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(54) ELECTRIC CABLES

(71) We, LYNENWERK GmbH & Co K.G., a Kommanditgesellschaft organised under the laws of Germany, of Durener Strasse, D-5180 Eschweiler, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be particularly described in and by the following statement:

5 This invention relates to electric cables, and more particularly to electric cables having undulated tension relief elements embedded in the cable jacket. 5

U.S. Patent Nos. 3,979,518 and 3,983,313 disclose electric cables having undulated tension relief elements embedded in the cable jacket. In accordance with such patents, the cable jacket is formed of polyethylene and the undulation of the tension relief elements results from the shrinkage of polyethylene during cooling thereof. 10

In some cases, it is highly desirable to provide cables with undulated tension relief elements in which the cable jacket is formed from a material other than polyethylene. For example, polyethylene is flammable and in cases where non-flammability is desired the cable jacket should be formed from a non-flammable material, such as polyvinyl chloride; however, polyvinyl chloride does not have the shrinkage properties of polyethylene. As a result, undulation of the tension relief element can not be effected by cooling of the cable jacket. 15

In accordance with the present invention there is provided a method for the production of electric cable in a cable extruder head wherein a cable core, a jacketing material and tension relief strands are fed into the extruder head so that the jacketing material produces a tubular jacket for the core having the tension relief strands embedded therein, wherein the tension relief strands and the jacketing material are introduced into the extruder head at a velocity greater than the velocity of the cable core and the velocity of the jacketing material having the tension relief strands therein is thereafter reduced to effect compression of the jacketing material and produce undulations in the tension relief strands. 20 25

In this manner, the cable jacket can be produced from materials other than polyethylene, since the shrinkage properties of polyethylene are no longer required for providing undulations in the tension relief elements.

More particularly, the relative velocities between the cable core and the jacketing material are controlled in a manner to generate an axial compressive force in the cable jacket and tension relief elements to provide the undulations. The greater the difference in the relative speeds, the greater the undulations and by proper coordination the desired undulation can be achieved. Accordingly, the abrupt axial compression which occurs at the extruder head outlet or beyond the discharge therefrom produces the undulation, whereby undulation of the tension relief elements can be obtained independently of the properties; i.e., shrinkage property, of the jacketing material. 30 35

Thus, there is a retarding effect on the jacketing material including the tension relief strands and such retarding effect is provided by the velocity difference between the jacketing material and cable core. In the case of a highly compressible and viscous jacketing material such compressive force is exerted immediately beyond the mouthpiece of the extruder head and there is a swelling of the jacketing material; i.e., the outer diameter of the jacket may be greater than the inner diameter of the mouthpiece. 40

It is also possible to obtain such a retarding effect with a material of low viscosity and compressibility within the mouthpiece of the extruder head by providing a mouthpiece having an increasing inner diameter in the direction of flow, whereby the velocity of the 45

jacketing material decreases as it passes through each larger area. In such a case, the tension relief elements would be fed at a rate corresponding to the velocity of the jacketing material in the smaller diameter area of the mouthpiece in order to provide the desired undulation.

5 The invention will be further described with respect to the accompanying drawings, 5 wherein:

Figure 1 is a schematic axial longitudinal sectional view through the extruder head of a cable extruding machine with a cable being produced therein; and,

10 *Figure 2* is a schematic perspective view of a cable segment with partly exposed tension 10 relief elements.

It is to be understood that the general principles for forming the jacketed cable in accordance with the present invention are in accordance with those set forth in the 15 aforementioned United States Patents Nos. 3,879,518 and 3,983,313, with the present invention differing from such patents by the fact that the jacket may be produced from 15 materials other than polyethylene and that the undulations are formed by controlling the parameters within the extruder head, as described, instead of depending on the shrinkage characteristics of the jacketing material.

Referring to the drawings, a cable extruder head 10 is provided with an opening 11 for 20 coupling the feed screw of an extruder (not shown). A prefabricated cable core 13 made of insulated electric conductors moves in the direction of arrow 12 into head 10 wherein the 20 outer jacket 14 is applied thereon, to provide a finished cable 15, which is cooled off in the commonly known manner.

