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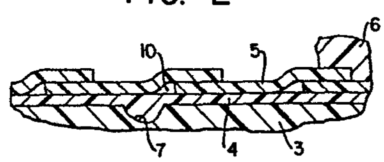
(54) **Insulation shield for a high-voltage cable.**

(57) A high voltage solid dielectric cable wherein a coating (4) of high dielectric constant material is applied to the surface of the insulation layer (3) prior to the application of a semi-conducting insulation shield (5) which is formed of semi-conducting tape wound helically over the coated insulation with overlapping adjacent edges. The combination of the high dielectric coating and the semi-conducting nature of the shield acts to reduce the occurrence of insulation deterioration caused by partial discharges in the gaseous voids formed under the tape in the regions of overlap (10). Scratches (7) in the insulation are filled with the coating thereby eliminating the occurrence of partial discharges within these scratches.

FIG. 2



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TITLE MODIFIED
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INSULATION SHIELD FOR EXTRUDED HIGH VOLTAGE CABLE

This invention relates to extruded-type high voltage cables, and in particular to those cables including an insulation shield formed of semi-conducting tape.

A high voltage cable to which the present invention is applicable typically comprises a metal conductor which is surrounded by a semi-conducting conductor shield, a body of polymeric insulation, a semi-conducting insulation shield, a metallic shield and an overall covering such as polyethylene or polyvinyl chloride (PVC). The insulation shield may be, for example, a body of semi-conducting compound which is extruded over the insulation. It is particularly advantageous, however, for this insulation shield to be formed of semi-conducting tape which is applied helically over the insulation. Such a tape-type insulation shield offers the advantage of being easily stripped back when it is desired to splice or terminate an end of the cable.

A tape-type insulation shield, such as the one above described, is typically applied in a manner such that the edges of adjacent windings of the tape overlap over about 10 to 50% of the area of the tape. Gaseous voids facing the insulation are thus formed under the tape in the region of these overlapped edges. When a high voltage is applied between the conductor and ground, high voltage stresses develop in these gaseous voids. Under such high voltage stresses partial discharges appear in the gaseous voids thus causing degradation of the insulation and premature failure of the cable. Since such partial discharges may occur in the gaseous voids under the typical operating voltage of a high voltage cable, the service length of such a cable may be shortened significantly.

The problem of partial discharges in gaseous voids is exacerbated when the tape has imperfections such as non-uniform edge thickness or torn edges. Such imperfections may result in increased size of the voids which results in more intense partial discharges and an increased rate of insulation degradation.

It is known that the application of a semi-conducting coating over the insulation before the application of the semi-conducting tape can reduce the voltage stresses within the gaseous voids and thereby mollify the partial discharge problem. Unfortunately, such semi-conducting coatings are difficult to remove from the cable ends during the preparation of terminations and splices.

US Patent No.3748369 of Durakis et al discloses a semi-conducting coating which has greater adhesion to the semi-conducting tape applied over it than to the insulation. When the semi-conducting tape is removed from the ends of the cable for termination purposes, the semi-conducting coating is removed together with the tape. There are, however, two problems associated with the shielding method set forth by Durakis.

Firstly, when the tape is removed for cable termination purposes, narrow strips of residual semi-conducting coating are often left on the insulation surface. Such residue may be difficult to remove and, if not removed, may cause premature failure of the cable termination.

Secondly, if the surface of the insulation layer is scratched during the processing of the cable core these scratches may be filled by the semi-conducting coating thereby forming semi-conducting protrusions into the insulation. Under high voltage operating conditions, high local voltage stresses appear at the ends of these protrusions. It is well established that such local high voltage stresses may significantly decrease the life expectancy of extruded-type cables.

It has been discovered that the application of an insulating material to the surface of the insulation layer prior to the application of the tape-type insulation shield offers a solution to the problem of partial discharges within the gaseous voids at the overlapped edges of the tape. Moreover, coating the surface of the insulation with such an insulating material avoids the disadvantages associated with the prior practice of applying a semi-conducting material to the insulation surface.

