United States Patent [19]

Garrett et al.

[11] 3,789,099

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[54] METHODS OF MANUFACTURING WATERPROOF CABLE

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[52] **U.S. Cl.** **264/174**, 156/48, 264/261

[51] **Int. Cl.** **B32b 31/06**

[58] **Field of Search** 264/261, 174; 117/115; 156/48

[56] **References Cited**

UNITED STATES PATENTS

3,601,967	8/1971	Wardley	156/48
3,301,932	1/1967	Chisholm	264/174
2,252,755	8/1941	Bruestle	117/115
3,672,974	6/1972	Tomlinson	156/48

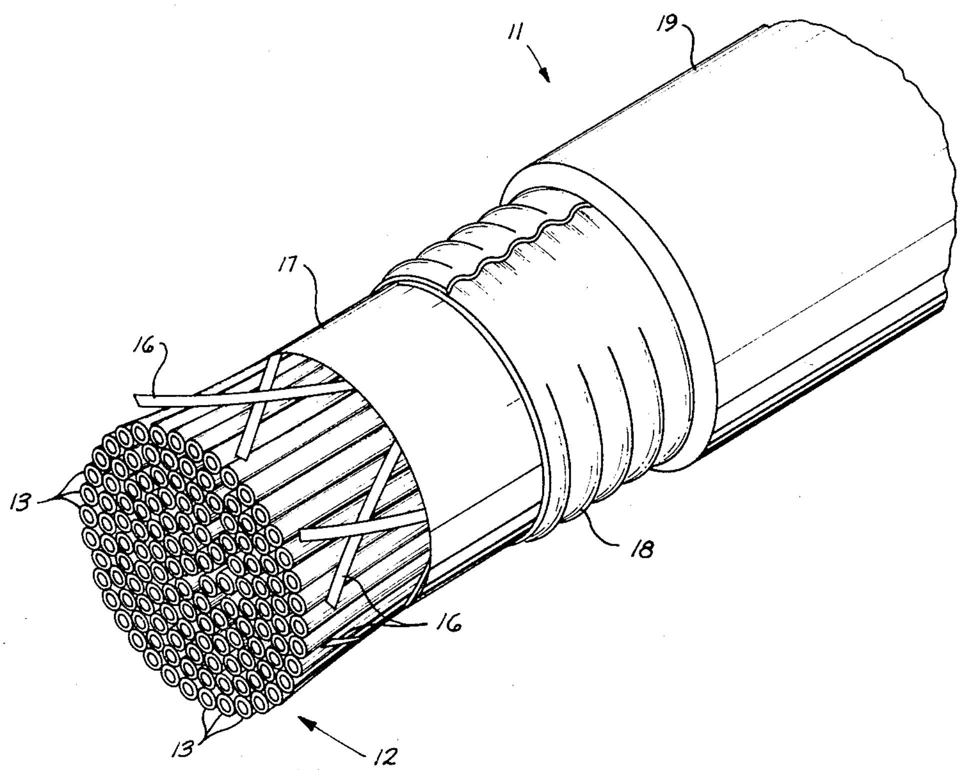
Primary Examiner—Robert F. White
Assistant Examiner—T. E. Balhoff
Attorney, Agent, or Firm—E. W. Somers

[57] **ABSTRACT**

Successive sections of a cable core having twisted pairs of insulated conductors stranded together are moved axially longitudinally through a series of in-line chambers having interconnecting dies of an apparatus with facilities for the pressure application of a heated waterproofing compound having a jelly-like consistency into the interstices between the stranded pairs of conductors. The apparatus is designed to direct the compound inwardly radially of the core after which a flow path of the compound is established into an upstream direction relatively longitudinally of the advancing cable core to more completely fill the interstices of the completed core. Provisions are made for cooling the cable core both prior to the filling thereof to limit the movement upstream of the compound and subsequent to the filling of the core to solidify and render self-sealing the compound.

Subsequently, the successive sections of the compound filled core are advanced through various stations whereat a core wrap and sheath are applied thereto together with additional applications of the waterproofing compound. A plastic jacket is extruded about the sheath and cooled prior to taking up of the successive sections of the jacketed cable onto a take-up reel.

