



(11)

EP 4 527 981 A1

(12)

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

(43) Date of publication:
26.03.2025 Bulletin 2025/13

(51) International Patent Classification (IPC):
C23F 13/02 (2006.01)

(21) Application number: **23806791.2**

(86) International application number:
PCT/CN2023/093353

(22) Date of filing: **11.05.2023**

(87) International publication number:
WO 2023/221839 (23.11.2023 Gazette 2023/47)

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

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(30) Priority: **16.05.2022 CN 202210531260**

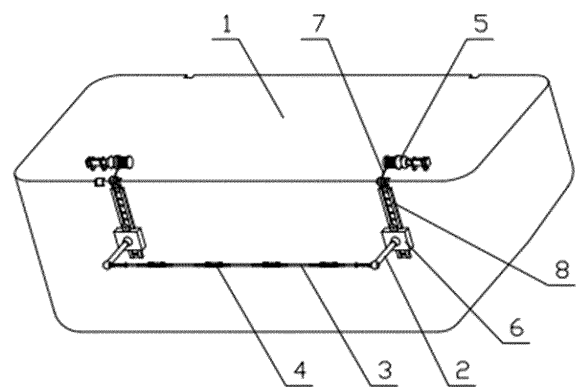
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(54) **FPSO EXTERNAL ANTI-CORROSION APPARATUS**

(57) The present invention provides an FPSO external anti-corrosion device, including: a hull; support arms; composite cables; and auxiliary anodes, wherein at least two of the support arms are provided on one side of the hull, ends of the support arms extending away from the hull, the ends of the support arms being connected to the composite cables, the composite cables being tensioned by the support arms, and the auxiliary anodes being arranged on the composite cables. The FPSO external anti-corrosion device according to the present invention provides auxiliary anodes outside a hull via support arms, solving the problem of underwater anti-corrosion for FPSOs. Furthermore, a protective current is adjustable, offering a wider range of applications. The external installation of auxiliary anodes does not affect the hull's structure, ensuring the stability and reliability of the hull structure. Additionally, the FPSO external anti-corrosion device is suitable for existing FPSOs, and the external anti-corrosion structure according to the present invention can be implemented with minimal modifications to the original hull structure, making it convenient to use and easy to maintain.

Fig. 1



Description

Technical Field

[0001] The present invention relates to a field of anti-corrosion technology, particularly to an FPSO external anti-corrosion device.

Background Art

[0002] FPSO (Floating Production Storage and Off-loading), also known as floating oil storage and offloading unit, is used for the preliminary processing and storage of crude oil and is referred to as "marine oil factory". The hull of an FPSO is often exposed to environments containing salt mist, moisture, and seawater, etc., causing severe electrochemical corrosion due to the surrounding media, leading to serious structural corrosion. Corrosion reduces the mechanical properties of structural materials and shortens the service life. FPSOs, being far from the coast, cannot be docked for regular maintenance and repairs like ships, making anti-corrosion measures for FPSO hulls very necessary.

[0003] Currently, anti-corrosion measures for FPSO hulls are basically the same as those for conventional ships, primarily involving coating and cathodic protection. Generally, the exterior surface below the waterline of the hull adopts combined protection, while the exterior surface above the waterline adopts coating protection.

[0004] However, sacrificial anode protection current is not adjustable, and is not suitable for high-resistance environments, limiting the applicable environments of FPSOs. The lifespan of sacrificial anodes is relatively short, requiring frequent replacement for FPSOs operating at sea for extended periods. Since sacrificial anodes are installed on the hull surface, frequent replacement and maintenance affect the stability of the hull structure. Additionally, sacrificial anodes consume non-ferrous metals, causing environmental pollution.

Summary of Invention

[0005] The present invention provides an FPSO external anti-corrosion device to solve the aforementioned problems.

[0006] The FPSO external anti-corrosion device includes: a hull; support arms; composite cables; and auxiliary anodes, wherein

at least two of the support arms are provided on one side of the hull, ends of the support arms extending away from the hull, the ends of the support arms being connected to the composite cables, the composite cables being tensioned by the support arms, and the auxiliary anodes being arranged on the composite cables.

[0007] The FPSO external anti-corrosion device further includes a lifting device, wherein the lifting device includes a winch, a lifting platform, steel cables, and rails, the winch being installed on the hull, the winch being

connected to the lifting platform via the steel cables, the lifting platform being arranged on the rails, the rails being vertically arranged on an outer side of the hull, and the support arms being fixed on the lifting platform.

[0008] The FPSO external anti-corrosion device further includes a lifting device, wherein the lifting device includes a motor and a reducer, the motor being installed on the hull and connected to the support arms via the reducer, and a winch being able to drive the support arms to rotate through the reducer, causing the composite cables to rotate to a top of the hull.

[0009] The FPSO external anti-corrosion device further includes a lifting device, wherein the lifting device includes a winch and steel cables, the winch being installed on the hull and connected to the ends of the support arms via the steel cables, the support arms being hinged to a side of the hull, and the winch being able to lift the support arms via the steel cables.