An insulation material in accordance with the present invention should have an apparent dielectric constant higher than that of the insulation. The high apparent dielectric constant together with the semi-conducting nature of the tape results in considerably decreased voltage stresses in the gaseous voids at the overlapped edges of the tape. Partial discharges in the gaseous voids are thereby eliminated at normal operating voltages and under typical overvoltage conditions.

In a preferred embodiment this coating provides a strong bond to the semi-conducting tape and a modest bond to the insulation surface. When the semi-conducting tape is removed prior to cable termination, therefore, most of the coating is removed with it. Moreover, any residual coating which is left on the cable surface will not affect the performance of the cable termination because of the insulating nature of the residue.

An additional advantageous aspect of the present invention is that the coating fills any scratches which may be present on the surface of the insulation layer of the cable. Due to the insulating nature of the coating, high local voltage stresses within the scratches are avoided and the life expectancy of the cable is, thereby, further extended.

It is an object of the present invention, therefore, to provide a high voltage extruded-type cable having a tape-type semi-conducting shield in which partial discharges are prevented from occurring in the gaseous voids in the region of the overlapping edges of the tape.

It is a further object of the invention to provide a high dielectric insulation coating which adheres strongly to a tape-type insulation shield and modestly to the insulation.

It is a still further object of the invention to provide a high dielectric coating for the insulation layer of an extruded-type cable which fills any scratches on the surface of the insulation layer, thereby preventing local high voltage stresses from occurring within the scratches.

The above objects and further objects, advantages and features of the present invention will be apparent from a consideration of the following description in conjunction with the appended drawings in which:

Figure 1 is a diagrammatic view of a high voltage power cable manufactured in accordance with the present invention; and

Figure 2 is a greatly enlarged sectional view taken on the line 2-2 of Figure 1.

Referring now to the drawings, there is shown a typical high voltage cable which is manufactured in accordance with the present invention. The cable includes a metallic conductor 1, which may be solid or stranded, a semi-conducting conductor shield 2, and a body of polymeric insulation 3 which may, for example, be formed of a material such as polyethylene, cross-linked polyethylene or ethylene propylene rubber. The surface of the insulation 3 is coated with a high dielectric constant insulating material 4 in accordance with the present invention. The coated insulation layer is covered by an insulation shield 5 which comprises semi-conducting tape which is applied helically over the insulation with the overlap between adjacent windings being typically between 10 to 50%. An extruded jacket 6 of, for example, polyethylene or polyvinylchloride (PVC) is typically applied over the insulation shield. Such a cable may also include a metallic shield (not shown in the diagrams) between the insulation shield 5 and the cable jacket 6.

Referring to Figure 2, it will be noted that a gaseous void will typically exist in the region at which adjacent edges of the insulation shield overlap (indicated by reference numeral 10). If it were not for the presence of the high dielectric constant coating 4 of the present invention, partial discharges would occur in these voids under the high voltage stress conditions typical of normal operation of the cable. These partial discharges would cause decomposition of the portion of the insulation 3 facing the void in which the partial discharge occurred. In the cable of the present invention , however, presence of the high dielectric constant coating 4, in combination with the semi-conducting nature of the insulation shield 5, acts to reduce the voltage stresses in the void, thereby preventing the occurrence of partial discharges and the consequent decomposition of the insulation.

Reference numeral 7 of Figure 2 indicates an area of the insulation at which its surface has been scratched. Even if great care is taken during the manufacture of the cable it is impossible to completely prevent the occurrence of such scratches. The high dielectric constant coating 4 fills the scratches thereby preventing high local voltage stresses from occurring at the ends of the scratches. Partial discharges are thereby prevented from occurring within the scratches and the degradation of the insulation and premature cable failure caused by such discharges is therefore, avoided. It will be appreciated that if such scratches were left unfilled, or if they were filled with a semi-conducting material, high local voltage stresses and/or partial discharges would occur within the scratches thereby causing degradation of the insulation and consequent premature cable failure.

The insulation coating 4 should be an insulating material which has an apparent dielectric constant higher than that of both the insulation 3 and the insulation shield tape 5. It may be paint-type material (eg. one which is suitable for application by spraying, dipping, washing, wiping, etc.) or a material suitable for extrusion over the insulation. It has been found, however, that a paint-type coating is best suited for being removed with the conductor shield tape during termination operations, and is thus preferable.

