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Description

The present invention relates to an improved composite overhead cable obtained by providing an optical fiber cable in an overhead power line formed by stranding a plurality of conductors, or in an overhead earth wire which is extended in parallel with such an overhead power line.

Copending U.K. Patent Application No. 82/9402 and DE-A-3225228 disclose composite overhead cable of this type, an example of which is shown in Fig. 1 herein. In Fig. 1, an optical unit 5 is composed of a plurality of optical fibers 2 arranged in a corresponding number of helical grooves 1 formed in the outer surface of an aluminum spacer member 3 surrounded by an outer tube 4 also made of aluminium. The outer surface of the optical unit 5 is surrounded by a stranded conductor layer composed of a plurality of aluminum-clad steel wires 6.

The composite cable shown in Fig. 1 exhibits an acceptable mechanical strength and excellent protective characteristics against lightning due to the fact that the optical unit 5 is received in the outer tube 4, which performs a protective function.

If the outer diameter of the optical fiber 2 is sufficiently smaller than both the width and depth of the helical groove 1 to be received therein loosely, compression and/or expansion stresses applied thereto are absorbed and/or weakened due to radial movement of the optical fibers 2 in the grooves 1, such as shown by thick arrows in Fig. 2. In the structure shown in Fig. 1, however, if the width of the groove 1 of the spacer 3 is much larger than the diameter of the optical fiber 2, bending and/or compression stresses applied to the composite cable cause the optical fiber to move not only radially but also circumferentially, resulting in irregular bending of the optical fibers. Accordingly, transmission loss of the optical fiber may increase.

The object of the present invention is to provide a composite overhead cable developed to resolve or reduce the problems inherent to the conventional composite overhead cables. To this end, the present invention relates to a composite overhead cable as defined in claim 1.

In the present specification, the optical bundle is intended to mean an assembly of a plurality of optical fibers which are arranged uniformly along the longitudinal direction. When the diameter is used in connection with the optical bundle, it means the maximum size in the radial direction of the bundle. With such a structure, the freedom of movement of the optical fiber in the grooves is restricted to thereby minimize loss increase caused by the bending. However, all external axial stresses applied to the fibers are absorbed by the radial movement of the fibers within the grooves. For example, when an expansion stress is applied to the composite cable of the invention while the optical fibers are positioned at the bottoms of the grooves, the diameter of the spacer is reduced and the stress is absorbed by

the radial movement of the fibers because the spacer itself is elongated.

It is preferred to round the bottoms of the grooves with a radius of curvature substantially equal to the radius of the optical fibers and/or the optical bundles, thereby preventing micro-bending of the optical fiber. When the radius is used in connection with the optical bundle, it is a half of its diameter which is defined in the above. Further, in such a case, if the optical fiber has a jacket coating of an elastic material such as silicon, the effect of stress absorption may be improved.

Moreover, since it is possible to make the narrowed grooves of the spacer deeper than the grooves in the spacer shown in Fig. 1, the optical fibers can be moved radially through a distance larger than is possible in the structure of Fig. 1.

Alternatively, the spacer itself can be thinned. This is advantageous when the composite cable is to be used as a substitute for an existing cable not having optical fibers therein, in which application the size and weight of the composite overhead cable must be nearly the same as the existing cable. The diameter of the spacer should not be larger than twice the diameter of each of the aluminum-clad steel wires which form the outer layer of the cable.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Fig. 1 is a cross-sectional view of a conventional composite cable;

Fig. 2 is an elongate cross-sectional view of a spacer used in the composite cable of Fig. 1;

Fig. 3 is a similar view of a spacer used in some embodiments of the present invention;

Fig. 4 is a cross-sectional view of one embodiment of a composite overhead cable of the present invention;

Fig. 5 is a cross-sectional view of another embodiment of the present invention; and

Fig. 6 is a cross-sectional view of a further embodiment of the present invention.

