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(54) **Subsea power cable**

(57) A subsea power cable (1) comprising a conductor (10) surrounded by at least one layer of insulation (20) and at least one layer of armouring (40), wherein the conductor (10) comprises at least a first conductor element (12b, 15b) and a second conductor element (12a, 15a), where the first conductor element is made of a first material and the second conductor element is made of a second material and where the first and the second materials are different.

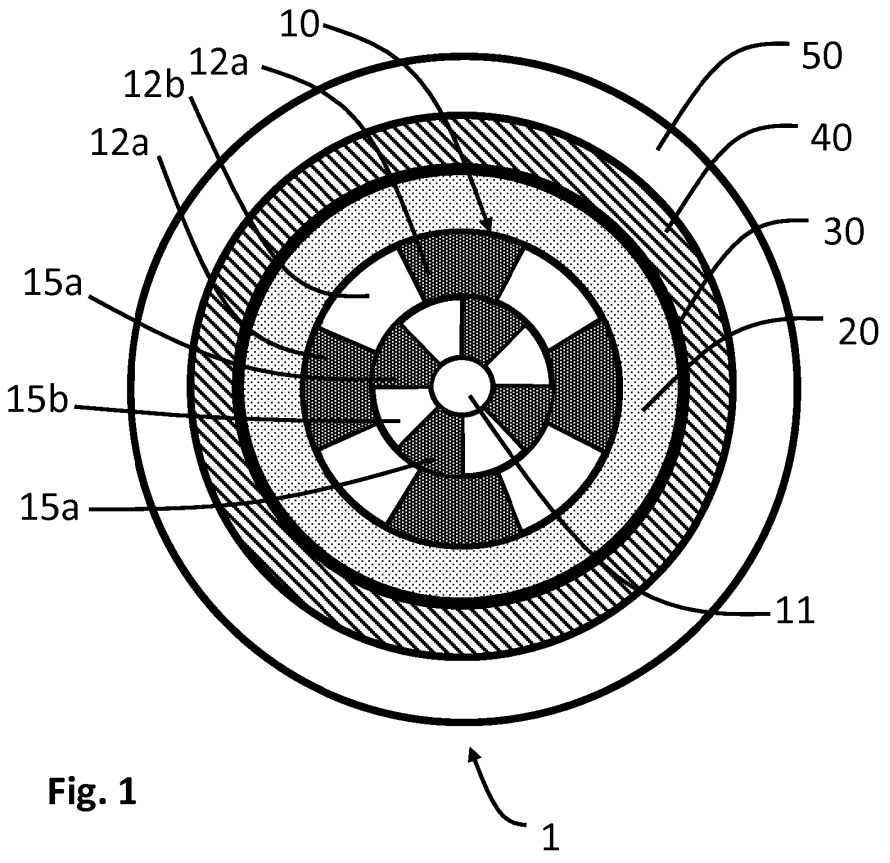

Fig. 1

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Description

Background

[0001] The present invention relates to a subsea power cable and the design of a conductor for such a cable, especially for a cable for deep waters where the cable during the laying of the cable is exposed to high tension.

Prior art

[0002] In particular for cables to be placed in deep waters the volume and weight of the cable is of high importance to the costs and size of equipment involved in the laying of the cable. The metal conductor contributes significantly to the weight of the cables and prior art solutions to reduce the weight comprise selecting lighter metals such as aluminium for the conductor. However under high laying tension in deep water the light metals such as pure aluminium yield and therefore the other cable elements, mainly the armour will have to take all the laying tension. In such case not only the conductor will be given a permanent elongation which is detrimental to the cable, but the consequence is also damage to the cable insulation. If the conductor yields due to high tension the conductor is elongated and thereby the diameter thereof is reduced. This reduces the radial pressure of the conductor on the insulation, the insulations attempt to adapt to this change is likely to result in damage to the insulation. When the conductor yields, the tension in the cable will have to be taken by the other cable elements (e.g. the armouring), which also may be negatively affected.

Objectives of the invention

[0003] An objective of the present invention is to provide a subsea cable with conductors optimized with respect to conductivity, volume and weight such that the conductor will not yield under high laying tension in deep waters. When the conductor does not yield the risk of damaging the insulation is avoided.

[0004] Another objective is to provide a solution that allows for individual optimization of the conductivity, weight and volume of the conductor.

[0005] These objectives are obtained by the subsea power cable according to the attached independent claim. Further embodiments are disclosed in the dependent claims.