[0010] Further, the support arms are hinged to a side of the hull via installation shafts, axes of the installation shafts being perpendicular to a horizontal plane, the installation shafts being connected to a driving structure, and the driving structure being used to drive the installation shafts to rotate.

[0011] Further, the support arms are hinged to a side of the hull via installation shafts, axes of the installation shafts being parallel to a bow-and-stern line of the hull, the installation shafts being connected to a driving structure, and the driving structure being used to drive the installation shafts to rotate.

[0012] Further, the support arms are hydraulic telescopic arms or electric telescopic arms, the support arms being installed on a side of the hull and located below a water surface, and the support arms being parallel to a horizontal plane.

[0013] Further, the support arms are hydraulic telescopic arms or electric telescopic arms, the support arms being installed on the hull, the support arms extending obliquely downward, with a support member provided between the support arms and a side of the hull, and the ends of the support arms extending below a water surface.

[0014] Further, the ends of the support arms are provided with tensioning devices, the tensioning devices being able to tension the composite cables.

[0015] The FPSO external anti-corrosion device according to the present invention provides auxiliary anodes outside a hull via support arms, solving the problem of underwater anti-corrosion for FPSOs. Furthermore, a protective current is adjustable, offering a wider range of applications. The external installation of auxiliary anodes does not affect the hull's structure, ensuring the stability and reliability of the hull structure. Additionally, the FPSO external anti-corrosion device is suitable for existing FPSOs, and the external anti-corrosion structure according to the present invention can be implemented with minimal modifications to the original hull structure, making it convenient to use and easy to maintain.

Brief Description of Drawings

[0016] In order to illustrate the embodiments of the present invention or the technical solutions in the prior art more clearly, the following briefly introduces the accompanying drawings that need to be used in the description of the embodiments or the prior art. Obviously, the accompanying drawings in the following description are some embodiments of the present invention, and for a person skilled in the art, other drawings can also be obtained from these accompanying drawings without creative effort.

[0017]

Fig. 1 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 1 of the present invention.

Fig. 2 is a side view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 1 of the present invention.

Fig. 3 is a front view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 1 of the present invention.

Fig. 4 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 2 of the present invention.

Fig. 5 is an enlarged schematic diagram of part A in Fig. 4.

Fig. 6 is a front view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 2 of the present invention.

Fig. 7 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 3 of the present invention.

Fig. 8 is a front view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 3 of the present invention.

Fig. 9 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 4 of the present invention.

Fig. 10 is an enlarged schematic diagram of part B in Fig. 9.

Fig. 11 is a top view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 4 of the present invention.

Fig. 12 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 5 of the present invention.

Fig. 13 is an enlarged schematic diagram of part C in Fig. 12.

Fig. 14 is a front view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 5 of the present invention.

Fig. 15 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 6 of the present invention.

Fig. 16 is a front view schematic diagram of the FPSO external anti-corrosion device structure ac-

cording to Embodiment 6 of the present invention.

Fig. 17 is a schematic diagram of an FPSO external anti-corrosion device structure according to Embodiment 7 of the present invention.

Fig. 18 is a front view schematic diagram of the FPSO external anti-corrosion device structure according to Embodiment 7 of the present invention.

[0018] In the drawing: 1. Hull; 2. Support arm; 3. Composite cable; 4. Auxiliary anode; 5. Winch; 6. Lifting platform; 7. Steel cable; 8. Rail; 9. Motor; 10. Reducer; 11. Installation shaft; 12. Driving structure; 13. Tensioning device

15 Description of Embodiments

[0019] In order to make the purposes, technical solutions and advantages of the embodiments of the present invention clearer, the technical solutions in the embodiments of the present invention will be clearly and completely described below with reference to the accompanying drawings in the embodiments of the present invention. Obviously, the embodiments to be described are some, but not all, embodiments of the present invention. Based on the embodiments of the present invention, all other embodiments obtained by a person skilled in the art without creative efforts are within the protection scope of the present invention.

30 First Embodiment

[0020] As shown in Figs. 1-3, the present embodiment discloses an FPSO external anti-corrosion device, including: a hull 1; support arms 2; composite cables 3; and auxiliary anodes 4, wherein

at least two of the support arms 2 are provided on one side of the hull 1, ends of the support arms 2 extending away from the hull 1, the ends of the support arms 2 being connected to the composite cables 3, the composite cables 3 being tensioned by the support arms 2, and the auxiliary anodes 4 being arranged on the composite cables 3.

[0021] The present embodiment also includes a lifting device, wherein the lifting device includes a winch 5, a lifting platform 6, steel cables 7, and rails 8, the winch 5 being installed on the hull 1, the winch 5 being connected to the lifting platform 6 via the steel cables 7, the lifting platform 6 being arranged on the rails 8, the rails 8 being vertically arranged on an outer side of the hull 1, and the support arms 2 being fixed on the lifting platform 6.