Fig. 3 is a cross-sectional view of a spacer adapted for use with embodiments of the present invention. In Fig. 3, the spacer 3 is made of a metal or heat resistant plastics material, and is formed on its outer periphery with a plurality (four in this case) of helical grooves in which respective optical fibers and/or respective optical bundles 2 are received. The width of each helical groove 1 is made substantially equal to the outer diameter of the optical fiber and/or the optical bundles 2 received therein so that the latter can move only radially.

Fig. 4 is a cross-sectional view of a composite cable to which the spacer 3 shown in Fig. 3 is applied. In Fig. 4, the spacer 3, as above, is made of a metal or a heat resistant plastics material and is formed in the outer surface thereof with helical grooves 1, each having a width substantially equal to the diameter of the optical fibers and/or the optical bundles 2 received therein. The spacer

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covered by an aluminum tube 4 to form an optical unit 5 surrounded by stranded aluminum-clad steel wires 6.

It is possible to deepen the grooves without reducing the mechanical strength of the spacer. This is one of advantages of the present invention over the conventional cable shown in Fig. 1. Further, it is possible to coat the surfaces of the grooves 1 and/or the surfaces of the optical fibers with a jelly-like material to damp the relative movement of the optical fibers with respect to the groove walls. Still further, it is possible to employ an elastic material such as silicon resin or silicon rubber in the grooves to elastically restrict the relative movement of the optical fibers with respect to the groove walls so that the optical fibers move together with the spacer 3 in response to thermal and mechanical stresses exerted thereon. In this case, any distortion applied to the optical fibers is made axially uniform so that the lifetime of the optical fibers and the stability of their transmission characteristics are improved.

If the spacer 3 is made of a metal material having an appreciable electrical resistivity, it is possible to restrict a temperature increase due to a lightning strike or a short circuit of the power transmission line. For example, for a composite cable provided with a spacer 3 made of an aluminum alloy having the same structure as that shown in Fig. 4, an optical unit 5 covered with aluminum tube 4 which is 5 mm diameter, and seven aluminum-clad stranded steel wires 6 each 3.8 mm diameter arranged around the optical unit 5, if the electric resistance per unit length and the cross-sectional area of the composite cable are 0.550 ohms/km and about 80 mm², respectively, the temperature increase of the conductor due to a short-circuit current is lower by about 30°C than that of a conductor of a composite cable with a non-metallic spacer or without such a spacer. For example, the approximate temperature increases of the conductor of the composite cable with a non-metallic spacer or without such a spacer for a current flow of 20 KA for 0.15, 0.20 and 0.30 seconds are 180°C, 230°C and 350°C, respectively, while, for the composite cable constituted with a spacer 3 of an aluminum alloy, the corresponding values are 150°C, 200°C and 300°C, respectively.

Further, in Fig. 4, either or both of the spacer 3 and the tube 4 can be made of heat durable plastics material. However, if the spacer 3 is made of a metal and the tube 4 of a heat durable plastics material or both of the spacer and the tube are made of metal with an insulating material such as a plastic tape layer between the spacer and the tube, due to the presence of the insulating material layer between the metal spacer 3 and the aluminum-clad steel wires 6, when a short-circuit current flows therethrough, breakdown of the insulating layer is caused and the tube is broken. Thus, the tolerance of the composite cable to short-circuit currents is low. For example, for the described composite cable having a conductor cross-sectional area of 80 mm², it has not been

observed that the tube 4 melted even when a short-circuit current of 20 KA flowed for 20 cycles (1 cycle = 1/60 seconds). On the other hand, for a composite cable which included a Mylar (trade-mark of Du Pont) tape layer 0.02 mm thick between the spacer 3 and the aluminum tube 4, the latter was melted due to insulation breakdown when a short-circuit current of 15 KA flowed for a period corresponding to 8 cycles.

