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(54) Title: DEVICE, SYSTEM AND METHOD FOR PROTECTING A SUBSEA MOORING CHAIN FROM CORROSION

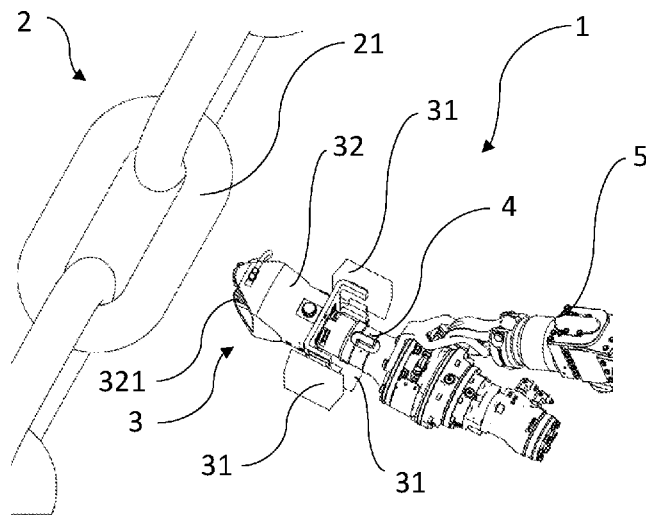


Fig. 1

(57) Abstract: Herein is disclosed a device (3), a system (1) and a method for protecting a subsea mooring chain (2) from corrosion. The system (1) comprises the device (3) as well as an installation tool (4) and an ROV having a manipulator arm (5) for bringing the device (3) close to the chain (2). The device (3) comprises at least one sacrificial anode (31) and a clamp (32) for carrying the at least one sacrificial anode (31), the clamp (32) having a jaw (321) for releasably connecting the sacrificial anode (31) to the mooring chain (2). (Fig. 1)



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DEVICE, SYSTEM AND METHOD FOR PROTECTING A SUBSEA MOORING CHAIN FROM CORROSION

The invention concerns a device, a system, and a method for protecting a subsea mooring chain from corrosion.

- 5 The background for the invention is the well-known problem of corrosion and corrosion fatigue which are two major reasons for mooring failure. The problem is particularly relevant when it comes to floating installations and vessels intended to be moored at one location for extended periods of time.

The prior art presents different attempts to solve this problem. The most common approach, and also the solution recognized by various mooring standards, is to increase
10 chain thickness. This is, as such, not a solution to the problem, but rather an acceptance of it, in that a corrosion allowance just allows the corrosion to go on for a longer period of time before replacement of the mooring chain is necessary. Another prior art approach is to replace mooring systems pre-emptively, in order to avoid mooring failure.

- 15 There have also been some attempts in the prior art to solve this problem by cathodic protection to reduce the corrosion rate. This is for instance described by the US "Naval Civil Engineering Laboratory" who conducted a series of experiments to this regard already in the years 1963 and 1969. They describe two methods, namely to either provide lump anodes cast around chain links, or to bolt sacrificial anodes to a chain prepared par-
20 ticularly for this purpose, i.e., not a standard chain. These methods have been implemented in standard operating procedures for permanent harbour moorings. There are some limitations with these specially prepared mooring chains, for instance that they

seem to be practical for use in shallow waters only, and also that they have to be prepared onshore.

Publication KR 20170000815 U discloses a studless chain comprising a studless link body and a fastening type anticorrosion anode member detachably coupled to an outer
5 periphery of the studless link body.

Publication NO134528 discloses a device for electrolytic corrosion protection. The device comprising a metal body provided with an anode material covering one side of the metal body.

Publication JP2000273666A discloses an example of galvanic protection wherein a sacrificial anode consisting of two semi-elliptic spheres is fixed by bolts and nuts around one or
10 more chain links.

The invention has for its object to remedy or to reduce at least one of the drawbacks of the prior art, or at least to provide a useful alternative to prior art.

