

[54] **METHOD OF SHIELDING HIGH VOLTAGE
SOLID DIELECTRIC POWER CABLES**

[75] Inventors: **Manuel A. Durakis**, Brooklyn; **David A. Silver**, Roslyn, both of N.Y.;
Frank P. Destito, Little Silver, N.J.

[73] Assignee: **General Cable Corporation**, New York, N.Y.

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[58] Field of Search **174/36, 102 SC, 105 SC, 174/106 SC, 107, 108, 109, 110 R, 110 AR, 110 PM, 110 N, 120 SC, 127; 156/51, 52, 53, 56**

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Primary Examiner—Bernard A. Gilheany
Assistant Examiner—A. T. Grimley
Attorney—Sandoe, Hopgood & Calimafde

[57] **ABSTRACT**

This insulation shielding for high voltage solid dielectric power cables includes a semi-conducting tape helically wrapped on the cable with overlapping convolutions. Voids that exist along the edges of the overlaps are bridged by semi-conducting coating sprayed, dipped, washed, wiped or otherwise applied substantially uniformly in thickness around the circumference of the insulation and lengthwise thereof. This bridging of the voids on the inner side thereof prevents corona in the voids and increases the voltage rating of the cable. The coating is bonded to the tape much more strongly than it is to the insulation so that the coating is pulled off the insulation when the tape is removed for terminations. The invention includes method aspects of applying the coating and the tape wrapping.

11 Claims, 2 Drawing Figures

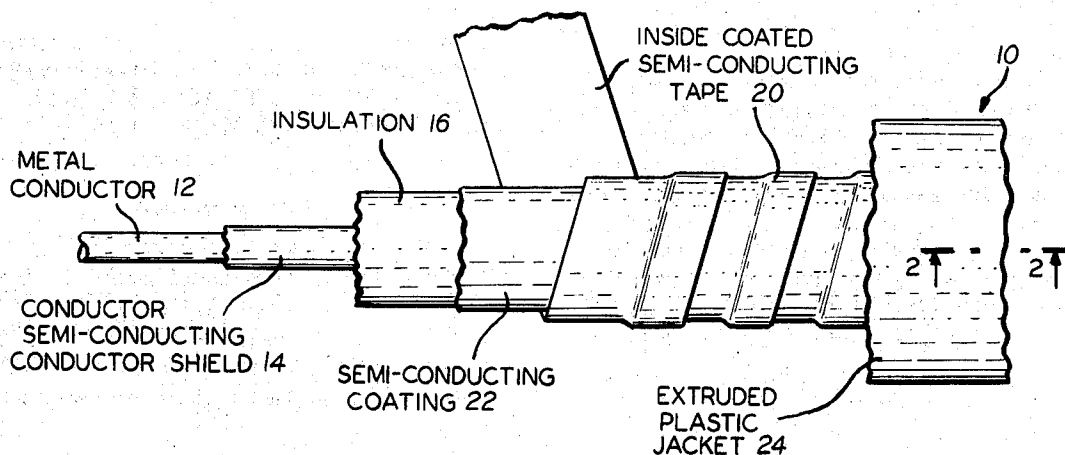


FIG. 1.

