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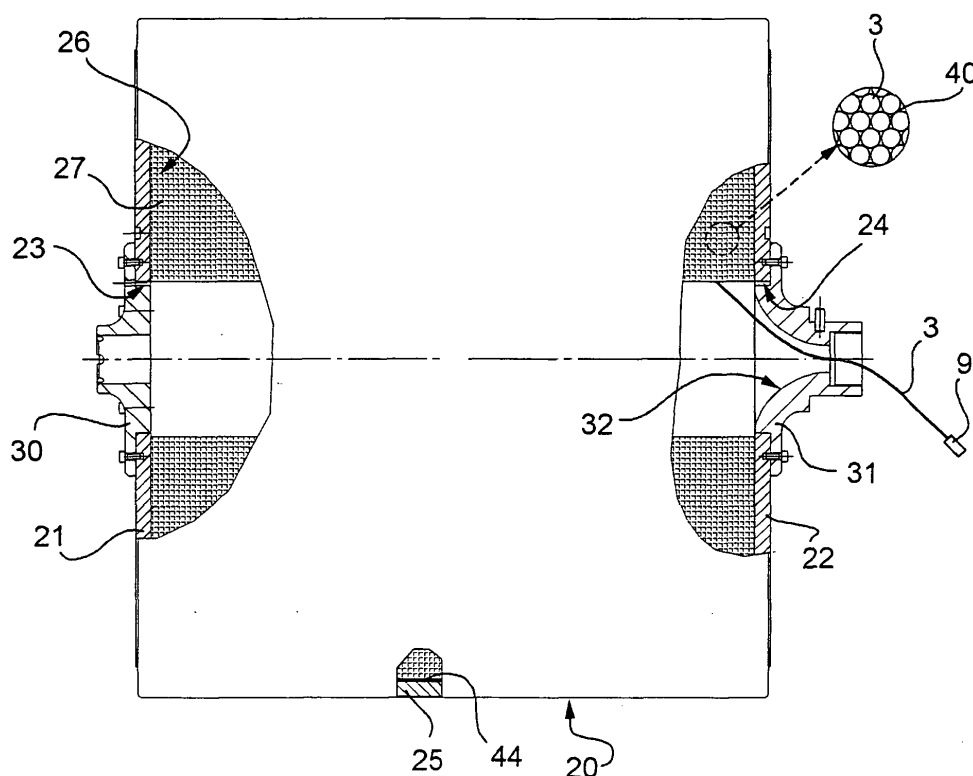
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(54) **Torpedo guidance wire reel and relative fabrication method**

(57) A guidance wire reel (1) for a torpedo (2), having a casing (20), and a coil of optical-fibre cable (3) housed inside the casing (20); the coil (27) is formed of one type

of cable (3) with no joins, is designed for maximum compactness of the turns, and is locked rigidly inside the casing (20).

FIG. 3



Description

[0001] The present invention relates to a torpedo guidance wire reel.

[0002] Torpedo wire guidance systems are known which substantially comprise a reel on the torpedo, containing tens of kilometres of optical-fibre cable; and a reel on a launch pad of a submarine, containing a few kilometres of cable.

[0003] The cables of the two reels are connected by an underwater optical connector.

[0004] Both reels unwind outwards. The reel on the torpedo (hereinafter referred to as the "torpedo reel") is the more critical in terms of static and dynamic stress, by having to withstand the operating conditions of the torpedo itself (speed of tens of knots; sharp horizontal acceleration; sudden changes in pressure, of a few bars per second, caused by changes in depth; static pressure of tens of bars) as well as storage temperature gradients.

[0005] In one known solution, the coil is housed inside a protective casing comprising two ends; and a tubular jacket to which the ends are seamed. And, to keep the coil compact in use, filler material - normally vinyl resin - is poured between the outer surface of the coil and the tubular jacket.

[0006] One drawback of the known solutions briefly described above is their poor resistance to axial compression, especially when most of the layers of cable have been unwound. Also, the filler resin may contain air bubbles, which compress in deep water, thus resulting in deformation of the cable and in irreversible increases in attenuation.

