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(54) DYNAMIC SUBMARINE CABLE AND FORMING METHOD FOR DYNAMIC SUBMARINE CABLE

(57) The invention provides a dynamic submarine cable and a forming method for the dynamic submarine cable. The dynamic submarine cable includes an optical unit and a plurality of cable cores, where an inner sheath, an armor layer and an outer sheath are sequentially arranged around the optical unit and the plurality of cable cores from inside to outside; and the plurality of the cable cores form a triangular structure, adjacent two cable cores make contact with each other in an abutting manner, each cable core includes an aluminum alloy conductor unit, a conductor shielding layer, an insulating layer and an insulating shielding layer which are sequentially arranged from inside to outside, the aluminum alloy conductor unit includes a plurality of conductor layers and a water blocking glue arranged between two adjacent conductor layers, and each conductor layer includes a plurality of conductor single wires. According to the technical solution of the invention, the dynamic submarine cable has better water blocking performance and fatigue performance, such that the service life of the dynamic submarine cable is prolonged.

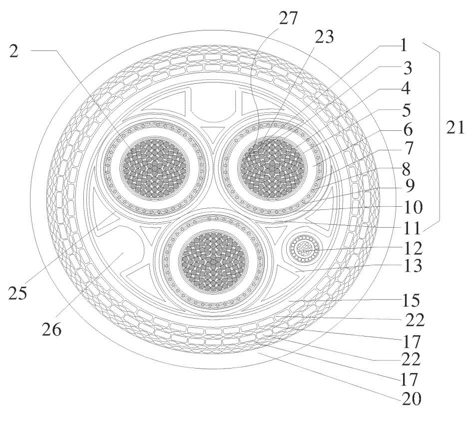

Fig. 1

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Description

Cross-Reference to Related Application

[0001] The invention claims the priority of Chinese Patent Application No. 202210761675.2, filed with the Chinese Patent Office on June 30, 2022 and entitled "Dynamic submarine cable, and forming method for dynamic submarine cable".

Technical Field

[0002] The invention relates to a technical field of submarine cables, and particularly relates to a dynamic submarine cable, and a forming method for a dynamic submarine cable.

Background

[0003] In recent years, as the development of low carbon, sea areas deeper than 50 m in China contain more than 1268 GW of wind energy reserves, accounting for 60% or more of the entire offshore wind energy. It is difficult to install fixed-pile wind turbines in these sea areas. In order to satisfy a huge demand for clean energy in the economically developed coastal provinces of China, floating wind power has become the best way to develop wind power in China in the future. Most of the international oceanic countries, continental slopes extend dramatically into the deep sea. In order to obtain better wind resources, the use depth of a dynamic cable often reaches 1,000 m with large-capacity transmission, and the unit weight and size of a dynamic cable are becoming increasingly large.

[0004] At present, with the development of floating wind power, a dynamic submarine photoelectric composite cable that connects a floating structure and underwater apparatus has the problem of poor water blocking performance and fatigue performance at a large water depth, which leads to the low service life of the dynamic submarine cable.

Summary

[0005] A main objective of the invention is to provide a dynamic submarine cable and a forming method for a dynamic submarine cable, to solve the problem that the service life of the dynamic submarine cable in a prior art is relatively short due to poor water blocking performance and fatigue performance at a large water depth.

[0006] In order to achieve the above objective, according to an aspect of the invention, a dynamic submarine cable is provided, including an optical unit and a plurality of cable cores, where an inner sheath, an armor layer and an outer sheath are sequentially arranged around the optical unit and the plurality of cable cores from inside to outside; and the plurality of the cable cores form a triangular structure, adjacent two cable cores make contact with each other in an abutting manner, each cable core includes an aluminum alloy conductor unit, a conductor shielding layer, an insulating layer and an insulating shielding layer which are sequentially arranged from inside to outside, the aluminum alloy conductor unit includes a plurality of conductor layers and a water blocking glue arranged between two adjacent conductor layers, and each conductor layer includes a plurality of conductor single wires.

[0007] Further, each of the conductor single wires is an aluminum alloy single wire, the each of the conductor single wires has strength of 305 Mpa-330 Mpa, and the each of the conductor single wire is annealed.

[0008] Further, a pitch of the each conductor layerand an outer diameter of the each conductor layer satisfy the following condition: $10\ D_A \leq h \leq 16\ D_A$; where D_A is the outer diameter of the each conductor layer, and h is the pitch of the each conductor layer.

[0009] Further, the plurality of conductor single wires are stranded into the aluminum alloy conductor unit in a non-compacted stranding manner, the each conductor layer includes 6n conductor single wires, and the each conductor layer has an outer diameter D_A _ (2n + 1) d, where n is the number of the conductor layers, and d is a diameter of the conductor single wires.

[0010] Further, the cable core further includes a metal shielding layer, arranged at a periphery of the insulating shielding layer, and the metal shielding layer includes two copper tapes spaced in a radial direction and a semiconductive water-blocking tape arranged between the two copper tapes.

[0011] Further, the dynamic submarine cable further includes at least one filling structure, the at least one filling structure is arranged between two adjacent cable cores, a first side of each filling structure is provided with a contact surface fitted to an outer wall surface of the cable core, and a second side of the each filling structure is provided with an accommodating groove for accommodating the optical unit.

[0012] Further, three cable cores and three filling structures are provided, the each filling structure is provided with the plurality of accommodating grooves, and each accommodating groove is provided with the optical unit.

