(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 150 304 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
31.10.2001 Bulletin 2001/44

(51) Int Cl.[7]: **H01B 9/06**

(21) Application number: **00201513.9**

(22) Date of filing: **27.04.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(71) Applicant: **NKT Cables A/S**
2605 Bröndby (DK)

(72) Inventor: **Kvarts, Thomas**
2100 Kobenhavn 0 (DK)

(74) Representative: **Elmeros, Claus**
Patentgruppen ApS,
Arosgaarden,
Aboulevarden 23, 5.
8000 Aarhus C (DK)

(54) An electrical cable

(57) The invention relates to high-voltage power cables, such as flat submersible electrical cables. The invention consists of an electrical power cable comprising multiple cable cores (1), each core (1) comprising a conductor (2) and an insulation system (3), said cable cores (1) being jacketed by a protective sheath (4), whereby two or more volume channels (5) are formed between two neighbouring cable cores (1) and the inside of an associated intermediate portion (4a) of the sheath (4), wherein volume reduction means are provided in the volume channels (5). The sheath (4) can be provided with indentations (6) at the intermediate portions (4a) between at least some of the cable cores (1). Hereby, the volume of insulating oil underneath the sheath of the cable is reduced. As a consequence thereof, the risk of environmental damage is reduced in case of a leak in the power cable.

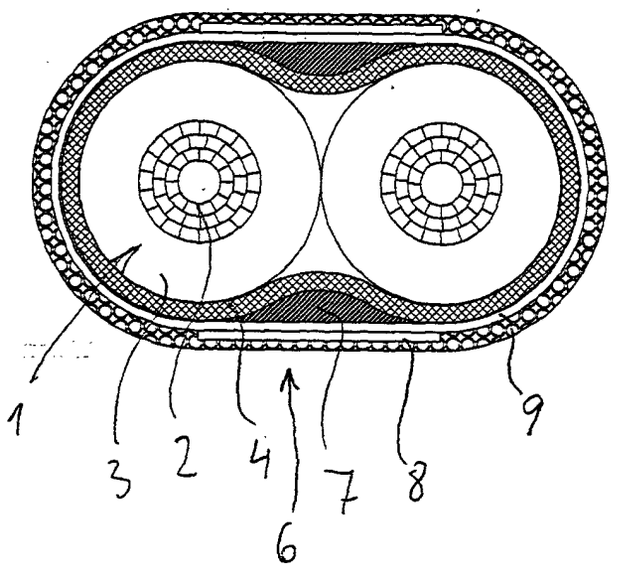

Fig. 2

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Description

[0001] The present invention relates to an electrical power cable comprising multiple cable cores, each core comprising a conductor and an insulation system, said cable cores being jacketed by a protective sheath, whereby two or more volume channels are formed between two neighbouring cable cores and the inside of an associated intermediate portion of the sheath.

[0002] A power cable of this kind is typically an oil-filled cable, such as a cable known from e.g. US 4,853,490 or US 4,602,121. The multiple cable cores are arranged in a flat configuration as shown in US 4,600,805 or DE 32 29 257 C2.

[0003] In a flat configuration power cable of the initially mentioned kind, longitudinal volume channels will be present underneath the lead sheath of the cable. This volume is filled with insulation oil. The oil is under pressure in the free volume of the cable channels. The cable construction allows the cable to expand and contract as the pressure of the oil alternates due to changes in e.g. the electric load of the cable and the soil temperature. The changes in oil pressure can be in the range of 0.5 to 6 bar positive pressure.

[0004] The size of the cables is chosen on the basis of the electrical capacity of the cable. Consequently, an increase in size results in an increase in the core diameter that, in turn, generates a larger volume of the oil channels. This means that the amount of oil in the cable is increased.

[0005] The length of a submarine power cable can be very long, e.g. 200 km or more. This means that the amount of oil in such a submersible high-voltage cable constitutes a potential environmental risk, should a cable leakage occur. Thus, it is often necessary to acquire authorization from various environmental and governmental authorities before placing a high-voltage power cable on the seated.

[0006] The environmental authorizations must be obtained on an individual basis, as the environmental risk assessment can vary from cable to cable.

[0007] However, by the present invention, it is realised that the load capacity of a flat power cable can be increased without increasing the amount of oil and thus the environmental risk. The invention consists of a cable of the initially mentioned kind, wherein volume reduction means are provided in the volume channels.

