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[54] **FILLED TELEPHONE CABLES WITH IRRADIATED POLYETHYLENE INSULATION**

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[52] **U.S. Cl.** .... **174/107**, 156/48, 174/56, 174/25 R, 174/110 PM, 174/116

[51] **Int. Cl.** **H01b 7/18**

[58] **Field of Search** .... 174/25 R, 25 C, 102 R, 174/102 D, 107, 110 PM, 116; 156/48, 51, 52, 53, 54, 55, 56; 204/159.2

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[57] **ABSTRACT**

This filled communication cable has polyethylene insulation on the conductors irradiated to avoid degrading of the polyethylene by contact with the filler material which is a grease. Ordinarily the filler material contains petrolatum as its major ingredient. The irradiation of the insulation is performed after the insulation is applied to the conductors and before the conductors are brought together in contact with the petrolatum in the cable core.

8 Claims, 4 Drawing Figures

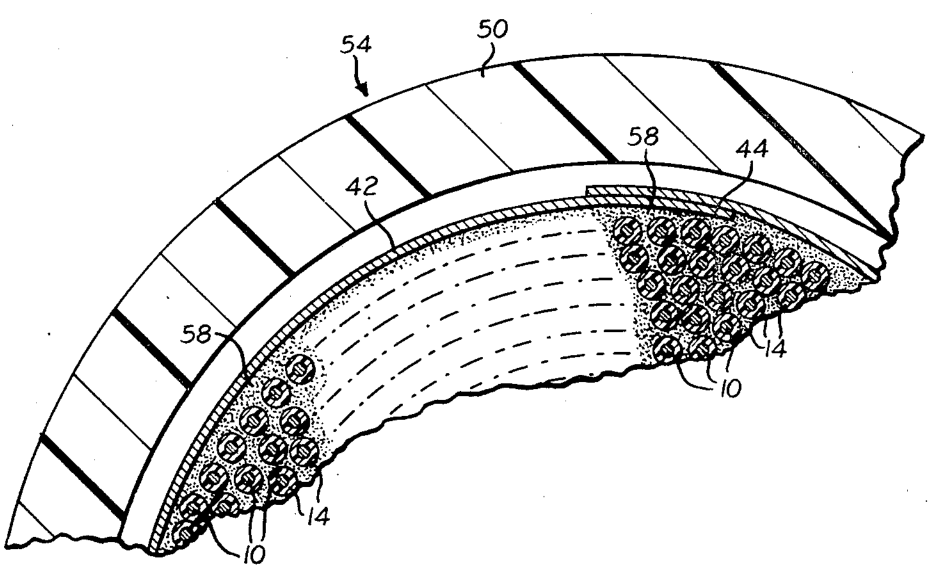

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FIG. 1a.

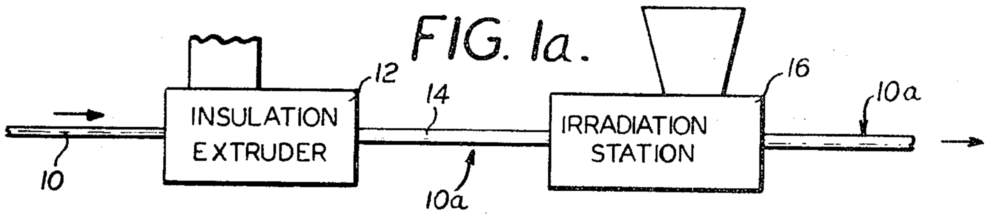


FIG. 1b.