[0013] Further, the armor layer is made of stranded flat steel wires, a plurality of armor layer are provided, and stranded directions of flat steel wires of adjacent two armor layers are opposite.

[0014] Further, a periphery of the armour layer is coated with bitumen or bituminous paint; or, a polypropylene (PP) rope is wrapped around a periphery of the armor layer.

[0015] Further, the cable core further includes a first semiconductive buffer tape and a second semiconductive buffer tape, the first semiconductive buffer tape is located inside the metal shielding layer, and the second semiconductive buffer tape is located outside the metal shielding layer.

[0016] According to an aspect of the invention, a forming method for a dynamic submarine cable is provided, including: preparing a cable core, where the cable core includes an aluminum alloy conductor unit, a conductor shielding layer, an insulating layer and an insulating shielding layer which are sequentially arranged from inside to outside, the aluminum alloy conductor unit includes a plurality of conductor layers and a water blocking glue arranged between two adjacent conductor layers, and each conductor layer includes a plurality of conductor single wires; arranging a plurality of cable cores to form a triangular structure; performing a process for preparing an optical unit; and sequentially arranging an inner sheath, an armor layer and an outer sheath from inside to outside around the optical unit and the plurality of cable cores.

[0017] Further, the preparing a cable core further includes: performing a plurality-of-conductor-layer forming step for forming the plurality of conductor layer by stranding the plurality of conductor single wires in a non-compacted concentric stranding manner; and pressing a conductor layer located at an outermost layer.

[0018] Further, the forming method further includes coating a periphery of the armor layer with bitumen or bituminous paint on, and/or the forming method further includes wrapping a PP rope around a periphery of the armor layer.

[0019] According to the technical solution of the invention, an aluminum alloy water-blocking conductor has a circular non-compacted design, which can relieve the plastic hardening problem of an aluminum alloy structure, and prolong fatigue service life of the aluminum alloy conductor. Arranging the water blocking glue between two adjacent conductor layers can make aluminum alloy conductor units form a compact entity. The water blocking glue can improve water-blocking performance of gaps between the plurality of conductor single wires. Moreover, when subjected to bending-tensile loads, the water blocking glue can also relieve frictional stress and damage between adjacent conductor single wires, such that service life of the dynamic submarine cable can be prolonged at a large water depth. Furthermore, the conductor shielding layer, the insulating layer and the insulating shielding layer form a three-layer co-extrusion structure. The conductor shielding layer can reduce local electric field concentration caused by uneven surfaces formed by stranding of the aluminum alloy conductor units, such that uniform electric field distribution on the surfaces of the aluminum alloy conductor units is guaranteed. The insulating layer can achieve insulating. The insulating shielding layer is configured to shield an electric field, that is, by arranging the insulating shielding layer, no distribution of electric lines are distributed outside the insulating shielding layer, such that an air gap between the inside and the outside of the insulating shielding layer can be avoided, and then an influence of insulation strength on the dynamic submarine cable can be reduced.

Brief Description of the Drawings

[0020] The accompanying drawings of the specification forming a part of the invention serve to provide a further understanding of the invention, and the illustrative examples of the invention and the description of the illustrative examples serve to explain the invention and are not to be construed as unduly limiting the invention. In the drawings:

Fig. 1 is a schematic structural diagram of an embodiment of a dynamic submarine cable according to the invention;
Fig. 2 is a schematic structural diagram of an aluminum alloy conductor unit of the dynamic submarine cable in Fig. 1;
Fig. 3 is a side view of a metal shielding layer of the dynamic submarine cable in Fig. 1; and
Fig. 4 is a flowchart of a forming method for a dynamic submarine cable according to the invention.

[0021] The above-mentioned figures include the following reference numerals:
1, conductor single wire; 2, water blocking glue; 3, water blocking tape; 4, semiconductive binding tape; 5, conductor shielding layer; 6, insulating layer; 7, insulating shielding layer; 8, first semiconductive buffer tape; 9, metal shielding layer; 91, copper tape; 92, semiconductive water-blocking tape; 10, second semiconductive buffer tape; 11, anti-corrosion layer; 12, optical unit; 13, filling structure; 15, inner sheath; 17, PP rope; 20, outer sheath; 21, cable core; 22, armor layer; 23, conductor layer; 25, contact surface; 26, accommodating groove; and 27, aluminum alloy conductor unit.

Detailed Description of the Embodiments

[0022] It should be noted that the examples in the invention and features in the examples can be combined without conflicts. The invention will be described below with reference to the drawings and in combination with the examples in detail.

[0023] As shown in Figs. 1-3, the embodiment of the invention provides a dynamic submarine cable. The dynamic submarine cable includes an optical unit 12 and a plurality of cable cores 21. An inner sheath 15, an armor layer 22 and an outer sheath 20 are sequentially arranged around the optical unit 12 and the plurality of cable cores 21 from inside to outside. The plurality of the cable cores 21 form a triangular structure, adjacent two cable cores 21 make contact with each other in an abutting manner, each cable core 21 includes an aluminum alloy conductor unit 27, a conductor shielding layer 5, an insulating layer 6 and an insulating shielding layer 7 which are sequentially arranged from inside to outside, the aluminum alloy conductor unit 27 includes a plurality of conductor layers 23 and a water blocking glue 2 arranged between two adjacent conductor layers 23, and each conductor layer 23 includes a plurality of conductor single wires 1.

