is winched on board the vessel 100. This feature simplifies the connection process and reduces the risk of misalignment between the cable connector 106 and the vessel connector 108.

- 20 Reference will now be made to Figures 2 to 4 to describe how the charging cable 104 is transferred between the offshore charging installation 102 and the vessel 100.

25 Figure 2 shows a side view of a messenger line 182 between an offshore charging installation 102 and a vessel 100 according to some examples. The messenger line 182 is optionally connected to a messenger line buoy 184 and is used to facilitate the transfer of the charging cable 104 between the offshore charging installation 102 and the vessel 100. In some examples, the messenger line buoy 184 is not used.

Figure 3 shows a side view of a messenger line 182 and charging cable 104 between an offshore charging installation 102 and a vessel 100 according to some examples. The charging cable 104 is connected to the messenger line 182 and is being winched onto the vessel deck 172 using a cable winch 190 mounted on the vessel 100.

Figure 4 shows a side view of a charging cable 104 between an offshore charging installation 102 and a vessel 100 according to some examples. The charging cable 104 is shown connected to the vessel 100 via a vessel connector 108, which is electrically connected to a vessel electrical circuit 110.

The vessel 100 as shown in Figures 1 to 4 includes various components and systems that enable it to perform its intended functions, including a vessel controller 112, a user interface 130, a vessel communication module 132, and other components, which are best shown in Figure 10.

In one configuration, the vessel controller 112 is a central control unit responsible for controlling and monitoring various operations and systems of the vessel 100. The vessel controller 112 is configured to control and coordinate the connection and charging process between the vessel 100 and the offshore charging installation 102. The vessel controller 112 is also responsible for controlling the cable handling mechanism 114, which includes the cable securing mechanism 136 and the connector mating mechanism 134.

The vessel controller 112 is further configured to receive signals from various sensors and systems of the vessel 100, such as the tension sensor 150 (best shown in Figure 10) and the hydraulic control system 116 (again best shown in Figure 10), and to respond accordingly based on the received signals.

In some examples, the vessel controller 112 includes a user interface 130 (best shown in Figure 10) that allows a user to interact with and control the vessel controller 112.

The user interface 130 may include various input and output devices that facilitate user interaction with the vessel controller 112.

5 In one implementation, the user interface 130 includes a display screen that provides visual feedback to the user. The display screen may display various types of information related to the operation of the vessel 100, such as the status of the charging process, the tension in the charging cable 104, the position of the vessel 100 relative to the offshore charging installation 102, and other relevant information.

10 In some configurations, the user interface 130 includes control buttons that allow the user to input commands to the vessel controller 112. The control buttons may be physical buttons, touch-sensitive buttons, or other types of input devices. The control buttons may be used to start or stop the charging process, to control the movement of the vessel connector 108, to trigger an emergency release event, or to perform other
15 functions.

In one example, the user interface 130 includes status indicators that provide visual indications of the status of various systems and operations of the vessel 100. The status indicators may include lights, symbols, text, or other visual elements that
20 indicate the status of the charging process, the tension in the charging cable 104, the connection status of the vessel connector 108 and the cable connector 106, and other statuses.

In some implementations, the user interface 130 includes an alarm system that alerts
25 the user to certain conditions or events. The alarm system may generate audible, visual, or other types of alarms in response to certain conditions or events, such as when the tension in the charging cable 104 exceeds a safe level, when an emergency release event has been triggered, or when other conditions or events occur. For example, the user interface 130 can show the yellow warning message or the red
30 warning message as described when the tension in the charging cable 104 respectively exceeds safe tension threshold and a dangerous tension threshold. The method of warning and disconnection is described in more detail below.

In one configuration, the vessel 100 includes a vessel communication module 132 (best shown in Figure 10) that enables the vessel 100 to communicate with the offshore charging installation 102 or other external systems. As mentioned above, the vessel communication module 132 uses wireless communication technology to communicate with the offshore charging installation 102. However, the vessel communication module 132 can additionally or alternatively communicate via a wired connection such as an optical fibre. The vessel communication module 132 may include various types of communication devices, such as a Wi-Fi module, a cellular module (e.g., GSM, LTE), a satellite communication module, or other types of communication devices. The vessel communication module 132 is configured to communicate with the offshore communication module 126 of the offshore charging installation 102, allowing the vessel controller 112 to control and coordinate the charging process with the offshore charging installation 102. The vessel 100 includes a vessel electrical circuit 110 as shown in Figure 10. The vessel electrical circuit 110 is electrically connected to one or more electrical components of the vessel 100, including the vessel controller 112, the user interface 130, the vessel communication module 132, and other components. The vessel electrical circuit 110 provides power to these components and enables them to perform their intended functions.

In one example, the vessel electrical circuit 110 includes a switchboard 128 as shown in Figure 10. The switchboard 128 can include one or more electrical circuits that distribute power to various components of the vessel 100. The switchboard 128 can also include various switches, circuit breakers, and other components that control the flow of electricity through the vessel electrical circuit 110.

In reference to Figures 5 to 7, the vessel 100 will now be discussed in more detail. In particular, the vessel 100 includes a vessel connector 108. The vessel connector 108 is an electrical socket or electrical plug that is configured to electrically and mechanically connect to the cable connector 106 of the charging cable 104. The vessel connector 108 is electrically connected to the vessel electrical circuit 110, allowing power to be transferred from the charging cable 104 to the vessel 100 during the

charging process. The vessel connector 108 is also moveable with respect to the vessel deck 172, allowing it to move towards the cable connector 106 during the connection process. Movement of the vessel connector 108 will be discussed in more detail below.

5

Although not shown in the Figures, in some examples the cable handling mechanism 134 is configured to actively orientate the vessel connector 108 and the cable connector 106. This means that the vessel connector 108 or the cable connector 106 are actively moved and positioned by the cable handling mechanism 134 into the correct position before connection between the vessel connector 108 and the cable connector 106. In some examples, the cable handling mechanism 134 is configured to rotate the vessel connector 108 with respect to the cable connector 106 to rotationally orientate the vessel connector 108 thereto. In some examples, the vessel connector 108 is rotatable about a centre point of the vessel connector 108 which is aligned with a longitudinal axis of the vessel connector 108. When the vessel connector 108 is connected to the cable connector 106, the centre point of the vessel connector 108 is aligned with the longitudinal axis of the cable connector 106 and the charging cable 104.

In some examples, the cable handling mechanism 134 comprises a vessel connector rotation mechanism (not shown). The vessel connector alignment mechanism comprises a servo and gearbox operatively coupled to a rotatable vessel connector 108. Any suitable mechanism can be used to rotate the vessel connector 108 such as a hydraulic actuator connected to the hydraulic control system 116. Alternatively, pneumatic actuators, mechanical actuators, electric actuators, or any other suitable actuator can be used as an alternative to rotate the vessel connector 108. The vessel connector 108 may be electrically coupled to a slip ring (not shown) so that the vessel connector 108 can fully rotate about the centre point of the vessel connector 108. Alternatively, the vessel connector 108 does not need to fully rotate and may only partially rotate about the centre point of the vessel connector 108. In this case, the vessel connector 108 is connected to flexible electrical connections which permit some relative rotation of the vessel connector 108.

In some examples, the vessel controller 112 is configured to send a control signal to the vessel connector alignment mechanism in order to actively align the vessel connector 108 and the cable connector 106. In some examples, the vessel connector alignment mechanism comprises a cable orientation sensor (not shown). The cable orientation sensor is configured to determine a reference position of the cable connector 106. For example, the cable orientation sensor is an optical sensor, a mechanical switch or a hall effect sensor configured to detect a reference feature (not shown) in the cable connector 106. The reference feature may be a notch, projecting rib, optical indicator, mark, or otherwise located at a predetermined position, such as the 12 o'clock position on the cable connector 106. The cable orientation sensor is then configured to send a signal to the vessel controller 112 and the vessel controller 112 is configured to determine the relative position of the vessel connector 108 with respect to the cable connector 106. The vessel controller 112 then issues a control signal to the vessel connector alignment mechanism to rotate the vessel connector 108 to rotate the vessel connector 108 with respect to the cable connector 106.

Additionally, or alternatively, the vessel connector alignment mechanism is configured to align the vessel connector 108 in other directions. For example, the vessel connector alignment mechanism is configured to move the vessel connector 108 with respect to the cable connector 106 in a plane perpendicular to the longitudinal axis of the vessel connector 108. For example, this can be in a lateral direction across the vessel deck 172 in a direction into the page as shown in Figures 5 to 7 or in a vertical direction adjusting the height of the vessel connector 108 above the vessel deck 172. Linear actuators (e.g. hydraulic, pneumatic, electric etc) can be controlled by the vessel controller 112 in order to move the vessel connector 108 into the correct position with respect to the cable connector 106.

In one configuration, the vessel 100 includes a hatch 170 which may be sealable with a hatch door (not shown). The hatch 170 is configured to receive the charging cable 104 as it is winched onto the vessel deck 172. The hatch 170 provides easy access to the vessel deck 172 and reduces bending of the charging cable 104, helping to prevent

damage to the charging cable 104 during the winching process. The hatch 170 is particularly useful when the charging cable 104 is being winched onto the vessel deck 172 under tension.

5 In some examples, the vessel 100 includes a hydraulic control system 116. The hydraulic control system 116 is connected to various hydraulic actuators of the vessel 100, including the locking arm hydraulic actuator 194, the gripping mechanism hydraulic actuator 146, and the mating mechanism hydraulic actuator 138. The hydraulic control system 116 is configured to selectively actuate one or more of these
10 hydraulic actuators in response to signals received from the vessel controller 112. This allows the hydraulic control system 116 to control the movement of various components of the vessel 100, such as the locking arm 176, the moveable gripping jaws 144, and the vessel connector 108.