The object is achieved through features, which are specified in the description below and
15 in the claims that follow.

In a first aspect the invention relates more particularly to a device for protecting a subsea mooring chain from corrosion, the device comprising:

- at least one sacrificial anode; and
- a clamp for carrying the at least one sacrificial anode, the clamp having a jaw for releasably connecting the sacrificial anode to a chain link of the mooring chain and establishing
20 electrical contact between the sacrificial anode and the chain link.

One of the main advantages of the device according to the first aspect of the invention, is that the jaw of the clamp allows easy and secure installation of the device on a chain link. In addition, the device may easily be moved or replaced in a simple operation. The device
25 may be installed on the chain link by means of an ROV, more specifically by an installation tool connected to the ROV.

The device is provided with at least one sacrificial anode. A plurality of sacrificial anodes

may be provided on the same clamp, and the sacrificial anodes may vary in size and shape. The sacrificial anodes prevent corrosion of the chain itself, and the device therefore offers a solution to the problem of having to increase chain thickness, i.e. ensure corrosion allowance, which is the protection strategy recognized by the various mooring standards.

Further, the jaw may be provided with at least one, preferably two or more, sharp elements for penetrating any fouling, corrosion products, and/or coating on the chain link to establish electrical contact and a thorough grip of the chain link. The sharp element may be a knife-like elongated element, a pointed element, a tooth, or the similar. In one embodiment of the device, the jaw is a toothed jaw. The jaw of the clamp may be rounded in order to complement the shape of the chain link. The size and shape may be adapted to different chain types, i.e., studded and studless, and from any supplier.

Another advantage of the present device is that it is easily installed on mooring chain already in use. This means that the device may be retrofitted on mooring chains of existing offshore installations, without having to retract the mooring chains or replace the chains as such. Further, the protection of the mooring chain may be adjusted to the local corrosivity of the water surrounding the mooring chain, since devices may be arranged on chain links further apart or closer together, all depending on the environment. The device may be used in all water depths.

Since the device is securely connected to separate chain links, the device is robust to dynamic motion of the mooring chain. Also, should some devices fall off, the chain is still protected, and the system may be supplemented with new protection devices. This also solves the problem that for instance due to microbes or other environmental factors, the actual corrosion rates may vary from location to location and be several times faster than the standard predictions. The number of devices may easily be increased, the devices may be placed closer to each other along the chain, and devices may be replaced separately, without having to replace the entire mooring system.

The at least one sacrificial anode may comprise a plurality of sacrificial anodes which may be distributed on the clamp for optimizing weight and minimizing drag. In one embodi-

ment of the device, the at least one sacrificial anode is indeed one anode which is circular, or at least rounded, in shape for minimizing kinetic resistance, i.e. drag, in water.

The at least one sacrificial anode typically comprises aluminium, whereas the clamp and any brackets or other attachments for the at least one sacrificial anode comprise steel
5 which is heavier than aluminium. Having one larger anode instead of a plurality of smaller anodes may therefore result in a lighter device.

The at least one sacrificial anode may be releasably connected to the clamp for replacing sacrificial anodes without replacing the device as such.

The device may be configured for ROV operation. It has already been disclosed here-
10 inabove, that the preferred installation method is by means of an ROV. However, it must be understood that also installation by a diver is possible. It is also conceivable that the device may be installed on chain on land or near the water surface, which might not require the device being configured for ROV operation.

In a second aspect the invention relates more particularly to a system for protecting a
15 subsea mooring chain from corrosion, the system comprising the device according to the first aspect of the invention, an installation tool, and an ROV.

In a third aspect the invention relates more particularly to a method of protecting a sub-
sea mooring chain from corrosion, the method comprising the following steps:

- arranging the device according to the first aspect of the invention on an installation tool
20 connected to an ROV;
- bringing the ROV close to the subsea mooring chain;
- connecting the device to a first link on the mooring chain; and
- releasing the installation tool from the device, leaving the device connected to the chain link.