[0024] In the technical solution, three cable cores 21 are provided, any two adjacent cable cores 21 make contact with each other in an abutting manner, to form a triangular structure. The optical unit 12 and the three cable cores 21 are spaced. Arranging the water blocking glue 2 between two adjacent conductor layers 23 can make aluminum alloy conductor units 27 form a compact entity. The water blocking glue 2 is able to improve water-blocking performance of gaps between the plurality of conductor single wires 1. Moreover, when subjected to bending-tensile loads, the water blocking glue 2 can also relieve frictional stress and damage between adjacent conductor single wires 1, such that service life of the dynamic submarine cable can be prolonged at a large water depth. Furthermore, the conductor shielding layer 5, the insulating layer 6 and the insulating shielding layer 7 form a three-layer co-extrusion structure. Stranding of the aluminum alloy conductor unit 27 may form uneven surfaces, which may lead to local electric field concentration, and the conductor shielding layer 5 can reduce the local electric field concentration on the aluminum alloy conductor unit 27, such that uniform electric field distribution on the surface of the aluminum alloy conductor unit 27 is guaranteed. The insulating layer 6 can achieve insulating. The insulating shielding layer 7 is configured to shield an electric field, that is, by arranging the insulating shielding layer 7, no distribution of electric lines are distributed outside the insulating shielding layer 7, such that an air gap between the inside and the outside of the insulating shielding layer 7 can be avoided, and then an influence of insulation strength on the dynamic submarine cable can be reduced.

[0025] By the arrangement, the dynamic submarine cable has better water blocking performance and tensile strength, can satisfy a strength use requirement at a large water depth, and thus the service life of the dynamic submarine cable can be prolonged. When the dynamic submarine cable faces large-range deviation of a floating wind turbine or violent shaking under the action of typhoon, power and communication transmission can be guaranteed.

[0026] In some embodiments, the conductor single wire 1 is a high-strength aluminum alloy single wire 6201-T81, and strength of the aluminum alloy single wire needs to reach 305 Mpa-330 Mpa. Compared with a copper single wire, the aluminum alloy single wire has higher specific strength in water. That is to say, the dynamic submarine cable using aluminum alloy single wires can satisfy requirements of tensile strength with a smaller section. Moreover, a weight of the dynamic submarine cable can be reduced. Therefore, the dynamic submarine cable can satisfy the strength requirement at a large water depth. Furthermore, annealing treatment on the conductor single wire 1 can eliminate mechanical stress of the conductor single wire 1.

[0027] In some embodiments, the outer sheath 20 is a low-density or high-density polyethylene material depending on use requirements of flexibility and watertightness of the dynamic cable.

[0028] In the embodiment of the invention, the aluminum alloy conductor unit 27 is sequentially wrapped with a water blocking tape 3 and a semiconductive bindinging tape 4, such that water blocking performance of the aluminum alloy conductor unit 27 can be further improved. A three-layer co-extrusion structure formed by the conductor shielding layer 5, the insulating layer 6 and the insulating shielding layer 7 is arranged on a periphery of the semiconductive binding tape 4.

[0029] In the embodiment of the invention, a pitch of each conductor layer 23 and an outer diameter of the conductor layer 23 satisfy the following condition: $10\ D_A \leq h \leq 16\ D_A$, where D_A is an outer diameter of the conductor layer, and h is the pitch of the conductor layer.

[0030] It should be noted that the "pitch" refers to a distance advanced by one rotation of the conductor single wire 1 in an axial direction of stranding (that is, an axial length of the cable core 21). The aluminum alloy conductor unit 27 arranged in such way thus has higher tensile strength.

[0031] In some embodiments, the pitch of the each conductor layer 23 is 13.5 times an outer diameter of the conductor layer.

[0032] In the embodiment of the invention, the plurality of conductor single wires 1 are stranded into the aluminum alloy conductor unit 27 in a non-compacted stranding manner, each conductor layer 23 includes 6n conductor single wires1, and each conductor layer 23 has an outer diameter $D_A = (2n + 1)\ d$, where n is the number of the conductor layers, and d is a diameter of the conductor single wire.

[0033] In the above technical solution, n is a natural number. A nanomedie is used as a mold for stranding the aluminum alloy conductor unit 27, and an inner diameter of the mold is 0.3 mm-0.5 mm less than the outer diameter D_A of each conductor layer 23. In this way, plastic hardening of an aluminum alloy structure can be relieved, so as to prolong the fatigue life of the aluminum alloy conductor unit 27.

[0034] In the embodiment of the invention, the water blocking glue 2 should be paste-like before filling, is thermosetting in curing type, and is an elastic body after curing, such that friction stress and damage between the conductor single wires 1 under bending-tensile load can be relieved.

[0035] In some embodiments, the water blocking glue 2 is a semiconductive water blocking glue, has high temperature resistance, does not drip at 130°C, and has a volume resistivity of less than or equal to $1\times10^5\Omega\cdot cm$.

[0036] As shown in Figs. 1 and 3, in the example of the invention, the cable core 21 further includes a metal shielding layer 9 arranged at a periphery of the insulating shielding layer 7, and the metal shielding layer 9 includes two copper tapes 91 spaced in a radial direction and a semiconductive water-blocking tape 92 arranged between the two copper tapes 91.

