United States Patent

Ling et al.

[15] 3,646,248

[45] Feb. 29, 1972

[54] ELECTRIC CABLE

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[73] Assignee: Anaconda Wire and Cable Company

[22] Filed: Feb. 22, 1971

[21] Appl. No.: 117,475

[52] U.S. Cl. ....174/120 SC, 174/102 SC, 174/105 SC, 117/215

[51] Int. Cl. H01b 7/02

[58] Field of Search ....174/120 R, 120 SR, 120 SC, 174/120 AR, 102 SC, 110 R, 105 SC, 106 SC; 117/215

[56] **References Cited**

UNITED STATES PATENTS

3,571,490	3/1971	Bunish et al.	174/120 R X
3,479,446	11/1969	Arnaudin et al.	174/120 R
3,258,522	6/1966	Bartos et al.	174/120 X
3,206,542	9/1965	Dawson et al.	174/120 R

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Assistant Examiner—A. T. Grimley
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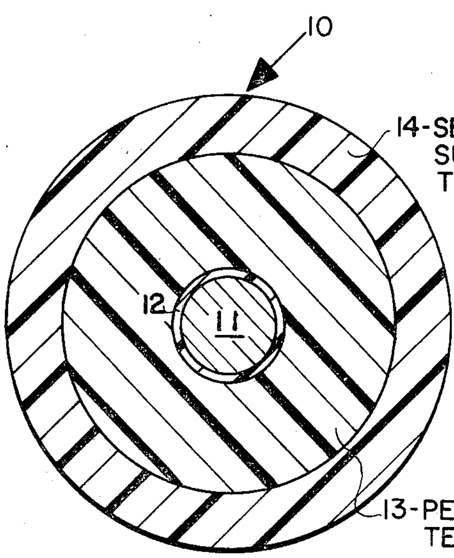
[57] **ABSTRACT**

An electric cable is insulated with a cross-linked olefinic terpolymer and has a semiconducting cross-linked olefinic terpolymer jacket closely applied over the insulation. Different curing systems are employed for the insulation and jacket with the result that the jacket will maintain a void-free contact with the insulation but may still be stripped cleanly from it.

7 Claims, 2 Drawing Figures



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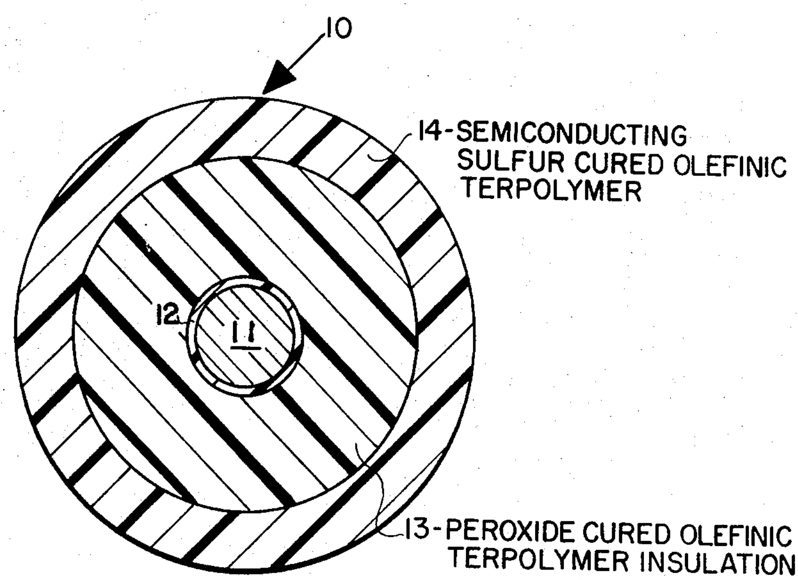

Fig. 1

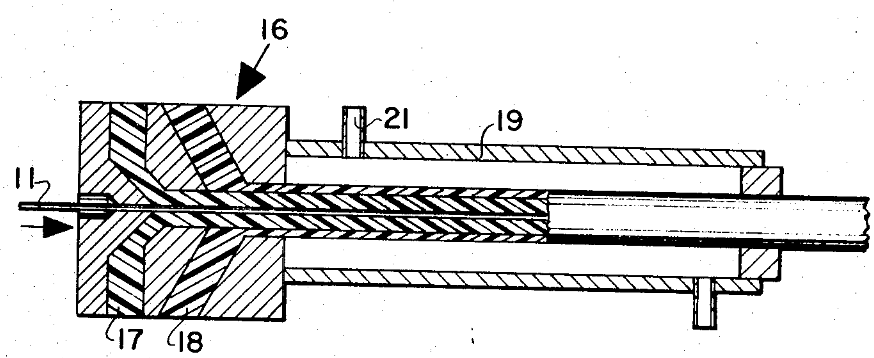

Fig. 2

INVENTOR.