[0008] In the preferred embodiment of the invention, the volume reduction means comprises a sheath provided with indentations at the intermediate portions between at least some of the cable cores. By applying this geometry to the lead sheath, smaller volume channels are achieved reducing the amount of oil in the channels. This means that a cable with an increased conducting core diameter can be produced having the same or even a reduced volume of insulation oil. The indentation is preferably concave in a cross-sectional shape. The effect of the invention can be appreciated from the table below, in which a cable according to the present invention with indentations on each side is compared with a cable known in the art.

	Prior Art Cable	New Cable
Indentation		2 mm
Core diameter	65 mm	69 mm
Channel area	907 mm^2	904 mm^2

[0009] In the preferred embodiment of the invention, a filling strip is arranged on the outside of the sheath and essentially fills an indentation. Hereby, a simple design is achieved which is easy to manufacture as the pressure amour, membrane and other protective layers of the cable construction can retain their usual cross-sectional geometry. In the preferred construction of the cable, the pressure armour is jacketing the sheath and the fillings and a longitudinal membrane is disposed by the indentations on the outside of said armour. This provides a compact and robust structure of the cable.

[0010] In a second preferred embodiment of the invention, the sheath is provided with an extruded polymer layer for filling of the indentations. Hereby, the fillings are integrated in a layer outside the sheath which is either intermediate or encompassing the shaft. This means that the fillings are fixed in their positions. The material of the polymer layer is preferably a semi-conductive polymer, so that electrical currents may pass between the lead sheath and the pressure amour.

[0011] In another aspect of the invention, the volume reduction means comprises a bar disposed in one or more of the volume channels. This bar may feature an appropriate cross-section area in order to reduce the volume. The bar could be inflatable or in other ways expandable in volume. It is possible to use the volume reduction means on its own or in combination with the above-mentioned preferred first and second embodiments.

[0012] In a third aspect of the invention, a different approach is used to reduce the risk of environmental damage due to an oil leak. This aspect of the invention consists of an oil-filled electrical power cable comprising multiple cable cores, each core comprising a conductor and an insulation system, said cable cores being jacketed by a protective sheath, whereby two or more volume channels are formed between two neighbouring cable cores and the inside of an associated intermediate portion of the sheath, wherein the volume channels are filled with high viscosity oil.

[0013] By using high viscosity oil, the amount of and the speed with which oil is leaking out of the cable can be reduced in the event of damage, whereby environmental pollution following from such a leak can be reduced. By the invention, it is realised that this aspect can be combined with one or both of the other two aspects of the invention.

[0014] In the following, the invention is described in detail with reference to the accompanying drawings, of which

fig. 1 shows a cross-section view of a high-voltage cable according to a first preferred embodiment of the invention,
fig. 2 is a second preferred embodiment of the invention showing a cable with two conductors,
fig. 3 is the same showing three conductors,
fig. 4 is a third preferred embodiment of the invention, and
fig. 5 is a schematic cross-section view of a second aspect of the invention.

[0015] As shown in figure 1, the high-voltage cable comprises multiple cores 1 comprising an electrically conducting core 2 carrying the load currents. An insulation system 3 is provided around the conducting core 2.

[0016] The conducting cores 1 are arranged side-by-side and are encompassed by a lead sheath 4 wrapped around the cores 1 whereby two volume channels 5 are created between the cores 1 underneath the sheath 4.

[0017] The volume channels 5 are filled with oil under pressure.

[0018] On the intermediate portion 4a of the sheath 4, i.e. the flat top and bottom sides thereof, indentations 6 or dimples are provided. These indentations 6 in the sheath 4 are essentially filled with fillings 7 on the outside and jacketed by pressure armour tapes 9 wound around the sheath 4 and the fillings 7.

[0019] Outside the fillings on the flat portion 4a, a corrugated membrane 8 is provided. This ensures that the cable can both expand and contract due to variations in soil and operating temperatures. When the load is high and the soil temperature is high, the oil builds up pressure in the channels 5 and the cable will expand accordingly. Due to the corrugated membrane 8, the sheath portion 4a will be subjected to a spring load causing the cable to contract when load and temperature are reduced.

[0020] On the outside, further protecting and strengthening layers are provided to give the cable the required robustness and durability.

[0021] This insulation system 3 comprises an inner semi-conducting shield (no reference sign shown) in order to ensure as even a distribution of the electric field as possible within the insulation 3. Outside the inner semi-conducting shield, insulation (no reference sign shown) is provided. This insulation can be a paper insulation, a paper-plastic insulating tape or the like. On the outside of the insulation, a second outer semi-conducting shield (no reference sign shown) is provided in order to ensure an even distribution of the electric field and to retain space charges accumulating in the insulation.

