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Amended claims in accordance with Rule 137(2)
EPC.

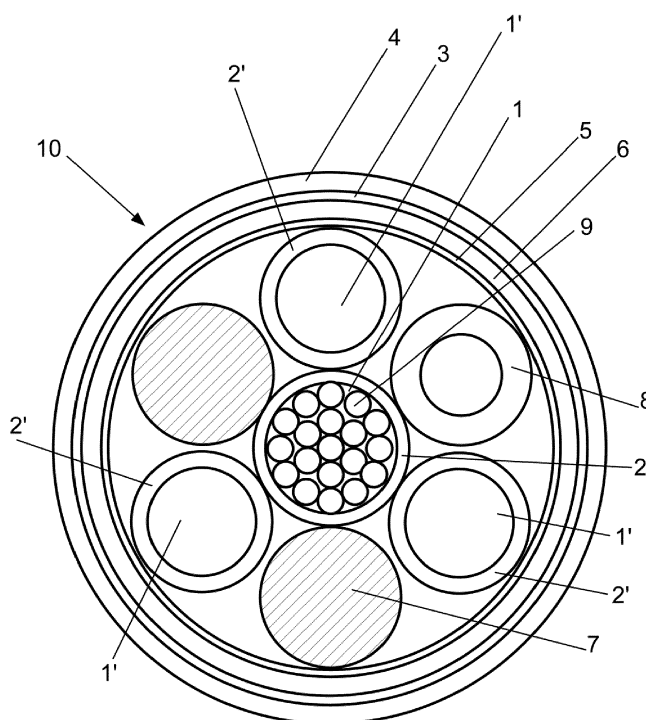
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(54) **CABLE**

(57) The invention relates to a cable suitable for supplying power to a top-drive assembly on a drilling rig. In a typical embodiment, the power cable includes a central conductor (1), a central conductor insulation layer (2), electromagnetic shielding (5) enclosing the central conductor, a first polymeric sheath (6), a reinforcing layer (3)

and a second polymeric sheath (4) enclosing said reinforcing layer. According to the invention, the reinforcing layer is made of a densely packed braid covering between 95% and 100% of the surface of the first polymeric sheath.

FIGURE 3



Description

[0001] The present invention relates to a cable for supplying power to a top-drive assembly on a drilling rig.

[0002] On offshore and land-based drilling rigs, a top-drive assembly is generally used to provide the rotational force needed to drill a hole. The power to the motors within the top-drive assembly is supplied by power cables ("top-drive power cables").

[0003] Typically, the power cables are located within rubber hoses. The rubber hoses protect the power cables from mechanical and chemical damage and against the generally harsh conditions on drilling rigs. Without the additional protecting hoses, the lifetime of the cables would be severely reduced. The cables are normally glued to the rubber hose to prevent movement of the cable relative to the hose. The rubber hoses add weight to the overall structure and the positioning and gluing of the cable inside the hose is time consuming.

[0004] During operation, the top-drive assembly typically performs repetitive vertical movements. The rubber hoses and the power cables enclosed within reciprocate these movements. The power cables therefore need to be designed for continuous flexing operations. Insufficient flexibility can lead to failure of the cable.

[0005] Drill-heads can get stuck during operation. To free the drill-head, a large torque is applied to the former by the top-drive assembly which can lead to a momentarily uncontrolled motion ("jumping") of the power cables that are mechanically connected to the top-drive assembly. To prevent damage to the cable or disconnection of the cable from the top-drive assembly during these special operations, the cable is typically mechanically clamped. During routine operation, the cable clamp exerts pressure on the cable sheath and the conductors within the cable. Due to the repetitive flexing of the cable during routine operation, the clamping of the cable can lead to damage to the cable sheath and the conductors and ultimately to the failure of the cable.

[0006] The problem of the present invention is to provide a cable, for supplying power to a top-drive assembly, which does not need to be positioned within a rubber hose.

[0007] More particularly, the cable shall withstand mechanical and chemical conditions that are encountered on a drilling rig.

[0008] Further, the cable shall be easy to dismantle even over long distances of several meters.

[0009] The problem is solved by a top-drive power cable according to claim 1. Further preferred embodiments are subject of the dependent claims.

