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[56]

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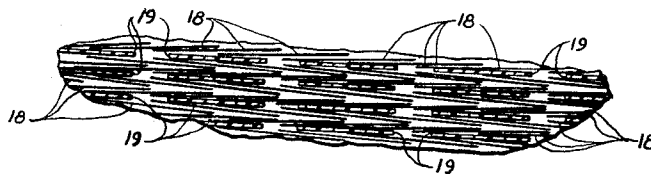
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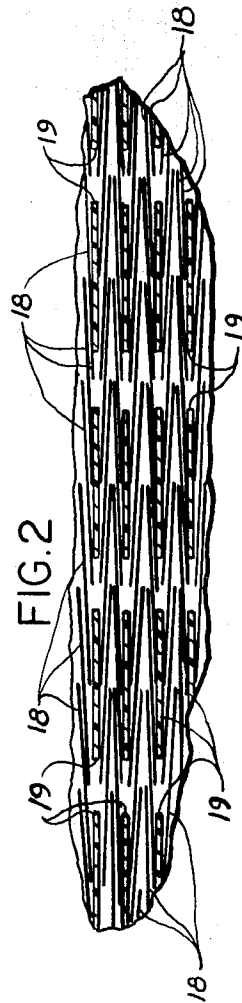
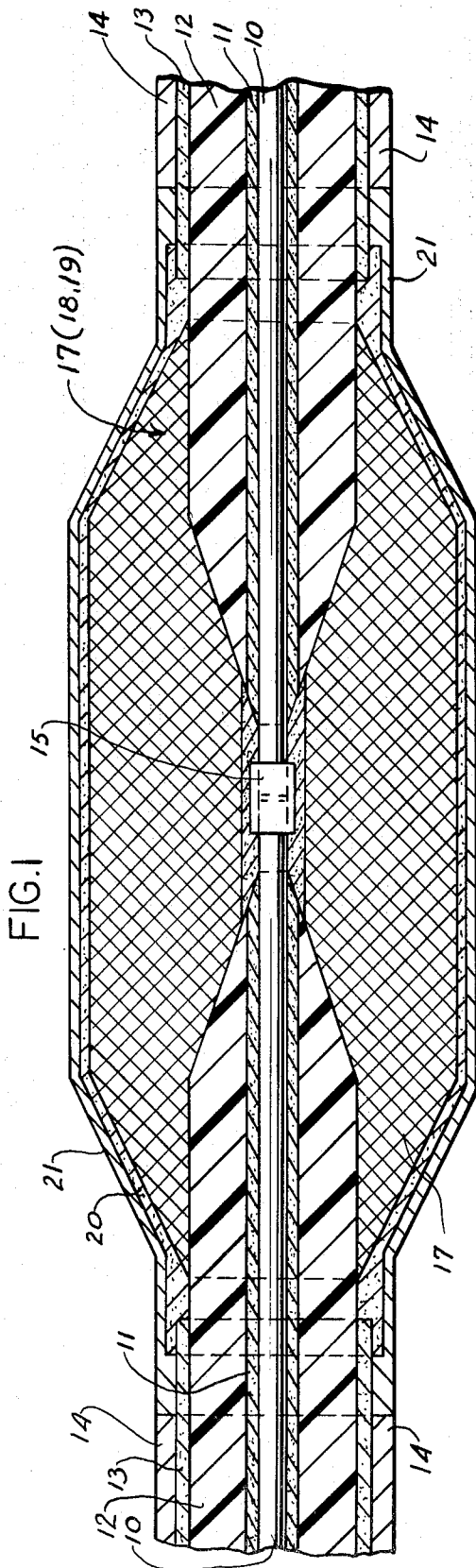
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[54] INSULATED CABLE JOINT
12 Claims, 4 Drawing Figs.