25 The method may further comprise the steps:

- arranging a further device on the installation tool; and
- connecting the further device to a second link of the mooring chain.

The second link may be separated from the first link by at least one chain link.

The method may further comprise the step:

- estimating an optimal number of chain links between the devices based on at least one of: the corrosivity and the conductivity of the water.

- 5 Cathodic protection from a sacrificial anode is dependent on an electric current running from the anode to the parts of the chain that is intended to be protected. The electric current run both in the chain itself between the chain links provided with a device as disclosed herein, and in the surrounding sea water. The optimal distance between the chain links to which devices with sacrificial anodes are connected, and number of chain links
- 10 protected by one device may be estimated based i.a. on local environmental data such as for example prevailing water temperatures, ocean currents, and salinity of the water. Preferably, such an estimate is established by computer models using local environmental data as at least part of the input data.

- The advantage of this step is that instead of putting out a standard number of devices, a
- 15 more accurate number of devices may be used.

The method may further comprise the step:

- re-connecting the installation tool to the device for detaching the device from the chain link.

This step is useful if the device needs to be replaced.

- 20 The method may further comprise the step:
- replacing the at least one sacrificial anode with a new sacrificial anode, by means of the ROV.

- The method in its simplest form is to install one device according to the first aspect of the invention to a chain link by means of an ROV. The method may thereafter be repeated as
- 25 many times as necessary for installing a suitable number of devices to the desired number of chain links. Then the method may be extended to include as many or few of the optional steps, as desired.

In the following is described an example of a preferred embodiment illustrated in the accompanying drawings, wherein:

- Fig. 1 illustrates a submerged chain and a first embodiment of the device connected to an installation tool and manoeuvred by an ROV manipulator arm;
- 5 Fig. 2 shows the same as Fig. 1 but where the device is connected to one of the links of the chain;
- Fig. 3 shows the same as Fig. 2 but after removal of the installation tool;
- Fig. 4 shows a submerged chain with a device according to the present invention installed on two chain links at a distance from each other;
- 10 Fig. 5a shows in perspective view, a second embodiment of the device; and
- Fig. 5b is a side view of the embodiment of Fig. 5a.

Reference is first made to Fig. 1 which shows a system 1 for protecting a subsea mooring chain 2 from corrosion. The system 1 comprises a device 3 which is provided with at least one sacrificial anode 31. In this figure the device 3 is shown comprising three sacrificial
15 anodes 31. Further, the device 3 comprises a clamp 32 whereon the anodes 31 are arranged. The clamp 32 is provided with a jaw 321, here shown as a toothed jaw 321, for connection to a chain link 21 of the chain 2. Fig. 1 illustrates the device 3 connected to an installation tool 4 which in turn is arranged on a manipulator arm 5 of an ROV. The installation tool 4 and the ROV are also parts of the system 1, and Fig. 1 illustrates how the
20 manipulator arm 5 of the ROV moves the installation tool 4 and thereby the device 3 towards the chain link 21 in a manner such that the toothed jaw 321 is arranged for receiving and gripping the chain link 21. This next step is illustrated on Fig. 2 where the jaw 321 "bites" over a portion of the chain link 21 and establishes electrical connection between the device 3 and the chain link 21. On Fig. 3 the device 3 is shown connected to the chain
25 link 21 after removal of the installation tool 4, and Fig. 4 shows an example of how a further device 3 may be arranged on a second chain link 22 at a distance from the first chain link 21. Note that the circles on Fig. 4 are only there to highlight the chains 21, 22 provid-

ed with devices 3. The chain 2 may be provided with multiple devices 3 arranged at regular or irregular intervals along the chain 2. The distance between the devices 3 may be estimated based on actual environmental factors or it may be estimated based on for instance gained experience from the relevant area.