[0022] The ends of the support arms 2 are provided with tensioning devices 13, the tensioning devices 13 being able to tension the composite cables 3.

[0023] In the present embodiment, the support arms 2 are parallel to a horizontal plane and vertically fixed to the lifting platform 6. The lifting platform 6 is provided with a slider that can move along the rails 8. The steel cables 7 are fixedly connected to the lifting platform 6. The winch 5

pulls the steel cables 7, driving the lifting platform 6 to move, thus allowing the support arms 2 to move with the lifting platform 6 so that the composite cables 3 can leave the water surface or go underwater.

[0024] The size and number of auxiliary anodes are calculated and determined based on the area of the structure to be protected, the coating situation, operating conditions, the designed protection years, etc. The position of the auxiliary anodes is calculated and determined using cathodic protection numerical simulation software. The auxiliary anodes are installed on the composite cables. Based on the hydrodynamic calculation results of the composite cables, corresponding mechanical calculations are carried out to determine the specifications of the composite cables, the fixing device between the composite cables and the lifting platform, and the tensioning device.

[0025] The tensioning device 13 can adopt turnbuckle bolts or waterproof electric telescopic rods, as well as other forms of tensioning structures. By prefabricating the tensioning force to tension the auxiliary anode composite cables, the overall rigidity of the composite cables is improved, effectively resisting alternating stress loads from seawater waves and flow, preventing external damage under extreme marine conditions, and preventing the composite cables from colliding with the hull under the action of ocean currents.

[0026] During normal operation, the composite cables 3 and the auxiliary anodes 4 are both underwater. For maintenance or repair, the composite cables 3 can be pulled up by the winch 5.

[0027] The FPSO external anti-corrosion device according to the present invention can be implemented with minimal modifications to the original structure of the FPSO, and thus is easy to install, does not require operation on the hull during maintenance, does not affect the hull structure, and is convenient for maintenance.

[0028] The FPSO external anti-corrosion device according to the present invention adopts an applied current cathodic protection and provides auxiliary anodes outside a hull via support arms, solving the problem of underwater anti-corrosion for FPSOs. Furthermore, a protective current is adjustable, offering a wider range of applications. The external installation of auxiliary anodes does not affect the hull's structure, ensuring the stability and reliability of the hull structure. Additionally, the FPSO external anti-corrosion device is suitable for existing FPSOs, and the external anti-corrosion structure according to the present invention can be implemented with minimal modifications to the original hull structure, making it convenient to use and easy to maintain.

Second Embodiment

[0029] As shown in Figs. 4-6, the present embodiment differs from Embodiment 1 in that the lifting device includes a motor 9 and a reducer 10, the motor 9 being installed on the hull 1 and connected to the support arms

2 via the reducer 10, and a winch 5 being able to drive the support arms 2 to rotate through the reducer 10, causing the composite cables 3 to rotate to a top of the hull 1.

[0030] In the present embodiment, the motor 9 and the reducer 10 are installed on the side of the hull, a torque is transmitted through the motor 9 and the reducer 10 to rotate the support arms 2, and the axes of rotation of the support arms 2 are parallel to the bow-and-stern line of the hull 1.

[0031] During operation, the support arms 2 extend obliquely downward into the water, providing anti-corrosion protection for the hull surface. For maintenance, the motor 9 is activated to rotate the support arms 2 to the top of the hull 1 for inspection.

Third Embodiment

[0032] As shown in Figs. 7 and 8, the present embodiment differs from Embodiment 1 in that the lifting device includes a winch 5 and steel cables 7, the winch 5 being installed on the hull 1 and connected to the ends of the support arms 2 via the steel cables 7, the support arms 2 being hinged to a side of the hull 1, and the winch 5 being able to lift the support arms 2 via the steel cables 7.

[0033] In the present embodiment, the winch 5 drives the support arms 2 through the steel cables 7, allowing the support arms 2 to rotate and thus causing the composite cables 3 provided at the ends of the support arms 2 to enter or leave the water.

Fourth Embodiment

[0034] As shown in Figs. 9-11, the present embodiment differs from Embodiment 1 in that the support arms 2 are hinged to a side of the hull 1 via installation shafts 11, axes of the installation shafts 11 being perpendicular to a horizontal plane, the installation shafts 11 being connected to a driving structure 12, and the driving structure 12 being used to drive the installation shafts 11 to rotate.

[0035] In the present embodiment, the driving structure 12 adopts a waterproof motor. The motor drives the installation shafts 11 and the support arms 2 to rotate, and other forms of driving structures can also be adopted. The rotation of the support arms 2 makes the composite cables 3 and the auxiliary anodes 4 lean against the side of the hull, allowing maintenance personnel to carry out inspections through rope ladders or a hull maintenance platform.