Fig. 5 shows another embodiment of the present invention in which the diameter of the spacer 3 is made smaller than the inner diameter of the tube 4 so that the spacer can be moved within the tube 4. The structure shown in Fig. 5 is advantageous in case the optical fibers 2 break. That is, the optical fibers 2 received in the spacer 3 be moved together with the spacer 3 with respect to the tube 4 so that repair of the broken fibers is made possible. For instance, in a test, a force required for extracting or inserting a spacer 2.5 mm diameter and 1 km long from or into an aluminum tube whose inner diameter and length were 4 mm and 1 km, respectively, was 50 kg or less.

Fig. 6 shows another embodiment of the present invention, in which, instead of aluminum-clad steel wires each having a circular cross section, aluminum-clad steel wires 7 having fan-shaped cross sections are used. The cross sections of the aluminum-coated steel wires 7 are substantially wedge shaped so that adjacent ones of the steel wires 7 are intimately contacted with each other to provide a so-called bridge effect, thereby to make the layer of steel wires rigid. In this embodiment, the tube 4 of the spacer 3 undergoes little deformation. Even if it is deformed, the optical unit 5 is protected by the spacer 3, and therefore it is possible to replace the optical unit 5 without damage to its components.

As described in detail hereinbefore, since the optical fibers are received in helical grooves formed in the spacer with the width of the helical grooves being substantially equal to the outer diameter of the optical fibers and/or the optical bundles, the freedom of movement of the optical fibers in the grooves is reduced, and thus the bending losses thereof are minimized. Further, external stress applied axially to the composite stranded conductor is absorbed by radial movements of the optical fibers. Since the optical fibers always move together with the spacer, the optical fibers are not subjected to local concentration of deformation due to thermal and/or mechanical forces applied thereto externally, resulting in a stable transmission characteristics and extended life time of the optical fibers.

In addition, if the optical fiber has a core and/or a cladding which contains fluorine, the transmission characteristics of the optical fiber in the composite cable can be stably maintained even under high temperature conditions.

Claims

1. A composite overhead cable comprising:

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covered by an aluminum tube 4 to form an optical unit 5 surrounded by stranded aluminum-clad steel wires 6.

It is possible to deepen the grooves without reducing the mechanical strength of the spacer. This is one of advantages of the present invention over the conventional cable shown in Fig. 1. Further, it is possible to coat the surfaces of the grooves 1 and/or the surfaces of the optical fibers with a jelly-like material to damp the relative movement of the optical fibers with respect to the groove walls. Still further, it is possible to employ an elastic material such as silicon resin or silicon rubber in the grooves to elastically restrict the relative movement of the optical fibers with respect to the groove walls so that the optical fibers move together with the spacer 3 in response to thermal and mechanical stresses exerted thereon. In this case, any distortion applied to the optical fibers is made axially uniform so that the lifetime of the optical fibers and the stability of their transmission characteristics are improved.

If the spacer 3 is made of a metal material having an appreciable electrical resistivity, it is possible to restrict a temperature increase due to a lightning strike or a short circuit of the power transmission line. For example, for a composite cable provided with a spacer 3 made of an aluminum alloy having the same structure as that shown in Fig. 4, an optical unit 5 covered with aluminum tube 4 which is 5 mm diameter, and seven aluminum-clad stranded steel wires 6 each 3.8 mm diameter arranged around the optical unit 5, if the electric resistance per unit length and the cross-sectional area of the composite cable are 0.550 ohms/km and about 80 mm², respectively, the temperature increase of the conductor due to a short-circuit current is lower by about 30°C than that of a conductor of a composite cable with a non-metallic spacer or without such a spacer. For example, the approximate temperature increases of the conductor of the composite cable with a non-metallic spacer or without such a spacer for a current flow of 20 KA for 0.15, 0.20 and 0.30 seconds are 180°C, 230°C and 350°C, respectively, while, for the composite cable constituted with a spacer 3 of an aluminum alloy, the corresponding values are 150°C, 200°C and 300°C, respectively.