10 Claims, 8 Drawing Figures



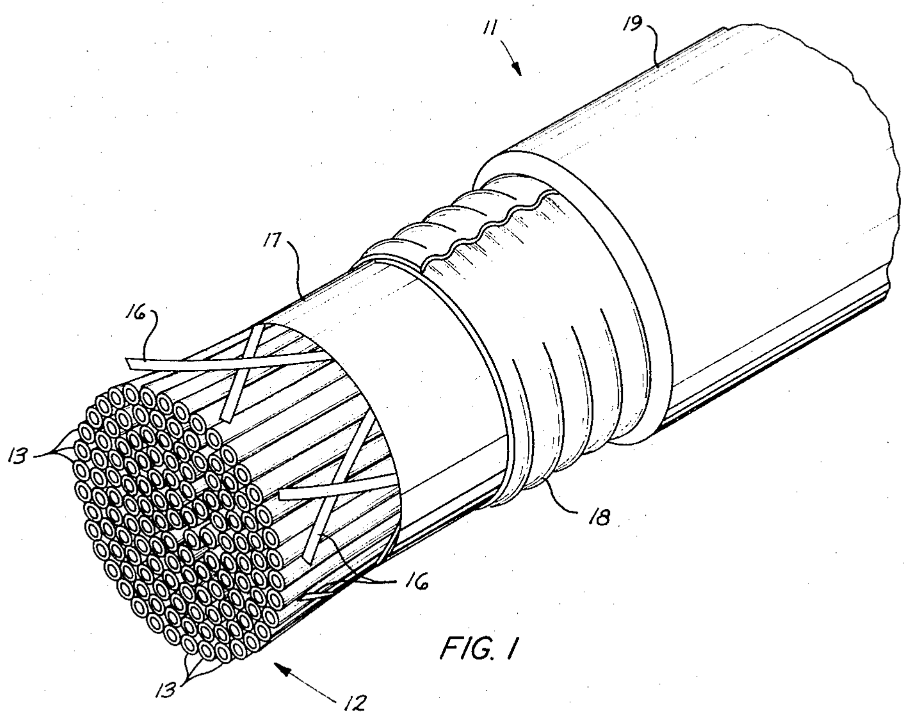


FIG. 1

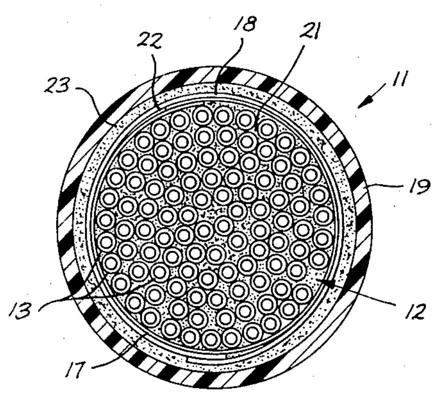


FIG. 2

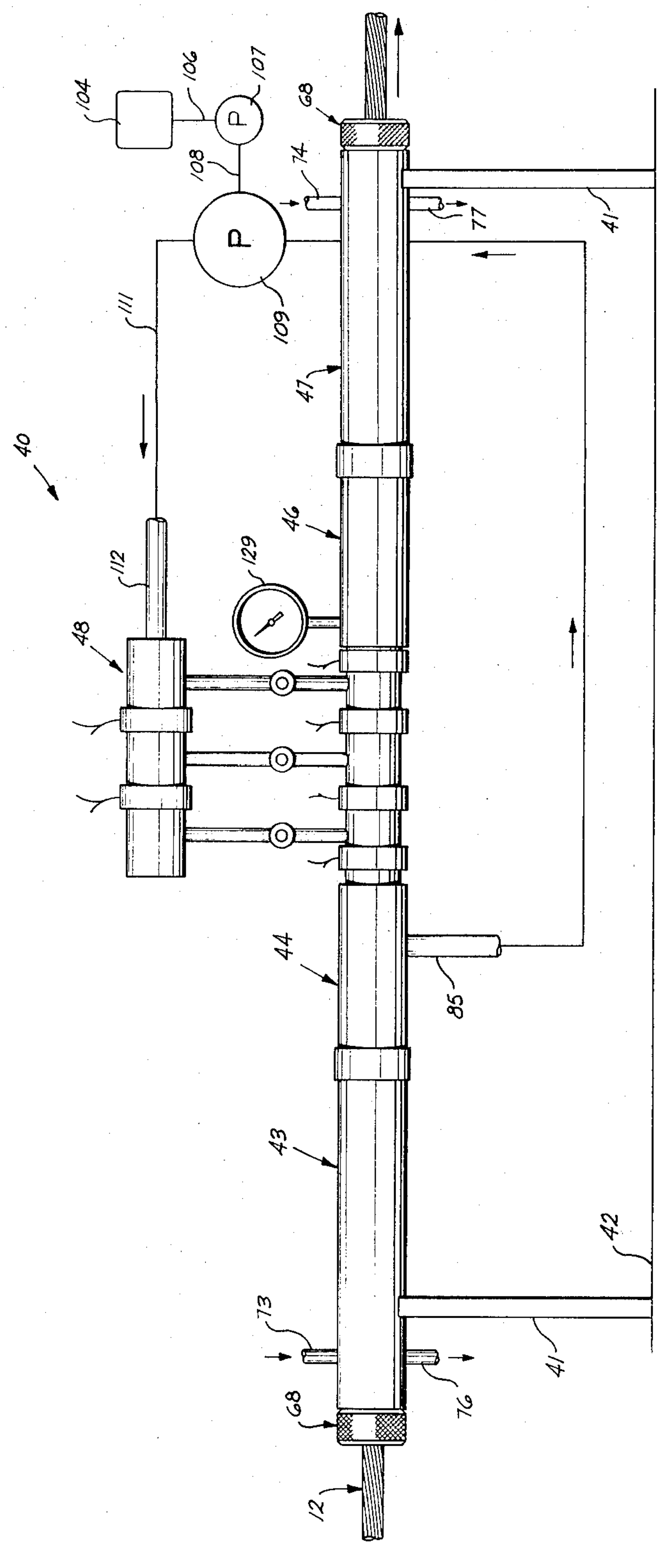

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FIG. 3

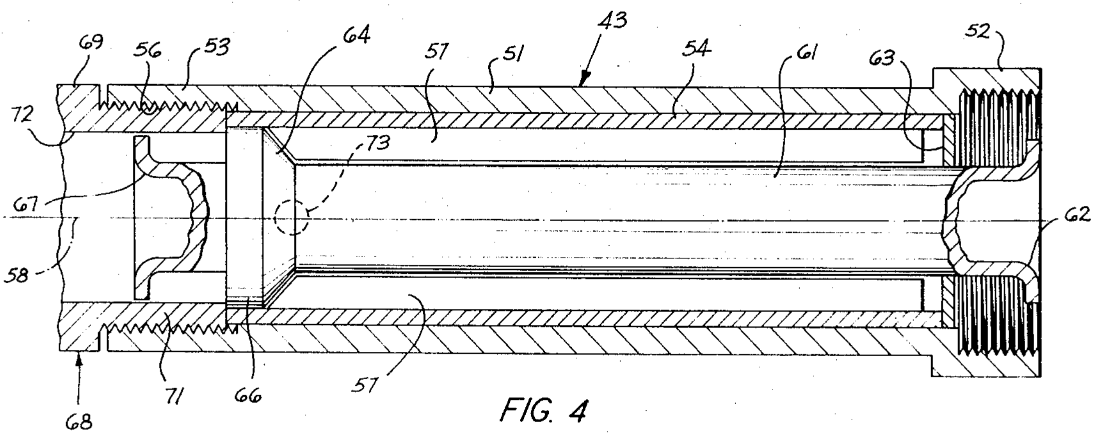

FIG. 4

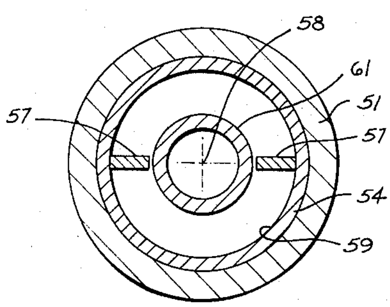

FIG. 5

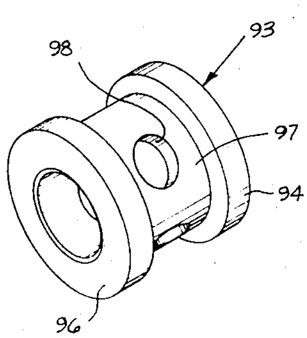

FIG. 7

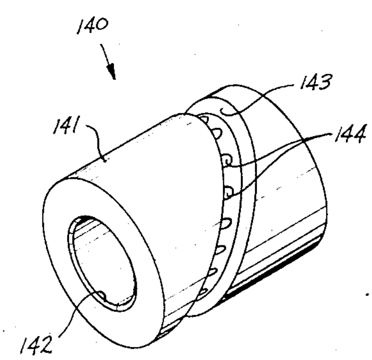

FIG. 8

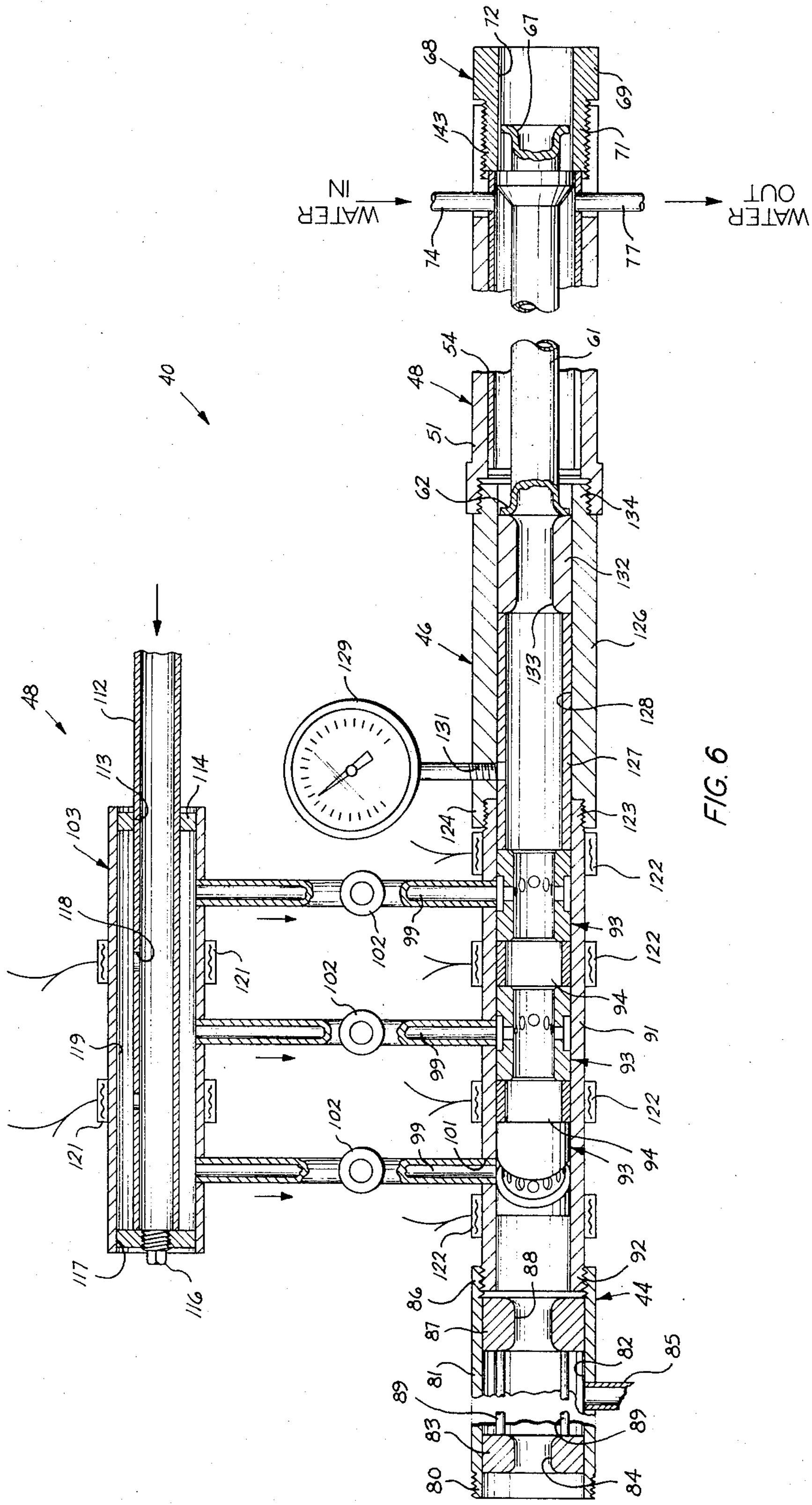

FIG. 6

METHODS OF MANUFACTURING WATERPROOF CABLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods of manufacturing waterproof cable, and more particularly, to methods of pressure filling the interstitial voids of a stranded cable core with a waterproofing compound to facilitate the construction of an essentially waterproof cable having a core wrap, sheathing and jacketing together with additional applications of the waterproofing compound over the core.

2. Technical Considerations and Description of the Prior Art

In the manufacture of various communications cables, such as those contemplated for use as underground or buried cable in telephone communications systems, individual bare conductors are extrusion coated with an insulative coating with the insulated conductors being twisted in pairs. A plurality of the twisted pairs of the insulated conductors are subsequently stranded together to form a cable core with a binding ribbon then being wound helically about the successive sections of the cable core for coding purposes. A thermal and dielectric barrier tape, commonly referred to in the art as a core wrap, and a metallic shield are wrapped about the advancing successive sections of the cable core. Then a jacketing layer of a plastic insulating material is extruded over the successive sections of the enclosed cable core.

Provisions must be made to protect the insulated conductors of the cable core to minimize the entry of moisture into the cable core. Since communications cables of the type described hereinbefore may be contemplated for underground or buried environments, moisture diffusion into the interior of the core is likely with accompanying corrosive attack causal of damage to the conductors and change in capacitance. Further, the presence of moisture in the cable core would result in the inefficient, and in some cases, the failure of, the operation of the telephone circuits formed by the conductors. There is also the possibility that the jacket and the metallic barrier could be broken open by external forces, such as shifting rock formations in the buried configurations or inadvertent blows to above-ground portions of the cable which could expose the cable core to moisture.

A presently used technique for minimizing moisture penetration into the cable core of a communications cable includes the use of metal strip precoated with an adhesive material and which is wrapped longitudinally about the core wrapped cable core. A jacket of hot plastic material is extruded about the adhesive coating on say one outwardly facing surface of the moisture barrier with the heat of extrusion causing the metal barrier to be bonded to the inner wall of the jacket to thereby form a bonded sheath about the cable core. The bonded sheath provides a moisture barrier which reduces the penetration of corrosive, damaging moisture into the core of the cable. Additionally, the cable core may be pressurized subsequently, which further tends to reduce the penetration of moisture into the core.

Another technique used to minimize the entry of moisture into a cable core includes the flooding of the interstitial voids in the core structure of the cable with

