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(54) A floating object provided with a permanent mooring system and a mooring line

(57) A floating object (1) provided with a permanent mooring system for securing said floating object to at least one anchor (8) on a seabed, wherein said mooring system comprises at least one mooring line (9) and at least one guidance member (10) arranged to guide the mooring line from the exterior of said floating object to the interior of said floating object such that the upper end (15) of said mooring line can be secured to said floating object at a location other than the exterior contact location between said mooring line and said floating object; said mooring line comprising: a relatively long main mooring line section (9b) of a material having a relatively low axial stiffness; and a relatively short upper mooring line section (9a) of synthetic material having a relatively high axial stiffness; wherein in use the lower end of said main mooring line section is secured to said anchor, the upper end of said main mooring line section is secured to the lower end of said upper mooring line section, said upper mooring line section extends though said guidance member and the upper end of said upper mooring line section is secured (14) to said floating object.

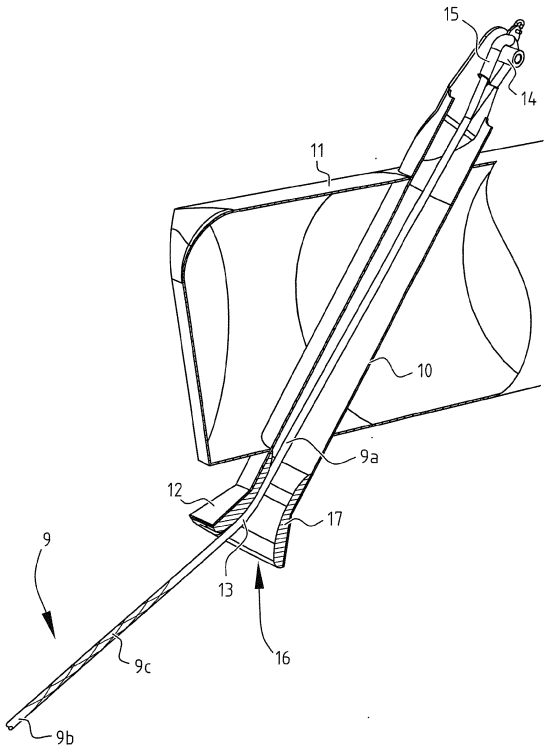

FIG. 3

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Description

[0001] The invention relates to a floating object provided with a permanent mooring system for securing said floating object to at least one anchor on a seabed, wherein said mooring system comprises at least one mooring line and at least one guidance member arranged to guide the mooring line from the exterior of said floating object to the interior of said floating object such that the upper end of said mooring line can be secured to said floating object at a location other than the exterior contact location between said mooring line and said floating object. Said floating object may for instance be a floating marine energy converter platform, a single point mooring buoy or a floating offshore oil or gas platform.

[0002] "Permanent" in this context means "for a longer period", for instance several or many years.

[0003] Permanently moored floating objects require a mooring system in which the mooring connection point between each mooring line and the floating object is located well underneath the water line to achieve a better force balance. However, this poses the person skilled in the art with the following challenges to solve:

submerged connection makes the connection procedure complex and sensitive for failure;
multiple connections and disconnections during lifetime; and
short installation window, especially in the case of tidal energy converters which are for its purpose always located in areas with very high current velocities.

[0004] An important requirement of mooring lines which are used to fix a floating objet to a seabed, is that they have a certain elasticity to accommodate differences in their length, caused by waves and different water levels at different tides.

[0005] Applying synthetic lines in a mooring system can resolve the mentioned challenges, as these materials lower the mooring loads and reduce the weight compared to chain and steel wire mooring lines. However, conventional synthetic mooring lines are prone to wear and contact damage. In permanent mooring lines applications, this problem is normally avoided by connecting a synthetic line to the floating object with either a shackle to an (underwater) pad eye, or a (double pivoting) chain stopper in combination with an upper section of chain to secure the lines.

[0006] The shackle/pad eye solution is straight forward but does not allow post installation adjustment of the mooring line length. The use of an upper section of chain allows adjustment of the line length but requires heavy equipment for handling of the chain section.