TING H. LING

BY Victor F. Volk

HIS AGENT

ELECTRIC CABLE

BACKGROUND OF THE INVENTION

Power cables for operation above about 2,000 volts are required to have an electrical shielding layer surrounding the outer surface of the cable insulation. This layer should be intimately in contact with all points of the entire outer surface of the insulation so that there will, at no time, be any voids or pockets of ionized air or vapor adjacent to the insulation. It is well documented that ionization or corona on an insulation surface will cause deterioration of the dielectric properties of the insulating wall and may eventually lead to cable failure. One known method of making intimate contact between the insulation surface and the shielding layer is to employ a semiconducting polymeric composition for shielding and to extrude this composition directly over the insulated cable conductor. A disadvantage of known cables, made in this manner, resides in the fact that when the insulating and shielding compositions comprise different polymers the walls of insulation and shielding will have different thermal coefficients and, in addition, may require some adhesive interface to assure adequate contact. When, on the other hand, the same polymer is used for the insulation and the shielding layer, the latter bonds so firmly to the former that it is difficult and costly to strip the shielding layer at joints and terminations.

SUMMARY

I have overcome the deficiencies of known cables by the invention of an electric power cable comprising an elongated conductor and a wall of electrical insulating composition comprising an olefinic terpolymer and a first curing system, surrounding the conductor. A wall of semiconducting composition directly surrounds the wall of insulating composition. This semiconducting composition comprises an olefinic terpolymer and a second curing system for olefinic terpolymers differing essentially from the first curing system. The semiconducting composition is cured by means of this second curing system. The first curing system of my invention may advantageously comprise an organic peroxide such as di-α-cumyl peroxide, and the second curing system may advantageously comprise sulfur.

In a method of my invention for making an electric power cable I continuously extrude a wall of insulating composition, comprising an olefinic terpolymer and a first curing system over an elongated conductor, and before curing this insulating composition I continuously extrude a wall of semiconducting composition comprising the olefinic terpolymer and a second different curing system over it. Then I continuously heat the cable so as to cure both the insulating and semiconducting compositions.

I have found that by the use of olefinic terpolymer compositions for both the insulation and shielding jacket of my cable I can realize the good electrical and water resistant properties of the terpolymer for an insulation and its excellent abrasion resistance and toughness for a jacket which combines on a shield. At the same time the interface between the insulation and shield is sufficiently intimate, because the surfaces are so essentially compatible. Furthermore, there is no separation due to thermal effects during the life of the cable. At the same time, since I have applied different curing systems to each layer, the shielding layer does not bond so firmly to the insulation as to create difficulties in stripping. Particularly my present cable can have the semiconducting jacket stripped from the insulation without, as frequently occurred with prior art cables, tearing any of the insulation from the outer insulation surface.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a cross-sectional view of a cable of my invention.

FIG. 2 shows a diagram of the steps of the method of my invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1 the cable of my invention, indicated generally by the numeral **10**, comprises a conductor **11** which is conventional and will usually be copper or aluminum and may comprise a plurality of wires, stranded together in a known manner. Particularly where the conductor is stranded it is known to surround it with a layer **12** of semiconducting strand-shielding composition which, in this application, is considered as being included in the expression "conductor."

Surrounding the conductor **11** I have provided a wall **13** of insulation to a thickness determined by the voltage for which the cable is intended. This insulating wall **13** comprises an olefinic terpolymer such as that sold by E. I. duPont de Nemours and Company under the trademark Nordel. Terpolymers suitable for use in the practice of my invention are described in U.S. Pat. No. 2,933,480 and are characterized by the fact that they can be cured by a sulfur curing system as well as being curable by peroxide. A composition which I prefer for the wall of insulation **13** is given in Example 1.

EXAMPLE 1.

	Parts by weight
Nordel olefinic terpolymer	100
ZnO	5
*polymerized trimethyl-dihydroquinoline	1.5
fine thermal carbon black	10
**clay filler, silicone treated	110
paraffinic oil	15
paraffin	5
***vinyl silane	1
red lead	5
di-α-cumyl peroxide	3.5

*Age-Rite Resin D, R. I. Vanderbilt Co. Inc.

**described in U.S. Pat. No. 3,148,169

***A-172 Silane, Union Carbide Corp.

Although I prefer the composition of Example 1, I have found that compositions within the ranges shown in Example 2 are particularly advantageous for the wall 13 in the practice of my invention.