[52] **U.S. Cl.**..... 174/84,
156/49, 156/56, 174/120
[51] **Int. Cl.**..... **H01b 7/02,**
H02g 15/08
[50] **Field of Search**..... 174/84, 88,
120; 156/49, 51—53, 56

ABSTRACT: The conductor at a cable joint is insulated by successive layers of a rubber type tape, such as butyl rubber or ethylene propylene rubber tape, around the conductors and incorporating a plurality of layers of another type of tape, such as cross-linked polyethylene or polypropylene tape, which has a lower electric loss value than the rubber type tape, in successive single layers with at least two layers of the rubber type tape under each layer of the other type. The layers of rubber type tape are bonded to each other and each layer of the other type is preferably arranged in an open spiral so that the layer of rubber type tape above bonds to the one below. Also, each layer of the other type is preferably shrunk on the layer of the rubber type below it.

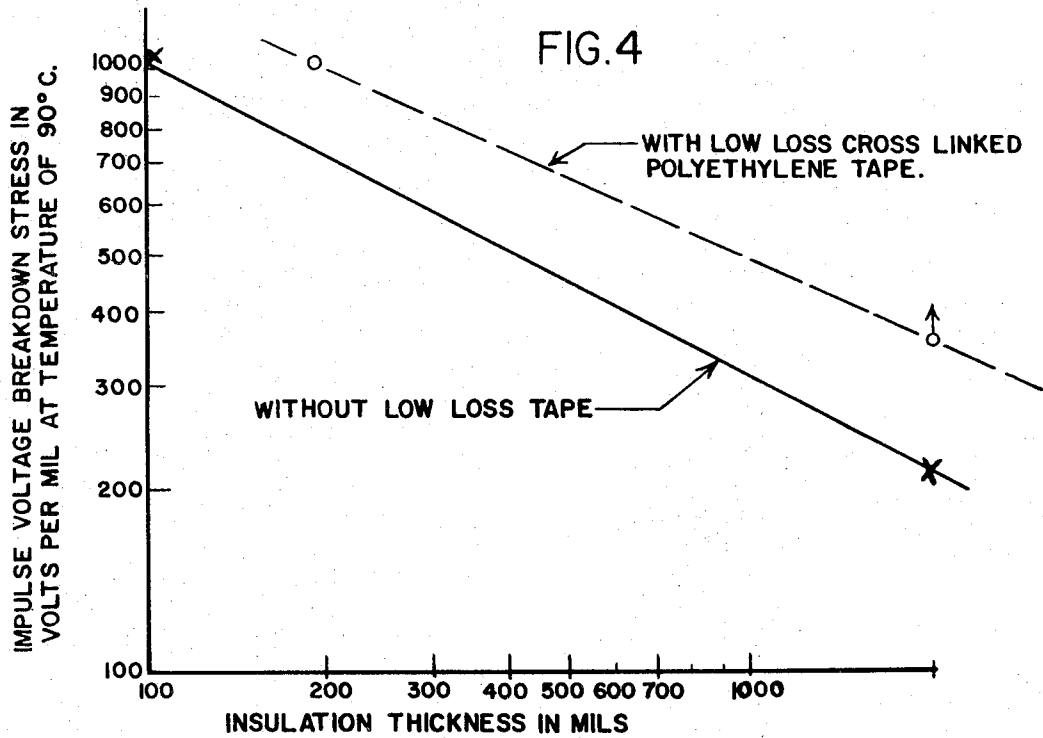
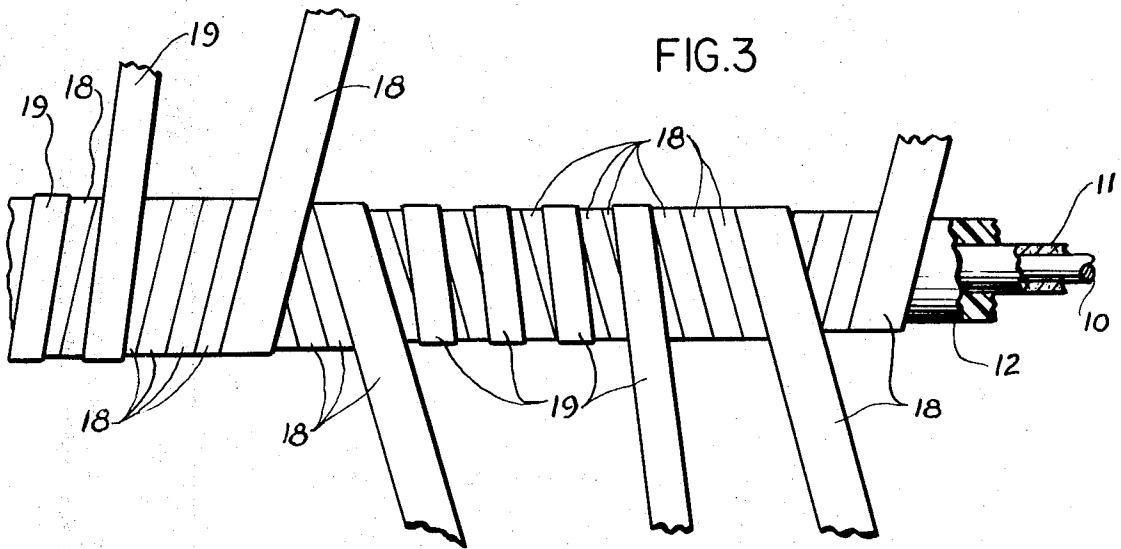