a compound which possesses properties sufficient to minimize the entry of moisture into the core. Ideally, the compound would fill all of the air spaces and voids within the cable which comprise the interstitial structure of the cable core. Because of the stranding together of twisted pairs of insulated conductors to form the core, difficulties have been experienced with prior art processes in insuring that all of the voids of the interstitial structure are filled with the waterproofing compound, particularly those which occupy the axially central portions of the core.

One approach in attempting to insure that all of the voids are filled with the waterproofing compound has been to advance the individual twisted pairs of conductors through a flooding chamber to coat each pair. Subsequently, the twisted pairs, having waterproofing compound adhered thereto, are stranded together into units which are then reflooded and cabled together to form a cable core. The cable core is advanced longitudinally with a protective tape or core wrap formed about the core and bound.

The wrapped cable core is advanced through a forming tube into which waterproofing compound under pressure, which may be as high as 50 psi, is introduced to coat the cable core assembly. The coated cable core is enclosed with an aluminum tape which is later covered with waterproofing compound prior to a jacketing operation. The process of covering the wrapped core is described in an application Ser. No. 69,837 filed 9–4–70 in the name of L. D. Moody. (See also U.S. Pat. No. 3,607,487 issued 9–21–71.)

Another method of cable filling is that shown in U.S. Pat. No. 1,681,566, in which successive sections of a cable are advanced through two vacuum chambers to evacuate the interstices of the loaded conductor. A filling chamber is connected to the downstream end of the vacuum chambers to fill the interstices within the cable. The compound could be maintained under pressure to force the compound most effectively into the interstices of the cable. Subsequently, a second compound chamber could apply a thin layer of compound to the surface of the cable after which the cable is fed directly into the core tube of an extrusion apparatus where a covering of, say, gutta percha, is applied over the cable. The compound is in a relatively fluid state with the pressures of application of the compound and gutta percha equalized to prevent deformation of the compound.

One prior art patent, U.S. Pat. No. 1,892,663, also shows methods and apparatus for impregnating solid insulating material of cables with an insulating fluid with the solid insulating material being surrounded by a sheath of say, lead, for example. A portion of the lead sheath is removed and a perforated or pemerable metallic sheath is inserted in contact with the solid insulation and a casing is applied to the cable to replace the removed portion of the sheath and is arranged to leave a space between the inner surface thereof and the outer surface. A pressure device is connected to the casing for completing and/or maintaining the impregnation of the cable by maintaining a predetermined pressure within the cable and preventing the formation of ionizable voids.

Viscous lubricants have also been incorporated into rope material by methods such as that shown in U.S. Pat. No. 2,028,158. A lubricant nozzle is positioned over the area of convergence of a plurality of individual fibers with the strands being stranded downstream of the nozzle. The lubricant is ejected under pressure to form an annulus about the rope with the lubricant being forced into the interstices between the individual fibers by a wiper.

Another method of lubricating wire rope is disclosed in U.S. Pat. No. 2,195,461, in which the lubricant may be applied "cold". Unheated lubricant is applied to individual fibers as the fibers are advanced into a forming die. Once the lubricant has been brought into contact with the moving wire, further movement of the wires pulls the lubricant outward of the container thereof. The flow continues as long as the individual fibers are advanced into and through a forming die to assemble a rope.

