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(54) **A high-voltage power cable**

(57) The invention relates to a high-voltage power cable for submarine power transmission comprising two or more cable cores, each core comprising a conductor with an insulation system around the conductor, a sheath encompassing the cable cores, a tensile armour comprising a plurality of helical tensile wires wound around the sheath, and an outer protective cover jacketing the tensile armour, wherein one or more of the ten-

sile wires, which are helically wound around the sheath, are wire ropes made of a multiple of braided or twisted strands or filaments. Hereby, the residual torsion in the tensile armour is reduced. This means that a flat high-voltage power cable is more flexible, easier to bend and that problems of torsion within the cable may be reduced or even eliminated without having to apply a further armour layer, thereby making the cable stiff and inflexible.

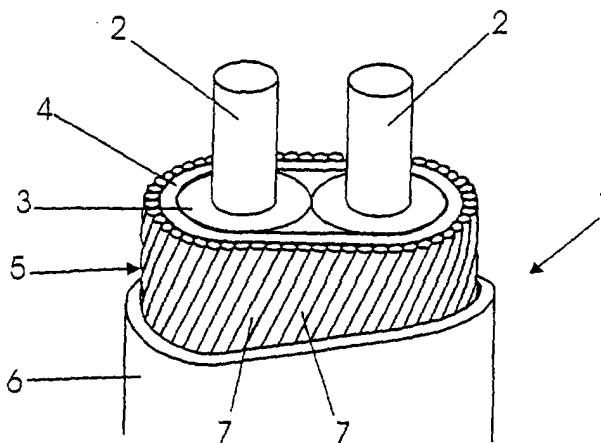


Fig 1

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Description

[0001] The present invention relates to a high-voltage power cable for submarine power transmission comprising two or more cable cores, each core comprising a conductor with an insulation system around the conductor, a sheath encompassing the cable cores, a tensile armour comprising a plurality of helical tensile wires wound around the sheath and an outer protective cover jacketing the tensile armour.

[0002] Power cables, such as submarine power cables, are typically flat configuration power cables with the cable cores arranged parallelly next to each other. The cores are jacketed by a sheath typically made of lead. The armour is steel rods helically wound around the sheath of the cable in order to provide the cable with a good tensile strength. The armour rods are wound in a certain helical angle around the sheath so that the armour is permanently positioned around the lead sheath. Hereby, a tensile armour is provided which is simple to produce and which can absorb a relatively high tension force, just as the armour offers good protection of the cable.

[0003] When the tension rods are wound around the flat cable for the creation of the armour, a permanent deformation is created in the rods. However, the elasticity of the rods means that each of the rods will spring back in free state. The residual force created in each of the rods when fixed in their geometry onto the cable, will cause the cable to twist if the cable is cut through. This may result in significant damage to the cable and make the handling of the cable end difficult. If there is a multiple of armour layers wound in the same direction, the problems may become critical. If two armour layers are counter-wound, the resulting twist is very limited if the cable is cut. However, the power cable then becomes very stiff which makes it difficult to handle in relation to e.g. layout of the cable.

[0004] The object of the invention is to provide an electric high-voltage power cable for submarine purposes which is flexible and consequently easy to handle, in particular during layout of the cable.

[0005] This object is achieved by a high-voltage power cable of the initially mentioned kind, wherein one or more of the tensile wires, which are helically wound, are wire ropes made of a multiple of braided or twisted strands or filaments.

[0006] Hereby, the residual bending stress in the tensile armour is reduced. This means that a flat high-voltage power cable is more flexible, easier to bend and the problems of torsion within the cable may be reduced or even eliminated without having to apply a further armour layer, thereby making the cable stiff and inflexible. By cutting a power cable according to the invention, no or at least a reduced amount of residual forces are released whereby the twisting of the cable end is significantly reduced and thus easier to handle.

[0007] By replacing at least some of the wire rods in

the armour by wire ropes as suggested by the present invention, less residual forces are present in the armour. This means that more wires can be fitted into the armour adding tensional strength or impact protection without causing inflexibility to the cable.

[0008] By high-voltage power cables for use in shallow waters, such as sea depths of less than 300 m, an armour exclusively made of wire ropes can be used. However, by deep sea applications, it may be critical that the wire ropes have less axial rigidity. This means that the elongation may become critical by deep sea power cables, mainly due to the weight of the power cable. However, a tensile armour comprising a combination of rods and ropes may be used to increase the axial rigidity.