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INSULATED CABLE JOINT

The present invention relates to cable joints where in the cable insulation is stripped from the end portion of the conductors which are joined. In particular the invention relates to insulation for such joints and to a method of insulating them.

This invention is particularly adapted for insulating the joints of cable, such as extruded cable wherein the cable core, consisting of a conductor with a semiconductive shield around it, is encased in insulation, has a semiconductive shield around it and is enclosed by a sheath of metal, such as lead. At present joints in this type of cable are insulated either by molding insulation around them or by wrapping them with dielectric insulating tape. Suitable insulation for the joints should avoid corona discharges at the operating voltage of the cable and also have a high level of breakdown voltage. In general, corona discharge is controlled by eliminating voids in the insulation; the level of breakdown voltage is determined by the electric loss value of the insulation.

Molded insulation for such joints can, by present technology, be made with a high impulse level. However, it provides a relatively low level of corona discharge voltage due to present technological problems concerning elimination of voids in the joint insulation.

The wrapped tape insulation for the joints are normally formed by layers of a rubber-type tape, such as butyl or ethylene propylene rubber tapes, that are stretchable and self-bonding so that, if they are carefully and tightly wrapped, the occurrence of voids is minimized and the corona discharge voltage level is kept high. But these tapes have high electric loss values resulting in low levels of breakdown voltage. The breakdown is of the thermoelectrical type and the breakdown voltage is proportional approximately to the square root of the insulation thickness.

Butyl or ethylene propylene rubber tapes are useful in joints rated up to 35—40 kv, but they are marginal or unsuitable for the joints rated 69 kv. This is due to the fact that at reasonable thicknesses of the joint insulation—up to 3 times the thickness of the cable—the impulse and AC breakdown voltages are relatively low, and very often are below the desired value of the basic impulse level.

It is a principal object of the present invention to provide a wrapped tape form of insulation for cable joints, and a method of forming the insulation on the joint with which the corona discharge level is kept down to an acceptable value and in which the level of breakdown voltage is higher than can be provided with known forms of molded or wrapped tape joint insulation.

In accordance with the present invention, the insulation for the joint is formed by a plurality of layers of a stretchable, self-bonding dielectric rubber-type tape, such as butyl or ethylene propylene rubber tape, wrapped around the conductor, over any semiconductive shield around the conductor and the joint, with a single layer of another type of tape which has a lower electric loss value than the rubber-type tape, such as cross-linked polyethylene or polypropylene, between each few layers of the rubber-type tape.

A layer of the other type tape, which will hereinafter be referred to as the low-loss tape for convenience, is wound over every second, third, fourth or more layers of the rubber-type tape so that in the total thickness of the insulation a plurality of separate layers of the low-loss tape—at very least two and preferably more—are provided.