[0007] The cable must be of high tensile strength to withstand the loads to which it is subjected, especially over the first part of the mission just after launching, and must be of a diameter compatible with the coil on the torpedo reel, which must contain tens of kilometres of cable for long-range missions.

[0008] Accordingly, in one known solution, the torpedo reel is formed with two different types of cable : a first reinforced cable of good tensile strength but relatively large diameter (as much as 0.85 mm), and a second non-reinforced cable, smaller in diameter (less than 0.75 mm) but of poor tensile strength. The first cable is used over the first part of the mission (e.g. a few hundred metres) and so forms the inner portion of the reel, while the second cable forms the rest of the reel; and the two cables are connected by a flexible joint.

[0009] The hybrid solution briefly described above, however, has several drawbacks.

[0010] Using two types of cable in the same reel makes the reel vulnerable to sharp temperature gradients typical of military equipment storage : because of the difference in the expansion coefficients of the two cables, deformation occurs at the interface areas, thus resulting in irreversible, localized increases in attenuation:

Moreover, using two different types of cable - espe-

cially a non-reinforced cable for the outermost part of the torpedo reel - limits the pull that can be applied to the cable when winding it, and so results in an uneven coil in terms of residual stress. This in turn results in potential collapse of the coil at the unwinding stage, at which the innermost layers of the reel are released into the sea first, and potential release of residual stress in the presence of a temperature gradient.

Another drawback is that, in the event the torpedo is recovered after an exercise mission, the reel cannot be used again, on account of all the reinforced cable having been unwound.

Moreover, because of the poor tensile strength of the non-reinforced cable, the filler grease used to fill the gaps between the turns cannot be applied automatically, and must therefore be applied by hand to each layer of turns, which makes the process difficult to control and results in inconsistent quality of the finished reels.

Finally, using a non-reinforced cable for most of the torpedo reel increases the risk of accidental breakage caused by the dynamics of the torpedo or external events (abrasion on the sea bed, collision with obstacles).

It is an object of the present invention to provide an improved reel designed to meet both operation and storage requirements, to ensure maximum operating efficiency, and to eliminate the aforementioned drawbacks typically associated with the known art. According to the present invention, there are provided a reel as claimed in Claim 1, and a reel fabrication method as claimed in Claim 10.

A preferred embodiment of the present invention will be described with reference to the accompanying drawings, in which:

Figure 1 shows, schematically, a wire guidance system comprising a reel in accordance with the present invention;

Figure 2 shows a schematic cross section of an optical-fibre cable of the Figure 1 system;

Figure 3 shows an axial section of the reel;

Figure 4 shows a diagram of a reel fabrication system.

[0011] Number 1 in Figure 1 indicates a wire guidance system of a torpedo 2, employing an optical-fibre cable 3. The system substantially comprises a reel 4 on torpedo 2 (hereinafter referred to as "torpedo reel 4"), containing tens of kilometres of cable 3; and a reel 5 on a launch pad 6 of a submarine 7 (hereinafter referred to as "submarine reel 5"), containing a few kilometres of cable. Both reels 4, 5 unwind outwards, and the respective cables 3 are connected by an optical connector 9.

[0012] Torpedo reel 4 comprises one type of reinforced cable 3; and submarine reel 5 preferably comprises the same type of cable.

[0013] With reference to Figure 2, cable 3 of torpedo reel 4 comprises a monomodal inner optical fibre 10, preferably an ITU-T G625D type, of less than 0.36dB/km @ 1310 nm attenuation, and which comprises, in known manner, a glass core, cladding, and mantle (not shown) to a total outside diameter of about 250 µm.

[0014] Optical fibre 10 is covered with a first roughly 4 µm thick coat 11 of acrylic dye for cable identification and primary protection.

[0015] From the inside outwards, cable 3 also comprises a second acrylic protective coat 12; a reinforcing layer 13; and a polyamide 12 outer sheath 14. Reinforcing layer 13 conveniently comprises a longitudinal armour of non-twisted yarn made of aramidic fibres, glass fibres, carbon fibres, or combinations of these, and which is distributed evenly about optical fibre 10.

