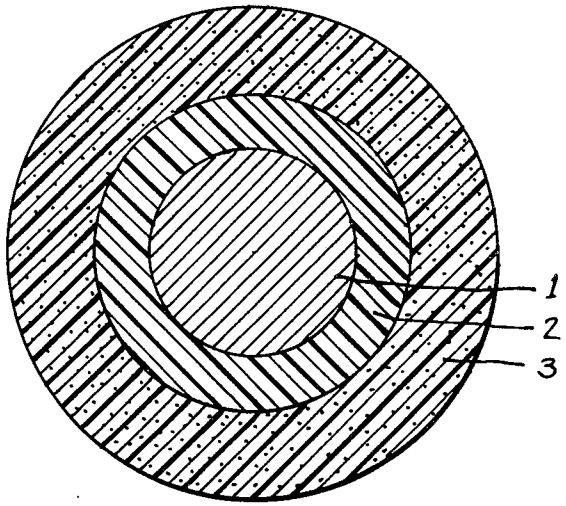
July 18, 1972 L. LOMBARDI 3,677,849

MEDIUM VOLTAGE CABLES

Original Filed May 20, 1968



INVENTOR.
LUIGI LOMBARDI
BY
Ward McElhannon Brooks & Fitzpatrick
ATTORNEYS

United States Patent Office 3,677,849
Patented July 18, 1972

3,677,849

MEDIUM VOLTAGE CABLES

Luigi Lombardi, Milan, Italy, assignor to Pirelli Società per Azioni, Milan, Italy

Original application May 20, 1968, Ser. No. 730,657, now Patent No. 3,541,228, dated Nov. 17, 1970. Divided and this application Oct. 6, 1969, Ser. No. 870,906
Claims priority, application Italy, May 23, 1967, 16,392/67
Int. Cl. H01b 13/08, 13/19
U.S. Cl. 156—53 5 Claims

ABSTRACT OF THE DISCLOSURE

Describes a medium voltage cable including an insulating layer and a semiconductive layer in contiguous but not adhesive relationship. The insulating layer is an amorphous olefine copolymer, saturated or unsaturated, and the semiconductive layer is a composition containing carbon particles dispersed in chlorosulfonated polyethylene.

Product is prepared by heat treatment of the superimposed layers on a conductor.

This application is a division of application Ser. No. 730,657, filed May 20, 1968, now U.S. Pat. 3,541,228, issued Nov. 17, 1970.

BACKGROUND OF THE INVENTION

Medium voltage cables, i.e. cables designed for the range of about 1000 to 30,000 volts are known. Generally they comprise a conductor such as a copper wire or tube insulated with elastomeric materials, particularly cured polyolefin polymers, especially amorphous copolymers which may be saturated or unsaturated. The cables also include at least one semiconductive or screening layer.

These cables are often designed with an insulating layer disposed or sandwiched between two semiconductive layers in order to provide an equipotential surface to make the electric field of the insulating material uniform. The semiconductive layer forming the outer covering can be placed either by extruding the semiconductive composition on the conductor which is coated with at least the insulating layer, or by helically winding a tape of semiconductive composition on the same unit. In the latter case the semiconductive composition is normally a tape of fabric impregnated with conductive carbon particles and an adhesive agent.

Medium voltage cables prepared by either of these measures have proved deficient in that the semiconductive layer is merely superimposed on the insulating layer and that there are hollow spaces between the two layers which give rise to loss of efficiency due to ionization phenomena.

Attempts to avoid these difficulties by the use of adhesives to adhere the one layer to the other have been unsatisfactory because of the difficulties which arise in separating the layers when it is necessary to join or splice one cable to another.

It has therefore long been a problem in the art to provide a medium voltage cable charatcerized by a close, intimate, contiguous surface to surface contact between the insulating and semiconductive layers to thereby avoid losses due to ionization phenomena. The contact should be non adhesive so that separate cables can be readily spliced with out undue difficulty.

