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(54) Title: DEVICE FOR AND METHOD OF TENSIONING CHAINS, IN PARTICULAR MOORING LEGS

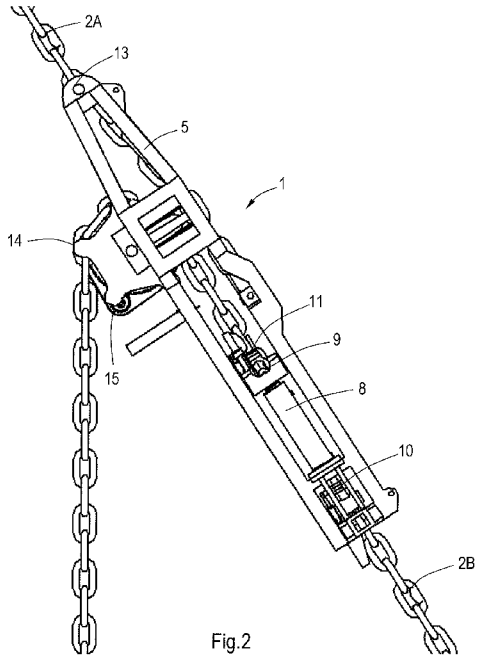


Fig.2

(57) Abstract: The invention relates to a device (1) for tensioning anchor chains, in particular mooring legs (2) of off-shore vessels (3) and installations, comprising a frame (5) carrying connectors (10, 11, 13) for holding together lower and upper portions (2B, 2A) of the chain (2) to be tensioned. The frame (5) further carries a tensioning mechanism (7) for pulling at least one portion of the chain (2A, 2B) towards the other portion of the chain (2A, 2B) while the device (1) is submerged.

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Device for and method of tensioning chains, in particular mooring legs

The invention relates to a device for tensioning anchor chains, in particular mooring legs of off-shore vessels, such as FPSOs, and installations, such as oil rigs, comprising a frame carrying connectors for holding together lower and upper portions of the chain to be tensioned. The invention further relates to a method of tensioning anchor chains.

In US 2006/060126, it is explained that "Mobile offshore drilling units (MODUs), floating production platforms (FPPs), SPARs, and similar vessels are often moored at offshore venues utilizing either preset catenary mooring lines or preset taut-leg mooring lines. Mooring is accomplished by first attaching a plurality of preset mooring lines to the vessel to be moored, and thereafter applying a predetermined tension to each of the mooring lines. Heretofore the necessary tension has been applied to the mooring lines utilizing winches mounted on the vessel to be moored."

US 2006/060126 discloses a clamping apparatus provided at the distal end of either a preset catenary mooring line or a preset taut-leg mooring line. A wire or chain pendant extends from the vessel to be moored through the clamping apparatus. The distal end of the pendant is connected to a line which extends to a winch mounted on an anchor handling vessel. The winch is utilized to pull the pendant through the clamping apparatus until a predetermined tension is exerted on the mooring line and the pendant. The clamping apparatus is then actuated to securely clamp the pendant to the mooring line while maintaining the predetermined tension. In this manner the tension necessary to properly moor the vessel at the offshore site is achieved

without requiring the use of mooring winches on the vessel being moored.

It is an object of the present invention to provide a device for tensioning chains that does not require a chain tensioning mechanism, such as a winch, on board any surface vessel and/or that can be re-used, i.e. used to tension more than one chain.

To this end, the device according to the invention is characterized in that the frame further carries a tensioning mechanism for pulling at least one portion of the chain towards the other portion of the chain while the device is submerged.

Thus, the device temporarily forms a link in the chain and no tensioning winch or jack is required on the ship to be moored or on an anchor handling vessel.

In an embodiment, the connectors for the lower and upper portions of the chain both releasably engage the chain during holding. Thus, the tensioning device can be removed from the tensioned chain and (re-)used to tension further chains.

In a further embodiment, at least one of the connectors comprises a chain stopper, e.g. a pawl or pair of pawls operated by means of a spring and/or a hydraulic cylinder.

Although the tensioning mechanism can take many forms, such as a winch combined with at least one chain stopper, it is preferred that the tensioning mechanism comprises one or more, e.g. two parallel, jacks, such as hydraulic cylinders, a first chain stopper fixed relative to one end of the jack(s) and a second chain stopper fixed relative to the other end of the jack(s). Such a mechanism can be kept compact and configured to exert a pulling force that is in line with the lower and upper portions of the chain.

In an embodiment, the frame carries a chain handling mechanism, in particular a wildcat associated with driving means, for guiding the pulled-in chain away from the tensioning mechanism and preferably for generating a pre-tension in the chain at least between the handling and tensioning mechanisms.

In a further embodiment, the frame carries a cutter, such as a blade saw or diamond wire, for separating pulled-in chain from the tensioned portion of the chain, a mechanism for aligning and interconnecting the ends of the lower and upper portions of the chain, and, preferably, a power pack and controls. Thus, all tools for tensioning, chain handling, chain cutting and interconnecting the lower and upper portions of the chain are integrated in a single, submersible and re-usable device.