15 Whilst the arrangements discussed in reference to the Figures describe a hydraulic control system 116 and hydraulic actuators, other suitable control mechanisms can be used instead. For example, the pneumatic actuators, mechanical actuators, electric actuators, or any other suitable actuator can be used as an alternative.

20 The vessel 100 as shown in e.g. Figures 2 to 7, the vessel 100 includes a vessel deck 172. The vessel deck 172 is a flat surface on the vessel 100 where various components and systems of the vessel 100 are mounted. The vessel deck 172 may refer to a top deck, but can alternatively refer to any other deck of the vessel 100 e.g. a lower or intermediate decks of the vessel 100. The cable handling mechanism 114, for
25 example, is optionally mounted on the vessel deck 172. The vessel deck 172 provides a stable platform for the operation of these components and systems, and also provides a surface for the charging cable 104 to be winched onto during the connection process. However, in other examples the cable handling mechanism 114 can be located in other suitable parts of the vessel 100 e.g. the stern of the vessel, the back
30 deck of the vessel 100, mid-ships of the vessel 100 or any other suitable position. When the cable handling mechanism 114 has secured the charging cable 104 which is ready for charging the vessel 110, the charging cable 104 can be secured to the

vessel 100 the bow, stern or any other position on the vessel 100 depending on the location of the cable handling mechanism 114.

5 In some implementations, the vessel 100 includes a cable winch 190. The cable winch 190 is mounted on the vessel deck 172 and is configured to winch in the charging cable 104 and the messenger line 182 onto the vessel deck 172. The cable winch 190 includes a winch drum and a winch motor, which work together to wind in or let out the charging cable 104 and the messenger line 182. The operation of the cable winch 190 is controlled by the vessel controller 112, which sends signals to the winch motor to control the rotation of the winch drum. As shown in the Figures, the cable winch 190 is located at the bow of the vessel 100. However, in other examples the cable winch 190 can be located in other suitable parts of the vessel 100 e.g. the stern of the vessel, the back deck of the vessel 100, mid-ships of the vessel 100 or any other suitable position. When the charging cable 104 is recovered on to the vessel 100, the charging cable 104 can be drawn on to the bow, stern or any other position on the vessel depending on the location of the cable winch 190.

As mentioned above, the vessel controller 112 is configured to control the cable handling mechanism 114, which includes the cable securing mechanism 136 and the connector mating mechanism 134. The cable handling mechanism 114 will now be discussed in more detail with reference to Figures 5 to 7.

Figure 5 shows a side view of a cable handling mechanism 114 on a vessel 100 when the cable connector 106 is disconnected from a vessel connector 108 according to some examples. The cable handling mechanism 114 includes a cable securing mechanism 136 and a connector mating mechanism 134. The cable securing mechanism 136 is configured to secure the charging cable 104 with respect to the vessel deck 172, while the connector mating mechanism 134 is configured to move the vessel connector 108 with respect to the cable connector 106 between a disconnected position and an engaged position. When the charging cable 104 has been secured by the cable securing mechanism 136, a portion of the charging cable

104 and the cable connector 106 are fixed with respect to a portion of the vessel 100. For example, this is the vessel deck 172 in some examples shown in the Figures. The cable securing mechanism 136 is configured to secure the cable connector 106 and / or the charging cable 104. This means in some examples the cable securing mechanism 136 may directly engage the surface of the charging cable 104. Alternatively, or additionally, the cable securing mechanism 136 may directly engage the surface of the cable connector 106.

10 In one implementation, the cable securing mechanism 136 is part of the cable handling mechanism 114 and is configured to secure the charging cable 104 with respect to the vessel deck 172. The cable securing mechanism 136 includes a gripping mechanism 140 and a locking mechanism 142, which work together to securely grip and lock the charging cable 104 in place during the charging process.

15 In some examples, the gripping mechanism 140 is part of the cable securing mechanism 136 and is moveable between open and closed positions. The gripping mechanism 140 includes moveable gripping jaws 144, which are configured to grip the charging cable 104 when in the closed position and release the charging cable 104 when in the open position.

20 The movement of the moveable gripping jaws 144 is controlled by a gripping mechanism hydraulic actuator 146, which is connected to a hydraulic control system 116. The moveable gripping jaws 144 are designed to securely grip the charging cable 104 when in the closed position, ensuring a secure and stable connection during the charging process. The operation of the gripping mechanism hydraulic actuator 146 is controlled by the hydraulic control system 116, which receives signals from the vessel controller 112 to control the movement of the moveable gripping jaws 144.

30 The moveable gripping jaws 144 are configured to be arranged either side of the charging cable 104 when the charging cable 104 has been winched onto the vessel deck 172. Whilst Figures 5 to 7 describe a pair of gripping jaws 144 to selectively grip or release the charging cable 104, any other suitable gripping mechanism 140 can be

used. For example, a clamping mechanism, or any other arrangement can be used. In some other examples the cable securing mechanism 136 alternatively comprises a restraining mechanism such as a collar or a locking dog for securing the charging cable 104.

5

In some configurations, the locking mechanism 142 is part of the cable securing mechanism 136 and is configured to mechanically lock the gripping mechanism 140 in the closed position. The locking mechanism 142 includes a shear pin 174 and a locking arm 176, which are controlled by a locking arm hydraulic actuator 194.

10

In one example, the shear pin 174 is part of the locking mechanism 142 and is designed to shear or break when the tension in the charging cable 104 exceeds a certain threshold force corresponding to a tension in the charging cable 104 which exceeds a dangerous tension threshold. This allows the gripping mechanism 140 to move to the open position, releasing the charging cable 104 and preventing damage to the vessel 100 and its components, in the case that the emergency release procedure described below is not initiated.

15

The locking arm 176 is moveable between a locked position and a release position. In the locked position, the locking arm 176 prevents the gripping mechanism 140 from moving between the open and closed positions. In the release position, the locking arm 176 allows the gripping mechanism 140 to move between the open and closed positions.

20

In one configuration, the locking arm hydraulic actuator 194 is connected to the locking arm 176 and is configured to move the locking arm 176 between the locked and released positions. The locking arm hydraulic actuator 194 is connected to the hydraulic control system 116, which controls the operation of the locking arm hydraulic actuator 194 based on signals received from the vessel controller 112.

25

30

In some examples, the cable handling mechanism 114 includes a cable guide arrangement 158 that is configured to guide and direct the charging cable 104 into the

correct position and orientation for connection. The cable guide arrangement 158 optionally includes a funnel 160 with a wide mouth portion and a narrow end portion, which work together to guide the charging cable 104 onto the vessel deck 172 and towards the vessel connector 108.

5

In some configurations, the wide mouth portion of the funnel 160 is adjacent to the hatch 170 on the vessel deck 172. The wide mouth portion is designed to receive the charging cable 104 as it is winched onto the vessel deck 172, guiding the charging cable 104 towards the narrow end portion of the funnel 160.

10

In one example, the narrow end portion of the funnel 160 is adjacent to the vessel connector 108. The narrow end portion is designed to guide the cable connector 106 into the correct position on the vessel deck 172 for connection with the vessel connector 108. The narrow end portion of the funnel 160 helps to ensure that the cable connector 106 is correctly aligned with the vessel connector 108 during the connection process.

15

In some implementations, the cable guide arrangement 158 includes a guiding slot 162. The guiding slot 162 is configured to engage with a self-aligning keyway 168 on the cable connector 106. This engagement helps to align the orientation of the cable connector 106 as it is winched on board the vessel 100. When the self-aligning keyway 168 is engaged with the guiding slot 162, the cable connector 106 is in the correct rotational orientation with respect to the vessel connector 108. This feature simplifies the connection process and reduces the risk of misalignment between the cable connector 106 and the vessel connector 108.

20

25

In one configuration, the cable guide arrangement 158 includes a bend stiffener 164. The bend stiffener 164 is configured to limit the bend radius of the charging cable 104 as it is winched on board the vessel 100. This feature helps to prevent damage to the charging cable 104 due to excessive bending. The bend stiffener 164 is particularly useful when the charging cable 104 is being winched onto the vessel deck 172 under tension.

30

Figure 6 shows a side view of a cable handling mechanism 114 on a vessel 100 when the cable connector 106 is secured with respect to a vessel connector 108 according to some examples. Since Figure 6 is a side view of the cable handling mechanism 114, only one of the gripping jaws 144 is shown. However, the gripping jaws 144 are positioned either side of the charging cable 104. The gripping jaws 144 are urged towards each other in order to exert a force on the charging cable 104 and prevent the charging cable 104 from moving with respect to the vessel 100. The cable securing mechanism 136 is shown gripping the charging cable 104, while the connector mating mechanism 134 is in a position to move the vessel connector 108 towards the cable connector 106.

In one example, the connector mating mechanism 134 is part of the cable handling mechanism 114 and is configured to move the vessel connector 108 with respect to the cable connector 106 between a disconnected position and an engaged position. The connector mating mechanism 134 includes a mating mechanism hydraulic actuator 138 and a moveable plate 180, which work together to move the vessel connector 108 towards the cable connector 106 during the connection process. The connector mating mechanism 134 is configured to move the vessel connector 108 towards the secured cable connector 106 e.g. after the charging cable 104 has been secured by the cable securing mechanism 136.

In some implementations, the mating mechanism hydraulic actuator 138 is part of the connector mating mechanism 134 and is connected to the moveable plate 180. The mating mechanism hydraulic actuator 138 is configured to move the moveable plate 180, and hence the vessel connector 108, towards the cable connector 106 when the charging cable 104 is secured. The operation of the mating mechanism hydraulic actuator 138 is controlled by the hydraulic control system 116, which receives signals from the vessel controller 112 to control the movement of the vessel connector 108.