In the prior art, methods of saturating fibrous coverings on wires and cables are typified by that disclosed in U.S. Pat. No. 2,252,755 in which the covered wires or cables are advanced through a tank of coating material. The coated wire is then pulled through a chamber having orifices designed to increase the pressure in the saturating material as the wire is drawn through the chamber to force the saturating material into the pores or interstices of fibrous covering on the wire or cable. The wire or cable is pulled through a plurality of chambers each of which is partially closed by orifices of form and size to create a pressure. Each successive orifice is smaller than the previous one thereof to successively squeeze back some of the saturating material. This builds up a pressure in an enlarged chamber just upstream of each orifice to move the material into the interstices of the wire covering. Relief valves are provided to prevent the build-up of unduly high pressures.

Another patent, U.S. Pat. No. 3,533,870, discloses methods of fabricating a flexible impregnated glass fiber tether which converges a plurality of filaments into a fixture charged with a thermosetting resin followed by passing the bundle of resin coated fibers into a vessel having facilities for removing air from the resin and then through a die sized to generate a high pressure to force the resin into the filament bundle. Then the bundle is passed into an oven to decrease the viscosity of the resin and then through a double vacuum to remove all volatiles in the air and then through sealing and sizing dies.

In one prior art patent, U.S. Pat. No. 3,538,235, issued on Nov. 3, 1970, moisture prevention is sought by disposing a powder mixture in the space between the wires of the core and is loosely packed over the full length of the cable. The mixture is capable, on contact with moisture, of rapidly swelling into a viscous material, inhibiting axial penetration of moisture along the cable and also capable after a longer period of time of expanding to many times its axial volume on having an even higher viscosity than before.

In U.S. Pat. No. 3,601,967 issued on Aug. 31, 1971, it is disclosed that in the manufacture of plastic insulated multi-conductor cables that are filled throughout with water impermerable filling material, it has been considered necessary to transfer such material from a storage vessel to the cable and to apply it to the cable under super-atmospheric pressure by some form of pump. To pump such material in a solid condition is difficult because of almost inevitable cavitation and degradation of the material and the lowering of the viscosity thereof thereby rendering it less capable of forming a barrier permanently resistant to water under pressure.

The aforementioned patent alleges that the degradation may be reduced if pumping takes place while the material is at a temperature just above the temperature at which crystallization begins, i.e., just above that at which the sealing material is in a sufficiently liquid state to permit pumping of the material to be effected with substantially no degradation of the material occurring.

There is shown a cable wire provided with sealing material which is pumped to a feeding station and to the core while at the recrystallization temperature. The material is cooled to effect crystallization by abstractions of heat by the insulated conductors of the core and cause the material to become solidified to form a moisture barrier. The patent discloses that it is not necessary to cool the sealing material while it is transferred from the cable feeding station to the cable core.

The sealing material is applied through a die having three entry ports which are distributed uniformly about the axis of the die and which are inclined to impart to the liquified material a component of movement in the same axial direction as the direction of travel of the cable core being advanced through the die. Heating coils are provided for use when the sealing material has been allowed to go solid, as for example, when commencing circulation of the sealing material in preparation for applying sealing material to a cable core.

The sealing material is applied through a sealing die which is detachably secured to the entry end of the closing die of a stranding head, with another feeding station used where two or more conductors may be brought together to form a core under which other groups are laid up. Surplus material is allowed to fall into an associated collecting tank to be reheated and recirculated.

The above described apparatus is used to fill each layer of a layered cable with the compound being "bled" off a feeder line and directed into a plurality of spaced applicator dies which are positioned individually at each stranding head. At each stranding head die, a "pool" of material is maintained to cover the strand or layer with a volume flow applied thereto. There is no creation of a definite positive pressure within the applicator facility, but rather application by volume flow.

Moreover, the material is applied by the applicator dies through angled ports so that there is a component of flow in the direction of travel of the layered strands. As the layer is advanced, the layer tends to pull the material from the angled ports to force the material downwardly against the layer. Of course, the material must only be pulled down one layer.

It is an object of this invention to provide methods of and apparatus for pressure filling the interstices of a completed cable core.

Also the above recently issued patent depends on the conductors to act as a heat sink to cool the compound. This may be effective when dealing with a single layer but may not be as effective when filling a completed core.

It is also an object of this invention to provide methods and apparatus for pressure filling the interstices of a cable core with provisions for cooling the compound.

Since the waterproofing compound desirably replaces the air in the interstitial structure of the cable core, the compound must have excellent electrical properties so that the compound-filled cable maintains transmission characteristics at least as good as those of cables having an air-filled core and which use other techniques of moisture exclusion. In addition, the compound must have excellent resistance to flow at atmospheric temperature since portions of the cable must be brought above ground for terminating purposes. Further, the compound must possess low-temperature properties, such as adhesion and resistance to cracking due to handling of the cables in cold environments. The compound must not possess any toxic properties which would be objectionable from the standpoint of handling by installation personnel who may come into intimate contact with the compound.

It has been found that a mixture of petrolatum and low-density polyethylene in a precise blend satisfied the above-outlined requirements. Facilities have been developed and are disclosed in co-pending, commonly assigned application, Ser. No. 155,055, filed June 21, 1971 in the names of E. L. Franke, Jr., W. J. Hyde and R. G. Schneider, for overcoming problems and high costs encountered when the petrolatum-polyethylene waterproofing compound was blended at a distant location and transported to a core filling station.

The above-identified application, Ser. No. 155,055, filed June 21, 1971, also discloses still other methods and apparatus for manufacturing waterproof cable. Air is evacuated from the interstitial structure of the core of a cable, a waterproof compound in a workable state is deposited into the air-evacuated voids of the cable core, and the waterproofing compound is placed into a nonflowable state so that the deposited compound remains in the voids of and on the surface of the cable core independently of any other supporting structure to substantially preclude the entry of moisture into the core. This process overcomes some of the prior art difficulties in that the filling operation is accomplished during the final sheathing operation which prevents air entrapment that may occur if the core is filled during an earlier manufacturing operation.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide new and improved methods of manufacturing waterproof cable.

Another object of this invention is to provide improved methods of injecting and depositing a preblended waterproofing compound into the voids of the interstitial structure of a cable core.

A still further object of this invention is to provide methods of depositing a waterproofing compound into the voids of the interstitial structure of an axially moving stranded cable core.

A method embodying certain principles of the invention may include the steps of advancing successive sections of a cable core, directing streams of the compound in a semifluid state generally inwardly and then relatively longitudinally of the stranded cable core to cause the compound to displace the air within the interstices of the stranded core and conditioning the compound associated with the stranded core to a consistency having a viscosity sufficient to facilitate the retention of the compound with the stranded core independently of any supporting structure.

Other objects and advantages of the present invention will be apparent from the following detailed description when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view showing a portion of a communications cable;

FIG. **2** is a sectional view of the communications cable showing waterproofing compound located within the interstices of the core as well as other portions of the cable;

FIG. **3** is a view in elevation showing an apparatus for directing waterproofing compound into the core of a cable and embodying certain principles of this invention;

FIG. **4** is a sectional view in plan view showing a typical end portion of the apparatus of FIG. **3** which includes provisions for cooling the waterproofing compound;

FIG. **5** is an end sectional view of the cooling chamber shown in FIG. **4**;

FIG. **6** is a detail view in elevation of a portion of the apparatus showing a pressure filling chamber in which waterproofing compound is directed into the interstices of the cable core;

FIG. **7** is a detailed view in perspective showing a pressure filling device; and

FIG. **8** is an alternative embodiment of the pressure filling device shown in FIG. **7**.