[0009] In a first embodiment, all tensile wires of the tensile armour are wire ropes. Hereby, a power cable is obtained wherein the internal torsion is reduced to a minimum since the twisted or braided strands do not significantly resist bending around the cable during the winding of the wire ropes onto the cable.

[0010] The tensile wires may be either twisted wire ropes or braided filaments forming wire bands. By a braided, flat wire band, a more compact armour may be achieved.

[0011] In the preferred embodiment, the twisted wire ropes in the tensile armour are wire ropes including a number of twisted steel, aluminium and/or copper strands. Hereby, the armour may be composed by wire ropes in a suitable material or materials in accordance with specific requirements, i.e. light weight, high strength-to-weight ratio, etc. In a preferred embodiment, the wire ropes in the tensile armour are litz wires.

[0012] In a further embodiment, one or more of the wire ropes may be provided with a core strand consisting of non-metallic filaments. Hereby, the flexibility of the armour may be further increased.

[0013] In an embodiment of the invention, the wire ropes may be supplied with a corrosion protective treatment individually or as a whole, such as an impregnation of an anticorrosion agent. In order to provide further corrosion protection, the armouring or individual wire ropes may be provided with a protective lining.

[0014] In a further embodiment, the tensile armour comprises two or more layers of helically counter-wound tensile wire, where at least one of the layers comprises wire ropes made up by a multiple of braided or twisted strands. By such a cross-wound armour, extra strength is provided to the tensile armour without reducing the flexibility of the cable.

[0015] In the preferred embodiment of the invention, the cable cores are arranged next to each other in a flat configuration. Hereby, a compact cable may be produced which is relatively easy to lay out due to its flexibility. The layout of a flat power cable at sea involves unwinding of the cable from a reel onboard a ship. Here, the cable is upright and must be twisted one quarter of a revolution so that the cable leaves the ship sliding on its broad side. The length required for twisting the flat

power cable may be significantly reduced by a power cable according to this embodiment of the invention.

[0016] The invention will be described in detail below with reference to the accompanying drawings, in which

Fig. 1 shows the assembly of a high-voltage power cable,
fig. 2 shows a detailed view of a high-voltage power cable according to an embodiment of the invention, and
figs. 3 to 5 show alternative wires of the tensile armour of a cable according to the invention.

[0017] In figure 1, a cable according to a first embodiment of the invention is shown. The cable 1 comprises two cable cores arranged next each other to form a flat configuration power cable. Each of the cable cores comprises a conductor 2 which is provided with an insulation system 3. The cable cores are encompassed by a lead sheath 4. The sheath 4 is protected by a tensile armour 5 jacketing the sheath 4. Finally, the tensile armour 5 is coated by an outer sheath 6 which protects the cable 1 and prevents water from penetrating the cable 1.

[0018] The tensile armour 5 is made up by a number of parallel wires 7 that are helically wound around the sheath 4. The wires 7 are arranged next to each other so that the surface around the sheath 4 is covered. The wires 7 are helically wound in such a way that each of the wires 7 is retained in its position in the cable construction. The tensile armour 5 serves the purpose of providing mechanical protection and tensile strength to the cable.

[0019] According to the invention, at least some of the wires 7 of the tensile armour 5 are made of wire ropes, as shown in fig. 2. By replacing the wire rods of the tensile armour 5 by wire ropes 7, the tensile armour 5 becomes more flexible and less resistant to bending while maintaining its tensile strength.

[0020] The type of wire 7 used in the tensile armour 5 of a cable according to the invention, may be chosen in accordance with specific requirements of the armour 5. In figures 3 to 5, some examples of preferred kinds of wire ropes are shown.

[0021] As shown in fig. 3, the wire rope 7 is made by a number of strands 8 twisted around a core strand 10. The strands 8, 10 are formed by twisted filaments 11. The material of the filaments may be steel, aluminium, or other metal or non-metallic materials, such as polymers or ceramic materials which may be reinforced by fibers or the like.

[0022] In fig. 4, the wire rope 7 shown in fig. 3 is provided with a coating or lining 9 for protection of the wire from corrosion. The coating 9 is preferably a polymer coating 9.