In one configuration, the moveable plate 180 is part of the connector mating mechanism 134 and is connected to the vessel connector 108. The moveable plate

180 is configured to move in a plane parallel with the vessel deck 172, allowing the vessel connector 108 to move towards the cable connector 106 during the connection process. The movement of the moveable plate 180 is controlled by the mating mechanism hydraulic actuator 138, which is connected to the hydraulic control system 116. The moveable plate 180 slides with respect to the vessel deck 172.

Figure 7 shows a side view of a cable handling mechanism 114 on a vessel 100 when the cable connector 106 is connected to a vessel connector 108 according to some examples. The vessel connector 108 is shown in an engaged position with the cable connector 106, establishing an electrical connection between the vessel electrical circuit 110 and the charging cable 104.

By moving the vessel connector 108 towards the secured charging cable 104, the process of connecting the vessel connector 108 and the cable connector 106 is simpler and safer. This is because the heavy charging cable 104 does not have to be moved during the connection of the vessel connector 108 and the cable connector 106.

In some examples, the cable handling mechanism 114 includes a cable tension detection system 148. The cable tension detection system 148 includes a tension sensor 150 that is configured to detect the tension in the charging cable 104. The tension sensor 150 can detect normal, elevated, and dangerous tension levels in the charging cable 104. If the tension in the charging cable 104 exceeds a safe level, the tension sensor 150 sends a signal to the vessel controller 112, which can trigger an emergency release event to prevent damage to the vessel 100 and its components.

In one implementation, the tension sensor 150 is part of the cable tension detection system 148. The tension sensor 150 is configured to detect the tension in the charging cable 104 and to send a signal to the vessel controller 112 when the tension exceeds a safe tension threshold. The safe tension threshold corresponds to a tension in the charging cable 104 that is permitted to safely operate the vessel charging system and no damage will occur to the vessel 100 or the offshore charging installation 102. The tension sensor 150 is also configured to detect the tension in the charging cable 104

and to send a signal to the vessel controller 112 when the tension exceeds a dangerous tension threshold. The dangerous tension threshold corresponds to a tension in the charging cable 104 that will damage the vessel charging system e.g. the vessel 100, the offshore charging installation 102, and or the charging cable 104. The
5 tension sensor 150 is a component of the cable handling mechanism 114, as it helps to ensure the safety of the vessel 100 and its crew during the charging process.

In some examples the cable tension detection system 148 monitors the length of the charging cable 104 that has been deployed. The vessel controller 112 determines the
10 length of deployed charging cable 104 and determines the current tension in the charging cable 104. Alternatively, the charging cable 104 is coupled to a tension sensor 150 such as strain sensor which sends a real-time tension signal of the charging cable 104 to the vessel controller 112. In some other examples, the vessel controller 112 further determines the relative positions of the vessel 100 from the
15 offshore charging installation 102 in order to determine the tension in the charging cable 104.

The method of handling and energising a charging cable 104 on a vessel 100 will now be described in more detail with reference to Figure 8.

20 First, the charging cable 104 is raised onto the vessel 100 as shown in step 800. This can be done by winching in the charging cable 104 onto the vessel deck 172 using a cable winch 190 mounted on the vessel 100. As mentioned previously various techniques or equipment can be used to transfer the charging cable 104 from the
25 offshore charging installation 102 to the vessel 100.

Next, the charging cable 104 is secured with a cable securing mechanism 136 of a cable handling mechanism 114 as shown in step 802. The cable securing mechanism 136 includes a gripping mechanism 140 and a locking mechanism 142, which work
30 together to securely grip and lock the charging cable 104 in place on the vessel deck 172.

Then, a vessel connector 108 is orientated with respect to a cable connector 106. This can be done by rotating the vessel connector 108 with respect to the cable connector 106, aligning the vessel connector 108 and the cable connector 106 in the correct orientation for connection. The orientation of the cable connector 106 with respect to the vessel connector 108 can be achieved passively, in that the cable connector 106 automatically is positioned and orientated due to the structure, shape and form of the cable handling mechanism 114 and the cable guide arrangement 158. Alternatively, the cable connector 106 can be actively rotated or positioned with respect to the vessel connector 108. For example, the crew can manually move the cable connector 106 before the charging cable 104 is secured. This may be less desirable because of the weight of the charging cable 104 and the potential danger to the crew.

Optionally the cable connector end cap 166 is removed after steps 802 or 804. In some cases, the charging cable 104 may not need a cable connector end cap 166. In this case, step 806 can be omitted.

The vessel connector 108 is moved towards the cable connector 106 as shown in step 808. This can be done by actuating a connector mating mechanism 134, which moves the vessel connector 108 towards the cable connector 106 until the vessel connector 108 and the cable connector 106 are connected. In some alternative examples the cable connector 106 is moved towards the vessel connector 108. This can be achieved by using a hydraulic actuator (not shown) to move the cable securing mechanism 136 towards the vessel connector 108. This may be less desirable because moving the cable securing mechanism 136 towards the vessel connector 108 will require dragging the heavy charging cable 104.

Both the steps of securing the charging cable 104 in step 802 and moving the vessel connector 108 in step 804 can be carried out in response to user input on the user interface 130. Alternatively, steps 802, and 804 can be autonomous without crew interaction and carried out by the vessel controller 112.

Once the vessel connector 108 is in electrical and physical engagement with the cable connector 106, the vessel controller 112 can determine the connection and the status of the charging cable 104 and other components of the system as shown in step 810. The purpose of the determination and checking in step 810 is to ensure that there are no faults and the charging cable 104 is safe to energise. This is advantageous because the connection and charging operation of the vessel 100 is inherently safer when working with the high voltage charging cable 104. This means that the crew working with the high voltage charging cable 104 do not have an increased risk of experiencing shock, flash, or explosion. Furthermore, the requirement for extensive training and experience of working with high voltage cables is less important. Accordingly, the cable handling mechanism 114 means that the connection and charging operation of the vessel 100 can be supervised by a single crew member.

Once step 810 has been carried out, the charging cable 104 can be energised as shown in step 812. In some examples, the charging cable 104 will only be energised in response to user input on the user interface 130. In this case, the vessel controller 112 will only send a control signal to the charging circuit controller 124 of the offshore charging installation 102 if the crew approve this step as shown in step 814.

This method allows the charging cable 104 to be securely and efficiently connected to the vessel 100, enabling power to be transferred from the offshore charging installation 102 to the vessel 100 during the charging process.

The method of handling and disconnecting a charging cable 104 on a vessel 100 will now be described in more detail with reference to Figure 9.

The tension in the charging cable 104 is monitored as shown in step 900. This can be done using a tension sensor 150, which is part of a cable tension detection system 148. The tension sensor 150 is configured to detect the tension in the charging cable 104 and to send a signal to the vessel controller 112 when the tension exceeds a safe tension threshold.

The tension of the charging cable 104 is determined to be above a safe tension threshold in step 902. This can be done by the vessel controller 112, which receives the signal from the tension sensor 150 and determines whether the tension in the charging cable 104 exceeds a safe tension threshold. If not, the vessel controller 112
5 returns to step 900 and continues to monitor the tension in the charging cable 104 in step 900.

The vessel controller 112 then determines whether the tension in the charging cable 104 is below a dangerous tension threshold that has been exceeded in step 904. If
10 the vessel controller 112 determines that the tension in the charging cable 104 is above a safe tension threshold, but below a dangerous tension threshold, the vessel controller 112 may issue a yellow warning message in step 906 on the user interface 130. The yellow warning message may indicate that action is needed to keep the tension in the charging cable 104 below the safe tension threshold. Thereafter, the
15 vessel controller 112 still continues to monitor the tension as shown in step 900.

If the vessel controller 112 determines that the tension in the charging cable 104 is above a safe tension threshold, and above a dangerous tension threshold, the vessel controller 112 may trigger an emergency event. This can be done by the vessel
20 controller 112, which triggers an emergency release event in response to the detected tension exceeding the safe threshold in step 908.

The emergency release event can include various actions, such as deenergising the charging cable 104 as shown in step 910, disengaging the cable securing mechanism
25 136 as shown in step 912, and disconnecting the charging cable 104 as shown in step 914.

The vessel controller 112 may issue a red warning message in step 916 on the user interface 130. The red warning message may indicate that the charging cable 104
30 must be disconnected to protect the crew and vessel 100, the charging cable 104 and / or the offshore charging installation 102.

This can be done by the vessel controller 112, which sends signals to the charging circuit controller 124 to deenergise the charging cable 104, to the cable securing mechanism 136 to disengage the gripping mechanism 140, and to the connector mating mechanism 134 to move the vessel connector 108 away from the cable connector 106.

Optionally, steps 910, and 912 may be carried out in response to user input on the user interface 130 as shown in step 918. However, alternatively, steps 910, 912 may be carried out autonomously by the vessel controller 112 in response to detecting the tension of the charging cable 104 above the dangerous tension threshold. This may be safer in case the crew are preoccupied with other safety issues on the vessel 100 or the offshore charging installation 102 e.g. fire.

Step 914 can be carried out by the vessel 100 moving away from the offshore charging installation 102 once steps 912 and 910 have been carried out.

Optionally, the steps of deenergising the charging cable 104 as shown in step 910, disengaging the cable securing mechanism 136 as shown in step 912, and disconnecting the charging cable 104 as shown in step 914 can be carried out in response to a command issued from the vessel 100. For example, the vessel controller 112 may be received from the user interface 130 or otherwise and not related to tension in the charging cable 104.