The use of the stretchable, self-bonding rubber type is adapted, as in known forms of wrapped tape insulation, to be wound around the conductor and over itself tightly without wrinkles or creases so as to minimize the occurrence of voids and to minimize the level of corona discharge. The inclusion of layers of low-loss tape prevents the buildup of hot spots in the insulation so as to increase the breakdown voltage. By incorporating a plurality of layers of the low-loss tape as single layers spaced among the layers of the rubber-type tape, each

single layer of low-loss tape may be wound on without itself causing voids, and by being interspersed throughout the thickness of the insulation, the several layers of the low-loss tape are well placed for effectively preventing the buildup of hot spots.

The cable joint insulation, and the method of forming it, in accordance with the invention will now be described in more detail with respect to the accompanying drawings in which:

FIG. 1 is a cross-sectional view longitudinally through a typical cable joint insulated in accordance with the present invention;

FIG. 2 is an enlarged cross section of a portion of the joint insulation appearing in FIG. 1, showing the layers of tape schematically;

FIG. 3, is an enlarged view of a section of the cable conductor at the joint illustrating a preferred manner of winding the successive tape layers thereon; and

FIG. 4 is a graph showing a comparison of the measured values of the breakdown voltages for joint insulation incorporating low-loss tape in accordance with this invention and for joint insulation from which the low-loss tape was omitted.

Referring to FIGS. 1 and 2, typical cable, for the joints of which insulation in accordance with this invention is particularly adapted to be used, is an extruded cable having a conductor 10 coated with a shield 11 of a semiconductive material and encased in insulation 12. The insulation 12 is coated with a shield 13 of semiconductive material and is enclosed in a sheath 14 metal, such as lead.

As indicated in FIG. 1, for joining sections of the cable sheath 14, the semiconductive shield 13, the insulation 12 and the semiconductive shield 11 are removed from the end portions of the cables to bare the end portions of the conductors 10. The insulation 12 is preferably tapered down to the bared end portions of the conductors. The ends of the respective conductors 10 are then brought together in a connector 15, which is a short tube of copper or other conductive material. The connector 15 may be a split tube and is usually crimped onto the conductor ends.

A shield 16 of semiconductive material is placed around the connector 15 and the adjacent bared portions of the conductors 10 and insulation 17, which consists of layers of a rubber type dielectric tape 18 with single layers of a low-loss tape 19 interspersed therein as illustrated in FIG. 2, is wrapped around the joint area. The insulation 17, which thus replaces the portion of cable insulation 12 removed for making the joint, will customarily be much thicker than the normal cable insulation 12, as shown. The nature of the insulation 17 and methods of applying it in accordance with the invention are subsequently described in detail. After the insulation 17 is in place it is covered with a shield 20 of semiconductive material, the ends of which overlap or are otherwise joined to the end edges of the shield 13 of conductive material that is around the cable insulation 12 under the metal cable sheath 14. Then a metal sheath 21 is placed around the joint area over the semiconductive shield 20 and connected at its ends to the ends of the metal cable sheath 14 to completely seal the joint. The metal sheaths 21 and 14 are suitably joined by butting and welding or soldering their adjacent edges together.

The rubber type dielectric tape 18 used in forming the insulation 17 is a stretchable, self-bonding tape which is suitably a butyl tape or ethylene propylene rubber tape. The low-loss tape 19 is a tape of dielectric material which has a lower electric loss value than the rubber-type tape 18. The tape 19 may be stretchable, but need not be, and is preferably a tape consisting essentially of cross-linked polyethylene or polypropylene.

The tapes 18 and 19 are wound around the cable joint area, the tape 18 being lapped, with at least two layers of the rubber-type tape 18 under each layer of the low-loss tape 19. A plurality of layers of the low-loss tape 19 (at least two and preferably more) are provided as single layers between multiple layers of the rubber-type tape 18 throughout the total thickness of the insulation 17 which is thus built-up in layers.

The rubber-type tape 18 is drawn taut and stretched as it is wound around the joint area so as to go on tight to assure a good bond between layers and to prevent the creation of voids.