In an embodiment, the end of one of the portions of the chain comprises an openable link, e.g. a D-shackle. In another embodiment, the ends of the chain are interconnected by a permanent e.g. a welded link.

In a more detailed embodiment, the aligning mechanism comprises a movable sub-frame and a means for interconnecting the ends of the lower and upper chain portions, e.g. an hydraulic cylinder for closing the pin of a D-shackle. Thus, after cutting, the ends of the chain can be moved relative to each other, aligned to facilitate interconnecting the ends, and interconnected.

The invention further relates to a method of tensioning an anchor chain, in particular a mooring leg of an off-shore vessel or installation, comprising the steps of

releasably connecting lower and upper portions of the chain to a tensioning device, preferably a device as described above, the tensioning device thus temporarily forming a link in the chain, and

tensioning the portions of the chain with the tensioning device while it is submerged.

In an embodiment, the chain is tensioned by pulling the portions of the chain towards each other.

For the sake of completeness, attention is drawn to the following prior art.

GB 1 457 711 relates to a chain hauling apparatus which comprises pairs of opposed pawls (numerals 10 and 17 in the Figures of GB 1 457 711), relatively movable along a cruciform sectional guide passage (6) for a chain (7), and alternately operable to engage the chain to respectively haul and hold the chain. First pawls (17) are pivoted to a fixed frame (1), second pawls (10) are pivoted to a plate (26) hinged to a yoke (9) reciprocable along guides (8) extending parallel with and longitudinally along the chain guide passage (6), the reciprocation being effected by hydraulic rams (14). At the end of the yoke stroke, the pawls 17 are applied to the chain to support it whilst the pawls 10 are withdrawn and the yoke rams retracted ready for the next hauling stroke.

US 2002/0084449 relates to a device for heaving in and paying out a chain by means of a hydraulic cylinder (5) which by means of gripping devices (2) engages the chain (11, 12) and lifts or lowers the chain a given distance.

A similar device is known from WO 2011/091995.

WO 2008/024527 relates to a tensioning device on an anchor handling vessel, which is employed to apply mooring tension to a forerunner chain thereby applying mooring tension to a mooring line secured between the forerunner chain and a floating structure.

US 6,112,691 relates to a damper device for mooring watercraft, of the type comprising at least two rigid elements (1, 2), to one end of each of which there can be secured a mooring rope or chain, said elements being able to move coaxially in opposition to each other against the action of an elastic body (3) which comprises at least one member (10) constructed of an elastically deformable

material. The damper device reduces stresses resulting from the rolling movement of the watercraft. Tensioning of the chains or ropes is not disclosed in or derivable from US 6,112,691. Nor is the damper suitable for tensioning chains.

DE 20 2007 004 526 U1 relates to an absorber having a purpose similar to that of the damper device in US 6,112,691 and allowing rapid mounting on steel cables, ropes and lines. Chains are not mentioned, nor is the absorber suitable for use in chains.

The invention will now be explained in more detail with reference to the drawings, which schematically show embodiments of the device and method according to the present invention.

Figure 1 is perspective view of a first embodiment of a subsea tensioning tool for a mooring leg.

Figure 2 is a side view of a second embodiment of a subsea tensioning tool for a mooring leg.

Figures 3A to 3C are front views of the second embodiment showing three steps of the tensioning of a mooring leg.

Figure 4 is a perspective view of the second embodiment showing the cutting off of pulled-in portion of a chain.

Figures 5A and 5B are perspective views of the second embodiment showing the interconnecting of tensioned portions of the chain.

Figure 6 is a perspective view of the second embodiment, shortly after disengaging from a tensioned mooring line.

Elements that are identical or performing substantially the same function are denoted by the same numeral.

Figure 1 shows a first embodiment of a subsea tensioning tool 1 (STT) for tensioning the mooring legs 2 of e.g. a floating production, storage and off-loading vessel 3

(FPSO). The mooring leg comprises a top chain or pendant 2A attached to the vessel 3 by means a swivel 4 and a lower installation chain 2B secured in the seabed by means of an anchor plate or pile (not shown, but known in itself).

The STT 1 comprises a frame 5 carrying, at its top end, a chain stopper 6 for the pendant 2A and a tensioning mechanism 7, having, in this example, two parallel hydraulic cylinders 8 the lower ends of which are fixed to the lower end of the frame 5 and the upper ends of which are interconnected by a yoke 9 that is slidably mounted inside the frame 5. A chain stopper 10 is fixed to the frame 5 below the hydraulic cylinders and a further chain stopper 11 is mounted on the yoke. The installation chain 2B is held by these two chain stoppers 10, 11 (cf. Figures 3A to 3B). In this example, each chain stopper 6, 10, 11 comprises a pair of pivotably mounted pawls 10A, 11A operated by hydraulic cylinders 10B, 11B. Details and operation of this tensioning mechanism are shown in and will be explained with reference to Figures 3A to 3C.