As mentioned above, optionally, the cable handling mechanism 134 comprises a shear pin 174. In some circumstances, the shear pin 174 breaks as shown in step 920. In this case the shear pin 174 breaks when the tension in the charging cable 104 exceeds the dangerous threshold force but the cable securing mechanism 136 has not released. This allows the gripping mechanism 140 to move to the open position, releasing the charging cable 104 and preventing damage to the vessel 100 and its components, in the case that the emergency release procedure is not initiated or develops a fault. This provides additional redundancy for the emergency release procedure. As shown in Figure 9, the shear pin 174 may optionally break and bypass

the other steps in the emergency release procedure if the tension in the charging cable 104 rises too quickly.

5 In some examples, the operation of the vessel 100 and the offshore charging installation 102 involves various processes and procedures that are controlled and coordinated by the vessel controller 112 and the charging circuit controller 124. These processes and procedures include the control of the cable handling mechanism 114, the operation of the cable handling mechanism 114, and other operations.

10 In one implementation, the operation of the vessel controller 112 involves receiving inputs from various sensors and systems of the vessel 100, processing these inputs, and sending control signals to various components and systems of the vessel 100. The vessel controller 112 receives inputs from the tension sensor 150, the user interface 130, the vessel communication module 132, and other sensors and systems. The
15 vessel controller 112 processes these inputs to determine the status of various operations and systems of the vessel 100, such as the tension in the charging cable 104, the status of the charging process, the position of the vessel 100 relative to the offshore charging installation 102, and other statuses. Based on these determinations, the vessel controller 112 sends control signals to various components and systems of
20 the vessel 100, such as the cable handling mechanism 114, the hydraulic control system 116, the vessel communication module 132, and other components and systems. These control signals control the operation of these components and systems, enabling the vessel 100 to perform its intended functions.

25 In some configurations, the operation of the vessel controller 112 includes controlling the cable handling mechanism 114. The vessel controller 112 sends control signals to the cable handling mechanism 114 to control the operation of the cable securing mechanism 136 and the connector mating mechanism 134. For example, the vessel controller 112 can send a control signal to the cable securing mechanism 136 to grip
30 or release the charging cable 104, or to the connector mating mechanism 134 to move the vessel connector 108 towards or away from the cable connector 106. The vessel controller 112 can also send control signals to the cable handling mechanism 114 in

response to signals received from the tension sensor 150, such as to trigger an emergency release event when the tension in the charging cable 104 exceeds a safe threshold.

5 In one example, the operation of the cable handling mechanism 114 involves various processes and procedures that are controlled by the vessel controller 112. These processes and procedures include securing the charging cable 104 with the cable securing mechanism 136, moving the vessel connector 108 with respect to the cable connector 106 with the connector mating mechanism 134, orientating the vessel
10 connector 108 with respect to the cable connector 106 with the cable guide arrangement 158, and other processes and procedures.

The cable securing mechanism 136 operates by gripping the charging cable 104 when in the closed position and releasing the charging cable 104 when in the open position.

15 The operation of the cable securing mechanism 136 is controlled by the vessel controller 112, which sends control signals to the gripping mechanism 140 and the locking mechanism 142 to control the movement of the moveable gripping jaws 144 and the locking arm 176.

20 The connector mating mechanism 134 operates by moving the vessel connector 108 with respect to the cable connector 106 between a disconnected position and an engaged position. The operation of the connector mating mechanism 134 is controlled by the vessel controller 112, which sends control signals to the mating mechanism hydraulic actuator 138 to control the movement of the vessel connector 108.

25 The cable tension detection system 148 operates by detecting the tension in the charging cable 104 and sending a signal to the vessel controller 112 when the tension exceeds a safe threshold. The operation of the cable tension detection system 148 is controlled by the vessel controller 112, which processes the signal from the tension
30 sensor 150 and triggers an emergency release event when the tension in the charging cable 104 exceeds a safe threshold.

In some examples, the cable tension detection system 148 may send the tension signal to the vessel controller 112 and the vessel controller 112 then carries out the steps as shown in Figures 8 and 9. Alternatively, the cable tension detection system 148 may carry out some of the steps of the cable tension detection system 148 and the vessel controller 112 carries out the other steps. For example, the cable tension detection system 148 may carry out the determination steps 902, 904 and 908 and then send a signal to the vessel controller 112. Alternatively in some other examples, the cable tension detection system 148 is part of the vessel controller 112 and implemented as a subsystem module in hardware or software in the vessel controller 112. In this way, the vessel controller 112 in some examples is also the cable tension detection system 148.

Furthermore, in some examples, as shown in Figure 10, the offshore charging installation 102 optionally additionally or alternatively comprises a cable tension detection system 152 and tension sensor 154. The cable tension detection system 152 and tension sensor 154 of the offshore charging installation 102 are mounted to the offshore charging installation 102. The cable tension detection system 152 of the offshore charging installation 102 may have the same functionality as previously described with reference to the cable tension detection system 148 and tension sensor 150 on the vessel. That is, the cable tension detection system 152 on the offshore charging installation 102 can determine the tension of the charging cable 104 in the determination steps 902, 904 and 908 and then send a signal to the vessel controller 112 and / or the charging circuit controller 124.

In this way, the charging circuit controller 124 can carry out the steps as shown in Figures 8 and 9 instead of the vessel controller 112. Alternatively, the charging circuit controller 124 can carry out the steps as shown in Figures 8 and 9 in addition to the vessel controller 112. This means that the charging circuit controller 124 can independently monitor the tension in the charging cable 104 as well as the vessel controller 112. This increases the redundancy when detecting the tension in the charging cable 104.

In one configuration, the operation of the hydraulic control system 116 involves controlling the operation of various hydraulic actuators of the vessel 100. The hydraulic control system 116 is connected to various hydraulic actuators, including the locking arm hydraulic actuator 194, the gripping mechanism hydraulic actuator 146, and the mating mechanism hydraulic actuator 138. The hydraulic control system 116 is configured to selectively actuate one or more of these hydraulic actuators in response to signals received from the vessel controller 112. This allows the hydraulic control system 116 to control the movement of various components of the vessel 100, such as the locking arm 176, the moveable gripping jaws 144, and the vessel connector 108.

The terminology used herein is for the purpose of describing particular aspects only and is not intended to be limiting of the disclosure. As used herein, the singular forms "a," "an," and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. It will be further understood that the terms "comprises," "comprising," "includes," and/or "including" when used herein specify the presence of stated features, integers, actions, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, actions, steps, operations, elements, components, and/or groups thereof.

It will be understood that, although the terms first, second, etc., may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element without departing from the scope of the present disclosure.

Relative terms such as "below" or "above" or "upper" or "lower" or "horizontal" or "vertical" may be used herein to describe a relationship of one element to another element as illustrated in the Figures. It will be understood that these terms and those discussed above are intended to encompass different orientations of the device in

addition to the orientation depicted in the Figures. It will be understood that when an element is referred to as being "connected" or "coupled" to another element, it can be directly connected or coupled to the other element, or intervening elements may be present. In contrast, when an element is referred to as being "directly connected" or
5 "directly coupled" to another element, there are no intervening elements present.

Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs. It will be further understood that terms used herein
10 should be interpreted as having a meaning consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealised or overly formal sense unless expressly so defined herein.

It is to be understood that the present disclosure is not limited to the aspects described
15 above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the present disclosure and appended claims. In the drawings and specification, there have been disclosed aspects for purposes of illustration only and not for purposes of limitation, the scope of the disclosure being set forth in the following claims.

Claims

1. A vessel (100) comprising:
a vessel electrical circuit (110);
5 a vessel connector (108) electrically connected to the vessel electrical circuit (110);
a cable handling mechanism (114) mounted on the vessel (100), the cable handling
mechanism (114) comprising:
a cable securing mechanism (136) configured to secure a charging cable (104)
having a cable connector (106) with respect to the vessel (100), the charging cable
10 (104) being electrically connected to an offshore charging installation (102); and
a connector mating mechanism (134) configured to move the vessel connector
(108) with respect to the cable connector (106) between a disconnected position and
an engaged position;
wherein the vessel further comprises a cable tension detection system (148)
15 having a tension sensor (150) configured to detect the tension in the charging cable
(104).
2. The vessel (100) according to claim 1, wherein the connector mating mechanism
(134) is configured to move the vessel connector (108) in a plane parallel with a vessel
20 deck (172).
3. The vessel (100) according to claims 1 or 2, further comprising a cable
guide arrangement (158) configured to orientate the vessel connector (108) with
respect to the cable connector (106).
25
4. The vessel (100) according to any one of the preceding claims, wherein the cable
securing mechanism (136) comprises a gripping mechanism (140) moveable between
open and closed positions.
- 30 5. The vessel (100) according to claim 4, further comprising a locking mechanism (142)
configured to mechanically lock the gripping mechanism (140) in the closed position,

wherein the locking mechanism (142) comprises a locking lever (176) moveable between a locked position and a release position.

5 6. The vessel (100) according to any one of the preceding claims, further comprising a vessel controller (112) configured to control the cable handling mechanism (114).

7. The vessel (100) according to claim 6, wherein the vessel controller (112) is configured to control the cable securing mechanism (136) and the connector mating mechanism (134).

10

8. The vessel (100) according to claims 6 or 7, wherein the vessel controller (112) is configured to receive a signal from the tension sensor (150) and trigger an emergency release event in response to the detected tension exceeding a safe tension threshold.

15 9. The vessel (100) according to any one of the preceding claims, further comprising a hydraulic control system (116) connected to the cable handling mechanism (114).

10. The vessel (100) according to any one of the preceding claims, wherein the cable handling mechanism (114) further comprises a cable guide arrangement (158) configured to guide and direct the charging cable (104) into the correct position and orientation for connection.

20

11. The vessel (100) according to claim 10, wherein the cable guide arrangement (158) comprises a funnel (160) narrowing towards the vessel connector (108).