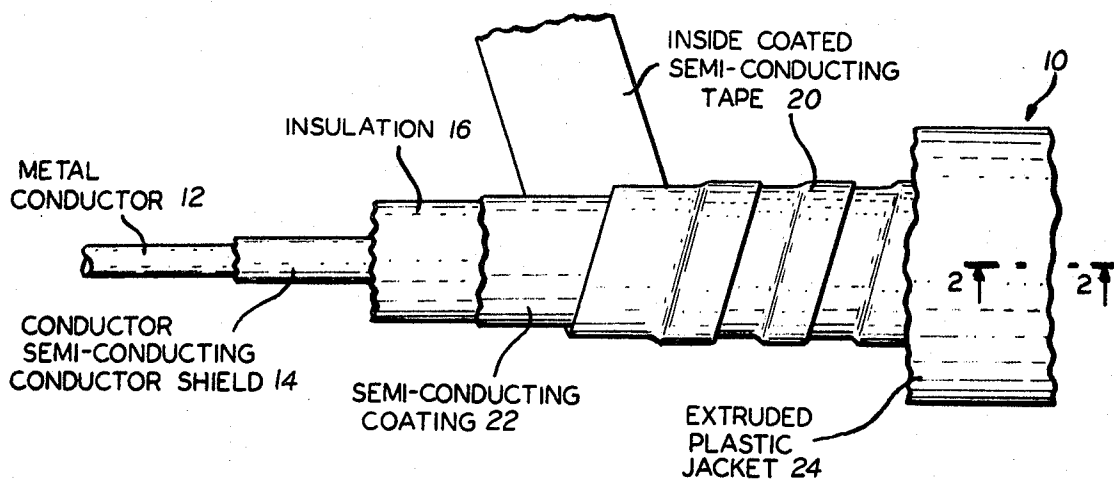
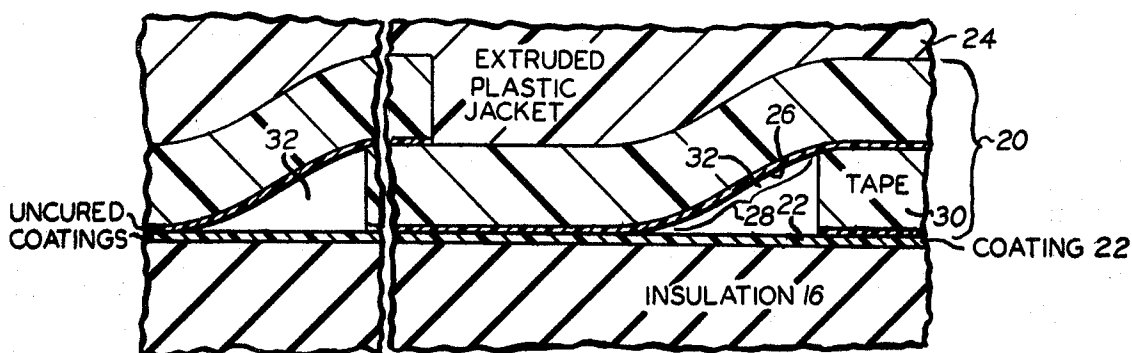


FIG. 2.



INVENTORS

Manuel A. Durkin
David A. Hilson
Donald P. Dettl

BY *Donald W. Haggard*
& *Colin M. De*

ATTORNEYS.

METHOD OF SHIELDING HIGH VOLTAGE SOLID DIELECTRIC POWER CABLES

BACKGROUND AND SUMMARY OF THE INVENTION

There are three basic ways of shielding the insulation of high voltage solid dielectric power cables, (1) a semi-conductive coating, (2) an extruded semi-conductive compound, and (3) a semi-conducting tape. The first method is not generally accepted because solvents are required to remove the shield and the installer's hands become contaminated with carbon black. The use of a semi-conducting tape is preferred by some users, even though it is more expensive than an extruded shield, because it can easily be removed at splicing or at terminating. This method, however, has been, over the years, one of the prime sources of trouble in high voltage cables meeting the minimum corona level.

This inconsistency in meeting the minimum corona level is primarily due to the voids created by the tape laps, the irregularities in the application of the tape, and in defects that sometime occur in the tape itself. This disclosure describes a method and a technique that completely overcomes these deficiencies in the use of a semi-conducting tape as the insulation shield on high voltage solid dielectric power cables and thereby assures a high corona level.

The improvement involves the addition of a supplemental thin coat of a semi-conducting material applied directly over the insulation prior to the application of the semi-conducting tape. This procedure bridges any voids that may have occurred at the taping operation, and assures that the completed cable will have a high corona level equivalent to a cable with an extruded semi-conductive insulation shield. As a result of this high corona level, this new method can now be considered for use as the insulation shield on high voltage cables rated 5 kV and higher.

The unique feature of this invention is that the semi-conductive coating is so formulated that it adheres, with the application of heat, to the semi-conducting tape and is removed with the semi-conducting tape when the cable is spliced or terminated. This feature eliminates the need of solvents to remove the coating and thereby overcomes the main objection to its use as an insulation shield in conjunction with a semi-conducting tape. The source of heat necessary for the semi-conducting tape to stick to the semi-conductive coating can be applied at taping or at any subsequent processing operation where heat is involved such as leading, thermoplastic jacketing, lead curing, continuous vulcanization (CV), oven heating, etc.

Other objects, features and advantages of the invention will appear or be pointed out as the description proceeds.

BRIEF DESCRIPTION OF DRAWING

In the drawing, forming a part hereof, in which like reference characters indicate corresponding parts in all the views;

FIG. 1 is a diagrammatic view of a high voltage power cable made in accordance with this invention and with each of the parts broken away to expose underlying parts; and

FIG. 2 is a fragmentary greatly enlarged sectional view taken on the line 2—2 of FIG. 1, and for a limited

portion of the radius of the cable so as to illustrate the tape and the coating between the insulation and the tape.

DESCRIPTION OF PREFERRED EMBODIMENT

A high voltage power cable 10 includes a metal conductor 12 which may be solid or stranded, and a semi-conducting conductor shield 14. There is the usual insulation 16 around the conductor shield 14. The construction thus far described is conventional.

