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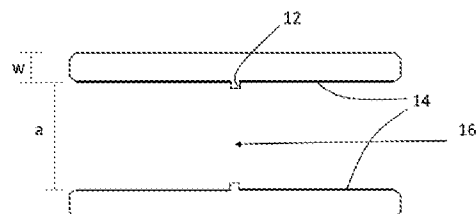
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(54) Title TENSION AND CONTINUITY JOINT FOR POWER CABLE

(57) Abstract

Disclosed is a compression ferrule with a longitudinal aperture for a high voltage power cable, wherein the compression ferrule has a radial wall thickness equivalent to 10-50% of the diameter of the aperture. A power cable comprising a joint, wherein a first conductor end is electrically and mechanically connected to a second conductor end with the compression ferrule is also disclosed.



Tension and continuity joint for power cable

5 The present invention relates to a compression ferrule for a tension and continuity joint for a conductor of a power cable. Especially, a power cable with a conductor joint with such a ferrule.

Background

10 The common solutions which use a ferrule is intended for land use and/or overhead lines. When using a ferrule on overhead lines this is for the conductor only, not combined with an insulation layer as the insulation is the air. Subsea power cables require insulation, such as cross-linked polyethylene XLPE. It must therefore be possible to insulate the cable joints.

15 For underground cables – there are limited requirements to mechanical tension properties. These limited requirements are ensured by relying on armour. A conductor joint by welding has reduced mechanical properties compared to the unwelded conductor and is often not sufficiently strong for subsea applications.

A joint on a subsea cable, especially for power cables without armour, will need to be able to withhold the mechanical tension similar as the force set up when the conductor in the subsea cable is approaching its yield strength and limit.

20 Power cables for direct electrical heating (DEH) cannot include metallic/conducting armour external of the conductor as this would have a negative effect on the function of the cable when it is arranged on a pipeline to providing heating of said pipeline. For DEH cables there is a particular need to provide a conductor joint which has a tensional strength and electrical conductivity similar to the conductor.

25

Prior art

30 DE1072671 discloses a compression sleeve comprising two concentric layers, where the inner layer provides the electrical connection and the outer layer the tensional strength. The sleeve is compressed with a tool not providing a circular circumference but a circumference with two circle sections and two extending flanges.

Objectives of the invention

The objective of the present invention is to be able to joint/splice a subsea cable such that the jointed cable has high mechanical tension properties without necessarily using external armour.

- 5 It is the objection to provide a joint that can be made both offshore also during repair and in a factory.

10 In a first aspect the present invention provides a compression ferrule with a longitudinal aperture for a high voltage power cable, wherein the compression ferrule has a radial wall thickness equivalent to 10-50% of the diameter of the aperture, preferably 15-30%, more preferably 20-25%. The increased wall thickness of the ferrule provides for both the required electrical conductivity and the tensional strength of the joint when the ferrule is compressed to form a joint between two conductor ends.

15 A typical high voltage power cable conductor has a cross-sectional area of 240,300,400,500,630,800,1000,1200,1400,1600,1800, or 2000 mm². Typical conductor cross sections for DEH cables are 630, 800, 1000, 1200, 1400 or 1600 mm². The ferrule can be designed with an aperture adapted to receive any one of such conductors. The ferrule is to be designed such that the aperture is adapted to have a diameter that exceeds the diameter of the conductor to be connected only
20 enough to allow for the conductor to be inserted into the aperture. In this way the diameter of the aperture is adapted to be 0.2 – 5 mm larger than diameter of the conductor to be inserted into it, preferably 1-3 mm, more preferably 1-2 mm.

High voltage refers to voltages of above 1000 V.

25 In one embodiment the compression ferrule can asymmetric with different aperture diameters at opposite sides, such that conductors of different cross-sectional diameter can be connected with the compression ferrule. When the compression ferrule is asymmetric the radial wall thickness on a first side is equivalent to 10-50% of the diameter of the aperture on the first side, preferably 15-30%, more preferably 20-25%. Similarly, the radial wall thickness on a second side is
30 equivalent to 10-50% of the diameter of the aperture on the second side, preferably 15-30%, more preferably 20-25%.

35 In one embodiment of the compression ferrule according to the first aspect an internal surface of the wall of the ferrule is provided with corrugations such as threads. The corrugations serve to further improve the tensile strength of the connection between the ferrule and a conductor end and the electrical connection therebetween.