[0010] The power cable of the present invention comprises a central conductor which is electrically insulated by a surrounding insulation layer, the central conductor insulation layer. The insulated central conductor is preferably designed to carry high loads of electrical power. To reduce electromagnetic interference with other cables, the insulated central conductor is preferably sur-

rounded by an electromagnetic shielding layer. The electromagnetic shielding layer preferably comprises a woven copper braid. The power cable further comprises a first polymeric sheath which fully encloses the electromagnetic shielding layer. The first polymeric sheath preferably comprises polyvinylchloride and/or polyolefins and/or polyurethane and/or another extrudable polymeric material. A reinforcing layer encloses the first polymeric sheath. The reinforcing layer provides mechanical protection to the internal components of the power cable. The mechanical protection relates as well to protection against punctures (e.g. due to projectiles, splinters or other moving objects which can collide with the power cable) as to protection against unwanted bending, kinking or jumping of the cable, particularly during the operation to free a stuck drilling head. The power cable further comprises a second polymeric sheath surrounding the reinforcing layer. This outermost layer preferably comprises polyvinylchloride and/or polyolefins and/or polyurethane and/or another polymeric material. The second polymeric sheath preferably further comprises additives which improve the mechanical and chemical stability of the layer to withstand the conditions generally encountered on a drilling rig. Preferably, the material for the second polymeric sheath is mud-resistant according to NEK606.

[0011] According to the present invention, the reinforcing layer of the power cable comprises a braid of interlaced strands of a flexible material. The interlaced strands are interwoven in a way to form a densely packed braid. Preferably, there are several layers of interlaced strands, with the individual layers being interlaced between each other. The braid covers 95% to 100% of the first polymeric sheath with the coverage defined as the surface area of the first polymeric sheath that is not directly visible through the braid from outside. Preferably, the braid is homogeneous without openings larger than 1mm². This coverage provides a high and uniform protection for the underlying layers against mechanical impact, even from sharp and/or small objects. Such small and/or sharp objects might be able to relatively easily traverse the second polymeric sheath but the reinforcing layer will ensure protection in particular of the central conductor and hence prevent the power cable from possible failure.

[0012] In a preferred embodiment, the reinforcing layer comprises a braid of aramid fibres. An aramid fibre braid can be woven by a suitable machine/robot directly onto the first polymeric sheath, hence allowing for easy and efficient production. Alternatively, a suitable circular braid can be woven separately and subsequently be slid onto the first polymeric sheath.

[0013] In a further preferred embodiment of the present invention. The reinforcing layer is not chemically bound to the first and/or second polymeric sheath. For the purpose of the present invention, chemically bound is defined as the regular and strong (i.e. neither coincidental nor punctual) formation of covalent and/or ionic and/or hydrogen bonds. If the braid is not chemically bound to

the neighbouring layers, it is easily accessible for clamping. Part of the clamp can easily be slid underneath the braid (on top of the first polymeric sheath) with another part of the clamp being placed onto the braid. The two parts of the clamp can then be clamped together, firmly fixing the braid within. This way of clamping ensures that mechanical stress on the cable will mainly act on the braid itself and not on the polymeric layers or the conductors.

[0014] In a further preferred embodiment of the present invention, the central conductor is a bunched type conductor. In a bunched type conductor, a large number of individual wires, preferably comprising copper and/or aluminium and/or zinc and/or a conducting polymer, are helically assembled together in the same direction without forming definite layers. The bunched type central conductor improves the flexibility of the cable and improves the cables capability to withstand repeated bending cycles.

[0015] In a preferred embodiment of the present invention, the cable further comprises one or several non-central conductors. Each of the non-central conductors is electrically insulated by a non-central conductor insulation layer surrounding the conductor. The one or several non-central conductors are preferably located within the electromagnetic shielding layer. Preferably, the cable comprises three or six non-central conductors which are evenly distributed around the central conductor. Further preferred, the distribution of the non-central conductors around the central conductor is symmetrical with respect to rotations of the cable around its axis. Preferably, the central conductor is positioned in the centre of the cable with the axis of the central conductor and the axis of the overall cable approximately coinciding. An even distribution of the non-central conductors around the central conductor improves the electromagnetic properties of the cable and improves the mechanical stability.

[0016] In a preferred embodiment of the present invention, the central conductor and/or the one or several non-central conductors comprise copper and/or aluminium and/or zinc and/or a conducting polymer. Preferably, the non-central conductors comprise several copper wires. The copper wires can be grouped together to form a bunched type conductor, a concentric stranded conductor or a multiple stranded conductor.

[0017] In a further preferred embodiment of the present invention, a tape layer is positioned between the reinforcing layer and the second polymeric sheath. The tape layer ensures that the second polymeric sheath and the braid reinforcing layer will not be chemically bonded together and remain well-separated when the second polymeric sheath is manufactured on top of the reinforcing layer. The tape layer is wound around the reinforcing layer during production of the cable, before the second polymeric sheath is applied. The tape layer preferably comprises a thin, preferably less than 0.5mm thick, elongated tape made of polyester and/or polytetrafluoroethylene. The tape layer is wound around the reinforcing

layer in a way that the reinforcing layer is fully covered by the tape layer.