DETAILED DESCRIPTION

Referring to FIG. **1**, there is shown a length of a a communications cable, designated generally by the numeral **11**. The cable **11** includes a cable core, designated generally by the numeral **12**, and which is composed of a plurality of insulated conductors **13—13** which have been twisted into pairs and then stranded into cable units. Colored binder ribbons **16—16** are wrapped about the cabled units to provide a visual color code indication as to certain characteristics of cable core **12**. A core wrap **17**, made from a plastic thermal barrier and dielectric tape, is wrapped longitudinally about the cable core **12**. Then one form of moisture protection, a corrugated aluminum shielding tape **18**, is wrapped longitudinally about the core wrap **17**, to prevent the ingress of moisture into the core and to provide a lightning shield for the cable core. Finally, a jacket **19** of insulating material is extruded over the corrugated aluminum shielding tape **18** to complete the construction of the cable **11**.

As can best be seen in FIG. **2**, the twisted conductors **13—13** and the stranded cable units **14—14** are constructed in a manner which creates air voids in the form of interstices **21—21** in the cable core **12**. In order to reduce the probability of moisture diffusion into and collection in the interstices **21** of the cable core **12**, the air voids of interstices are filled with a waterproofing jelly-like compound comprised of a mixture of petrolatum and polyethylene. An example of a range of proportions in ingredients of a waterproofing compound which may be used includes a mixture of approximately 85 percent petrolatum and 15 percent low density polyethylene to a mixture of 95 percent petrolatum and 5 percent low density polyethylene.

In order to more fully provide optimum waterproof protection for the cable **11**, additional amounts of the waterproofing compound are added to the cable. For example, waterproofing compound is applied in a space

22 between the core wrap 17 and corrugated aluminum shielding tape 18. Also, waterproofing compound is applied in a space 23 between the outwardly facing surface of the corrugated aluminum shielding tape 18 the extruded jacket 19, The so-called filled cable 11, as shown in FIG. 2 has been found to be substantially impervous to moisture. Adequate protection is thereby against moisture degradation of the conductors 13—13 of the cable 11, and eliminates the problems experienced when moisture diffuses into the cores of cables used in the communications industry.

The stranded structure of the cable core 12 is arranged with air voids existing throughout the cross-sectional configuration of the core. It should be obvious that difficulties may be encountered in insuring that the air voids of the centermost ones of the interstices 21—21 will be filled or will be filled with as much waterproofing compound as the air voids of the outermost interstices. In order to overcome this problem, methods or apparatus were developed which facilitated the application of the waterproofing compound to the cable core 12 in such a manner that substantially all the voids of the interstices 21—21 of the core are filled with the compound.

Referring now to FIG. 3, there is shown a compound applying apparatus, designated generally by the numeral 40, for carrying out the principles of the method of this invention for applying waterproofing compound into the interstices 21—21 of the cable core 12. The apparatus 40 includes a support frame 41 mounted on a stationary floor 42. Moreover, the apparatus includes an upstream cooling chamber, designated generally by the numberal 43, a pressure relief chamber, designated generally by the numeral 44, a pressure filling chamber, designated generally by the numeral 46, and a second or downstream cooling chamber, designated generally by the numeral 47, with successive sections of the cable core 12 being advanced through the aforementioned chambers in seriatum with the waterproofing compound being supplies to the pressure filling chamber 46 by a supply system, designated generally by the numeral 48.

The construction details of the cooling chambers 43 and 47 can best be seen by referring to FIG. 4. Although the upstream one 47 of the cooling chambers is shown there, the construction of both is identical.

As can best be seen in FIG. 4, the upstream cooling chamber 43 includes an outer tubular member 51 having a flanged internally threaded end 52 and an opposite end 53. It must be appreciated that in the upstream cooling chamber 43, the end 53 is positioned upstream of the flanged end 52. The cooling chamber 43 also has an internal sleeve 54 concentric and contiguous with the outer tubular member 51 extending from the external face of the flanged end 52 to an internal face of an internally threaded recess 56 formed at the end 53.

As can best be seen in FIGS. 4 and 5, the sleeve 54 has a pair of opposed baffle plates 57—57 extending radially inwardly toward a longitudinal axis 58 of the apparatus 40. The baffle plates 57—57 are longitudinally extending the length of a passageway 59 enclosed by the sleeve 54 and are adjacent to, but spaced slightly from the outer circumferential surface of a longitudinally extending tube 61. The successive sections of the cable core 12 are advanced through the end 53 into the cooling chamber 43 and through the longitudinally extending tube 61.

The longitudinally extending tube 61 is formed with a flared entrance portion 62 (see FIG. 4) which extends past a closed end 63 of the tube 61 at the flanged end 52 of the cooling chamber. The tube 61 has a tapered transition section 64 at the other end of the cooling chamber 43 connected to an entrance portion 66 having uniform cross section and which opens to the recess 56. The section 66 is in abutting fixed engagement with the inwardly facing surface of the inner sleeve 54. It should be observed from FIG. 4 that the baffle plates 57—57 are formed with sloped edges adjacent the tapered section 64 and spaced slightly therefrom. On the other hand, the ends of the baffle plates 57—57 are spaced considerably from the closed end 63. The construction of the baffle plates 57—57 with respect to the end portions of the cooling chamber 43 and the tube 61 is to effect a particular mode of cooling and sealing of the apparatus 40. Finally, a flared entrance portion 67 is connected to and extends axially longitudinally from the tube 61 through the section 64 and the portion 66.

It should be observed that the unitary construction of the sleeve 54 and tube 61 and the assembly thereof with the outer tubular member 51 permits the interchangeability of tubes to accommodate different size cores 12—12. The tube 61 may be conveniently slid longitudinally and replaced with a tube of the required diameter.

In order to complete the construction of the subassembly cooling chamber 43, an insert 68 includes a knurled threaded end 69 and having an externally threaded boss 71 extending therefrom. The insert 68 has a bore 72 formed therethrough concentric with the flared entrance portion 67 and with the axis of the bore 59 and connected to the inwardly facing surface of the insert. The insert 68 is designed so that the longitudinal axis thereof is aligned with the longitudinal axis 58 of the tube 61.

In order to cool the successive sections of the cable core 12 which are advanced through the cooling chambers 43 and 47, water is introduced through inlet tubes 73 and 74, respectively, (see FIG. 3) into the portion of the chamber between the inwardly facing surface of the sleeve 54 and the outwardly facing surface of the tube 61. The water is circulated through the cooling chambers 43 and 48 and then removed therefrom through outlet tubes 76 and 77 for return to a pump and chilling apparatus (not shown) for subsequent cooling. The chilled water which is supplied to the cooling chambers 43—43 is at a temperature of approximately 55°F which is sufficient to remove heat from the successive sections of the cable core 12 being advanced through the tube 61.

Successive sections of the cable core 12 which have been advanced through the upstream one 43 of the cooling chambers 43 and 47 are then moved into a pressure relief chamber 44 connected to the downstream end of the upstream one of the cooling chambers. The pressure relief section 44 includes a housing 81 having a bore 82 formed therethrough with an upstream end of the housing having a reduced diameter externally threaded portion 80 (see FIG. 6) to be attached threadably with the internally threaded flanged end 52 of the upstream one 43 of the cooling sections 43 and 48. A die 83 having an opening 84 therethrough is positioned within the upstream end of the bore 82. The downstream end of the housing 81 includes an internally threaded portion 86 with a die 87 having an opening 88 and positioned just upstream of the internally threaded portion. The die 83 and the die 87 are connected by longitudinal rods 89—89.