[0023] In fig. 5, an alternative embodiment of the wire rope 7 is shown. In this embodiment, the wire 7 is a braided wire band. The band 7' consists of braided fila-

ments 11 braided in a flat wire tape configuration. Hereby, a particularly compact tensile armour 5 may be provided.

[0024] The above description of the invention refers to some preferred embodiments of a cable according to the invention. However, it is realised that other variations and embodiments of the cable may be provided without deriving from the scope of the invention as described in the accompanying claims.

Claims

1. A high-voltage power cable for submarine power transmission comprising

two or more cable cores, each core comprising a conductor with an insulation system around the conductor,
a sheath encompassing the cable cores,
a tensile armour comprising a plurality of helical tensile wires wound around the sheath, and
an outer protective cover jacketing the tensile armour,

characterised by

one or more of the tensile wires, which are helically wound, being wire ropes made of a multiple of braided or twisted strands or filaments.

2. A power cable according to claim 1, wherein all tensile wires of the tensile armour are wire ropes.
3. A power cable according to claim 1 or 2, wherein the tensile wires are twisted wire ropes.
4. A power cable according to claim 3, wherein the twisted wire ropes in the tensile armour are wire ropes including a number of twisted strands made of alloys such as steel, metals of aluminium and/or copper, or a reinforced polymer or ceramics material.
5. A power cable according to claim 3 or 4, wherein the twisted wire ropes in the tensile armour are litz wires.
6. A power cable according to any of claims 3 to 5, wherein one or more of the wire ropes are provided with a core strand consisting of non-metallic filaments.
7. A power cable according to any of claims 3 to 6, wherein the wire ropes are provided with a corrosion protective treatment individually or as a whole.
8. A power cable according to any of claims 3 to 7, wherein the wire ropes are coated with a protective

lining individually or as a whole.

9. A power cable according to claim 1 or 2, wherein the tensile wires are braided filaments forming wire bands.

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10. A power cable according to any of the preceding claims, wherein the tensile armour comprises two or more layers of helically counter-wound tensile wire, where at least one of the layers comprises wire ropes made up by a multiple of braided or twisted strands.

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11. A power cable according to any of the preceding claims, wherein the cable cores are arranged next to each other in a flat configuration.

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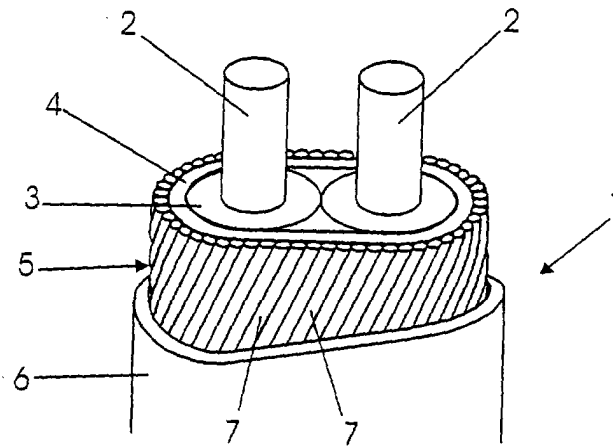