[0037] In the above technical solution, the metal shielding layer 9 includes two copper tapes 91. The two copper tapes 91 can improve a short-circuit current and also bear a charging current and a circulating current of a line. An inner side and an outer side of the metal shielding layer 9 are further provided with a first semiconductive buffer tape 8 and a second semiconductive buffer tape 10 respectively. In a process of wrapping the copper tape, the copper tape 91 presses the adjacent buffer tape. By arranging the semiconductive water-blocking tape 92, the copper tape 91 presses the semiconductive water-blocking tape 92 when wrapping, and the semiconductive water-blocking tape 92 can achieve water blocking in an axial direction of the aluminum alloy conductor unit 27. Moreover, the semiconductive water-blocking tape 92 can also relieve a pressure of the metal shielding layer 9 on the three-layer co-extrusion structure, to guarantee safety of electrical operation. On the other hand, in a repeated stretching and bending process of the submarine cable, the semiconductive water-blocking tape 92 can also reduce mutual friction between the two copper tapes 91, increase the dynamic fatigue performance of the cable core 21, and avoid the problem that the two copper tapes 91 are broken or even fail due to the mutual friction between the two copper tapes 91, such that a fatigue life of the copper tapes 91 can be prolonged.

[0038] As shown in Fig. 1, in the embodiment of the invention, the dynamic submarine cable further includes a filling structure 13, the filling structure 13 is arranged between two adjacent cable cores 21, a first side of the filling structure 13 is provided with a contact surface 25 fitted to an outer wall surface of the cable core 21, and a second side of the filling structure 13 is provided with an accommodating groove 26 for accommodating the optical unit 12.

[0039] By the above arrangement, the filling structure 13 can fill a gap between two adjacent cable cores 21, such that when the dynamic submarine cable generates large-range deviation or violent shaking, a relative movement of the plurality of cable cores 21 can be avoided, so as to guarantee stability of the dynamic submarine cable. Furthermore, by arranging the filling structure 13, roundness of the dynamic submarine cable can also be improved, and the lateral pressure resistance of the cable core 21 can be increased. Moreover, the optical unit is placed outside the filling structure 13, such that functions such as optical signal transmission and online monitoring can be implemented.

[0040] As shown in Fig. 1, in the embodiment of the invention, three cable cores 21 and three filling structures 13 are provided, each filling structure 13 is provided with the plurality of accommodating grooves 26, and each accommodating groove 26 is provided with the optical unit 12.

[0041] In the above technical solution, the each filling structure 13 is provided with two accommodating grooves 26 (not shown in Fig. 1), such that the each filling structure 13 can accommodate two optical units 12.

[0042] By the above arrangement, two optical units 12 can be simultaneously laid out and cabled by using a modified vertical cabling apparatus. In this way, an operator can select the number of optical units 12 to be placed according to actual use requirements.

[0043] In an embodiment of the invention, polypropylene (PP) plastic or polyethylene (PE) plastic, or both PP plastic and PE plastic are used as the filling structure 13. In this way, the lateral pressure resistance of the cable core 21 can be increased, and the optical unit 12 can also be prevented from bending.

[0044] In some embodiments, according to different application scenes, calcium carbonate, silica and other materials may be added to the filling structure 13 in a material forming process, so as to improve the strength of the filling structure 13.

[0045] As shown in Fig. 1, in the embodiment of the invention, the armor layer 22 is made of stranded flat steel wires, the plurality of armor layer 22 are provided, and stranded directions of the flat steel wires of adjacent two armor layers 22 are opposite.

[0046] In the above technical solution, two armor layers 22 are provided, and the stranded directions of the flat steel wires of the two armor layers 22 are opposite, such that torque balance design can be satisfied. In a stretching process, the flat steel wires of the two armor layers 22 can be uniformly stressed, such that the strength of the dynamic submarine cable can be improved, and bending rigidity of the dynamic submarine cable can also be improved. The flat steel wires need to be chamfered, such that the armor layers 22 can be compact after the two armor layers 22 are stranded in opposite directions.

[0047] By the above arrangement, the armor layer 22 uses flat steel wires, and since the flat steel wires mainly make surface contact, the armor layer 22 arranged in this way is more wear-resistant. Moreover, the flat steel wires has a less outer diameter, such that an overall outer diameter of the dynamic submarine cable can be reduced, which is convenient for transportation and construction.

[0048] In some embodiments, a pitch of each armor layer 22 is 14 times-15 times an outer diameter of the armor layer 22.

[0049] Alternatively, four armor layers 22 may also be provided.

[0050] As shown in Fig. 1, in the embodiment of the invention, the periphery of the armor layer 22 is coated with bitumen or bituminous paint.

[0051] By the above arrangement, the bitumen or the bituminous paint can prevent and reduce wear of the armor layer 22 under dynamic environmental loads. In this way, service life of the dynamic submarine cable can be further improved under large water depths, large weights and severe environmental loads.

[0052] As shown in Fig. 1, in the example of the invention, a PP rope 17 is wrapped around a periphery of the armor layer 22.

[0053] By the above arrangement, the PP rope can tighten the flat steel wires of the armor layer 22, so as to further enhance the fatigue resistance of the dynamic submarine cable.

[0054] In the example of the invention, an anti-corrosion layer 11 is further arranged on a periphery of the second semiconductive buffer tape 10. The anti-corrosion layer 11 has radial water-blocking performance, such that an interior of the dynamic submarine cable can be prevented from being corroded, and the service life of the dynamic submarine cable can be further prolonged.