Fifth Embodiment

[0036] As shown in Figs. 12-14, the present embodiment differs from Embodiment 1 in that the support arms 2 are hinged to a side of the hull 1 via installation shafts 11, axes of the installation shafts 11 being parallel to a bow-and-stern line of the hull 1, the installation shafts 11 being connected to a driving structure 12, and the driving structure 12 being used to drive the installation shafts

11 to rotate.

[0037] In the present embodiment, the driving structure 12 adopts a waterproof motor. The motor drives the installation shafts 11 and the support arms 2 to rotate, and other forms of driving structures can also be adopted. The rotation of the support arms 2 makes the composite cables 3 provided at the ends of the support arms 2 to enter or leave the water. Once out of the water, the composite cables 3 can rotate to a side of the hull, and thus, maintenance personnel can perform inspections and maintenance on the hull.

Sixth Embodiment

[0038] As shown in Figs. 15 and 16, the present embodiment differs from Embodiment 1 in that the support arms 2 are hydraulic telescopic arms or electric telescopic arms, the support arms 2 being installed on a side of the hull 1 and located below a water surface, and the support arms 2 being parallel to a horizontal plane.

[0039] In the present embodiment, the support arms 2 are telescopic arms, installed on both sides of the hull. The support arms 2 can be driven hydraulically or electrically. During normal operation, the support arms 2 extend. For maintenance, the support arms 2 retract.

Seventh Embodiment

[0040] As shown in Figs. 17 and 18, the present embodiment differs from Embodiment 6 in that the support arms 2 are installed on the hull 1, the support arms 2 extend obliquely downward, with a support member provided between the support arms 2 and a side of the hull 1, and the ends of the support arms 2 extend below a water surface.

[0041] In the present embodiment, the support arms 2 are installed on the side of the hull, and thus, the power structure of the support arms 2 is protected better. The ends of the support arms 2 extend below the water surface. The support arms 2 each have a certain angle with the horizontal plane, and a support member is provided between the support arms 2 and the hull to maintain the stability and firmness of the support arms 2. During normal operation, the support arms 2 extend. For maintenance, the support arms 2 retract, bringing the composite cables and the auxiliary anodes close to the hull for convenient inspection.

[0042] Finally, it should be noted that the above embodiments are only used to illustrate the technical solutions of the present invention, but not to limit them. Although the present invention has been described in detail with reference to the foregoing embodiments, a person skilled in the art should understand that the technical solutions described in the foregoing embodiments can still be modified, or some or all of the technical features thereof can be equivalently substituted. However, these modifications or substitutions do not make the essence of the corresponding technical solutions deviate from the scope

of the technical solutions of the embodiments of the present invention.

5 Claims

1. An FPSO external anti-corrosion device, comprising: a hull (1); support arms (2); composite cables (3); and auxiliary anodes (4), wherein
 at least two of the support arms (2) are provided on one side of the hull (1), ends of the support arms (2) extending away from the hull (1), the ends of the support arms (2) being connected to the composite cables (3), the composite cables (3) being tensioned by the support arms (2), and the auxiliary anodes (4) being arranged on the composite cables (3).
2. The FPSO external anti-corrosion device according to claim 1, further comprising a lifting device, wherein the lifting device includes a winch (5), a lifting platform (6), steel cables (7), and rails (8), the winch (5) being installed on the hull (1), the winch (5) being connected to the lifting platform (6) via the steel cables (7), the lifting platform (6) being arranged on the rails (8), the rails (8) being vertically arranged on an outer side of the hull (1), and the support arms (2) being fixed on the lifting platform (6).
3. The FPSO external anti-corrosion device according to claim 1, further comprising a lifting device, wherein the lifting device includes a motor (9) and a reducer (10), the motor (9) being installed on the hull (1) and connected to the support arms (2) via the reducer (10), and a winch (5) being able to drive the support arms (2) to rotate through the reducer (10), causing the composite cables (3) to rotate to a top of the hull (1).
4. The FPSO external anti-corrosion device according to claim 1, further comprising a lifting device, wherein the lifting device includes a winch (5) and steel cables (7), the winch (5) being installed on the hull (1) and connected to the ends of the support arms (2) via the steel cables (7), the support arms (2) being hinged to a side of the hull (1), and the winch (5) being able to lift the support arms (2) via the steel cables (7).
5. The FPSO external anti-corrosion device according to claim 1, wherein the support arms (2) are hinged to a side of the hull (1) via installation shafts (11), axes of the installation shafts (11) being perpendicular to a horizontal plane, the installation shafts (11) being connected to a driving structure (12), and the driving structure (12) being used to drive the installation shafts (11) to rotate.
6. The FPSO external anti-corrosion device according

to claim 1, wherein the support arms (2) are hinged to a side of the hull (1) via installation shafts (11), axes of the installation shafts (11) being parallel to a bow-and-stern line of the hull (1), the installation shafts (11) being connected to a driving structure (12), and the driving structure (12) being used to drive the installation shafts (11) to rotate. 5