[0018] In a further preferred embodiment of the present invention, the first polymeric sheath and the second polymeric sheath have different colours. Preferably, the two colours are easily distinguishable by eye. Due to the different colours, damage to the power cable is easily detectable through visual inspection. If the colour of the first polymeric sheath is visible, damage has occurred and maintenance, repair and/or replacement must be scheduled.

[0019] Preferably, the second polymeric sheath comprises an antistatic additive, reducing the sheet resistance of the cable surface to 10^9 Ohm to 10^4 Ohm. This will prevent accumulation of charges on the cable surface. Accumulation of charges on a surface can lead to arc discharges which can ignite explosions or fire in areas where flammable substance are encountered.

[0020] According to another aspect of the present invention, the power cable further comprises a stripping tube. The stripping tube facilitates stripping of the cable over distances of several meters. Cables often need to be stripped at the ends to connect the individual conductors to connectors, machines, robots or other electrical assemblies. For top-drive assemblies, cables typically need to be stripped over distances of several meters. One step of the stripping process generally consists in cutting through one or several outlying layers of the cable along the axis of the cable over the required distance with a sharp object, typically a blade or knife. Special care must be applied in order not to damage the conductors, shielding layers or inner polymeric layers. In particular, it is important not to cut too deep into the cable. At the same time, the cut must be deep enough to fully transverse the layers that want to be removed. The stripping tube is positioned within the cable at a depth until which the outer layers need to be cut for stripping the cable. When stripping the cable, a knife or blade is positioned at the end of the cable in a way that the end of the knife or blade is approximately at the centre of the stripping tube. A cut can then be made along the axis of the cable with the knife or blade being guided by the stripping tube. Failure to follow the stripping tube during cutting will lead to a change in force that needs to be applied to the knife, so that the operator or machine performing the cut receives a direct feedback if the cut is no longer performed in the correct way.

[0021] The stripping tube is preferably positioned inside the electromagnetic shielding layer.

[0022] Preferably, the wall of the stripping tube comprises a polymeric material. The stripping tube is hollow.

[0023] Preferably, the central conductor serves as the common grounding conductor for the electrical circuits powered by the non-central conductors. To be able to carry the power (to ground) of the combined non-central conductors, the central conductor preferably has a larger cross-section than any of the non-central conductors.

[0024] The present invention will be further described

by way of example only, with reference to the accompanying drawings, wherein:

Fig. 1 Schematically depicts a cross-sectional view of a top-drive power cable in accordance with one embodiment of the present invention;

Fig. 2 Schematically depicts a cross-sectional view of a top-drive power cable in accordance with a further embodiment of the present invention, comprising a stripping tube;

Fig. 3 Schematically depicts a cross-sectional view of a top-drive power cable in accordance with a further embodiment of the present invention, comprising three non-central conductors;

Fig. 4 Schematically depicts a cross-sectional view of a top-drive power cable in accordance with a further embodiment of the present invention, comprising six non-central conductors;

[0025] Figure 1 shows a schematic cross-sectional view of a top-drive power cable (10) according to an embodiment of the present invention. The cable (10) comprises a central conductor (1) which is composed of several individual wires (9). The central conductor (1) is surrounded by a central conductor insulation layer (2). A reinforcing layer (3) surrounds the central conductor insulation layer (2). A second polymeric sheath (4) surrounds the reinforcing layer (3) and the other inlying components. It is obvious to those skilled in the art, that the cable (10) may optionally further comprise an electromagnetic shielding layer and further polymeric sheaths.

[0026] Figure 2 shows a schematic cross-sectional view of a further embodiment of a top-drive power cable (10) according to the present invention. The cable (10) comprises a central conductor (1) which is composed of several individual wires (9) and electrically insulated by a central conductor insulation layer (2). The central conductor (1) is positioned in a way that its axis and the axis of the cable (10) approximately coincide. The cable (10) further comprises a stripping tube (8) and cylinder-shaped fillers (7). The fillers (7) are used to optimize the overall geometrical shape of the cable (10) and to reduce the amount of polymeric material used for the different polymeric sheath layers. An electromagnetic shielding (5) encloses the aforementioned components. A first polymeric sheath (6) encloses the electromagnetic shielding (5). On top of the first polymeric sheath (6), a reinforcing layer (3) is positioned. On top of the reinforcing layer (3), a tape layer (not shown) may be wound around the cable (10). A second polymeric sheath (4) is the outermost layer of the cable (10).