The dies 83 and 87 are formed with the central openings 84 and 88, respectively, concentrically disposed within the housing 81 to provide movement axially therethrough of the successive sections of the cable core 12. It should be appreciated that different size cable cores 12—12 must be accommodated by the apparatus 40. Accordingly, the dies 83 and 87 are mounted in the housing 81 to permit removal thereof and replacement at selected periods with dies to accommodate different size cable cores 12—12. For example, the cable core 12 could include 25, 50, 200 or 200 twisted pairs of conductors 13—13. Of course, the external diameter of the dies 83 and 87 remain the same to permit insertion and mounting within the upstream and downstream ends of the housing 81.

The pressure relief section 44 also includes a drain line 85 having an adjustable relief valve 90 for regulating the pressure in the pressure filling chamber 46. Another function of the drain line 85 and pressure relief valve 90 is to establish together with the pressure filling facilities a continuous flow of waterproofing compound in a direction opposite to that of the travel of the core 12. The axial longitudinal flow of the compound has been found to be effective to insure a more complete penetration of the core 12 than had heretofore been achieved.

After the successive sections of the cable core 12 are advanced through the pressure relief section 44, successive sections of the cable core are moved into and through the pressure filling chamber 46. The pressure filling chamber 46 includes an outer tubular member 91 having an externally threaded upstream end 92 onto which is turned the internally threaded end 86 of the pressure relief section 44 during the assembly of the apparatus 40. The pressure filling chamber 46 is provided with at least one, and preferably three, filling devices, designated generally by the numeral 93—93.

The filling devices 93—93 are mounted within the tubular member 91 and are spaced longitudinally along the axis thereof with spacers 94—94 being interposed therebetween. As can best be seen in FIG. 7, each of the filling devices 93—93 includes a pair of spaced flanges 94 and 96 connected by a sleeve 97. The outside diameter of the flanges 94 and 96 is designed to mate with the inwardly facing surface of the tubular member 91. The internal diameter of the sleeve 97 is designed to accommodate a particular size cable by having an anticipated number of twisted pairs of conductors 13—13. Provisions are made for removing the pressure filling devices 93—93 to provide interchangeability with others required to accommodate different size cable cores. In the alternative, the internal diameter of the sleeve 97 may be designed to accommodate the largest anticipated core size thereby eliminating the necessity of changing the filling devices 93—93 for each size core being processed. The filling device 93 also includes a plurality of openings 98—98 for directing the waterproofing compound into engagement with the successive sections of the cable core 12 being advanced through the sleeve 97.

As can best be seen in FIG. 6, the pressure filling devices 93—93 are positioned within the tubular member 91 so that the annular space between the flanges 94 and 96 of each is aligned with a feeder pipe 99 extending through an opening 101 in the tubular member. The feeder pipes 99—99 include shut-off valves 102—102 and are designed to convey waterproofing compound from a supply manifold 103 to the filling devices 93—93.

Referring now to FIGS. 3 and 6, it can be seen that the supply system 48 for supplying waterproofing compound to the pressure filling compound chamber 46 includes a central supply 104 which is connected along a conduit 106 to a first pump 107 and then along a conduit 108 to a central pumping system 109 and from there along a conduit 111 to supply conduit 112. The supply conduit 112 extends through an opening 113 in the end 114 of the supply manifold 103 and terminates at the other end thereof. A threaded thermocouple 116 is turned threadably through a threaded opening 117 formed in the end of the supply manifold 103. The thermocouple 116 is utilized to monitor and/or regulate the temperature of the supply compound.

The supply conduit 112 includes a plurality of openings 118 formed along a length therof which is positioned within a passage 119 of the supply manifold. Moreover, the supply 103 is provided with a plurality of portable strip heaters 121—121 which may be used to maintain the temperature of a particular composition waterproofing compound to a predetermined temperature which has been found to be advantageous to the filling process. A plurality of strip heaters 122—122 are also spaced along and connected to the outside surface of the tube 91 as shown in FIG. 6.

Referring now to FIG. 6, the downstream end of the tube 91 has an externally threaded section 123 for receiving an internally threaded end 124 of an extension section 126 of the cooling chamber 46. The section 126 is aligned concentrically with the tube 91 and the longitudinal axis 58 of the apparatus 40. The extension 126 also includes a sleeve 127 concentrically disposed within a bore 128 formed within the extension section. Of course, the section 126 need not be a separate element but could just as well have been constructed as an integral continuation of the tubular member 91. A pressure gauge 129 is connected into an opening 131 through the section 126 and the sleeve 127 to communicate with the sleeve passage to indicate to an operator the pressure therewithin.

A die 132 having an opening 133 designed to accommodate a particular core 12 having a predetermined number of twisted conductors 13—13 is mounted within the downstream end of the extension 126 and is designed to engage with the flared entrance 62 of the downstream one of the cooling chambers 43 and 47 (see FIG. 5). Also, the die insert 132 is adapted to be removed and interchangeable with other dies having varying openings 133—133 to accommodate different size cable cores 12—12. Of course, the dies 132—132 are constructed with the same outside diameter to permit reception within the bore 128.

As can best be seen in FIG. 6, the extension 126 has an externally threaded end 134 for reception within the internally threaded opening of the flanged end 52 of the cooling chamber 47. When the downstream one 47 of the cooling chambers 43 and 47 is connected to the downstream end of the extension section 126, the flared end 62 of the tube 61 engages the die.

The construction of the cooling chambers 43 and 47 prevents the cooling medium from escaping therefrom.

As can be seen in FIG. 4, the flared end portion 62 and the entrance portions 66 are connected to the sleeve 54. As cooling medium flows into the inlet tube 73 and say upstream in the cooling chamber 47, the portion of the cooling medium which does not trickle downwardly by gravity past the baffle plates 57—57 into the lower portion of the chamber is contained by the end member or closure plate 63 from moving further upstream and contaminating the waterproofing compound. The opening between the closure plate 63 and the baffle plates 57—57 permits the bulk of the cooling medium to enter the lower portion of the cooling chamber 47. Similarly, at the downstream end of the chamber 47, the connection of the portion 66 to the sleeve presents escape of the cooling medium.

ALTERNATIVE EMBODIMENT

It has been found that improvements may be made in the pressure filling device 93. For example, as shown in FIG. 8, an improved pressure filling device 140 may include a cylindrical portion 141 having an outside diameter approximately equivalent to the internal diameter to the tube 91 with a plurality of the devices arranged in tandem within the tube and maintained in a spaced relationship by the spacers 94—94 interposed therebetween.

The improved pressure filling device 140 has a passageway 142 formed therethrough, through which successive sections of the cable core 12 are advanced. Moreover, the cylindrical portion 141 includes a raceway 143 formed helically thereabout with a plurality of openings 144—144 communicating the raceway with the passageway 142. In this way, the waterproofing compound is moved, for example, through the openings 101—101 which are aligned with an upstream portion of the raceway 143 of an associated one of pressure filling devices 140—140. The compound under pressure of approximately 50 psi is urged along the raceway helically about the cylindrical portion 14 in a downstream direction and through successive ones of the openings 144—144 into engagement with the advancing cable core 12.

It is believed this arrangement of the openings in seriatum rather than in an opposed radial relationship may more completely fill the interstices of the advancing cable core 12.