[0006] The present invention provides a subsea power cable comprising at least one conductor surrounded by at least one layer of insulation and at least one layer of armouring, wherein the conductor comprises at least a first conductor element and a second conductor element, where the first conductor element is made of a first material and the second conductor element is made of a second material and where the first and the second materials are different.

[0007] The cross section of each conductor element of can be round or any other shape. The conductor comprises at least two conductor elements but may comprise any number, from 2 - 100, preferably between 2 and 50 conductor elements or alternatively 3 or more elements, preferably between 3-100 elements.

[0008] The conductor elements of different materials can be distributed in one or more layers of the conductor. In one aspect the two or more conductor elements are stranded together.

[0009] By preparing the conductor of two or more conductor elements and selecting conductor elements made of at least two different types of materials the properties of the conductor can be adapted to provide for optimization of the conductivity, weight and volume of the conductor.

[0010] According to an aspect of the present subsea power cable the conductor comprises a third conductor element made of a third material different from the first and the second material. By using elements of three or more types of different materials the flexibility of the construction of the conductor is further increased.

[0011] In a further aspect of the subsea power cable the conductor elements of different materials are distributed throughout the cross-section of the conductor. In an alternative aspect of the subsea power cable the conductor comprises a core, a first layer surrounding the core and a second layer surrounding the first layer, wherein the first layer is made of the first material and the second layer is made of the second material. To provide the conductor with the intended conductivity at least one of the conductor elements is conductive.

[0012] The two or more different types of materials are in one aspect each a material independently selected from the group comprising copper, copper alloys, aluminium, aluminium alloys, steel, other metals or non-metallic materials. In one aspect the first material is copper or a copper alloy and the second material is aluminium or an aluminium alloy. In another aspect the first material is aluminium or an aluminium alloy and the second material is copper or a copper alloy. These aspects can be combined in a cable comprising a third conductor element made a third material where the third material is steel.

[0013] In a further aspect the subsea cable is a high voltage power cable. High voltage means above 1000 V for AC or above 1500 V for DC, preferably 50 kV for AC or above 500 kV for DC or alternatively above 200 kV for AC or above 600 kV for DC

[0014] In another aspect at least one of the first, second or third material is aluminium or aluminium alloy.

[0015] In yet another aspect the selection and distribution of conductor elements of different materials within the conductor of the subsea power cable are such that the conductor will not yield during the laying of the cable as the yield stress limit of the conductor is not reached when laying at water depths of 400 - 3000 m. Alternatively when laying at water depths below 500 m or between 600 and 2500 m.

[0016] Even when the cable laying tension is in the

range of 50 tonnes or more, the conductor of the subsea power cable will not yield.

[0017] The term "power cable" as used herein refers to any cable which at least has the purpose of transferring electrical power. This may be the main purpose and it may be the only purpose, the cable may however have additional purposes such as transferring signals or fluids.

[0018] High cable laying tension is used here to refer to tensions which may expose the conductor to a stress which exceeds the yield stress of the traditional conductor material. Typically such critical laying tension could be in the range 50 tonnes, but the critical tension will depend on different parameters of the cable design, such as conductor size, the armour design etc.

[0019] The present invention is especially applicable for power cables to be laid at large water depths such as 400 m - 3000 m, 600-2500 m or 400-2000 m.

[0020] The term "alloy" as used in copper alloy, aluminium alloy and other alloys refers to a metal alloy which comprises the mentioned metal in an amount of between 50 and 99 w/w %.

[0021] The term "different" as used herein referring to the first, second and optionally more materials being different, is to be understood as describing solutions where the pure metal component or the main metal of the metal alloy is different such as one component is made of copper or copper alloy and the other is made of aluminium or aluminium alloy. Different also includes the situation with one metallic conductor element and one non metallic conductor element. Different also describes the situation where the two conductor elements are made of a pure metal and an alloy of the same pure metal or two different alloys of the same metal. For a pure metal and an alloy thereof of two alloys or the same metal to be different the materials have a difference in yield stress limit of at least 1 %, preferably at least 3 % more preferably at least 10%.

Brief description of the drawings

[0022] The present invention will be described by reference to the enclosed figures which are schematic illustrations of the present invention. All the figures illustrate cross-sectional views.

Figure 1 illustrates the configuration of a subsea power cable according to the present invention.

Figure 2 illustrates a second alternative configuration of the conductor for a subsea power cable according to the present invention.

Figure 3 illustrates a third alternative configuration of the conductor.

Figure 4 illustrates a fourth alternative configuration of the conductor.

Figure 5 illustrates a fifth alternative configuration of the conductor.