[0055] As shown in Fig. 4, the example of the invention provides a forming method for a dynamic submarine cable. The forming method includes:

prepare a cable core 21, where the cable core 21 includes an aluminum alloy conductor unit 27, a conductor shielding layer 5, an insulating layer 6 and an insulating shielding layer 7 which are sequentially arranged from inside to outside, the aluminum alloy conductor unit 27 includes a plurality of conductor layers 23 and a water blocking glue 2 arranged between two adjacent conductor layers 23, and each conductor layer 23 includes a plurality of conductor single wires 1;
arrange a plurality of cable cores 21 to form a triangular structure;
perform a process for preparing an optical unit 12; and
sequentially arrange an inner sheath 15, an armor layer 22 and an outer sheath 20 from inside to outside around the optical unit 12 and the plurality of cable cores 21.

[0056] In the above technical solution, a special gluing apparatus is used for coating the periphery of each conductor layer 23 with the water blocking glue 2. Three cable cores 21 form a triangular structure, and the optical unit 12 is located at an outer gap of the cable cores 21. The periphery of the cable cores 21 and the optical unit 12 is coated with the inner sheath 15, the armor layer 22 and the outer sheath 20, such that the dynamic submarine cable is formed.

[0057] In the example of the invention, the step of preparing a cable core 21 further includes:

form a plurality of conductor layer 23 by stranding the plurality of conductor single wires 1 in a non-compacted concentric stranding manner; and
press the conductor layer 23 located at an outermost layer.

[0058] In the above technical solution, the plurality of conductor single wires 1 are stranded in a non-compacted normal concentric stranding manner to form the plurality of conductor layers 23. A rubber band is added to the periphery of each conductor layer 23, such that the water blocking glue 2 is uniformly coated. An outermost layer of the aluminum alloy conductor unit 27 can be more rounded by pressing the outermost conductor layer 23, such that requirements of the next three-layer extrusion process can be satisfied. In this step, the outer diameter of the aluminum alloy conductor unit 27 should not be reduced by more than 3%.

[0059] In the example of the invention, in the step of stranding the aluminum alloy conductor unit 27, an increment k of mass or resistance of the aluminum alloy conductor unit 27 per unit length is a function of a stranding coefficient m, and an increment function of the mass or the resistance is k = 100 (m - 1).

[0060] In the above technical solution, m is the stranding coefficient, and a development length of the conductor single wire 1 rotating one circle in an axial stranded direction is L, and the stranding coefficient $m = \frac{L}{h}$.

[0061] Certainly, the stranding coefficient m may also be a ratio of the mass (or resistance) of the aluminum alloy conductor unit 27 per unit length to mass (or resistance) of a solid conductor with the same sectional area.

[0062] By the above arrangement, for the design of aluminum alloy conductor units 27 with different sectional areas, the stranding coefficient can be adjusted to change the increment based on the number of layers of the different conductor layers 23, such that the aluminum alloy conductor units 27 can satisfy the requirements of conductor direct current resistance.

[0063] In the example of the invention, when preparing the cable core 21, for the aluminum alloy conductor units 27 with different layers, rated loss coefficients are as follows:

Table 1 Rated loss coefficient of aluminum alloy conductor unit

Number of single wires	Number of layers	Loss coefficient (%)
7	1	96
19	2	93
37	3	91
61	4	90
91	5	90

[0064] In the above technical solution, number of single wires refers to the total number of the conductor single wires 1 in the aluminum alloy conductor unit 27, and the rated loss coefficient refers to a minimum loss coefficient of the aluminum alloy conductor unit 27 in a process of preparation and design, that is, a ratio of measured breaking strength to theoretically calculated breaking strength of the aluminum alloy conductor unit 27.

[0065] In the embodiment of the invention, the forming method further includes: coat the periphery of the armor layer 22 with bitumen or bituminous paint, to prevent and reduce wear of the armor layer 22.

[0066] In the embodiment of the invention, the forming method further includes: wrap a PP rope around the periphery of the armor layer 22, to tighten the flat steel wires of the armor layer 22. Therefore, the fatigue resistance of the dynamic submarine cable is further enhanced.

[0067] From the above description, it can be seen that the above examples of the disclsoure achieve the following technical effects. An aluminum alloy water-blocking conductor has a circular non-compacted design, which can relieve the plastic hardening problem of an aluminum alloy structure, and prolong fatigue service life of the aluminum alloy conductor. Arranging the water blocking glue between two adjacent conductor layers can make aluminum alloy conductor units form a compact entity. The water blocking glue can improve water blocking performance of gaps between the plurality of conductor single wires. Moreover, when subjected to bending-tensile loads, the water blocking glue can also relieve frictional stress and damage between adjacent conductor single wires, such that service life of the dynamic submarine cable can be prolonged at a large water depth. Furthermore, the conductor shielding layer, the insulating layer and the insulating shielding layer form a three-layer co-extrusion structure. The conductor shielding layer can reduce local electric field concentration caused by uneven surfaces formed by stranding of the aluminum alloy conductor units, such that uniform electric field distribution on the surfaces of the aluminum alloy conductor units is guaranteed. The insulating layer can achieve insulating. The insulating shielding layer is configured to shield an electric field, that is, by arranging the insulating shielding layer, no distribution of electric lines are distributed outside the insulating shielding layer, such that an air gap between the inside and the outside of the insulating shielding layer can be avoided, and then an influence of insulation strength on the dynamic submarine cable can be reduced. The semiconductive water-blocking tape can reduce friction between two copper tapes and increase dynamic fatigue performance of the cable core. The filling structure can improve roundness of the dynamic submarine cable and increase lateral pressure resistance of the cable core. The flat steel wires of the two armor layers can be stressed evenly, thus improving the strength of the dynamic submarine cable. The bitumen or the bituminous paint can prevent and reduce wear of the armor layers.