[0022] The indentations 6 are shown in schematic detail in figures 2 and 3. In figure 2, the cable comprises two conducting cores 1 jacketed by a sheath 4 having concave indentations 6 between the cores 1. Outside the sheath 4, further amours and protecting layers are provided. By a cable according to the invention, it is important to retain the two cores 1 to ensure that they are in contact with each other to prevent e.g. deformations of the concave indentations 6 of the sheath 4 as the oil pressure in the volume channels 5 is increased.

[0023] In figure 3, an embodiment of the invention is shown, where three conducting cores 1 are arranged in a flat configuration in a high-voltage power cable. Indentations 6 are provided in all intermediate portions of the sheath 4. The indentations 6 are filled on the outside of the sheath 4 by fillings 7. These are held in place, just as the sheath 4 is prevented from sideways expansion, by further amour tapes and protective layers jacketing the sheath 4.

[0024] In figure 4, another embodiment of the invention is shown. The indentations 6 are filled on the outside of the sheath 4 by an extruded polymer layer 10 encompassing the entire sheath 4. The polymer layer is extruded in a semi-conductive polymer material, so that electric currents may pass between the sheath 4 and the amour tapes 9 outside the intermediate polymer layer 10.

[0025] By this embodiment, the indentations 6 are always filled up, so that the form of the sheath 4 can be retained in an efficient manner.

[0026] In figure 5, another embodiment of the invention is shown, where volume bars 11 are provided in the volume channels 5 in order to reduce the volume of the channels 5. The bars 11 could be inflatable or in other ways expandable in order to regulate the volume of the channels 5.

[0027] The cables shown in the figures are filled with oil. By the invention, it is realised that an alternative or a supplement to the above-mentioned embodiments could be to use a high viscosity oil in order to reduce the risk of oil leaks in the event of a damage to the cable.

Claims

1. An electrical power cable comprising multiple cable cores (1), each core (1) comprising a conductor (2) and an insulation system (3),
said cable cores (1) being jacketed by a protective sheath (4), whereby two or more volume channels (5) are formed between two neighbouring cable cores (1) and the inside of an associated intermediate portion (4a) of the sheath (4),
characterised in that
volume reduction means (6, 7, 10, 11) are provided in the volume channels (5).

2. An electrical power cable according to claim 1, wherein the sheath (4) is provided with indentations (6) at the intermediate portions (4a) between at

least some of the cable cores (1).

3. An electrical power cable according to claim 2, wherein the indentations (6) are concave in a cross-sectional shape.

4. An electrical power cable according to claim 2 or 3, wherein a filling strip (7) is arranged on the outside of the sheath (4) and essentially fills an indentation (6).

5. An electrical power cable according to any of claims 2 to 4, wherein a pressure armour (9) is jacketing the sheath (4) and the fillings (7) and a longitudinal membrane (8) is disposed next to the indentations (6) on the outside of said armour (9).

6. An electrical power cable according to any of claims 2 to 5, wherein the sheath (4) is provided with an extruded polymer layer for filling of the indentations (6).

7. An electrical power cable according to claim 6, wherein the material of the polymer layer is a semi-conductive polymer.

8. An electrical power cable according to claim 1, wherein the volume reduction means comprises a bar (11) disposed in one or more of the volume channels (5).

9. An electrical power cable according to any of the previous claims, wherein the volume channels (5) are filled with oil.

10. An oil-filled electrical power cable comprising multiple cable cores (1), each core (1) comprising a conductor (2) and an insulation system (3), said cable cores (1) being jacketed by a protective sheath (4), whereby two or more volume channels (5) are formed between two neighbouring cable cores (1) and the inside of an associated intermediate portion (4a) of the sheath (4),
characterised in that
the volume channels (5) are filled with high viscosity oil.