In Figure 1, the mooring leg has been tensioned and completed by means of a D-shackle 12 and the subsea tensioning tool 1 is about to be removed. In general, it is preferred that the frame has a U-shaped cross-section to facilitate leading the upper and lower portions of the chain through the STT and to allow removal of the STT from the tensioned and completed chain.

Figure 2 shows a second embodiment of the subsea tensioning tool 1 according to the present invention. Instead of a chain stopper as a connector for the pendant 2A, the second embodiment is provided with an hydraulically operated pin 13. Further, it comprises, in addition to the elements described above, a chain handling mechanism, a cutter, and an aligning mechanism.

The chain handling mechanism comprises a so-called "wildcat" 14 (Figures 2 and 4) positioned above the yoke 9

and provided with a hydraulic motor 15. The wildcat guides the pulled-in chain away from the tensioning mechanism 7 and generates a pre-tension in the chain between the handling and tensioning mechanisms to provide better control over the position of the links of the pulled-in chain.

The cutter (Figure 4) comprises a blade saw 16 operated by an hydraulic cylinder 17 positioned between the yoke 9 and the wildcat 14. The cutter simplifies separating pulled-in chain from the tensioned portion of the installation chain 2B.

The aligning mechanism (Figures 5A and 5B) comprises a sub-frame 18 for accommodating the end link of the pendant 2A and is movable in the frame 5 by means of hydraulic cylinders 19. In this example, the end link again is a D-shackle 12 and the subframe 18 is provided with an hydraulic cylinder 20 for closing the D-shackle.

A mooring line is tensioned as follows. The subsea tensioning tool 1 (STT) is positioned on a fixed frame on a deck of an anchor handling vessel (AHV). The ends of the top chain and the installation chain are brought on board of the AHV. The top chain is secured to the frame by means of the hydraulically operated pin 13 and the a D-shackle 12 is positioned in the subframe 18 with its closing pin aligned with the hydraulic cylinder 20 for closing the D-shackle. The installation chain 2B is led through the chain stoppers 10, 11, underneath the subframe 18, and over the wildcat 14.

Once the chain portions 2A, 2B are secured in the STT 1, the STT 1 is picked up e.g. by means of an A-frame with its installation wires attached to hoisting eyes on the frame 5. A recovery rope with a buoy attached to it (not shown) is connected to the end link of the installation chain 2B. The pulled-in portion of the installation chain will be suspended from this buoy and be recovered after the mooring line has been completed. The STT is lowered into the

sea and to its tensioning start position, e.g. 100 meters away from the vessel 3 to be moored.

At the start of actual tensioning the lower and upper chain stoppers 10, 11 are closed (Figure 3A) and a pre-determined torque is exerted on the wildcat 14 resulting in a pre-tensioning of the chain 2B and taking up any slack. The tensioning cylinders 8 are moved out (Figure 3B) and the lower chain stopper 10 is urged open by the chain moving upwards. The pulled-in links move along the wildcat 14 to the outside of the frame 5. When e.g. two chain links are pulled in (Figure 3C), the cylinders 8 are returned to their initial position (Figure 3A) and the cycle is repeated.

If the required tension in the mooring line 2 is reached, the cylinders 8 are once more returned to their initial position (Figure 3A) and the cutter 16 is activated and moved upwards to cut the chain (Figure 4). After the installation chain 2B has been cut, the pulled-in portion is removed from the STT by means of the wildcat to eventually hang free under the buoy at a distance from the STT. The chain handling subframe 18 is moved in and the D-shackle 12 is put aligned with the end link of the installation chain 2B (Figures 5A and 5B). The hydraulic cylinder 20 for closing the D-shackle 12 is moved out thus pushing the D-shackle pin through the chain and connecting it to the other side of the D-shackle.

When the connection is completed, the cylinders 8 in the tensioning mechanism 7 move out a little further so the fixed chain stopper 10 can be opened. Then, the cylinders 8 are moved in again, slightly beyond the initial position shown in Figure 3A to get any slack out of the D-shackle chain. With the complete chain 2 now tensioned, the upper chain stopper 11 is opened, thus removing the load from the tensioning device. Finally, the upper connection pin 13 is opened and the STT is lowered under the mooring

leg 2 and subsequently used to tension and complete further mooring legs.

With this device all tools for tensioning, chain handling, chain cutting, and interconnecting the pendant and installation chain are integrated in a single, submersible and re-usable device.

The invention is not restricted to the above-described embodiments, which can be varied in a number of ways within the scope of the claims.