A paint-type coating as above described may be obtained by dispersing a high dielectric constant filler material in solution comprising a polymer or copolymer which has a dielectric constant similar to that of the material comprising the insulation layer of the cable , and a suitable solvent such as toluene. The filler material may be titanium dioxide powder or a material having a similar dielectric constant (eg. a material having a dielectric constant of approximately 3.0 or above). The polymeric material may be one such as polymer butyl rubber, ethylene propylene rubber or polyethylene. Preferably, the concentration of the filler in the coating should be in the range of about 20 to 60% by weight. The amount of solvent in the coating depends upon the desired viscosity of the coating and typically should be increased with increases in the amount of filler utilised.

If a paint-type coating, such as the one above described is employed, the semi-conducting tape employed as the insulation shield should be one of uncured butyl rubber, uncured ethylene propylene rubber or other forms of uncured plastics. The coating should be dried before the application of the semi-conducting tape because the solvent may adversely affect the adhesion properties of the coating to both the surface of the insulation and to the semi-conducting tape.

An alternative embodiment of the insulation coating 4 is one which is suitable for extrusion over the insulation. Such a material may be obtained by dispersing a filler material such as above described in a material such as ethylene vinyl acetate copolymer, ethylene propylene rubber or any other copolymer which is suitable for mixing with the filler employed. The amounts of filler material in the dispersion should be in the range of about 20 to 60% by weight. If such an extruded insulation coating is employed, cured cross-linked tape may be employed to form the insulation shield.

In both of the above described embodiments of the insulation coating, the thickness of the coating should be in the range of approximately 1 to 10 mils. In the case of the paint-like embodiment of the coating the desired thickness may be obtained by appropriately selecting the relative proportions of filler material and solvent to be utilised.

It will be understood that the foregoing description of preferred embodiments of the present invention is for purposes of illustration only, and that various structural and operational features as herein disclosed are susceptible to a number of modifications and changes, none of which entail any departure from the spirit and scope of the present invention as defined in the hereto appended claims.

CLAIMS:

1. A high voltage power cable comprising:

an inner core comprising a metallic conductor 1 surrounded by a semi-conducting conductor shield 2;

a body of polymeric insulation 3 surrounding said inner core; characterised in that

a coating 4 of high dielectric constant material covers the outside surface of said insulation 3, said coating having a thickness of less than approximately 10 mils and an apparent dielectric constant greater than the dielectric constant of said insulation 3; and that

a semi-conducting insulation shield tape wrapper 5 surrounds said insulation over said coating 4 with an overlapped helical wrap.

2. A cable in accordance with claim 1 characterised in that said coating 4 has the property of adhering strongly to said semi-conducting tape 5 and adhering less strongly to the outside surface of said insulation 3.

3. A cable in accordance with claim 1 characterised in that said coating has an apparent dielectric constant of approximately 3.0 or above.

4. A cable in accordance with claim 1 characterised in that said coating 4 consists essentially of an admixture of a high dielectric constant filler material and a polymer or copolymer, compatible with said filler material, and having a dielectric constant similar to that of said insulation 3.

5. A cable in accordance with claim 4 characterised in that said filler material consists of a powder of titanium dioxide;

and said polymer or copolymer is selected from the group consisting of butyl rubber, ethylene propylene rubber and polyethylene.

6. A cable in accordance with claim 4 characterised in that the proportion of said filler material in said coating is in the range of 20 to 60% by weight.

7. A cable in accordance with claim 4 characterised in

that said filler material consists of a powder of titanium dioxide and said polymer or copolymer is selected from the group consisting of ethylene vinyl acetate copolymer, and ethylene propylene rubber.

8. A cable in accordance with claim 4 characterised in that said tape 5 is uncured plastics material.

9. A cable in accordance with claim 8 characterised in that said uncured plastics material is selected from the group consisting of uncured butyl rubber and uncured ethylene propylene rubber.