In a further embodiment the compression ferrule comprises an internal flange in proximity of the longitudinal centre of the ferrule. The flange extends into the aperture and assists the arrangement of the ferrule centrally between two conductor ends introduced into the aperture from opposite sides.

- 5 In another embodiment the compression ferrule according to the present invention comprises at least two compression zones that can be compressed respectively onto a first conductor end and a second conductor end inserted into the aperture of the compression ferrule from opposite sides, such that the first conductor end is electrically and mechanically connected to the second conductor end with the
10 compression ferrule. The compression ferrule may comprise more than two, such as four, six or eight compression zones. The compression zones are sections in the longitudinal direction of the compression ferrule that will be compressed when the ferrule is installed. The compression zones are separated by sections that will not be compressed when the ferrule is installed.

- 15 The compression ferrule can be made of copper or a copper alloy.

- The present invention further provides a power cable comprising a joint, wherein a first conductor end is electrically and mechanically connected to a second conductor end with a compression ferrule, wherein the compression ferrule has a longitudinal aperture and a wall thickness equivalent to 10-50% of the diameter of the aperture,
20 preferably 15-30%, more preferably 20-25% prior to compression.

In one embodiment of the power cable the compression ferrule comprises at least two compression zones that have been compressed respectively onto the first conductor end and the second conductor end inserted into the aperture of the compression ferrule from opposite sides.

- 25 In a further embodiment of the power cable the compression ferrule comprises four or six compression zones that have been compressed.

- In yet another embodiment of the power cable one or more of the compression zones that have been compressed have a polygonal shaped radial circumference, preferably a hexagonal or octagonal shaped radial circumference. The polygonal
30 shaped compression provides increased joining strength. Preferably all compression zones are compressed to have similar polygonal circumference.

In a further embodiment of the power cable the first conductor end and the second conductor end have different diameters.

- 35 The method of joining a power cable with a compression ferrule according to the present invention comprises providing the two power cable end sections with conductor end sections not comprising any other layers such as semi-conducting or insulating layers. Inserting the conductor ends into the ferrule from opposite sides.

Compressing the ferrule onto a first conductor end and compressing the ferrule onto a second conductor end. If the ferrule comprises additional compression zones additional compression of the ferrule is performed, preferably the first compressions are preformed closest to the centre of the ferrule and alternating between the two conductor ends.

The term “ferrule” as applied here refers to a sleeve element with a throughgoing longitudinal aperture.

Brief description of the drawings

The present invention will be discussed in further detail with reference to the enclosed drawings, that are provided as illustrations of embodiments thereof.

Figure 1a shows a side view of a ferrule according to the present invention prior to installation.

Figure 1b illustrates the longitudinal cross-sectional view along A-A of figure 1a.

Figure 2 illustrates the circumference of a compression zone prior to compression.

Figure 3 illustrates the circumference of a compression zone after to compression with a circular compression tool.

Figure 4 illustrates the circumference of a compression zone after to compression with a hexagonal compression tool.

Figure 5 illustrates the circumference of a compression zone after to compression with an octagonal compression tool.

Figure 6 illustrates an embodiment of a compression ferrule according to the invention joining two cables.

Figure 7 illustrates a power cable with a conductor prior to joining.

Figure 8 illustrates a further embodiment of the ferrule.

Principal description of the invention

Figure 1a and 1b show respectively aside view and a cross sectional view of a ferrule 10 according to the present invention. On figure 1a the compression zones 20 are marked up. The marking is made to assist the installation of the ferrule and the application of the compression force in the intended areas. The placement of the compression zones can also be measured out when there are not marked up on the

ferrule. The marking of the compression zones can as in the illustrated embodiment be done by surface alterations but other alternatives such as colour markings or markings with tape or similar temporarily or permanently added material. In the illustrated embodiment two compression zones are arranged on either side of the ferrule for compression onto a conductor end to be inserted on either side thereof.

Additional features of the ferrule 10 are illustrated in the cross-sectional view in figure 1b. The ferrule has a longitudinal aperture 16 with a diameter "a". The wall thickness is w. The internal surface 14 of the wall of the ferrule may comprise corrugations such as threads or small ribs that serve to increase the strength of the connection between the compressed ferrule and the conductor end.