The insulation shield for the cable includes a semi-conducting layer of tape 20 wrapped in a helix around the insulation and with an overlap of adjacent convolutions of the helix. Under the semi-conducting tape 20, the insulation shielding includes a semi-conducting coating 22 which is sprayed, dipped, washed, wiped or otherwise applied to the surface of the insulation around the entire circumference of the insulation and lengthwise of the insulation. This semi-conducting coating 22 is preferably substantially uniform in thickness and a thickness of from 1 to 3 mils has been found satisfactory. The thickness of the tape is between 9 and 11 mils.

An outer jacket 24 is extruded over the insulation shielding and this extruded jacket 24 fills in any irregularities caused by the overlapping convolutions on the outside of the tape 20 and provides a smooth outside surface for the cable. Such outer jackets are conventional on power cables.

FIG. 2 is a fragmentary sectional view showing the insulation shielding on an enlarged scale and with exaggerated dimensions to illustrate the construction and the way in which it operates to prevent corona and thus increase the rating of the power cable.

The insulation 16 may be polyethylene or any other conventional solid dielectric insulation commonly used on power cables. The coating 22 is preferably made of electrically conductive carbon black dispersed in solution of polyethylene dissolved in toluene. The amount of carbon black used depends upon the degree of conductivity which is desired for the coating and the amount of solvent used for the polyethylene depends upon the viscosity of the coating which is desirable for the particular method of the application and for the desired thickness of the coating 22. If a thin coating of only 1 mil is to be applied to the insulation, then the coating material is mixed with more solvent to obtain a lower viscosity than if a coating 3 mils thick is desired. Other solvents for polyethylene can be used and other plastic carriers for the carbon black can be used such as hypalon, neoprene and polyvinyl chloride (PVC).

It is important that the coating 22 when mixed with its solvent for application to the insulation 16 be a composition which is compatible with the material of the insulation. The electrically conductive carbon black dispersed in a solution of polyethylene dissolved in toluene is compatible with solid dielectrics such as butyl, ethylene propylene rubber (EPR), both the terpolymer and the copolymer, styrene-butadiene rubber (SBR), polyvinyl chloride (PVC), cross-linked polyethylene and other polyolefins. The insulation 16 should be cured before the coating 22 is applied and the coating 22 is purposely made with uncured plastic.

The tape 20 may be made of semi-conducting uncured butyl, or it may be made of other material that is semi-conducting and with a skim 26 of uncured plas-

tic on its inside surface. This skim 26 is bonded to the tape and contacts with the coating 22 except at places where the convolutions of the tape overlap one another and at places where the tape extends away from the coating 22 near the edge of an overlapped convolution. For example in FIG. 2 a portion of the tape extends away from the coating 22 along a section 28 as it rises to overlap an adjacent convolution 30 of the tape.

There is a void between the tape 20 and the insulation 16 at the section 28 of the tape but it will be evident from FIG. 2 that the coating 22 bridges this void on the side of the void adjacent to the insulation 16 to prevent corona in the void. Voids are shown at both of the overlaps illustrated in FIG. 2 and these voids are designated by the reference character 32.

Depending upon the stiffness and compressibility of the tape 20 and upon the way in which it is wrapped, the voids 32 may be of various shapes and at some locations there may be substantially no void at the overlap; the voids 32 in FIG. 2 being exaggerated for clearer illustration.

In applying the insulation shielding of this invention to a cable, the equipment should be designed and the method carried out so that the semi-conducting coating 22 is dry prior to the application of the semi-conducting tape 20. If the tape is applied before the coating is dry, residual solvents in the coating 22 will adversely affect the firm adhesion of the semi-conducting coating 22 to the tape 20 and this adhesion is an important feature of the invention.

Because of the fact that the insulation 16 is already cured before the coating 22 is applied, the coating 22 adheres only lightly to the insulation 16 but the coating 22 adheres tenaciously to the uncured surface of the tape 20 whether it is the entire tape which is uncured or whether it is merely an uncured skim 26 bonded to the tape. These uncured plastic surfaces are caused to adhere to one another by subjecting the cable to sufficient heat during manufacture. This heat may be that involved in leading, or in applying a thermo-plastic extruded jacket such as the jacket 24, or by continuous vulcanization or oven heating, as previously explained; all of these sources of heat being commonly employed depending upon the particular manufacturing process by which the cable is made and the outer jacket applied.

When the tape 20 is to be removed from an end portion of the cable for splicing or terminating, the tape is unwrapped in the usual way and because of the tenacious bond between the tape and the coating 22, the coating is pulled off the insulation with the tape and the insulation is left bare of any semi-conducting material without requiring special treatment prior to the splicing or terminating.

The preferred embodiment of the invention has been illustrated and described, but changes and modification can be made, and some features can be used in different combinations without departing from the invention as defined in the claims.