CLAIMS

1. Device (1) for tensioning anchor chains, in particular mooring legs (2) of off-shore vessels (3) and installations, comprising a frame (5) carrying connectors (10, 11, 13) for holding together lower and upper portions (2B, 2A) of the chain (2) to be tensioned and **characterised in that** the frame (5) further carries a tensioning mechanism (7) for pulling at least one portion of the chain (2A, 2B) towards the other portion of the chain (2A, 2B) while the device (1) is submerged.

2. Device (1) according to claim 1, wherein the connectors (10, 11, 13) for the lower and upper portions (2B, 2A) of the chain (2) both releasably engage the chain (2).

3. Device (1) according to claim 2, wherein at least one of the connectors (10, 11, 13) comprises a chain stopper.

4. Device (1) according to any one of the preceding claims, wherein the tensioning mechanism (7) comprises one or more jacks (8), a first chain stopper (10) fixed relative to one end of the jack(s) and a second chain stopper fixed relative to the other end of the jack(s) (11).

5. Device (1) according to any one of the preceding claims, wherein the frame (5) carries a chain handling mechanism (14) for guiding the pulled-in chain (2B) away from the tensioning mechanism (7) and preferably generating a pre-tension in the chain (2B) at least between the handling and tensioning mechanisms (14; 7).

6. Device (1) according to any one of the preceding claims, wherein the frame (5) carries a cutter (16, 17) for separating pulled-in chain from the tensioned portion of the chain, a mechanism (18, 19) for aligning and interconnecting the ends of the lower and upper portions (2B, 2A) of the chain (2), and, preferably, a power pack and controls.

7. Device (1) according to claim 6, wherein the aligning mechanism comprises a movable sub-frame (18) for aligning the ends of the portions (2A, 2B) of the chain (2).

8. Device (1) according to any one of the preceding claims, wherein the end of one of the portions (2A, 2B) of the chain (2) comprises an openable link (12).

9. Device (1) according to any one of the preceding claims, which is removable from the tensioned chain (2) upon disengaging the connectors (10, 11, 13), the frame (5) preferably having a substantially U-shaped cross-section.

10. Method of tensioning an anchor chain, in particular a mooring leg (2) of an off-shore vessel (3) or installation, comprising the steps of

releasably connecting lower and upper portions (2B, 2A) of the chain (2) to a tensioning device (1), the tensioning device (1) thus temporarily forming a link in the chain (2), and

tensioning the portions (2A, 2B) of the chain (2) with the tensioning device (1) while it (1) is submerged.

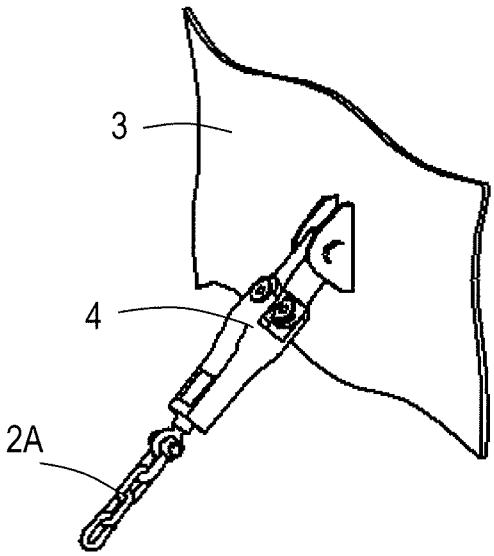
11. Method according to claim 10, wherein the chain (2) is tensioned by pulling the portions (2A, 2B) of the chain (2) towards each other.

12. Method according to claim 11, wherein a tensioned in applied to the pulled-in portion of the chain (2B).

13. Method according to any one of claims 10-12, wherein a pulled-in portion of the chain is cut from the chain (2B).

14. Method according to any one of claims 10-13, wherein portions (2a, 2B) of the chain (2) are interconnected while held in the device (1).

15. Method according any one of the claims 10-14, wherein the device (1) is removed from the tensioned chain (2) and subsequently used to tension a further chain (2).