[0007] Furthermore, both concepts require underwater activities to make the connection and are difficult to access for release/disconnect or maintenance. Moreover the concepts are not designed for quick connection-disconnection, because it's is not normally a concern for those applications.

[0008] It is an object of the invention to solve any of the above mentioned problems, and/or to provide a solution which allows a quick hook-up and release of the floating object once the mooring lines are installed without diver assistance or underwater activity.

[0009] According to the invention said mooring line comprises: a relatively long main mooring line section of a material having a relatively low axial stiffness (and the required elastic properties); and
a relatively short upper mooring line section of synthetic material having a relatively high axial stiffness; wherein in use the lower end of said main mooring line section is secured to said anchor, the upper end of said main mooring line section is secured to the lower end of said upper mooring line section, said upper mooring line section extends though said guidance member and the upper end of said upper mooring line section is secured to said floating object.A high axial stiffness of the upper mooring line section will reduce wear because strain is low so the sliding motions of the pendant through the guidance member are minimized.

[0010] Preferably said upper mooring line section has a smaller diameter than the main mooring line section, which has the advantage that it allows for a small design of the guidance member, and decreases the bending stiffness of the upper mooring line.

[0011] Preferably said synthetic material having a relatively high axial stiffness is an ultra-strong fibre material. More preferably said ultra-strong fibre material is chosen from the group consisting of: an ultra-high-molecular-weight polyethylene, for instance Dyneema™ or Spectra™, an aramid, for instance Twaron™ or Kevlar™, a thermoset liquid crystalline polyoxazole, for instance PBO™ or Zylon™, a thermotropic liquid-crystal polymer, for instance Vectran™ or Zenite™, carbon, a polyester. The core of said upper mooring line section may be a different, axially stiff material than the outer layer, which may be a wear resistant material.

[0012] Preferably said guidance member comprises a mooring line contact surface which is made of a wear resistant material relative to the upper mooring line or a wear protective sleeve around it, such a s a coating or a cladding. More preferably said wear resistant material is chosen from the group consisting of: epoxy, polymer, polyamide, polyester, polyurethane, or said wear resistant synthetic material comprises a composite synthetic material matrix with a filler of different materials, such as PTFE, FEP or graphite particles. Said wear resistant synthetic material is preferably a low friction material relative to the upper mooring line or a wear protective sleeve around it. Preferably said guidance member comprises a trumpet shaped outer end, on the inner surface of which said line contact surface is present. Such a guidance member as such is known for example from international patent application WO 2009/127832, which is incorporated herein by reference. The geometry of the guidance

member has said trumpet like shape to support the upper mooring line section in at least two degrees of freedom. The geometry is designed to reduce bending fatigue. The material is selected to provide minimal wear in the contact area with the upper mooring line section.

[0013] In the preferred embodiment, in use, the outer end of said guidance member is below the upper water level. And preferably the location where the mooring line is secured to the floating object is above the upper water level. This allows for a dry and direct connection of the synthetic mooring lines at the deck of the floating object while the point of action of the force remains under the water line.

[0014] If necessary a part of the upper mooring line section which is intended to contact the mooring line contact surface is provided with a protective sleeve.

[0015] Although the main mooring line may be a steel wire or chain, in the preferred embodiment the main mooring line section is also made of a synthetic material . In one preferred embodiment both the main mooring line section and the upper mooring line section are ropes of intertwined yarns, wherein the upper end of said main mooring line section is secured to the lower end of said upper mooring line section by intertwining yarns of both ends. In another preferred embodiment the main mooring line section and the upper mooring line section are connected by a splice eye and shackle connection.

[0016] The invention also relates to a mooring line for use in the mooring system of the floating object, comprising: a relatively long main mooring line section of a material having a relatively low axial stiffness; and a relatively short upper mooring line section of synthetic material having a relatively high axial stiffness; wherein one end of said main mooring line section is secured to one end of said upper mooring line section.

[0017] The invention will now be illustrated by means of a preferred embodiment, as shown in the figures, wherein:

Figure 1 is a front view of a floating object;

Figure 2 is a side view of the floating object of Figure 1;and

Figure 3 shows a cross sectional perspective side view of a detail of the mooring system in the hull of the floating object of Figure 1.