[0068] What are described above are merely some embodiments of the invention and are not intended to limit the invention, and various changes and modifications may be made to the invention by those skilled in the art. Any modifications, equivalent substitutions, improvements, etc. within the spirit and principles of the invention are intended to fall within the scope of protection of the invention.

Claims

1. A dynamic submarine cable, comprising an optical unit (12) and a plurality of cable cores (21), wherein an inner sheath (15), an armor layer (22) and an outer sheath (20) are sequentially arranged around the optical unit (12) and the plurality of cable cores (21) from inside to outside; and the plurality of the cable cores (21) form a triangular structure, adjacent two cable cores (21) make contact with each other in an abutting manner, each cable core (21) comprises an aluminum alloy conductor unit (27), a conductor shielding layer (5), an insulating layer (6) and an insulating shielding layer (7) which are sequentially arranged from inside to outside, the aluminum alloy conductor unit (27) comprises a plurality of conductor layers (23) and a water blocking glue (2) arranged between two adjacent conductor layers (23), and each conductor layer (23) comprises a plurality of conductor single wires (1).

2. The dynamic submarine cable according to claim 1, wherein each of the conductor single wires (1) is an aluminum

alloy single wire, the each of the conductor single wires (1) has strength of 305 Mpa-330 Mpa, and the each of the conductor single wires (1) is annealed.

3. The dynamic submarine cable according to claim 1, wherein a pitch of the each conductor layer (23) and an outer diameter of the each conductor layer (23) satisfy a following condition:

$$10\ D_A \leq h \leq 16\ D_A;$$

wherein
D_A is the outer diameter of the each conductor layer, and h is the pitch of the each conductor layer.

4. The dynamic submarine cable according to claim 1, wherein the plurality of conductor single wires (1) are stranded into the aluminum alloy conductor unit (27) in a non-compacted stranding manner, the each conductor layer (23) comprises 6n conductor single wires (1), and the each conductor layer (23) has an outer diameter D_A _ (2n + 1) d, wherein n is the number of the conductor layers, and d is a diameter of the conductor single wires.

5. The dynamic submarine cable according to claim 1, wherein the cable core (21) further comprises a metal shielding layer (9) arranged at a periphery of the insulating shielding layer (7), and the metal shielding layer (9) comprises two copper tapes (91) spaced in a radial direction and a semiconductive water-blocking tape (92) arranged between the two copper tapes (91).

6. The dynamic submarine cable according to any one of claims 1-5, further comprising at least one filling structure (13), the at least one filling structure (13) is arranged between any two adjacent cable cores (21), a first side of each filling structure (13) is provided with a contact surface (25) fitted to an outer wall surface of the cable core (21), and a second side of the each filling structure (13) is provided with an accommodating groove (26) for accommodating the optical unit (12).

7. The dynamic submarine cable according to claim 6, wherein three cable cores (21) and three filling structures (13) are provided, the each filling structure (13) is provided with the plurality of accommodating grooves (26), and each accommodating groove (26) is provided with the optical unit (12).

8. The dynamic submarine cable according to any one of claims 1-5, wherein the armor layer (22) is made of stranded flat steel wires, a plurality of armor layer (22) are provided, and stranded directions of flat steel wires of adjacent two armor layers (22) are opposite.

9. The dynamic submarine cable according to any one of claims 1-5, wherein a periphery of the armor layer (22) is coated with bitumen or bituminous paint; or,
a polypropylene (PP) rope (17) is wrapped around a periphery of the armor layer (22).

10. The dynamic submarine cable according to claim 5, wherein the cable core (21) further comprises a first semiconductive buffer tape (8) and a second semiconductive buffer tape (10), the first semiconductive buffer tape (8) is located inside the metal shielding layer (9), and the second semiconductive buffer tape (10) is located outside the metal shielding layer (9).

11. A forming method for a dynamic submarine cable, comprising:

preparing a cable core (21), wherein the cable core (21) comprises an aluminum alloy conductor unit (27), a conductor shielding layer (5), an insulating layer (6) and an insulating shielding layer (7) which are sequentially arranged from inside to outside, the aluminum alloy conductor unit (27) comprises a plurality of conductor layers (23) and a water blocking glue (2) arranged between two adjacent conductor layers (23), and each conductor layer (23) comprises a plurality of conductor single wires (1);
arranging a plurality of cable cores (21) to form a triangular structure;
performing a process for preparing an optical unit (12); and
sequentially arranging an inner sheath (15), an armor layer (22) and an outer sheath (20) from inside to outside around the optical unit (12) and the plurality of cable cores (21).

12. The forming method for the dynamic submarine cable according to claim 11, wherein the preparing a cable core

(21) further comprises:

performing a plurality-of-conductor-layer forming step for forming the plurality of conductor layer (23) by stranding the plurality of conductor single wires (1) in a non-compacted concentric stranding manner; and
pressing a conductor layer (23) located at an outermost layer.

13. The forming method for the dynamic submarine cable according to claim 11, further comprising coating a periphery of the armor layer (22) with bitumen or bituminous paint on, and/or
further comprising wrapping a PP rope (17) around a periphery of the armor layer (22).