- 5 Figs. 5a and 5b illustrate a second embodiment of the device 3 wherein the sacrificial anode 31 is specially made for this purpose. One large sacrificial anode 31 is a preferred embodiment compared to the first embodiment showing a plurality of sacrificial anodes 31 distributed on the clamp 32.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embod-
10 iments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. Use of the verb "comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The article "a" or "an" preceding an element
15 does not exclude the presence of a plurality of such elements.

C l a i m s

1. A device (3) for protecting a subsea mooring chain (2) from corrosion, the device (3) comprising at least one sacrificial anode (31),
c h a r a c t e r i z e d i n that the device further comprising a clamp
5 (32) for carrying the at least one sacrificial anode (31), the clamp (32) having a jaw (321) for releasably connecting the sacrificial anode (31) to a chain link (21) of the mooring chain (2) and establishing electrical contact between the sacrificial anode (31) and the chain link (21).
2. The device (3) according to claim 1, wherein the at least one sacrificial anode
10 (31) comprises a plurality of sacrificial anodes (31).
3. The device (3) according to claim 1 or 2, wherein the at least one sacrificial anode (31) is releasably connected to the clamp (32).
4. The device (3) according to any one of the preceding claims, wherein the device (3) is configured for ROV operation.
- 15 5. A system (1) for protecting a subsea mooring chain (2) from corrosion, the system (1) comprising the device (3) according to any one of claims 1-4, an installation tool (4), and an ROV.
6. A method of protecting a subsea mooring chain (2) from corrosion, the method comprising the following steps:
20 - arranging the device (3) according to any one of claims 1-4 on an installation tool (4) connected to an ROV;
- bringing the ROV close to the subsea mooring chain (2);
- connecting the device (3) to a first link (21) on the mooring chain (2); and
- releasing the installation tool (4) from the device (3), leaving the device (3) con-
25 nected to the chain link (21).

7. The method according to claim 6, further comprising the steps:
 - arranging a further device (3) on the installation tool (4); and
 - connecting the further device (3) to a second link (22) of the mooring chain (2).
- 5 8. The method according to claim 7, wherein the second link (22) is separated from the first link (21) by at least one chain link.
9. The method according to claim 8, further comprising the step:
 - estimating an optimal number of chain links between the first link (21) and the second link (22) based on at least one of: the corrosivity and the conductivity of the water.
- 10 10. The method according to any one of claims 6-9, further comprising the step:
 - re-connecting the installation tool (4) to the device (3) for detaching the device (3) from the chain link (21, 22).
11. The method according to any one of claims 6-9, further comprising the step:
 - replacing the at least one sacrificial anode (31) with a new sacrificial anode (31),
 - 15 by means of the ROV.

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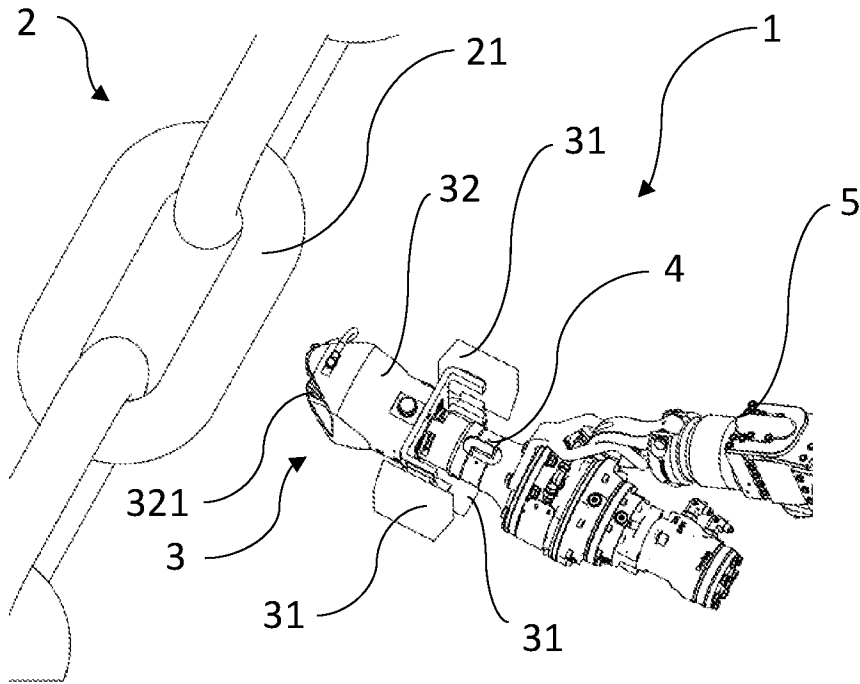