[0018] According to Figures 1 and 2 the part of a floating object 1 which is relevant for the current invention is shown, said object 1 comprising a substantially cylindrical hollow body 2.

[0019] The floating object 1 is secured to anchors 8 on the seabed by four mooring lines 9, two at each end of the hollow body 2.

[0020] In order to accommodate the difference in distance between the seabed and the floating object caused by the range of tide, the mooring lines 9 need to have a certain elasticity.

[0021] A cross section of the upper part of the mooring line system is shown in Figure 3. The mooring line 9 consist of two different parts: a relatively long main mooring line section 9b of a material having a relatively low axial stiffness and a relatively short upper mooring line section 9a of synthetic material having a relatively high axial stiffness.

[0022] The high strength and axially stiff material of the upper mooring line section 9a can for instance be any fibre based rope as for example, but not limited to, ultra-high-molecular-weight polyethylene, aramide, liquid crystal polymer, polyester, Dyneema™, PBO™, Zylon™, Spectra™, Vectran™, Twaron™, Technora™, Kevlar™, Zenite™, carbon, etcetera.

[0023] The material of the main mooring line section 9b can be any suitable synthetic line. However other materials for the main mooring line 9b can be used as well, for example steel wire or chain.

[0024] In the shown embodiment a the upper mooring line section 9a and the main mooring line section 9b are ropes of intertwined yarns, and the upper end of the main mooring line section is secured to the lower end of said upper mooring line section by intertwining yarns of both ends over a suitable length in the intermediate section 9c. However, both ends of the sections 9a and 9b may also be connected by means of for instance spliced eyes and a shackle.

[0025] The mooring line connection system consists of a mooring hawser pipe 10 protruding obliquely through the hull 11 of the hollow body 2. The mooring line 9 is pulled through the hawser pipe 10 and connected at deck level to connection point 14 by means of spliced eye 15.

[0026] The guidance member 12 at the lower end of the hawser pipe 10 supports the upper mooring line section 9a under tension and limits the bending radius of the upper mooring line section 9a. The part of the upper mooring line section 9a which is in contact with the trumpet mouth 16 of the guidance member 12 is covered with a braided jacket 13 to limit wear. Furthermore the trumpet mouth 16 of the guidance member 12 is covered with a plastic lining 17, made of a high wear resistant and low friction material relative to the outer surface of the upper mooring line.

[0027] The mooring line 9 will be installed by pulling the upper mooring line section 9a thought the hawser pipe 10 using a messenger line and for example a winch. On deck the upper mooring line section 9a can be secured by a suitable connection point 14. Alternatively the upper mooring line section 9a can be guided to a tensioning system to (automatically) adjust the line length after installation.

[0028] The contact area between the upper mooring line section 9a and the guidance member 12 will be most affected by wear and fatigue. The lifetime of the upper mooring line section 9a can be extended by changing the point of contact of the upper mooring line section 9a with the guidance member 12. This can be achieved by

for example using connection points 14 on the floating object 1 at different heights or having different length spliced eyes 15 in the upper mooring line section 9.

[0029] Inspection and replacement of the upper mooring line section 9a can be done without disconnecting the floating object 1. The upper mooring line section 9a can be released using the pull-in line attached and inspected above water. Alternatively the upper mooring line section 9a together with the main mooring line section 9b can be pulled through the hawser pipe 10 for inspection.

[0030] This concept offers specific advantages for (semi) permanent moored floating objects 1 suitable for wave and tidal energy converter systems. It may also offer a cost effective solution for the oil and gas industry as the concept is free of any additional moving parts under water as no equipment is required other than the main mooring line section 9b and upper mooring line section 9a to resolve issues with (bending) fatigue and wear in this invention.

[0031] The invention has thus been described by means of a preferred embodiment. It is to be understood, however, that this disclosure is merely illustrative. Various details of the structure and function were presented, but changes made therein, to the full extent extended by the general meaning of the terms in which the appended claims are expressed, are understood to be within the principle of the present invention. The description and drawings shall be used to interpret the claims. The claims should not be interpreted as meaning that the extent of the protection sought is to be understood as that defined by the strict, literal meaning of the wording used in the claims, the description and drawings being employed only for the purpose of resolving an ambiguity found in the claims. For the purpose of determining the extent of protection sought by the claims, due account shall be taken of any element which is equivalent to an element specified therein.