Principal description of the invention

[0023] Figure 1 illustrates the cross-section of a subsea power cable 1 according to the present invention. The power cable comprises a conductor 1 surrounded by a layer of insulation 20. Surrounding the insulation is an optional metal sheath 30. Surrounding the metal sheath 30 is an armouring layer 40 and outside of that is an outer serving 50. Subsea power cables are well known in the art and may comprise additional layers than the layers disclosed here. Further the conductor, insulation layer and the armouring layer may consist of one or more layers of material.

[0024] The armouring may comprise wires stranded or helically wound around the core of the cable. It is well known to include more than one layer of armouring around the core at different lay lengths and/or directions.

[0025] The present invention relates to providing a new conductor for an armoured subsea power cable. Accordingly the present invention is not limited to a specially structure of the layers surrounding the conductor other than that the structure comprises armouring in the form of wires or bands of metal or fibre reinforced polymers. However, if the conductor yields under high tension not only the conductor will be given a permanent elongation which is detrimental to the cable, but the consequence is also damage to the cable insulation.

[0026] The embodiment of the conductor 10 illustrated on figure 1 comprises an central wire 11 and a first inner layer and a second surrounding the first layer. In certain cables the central wire will not exist, but will form an oil channel as the first layer is self supported or supported by a tube or other kind of support. The first layer is made up of conductor elements 15a and 15b aligned around the central wire. The second layer is made up of conductor elements 12a and 12b aligned around the outer surface of the first layer. In the illustrated embodiment the central wire 11, the conductor elements 12b and 15b are all made of a first conducting material whereas the conductor elements 12a and 15a are made of a second conducting material different from the first conducting material. In the embodiment on figure 1 the elements of different materials within each layer are evenly distributed, every second element in each layer is made of the same material.

[0027] The first and second conductive material are selected from the group comprising copper, copper based alloys, aluminium, aluminium alloys, steel, other conductive metals, and other conductive or non-conductive materials.

[0028] Figure 2 illustrates an alternative embodiment of the conductor 10 for an armoured subsea cable according to the present invention. In this embodiment the conductor comprises a central wire and three layers of conducting elements 15a, 15b, 12a, 12b, 18a and 18b arranged around the core. In the illustrated embodiment

the central wire 11, the conductor elements 12b and 15b are all made of a first conducting material whereas the conductor elements 12a and 15a are made of a second conducting material different from the first conducting material. In the embodiment on figure 2 the elements of different materials within the first and the second layer are evenly distributed, every second element in each layer is made of the same material. In the third layer the number of elements 18a of the second material is less than the number of conducting elements 18b of the first material. According to this embodiment the conductor comprises layers with different ratio of the different materials.

[0029] In this embodiment the first and second conductive material are selected from the group comprising copper, copper based alloys, aluminium, aluminium alloys, steel, other conductive metals, and other conductive or non-conductive materials.

[0030] Figure 3 illustrates a third embodiment of a conductor for an armoured subsea cable according to the present invention. In this embodiment the conductor comprises a central wire and two layers of conducting elements 15a, and 12b arranged around the core. In the illustrated embodiment the central wire 11 and the conductor elements 12b are all made of a first conducting material whereas the conductor elements 15a are made of a second conducting material different from the first conducting material. In the embodiment on figure 3 the elements of different materials are arranged as layers of a second material arranged between the core and a second layer of a first material. Although the layers are illustrated as consisting of a number of separate elements arranged as a surrounding layer it is equally possible to prepare one or more of the layers as one single element.

[0031] In this embodiment the first and second conductive material are selected from the group comprising copper, copper based alloys, aluminium, aluminium alloys, steel, other conductive metals, and other conductive materials.

[0032] Figure 4 illustrates a fourth embodiment of a conductor for an armoured subsea cable according to the present invention. In this embodiment the conductor comprises a central wire and two layers of conducting elements 15a, 15b, 15c and 12a,12b, 12c arranged around the core. In the illustrated embodiment the central wire 11 and the conductor elements 12b and 15b are all made of a first conducting material whereas the conductor elements 12a and 15a are made of a second conducting material different from the first conducting material and the conducting elements 12c and 15c are made of a third conducting material different from the first and the second conducting material. In the embodiment on figure 4 the elements of three different materials are evenly distributed in each layer.

[0033] In this embodiment the first, second and third conductive material are selected from the group comprising copper, copper based alloys, aluminium, aluminium alloys, steel, other conductive metals, and other conductive or non-conductive materials.