10. A cable in accordance with claim 4 characterised in that said tape 5 is a cured cross-linked material.

11. A method for constructing a high voltage power cable characterised in that

a high dielectric coating is applied to the outside surface of a polymer insulated conductor, said coating having a thickness of less than approximately 10 mils and an apparent dielectric constant greater than the dielectric constant of the underlying polymer insulation; and that

a semi-conducting tape is applied helically over the coated insulation so that adjacent edges of the tape overlap.

12. The method of claim 11 characterised in that said coating applying step comprises:

painting the outside surface of the insulation with a mixture of titanium dioxide powder and a solution of polymeric material in toluene; and

drying the coating to eliminate the toluene solvent prior to the tape application step.

13. The method of claim 11 characterised in that said coating applying step is accomplished by extruding a layer of titanium dioxide powder filled copolymer uniformly over the surface of the insulation to a thickness in the range of between 1 and 10 mils.

FIG. 1

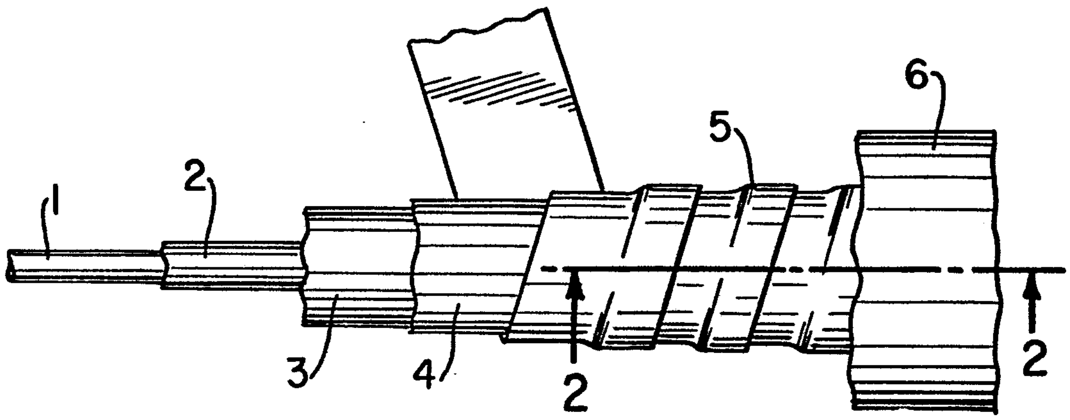
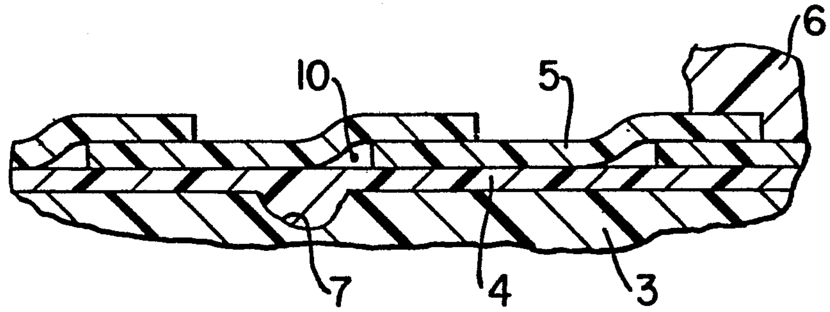


FIG. 2



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EUROPEAN SEARCH REPORT

0076579

Application number

EP 82304808.7

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
	US - A - 3 287 489 (HVIZD)		H 01 B 9/02
X	* Column 1, line 31 - column 3, line 2; column 3, lines 27-44; fig. 1,3 *	1,3-6	H 01 B 13/22
Y	* Column 1, line 31 - column 3, line 2; column 3, lines 27-44; fig. 1,3 *	7-10	
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D,Y	US - A - 3 748 369 (DURAKIS) * Fig. 1,2; column 2, lines 6-67 *	1-4,7-10,11-13	
	--		
Y	US - A - 4 008 367 (SÜNDERHAUF) * Column 1, line 29 - column 2, line 68; fig. *	1-4, 11-13	

			TECHNICAL FIELDS SEARCHED (Int. Cl ³)
			H 01 B 9/00
			H 01 B 13/00

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	10-12-1982	KUTZELNIGG

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document
T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
& : member of the same patent family, corresponding document