25

12. The vessel (100) according to claims 10 or 11, wherein the cable guide arrangement (158) comprises a guiding slot (162) configured to engage with a self-aligning keyway (168) projecting from the cable connector (106).

30 13. The vessel (100) according to any of the preceding claims, wherein the cable handling mechanism (114) is configured to actively align the vessel connector (108) with respect to the cable connector (106).

14. A vessel charging system comprising:

a vessel (100) according to any one of claims 1 to 13;

5 an offshore charging installation (102) having an offshore installation charging circuit (122) electrically connected to the charging cable (104); and a power source (118).

15. The vessel charging system according to claim 14, further comprising a mooring line configured to tether the vessel (100) to the offshore charging installation (102).

10 16. The vessel charging system according to any one of claims 14 to 15, wherein the offshore charging installation (102) is floating.

17. The vessel charging system according to any one of claims 14 to 15, wherein the offshore charging installation (102) is fixed with respect to the seabed.

15

18. A cable handling mechanism (114) for a vessel (100) comprising:

a cable securing mechanism (136) configured to secure a charging cable (104) having a cable connector (106) with respect to the vessel (100), the charging cable (104) being electrically connected to an offshore charging installation (102);

20 a connector mating mechanism (134) configured to move a vessel connector (108) electrically connected to a vessel electrical circuit (110) with respect to the cable connector (106) between a disconnected position and an engaged position; and

a cable tension detection system (148) having a tension sensor (150) configured to detect the tension in the charging cable (104).

25

19. A method of handling and mating a charging cable (104) on a vessel (100) comprising the steps of:

raising the charging cable (104) onto the vessel (100);

30 securing the charging cable (104) with a cable securing mechanism (136) of a cable handling mechanism (114);

orientating a vessel connector (108) with respect to a cable connector (106) of the charging cable; and

moving the vessel connector (108) towards the cable connector (106).

20. A method of handling and disconnecting a charging cable (104) on a vessel (100) comprising the steps of:

- 5 monitoring tension in the charging cable (104);
determining tension of the charging cable (104) above a tension threshold;
triggering an emergency event based on detected tension;
deenergising the charging cable (104);
disengaging a cable securing mechanism (136); and
10 disconnecting the charging cable (104).

21. A cable handling mechanism (114) for a vessel (100) comprising:

- a cable securing mechanism (136) configured to secure a charging cable (104) having a cable connector (106) with respect to the vessel (100), the charging cable
15 (104) being electrically connected to an offshore charging installation (102); and
a connector mating mechanism (134) configured to move a vessel connector (108) electrically connected to a vessel electrical circuit (110) with respect to the cable connector (106) between a disconnected position and an engaged position;
wherein the cable handling mechanism (114) is configured to actively align the
20 vessel connector (108) with respect to the cable connector (106).

22. A vessel comprising:

- the cable handling mechanism (114) of claim 21;
the vessel electrical circuit (110); and
25 the vessel connector (108) electrically connected to the vessel electrical circuit (110).