7. The FPSO external anti-corrosion device according to claim 1, wherein the support arms (2) are hydraulic telescopic arms or electric telescopic arms, the support arms (2) being installed on a side of the hull (1) and located below a water surface, and the support arms (2) being parallel to a horizontal plane. 10

8. The FPSO external anti-corrosion device according to claim 1, wherein the support arms (2) are hydraulic telescopic arms or electric telescopic arms, the support arms (2) being installed on the hull (1), the support arms (2) extending obliquely downward, with a support member provided between the support arms (2) and a side of the hull (1), and the ends of the support arms (2) extending below a water surface. 15 20

9. The FPSO external anti-corrosion device according to claim 1, wherein the ends of the support arms (2) are provided with tensioning devices (13), the tensioning devices (13) being able to tension the composite cables (3). 25 30

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Fig. 1

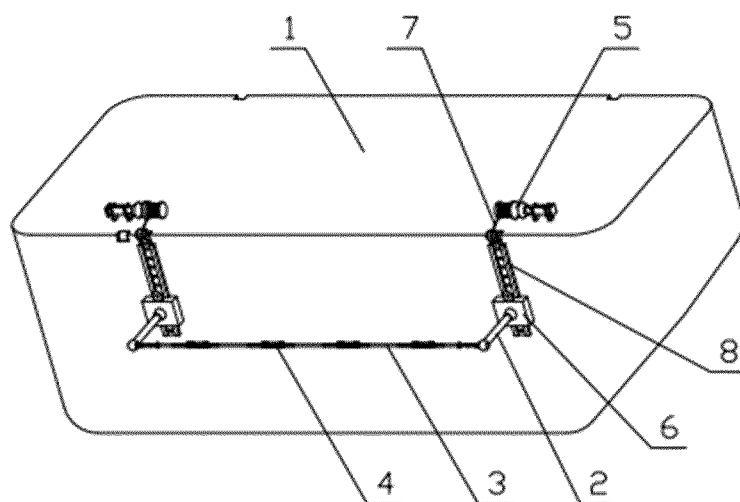


Fig. 2

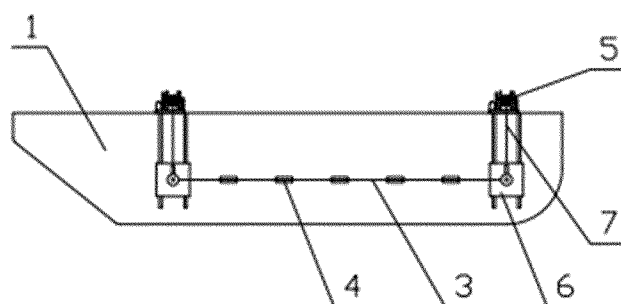


Fig. 3

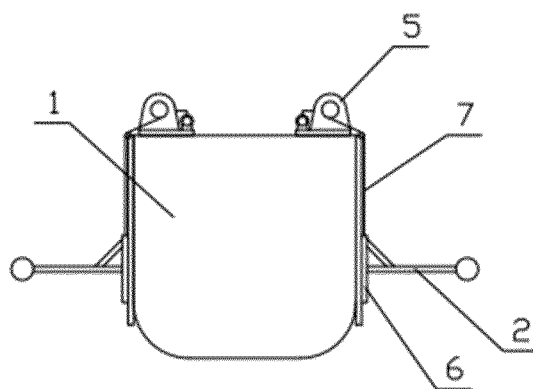


Fig. 4

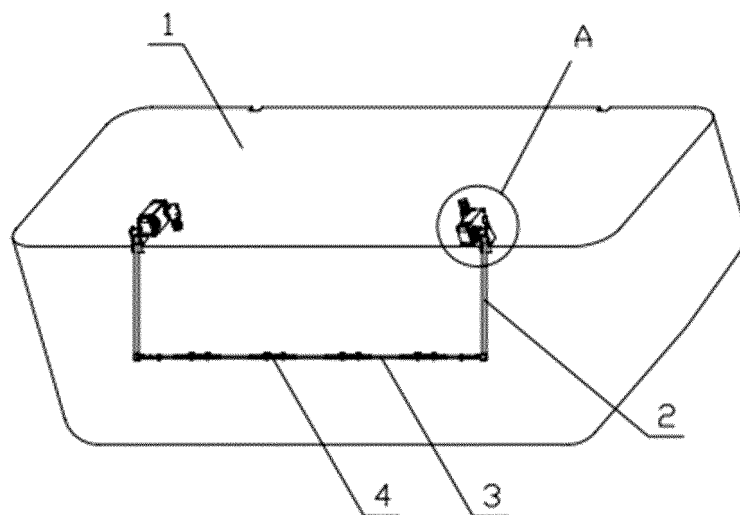


Fig. 5

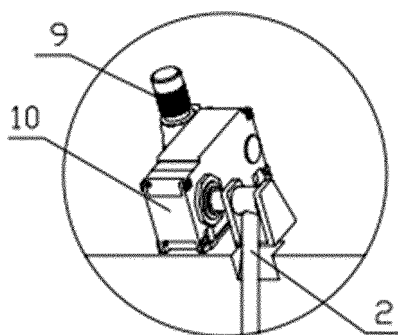


Fig. 6

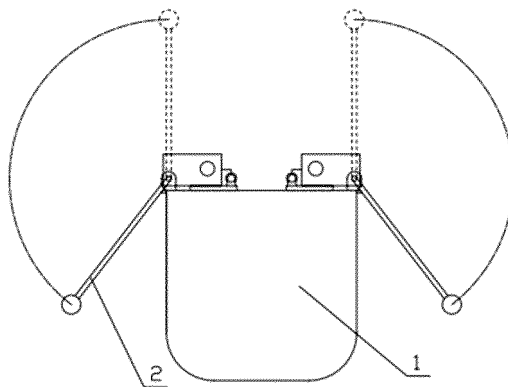


Fig. 7

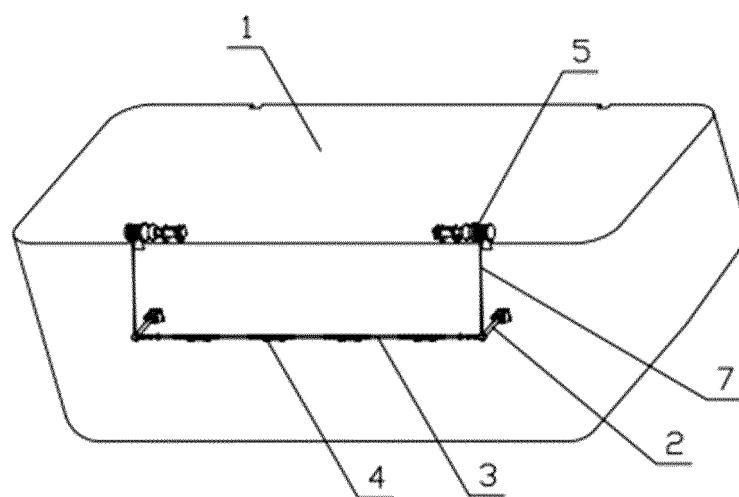


Fig. 8

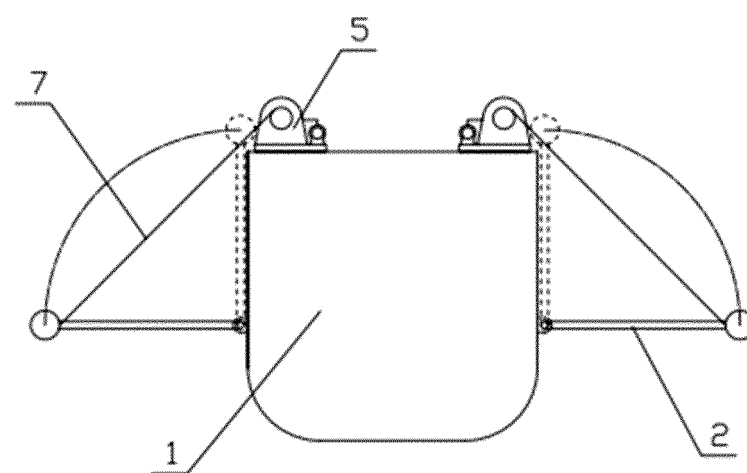


Fig. 9

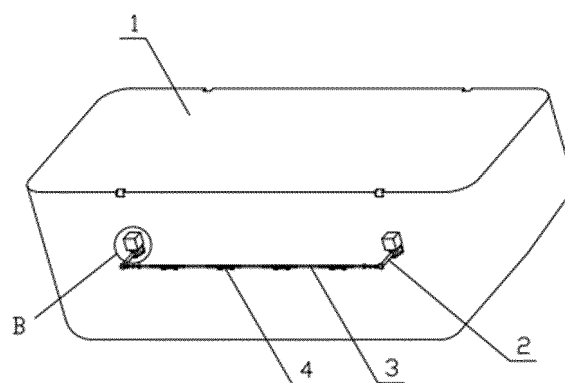


Fig. 10

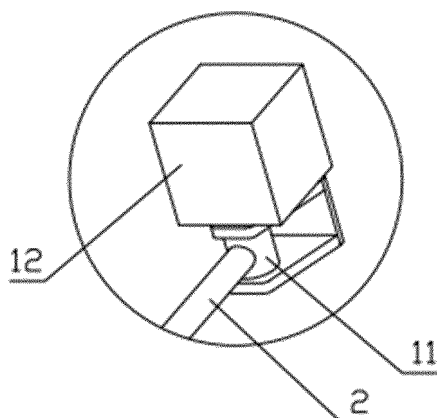


Fig. 11

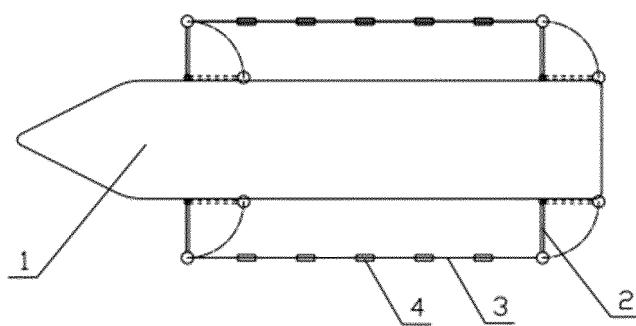


Fig. 12

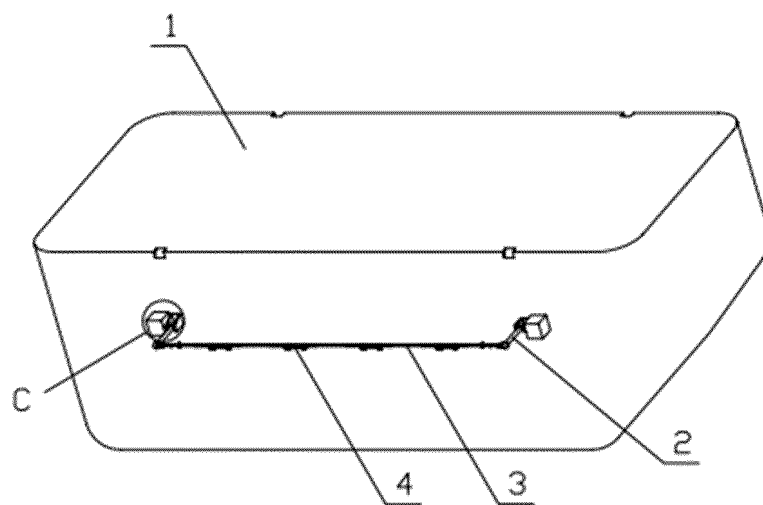


Fig. 13

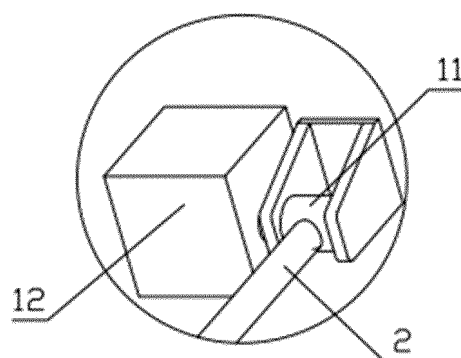


Fig. 14

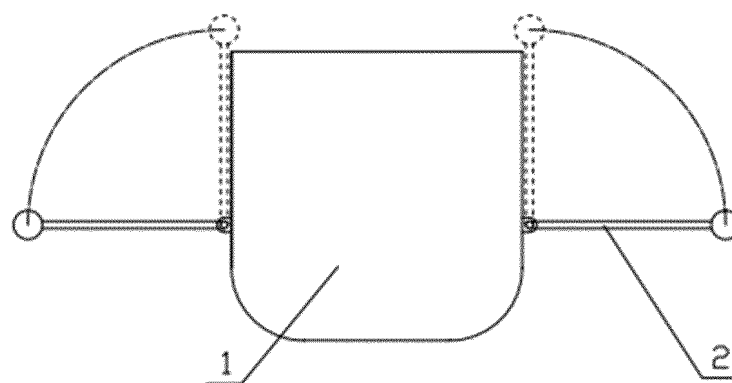


Fig. 15

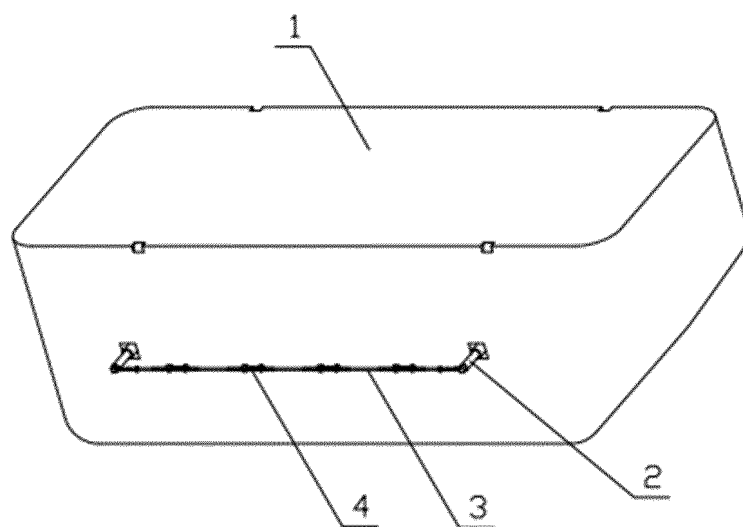