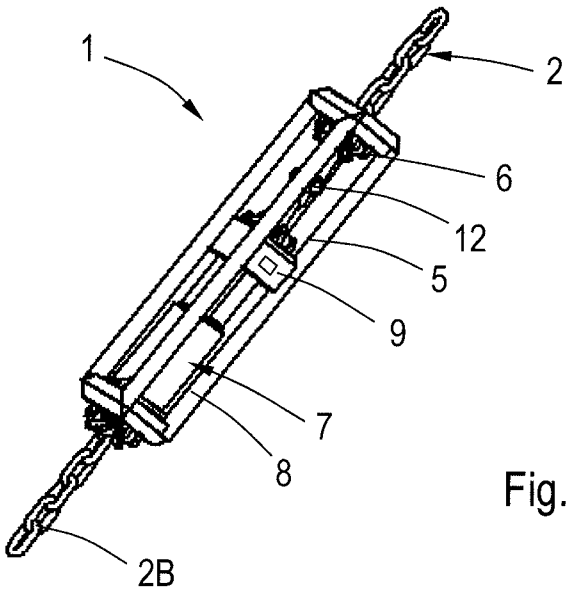


Fig.1

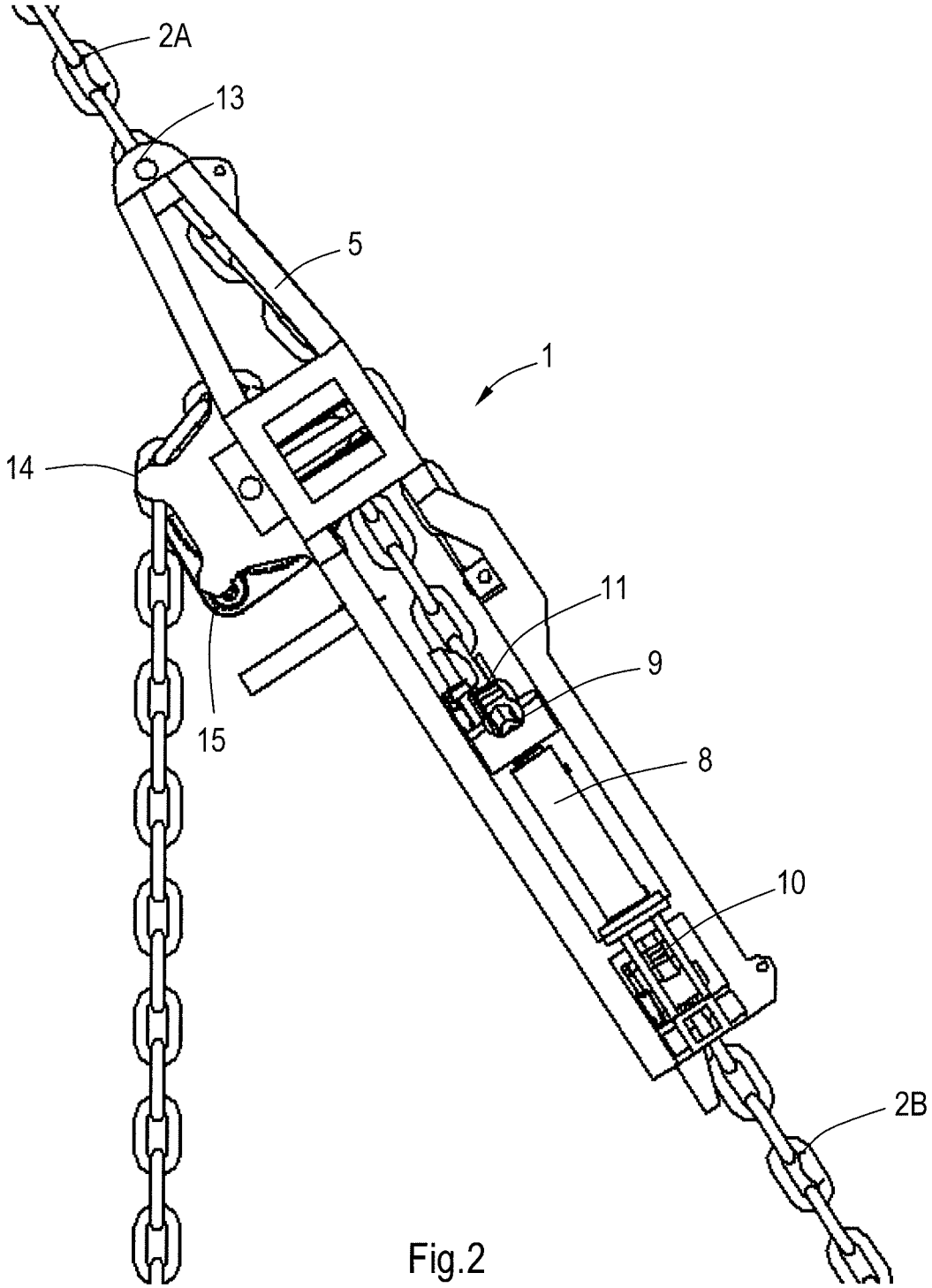


Fig.2

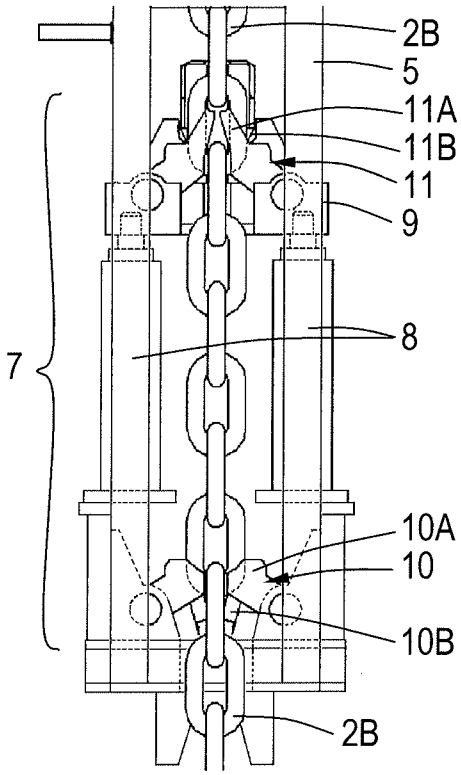


Fig.3A

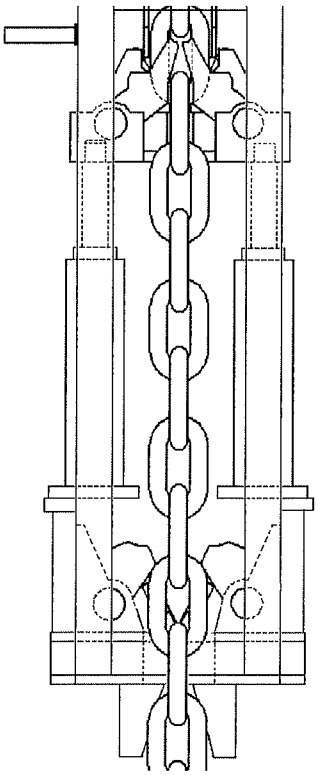


Fig.3B

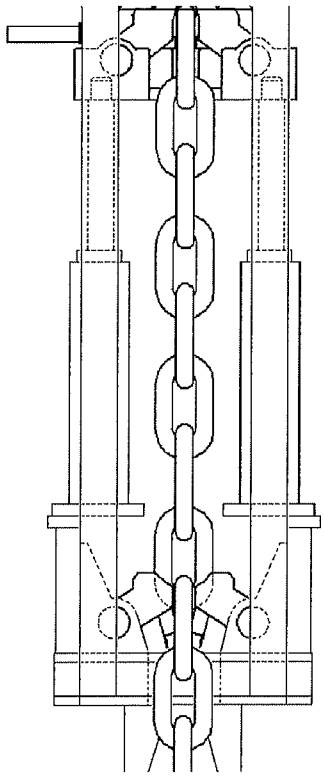


Fig.3C

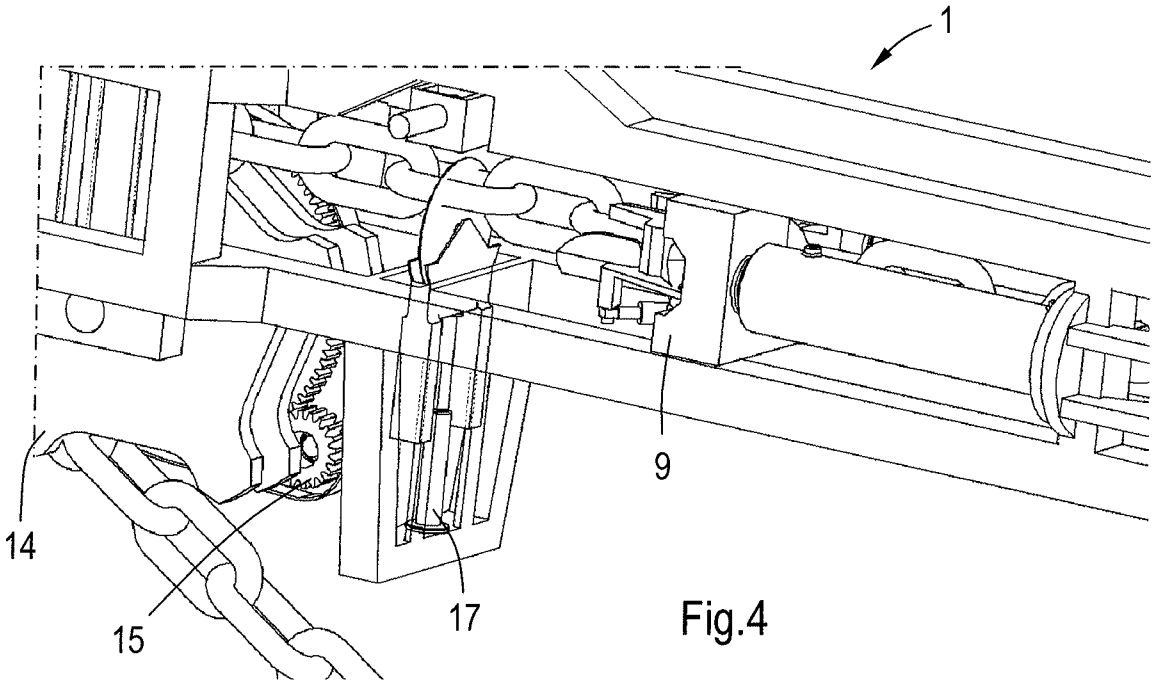


Fig.4

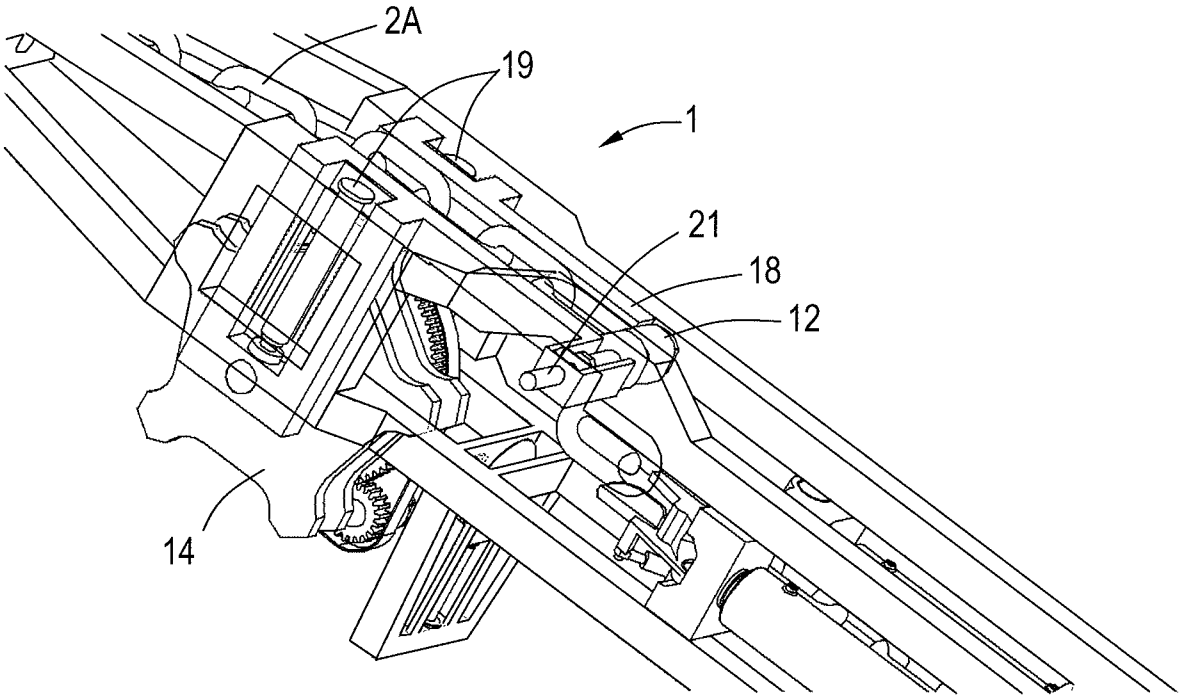