1/10

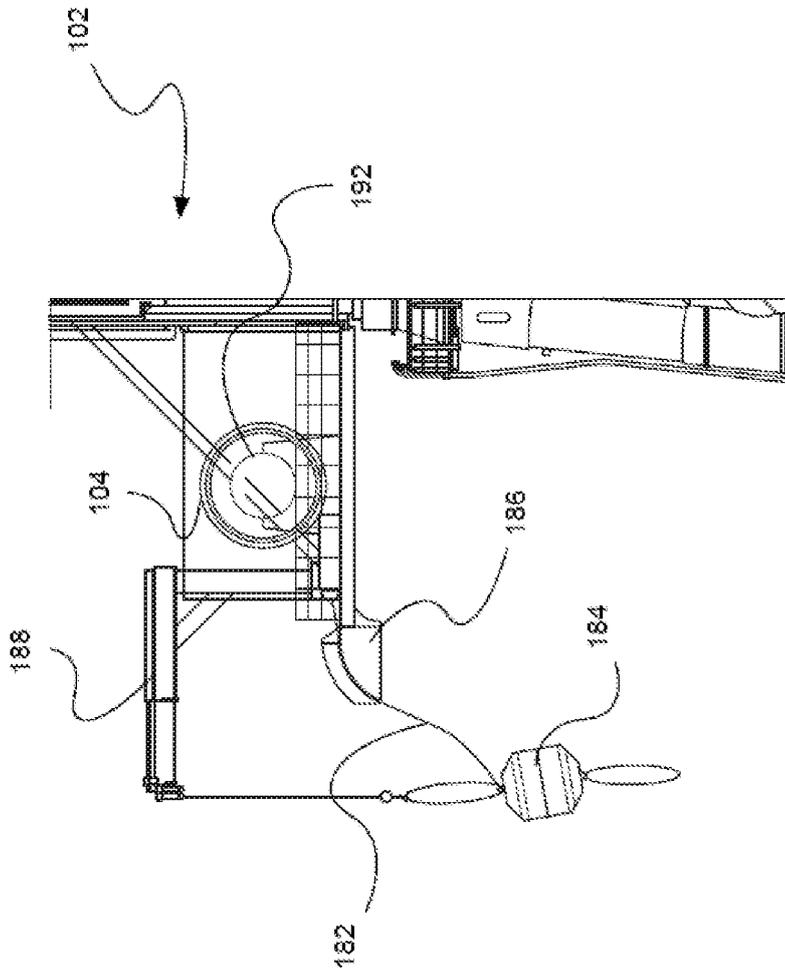


Fig. 1

2/10

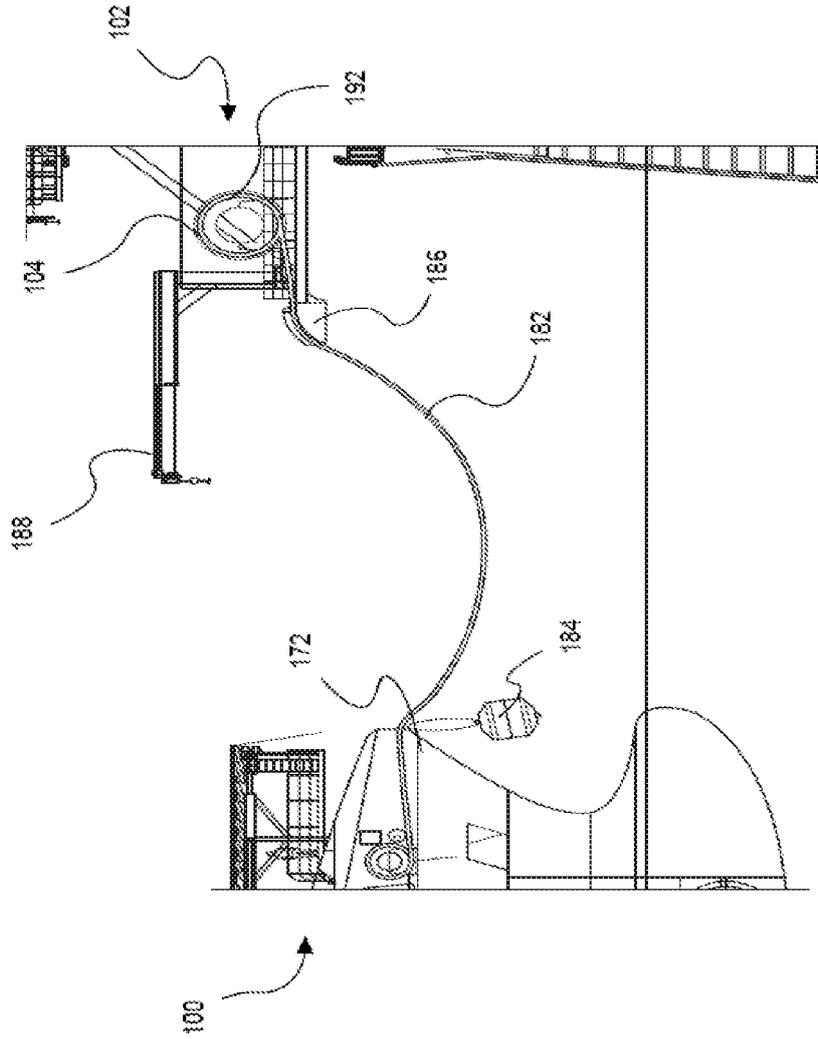


Fig. 2

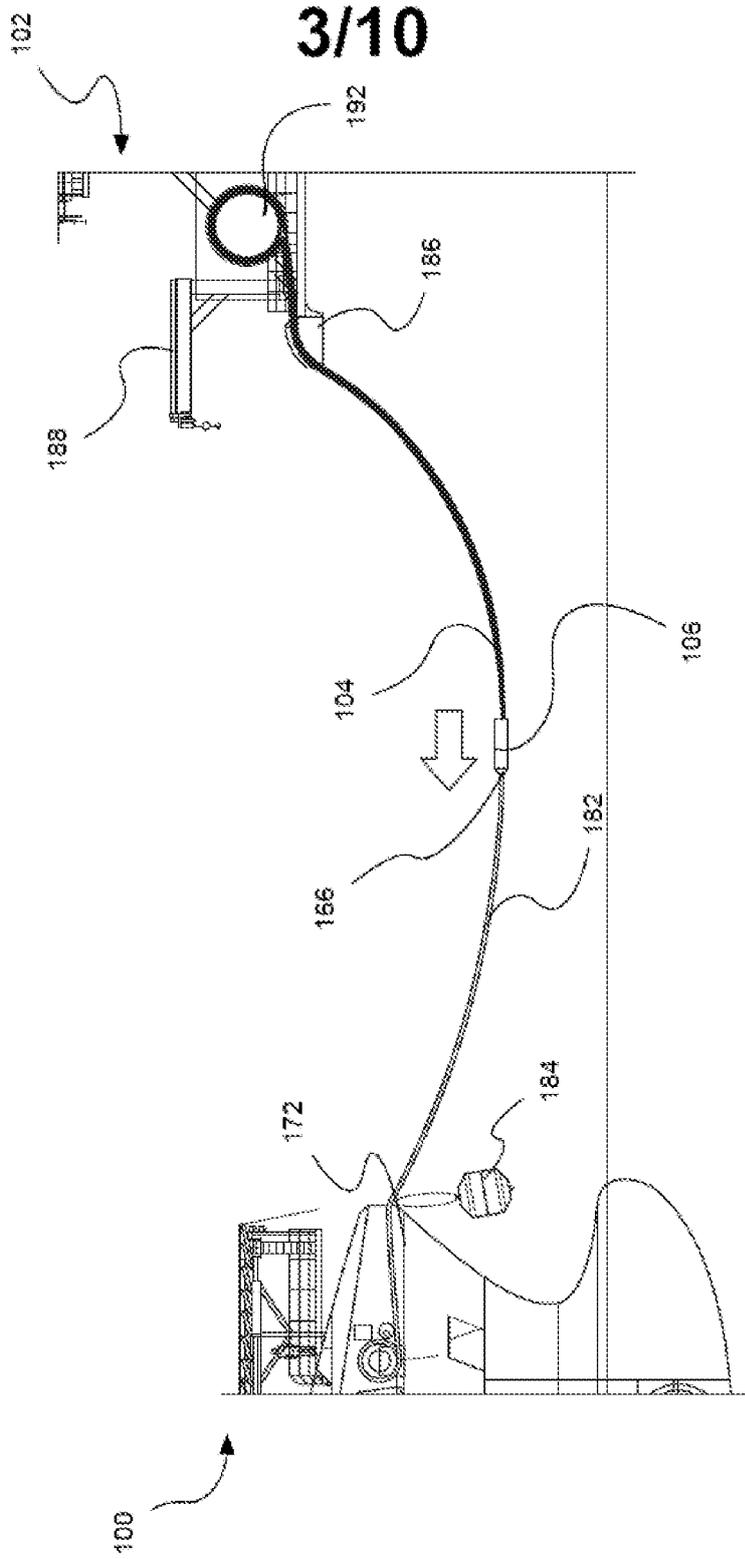


Fig. 3

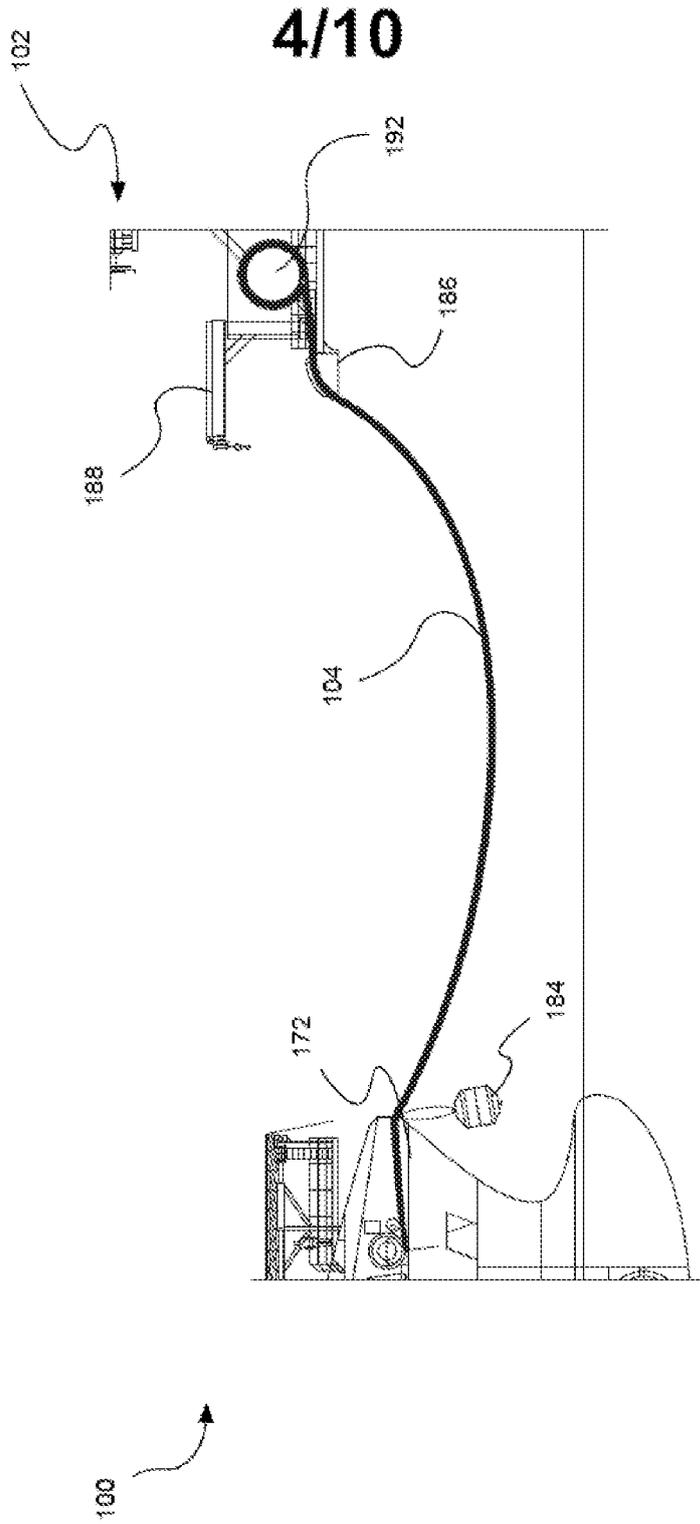


Fig. 4

6/10

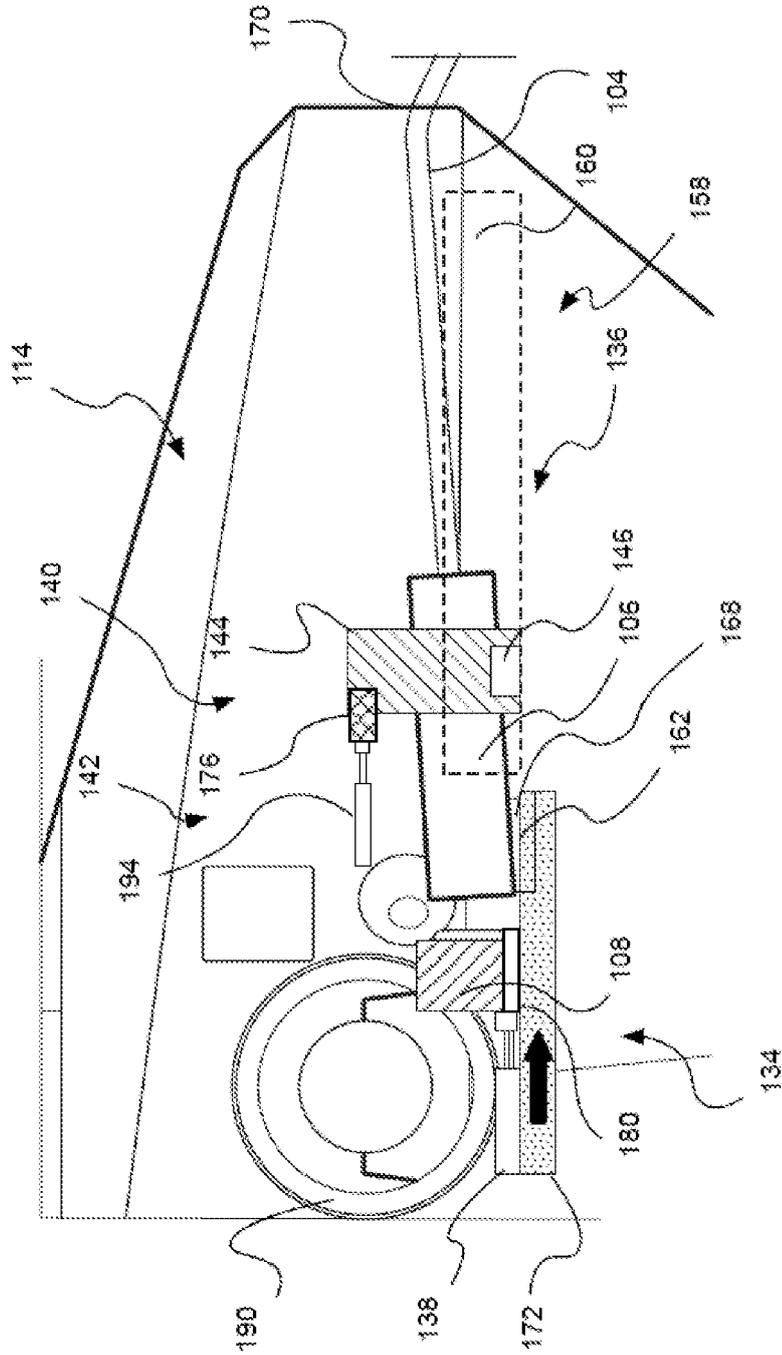


Fig. 6

7/10

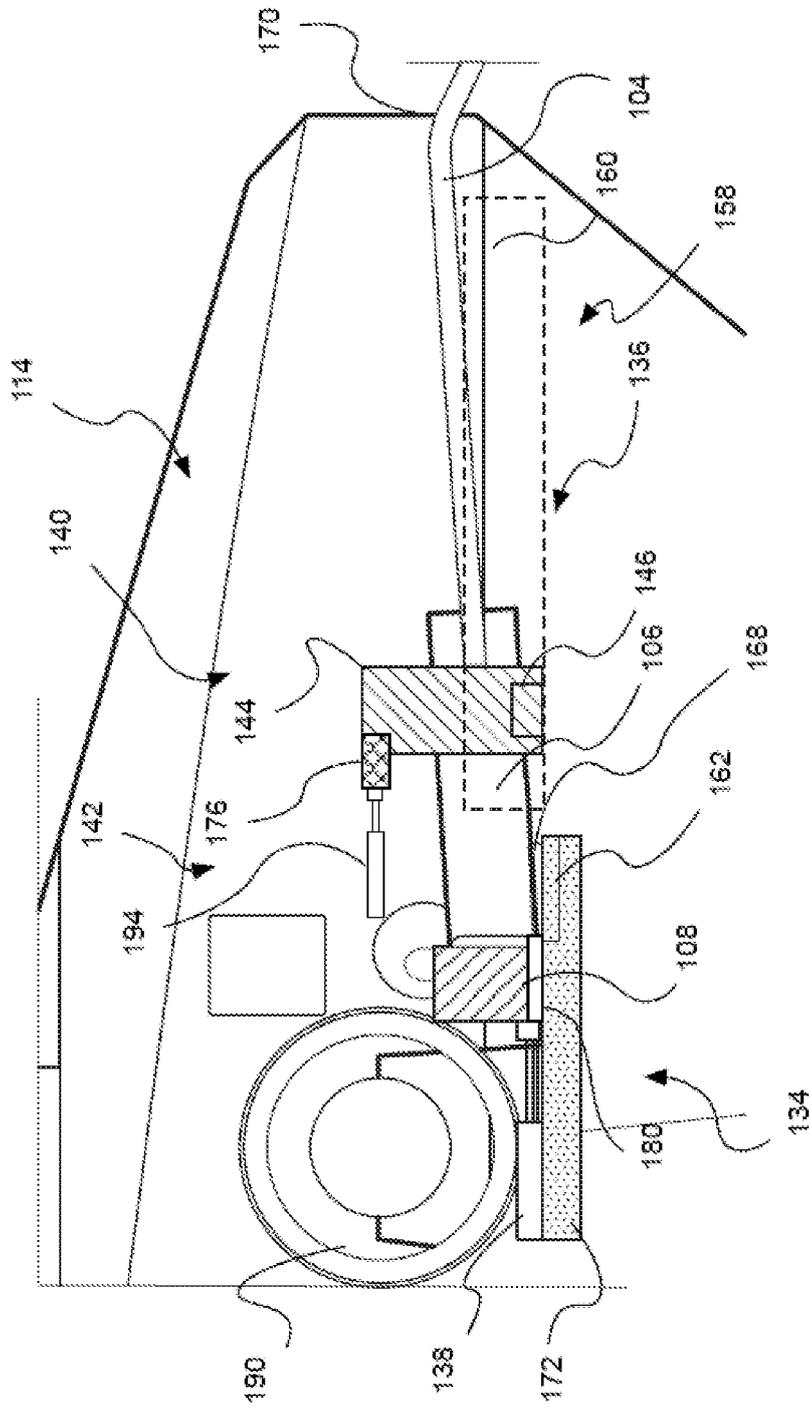


Fig. 7

8/10

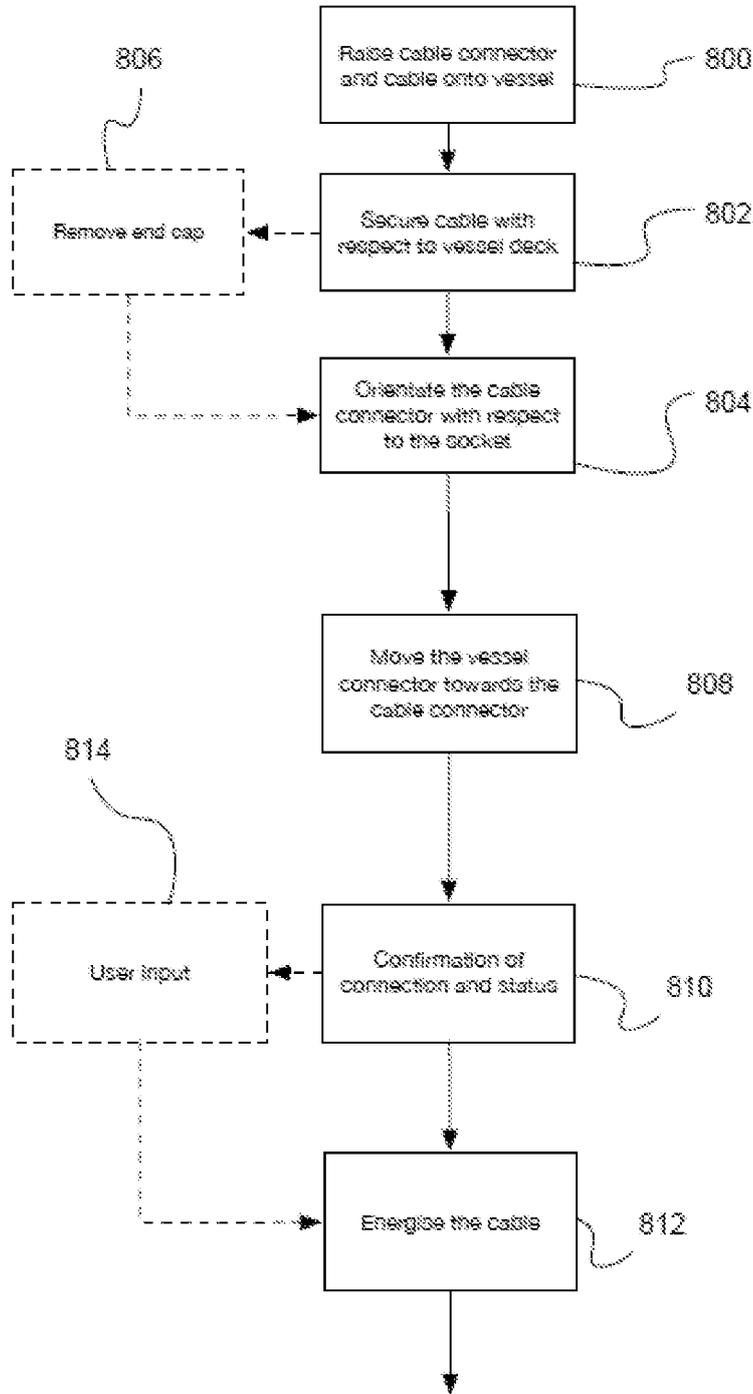


Fig. 8

9/10

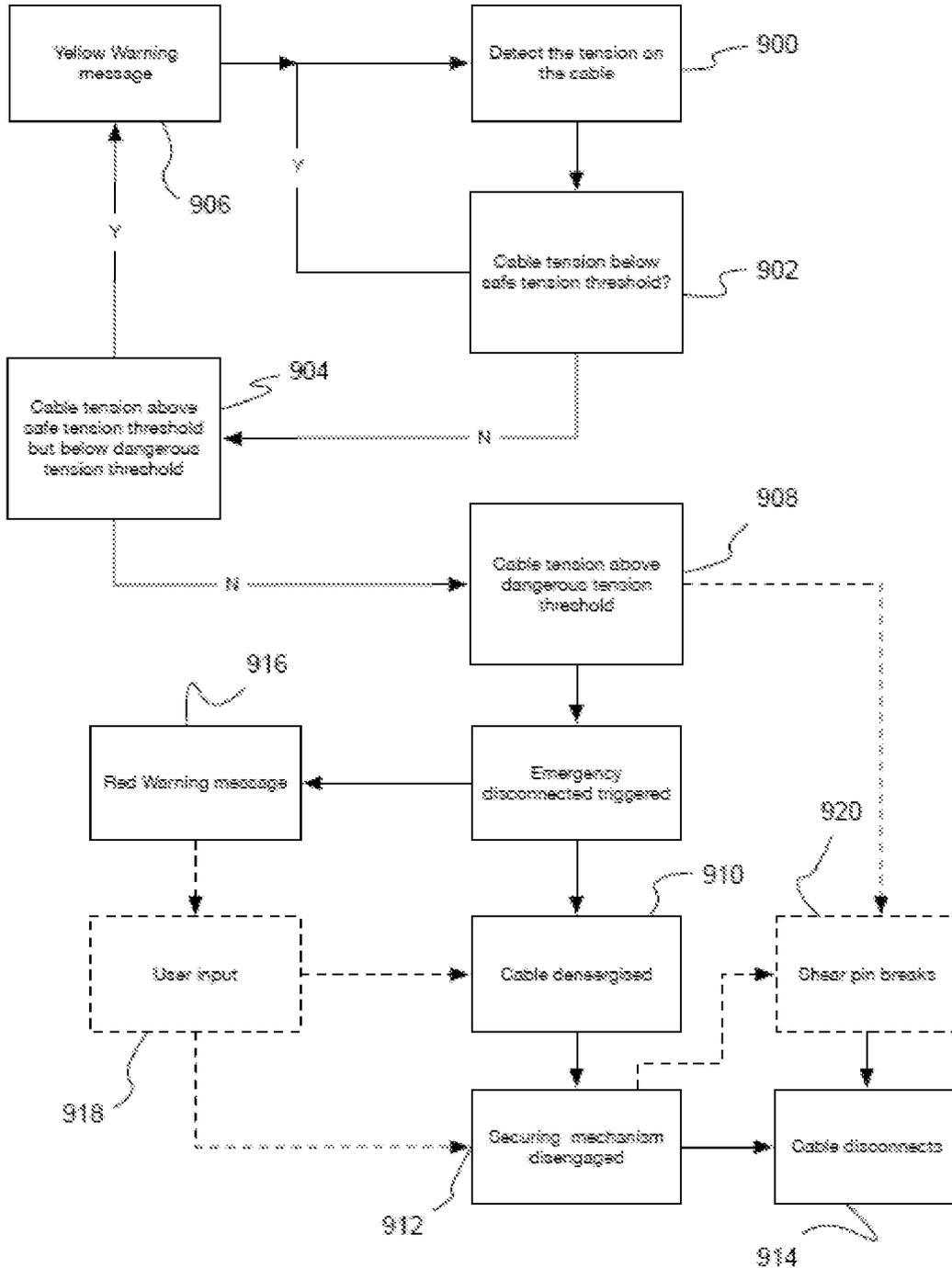


Fig. 9

10/10

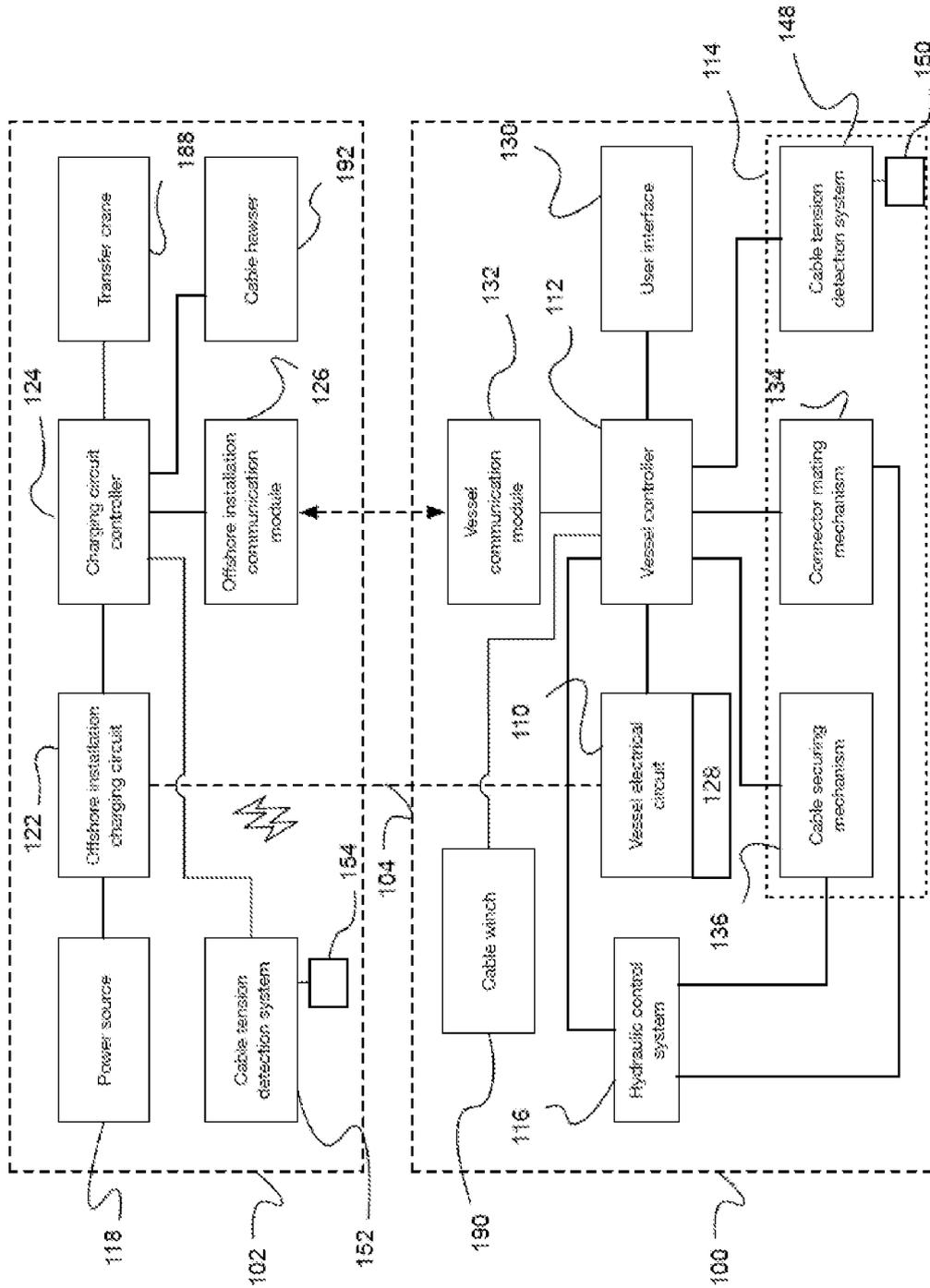


Figure 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2024/050306

A. CLASSIFICATION OF SUBJECT MATTER B63J 3/04 (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) B63J; B60L CPC: B63J; B60L; Y02T		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, FI, NO, SE: Classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, GOOGLE		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	MJR Power & Automation Offshore Wind On-Turbine Vessel Charging System. YouTube [online] [video]. MJR Power & Automation, 2022-04-06 [retrieved on 2024-05-22]. Retrieved from: https://www.youtube.com/watch?v=3PMSioCF7Zk , see video.	19, 21, 22 1-18, 20
A	Electric ferries are technological masterpieces. YouTube [online] [video]. DEIF global supplier of energy control solutions, 2018-06-12 [retrieved on 2024-05-22]. Retrieved from: https://www.youtube.com/watch?v=dgg_pohK-q8 , see video.	1-22
A	CN 116788070 A (JIANGSU JIANLONG ELECTRICAL CO LTD) 22 September 2023 (2023-09-22) Whole document	1-22
A	US 2010218710 A1 (SNECMA [FR]) 02 September 2010 (2010-09-02) Whole document	1-22
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> 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 "D" document cited by the applicant in the international application "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 03 January 2025		Date of mailing of the international search report 14 January 2025
Name and mailing address of the ISA/XN Nordic Patent Institute Helgeshoj Allé 81, 2630 Taastrup Denmark Telephone No. +45 43 50 85 00 Facsimile No. +4543508008		Authorized officer Anders Budtz-Olsen Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK2024/050306