As illustrated in FIG. 3, in accordance with the preferred method successive layers of the rubber-type tape 18 are wound on in opposite directions. Each layer of low-loss tape 19 is wound on in the same direction as the layer of tape 18 below it; the next layer of the rubber-type tape 18 wound over it is then wound in the same direction, the next successive layer of the rubber-type tape 18 being wound in the opposite direction. The low-loss tape 19 is preferably wound in shorter lays than the rubber-type tape 18 and is preferably wound in an open spiral so that the layer of rubber-type tape 18 over a layer of the low-loss tape bonds through the openings to the layer of rubber-type tape below.

In a preferred form using cross-linked polyethylene low-loss tape 19, the tape may be heated to a temperature of 130° F. as it is applied so that it shrinks when it cools, tightening it on the tape layers below to further assure the absence of voids.

As previously discussed, the inclusion of separate layers of low-loss tape 19 interspersed between layers of rubber-type tape 18 as described provides thermal barriers which prevent the buildup of hot spots and increases the breakdown voltage level of the insulation 17. And, by eliminating the creation of voids as much as possible, the level of corona discharge is minimized.

FIG. 4 is a graph comparing the impulse voltage breakdown stress in insulation incorporating layers of cross-linked polyethylene low-loss tape 19 according to this invention with the impulse voltage breakdown stress in insulation from which the low-loss tape was omitted. The insulation specimens were at a temperature of 90° C., and the breakdown voltage stresses are shown in volts per mil of insulation thickness. As indicated by this graph, the inclusion of the low-loss tape in accordance with this invention increases the stress level by more than 200 volts per mil. in insulation 200 mils. thick; for insulation 2000 mils. thick, the increase in stress level is over 150 volts per mil.

I claim:

1. A method of insulating a cable joint wherein the cable insulation has been removed from the adjacent end portions of two cable conductors which are joined, said method comprising successively wrapping at least two layers of a stretchable, self-bonding dielectric rubber-type tape spirally around the uninsulated portions of joined conductors, wrapping a layer of another type of dielectric tape, which has a lower electric loss value than said rubber-type tape, spirally around the outer

layer of said rubber-type tape, and similarly wrapping additional layers of said rubber-type tape and said other type tape to provide a plurality of layers of said other type tape with at least two layers of said rubber-type tape under each layer of said other type tape.

2. The method of claim 1 characterized by winding each successive layer of said rubber-type tape in the opposite direction from the layer directly below, winding each layer of said other type of tape in the same direction as the layer of said rubber-type tape directly below, and winding each layer of said rubber type above a layer of said other type tape in the same direction as the latter layer of said other type tape.

3. The method of claim 1 characterized by winding the layers of said other type of tape with shorter lays than the layers of said other type.

4. The method of claim 1 in which said other type of tape is wound in an open spiral.

5. The method of claim 1 in which said rubber type of tape is wound in overlapping spiral turns.

6. The method of claim 1 in which said rubber-type tape is from the group consisting of butyl rubber tapes and ethylene propylene rubber tapes.

7. The method of claim 1 in which said other type of tape is from the group consisting of cross-linked polyethylene tape and polypropylene tape.

8. The method of claim 1 in which said other type of tape is cross-linked polyethylene and is at a temperature of about 130° C. when it is applied whereby it shrinks in situ when it cools.

9. A cable joint wherein insulation around the joined conductors comprises a plurality of layers of a dielectric rubber type tape bonded to each other and a plurality of layers of another type of dielectric tape, which has a lower electric loss value than the rubber-type tape, interspersed between layers of the rubber-type tape with at least two layers of the rubber-type tape between each two layers of the said other type.

10. The cable insulation of claim 9 characterized by winding each layer of said other type tape in an open spiral, and wherein the layer of rubber-type tape above a layer of the other type tape is bonded through the openings in said spiral to the layer of rubber-type tape below.

11. The cable joint of claim 9 in which said rubber-type tape is selected from the group consisting of butyl rubber tapes and ethylene propylene rubber tapes.

12. The cable joint of claim 9 in which said other type of tape is selected from the group consisting of cross-linked polyethylene tape and polypropylene tape.

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