Operation

Referring now to FIGS. 3 and 6, successive sections of the cable core 12 are moved axially from a supply stand (not shown) or from other apparatus of a tandem line and through the in-line elements of the compound applying apparatus 40. The successive sections of the cable core 12 are advanced through the bore 72 of the insert 68 and into the flared opening 67 of the first cooling chamber 43. Because of the essentially close openings of the flared entrance 67 (see FIG. 4), the flared entrance forms an essentially air-tight entry for the cable core 12 into the compound applying apparatus 40. Thereafter, the successive sections of the cable core 12 are advanced into and through the tube 61 of the cooling chamber 43.

Chilled water is pumped from the pumping system (not shown) into the water inlet tubes 73 and 74 and into a topmost portion of the chamber 43 between the tube 61 and the sleeve 54. The water under pressure moves in a downstream direction in the cooling chamber 43 simultaneously having portions thereof trickle through the space between the baffle plates 57—57 and the tube 61 to fill the lower portion of the chamber. The bulk of the water is moved within the upper portion of the chamber toward the downstream end thereof and flows between the closed end 63 and the end portions of the baffle plates 57—57 upstream of the flared end 62 of the tube 61 and into the lower chamber. The water in the lower portion of the chamber is evacuated therefrom through the water outlet tubes 76 and 77 for recirculation to chilling apparatus and subsequent redistribution.

Simultaneously, the water in the downstream cooling chamber moves upstream with portions thereof trickling between the baffle plates 57—57 and the tube 61 to drop into the lower portion of the cooling chamber. The majority of the water descends into the lower portion of the chamber at the upstream end of the cooling chamber 43 between the end of the sleeve 54 and the flared entrance portion 62.

Successive sections of the cable core 12 are then moved into and through the pressure relief section 44 of the apparatus 40 with the cable core 12 first engaging with the walls of the die 83 and then with the walls of the die opening 88.

Subsequently, the successive sections of the cable core 12 are moved into and then into the compound filling chamber 46 and successively through each one of the pressure filling devices 93—93 or 140—140, in the alternative. The waterproofing compound is pumped from the supply 104 along the lines 106 and 108 and the line 111 into the supply conduit 112. From there, the waterproofing compound is urged through the openings 118—118 into the passage 119 of the supply manifold 103. The heaters 121—121 are rendered effective to maintain the waterproofing compound to a particular temperature composition so that compound may more appropriately fill the interstices 21—21 of the cable core 12. The waterproofing compound is moved from the supply manifold 103 through the the feeder pipes 99—99.

Waterproofing compound at a pressure of approximately 50 pounds per square inch is then moved through the openings 101—101 in the wall of the tube 91 and into the annular space formed between the flanges 94 and 96 of the associated pressure filling device 93. From there, the waterproofing compound is urged through the openings 98—98 and radially inward into engagement with the core 12. As the heated waterproofing compound is continually moved into engagement with the outer ones of the insulated conductors 13—13, the waterproofing compound is moved inwardly of the cable core 12 to displace the air from and to fill the interstices 21—21.

The pressure within the filling chamber 46 causes the waterproofing compound to be urged axially longitudinally of the chamber in an upstream direction toward the pressure relief chamber 44. In the upstream direction, the waterproofing compound is squeezed past the die opening 88 and into the pressure relief chamber 44. Any of the waterproofing compound which has passed or moved into the pressure relief chamber 44 passes into the discharge pipe 85 to be returned to the central pumping system 109 for recirculation to the supply manifold 103.

It should be observed that even though the cable core 12 may be very close fitting within the die opening 88, that some of the waterproofing compound may be urged axially longitudinally within the interstices of the core itself so that to find a path into the pressure relief chamber for discharge into the recirculated system. This is extremely important in being able to fill the interstices of the cable core **12.** A flow path of the compound is established to more positively direct the compound to be moved internally through the plural core units or layers to insure a complete filling. A combination of the velocity of the compound and the pressure has been found adequate to fill the very largest cores manufactured.

In order to prevent the waterproofing compound from moving still further in an upstream direction, the apparatus **40** incorporates the upstream one **43** of the cooling chambers **43** and **47.** The operation of the cooling chamber **43** is closely allied to the character of the compound which is that the compound becomes very viscous at lower temperatures. The compound cools and tends to be self-sealing at temperatures such as those of the chilled water which is supplied to the cooling chambers **43** and **47.** Consequently, any of the waterproofing compound which is urged within the interstices **21—21** of the cable core **12** in an upstream direction from the pressure relief section **44** tends to become very viscous and self-sealing to prevent a mass exodus of waterproofing compound into the cooling chamber **43.** This, in effect, tends to stabilize the system and maintain the flow of the waterproofing compound only so far as the pressure relief chamber **44** from where the compound is pulled into the conduit **85** by the pump **109.**

Similarly, in the downstream direction, the construction of the apparatus **40** tends to inhibit the disassociation of the compound from the core **12** beyond the insert **68** of the cooling chamber **47.** The die **132** sizes the layer of waterproofing compound on the surface of the core **12.** Then the temperature of the waterproofing compound both within and on the surface of the core **12** is rendered viscous by the advance of the successive sections of the cable core through the cooling chamber **47.** The waterproofing compound is rendered nonflowable and is retained within the interstices of the core **12** independently of any other supporting structure.

The cable core **12** which now includes the waterproofing compound essentially filling the interstices thereof is then advanced through a series of operations in which the core wrap **17** is wrapped longitudinally about the cable core. Then additional amounts of the waterproofing compound may be applied to the cable core **12** after which a band or ribbon is wrapped helically about the core wrap. Subsequently, corrugated aluminum shielding tape **18** is wrapped longitudinally about the core wrap.

As the corrugated aluminum shielding tape **18** is being formed for subsequent longitudinal wrapping about the cable core **12** and the core wrap **17,** the cable core and the core wrap may be passed through a mandrel into which is injected additional amounts of the waterproofing compound immediately prior to the longitudinal forming of the aluminum shielding tape **18** about the core wrap. This feature of the operation is disclosed in a co-pending application, Ser. No. 69,837, filed in the name of L. D. Moody on Sept. 4, 1970.

Thereafter, cable core **12** having the core wrap **17** and the corrugated aluminum shielding tape **18** wrapped thereabout is passed through a path (not shown) of the waterproofing compound so that the compound fills essentially the valleys of the corrugations of the shielding tape. The cable core **12** with the core wrap **17** and the aluminum shielding tape **18** is then passed through an extruder head (not shown) where the polyethylene jacket **19** is applied. The jacketed product is then passed through a cooling trough (not shown) and on to a take-up reel (not shown).

The waterproofing compound may be prepared in a compound preparation area with facilities which are described in co-pending application, Ser. No. 155,055, filed in the names of E. L. Franke, Jr., W. J. Hyde and R. G. Schneider on June 21, 1971.

The waterproofing compound is generally heated by the strip heaters **121—121** and the strip heaters **122—122** to a temperature of approximately 200°F. This temperature has been found to be adequate to render the waterproofing compound semifluid and of a consistency sufficiently viscous to fill the interstices **21—21** of the cable core **12.**

Although the hereinbefore described apparatus **40** included facilities for heating the waterproofing compound, it is within the scope of this invention to fill the interstices **21—21** of the cable core **12** with a compound at an ambient temperature of approximately 75°F. In those instances a different composition compound may be used with the apparatus **40** and with the strip heaters **121** and **122** not being used. Also, when using waterproofing compound at an ambient temperature especially with the larger size cable cores, it may be necessary to use an injection pressure in the range of 100 to 150 psi. For smaller size cables, pressure of approximately 50 psi is acceptable with the compound applied at an ambient temperature.