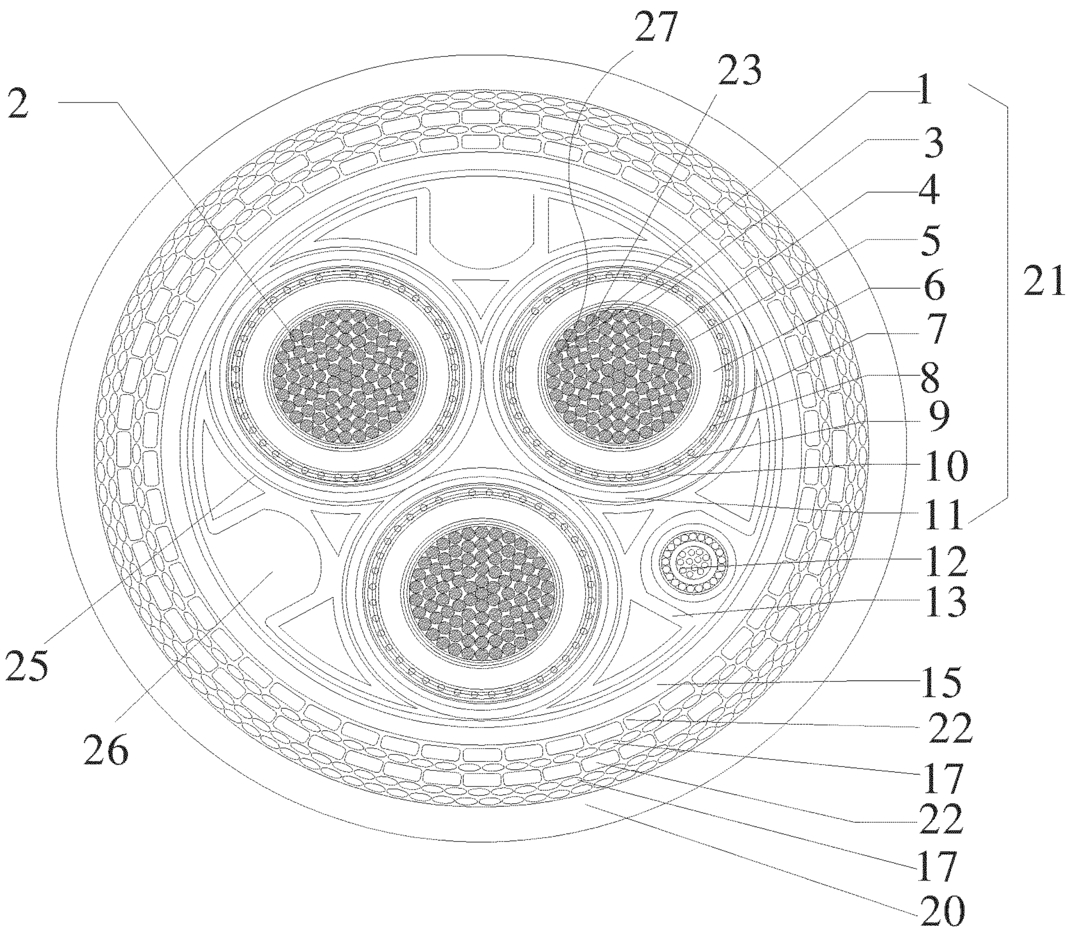

Fig. 1

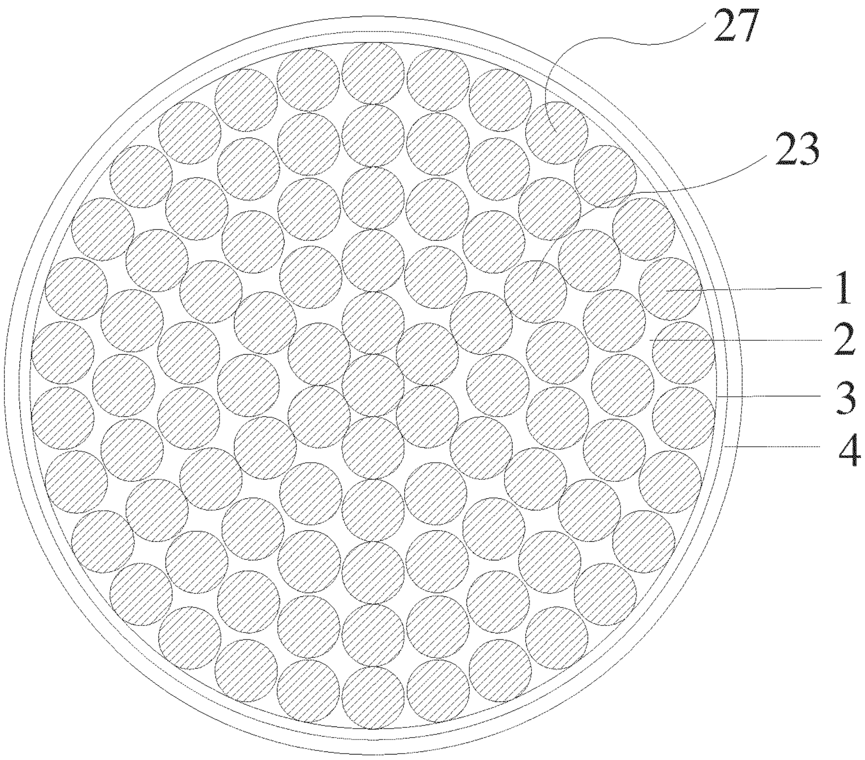

Fig. 2

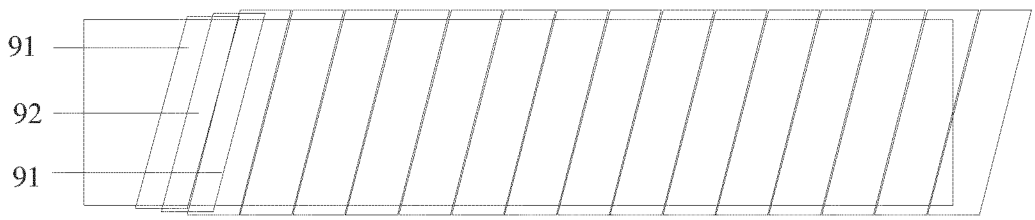

Fig. 3

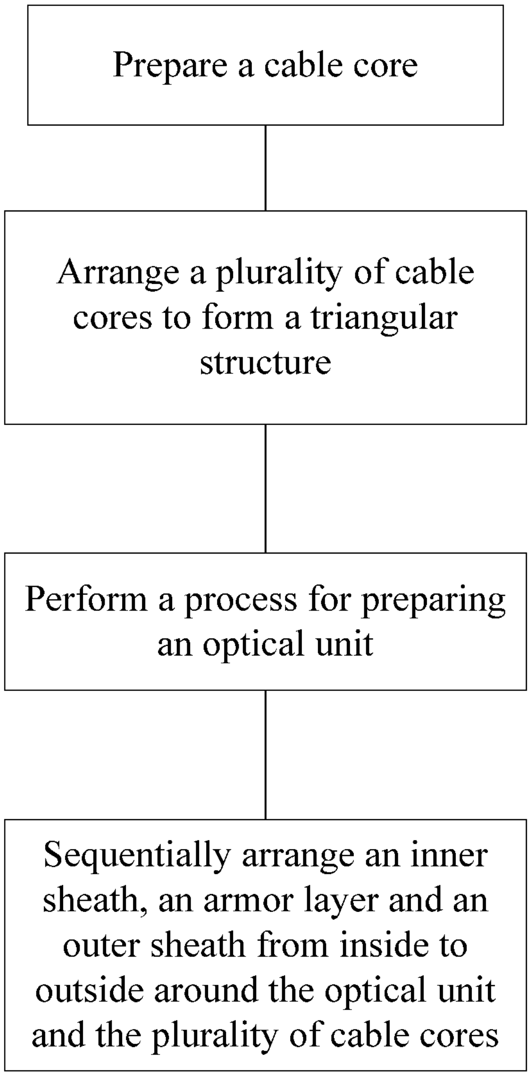
Prepare a cable core
Arrange a plurality of cable cores to form a triangular structure
Perform a process for preparing an optical unit
Sequentially arrange an inner sheath, an armor layer and an outer sheath from inside to outside around the optical unit and the plurality of cable cores

Fig. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/081443

A. CLASSIFICATION OF SUBJECT MATTER

H01B7/14(2006.01)i;H01B7/285(2006.01)i;H01B7/17(2006.01)i;H01B7/282(2006.01)i;H01B7/02(2006.01)i;H01B7/18(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC：H01B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT, ENTXTC, CNKI: 导体, 电缆, 海底, 铝合金, 三角, 节距, 外径, conductor, cable, subsea, aluminum w alloy, triangle, pitch, outer w diameter

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 202711831 U (SICHUAN MINGXING CABLE CO., LTD.) 30 January 2013 (2013-01-30) claims 1-4, and figure 1	1-13
Y	CN 110176326 A (DONGFANG JIAOLIAN ELECTRIC POWER CABLE CO., LTD.) 27 August 2019 (2019-08-27) claim 1, description, paragraph 18, and figure 2	1-13
Y	CN 103123825 A (STATE GRID ELECTRIC POWER RESEARCH INSTITUTE et al.) 29 May 2013 (2013-05-29) claim 4, and figure 1	1-13
Y	CN 111883310 A (ZHONGTIAN TECHNOLOGY SUBMARINE CABLES CO., LTD.) 03 November 2020 (2020-11-03) claims 1, 4, 5 and 8, description, paragraphs 25-28, and figure 1	5