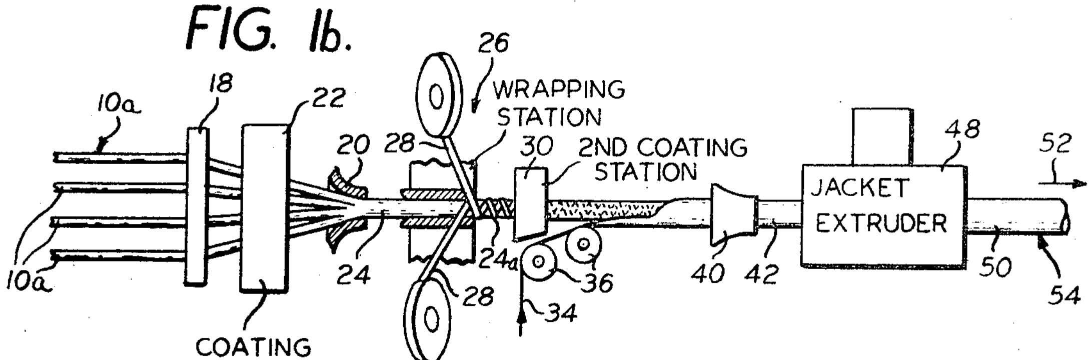


FIG. 2.

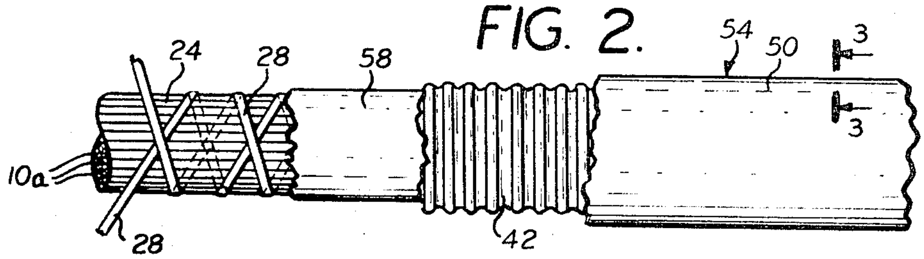
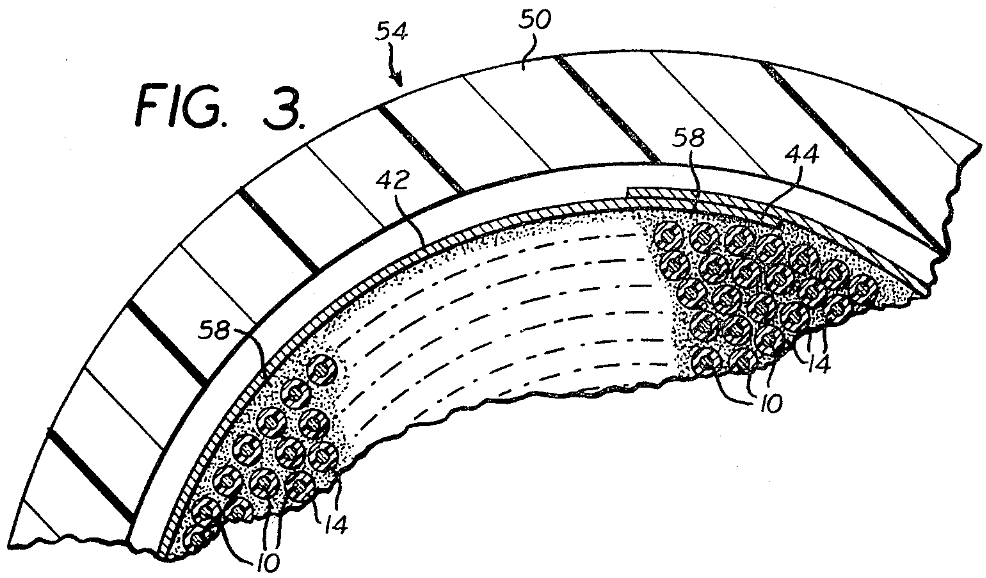


FIG. 3.



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FILLED TELEPHONE CABLES WITH IRRADIATED POLYETHYLENE INSULATION

BACKGROUND AND SUMMARY OF THE INVENTION

This invention is an improvement in communication cables, such as telephone cables, where separately insulated conductors are assembled side by side in the core of the cable, and the core is enclosed in an electrostatic shield with a plastic jacket around the shield. Some cables have a vapor barrier around the core for protecting the insulation of the conductors from water which may reach the core through pinholes in the jacket and through the seam of the electrostatic shield.