Further, in Fig. 4, either or both of the spacer 3 and the tube 4 can be made of heat durable plastics material. However, if the spacer 3 is made of a metal and the tube 4 of a heat durable plastics material or both of the spacer and the tube are made of metal with an insulating material such as a plastic tape layer between the spacer and the tube, due to the presence of the insulating material layer between the metal spacer 3 and the aluminum-clad steel wires 6, when a short-circuit current flows therethrough, breakdown of the insulating layer is caused and the tube is broken. Thus, the tolerance of the composite cable to short-circuit currents is low. For example, for the described composite cable having a conductor cross-sectional area of 80 mm², it has not been

observed that the tube 4 melted even when a short-circuit current of 20 KA flowed for 20 cycles (1 cycle = 1/60 seconds). On the other hand, for a composite cable which included a Mylar (trade-mark of Du Pont) tape layer 0.02 mm thick between the spacer 3 and the aluminum tube 4, the latter was melted due to insulation breakdown when a short-circuit current of 15 KA flowed for a period corresponding to 8 cycles.

Fig. 5 shows another embodiment of the present invention in which the diameter of the spacer 3 is made smaller than the inner diameter of the tube 4 so that the spacer can be moved within the tube 4. The structure shown in Fig. 5 is advantageous in case the optical fibers 2 break. That is, the optical fibers 2 received in the spacer 3 be moved together with the spacer 3 with respect to the tube 4 so that repair of the broken fibers is made possible. For instance, in a test, a force required for extracting or inserting a spacer 2.5 mm diameter and 1 km long from or into an aluminum tube whose inner diameter and length were 4 mm and 1 km, respectively, was 50 kg or less.

Fig. 6 shows another embodiment of the present invention, in which, instead of aluminum-clad steel wires each having a circular cross section, aluminum-clad steel wires 7 having fan-shaped cross sections are used. The cross sections of the aluminum-coated steel wires 7 are substantially wedge shaped so that adjacent ones of the steel wires 7 are intimately contacted with each other to provide a so-called bridge effect, thereby to make the layer of steel wires rigid. In this embodiment, the tube 4 of the spacer 3 undergoes little deformation. Even if it is deformed, the optical unit 5 is protected by the spacer 3, and therefore it is possible to replace the optical unit 5 without damage to its components.

As described in detail hereinbefore, since the optical fibers are received in helical grooves formed in the spacer with the width of the helical grooves being substantially equal to the outer diameter of the optical fibers and/or the optical bundles, the freedom of movement of the optical fibers in the grooves is reduced, and thus the bending losses thereof are minimized. Further, external stress applied axially to the composite stranded conductor is absorbed by radial movements of the optical fibers. Since the optical fibers always move together with the spacer, the optical fibers are not subjected to local concentration of deformation due to thermal and/or mechanical forces applied thereto externally, resulting in a stable transmission characteristics and extended life time of the optical fibers.

In addition, if the optical fiber has a core and/or a cladding which contains fluorine, the transmission characteristics of the optical fiber in the composite cable can be stably maintained even under high temperature conditions.

Claims

1. A composite overhead cable comprising:



plurality of optical fibres (2) and/or optical bundles;

a protective tube (4) enclosing said optical fibres (2) or bundles;

a stranded layer of a plurality of conductors (6, 7) of a metal or metal alloy disposed around said protective tube (4); and

a spacer (3) received in said protective tube (4), said spacer having a plurality of axially extending helical grooves (1) formed in an outer surface of said spacer (3) and receiving respective ones of said optical fibres (2) and/or said optical bundles, characterized by the fact that each of said helical grooves (1) is formed so as to have a substantially constant width substantially equal to an outer diameter of the associated optical fibres (2) and/or optical bundles received therein, the depth of each groove being substantially larger than its width, whereby said optical fibres (2) or bundles are restricted from movement in said grooves (1) in a circumferential direction of said spacer (3) whilst being free to move in a radial direction.