What is claimed is:

1. A high voltage solid dielectric power cable including an insulated conductor, a continuous coating of semi-conducting material covering the outside surface of the insulation, a semi-conducting shielding tape wrapped around the insulation over said semi-conducting coating and adhered to said semi-conducting coating, the coating adhering to said semi-

conducting shielding tape more strongly than any adherence of the coating to the insulation so that removal of the semi-conducting shielding tape from an end portion of the cable removes the coating from the insulation along said end portion of the cable.

2. The high voltage power cable described in claim 1 characterized by the semi-conducting coating being a layer of substantially uniform thickness adhered to the insulation but much more strongly adhered to the semi-conducting shielding tape, and the semi-conducting shielding tape being applied to the insulation with a helical wrap.

3. The high voltage power cable described in claim 1 characterized by the tape being applied to the insulation over said coating with an overlapping helical wrap with voids where convolutions of the tape in contact with the coating extend outward to overlap the next convolution of the tape, the tape being a semi-conducting tape and the semi-conducting coating on the insulation bridging the voids of said overlaps to prevent corona in said voids.

4. The high voltage power cable described in claim 1 characterized by the semi-conducting coating being a thermoplastic material and the insulation having a cross linked polymer surface to prevent formation of any substantial bond between the semi-conducting coating and the insulation, the semi-conducting tape having on its inside surface a semi-conducting uncured elastomeric skim that forms a strong bond to the semi-conducting coating when the cable is subjected to heat.

5. The high voltage power cable described in claim 3 characterized by an extruded plastic jacket over the outside of the tape and filling in irregularities on the outside of the tape caused by overlapping of convolutions of the tape and providing a smooth outside surface for the cable.

6. The high voltage power cable described in claim 4 characterized by coating being coating being a mixture of conductive carbon black dispersed in a solution of polyethylene dissolved in toluene and the coating being a mixture that dries to a smooth non-tacky surface and of a thickness of approximately 1 to 3 mils and the coating being compatible with insulation from the group consisting of butyl, ethylene propylene rubber (EPR), both the terpolymer and the copolymer, styrene-butadiene rubber (SBR), polyvinyl chloride (PVC), cross-linked polyethylene and other polyolefins, the semi-conducting tape having on its inside surface a semi-conducting uncured elastomeric skim, the total thickness of the tape being between 9 and 11 mils.

7. A high voltage solid dielectric power cable including a conductor, a coating of semi-conducting material on the conductor, insulation surrounding the semi-conducting coating, a coating a semi-conducting material on the insulation and in continuous contact with the insulation circumferentially and longitudinally, a helical wound insulation shielding tape surrounding the insulation and having overlapping convolutions with some voids under the tape at the end of the overlaps of the tape convolutions, each void being of generally triangular longitudinal cross section and being bounded at one end by an edge of the tape and at its other respective sides by the inside surface of the tape and the outside surface of the coating of semi-conducting material on the insulation whereby the voids are rendered harmless.

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8. The high voltage power cable described in claim 7 characterized by the coating on the insulation being from 1 to 3 mils in thickness and having a smooth, non-tacky surface bridging the voids, and the tape being of substantially greater thickness than the coating, and the overlapping portions of the tape being bonded to each other.

9. The method of shielding a high voltage solid dielectric power cable which comprises applying to the outside surface of a cross-linked insulated conductor a semi-conducting coating containing electrically conductive particles dispersed through a thermoplastic carrier dissolved in a solvent applying the semi-conducting coating as a continuous covering around the circumference of the cross-linked insulation and lengthwise thereof, drying the coating to a smooth non-tacky surface by evaporation of the solvent, and after the coating is dry helically wrapping the coated insulation with a semi-conducting tape having overlapping convolutions with voids at edges of the overlaps, the voids being bridged by the semi-conducting coating on the insulation.

10. The method described in claim 9 characterized

by cross-linking the insulation prior to coating it, using a semi-conducting thermoplastic as the coating, applying the semi-conducting tape with an inside surface that is uncured elastomer with electrically conductive carbon black dispersed therein, and heating the cable to bond the thermoplastic semi-conducting coating to the uncured elastomer.

11. A high voltage cable comprising a conductor, a shielding layer of semi-conducting material on the conductor, a primary insulating layer of extruded material covering such shielding layer and having minute depressions in its outer surface, a semi-conducting tape wound around said insulating layer along substantially the entire cable length and partially lapped, resulting in a void where the tape overlaps, and a coating of semi-conducting adhesive dried on the outer surface of the insulating layer throughout its length and covered by the tape, said adhesive filling said depressions, enclosing and rendering harmless said void along the lap of the overlying tape, and having stronger adhesion to the tape than to said insulating layer.

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