[0027] Figure 3 shows a schematic cross-sectional view of a further embodiment of a top-drive power cable (10) according to the present invention. The cable (10) comprises a central conductor (1) which is composed of

several individual wires (9) and electrically insulated by a central conductor insulation layer (2). The central conductor (1) is positioned in a way that its axis and the axis of the cable (10) approximately coincide. The cable (10) further comprises a stripping tube (8) and cylinder-shaped fillers (7). The cable (10) further comprises several non-central conductors (1'), each of which is electrically insulated by a non-central conductor insulation layer (2'). An electromagnetic shielding (5) encloses the aforementioned components. A first polymeric sheath (6) encloses the electromagnetic shielding (5). On top of the first polymeric sheath (6), a reinforcing layer (3) is positioned. A second polymeric sheath (4) is the outermost layer of the cable (10).

[0028] Figure 4 shows a schematic cross-sectional view of a further embodiment of a top-drive power cable (10) according to the present invention. The cable (10) comprises a central conductor (1) which is composed of several individual wires (9) and electrically insulated by a central conductor insulation layer (2). The central conductor (1) is positioned in a way that its axis and the axis of the cable (10) approximately coincide. The cable (10) further comprises a stripping tube (8) and cylinder-shaped fillers (7). The cable (10) further comprises several, in the shown embodiment six, non-central conductors (1'), each of which is electrically insulated by a non-central conductor insulation layer (2'). An electromagnetic shielding (5) encloses the aforementioned components. A first polymeric sheath (6) encloses the electromagnetic shielding (5). On top of the first polymeric sheath (6), a reinforcing layer (3) encloses and protects the aforementioned components. A second polymeric sheath (4) is the outermost layer of the cable (10).

List of reference signs

[0029]

- | | |
|----|--|
| 1 | Central conductor |
| 2 | Central conductor insulation layer |
| 1' | Non-central conductor |
| 2' | Non-central conductor insulation layer |
| 3 | Reinforcing layer |
| 4 | Second polymeric sheath |
| 5 | Electromagnetic shielding |
| 6 | First polymeric sheath |
| 7 | Filler |
| 8 | Stripping tube |
| 9 | Wire |
| 10 | Cable |

Claims

1. A top-drive power cable (10) for use on a drilling rig, comprising:

a central conductor (1);

- a central conductor insulation layer (2) enclosing said central conductor (1);
electromagnetic shielding (5) enclosing said central conductor (1) and said central conductor insulation layer (2) ;
a first polymeric sheath (6) surrounding said electromagnetic shielding (5);
a reinforcing layer (3);
a second polymeric sheath (4) surrounding said reinforcing layer (3),
characterized in that the reinforcing layer (3) is made of a densely packed braid covering between 95% and 100% of the surface of the first polymeric sheath (6).
2. A top-drive power cable (10) according to claim 1, wherein the reinforcing layer (3) comprises aramid fibres.
 3. A top-drive power cable (10) according to claim 1 or 2, wherein the reinforcing layer (3) is not chemically bonded to the first and/or second polymeric sheath (4, 6).
 4. A top-drive power cable (10) according to one or more of the preceding claims, wherein said central conductor (1) is a bunched type conductor.
 5. A top-drive power cable (10) according to one or more of the preceding claims, further comprising at least one non-central conductor (1').
 6. A top-drive power cable (10) according to claim 4 or 5, wherein the cable comprises at least three, preferably at least six, non-central conductors (1').
 7. A top-drive power cable (10) according to claims 4, 5 or 6, wherein the central conductor (1) is positioned centrally with respect to the cable (10) axis with the non-central conductors (1') being positioned in a symmetrical arrangement around said central conductor (1).
 8. A top-drive power cable (10) according to claim 7, wherein said central conductor (1) and/or said non-central conductors (1') comprise copper and/or aluminium and/or zinc and/or a conductive polymer.
 9. A top-drive power cable (10) according to one or more of the preceding claims, comprising a tape layer positioned between said reinforcing layer (3) and said second polymeric sheath (4).
 10. A top-drive power cable (10) according to one or more of the preceding claims, wherein said first polymeric sheath (6) and said second polymeric sheath (4) are differently coloured.
 11. A top-drive power cable (10) according to one or more of the preceding claims, wherein said second polymeric sheath (4) comprises an antistatic additive.
 12. A top-drive power cable (10) according to one or more of the preceding claims, further comprising a stripping tube (8).
 13. A top-drive power cable (10) according to claim 12, wherein the stripping tube (8) is located within the electromagnetic shielding (5).
 14. A top-drive power cable (10) according to claim 12 or 13, wherein the stripping tube (8) comprises a polymeric material.
- Amended claims in accordance with Rule 137(2) EPC.**
1. A top-drive power cable (10) for use on a drilling rig, comprising:
a central conductor (1);
a central conductor insulation layer (2) enclosing said central conductor (1);
electromagnetic shielding (5) enclosing said central conductor (1) and said central conductor insulation layer (2) ;
a first polymeric sheath (6) surrounding said electromagnetic shielding (5);
a reinforcing layer (3) surrounding said polymeric sheath (6);
a second polymeric sheath (4) surrounding said reinforcing layer (3),
characterized in that the reinforcing layer (3) is made of a densely packed braid covering between 95% and 100% of the surface of the first polymeric sheath (6).
 2. A top-drive power cable (10) according to claim 1, wherein the reinforcing layer (3) comprises aramid fibres.
 3. A top-drive power cable (10) according to claim 1 or 2, wherein the reinforcing layer (3) is not chemically bonded to the first and/or second polymeric sheath (4, 6).
 4. A top-drive power cable (10) according to one or more of the preceding claims, wherein said central conductor (1) is a bunched type conductor.
 5. A top-drive power cable (10) according to one or more of the preceding claims, further comprising at least one non-central conductor (1').