Fig. 16

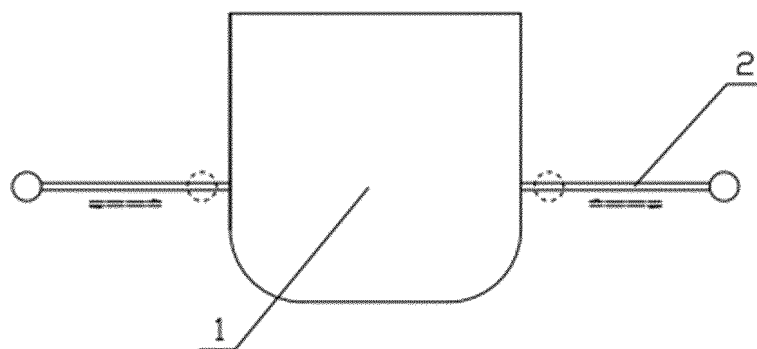


Fig. 17

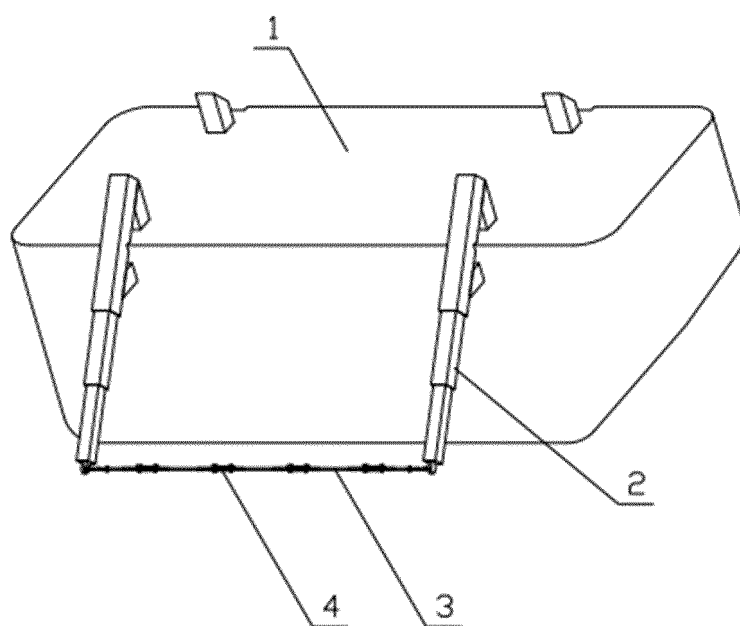
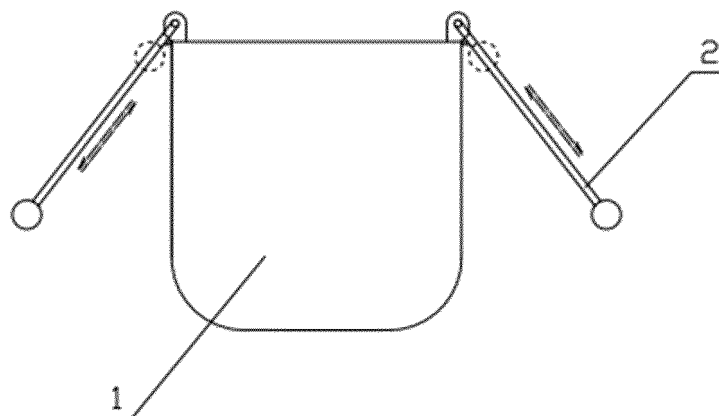


Fig. 18



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/093353

A. CLASSIFICATION OF SUBJECT MATTER

C23F13/02(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)

C23F

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

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

CNTEXT, DWPI, ENTXTC, WPABS: 大连科迈尔防腐科技有限公司, 刘磊, 秦铁男, 朱东旭, 张馨予, 封加全, 浮式, 船舶, 船体, 阴极保护, 阴极防腐, 辅助阳极, 外加电流, 外置, 远离, 支撑, 支架, 升降, 提升, 伸缩, 复合缆, 电缆, 线缆, 张拉, 张紧, 张力, FPSO, floating, hull, ICCP, impressed current, cathode protection, cathodic protection, anti w corrosion, preventing corrosion, auxiliary anode, external, far, support+, lifting, cable, tension

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 114717563 A (DALIAN KINGMILE ANTICORROSION TECHNOLOGY CO., LTD.) 08 July 2022 (2022-07-08) claims 1-9	1-9
A	CN 215328376 U (DALIAN UNIVERSITY OF TECHNOLOGY) 28 December 2021 (2021-12-28) description, paragraphs 0006-0009	1-9
A	CN 109913877 A (QINGDAO SUNRUI MARINE ENVIRONMENT ENGINEERING CO., LTD.) 21 June 2019 (2019-06-21) entire document	1-9
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☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"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
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Date of the actual completion of the international search 02 August 2023	Date of mailing of the international search report 09 August 2023
Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/CN) China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/093353

C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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