Claims

1. A floating object provided with a permanent mooring system for securing said floating object to at least one anchor on a seabed, wherein said mooring system comprises at least one mooring line and at least one guidance member arranged to guide the mooring line from the exterior of said floating object to the interior of said floating object such that the upper end of said mooring line can be secured to said floating object at a location other than the exterior contact location between said mooring line and said floating object;
said mooring line comprising:

a relatively long main mooring line section of a material having a relatively low axial stiffness; and

a relatively short upper mooring line section of synthetic material having a relatively high axial stiffness;

wherein in use the lower end of said main mooring line section is secured to said anchor, the upper end of said main mooring line section is secured to the lower end of said upper mooring line section, said upper mooring line section extends though said guidance member and the upper end of said upper mooring line section is secured to said floating object.

2. The floating object of claim 1, wherein said synthetic material having a relatively high axial stiffness is an ultra-strong fibre material.

3. The floating object of claim 2, wherein said ultra-strong fibre material is chosen from the group consisting of: an ultra-high-molecular-weight polyethylene, for instance Dyneema™ or Spectra™, an aramid, for instance Twaron™ or Kevlar™, a thermoset liquid crystalline polyoxazole, for instance PBO™ or Zylon™, a thermotropic liquid-crystal polymer, for instance Vectran™ or Zenite™, carbon, a polyester.

4. The floating object of any of the previous claims, wherein said guidance member comprises a mooring line contact surface which is made of a wear resistant material relative to the material of the upper mooring line section or a protecting sleeve around it, such as a coating or cladding.

5. The floating object of claim 4, wherein said wear resistant material is chosen from the group consisting of: epoxy, polymer, polyamide, polyester, polyurethane.

6. The floating object of claim 4, wherein said wear resistant synthetic material comprises a composite synthetic material matrix with a filler of different materials, such as PTFE, FEP or graphite particles.

7. The floating object of claim 4, 5 or 6, wherein said wear resistant synthetic material of the guide member is a low friction material relative to the material of the upper mooring line section or a protecting sleeve around it.

8. The floating object of any of the previous claims, wherein said guidance member comprises a trumpet shaped outer end, on the inner surface of which said line contact surface is present.

9. The floating object of any of the previous claims, wherein in use the outer end of said guidance member is below the upper water level.

10. The floating object of any of the previous claims,

wherein in use the location where the mooring line is secured to the floating object is above the upper water level.

11. The floating object of any of the previous claims, wherein a part of the upper mooring line section which is intended to contact the mooring line contact surface is provided with a protective sleeve to avoid wear.

12. The floating object of any of the previous claims, wherein the main mooring line section is made of a synthetic material.

13. The floating object of any of the previous claims, wherein both the main mooring line section and the upper mooring line section are ropes of intertwined yarns, wherein the upper end of said main mooring line section is secured to the lower end of said upper mooring line section by intertwining yarns of both ends.

14. The floating object of any of the previous claims, wherein said floating object is a floating marine energy converter platform, a single point mooring buoy or a floating offshore oil or gas platform.

15. A mooring line for use in the mooring system of the floating object in accordance with one of the preceding claims, comprising:

a relatively long main mooring line section of a material having a relatively low axial stiffness; and
a relatively short upper mooring line section of synthetic material having a relatively high axial stiffness;
wherein one end of said main mooring line section is secured to one end of said upper mooring line section.