Should it be decided to waterproof a particular cable core **12** with waterproofing compound at ambient temperature, the cooling chambers **43** and **47** need not be rendered effective. Therefore, valves (not shown) may be operated to discontinue the supply of chilled water to the cooling chambers **43** and **47.**

Moreover, the flow path of the waterproofing compound which is established subsequent to the directing of the streams of compound into the pressure filling chamber **46** may be varied depending upon such variables as the composition of the compound used and pair size of the cable cores. For example, it would be within the scope of this invention to have the waterproofing compound moved relatively longitudinally in a downstream direction with the advancing cable core **12** as opposed to movement in an upstream direction as described hereinbefore. In that event, provisions must be made, say in the extension section **126** for pulling the compound from the pressure filling devices **93—93** in a downstream direction, i.e., the same direction as the path of travel of the cable core **12,** to establish a flow path of the compound to more completely fill the interstices **21—21.**

It is to be understood that the above-described arrangements are simply illustrative of the invention. Other arrangements may be devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A method of filling substantially the interstices of an already stranded core of a communications cable with a waterproofing compound, which includes the steps of:

advancing successive sections of the stranded core along a predetermined path; through a laterally confined pressure relief chamber and then through a filling chamber;

directing a plurality of streams of the compound in a semifluid state generally radially inwardly of the longitudinal axes of the successive sections of the stranded core in the filling chamber at a velocity and pressure sufficient to cause the compound to displace the air within the interstices of the core and to fill the interstices thereof, while creating a pressure differential between the filling chamber and the pressure relief chamber to establish a flow path of the compound which has been moved in engagement with the core longitudinally along the core and move portions of the compound from the filling chamber within the stranded core to the pressure relief chamber to cause the interstices of the core to become filled substantially; and

providing a cooling chamber along the path downstream of the filling chamber and through which the core is advanced to cool the core and the compound associated with the successive sections of the core in the interstices and on the surface thereof to a consistency having a viscosity sufficient to facilitate the retention of the compound with the core independently of any supporting structure.

2. The method of claim **1**, wherein the plurality of streams of compounds are arranged in a single plane transverse of the axes of the successive sections of the core.

3. The method of claim **1**, wherein the plurality of streams of compound are spaced along the longitudinal axes of the successive sections of the core.

4. A method of applying a compound to a stranded core of a communications cable, which comprises the steps of:

advancing successive sections of the stranded core along a path of travel;

directing streams of the compound in a semifluid state generally inwardly of the successive sections of the stranded core;

establishing a flow path of the compound longitudinally along the advancing successive sections of the stranded core in a direction opposite to the path of travel;

the velocity of the streams and the flow paths and the pressure of the compound being sufficient to cause the compound to displace the air within the interstices of the stranded core and to fill the interstices of the stranded core;

cooling the successive sections of the stranded core prior to the entry of the sections into the flow path of the compound to place in a jelly-like state any portions of the compound which are drawn from the flow path in a direction opposite that of the path of travel to preclude further movement of the compound along the path of travel; and

conditioning the compound associated with the stranded core to a consistency having a viscosity sufficient to limit the flow path and to facilitate the retention of the compound with the stranded core independently of any supporting structure.

5. A method of applying a compound to an elongated stranded article, which comprises the steps of:

moving successive sections of the stranded article along a path of travel successively through a cooling chamber, a pressure-relief chamber and compound-filling chamber;

directing a plurality of streams of compound in a semifluid state into the compound-filling chamber and into engagement with the successive sections of the stranded article at a pressure sufficient to move the compound into the interstices of the successive sections of the stranded article;

establishing a flow path of the compound from the filling chamber in a direction opposite to the path of travel of the successive sections of the stranded article to move the compound from the filling chamber along and within the stranded article into the pressure-relief chamber;

the cooling chamber being effective to preclude further movement of the filling compound in the direction opposite to the path of travel; and

conditioning the compound associated with the stranded article to a consistency having a viscosity sufficient to facilitate the retention of the compound with the stranded article independently of any supporting structure.

6. A method of applying a compound to an elongated stranded article, which comprises the steps of:

moving successive sections of the stranded article through a compound-applying chamber;

moving amounts of the compound in a semifluid state into the compound-applying chamber and into contact with the successive sections of the stranded article at a pressure sufficiently high to displace the air in interstices of the stranded article with compound; then

moving the compound relatively generally longitudinally of the movement of the successive sections of the stranded article, the moving of the compound into contact with the article and then relatively generally longitudinally thereof causing the compound to be moved first into the interstices and then along the article to facilitate the displacement of the air within the interstices throughout the cross-sectional area of the stranded article to insure that substantially all the interstices are filled with the compound;

moving the compound-filled stranded article through an environment whereat the semifluid compound is conditioned to place the compound in a jelly-like state so that the compound is non-flowable and is retained within the interstices and on the surface of the stranded article independently of any other supporting structure; and

cooling the successive sections of the stranded article prior to the entry of the portions into the flow path of the compound to place in a jelly-like state any portions of the compound which are drawn from the compound-applying chamber along the flow path to preclude further movement of the compound.

7. A method of applying a compound to an elongated stranded article, which comprises the steps of:

advancing successive sections of the stranded article in a first direction along a path of travel;

cooling initially the successive sections of the stranded article; and then directing streams of the compound in a smeifluid state generally radially inwardly of the successive sections of the stranded article;

establishing a flow of the compound relatively longitudinally of the stranded article in a second direction opposite to the first direction;

the pressure of the compound and the flow paths of the compound being sufficient to displace the air from the interstices of the stranded article and to fill the interstices with the compound;

the cooling of the successive sections prior to the application of the compound being sufficient to condition the compound to a consistency having a viscosity sufficient to seal the stranded article and preclude further longitudinal movement of the compound; and

cooling the successive sections of the article subsequent to the directing of the compound into engagement therewith to condition the compound to a consistency having a viscosity sufficient to facilitate retention of the compound with the stranded article independently of any supporting structure.

8. The method of claim **7** wherein the directing of the streams and the longitudinal flow of the compound is caused to occur in an enclosed environment.

9. The method of claim **7**, which further includes:

heating the compound to a predetermined temperature prior to the directing of the streams thereof into engagement with the successive portions of the stranded article.

10. A method of applying a compound to an elongated stranded article, which comprises the steps of:

advancing successive sections of the stranded article in a first direction along a path of travel;

cooling initially the successive sections of the stranded article; and then

directing streams of the compound in a semifluid state generally radially inwardly of the successive sections of the stranded article;

establishing a flow of the compound relatively longitudinally of the stranded article in a second direction opposite to the first direction which includes the steps of;

reducing the pressure intermediate the directing of the streams and the cooling initially of the successive sections of the stranded article; and

moving compound in excess of that required to fill the interstices and to cover the surface of the stranded article out of engagement with the stranded article;

the pressure of the compound and the flow paths of the compound being sufficient to displace the air from the interstices of the stranded article and to fill the interstices with the compound;

the cooling of the successive sections prior to the application of the compound being sufficient to condition the compound to a consistency having a viscosity sufficient to seal the stranded article and preclude further longitudinal movement of the compound; and

cooling the successive sections of the article subsequent to the directing of the compound into engagement therewith to condition the compound to a consistency having a viscosity sufficient to facilitate retention of the compound with the stranded article independently of any supporting structure.

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