As particularly shown in Figure 2, the finished cable 15 has a cable core comprised of 25 conductors 16, insulation 17; i.e., five sets of two twisted conductor pairs 19, and a core made of a plastics material. Around the conductor pairs 19 is a commonly used wrapping 22 25 made of plastic tape.

The outer jacket 14 is extruded over wrapping 22 which moves with the cable core 13 into 30 the extruder head wherein a variable amount of tension relief elements 23 are provided. These elements may be constructed from groups of yarns or twines having different thread 30 dimensions whereby the number of yarns or twines for each group on the other hand depend on the number of conductor pairs 19, the required minimum braking stress of the cable and the thread size. Such numbers also depend on the distance of the groups from 30 each other and the distance of the groups from the inner jacket circumference. These tolerances are disclosed in the aforementioned United States Patent Specifications. It is 35 essential that the tension relief elements 23 do not run through jacket 14 absolutely parallel 35 to the cable axis (core 21); i.e., the tension relief elements should be undulated, as shown in Figure 2. This provides an intimate positive locking between the tension relief elements and the jacket material.

Cable core 13 moves through a nozzle 25 in extruder head 10 and discharges into a hollow 40 chamber 30 into which the front ends of channels 26 discharges, with channels 26 being 40 concentrically arranged with respect to the fed cable core 13 and of which only two channels are shown in Figure 1. The channels 26 are provided with tension relief elements 28 from a supply station, preferably in the form of suspended bobbins 27 which carry the yarn or 45 twines 28.

The front end of extruder head 10 has an outer matrix or mouthpiece 29 through which 45 the finished cable 15 is with drawn. The tension relief elements 28 are embedded in the jacketing material (thermoplastic or elastomeric) introduced through screw coupling 11, and the funnel-shaped hollow chamber 30 receives the jacketing material with the 50 embedded tension relief elements 28.

The speed or velocity of the jacketing material is dependent upon the exerted pressure 50 and the inner diameter of the mouthpiece 29 and the speed or velocity of the cable core 13 is equal to the drawing-off speed of the finished cable 15. The relative speed or velocity between the cable core and jacketing material is controlled in a manner such that the 55 jacketing material moves through the head 10 at a velocity greater than the cable core.

The tension relief elements 23 also move at a velocity greater than the velocity of the 55 cable core and such velocity generally corresponds to the flow speed of the jacketing material. As a result, the length of the tension relief elements 23 is longer than the length of cable core 13 or finished cable 15, with the additional length being taken up in the undulation of the tension relief elements 23.

As a result, the dimensions of the undulations can be controlled by controlling the 60 relative velocities of the jacketing material and tension relief elements with respect to the cable core. Such velocities can be controlled by controlling and/or adjusting the velocity of the cable core (draw-off speed of finished cable), mouthpiece diameter, pressure on 60 jacketing material, etc.

65 A convenient manner of determining that there is a difference in relative velocities is by 65

measuring the outer diameter of the cable after its discharge from the mouthpiece with respect to the mouthpiece inner diameter. The outer diameter of the cable should preferably be greater than the inner diameter of the mouthpiece with the difference in diameter increasing as the relative speed of the jacketing material and tension relief elements increases with respect to the cable core. It has been found that the degree of undulation increases as the velocity difference increases (and the diameter difference between the finished cable and mouthpiece inner diameter increases) and such difference should be coordinated to provide the required undulation without the tension relief elements overtaking themselves and forming S-like loops. At the extreme, this could result in retarding the feed movement of the tension relief elements which would result in too great a tension which would reduce cable flexibility. As should be apparent, proper undulation improves flexibility as a result of the bellows effect which permits bending.

As should be apparent from the above description, as a result of the velocity difference between the jacketing material and cable core, the slower moving cable core has a retarding effect on the faster moving tension relief elements at the time of forming the jacket on the core, whereby the tension relief elements are undulated.

The invention will be further described with respect to the following example; however, the scope of the invention is not to be limited thereby:

Example

In the following tests, the dimensions of the extruder head, pressure and charging rate of the jacketing material is maintained constant for the several tests with respect to each jacketing material. The drawing off speed of the cable is changed to thereby change the velocity difference between the jacketing material and cable core. As the velocity of the jacketing material increases with respect to the cable core, the diameter of the finished cable increases with respect to the mouthpiece inner diameter and the degree of undulation increased.