EXAMPLE 2

	Parts by weight
Nordel olefinic terpolymer	100
ZnO	2–10
polymerized trimethyl-dihydroquinoline	0.5–3
fine thermal carbon black	2–20
clay filler, silicone treated	50–150
paraffinic oil	5–25
paraffin	2–10
vinyl silane	0.5–3
red lead	2–10
di-α-cumyl peroxide	2–5

Directly over the wall **13** my cable has a layer **14** of semiconducting composition which also comprises the olefinic terpolymer of the wall **13** or another olefinic terpolymer, as described in U.S. Pat. No. 2,933,480. The layer **14** makes intimate, void-free contact with the layer **13** over its entire surface and serves not only as an electrical shielding but as a mechanical jacket to protect the insulation from abrasion, dirt, and physical injury. My preference for the composition of the jacket layer **14** is shown in Example 3.

EXAMPLE 3

	Parts by weight
Nordel olefinic terpolymer	100

ZnO	5
*semiconducting carbon black	50
paraffinic oil (plasticizer)	10
**copper diethyldithiocarbamate	0.75
sulfur (accelerator)	2.5
***n-oxydiethylene benzothizole-2-sulfenamide (accelerator)	2

*Vulcan XC-72, Godfrey L. Cabot, Inc.

**Cumate, R. T. Vanderbilt Co.

***NOBS special accelerator, American Cyanamide Co.

Although I prefer the composition of Example 3 for my layer **14** I have found that compositions within the range of Example 4 are particularly useful for the layer **14** in the practice of my invention.

EXAMPLE 4

	Parts by weight
olefinic terpolymer	100
ZnO	3-15
semiconducting black	30-100
plasticizer	5-20
sulfur	1-5
accelerators	2-9

To test the stripability of the insulation-shielding combinations of my invention a sheet of the composition of Example 1 and a sheet of the composition of Example 3 were pressed together during vulcanization. The bonding force was then determined by measuring the force required to pull apart a ½-inch strip of the double sheet. This force varied between 3 and 4 pounds. Compared to this, a force in excess of 20 pounds has been required when the same test has been applied to two sheets both employing the same curing system.

The advantages of my invention are most greatly realized in a method of manufacture of my cable where the shielding is extruded over the insulation without intermediate curing, because the likelihood of excessive bonding of prior art cables would be the greatest under these circumstances. This method is shown diagrammatically in FIG. 2. Here the conductor **11** is being continuously paid from a source, not shown, into a dual extrusion head **16** wherein a stock **17** of a composition of Example 2 is being extruded to form the wall of insulation **13** and a stock **18** of a composition of Example 4 is being extruded directly over the insulation to form the shielding jacket **14**.

The cable then passes directly into a continuous vulcanizing tube **19** wherein both the compositions **17** and **18** are cured by the heat and pressure of steam that is supplied through the pipe **21**. This improved cable making method and cable has particular application to cables where drain wires are embedded in the semiconducting shield jacket, exemplified by the disclosures of U.S. Pat. No. 3,474,189.

I have made a new and useful invention of which the foregoing description has been exemplary rather than definitive and for which I desire an award of Letters Patent as defined in the following claims.

We claim:

1. An electric power cable comprising:
   A. an elongated conductor,
   B. a wall of electrical insulating composition surrounding said conductor, said composition comprising:
      1. an olefinic terpolymer, and
      2. a first curing system for said terpolymer, said insulating composition being cured by means of said system, and
   C. a wall of semiconducting composition directly surrounding said wall of insulating composition comprising:
      1. an olefinic terpolymer and
      2. a second curing system for olefinic terpolymers differing essentially from said first curing system, said semiconducting composition being cured by means of said second system.
2. The cable of claim 1 wherein said first curing system comprises an organic peroxide.
3. The cable of claim 1 wherein said first curing system comprises di-α-cumyl peroxide.
4. The cable of claim 1 wherein said second curing system comprises sulfur.
5. The cable of claim 2 wherein said second curing system comprises sulfur.
6. The cable of claim 3 wherein said second curing system comprises sulfur.
7. The method of making an electric power cable comprising the steps of:
   A. continuously extruding a wall of insulating composition, comprising an olefinic terpolymer and a first curing system, over an elongated conductor,
   B. before curing said insulating composition continuously extruding a wall of semiconducting composition comprising an olefinic terpolymer and a second different curing system directly over said insulating wall, and
   C. continuously heating said cable so as to cure said insulating and said semiconducting compositions.

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