Figure 2 illustrates the circumference of a compression zone prior to compression. The figures 3, 4, and 5 illustrate the circumference of a compression zone after compression with respectively a circular, hexagonal or octagonal compression tool. The compression tool has compressed substantially the full circumference of the compression zone such that any surplus material is moved sideways into the zones not dedicated as compression zones.

Figure 6 is a picture of a power cable with conductors connected with a compression ferrule 10 according to the present invention. The first power cable 30 is connected to the second power cable 30'. Figure 7 illustrate the end of a power cable prior to connection to the ferrule. The power cable 30 comprises a central conductor 33, in the end section to be inserted into the aperture of the ferrule the layers surrounding the conductor has been removed. These layers comprise an inner semi-conducting layer 32, surrounded by an insulation layer 34 and an outer semi-conducting layer 36. In the picture in figure 6 the free conductor end of each cable 30,30' has been inserted into the aperture of the ferrule 10 from opposite sides and six compression zones, three around each conductor end has been compressed with a hexagonal compression tool. In the illustrated embodiment the rebuilding of the semi-conducting and insulating layers around the joint has started.

Figure 8 illustrates an asymmetric ferrule 110 with four compression zones 120. The ferrule is for joining two conductors of different cross-section and diameter in that the aperture on the left side is larger than the aperture on the right side, and each adapted to have a diameter that exceeds the diameter of the conductor to be connected only enough to allow for the conductor to be inserted into the aperture.

CLAIMS

1. Compression ferrule (10) with a longitudinal aperture for a high voltage power cable, **characterised in that** the compression ferrule has a radial wall thickness (w) equivalent to 10-50% of the diameter (a) of the aperture, preferably 15-30%, more preferably 20-25%.
2. Compression ferrule according to claim 1, wherein an internal surface (14) of the wall is provided with corrugations such as threads.
3. Compression ferrule according to claim 1 or 2, wherein the ferrule comprises an internal flange (12) in proximity of the longitudinal centre of the ferrule.
4. Compression ferrule according to any one of the proceeding claims, wherein the compression ferrule comprises at least two compression zones (20) that can be compressed respectively onto a first conductor end and a second conductor end inserted into the aperture of the compression ferrule from opposite sides, such that the first conductor end is electrically and mechanically connected to the second conductor end with the compression ferrule.
5. Compression ferrule according to claim 4, wherein the compression ferrule comprises four or six compression zones (20).
6. Compression ferrule according to any one of the proceeding claims, wherein the compression ferrule is made of copper or a copper alloy.
7. Compression ferrule according to any one of the proceeding claims, wherein the compression ferrule (110) is asymmetric with different aperture diameters (a) at opposite sides.
8. Power cable comprising a joint, wherein a first conductor end is electrically and mechanically connected to a second conductor end with a compression ferrule, **characterised in that** the compression ferrule has a longitudinal aperture and a wall thickness (w) equivalent to 10-50% of the diameter (a) of the aperture, preferably 15-30%, more preferably 20-25% prior to compression.
9. Power cable according to claim 8, wherein the compression ferrule comprises at least two compression zones (22) that have been compressed respectively onto the first conductor end and the second conductor end inserted into the aperture of the compression ferrule from opposite sides.
10. Power cable according to claim 9, wherein the compression ferrule comprises four or six compression zones that have been compressed.

11. Power cable according any one of the claims 8-10, wherein one or more of the compression zones (22) that have been compressed have a polygonal shaped radial circumference, preferably a hexagonal or octagonal shaped radial circumference.
- 5 12. Power cable according any one of the claims 8-11, wherein the first conductor end and the second conductor end have different diameters.