[0034] Figure 5 illustrates a fifth embodiment of a conductor for an armoured subsea cable according to the present invention. In this embodiment the conductor comprises a central wire and two layers of conducting elements 15a, 15b and 12a, 12b arranged around the core. In the illustrated embodiment the conductor elements 12b and 15b are all made of a first conducting material whereas the central wire 11a and the conductor elements 12a and 15a are made of a second conducting material different from the first conducting material. In the embodiment on figure 5 the conducting elements each have a circular cross-section. The elements conductor may be stranded together.

[0035] In this embodiment the first and second conductive material are selected from the group comprising copper, copper based alloys, aluminium, aluminium alloys, steel, other conductive metals, and other conductive or non-conductive materials.

[0036] A person skilled in the art will appreciate the different embodiments illustrated in the figures 1-5 may be free combined providing conductors comprising at least two conductor elements of different materials joint to form one conductor, wherein the cross-sectional structure of each conductor element may be freely selected.

Claims

1. Subsea power cable comprising a conductor surrounded by at least one layer of insulation and at least one layer of armouring, **characterised in that** the conductor comprises at least a first conductor element and a second conductor element, where the first conductor element is made of a first material and the second conductor element is made of a second material and where the first and the second materials are different.

2. Subsea power cable according to claim 1, wherein the conductor comprises a third conductor element made of a third material different from the first and the second material.

3. Subsea power cable according to claim 1 or 2, wherein the conductor elements of different materials are distributed throughout the cross-section of the conductor.

4. Subsea power cable according to any one of the claims 1-2, wherein the conductor comprises a core, a first layer surrounding the core and a second layer surrounding the first layer, wherein the first layer is made of the first material and the second layer is made of the second material.

5. Subsea power cable according to any one of the previous claims, wherein the two or more different types

of materials are each a material independently selected from the group comprising copper, copper alloys, aluminium, aluminium alloys, steel, other metals or non-metallic materials.

6. Subsea power cable according to claim 5, wherein the first material is copper or a copper alloy and the second material is aluminium or an aluminium alloy.

7. Subsea power cable according to claim 5, wherein the first material is aluminium or an aluminium alloy and the second material is copper or a copper alloy.

8. Subsea power cable according to claim 2 and claim 6 or 7, wherein the third material is steel.

9. Subsea power cable according to any one of the previous claims, wherein the subsea cable is a high voltage power cable.

10. Subsea power cable according to any one of the previous claims, wherein al least one of the first, second or third material is aluminium or aluminium alloy.

11. Subsea power cable according to any one of the previous claims, wherein the selection and distribution of conductor elements of different materials are such that the conductor will not yield during the laying of the cable as the yield stress limit of the conductor is not reached when laying at water depths of 400 - 3000 m.

12. Subsea power cable according to any one of the previous claims, wherein the conductor is designed such that the conductor will not yield even if the cable laying tension is in the range of 50 tonnes or more.

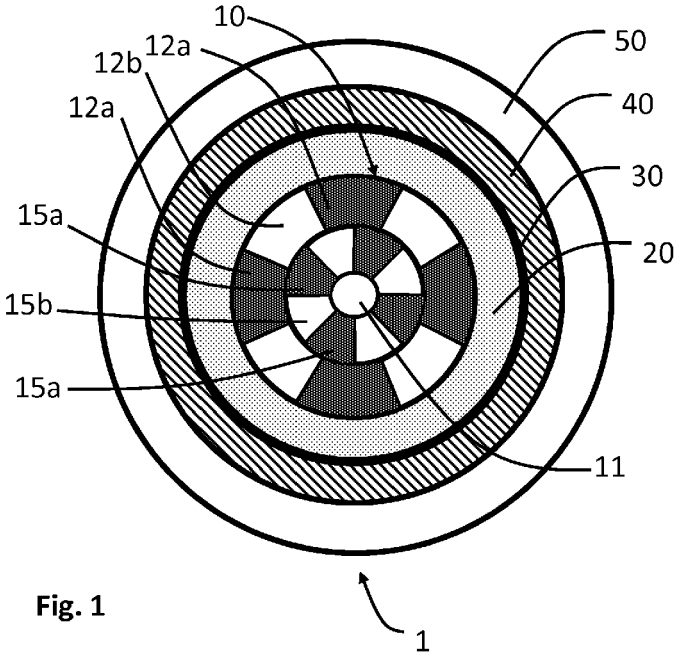
10
12b
12a
12a
50
40
30
20
15a
15b
15a
11
1