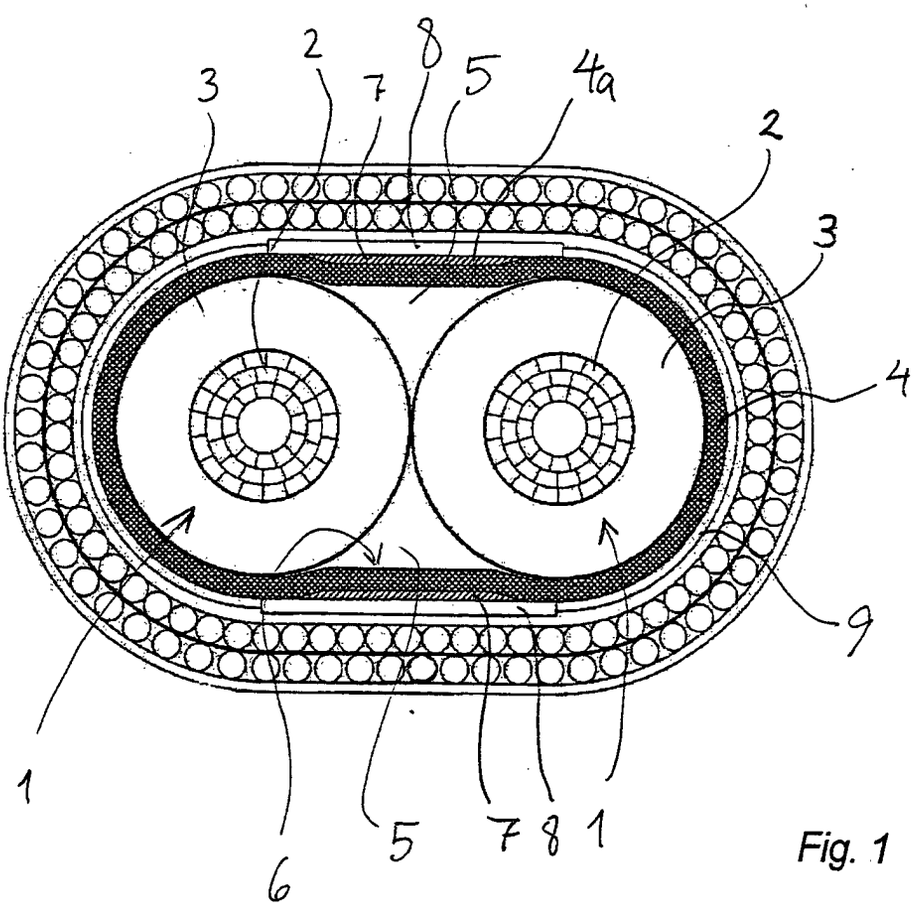

Fig. 1

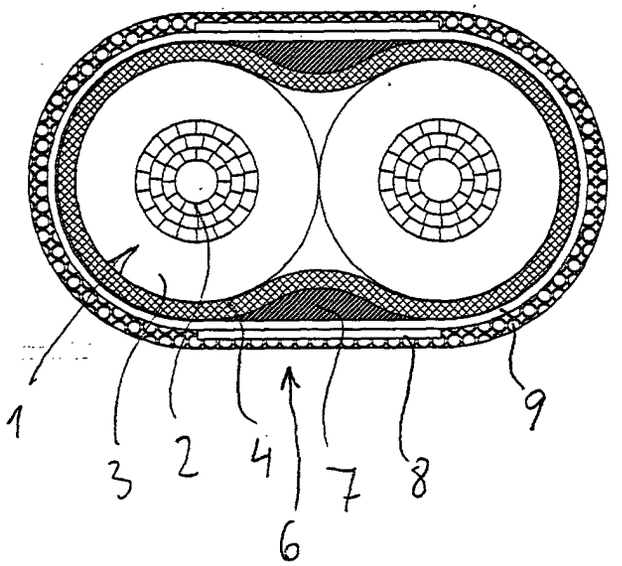

Fig. 2

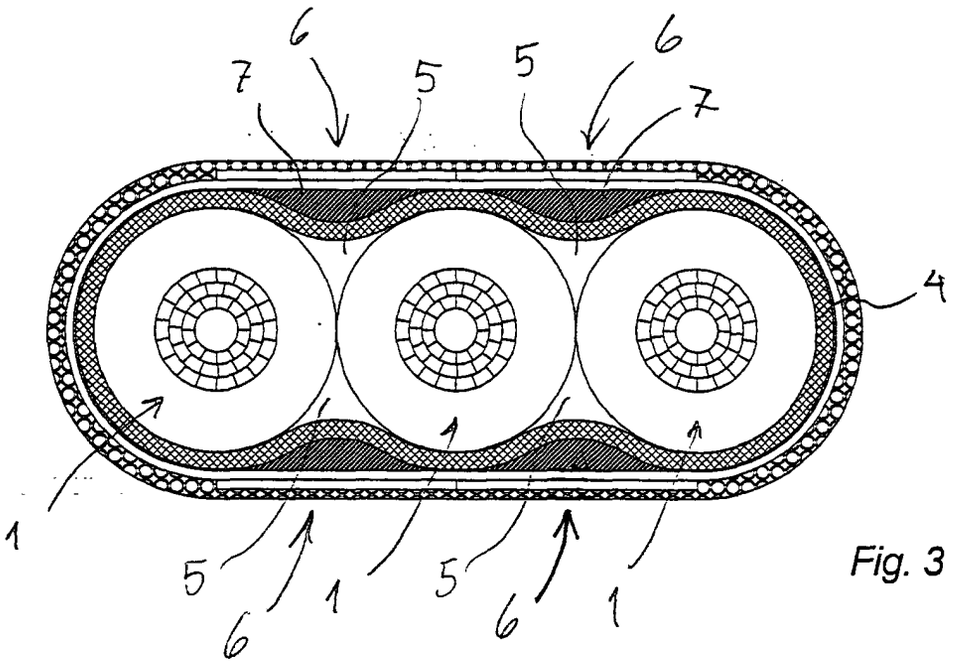

Fig. 3

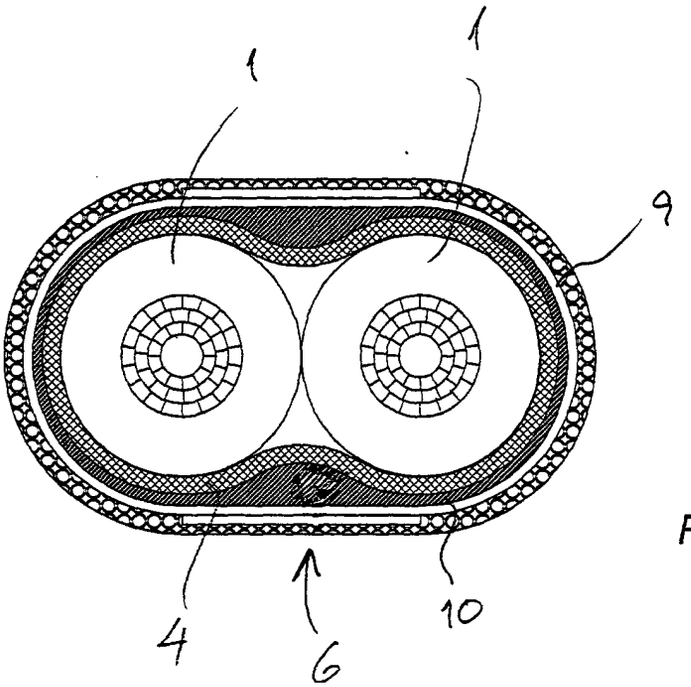

Fig. 4

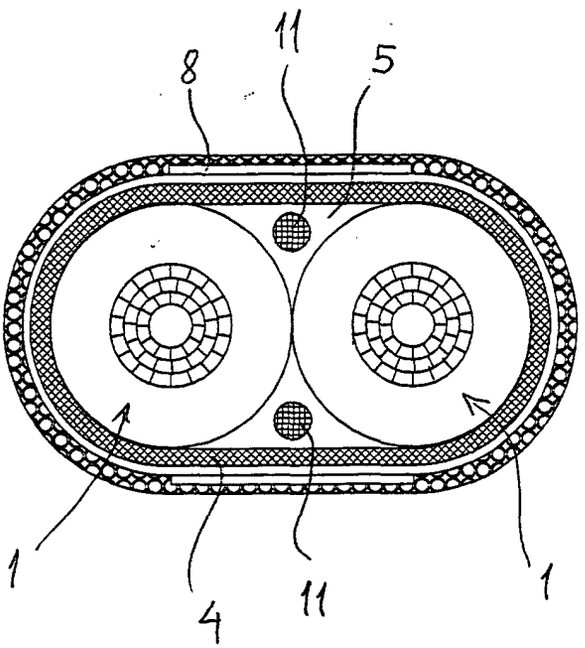

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 1513

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)
X	GB 1 264 625 A (B.I.C.C.) 23 February 1972 (1972-02-23)	1,9	H01B9/06
A	* page 2, column 1, line 63 - page 3, column 1, line 30; figures 1,2 *	10	
A,D	US 4 600 805 A (GLYNN JOHN R ET AL) 15 July 1986 (1986-07-15) * claim 1; figure 1 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
H01B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 September 2000	Demolder, J

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 00 20 1513

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