[0016] The reinforcing layer yarn is preferably Kevlar® (DuPont registered trademark).

[0017] Optical fibre 10 with coats 11 and 12 has an outside diameter of about 0.35 mm; and the complete cable 3 has an outside diameter of 0.75 mm or less.

[0018] This structure enables cable 3 to withstand the stress exerted by use in a heavy-duty torpedo, with no impairment in the optical characteristics of the optical fibre, and in particular to achieve the following performance:

- maximum operating pressure : 125 bars
 - tensile strength : 300 N
 - minimum radius of curvature : 35 mm
 - resistance to prolonged immersion in seawater.
- The small diameter and weight - 0.45 kg/km or less of cable 3 enable tens of kilometres of cable to be housed, in the form of a reel, in the confined space available on torpedo 2.

[0019] Cable 3 may be produced in lengths compatible with the maximum length of reels 4, 5 employed in the wire-guidance system, so no joins inside reels 4, 5 are required.

[0020] Cable 3 is preferably fitted with magnetic markers 15 comprising Mu-metal bands covered with a thin coating of acrylic material.

[0021] Magnetic markers 15 are equally spaced, e.g. every few hundred metres, along the cable, and are detectable by an induction sensor inside torpedo 2, so the length of the travelled trajectory can be measured directly, and the position of the torpedo with respect to the launcher determined accurately. Magnetic markers 15 are so sized as not to affect the radius of curvature of cable 3 and therefore winding of the cable into reels 4, 5.

[0022] Figure 3 shows a section of torpedo reel 4.

[0023] Torpedo reel 4 comprises a protective casing 20 defined by two flat circular ends 21, 22 with respective central holes 23, 24, and by a tubular jacket 25 fixed rigidly, conveniently stitch-welded, at the ends to ends 21, 22. Casing 20 defines a cylindrical cavity 26 housing a hollow cylindrical coil 27 of cable 3.

[0024] Ends 21, 22 are fitted with respective flanges 30, 31 fitted inside respective holes 23, 24, and which provide for locating and locking reel 4 inside its seat (not shown) on torpedo 2.

[0025] One of the flanges (31) has a funnel-shaped axial hole 32 for guiding cable 3 as it is unwound, and so preventing it from assuming too small a radius of curvature.

[0026] Figure 4 shows a schematic of a system 35 for producing reel 4.

[0027] System 35 comprises a huge supply reel 36, from which cable 3 is unwound by a pull and feed speed control station 37, and then fed to a marking station 38 where markers 15 are applied.

[0028] A coating of filler grease 40 is applied to cable 3 at a follow-up extrusion station 39.

[0029] Filler grease 40 is conveniently a low-viscosity, low-density grease suitable for use in the typical military equipment storage temperature range. For example, TFC 1509 grease manufactured by MWO GmbH (Brahmsdorf, Germany) may be used; and a litre of grease per 10 km of cable is conveniently applied.

[0030] Once grease 40 is applied, cable 3 is fed to a winding station 41 where, guided by a wire guide 42, it is wound onto an auxiliary core 43 fitted removably with ends 21, 22 of reel 4.

[0031] Winding station 41 comprises a device (not shown) for moving core 43 axially back and forth, so that winding is performed with wire guide 42 and cable 3 stationary (except, obviously, for the axial movement of the cable) to achieve much more accurate position control of the turns.

[0032] The winding pitch and the relative positions of the layers of turns are controlled to achieve as compact a coil 27 as possible. More specifically, each turn is wound along the centre line between two adjacent turns in the layer underneath, the spacing of the turns is calculated to achieve substantially no axial clearance between axially adjacent turns and between coil 27 and ends 21, 22, and filler grease 40 (as shown in the enlarged detail in Figure 3) substantially eliminates any air from the gaps between the turns.

[0033] As it is wound, the pull on cable 3 is controlled in a manner inversely proportional to the coil diameter, so as to leave no harmful residual stress in cable 3.