Fig. 1

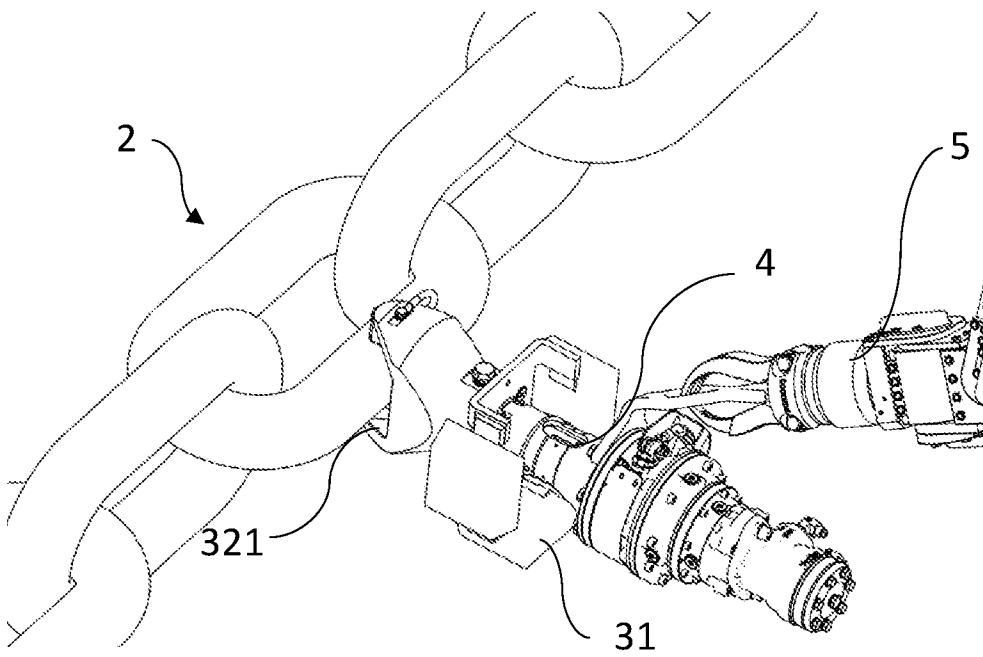


Fig. 2

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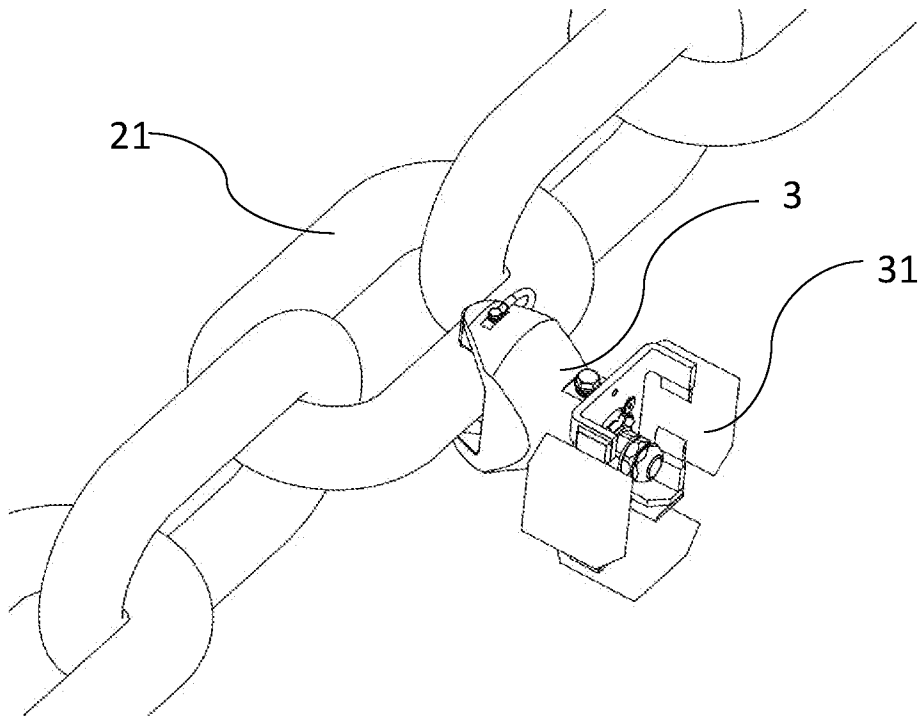