This invention relates to that type of communication cable where the insulated conductors are protected from water by filling all of the interstitial space among the conductors in the core with a water repellant filler material comprising a grease. The material most commonly used for filling such communication cables is petrolatum, often blended with polyethylene to increase the viscosity so that the filler material will not run out of the cable at the temperature encountered in use.

Communication cables are not subject to heating because of heavy current flow as in the case of power cables; but they are subject to substantial heating in southern climates. Temperatures as high as 50° – 70° C and higher are encountered in storage and in aboveground ready-access pedestals. The runs of cable between cable ends and termination points are under ground. For cables that are to be used in southern climates, the specifications require that the cable be capable of withstanding a temperature of 86° C.

To meet this specification it has been necessary to substitute polypropylene in place of polyethylene as the insulation on the conductors in the core. Petrolatum has no injurious effect on polyethylene at temperatures of 60° C, but polyethylene is rapidly degraded by contact with petrolatum at temperatures as high as 86° C. Cracks develop in the polyethylene insulation and the insulation comes off the conductors when subjected to the wrap-around test. This is true of both high density and low density polyethylene, though in different degrees.

This invention provides a communication cable and method of making it with polyethylene insulation for the conductors in a cable filled with petrolatum or a blend of petrolatum with a polyolefin such as polyethylene. This invention avoids cracking of the polyethylene when exposed to petrolatum at temperatures up to 86° C by irradiating the polyethylene insulation after it has been applied to the conductors. The effect seems to be that the irradiation breaks the molecular chains and reinstates cross-linking extending around the conductors in such a fashion that a crack which is initiated is arrested "in situ" and, therefore, the crack propagation effect previously encountered is rendered inoperative.

The ability to use polyethylene in place of polypropylene is important in the manufacture of commercial cable because the present price of polypropylene is approximately 44 percent higher than that of polyethylene. The research work on this invention shows that even the lower commercial grade (and lower priced) polyethylene can be used if irradiated after being extruded on the conductors and before being brought into contact with the petrolatum. This is true for both solid insulation and expanded (foamed) polyethylene.

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 showing the successive steps in the manufacture of a communication cable in accordance with this invention;

FIG. **2** is a view, on a greatly enlarged scale, showing the finished cable of FIG. **1** with successive layers broken away to show the construction on a larger scale; and

FIG. **3** is a fragmentary view, on a greatly enlarged scale, taken on the section line **3—3** of FIG. **2.**

DESCRIPTION OF PREFERRED EMBODIMENT

FIG. **1** shows a method by which the communication cable of this invention can be made. A conductor **10** is advanced through an extrusion die **12** in which a coating of polyethylene **14** is extruded over the conductor. The insulated conductor designated by the reference character **10*a***, passes through a housing **16** in which the polyethylene insulation is subjected to an electron beam which irradiates the polyethylene. This causes a cross-linking of the polyethylene and for purposes of this invention it has been found that the required cross-linking can be obtained with between 5 and 15 megarads.

The insulated and irradiated conductor **10*a***, together with a plurality of similar conductors, similiarly insulated and similarly irradiated, and indicated by the same reference character **10*a***, pass through a spacer plate **18** from which they converge to a bell die **20** in which they are brought together to form the core of the communication cable,

The four conductors **10*a*** shown in FIG. **1b** are representative of a plurality of conductors and in actual practice a communication cable, such as a telephone cable, may have hundreds of such conductors in the core.

Between the spacer plate **18** and the die **20,** there is a housing **22** through which the conductors pass and in which they are coated with the grease that is the filler for the cable. Thus the housing **22** is the coating station.

Beyond the die **20**, the assembled conductors comprising a core **24** pass through a wrapping station **26** where one or more tapes **28** are wrapped around the core in helical paths and preferably with space between successive convolutions. The purpose of the tapes **28** is not to form a protective layer around the core but merely to hold the conductors closely together in the core.