Fig.5A

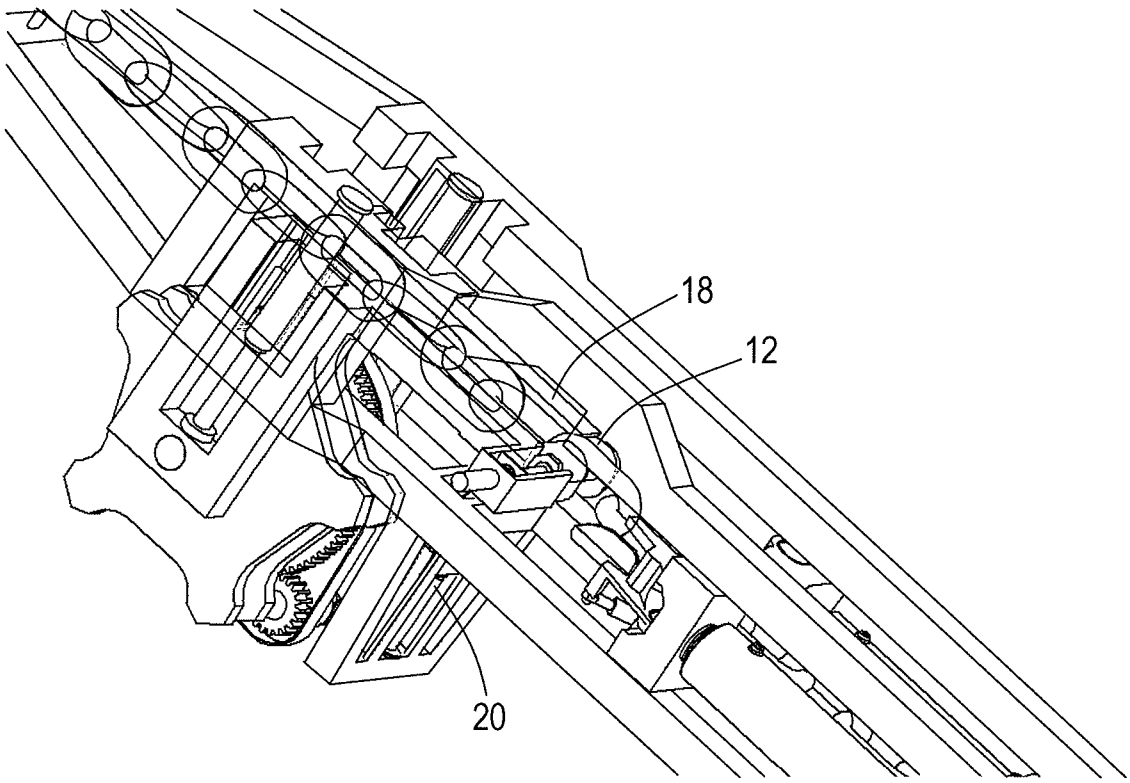


Fig.5B

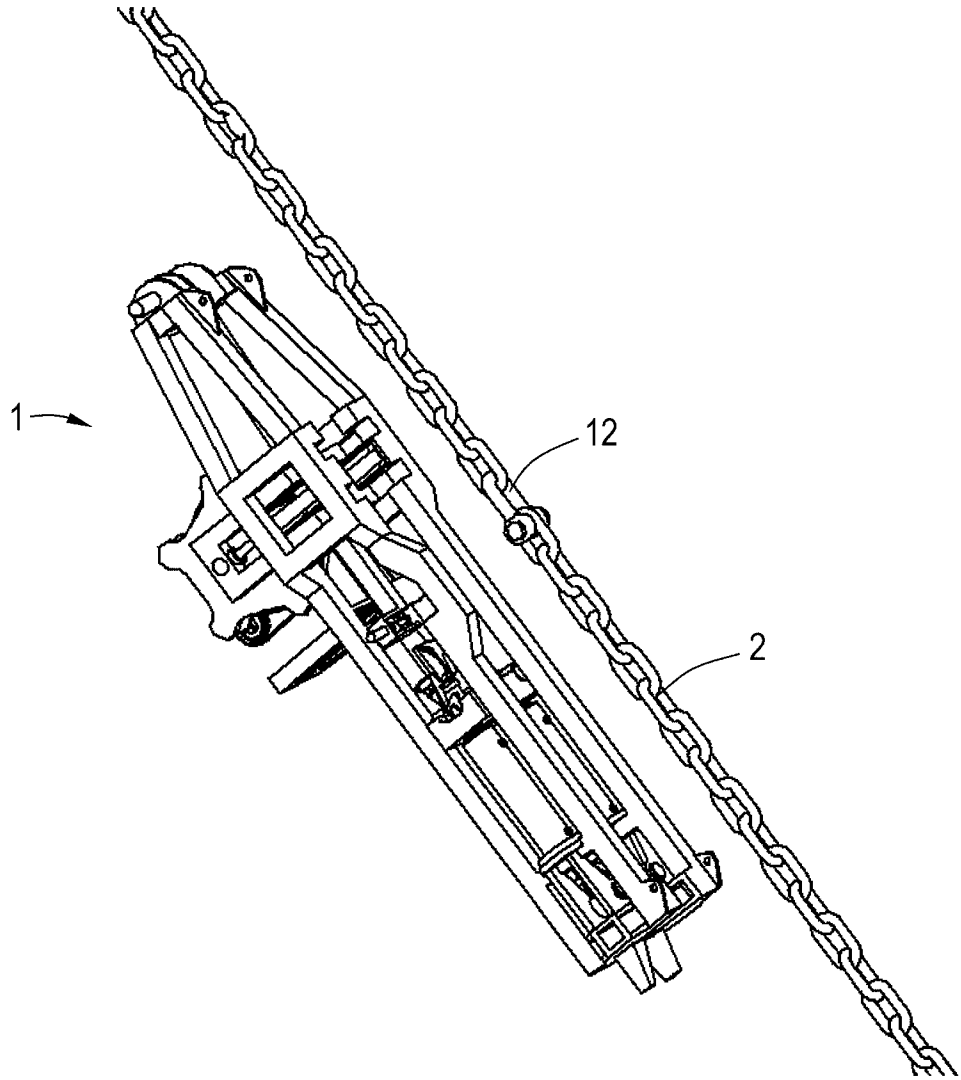


Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2012/050662

A. CLASSIFICATION OF SUBJECT MATTER
INV. B63B21/04 B63B21/20
ADD.

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

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)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 6 112 691 A (BAJELI MARIO [IT] ET AL) 5 September 2000 (2000-09-05) column 1, line 6 - column 2, line 35; figures 1,2	1 2,8-11, 15
Y A	DE 20 2007 004526 U1 (LEPPLE MARTIN [DE]) 31 May 2007 (2007-05-31) paragraph [0022] - paragraph [0029]; figures 1-5	2,9-11, 15 1
Y A	US 3 664 122 A (LINNENBANK CHARLES D) 23 May 1972 (1972-05-23) column 2, line 14 - line 73; figures 1,2	8 1,10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 October 2012	26/10/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Martínez, Felipe

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/NL2012/050662

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