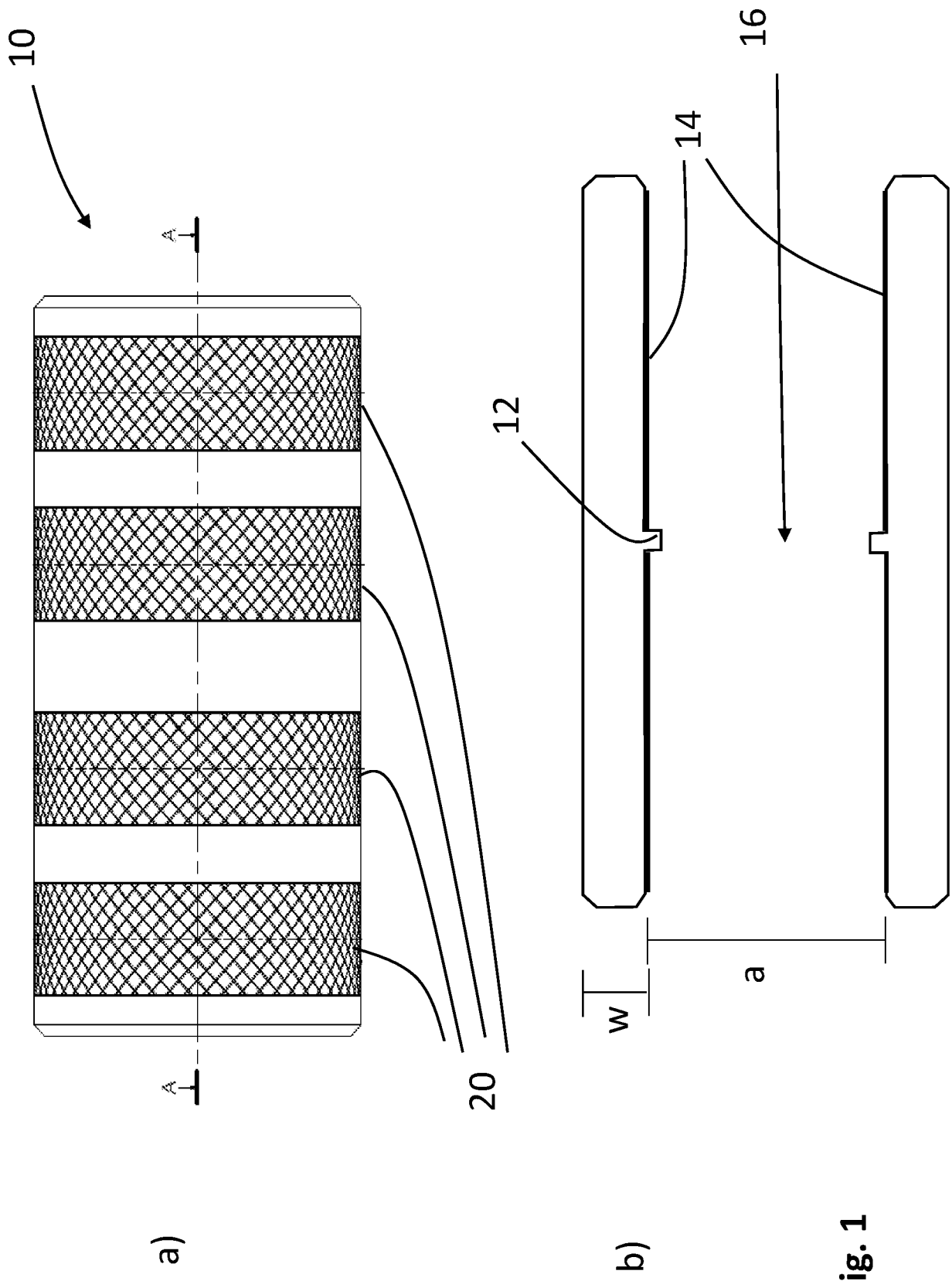


Fig. 1

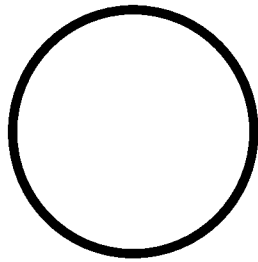


Fig. 2

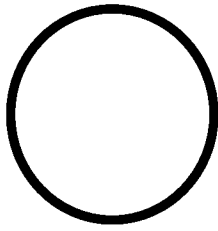