2. A composite overhead cable as claimed in claim 1 characterized in that said spacer (3) is made of a metal.

3. A composite overhead cable as claimed in claim 1 characterized in that said spacer (3) is made of a heat-resistant plastics material.

4. A composite overhead cable as claimed in any one of claims 1 to 3 characterized in that said protective tube (4) is made of a metal.

5. A composite overhead cable as claimed in any one of claims 1 to 4 characterized in that an inner diameter of said protective tube (4) is substantially equal to an outer diameter of said spacer (3).

6. A composite overhead cable as claimed in any one of claims 1 to 4 characterized in that an inner diameter of said protective tube (4) is larger than an outer diameter of said spacer (3).

7. A composite overhead cable as claimed in claim 5 or 6 characterized in that each of said conductors of said stranded layer is an aluminum-clad steel wire (7), and in that said aluminum-clad steel wires (7) are substantially wedge-shaped in cross-section so that adjacent ones of said aluminum-clad steel wires are intimately contacted with each other to provide a bridge effect.

8. A composite overhead cable as claimed in claim 5 or 6 characterized in that the outer diameter of said spacer (3) is equal to or smaller than twice the outer diameter of any one of said aluminum-clad steel wires (6).

9. A composite overhead cable as claimed in any one of claims 1 to 8 characterized in that each of said grooves (1) has a rounded bottom portion having a radius of curvature substantially equal to a radius of said one of said optical fibres (2) and/or said optical bundles received therein.

Patentansprüche

1. Geschichtetes Freiluftkabel mit
 - einer Vielzahl von Lichtleitern (2) und/oder optischen Bündeln

— einer schützenden Röhre (4), die die Lichtleiter (2) oder die Bündel umschließt

— einer verseilten Schicht, bestehend aus einer Vielzahl von Leitern (6, 7) aus einem Metall oder einer Metallegierung, die um die schützende Röhre (4) angeordnet ist und

— einem Abstandshalter (3), der in der schützenden Röhre (4) enthalten ist, wobei der Abstandshalter eine Vielzahl axial ausgedehnter schraubenförmig gewundener Nuten (1) besitzt, die in einer äußeren Oberfläche des Abstandshalters (3) ausgebildet sind und die jeweils entsprechende Lichtleiter (2) und/oder optische Bündel aufnehmen

dadurch gekennzeichnet, daß jede der schraubenförmig gewundenen Nuten (1) so geformt ist, daß sie eine im wesentlichen konstante Weite besitzt, die im wesentlichen gleich dem äußeren Durchmesser des zugehörigen Lichtleiters (2) und/oder optischen Bündels ist, das darin aufgenommen wird, wobei die Tiefe jeder Nut im wesentlichen größer als ihre Weite ist, wodurch die Lichtleiter (2) oder Bündel an einer Bewegung in den Nuten (1) in einer Umfangsrichtung des Abstandshalters (3) gehindert werden, während sie sich frei in einer radialen Richtung bewegen können.

2. Geschichtetes Freiluftkabel nach Anspruch 1, dadurch gekennzeichnet, daß der Abstandshalter (3) aus Metall hergestellt ist.

3. Geschichtetes Freiluftkabel nach Anspruch 1, dadurch gekennzeichnet, daß der Abstandshalter (3) aus einem hitzebeständigen Plastikmaterial hergestellt ist.

4. Geschichtetes Freiluftkabel nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß die schützende Röhre (4) aus Metall hergestellt ist.

5. Geschichtetes Freiluftkabel nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß ein innerer Durchmesser der schützenden Röhre (4) im wesentlichen gleich einem äußeren Durchmesser des Abstandshalters (3) ist.

6. Geschichtetes Freiluftkabel nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß ein innerer Durchmesser der schützenden Röhre (4) größer als ein äußerer Durchmesser des Abstandshalters (3) ist.