Fig. 3

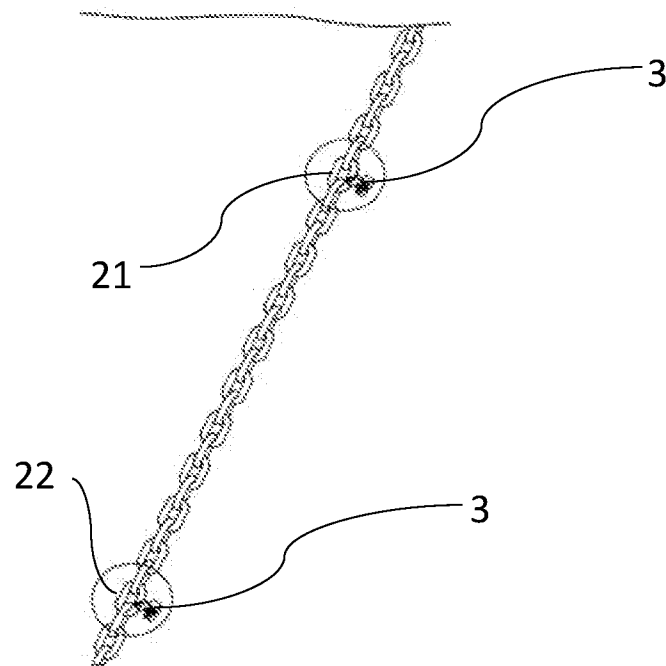


Fig. 4

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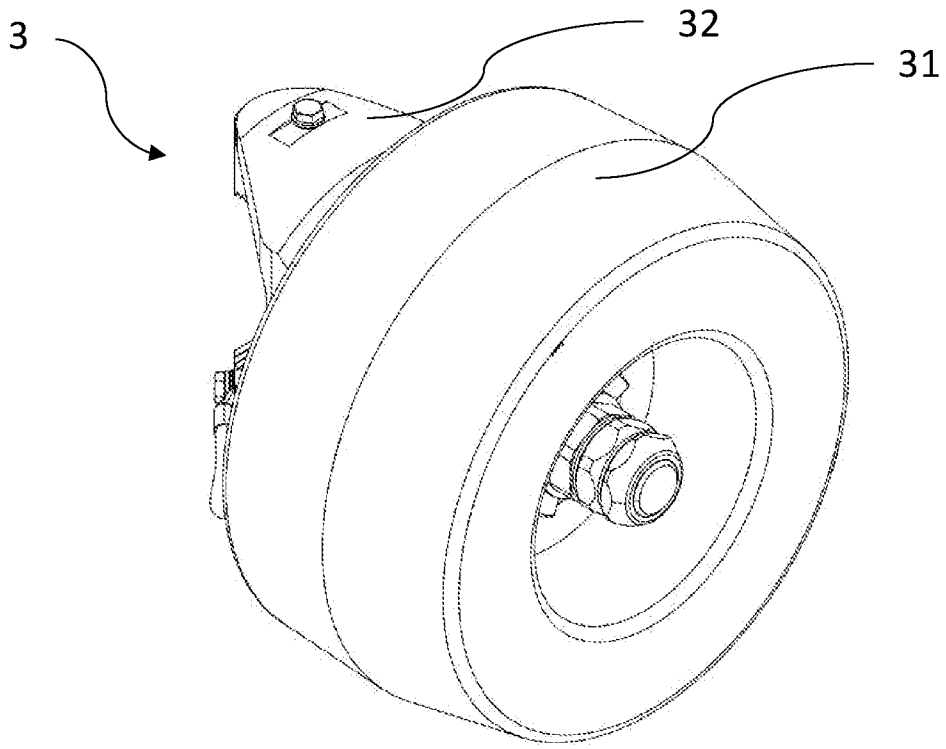