[0034] Once completed, the coil is fitted with tubular jacket 25, which is welded to ends 21, 22 to form a rigid casing; and epoxy resin 44, which, when set, is also rigid, is poured between tubular jacket 25 and the outer surface of coil 27.

[0035] The fabrication method described therefore provides for obtaining a compact, perfectly rigid reel 4 with substantially no air bubbles, and in which the turns of cable 3 are locked and safeguarded against deformation by both mechanical loads and temperature gradients typical of military equipment storage conditions.

[0036] Using a single cable 3 for torpedo reel 4 eliminates the problems caused by thermal-gradient-induced

deformation at the interface between different cables, thus also eliminating consequent attenuation problems.

[0037] Given the improvement and consistency in the tensile strength of cable 3, the filler grease can be applied automatically and therefore in controllable manner to achieve consistent product quality.

[0038] Clearly, changes may be made to reel 4 as described herein without, however, departing from the protective scope as defined in the accompanying Claims.

Claims

1. A guidance wire reel for a torpedo (2), comprising a casing (20), and a coil (27) of optical-fibre cable (3) housed inside the casing (20);
characterized in that said coil (27) is formed of one type of cable (3) with no joins, is designed for maximum compactness of the turns, and is locked rigidly inside the casing (20). 5
2. A reel as claimed in Claim 1, **characterized in that** the gaps between the turns are filled with filler grease (40). 10
3. A reel as claimed in Claim 1 or 2, **characterized in that** said casing (20) comprises two ends (21, 22) axially defining said coil (27); and an outer tubular jacket (25) fixed rigidly to said ends (21, 22). 15
4. A reel as claimed in Claim 3, **characterized in that** said tubular jacket (25) is welded to said ends (21, 22). 20
5. A reel as claimed in Claim 4, **characterized by** comprising a layer (44) of rigid resin interposed between an outer surface of said coil (27) and said tubular jacket (25). 25
6. A reel as claimed in Claim 5, **characterized in that** said resin is an epoxy resin. 30
7. A reel as claimed in any one of the foregoing Claims, **characterized in that** said cable (3) comprises a reinforcing layer (13) along its whole length. 35
8. A reel as claimed in Claim 7, **characterized in that** said reinforcing layer (13) comprises a longitudinal armour of yarn made of fibres selected from the group comprising aramidic fibres, glass fibres, carbon fibres, and combinations of these. 40
9. A reel as claimed in any one of the foregoing Claims, **characterized in that** said cable (3) has an outside diameter of maximum 0.75 mm. 45
10. A method of fabricating a guidance wire reel (4) for a torpedo (2), the method comprising a step of winding a coil (27) formed of one type of cable (3) with no joins; the pitch and tension of the coil (27) being controlled to achieve a highly compact configuration of the turns. 50
11. A method as claimed in Claim 10, **characterized by** comprising the steps of fitting two ends (21, 22) to a cylindrical core (43); winding said coil (27) onto said core (43), between said ends (21, 22); fitting a tubular jacket (25) onto said coil; fixing said tubular jacket (25) rigidly to said ends (21, 22); and removing said core (43). 55
12. A method as claimed in Claim 11, **characterized in that** said tubular jacket (25) is welded to said ends (21, 22).
13. A method as claimed in Claim 11 or 12, **characterized by** comprising the step of pouring a layer of resin (44) between an outer surface of said coil (27) and said tubular jacket (25); said resin (44) being rigid when set.
14. A method as claimed in Claim 13, **characterized in that** said resin (44) is an epoxy resin.
15. A method as claimed in any one of Claims 11 to 14, **characterized by** comprising a step of applying filler grease (40) automatically to said cable (3) prior to said winding step.