6. A top-drive power cable (10) according to claim 4 or 5, wherein the cable comprises at least three, preferably at least six, non-central conductors (1').
7. A top-drive power cable (10) according to claims 4, 5 or 6, wherein the central conductor (1) is positioned centrally with respect to the cable (10) axis with the non-central conductors (1') being positioned in a symmetrical arrangement around said central conductor (1). 5 10
8. A top-drive power cable (10) according to claim 7, wherein said central conductor (1) and/or said non-central conductors (1') comprise copper and/or aluminium and/or zinc and/or a conductive polymer. 15
9. A top-drive power cable (10) according to one or more of the preceding claims, comprising a tape layer positioned between said reinforcing layer (3) and said second polymeric sheath (4). 20
10. A top-drive power cable (10) according to one or more of the preceding claims, wherein said first polymeric sheath (6) and said second polymeric sheath (4) are differently coloured. 25
11. A top-drive power cable (10) according to one or more of the preceding claims, wherein said second polymeric sheath (4) comprises an antistatic additive. 30
12. A top-drive power cable (10) according to one or more of the preceding claims, further comprising a stripping tube (8). 35
13. A top-drive power cable (10) according to claim 12, wherein the stripping tube (8) is located within the electromagnetic shielding (5).
14. A top-drive power cable (10) according to claim 12 or 13, wherein the stripping tube (8) comprises a polymeric material. 40