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2020242320 A1 (ZINUS AS [NR]) 03 December 2020 (2020-12-03) Whole document	1-22
A	WO 2016185144 A1 (NEW GENERATION NATURAL GAS NATURAL GROWTH [FR]) 24 November 2016 (2016-11-24) Whole document	1-22

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The application does not comply with the requirements of unity of invention because it does not relate to one invention or to a group of inventions so linked as to form a single general inventive concept.

In our search we found that there initially are at least two inventions (groups of inventions).

As a vessel, a system, a cable handling mechanism and a method of handling and mating or disconnecting a charging cable on a vessel is known from MJR Power & Automation Offshore Wind On-Turbine Vessel Charging System. MJR Power & Automation (2022-04-06) we find that the at least two inventions (groups of inventions) are defined by the following special technical features:

Invention I: Claims 1-18 and 20:

A vessel, a system, a cable handling mechanism, and a method of handling and disconnecting a charging cable on a vessel with detection of tension in the charging cable.

Invention II: Claims 19, 21 and 22:

A vessel, a cable handling mechanism and a method of handling and mating a charging cable on a vessel with orientation of a vessel connector with respect to a cable connector of the charging cable.

Since the abovementioned groups of claims do not share special technical features identified, a technical relationship between the inventions does not exist (Rule 13.2 PCT). Therefore, the two groups of claims are not linked by common or corresponding special technical features and define two different inventions not linked by a single general inventive concept. The application, hence does not meet the requirements of Unity of Invention as defined in Rule 13(1) & (2) PCT.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