FIG. 1

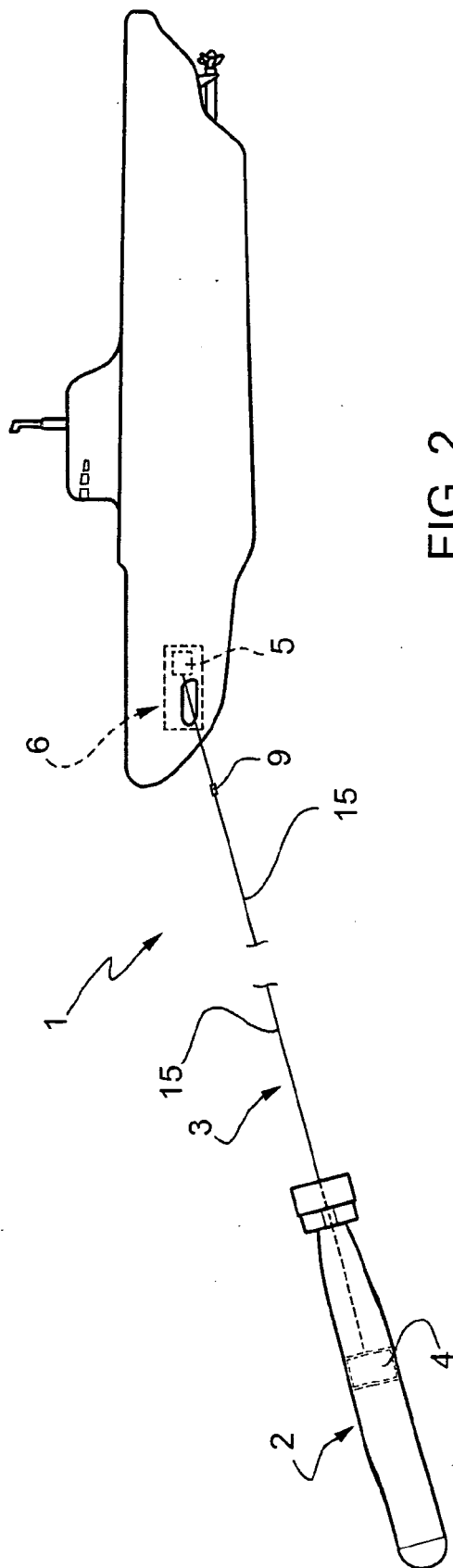


FIG. 2

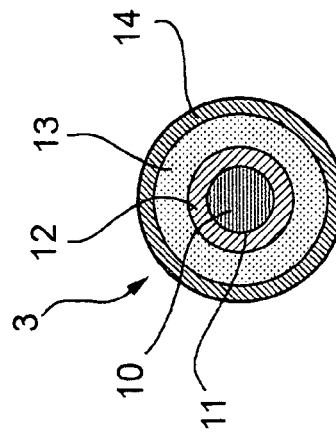


FIG. 3

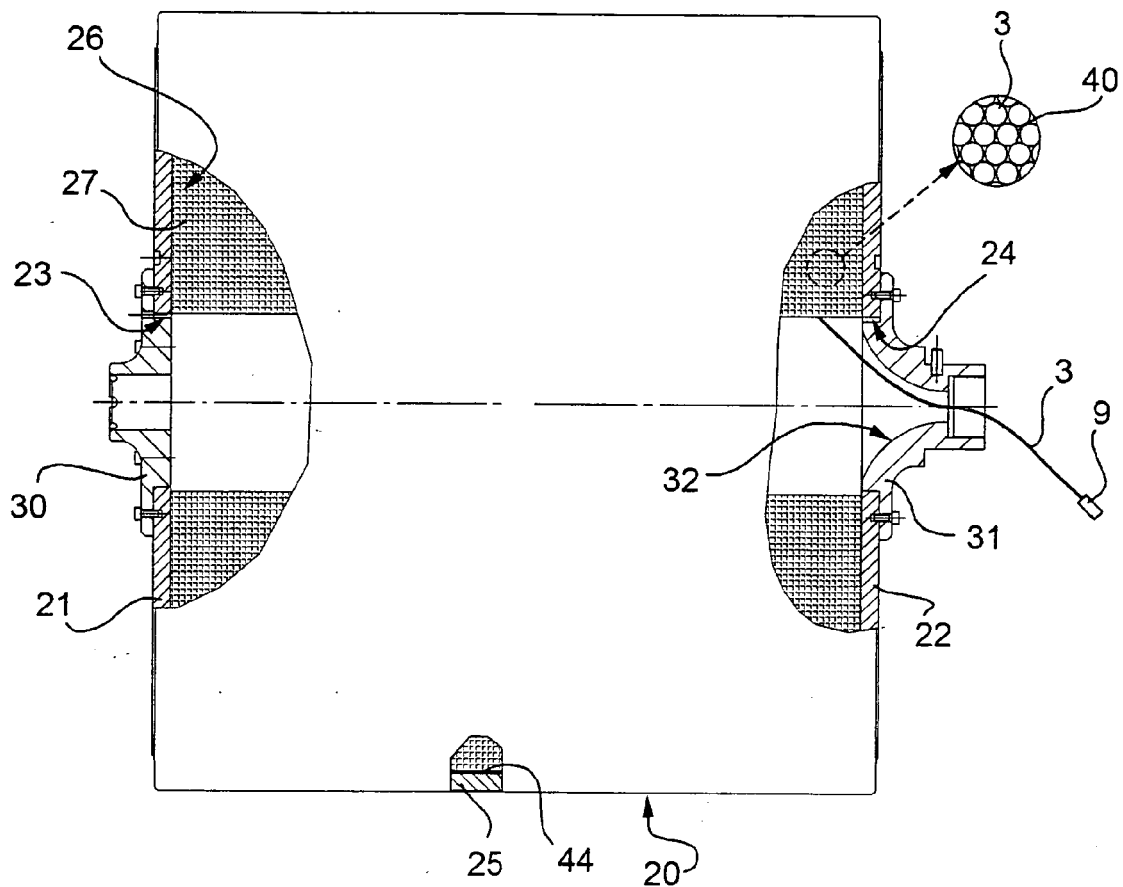
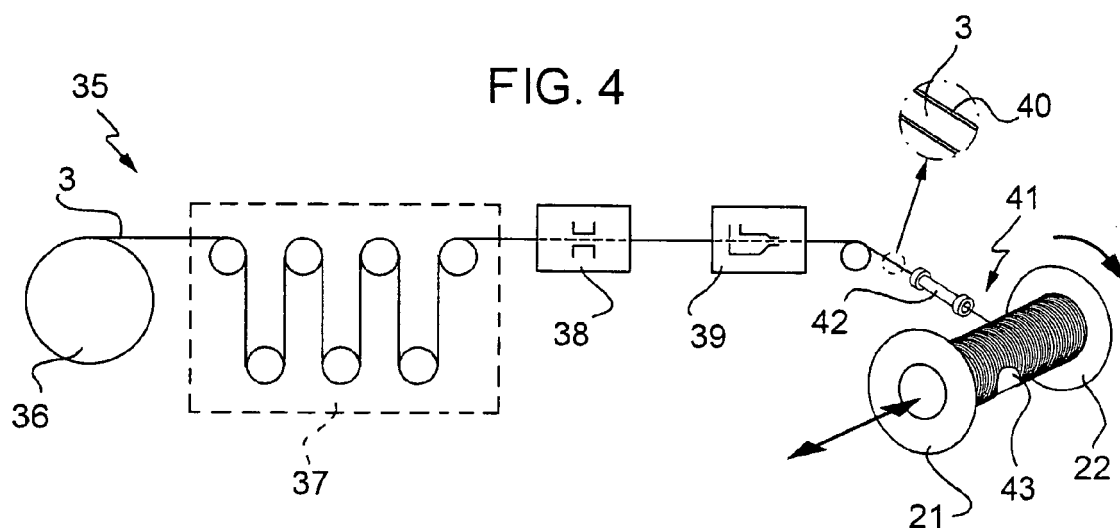


FIG. 4





EUROPEAN SEARCH REPORT

 Application Number
 EP 08 42 5222

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Place of search The Hague		Date of completion of the search 15 October 2008	Examiner Giesen, Maarten
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)



EUROPEAN SEARCH REPORT

Application Number
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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