Fig. 3

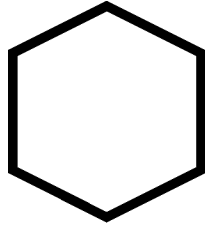


Fig. 4

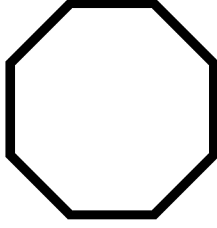


Fig. 5

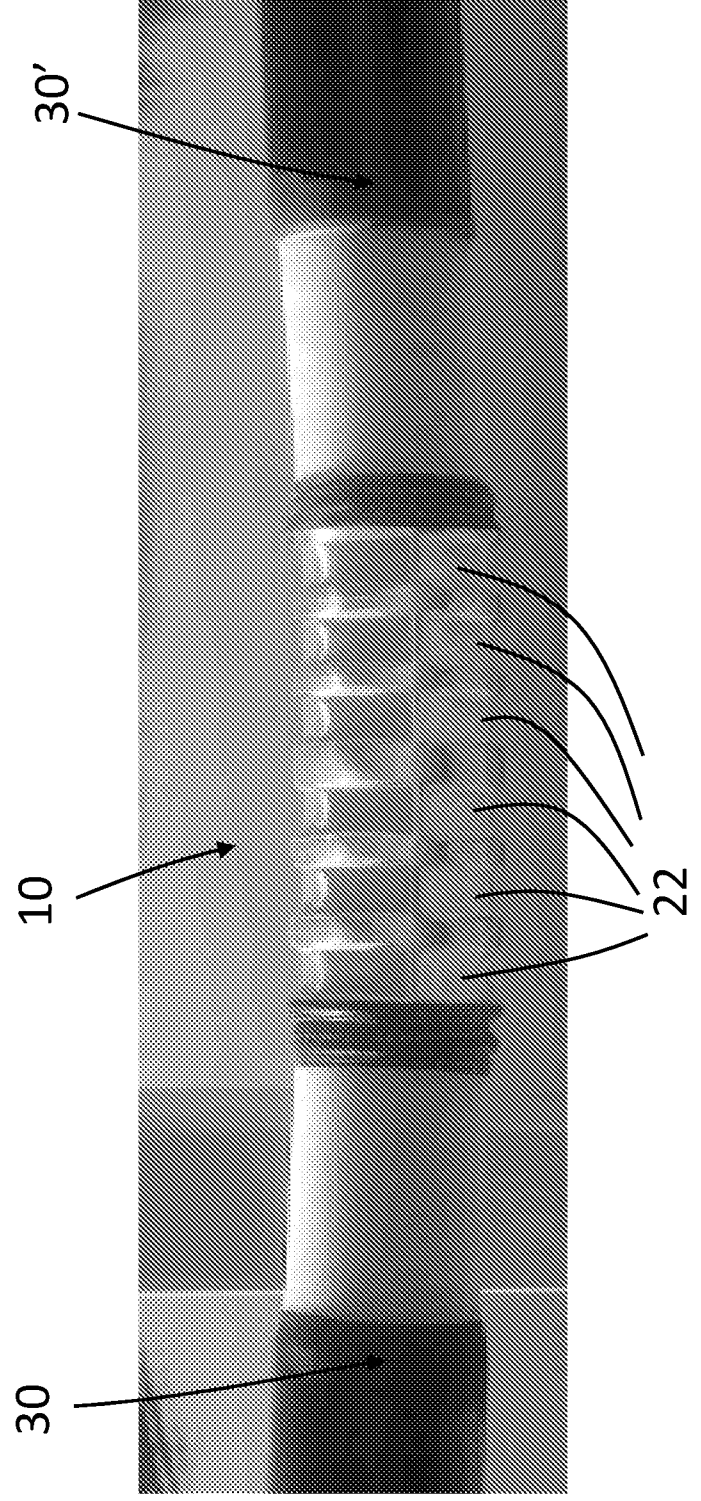


Fig. 6

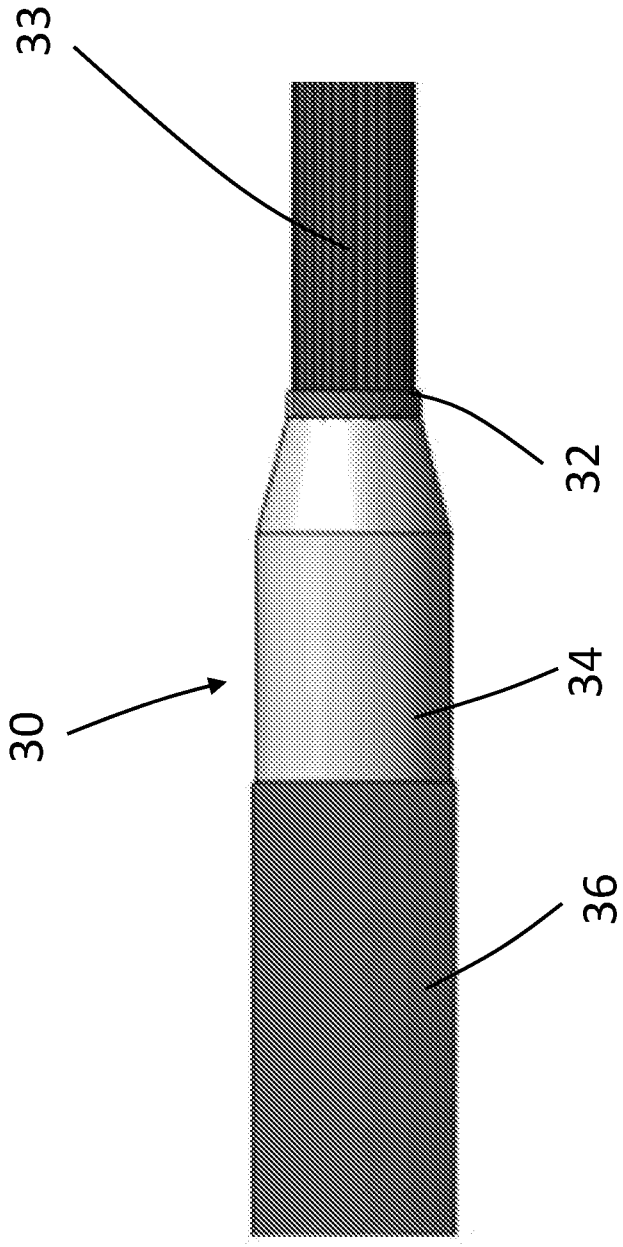


Fig. 7

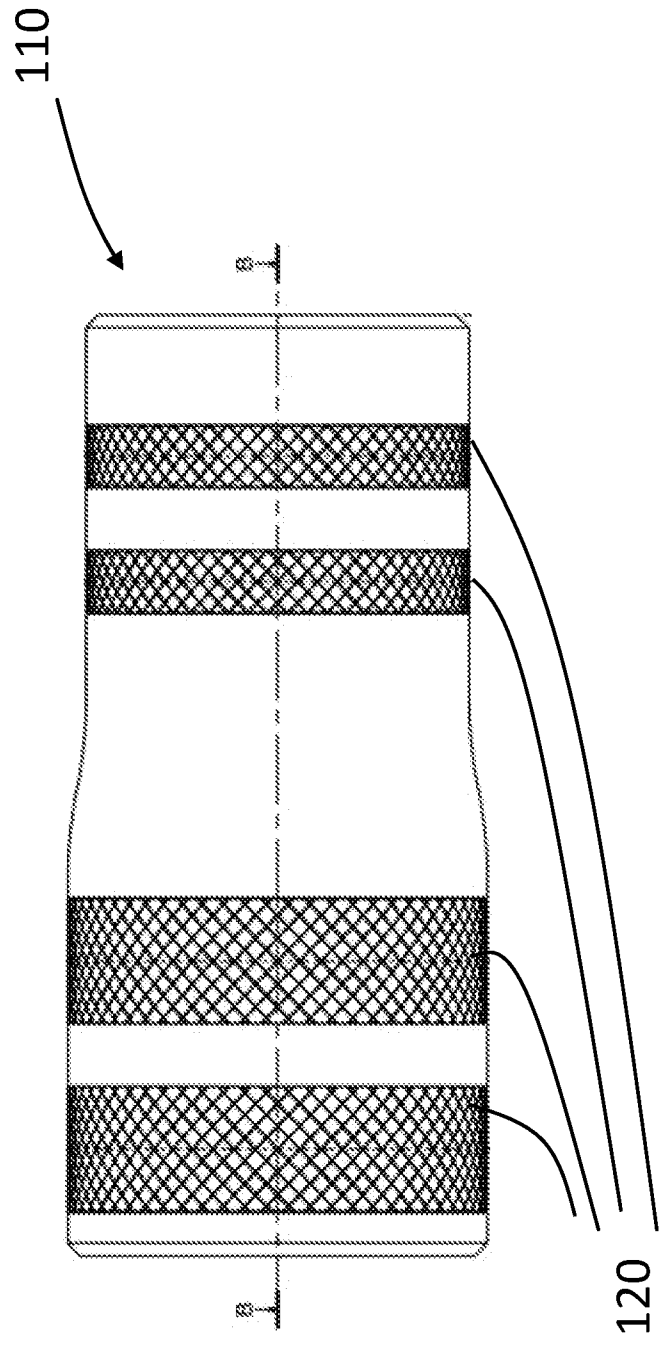


Fig. 8