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FIGURE 1

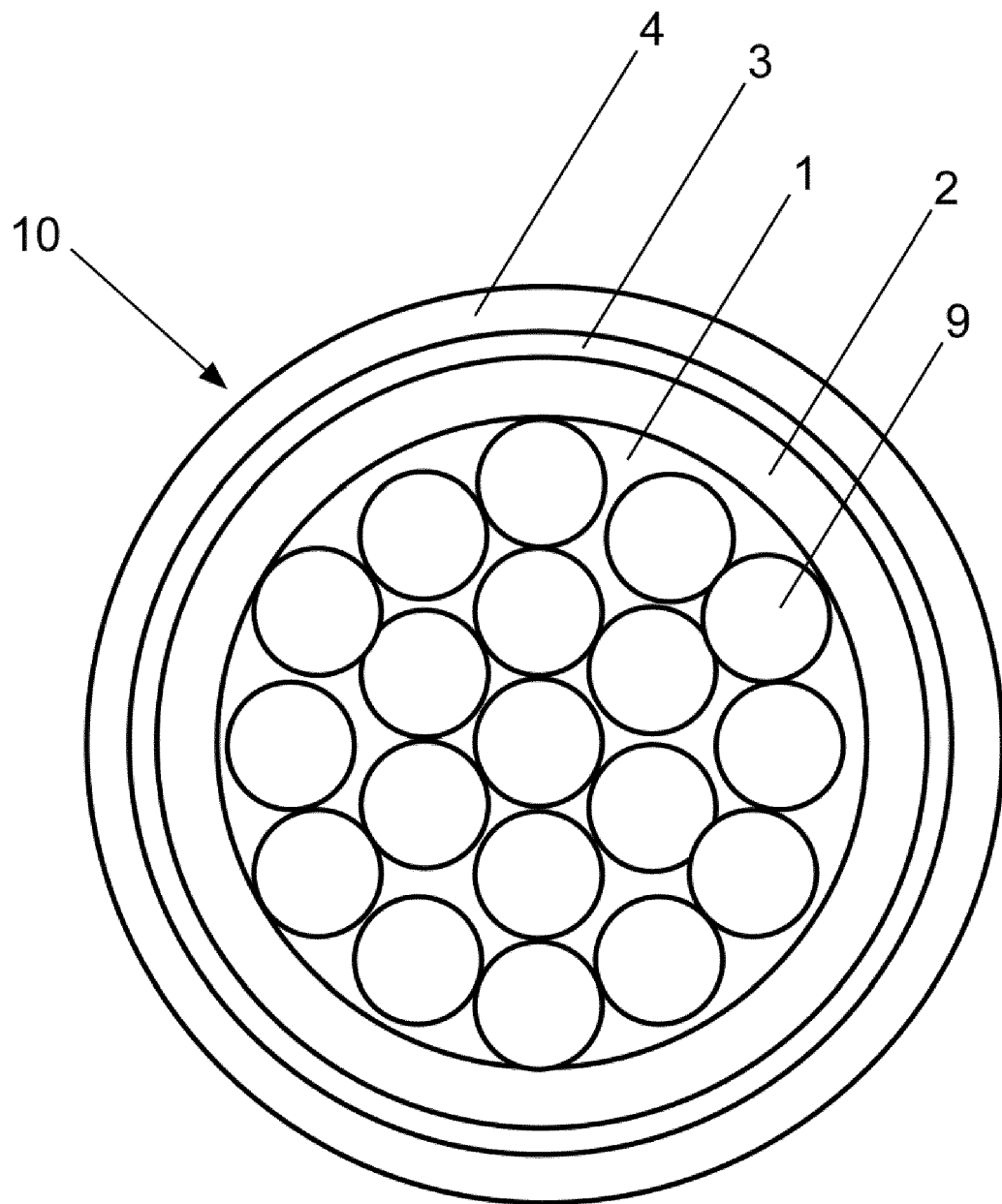


FIGURE 2

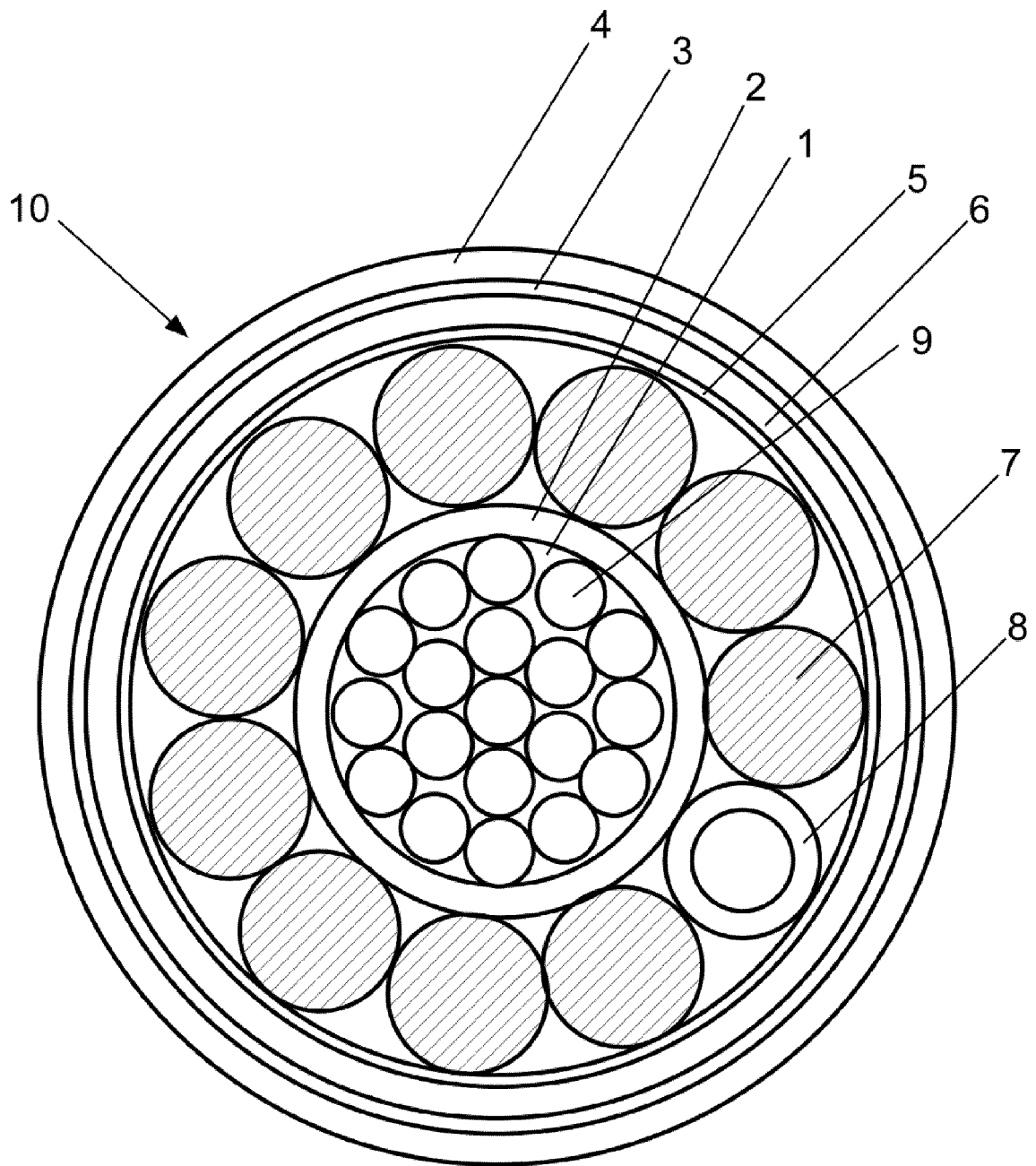


FIGURE 3

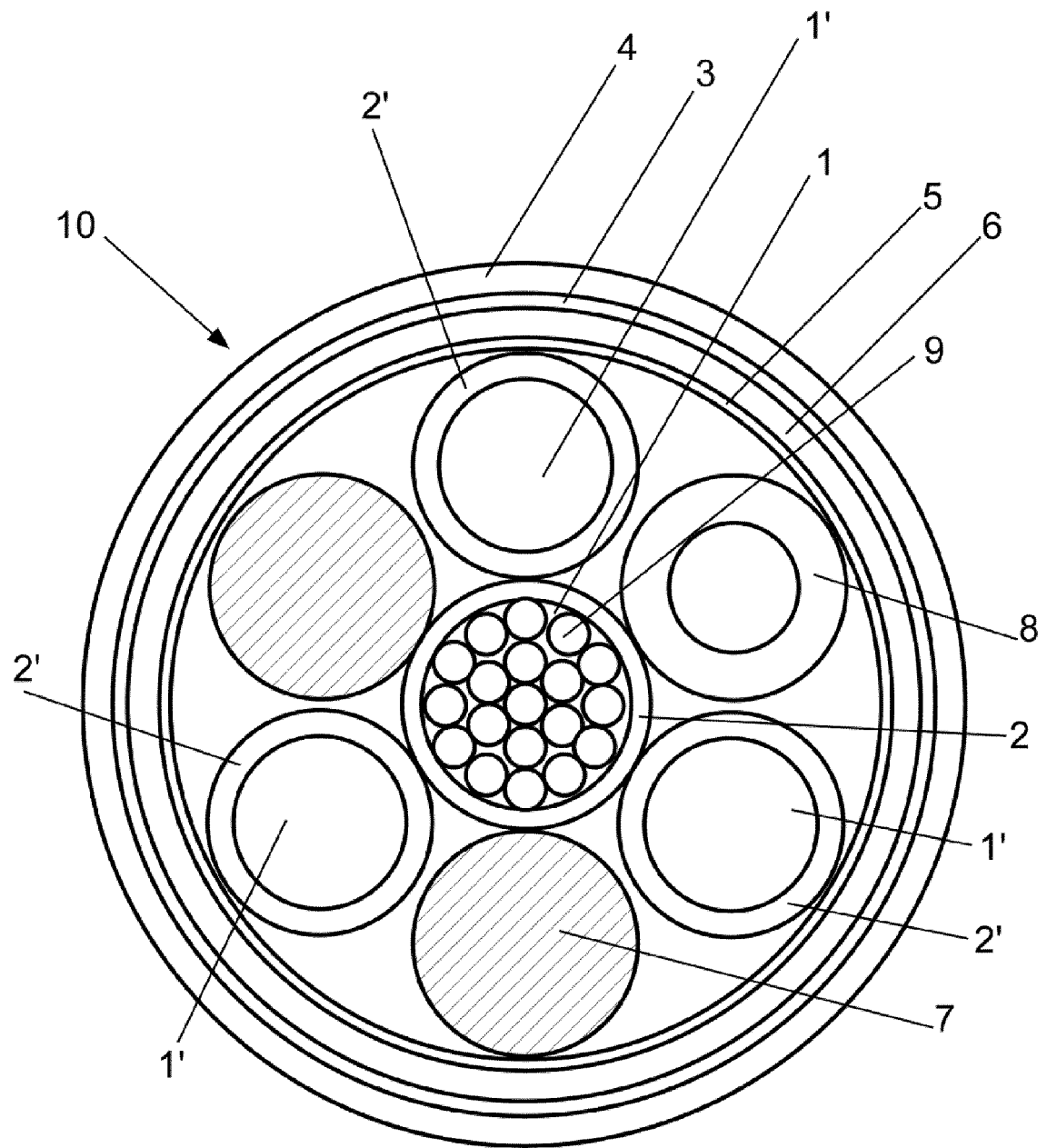
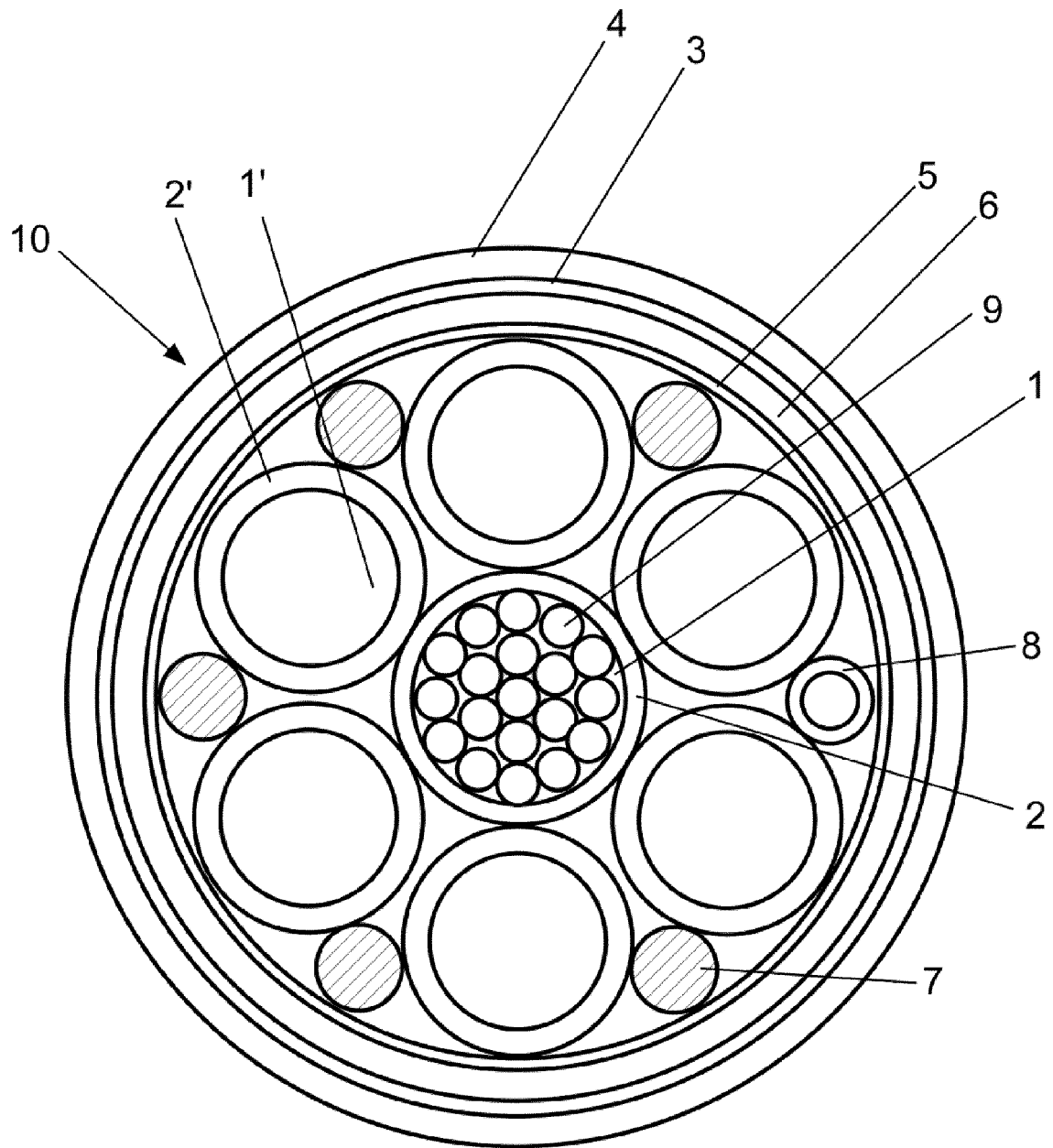


FIGURE 4





EUROPEAN SEARCH REPORT

Application Number
EP 15 16 9612

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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	WO 2011/140034 A2 (DRAKA HOLDING N V [NL]; BODZIONY MATTHEW [US]; CONSTANTINE WALTER [US]) 10 November 2011 (2011-11-10) * paragraph [0023] - paragraph [0025]; figure 1 *	1	INV. H01B7/04
A	US 5 475 185 A (TOKARSKY EDWARD W [US]) 12 December 1995 (1995-12-12) * column 2, line 65 - column 3, line 3; figure 1 *	1	
A	US 2005/150678 A1 (TAKASE KOUJI [JP] ET AL) 14 July 2005 (2005-07-14) * abstract *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 29 September 2015	Examiner Salm, Robert
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 03/02 (P04C01)

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

EP 15 16 9612

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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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29-09-2015

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