THE INVENTION

This invention provides medium voltage cables in which a conductor is insulated with a layer of a cured polyolefin copolymer insulating material. The insulating layer is in a contiguous relationship with at least one semiconductive layer which is derived from a semiconductive composition comprising conductive carbon particles dispersed in chlorosulfonated polyethylene. The insulating layer may be adjacent to the conductor and under the semiconductive layer, or it may be sandwiched between two semiconductive layers, one of which is adjacent the conductor.

In the accompanying drawing, a cable prepared according to the present invention is shown in tranverse section.

The term "contiguous" is used herein to define the relationship between the layers. It means that there is close, intimate, non-adhesive contact between the surfaces of adjacent layers, and that there is substantially no air space between the surfaces. The contact between the adjacent surfaces is a pressure contact similar to the contact achieved by the well known process of force fitting a metal shaft in a disc. Because of the adhesive free contact between layers they can be readily separated for splicing.

It has been discovered that a contiguous relationship can be achieved between adjacent layers of cured, amorphous, saturated or unsaturated, polyolefin elastomers and semiconductive compositions comprising conductive carbon particles dispersed in a chlorosulfonated polyethylene polymer. This relationship is achieved by a heat treatment either subsequent to the placing of the layers in adjacent contact or while the layers are being placed in this relationship.

In one embodiment of the invention, which is preferred because of economy and efficiency, the semiconductive screening layer is placed over the insulating layer by winding a tape of the semiconductive composition obtained from a calendered sheet.

The insulating elastomeric materials utilized in the instant invention are cured compositions which are either saturated or unsaturated amorphous polyolefins. They are known insulating materials which are substantially linear, amorphous, high molecular weight copolymers obtained by copolymerization of ethylene with α-olefins containing one or more double bonds. If the olefin is a diene the double bonds may be conjugated or unconjugated. Copolymerization is effected by known techniques. The most common α-olefin used in the preparation of these products is propylene. Unsaturated products are obtained from conjugated or unconjugated dienes such as

butadiene;
isoprene;
2,3-dimethyl butadiene;
1,4-pentadiene;
2-methyl-1,4-pentadiene;
1,5-hexadiene;
2-methyl-1,5-hexadiene;
1,4-hexadiene;
1,4-heptadiene;
1,5-heptadiene;
1,5-octadiene;
dicyclopentadiene;
2-methylene-2,5-norbornene;
4,7,8,9-tetrahydromethylindene; and similar compounds.

For use in this invention the insulating compositions are compounded by previously known methods with the appropriate curing or cross-linking agents, accelerators, plasticizers, anti-oxidants, reinforcing fillers and the like. The composition may be extruded onto the base conductor or onto the conductor already coated with a semiconductive layer. They are then cured as described in more detail below.

The chlorosulfonated polyethylenes used in the invention are known products obtained by reacting polyethylene with chlorine and sulfur dioxide in accordance with known methods. Generally the polyethylene utilized has a num-

ber average molecular weight of the order of about 20,000. The sulfur content of the product is normally from about 1.2% to 1.7%, and the chlorine content from about 26% to 40%. The use of chlorosulfonated polyethylene as the carrier for the semiconductive compositions is a special feature of this invention. In addition to the fact that it is possible by utilization of the polymer to effect the above descrbed contiguous relationship, the polymer also has excellent physical and mechanical characteristics. This makes it possible to obtain calendered sheets of minimum thickness to be utilized in the preparation of the winding tapes employed in the invention.

Referring to the accompanying drawing which represents an embodiment of the present invention, metallic conductor **1** is surrounded by covering **2** which is an insulating layer of a cured polyolefin copolymer insulating material. Insulating layer **2** is in turn covered by conductive layer **3** derived from a composition comprising conductive carbon particles dispersed in chlorosulfonated polyethylene. Layers **2** and **3** are in close, intimate, non-adhesive contact with each other at their adjacent surfaces.