Fig. 5a

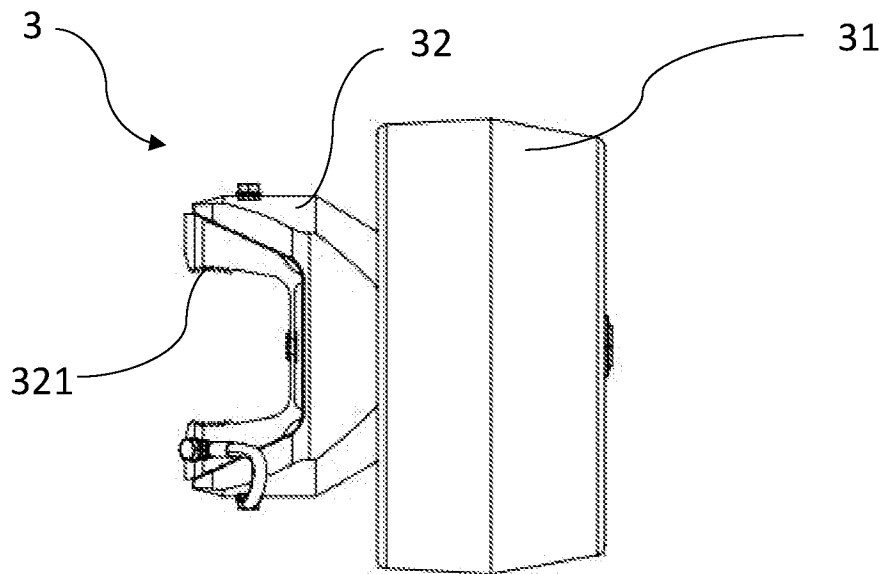


Fig. 5b

INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO2022/050096

A. CLASSIFICATION OF SUBJECT MATTER		
B63B 21/20 (2006.01)i; C23F 13/00 (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) B63B; C23F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched DK, NO, SE, FI: Classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN, FRENCH		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A,D	KR 20170000815 U (DAEWOO SHIPBUILDING & MARINE ENG CO LTD) 07 March 2017 (2017-03-07) Claim 1, paragraphs [0028], [0029] and fig. 2, 5	1-11
A	KR 20170000730 U (DAEWOO SHIPBUILDING & MARINE ENG CO LTD) 28 February 2017 (2017-02-28) Abstract and fig. 1, 2	1-11
A	CN 209225342U U (UNIV NINGBO) 09 August 2019 (2019-08-09) Abstract and fig. 1	1-11
A,D	JP 2000273666 A (MIYOSHI ISAO) 03 October 2000 (2000-10-03) Abstract and fig. 1	1-11
A	JP 2007043987 A (SHOWA KIKAI SHOJI KK) 22 February 2007 (2007-02-22) Abstract and fig. 1	1-11
A	GB 2132733 A (TIMMINGTON DAVID ARTHUR) 11 July 1984 (1984-07-11) Abstract and fig. 1	1-11
<input 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		
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

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Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
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CN	209225342U	U	09 August 2019	NONE			
JP	2000273666	A	03 October 2000	NONE			
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