7. Geschichtetes Freiluftkabel nach einem der Ansprüche 5 oder 6, dadurch gekennzeichnet, daß die Leiter der verseilten Schicht ein aluminiumplattierter Stahlleiter (7) ist und daß die aluminiumplattierten Stahlleiter (7) im Querschnitt im wesentlichen keilförmig sind, so daß aneinanderliegende aluminiumplattierte Stahlleiter eng miteinander kontaktiert sind, um einen Brückeneffekt zu erzielen.

8. Geschichtetes Freiluftkabel nach einem der Ansprüche 5 oder 6, dadurch gekennzeichnet, daß der äußere Durchmesser des Abstandshalters 3 gleich oder kleiner als der zweifache äußere Durchmesser von einem der aluminiumplattierten Stahlleiter (7) ist.

9. Geschichtetes Freiluftkabel nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß



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jede Nut einen abgerundeten Bodenbereich besitzt, der einen Krümmungsradius aufweist, der im wesentlichen gleich dem Radius der Lichtleiter (2) und/oder der optischen Bündel ist, die darin aufgenommen werden.

Revendications

1. Câble composite suspendu comprenant: plusieurs fibres optiques (2) et/ou faisceaux de fibres,

un tube protecteur (4) entourant les fibres optiques (2) ou les faisceaux,

une couche torsadée de plusieurs conducteurs (6, 7) d'un métal ou d'un alliage métallique placés autour du tube protecteur (4), et

une entretoise (3) logée dans le tube protecteur (4), l'entretoise ayant plusieurs gorges hélicoïdales (1) disposées axialement, formées à une surface externe de l'entretoise (3) et contenant des fibres optiques (2) et/ou des faisceaux optiques respectifs, caractérisé par le fait que chacune des gorges hélicoïdales (1) est formée de manière que sa largeur soit sensiblement constante et sensiblement égale au diamètre externe des fibres optiques associées (2) et/ou des faisceaux optiques associés qui y sont logés, la profondeur de chaque gorge étant nettement supérieure à sa largeur, si bien que les fibres optiques (2) ou faisceaux ont un déplacement limité dans les gorges (1) en direction circonferentielle de l'entretoise (3) tout en étant libres de se déplacer en direction radiale.

2. Câble composite suspendu selon la revendication 1, caractérisé en ce que l'entretoise (3) est formée d'un métal.

3. Câble composite suspendu selon la reven-

dication 1, caractérisé en ce que l'entretoise (3) est formée d'une matière plastique résistant à la chaleur.

4. Câble composite suspendu selon l'une quelconque des revendications 1 à 3, caractérisé en ce que le tube protecteur (4) est formé d'un métal.

5. Câble composite suspendu selon l'une quelconque des revendications 1 à 4, caractérisé en ce que le diamètre interne du tube protecteur (4) est sensiblement égal au diamètre externe de l'entretoise (3).

6. Câble composite suspendu selon l'une quelconque des revendications 1 à 4, caractérisé en ce que le diamètre interne du tube protecteur (4) est supérieur au diamètre externe de l'entretoise (3).

7. Câble composite suspendu selon l'une des revendications 5 et 6, caractérisé en ce que chacun des conducteurs de la couche torsadée est un fil (7) d'acier gainé d'aluminium, et en ce que les fils (7) d'acier gainés d'aluminium ont une section sensiblement en forme de coin, si bien que les fils adjacents d'acier gainés d'aluminium sont en contact mutuel intime et donnent un effet de pontage.

8. Câble composite suspendu selon l'une des revendications 5 et 6, caractérisé en ce que le diamètre externe de l'entretoise (3) est inférieur ou égal au double du diamètre externe de l'un quelconque des fils (6) d'acier gainés d'aluminium.

9. Câble composite suspendu selon l'une quelconque des revendications 1 à 8, caractérisé en ce que chacune des gorges (1) a une partie inférieure arrondie dont le rayon de courbure est sensiblement égal au rayon de la fibre optique (2) et/ou du faisceau optique qui y est logé.