For the preparation of the semiconductive compositions, the chlorosulfonated polyethylene is compounded with the appropriate ingredients, including the conductive particles, plasticizers such as basic lead phthalate and stabilizers such as polyethylene glycol. The compounding procedures are in accordance with standard practice. Useful compositions suggested by way of example may contain, for example, from about 40 to 70 parts carbon black, 10 to 20 parts basic lead phthalate and 0.5 to 1 part of polyethylene glycol per 100 parts of chlorosulfonated polyethylene. For the preparation of tapes the composition is calendered to produce a sheet having a thickness of from about 0.1 to 0.5 mm. from which the tapes can be prepared by cutting.

The products of this invention may be prepared by any of a number of methods. All of them include a step in which a semiconductive layer in contact with an insulating layer is heated at a temperature of from about 100° C. to 200° C. for a sufficient period of time to effect the contiguous relationship. During this period the semiconductive material may seal to itself at overlapping points. The time of heating may vary within a very wide range, and the best time will be selected on the basis of the selected temperature, the dimensions of the cable, economy and ease of operation. Suitable heating periods will normally be within the range of from about 30 minutes to 3 hours.

In one procedure a tape of the semiconductive composition is helically wound on a conductor previously coated with the cured polyolefin elastomer and the resulting product heated as described above.

Alternatively the semiconductive composition may be coated directly on the conductor by extruding or by winding a tape, and the insulating material extruded onto the first layer. This product may be coated with a second semiconductive layer, and the completed unit heated to effect simultaneous curing of the insulator and pressure fitting of the semi-conductive layers to the conductor and to the insulating layer.

In still another embodiment of the invention the semiconductive composition may be extruded directly on an insulated conductor at a temperature in the above defined

range so as to obtain a semiconductive layer in contiguous relationship with the insulating layer in one operation.

One very convenient procedure for heating the unit comprising the conductor and the insulating and semiconductive layers is to cover it with a protective sheath in the form of a heat stable fabric such as cotton, rayon, nylon or the like, or to cover it with a metallic sheath. In either event the protected unit is then conducted through a heating zone such as an oven to bring the temperature to the defined level. The protective sheath is then removed.

A permanent protective sheath can also be used. For example, the unit could be coated with an elastomer such as polychloroprene, by any of the usual methods such as extrusion, and the protected unit then heated to cure the elastomer while at the same time bringing the semiconductive layer into contiguous relationship with the insulating layer.

What is claimed is:

1. A process for the production of a medium voltage electric cable including the steps of covering a conductor with an insulating layer based on an amorphous olefin copolymer selected among the saturated and unsaturated amorphous olefine copolymers and then curing said copolymer, placing a semiconductive layer comprising a conductive composition containing carbon particles dispersed in chlorosulfonated polyethylene over said cured copolymer layer, and heating the resulting product at a temperature of from about 100° C. to 200° C. to establish close, intimate, non-adhesive contact between the cured insulating layer and the semiconductive layer.

2. A process as in claim **1**, in which the semiconductive layer is placed over the insulating layer by winding a tape of the composition around the insulating layer.

3. A process as in claim **1** wherein the semiconductive layer is placed and heated simultaneously by extruding the semiconductive composition onto the conductor coated with the insulating layer at a temperature of from about 100° C. to 200° C.

4. A process as in claim **1** in which heating is effected by enclosing the product to be heated in a heat stable sheath and passing it through a heated oven.

5. A process as in claim **1** in which heating is effected by enclosing the resulting product in an extruded curable elastomeric sheath and curing the sheath.

References Cited

UNITED STATES PATENTS

3,378,419	4/1968	Eich et al.	156—53
3,229,012	1/1966	Garner	156—51 X
2,960,426	11/1960	O'Mahoney	156—306 X
2,471,905	5/1949	Smith	156—309 X
2,624,777	1/1953	Abbott et al.	156—51 X
3,187,071	6/1965	Radziejowski	156—51 X
3,197,553	7/1965	Nicolas	156—51 X
3,479,446	11/1969	Arnaudin et al.	156—51 X

CARL D. QUARFORTH, Primary Examiner

G. G. SOLYST, Assistant Examiner

U.S. Cl. X.R.

156—187, 195, 244