Box No. IV **Text of the abstract (Continuation of item 5 of the first sheet)**

A system includes a vessel (100) with a cable handling mechanism (114) and an electrical circuit (110), a charging cable (104) with a connector end configured to electrically connect to the electrical circuit (110) of the vessel (100), and an offshore charging installation (102) electrically connected to the charging cable (104) and configured to provide power to the vessel (100) through the charging cable (104). The cable handling mechanism (114) comprises a connector mating mechanism (134) configured to move the connector end with respect to a vessel connector (108) between a disconnected position and an engaged position.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/DK2024/050306

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	116788070	A	22 September 2023	CN	116788070	B	22 December 2023
US	2010218710	A1	02 September 2010	US	8122841	B2	28 February 2012
				AT	E486776	T1	15 November 2010
				DE	602007010252	D1	16 December 2010
				DK	1996455	T3	14 February 2011
				EP	1996455	A1	03 December 2008
				EP	1996455	B1	03 November 2010
				ES	2355851	T3	31 March 2011
				FR	2899029	A1	28 September 2007
				FR	2899029	B1	27 June 2008
				JP	2009530174	A	27 August 2009
				JP	5417165	B2	12 February 2014
				KR	20090003265	A	09 January 2009
				WO	2007107673	A1	27 September 2007
WO	2020242320	A1	03 December 2020	DE	112020002581	T5	24 February 2022
				EP	3977571	A1	06 April 2022
				GB	202117103	D0	12 January 2022
				GB	2599264	A	30 March 2022
				GB	2599264	B	26 April 2023
				NO	344931	B1	06 July 2020
WO	2016185144	A1	24 November 2016	CA	2986189	A1	24 November 2016
				CA	2986189	C	28 January 2020
				CN	107636909	A	26 January 2018
				CN	107636909	B	02 August 2019
				EP	3298661	A1	28 March 2018
				EP	3298661	B1	03 July 2019
				FR	3036545	A1	25 November 2016
				FR	3036545	B1	05 May 2017
				US	2018151974	A1	31 May 2018
				US	10103474	B2	16 October 2018