The wrapped core indicated by the reference character **24*a***, passes through a housing **30** in which grease is applied over the entire circumference of the core, this housing **30** being a second coating station and the grease applied being preferably the same grease as is applied to the individual conductors at the housing **22** of the first coating station.

An electrostatic shield is applied to the core by advancing a strip of metal **34** over guide rolls **36** into a position parallel to the core **24*a*;** and this strip is then formed by a forming die 40 into a longitudinally seamed tube 42 which preferably has a lap seam 44, as shown in FIG. 3. The strip 34 and the tube 42 which it forms are preferably corrugated to increase the flexibility of the cable in accordance with conventional practice.

The metal strip 34 used for forming the tube 42 which serves as electrostatic shield of the cable is preferably made of aluminum of a thickness of substantially 8 mils. The aluminum may have a coating on both sides to protect it from corrosion.

After the electrostatic shield has been applied over the core, the shield passes through an extruder die 48 in which a plastic outer jacket 50 is applied over the shield. Mechanism for pulling the cable through the extruder die 48, the forming die 44, and the other apparatus such as the coating stations and the conductor collecting die 20 is located beyond the last extruder 48 and is not shown in the drawing since it is conventional. The pulling force and direction of the force is indicated by the arrow 52 in FIG. 1*b*.

The finished cable, as it comes from the extruder die 48, is indicated by the reference character 54.

FIG. 2 shows the cable 54 on a larger scale. The plastic jacket 50, which is preferably made of polyethylene, is broken away to expose the corrugated electrostatic shield 42. This shield has a longitudinal seam and when the shield has a plastic coating to protect it from corrosion, the heat of the extrusion of the outer jacket is likely to seal the seam closed along part of its length since the plastic coating is melted by the heat of the extrusion. This seam is not likely to be watertight, however, because the corrugations are curves of the same radius and therefore do not fit all the way down into one another. This leaves some space at the high and low points of each corrugation and unless special constructions are used this causes a series of gaps which are wide enough to prevent sealing of the seam by the thin corrosive protecting coating on the aluminum. With a filled cable such as this invention relates to, there is no necessity for having the seam 44 (FIG. 3) closed and sealed since the grease for filler, designated by the reference character 58, prevents water from reaching the insulated conductors even though pinholes develop in the outer jacket 50 and permit water to reach the shield 42 and to pass through the gaps at the seam 44.

In FIG. 2, the electrostatic seal 42 is broken away to expose the coating of grease 58 which is applied over the outside of the core at the second coating station 30 (FIG. 1*b*) and the grease 58 is broken away in FIG. 2 to expose the core 24 with its tapes 28 for holding the insulated conductors 10*a* closely packed together with the grease which coats them filling all of the interstitial spaces between the insulated conductors. In applying the grease to the conductors at the first coating station 22 (FIG. 1*b*), sufficient grease is applied so that there will be enough to completely fill the interstitial spaces with some grease squeezed out around the circumference of the core.

The grease which is used as the filling compound for cables of the type to which this invention relates is limited by the following considerations:

1. compound should be water repellant,
2. compound should have low dielectric constant,
3. compound should be easily applied, flexible, not gripping or migrating when the cable is installed on an incline.

A material that has been used for filled communication cables is petrolatum, a mixture of oils and microcrystalline waxes. Amorphous polyethylene greases have been used but have the disadvantage of being considerably more expensive than petrolatum.

The preferred filling material of this invention is a blend of petrolatum with polyethylene. The material as prepared is a gel-type, hot melt filling compound consisting of a mixture of petrolatum and low molecular weight polyethylene with an antioxidant. Such material can be purchased from the Western Electric Company. Increase in the amount of polyethylene increases the viscosity of the filling compound.