Y	CN 204029421 U (JIANGSU HENGTONG HIGH VOLTAGE CABLE CO., LTD.) 17 December 2014 (2014-12-17) description, paragraphs 27-35, and figure 3	6

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
18 April 2023	**23 April 2023**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2023/081443

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CN 106024187 A (FAR EAST CABLE CO., LTD.) 12 October 2016 (2016-10-12) claim 6, and figure 2	11-13
PX	CN 114974676 A (ZHONGTIAN TECHNOLOGY SUBMARINE CABLES CO., LTD. et al.) 30 August 2022 (2022-08-30) claims 1-13	1-13
A	CN 102903442 A (JIANGSU SINOSTAR CABLE CO., LTD.) 30 January 2013 (2013-01-30) entire document	1-13
A	CN 106128582 A (ZHONGTIAN TECHNOLOGY SUBMARINE CABLES CO., LTD.) 16 November 2016 (2016-11-16) entire document	1-13
A	EP 3926645 A1 (NEXANS) 22 December 2021 (2021-12-22) entire document	1-13

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/081443

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	202711831	U	30 January 2013		None		
CN	110176326	A	27 August 2019		None		
CN	103123825	A	29 May 2013		None		
CN	111883310	A	03 November 2020	WO	2022027849	A1	10 February 2022
CN	204029421	U	17 December 2014		None		
CN	106024187	A	12 October 2016		None		
CN	114974676	A	30 August 2022		None		
CN	102903442	A	30 January 2013		None		
CN	106128582	A	16 November 2016		None		
EP	3926645	A1	22 December 2021	EP	EP3926645	A4	22 December 2021

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 202210761675 **[0001]**