Tested No.	Material	Inner Nozzle Diameter (mm)	Mouthpiece Inner Diameter (mm)	Screw Rotation min^{-1}	Charging Rate of material (A)
1	PVC	7.7	12.1	20	65
2	PVC	7.7	12.1	20	65
3	PVC	7.7	12.1	20	65
4	PVC	7.7	12.1	20	65
5	PVC	7.7	12.1	20	65
6	PE	7.7	12.1	20	78
7	PE	7.7	12.1	20	78
8	PE	7.7	12.1	20	78
9	PE	7.7	12.1	20	78
10	PE	7.7	12.1	20	78

PVC = polyvinyl chloride
PE = polyethylene

Material Pressure (kp/cm ²)	Drawing Off Speed of Cable (m/min)	Outer Diameter of Cooled Cable (mm)	Degree of Undulation
25	12	12.9	medium
25	20	11.9	small
25	22	11.6	small
25	10	14.5	high
25	10	14.5	high
25	12	13.6	high
25	20	12.5	medium
25	22	11.9	small
25	26	11.4	none
25	32	11.3	none

The present invention is particularly advantageous in that it is possible to provide a jacketed cable having undulated tension relief elements without limiting the choice of jacketing

material to only those that have certain shrinkage characteristics. Thus, for example, if flammability is a concern; e.g., for cables used in mines, a jacket material of low flammability such as polyvinyl chloride can be used. Any one of a wide variety of cables can be produced in accordance with the invention and the desirable properties imparted by undulated tension relief elements, and in particular undulated glass fibers, are not limited to self supporting air cables. For example, such properties would also have applicability in cables which have to be drawn in lengths into pipes or shafts or which have to be placed into the ground.

Numerous modifications and variations of the present invention are possible in light of the above teachings and, therefore, within the scope of the appended claims the invention may be practiced otherwise than as particularly described.

WHAT WE CLAIM IS:

1. A method for the production of electric cable in a cable extruder head wherein a cable core, jacketing material and tension relief strands are fed into the extruder head so that the jacketing material produces a tubular jacket for the core having the tension relief strands embedded therein, wherein the tension relief strands and the jacketing material are introduced into the extruder head at a velocity greater than the velocity of the cable core and the velocity of the jacketing material having the tension relief strands therein is thereafter reduced to effect compression of the jacketing material and produce undulations in the tension relief strands.

2. A method as claimed in claim 1, wherein the jacket cable has a diameter greater than the diameter of the outlet of the head.

3. A method as claimed in claim 1 or 2, wherein the tension relief strands are glass fibres.

4. A method as claimed in any preceding claim wherein the jacketing material is polyvinyl chloride.

5. A method for the production of electric cable substantially as herein described with reference to the accompanying drawings.

6. An electric cable when produced by the method of any preceding claim.

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FIG.1.

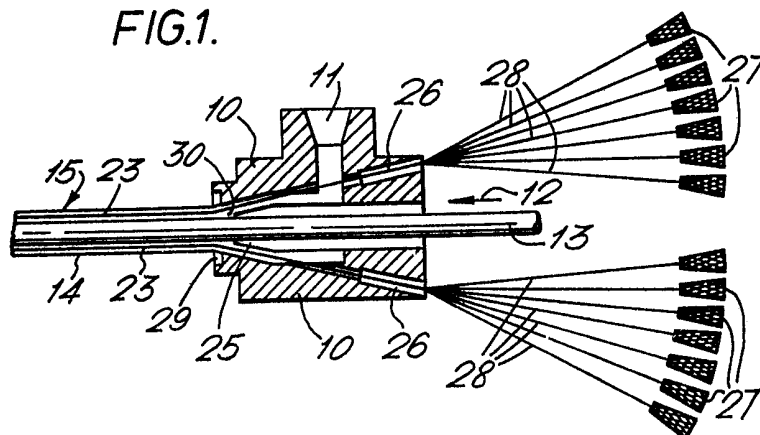


FIG.2.