When polyethylene was used as the insulation in filled cables without any irradiation of the polyethylene, a degrading effect occurred from the action of the petrolatum on the polyethylene at temperatures approaching 86° C. When a conductor which had been subjected to contact with petrolatum at such temperature for a substantial period was wiped dry for a termination, and the conductor was bent to make the termination, cracks in the polyethylene developed and propagated so that the insulation opened up and completely pealed off the conductor. A somewhat lesser defect of cracking was observed on expanded (foamed) polyethylene since lesser stresses are developed in the insulating envelope when it is not of solid structure. However, the degree of improvement was not significant enough to allow for use of foamed polyethylene compound in contact with the filling compound without failure at temperatures approaching 86° C.

If irradiation of the polyethylene amounts to from 6 to 15 megarads, this cracking does not occur.

Experience has shown that insulation compounds which crack within one to two hours after exposure to 85° C in dry air can, if irradiated, withstand twenty five days exposure without showing any traces of cracking. In testing communication cables an exposure of 24 hours is regarded as sufficient to sort out acceptable cable from that which is unacceptable. The test used to determine cracking is to form a bend in the end portion of the wire and then wrap the wire beyond the bend around that portion of the wire ahead of the bend. This produces a stress condition which is common in terminating and one under which it is important to have the insulation remain on the wire without cracking.

The preferred embodiment of the invention has been illustrated and described, but changes and modifications 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 communication cable including a plurality of conductors forming a core of the cable, polyethylene insulation on the individual conductors, an open wrapping on the conductors holding them together in a cable core, a shield enclosing the core, filler material that fills the interstitial spaces between the conductors of the core, the open wrapping and any other clearances within the shield, the filler being a viscous fluid at the intended operating temperatures of the cable and said fluid containing material that causes degrading of amorphous polyethylene insulation to a degree that causes the insulation to crack when conductors are

twisted together at cable ends, the polyethylene being irradiated to the extent of between 6 – 15 megarads with resulting partial cross-linking of the polyethylene insulation sufficient to enclose the remaining amorphous polyethylene in a cross-linked polyethylene lattice that will arrest in situ any crack which is initiated by failure in tension of the polyethylene insulation when the end of a conductor is bent to make a termination.

2. The filled communication cable described in claim 1 and characterized by the filler material including petrolatum, and the polyethylene being irradiated by electronic irradiation.

3. The filled cable described in claim **1** characterized by the conductors having extruded polyethylene insulation thereon, and the cross-linking being that produced after the insulation is on the conductor.

4. The filled communication cable described in claim 1 characterized by the filler material being a blend of petrolatum and polyethylene with the petrolatum the major ingredient of the blend, the insulation on the conductors being an extruded polyethylene coating irradiated after extrusion.

5. The method of making a filled communication cable that comprises insulating individual conductors with polyethylene, irradiating the polyethylene, as it comes from the insulation applying and before gathering the conductors together, to partially cross-link the conductor insulation, bringing a plurality of conductors together in a core after coating the conductors with a grease that swells and degrades amorphous polyethylene as a result of continued contact of the insulation with the grease and to an extent that causes cracking of the insulation when the conductors are twisted together at cable ends, applying an open wrapping to the core to hold the conductors together in the core so that the interstitial spaces of the core remain filled with grease, applying grease as a circumferential coating on the core over the open wrapping, applying an electrostatic shield over the core and over the grease that covers the open wrapping to fill any clearances between the core and shield with said grease, and applying a plastic jacket over the shield.

6. The method described in claim **5** characterized by extruding the polyethylene insulation over the conductors, irradiating the polyethylene insulation after it has been extruded over the conductors.

7. The method described in claim **6** characterized by the irradiation being between 5 and 15 megarads.

8. The method of making a telephone cable as described in claim **5** characterized by applying the open wrapping directly to the conductors of the core to hold the conductors together in the core, applying grease that includes petrolatum as the circumferential coating on the core over the open wrapping and in the interstitial spaces of the core; and further characterized by irradiating the polyethylene insulation after it has been extruded over the conductors with irradiation between 5 and 15 megarads, and applying a corrugated electrostatic shield over the grease coating on the core by longitudinally and progressively folding over the core an aluminum strip having a thickness of substantially 8 mils and having a non-corrosive coating on both surfaces of said strip.

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