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**MANUFACTURE OF PLASTIC-INSULATED
 ELECTRICAL CABLE**

Sidney W. Trill, Scarsdale, N.Y., assignor to Phelps Dodge
 Copper Products Corporation, New York, N.Y., a corporation of Delaware

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6 Claims. (Cl. 156—51)

This invention relates to a method for the improvement in quality of thermosetting and thermoplastic insulated electric cables by the elimination of voids between an electrical conductor and the insulation on the conductor. This present application is a continuation-in-part of applicant's prior and co-pending application Ser. No. 339,252 filed Jan. 21, 1964 now abandoned.

It is well known in the manufacture of insulated electrical cables to form a cable having a thermoplastic or thermosetting insulation covering the conductor. In the customary way of forming such cable the insulation is continuously extruded at a high temperature in plastic condition to form a coating about the conductor. Typically, the conductor of this type cable consists of several copper strands surrounded by a thin semi-conductor layer. After the extrusion the insulating material must be cooled to solidify it. The cooling step has presented difficulties in the past. In order to provide a durable and efficient cable it is necessary to have the insulation and the conductor in continuous contact without the presence of gaps or voids between the two. The cooling step used in the past has resulted in the formation of such voids and gaps. The prior-art process of cooling consists of taking the high-temperature coated cable and immersing it in hot water. The hot-water step is followed by several immersion steps utilizing water of decreasing temperature. The sudden initial temperature drop, from about 350° F. in the case of typical thermoplastic polyethylene, to a temperature below 212° F. results in a case hardening of the outer surface of the thermoplastic insulating material. The insulation then tends to cool toward the outer hardened surface resulting in cavities between the surface of the conductor and the insulation and mechanical stresses in the polyethylene. With a high voltage over the conductor, corona discharge may occur across the voids. The corona effect, when it occurs over an extended period of time, leads to an erosion of the insulation at the void, producing a larger gap and continued erosion until the cable fails or is otherwise rendered defective for service. With the elimination of voids the insulated conductor may be subjected to higher voltages without a corona discharge.

The problem of voids in the formation of polyethylene or polypropylene insulation is particularly acute due to their high co-efficient of expansion and poor thermal conductivity. The prior art process of hot-water cooling is a slow process and reduces the speed at which cable may be manufactured in addition to having limitations on the minimum void size that can be achieved.

The invention of applicant reduces the presence of voids by the use of a high-temperature pressurized steam system for initial cooling of the thermoplastic or thermosetting insulation on the conductor. After the insulation is extruded on to the conductor, it emerges from the extrusion machine and is then passed into a chamber containing live steam under pressure. The temperature and pressure of the steam may be varied according to material being extruded, the speed of extrusion and the

desired cooling to be achieved. Since the steam is under pressure, temperatures in excess of 212° F. may be achieved resulting in a more moderate first stage of cooling. After passing through the steam section the insulated conductor then passes into hot water followed by cool water, both being under pressure, where final cooling is achieved. Since the cooling is controlled to achieve a more gradual change from the temperature of extrusion the insulation tends to contract inwardly against the conductor resulting in a more satisfactory and durable product because of the substantial absence of voids between the insulation and conductor and the reduction of mechanical stress in the insulation material. Also, about 20% higher rate of production is obtained than with the prior hot-water cooling process.

The invention of applicant is described in greater detail in the description below and in the drawings in which:

FIG. 1 is a simplified flow diagram showing the passage of the insulated cable through the various processing steps; and

FIG. 2 is a cross-section of the steam chamber of FIG. 1.

Referring to FIGS. 1 and 2 a conductor 1 having an extruded outer thermoplastic coating 2 leaves the extrusion machine 3, shown schematically, and passes into a chamber 5 larger than the finished cable diameter and which is sealed by mechanical means 4 against the extrusion head to retain steam pressure. The chamber shown in the drawing is catenary-shaped to prevent contact between the walls of the chamber and the hot thermoplastic insulation. If it is desired the chamber may be vertical and the hot thermoplastic insulation will pass downwardly through the steam chamber without contacting the walls, or it may be horizontal, for a smaller limited range of conductor and insulation sizes.

Pressurized live steam 6 at a temperature above 212° F. and below the temperature of the thermoplastic insulation is introduced into the chamber through an inlet 7. The pressurized steam causes a decrease in the temperature of the insulation while inducing an inward contraction toward the conductor.

The partially cooled cable passes from the steam chamber through a steam-water interface 8 into a pressurized water section which continues the cooling of the cable. The water between exit pipe 11 and interface 8 is heated by the contact at the interface between the steam and the water and provides an intermediate temperature to further reduce the temperature of the cable. The water in this section is essentially stagnant. The length of the section between interface 8 and pipe 11 is adjustable by means of water level control 9, shown schematically, which controls the position of the steam-water interface 8. The location of the interface can be adjusted to compensate for the use of different materials and temperatures.

The cable, after travelling through the interface 8, passes through the intermediate temperature section and then into a cool-water section located between outlet pipe 11 and water seal 17. Cool water 10 is continuously fed to this section by a high-pressure water pump 14 through inlet pipe 16 at a pressure equal to the steam pressure. The temperature of the water entering through pipe 16 may be ambient or any other selected cool temperature.

The cable finally passes out through water seal 17. The seal is adjusted to allow the passage of some water outward with the cable to lubricate the cable as it passes through. A caterpillar having elements 12 and 13 grip-