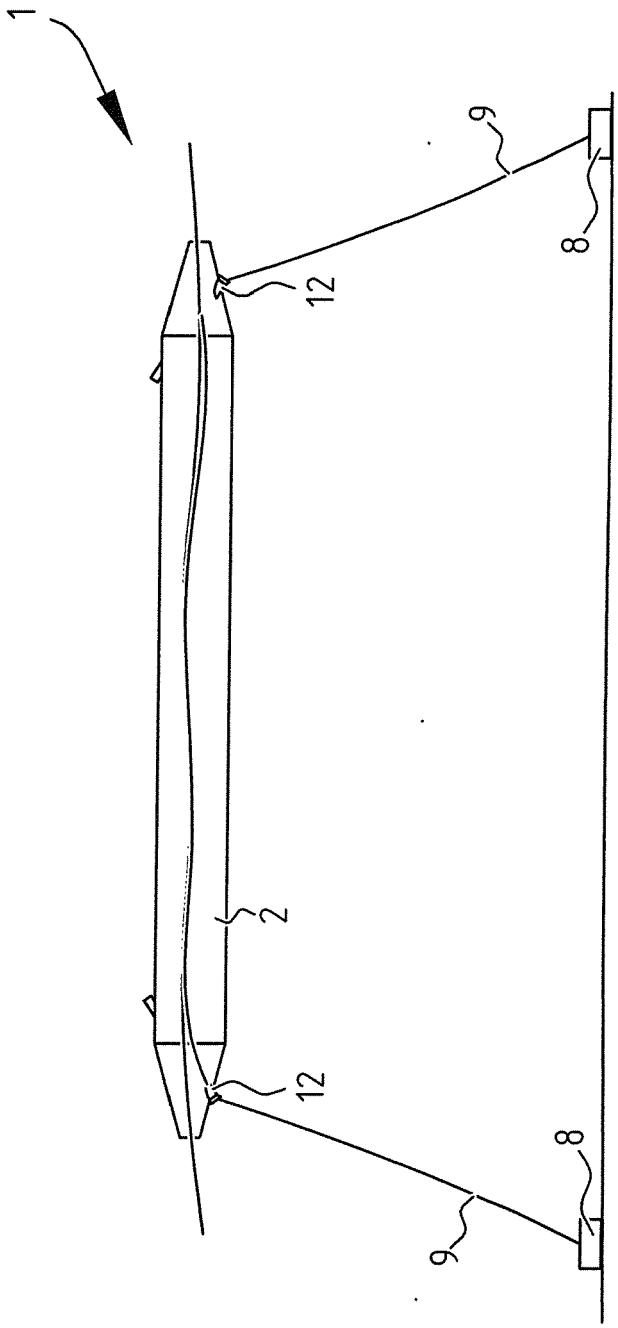

FIG. 1

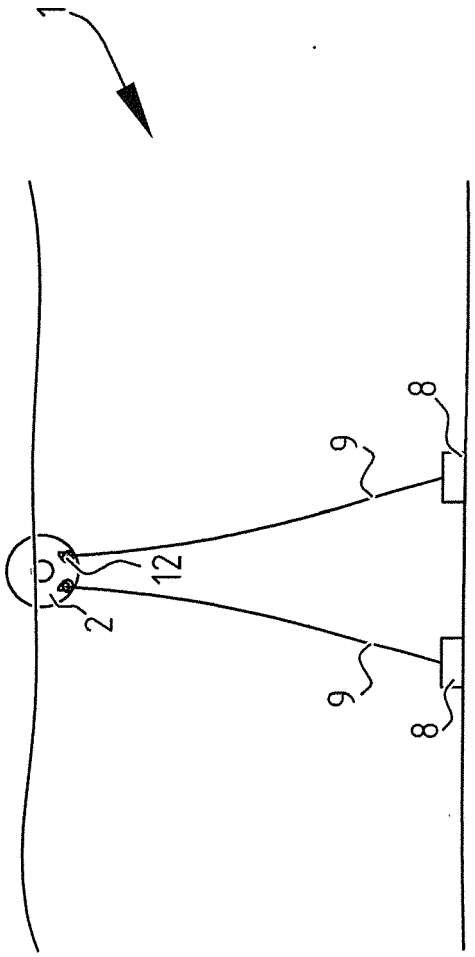

FIG. 2

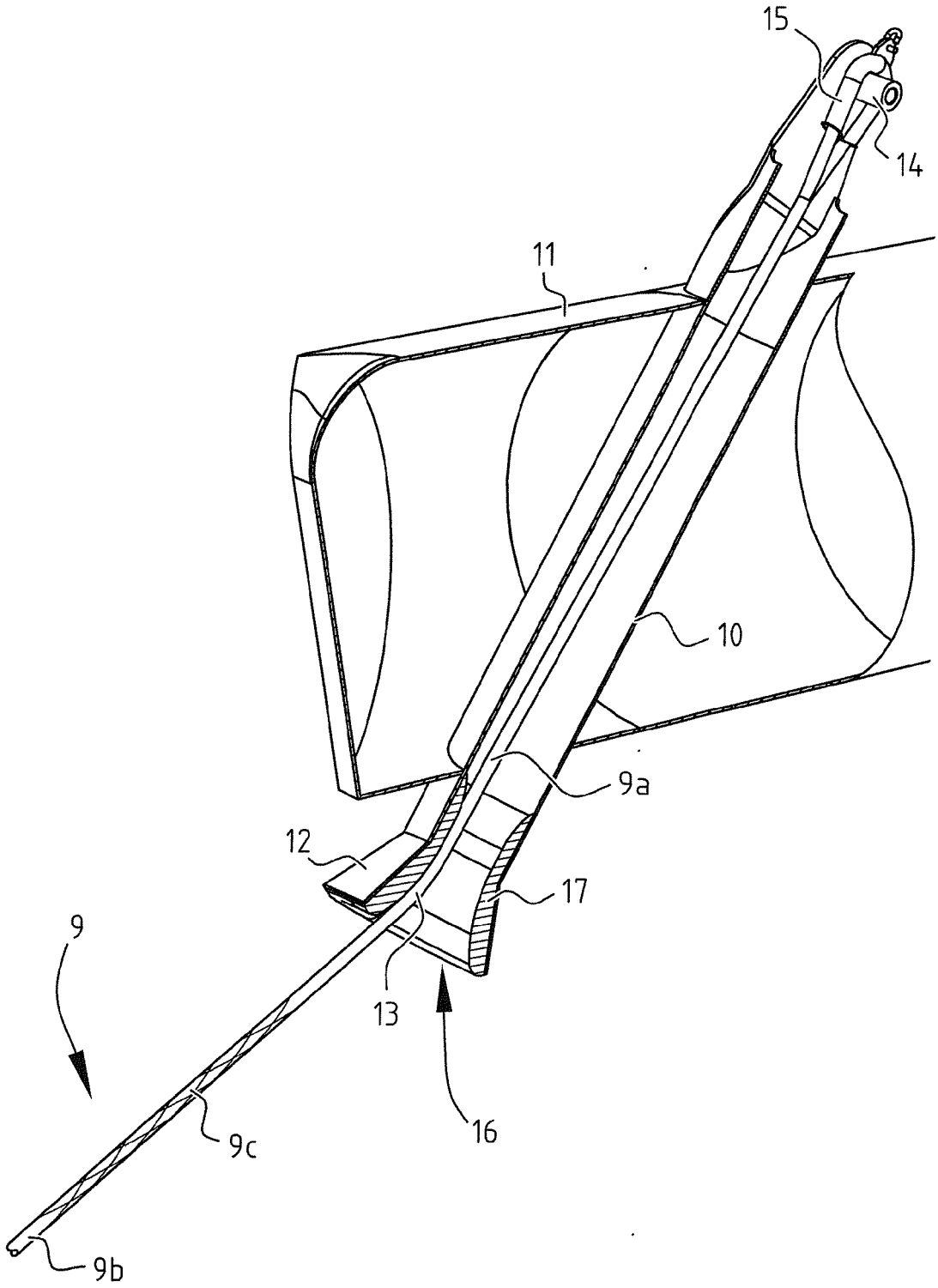

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 6678

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	DE 34 31 527 A1 (SOHMEN GERTRUD) 13 March 1986 (1986-03-13) * page 2, paragraph 4 * * page 4, paragraph 6 - paragraph 7; figure 1 * -----	1-15	INV. B63B21/20
A	US 2002/053277 A1 (PELLERIN GILLES [CA]) 9 May 2002 (2002-05-09) * the whole document * -----	1-15	

TECHNICAL FIELDS SEARCHED (IPC)

B63B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28 February 2013	De Sena Hernandorena

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 18 6678

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28-02-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 3431527 A1	13-03-1986	NONE	
US 2002053277 A1	09-05-2002	NONE	

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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