Fig. 1

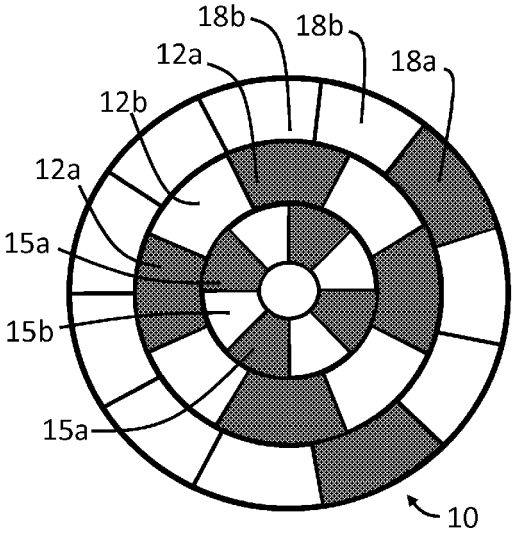
18b
18b
18a
12a
12b
12a
15a
15b
15a
10

Fig. 2

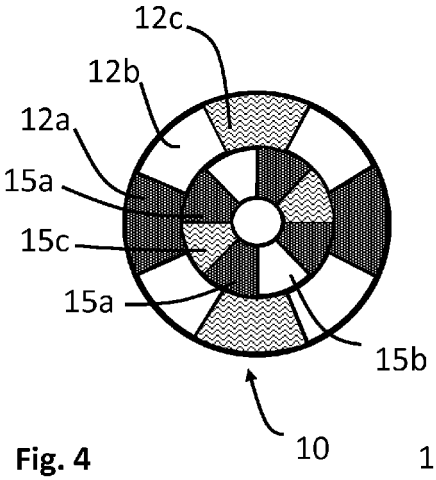

Fig. 4

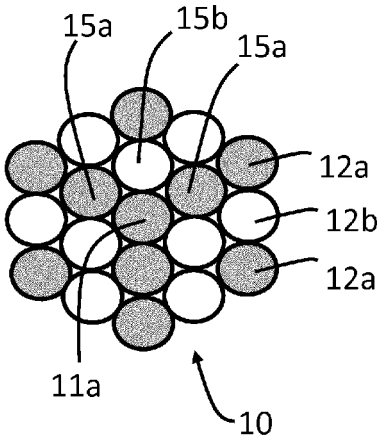

Fig. 5

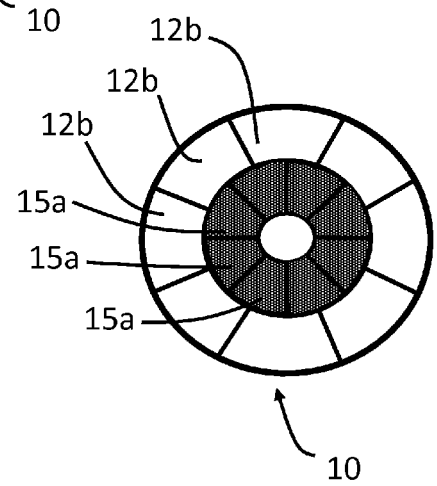

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 14 30 5168

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2012/061123 A1 (DEIGHTON ALAN WILLIAM [GB] ET AL) 15 March 2012 (2012-03-15) * paragraphs [0001], [0005], [0010], [0017], [0022] - [0024], [0027] - [0028], [0036], [0054] * * figures 1,4 * -----	1-3,5-12	INV. H01B7/14 H01B1/02 ADD. H01B9/00
X	US 2007/237469 A1 (ESPEN OLSEN [NO]) 11 October 2007 (2007-10-11) * paragraphs [0029] - [0031] * * figure 2 * -----	1,3	
X	CN 101 807 453 A (ZHOUSHAN ELECTRIC POWER BUREAU OF ZHEJIANG ELECTRIC POWER CORP) 18 August 2010 (2010-08-18) * figures 1,5 * -----	1,4	

TECHNICAL FIELDS SEARCHED (IPC)

H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 June 2014	Hillmayr, Heinrich

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 30 5168

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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12-06-2014

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012061123 A1	15-03-2012	AU 2009275328 A1	28-01-2010
		CA 2731782 A1	28-01-2010
		CN 102160126 A	17-08-2011
		GB 2462130 A	27-01-2010
		US 2012061123 A1	15-03-2012
		WO 2010010396 A1	28-01-2010
US 2007237469 A1	11-10-2007	BR PI0700420 A	06-11-2007
		CA 2577488 A1	17-08-2007
		GB 2435347 A	22-08-2007
		NO 329604 B1	22-11-2010
		US 2007237469 A1	11-10-2007
CN 101807453 A	18-08-2010	NONE	

EPO FORM P0459

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