Fig 1

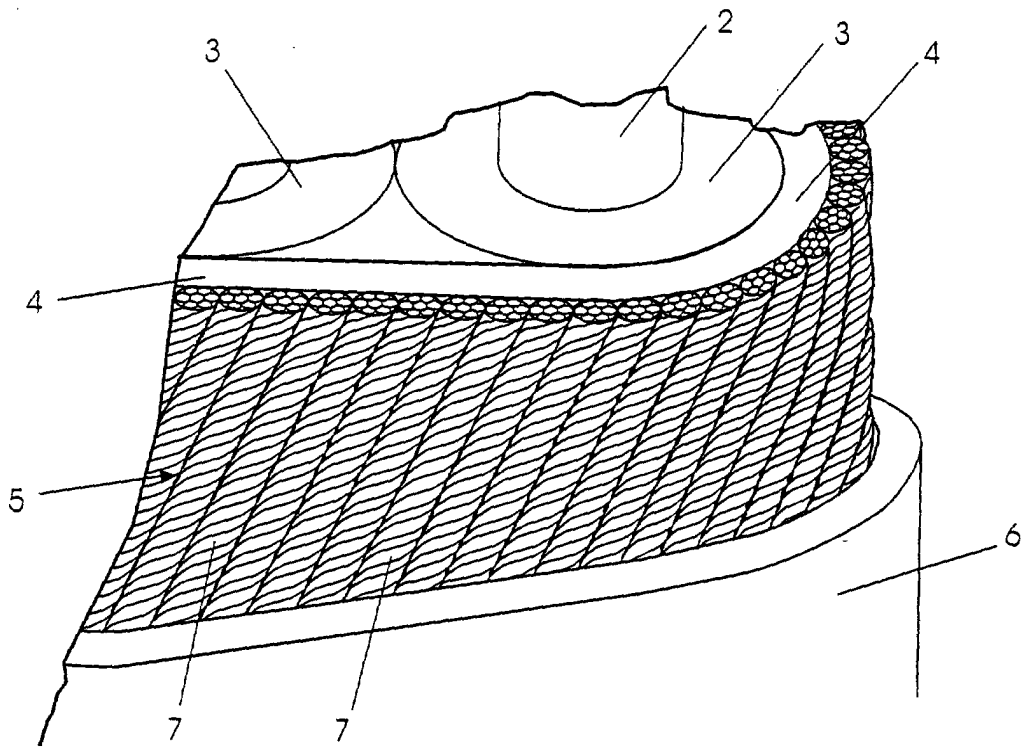


Fig 2

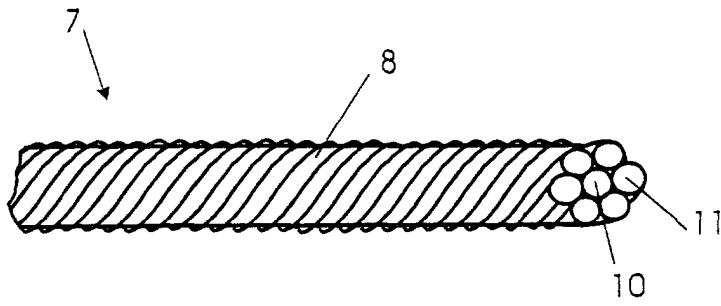


Fig 3

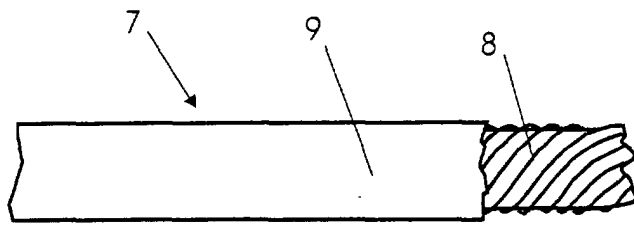
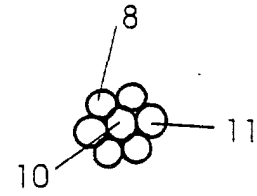


Fig 4

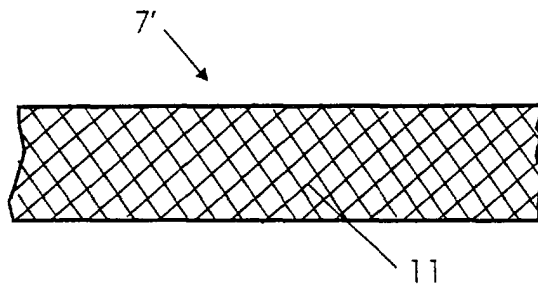
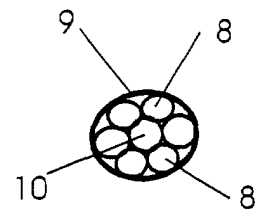
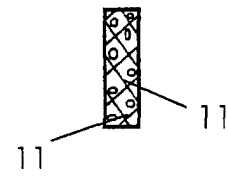


Fig 5





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EUROPEAN SEARCH REPORT

Application Number
EP 00 20 3293

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	DE 11 93 122 B (LAND- UND SEEKABELWERKE) * column 2, line 20 - line 33; figures 1-4 *	1-4	H01B7/14
A	US 3 584 139 A (SWANSON ROBERT A) 8 June 1971 (1971-06-08) * column 2, line 1 - line 36; figure 1 *	1-4,6	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 7 February 2001	Examiner Demolder, J
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 (P04001)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 00 20 3293

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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07-02-2001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 1193122	B	NONE	
US 3584139	A	08-06-1971	NONE