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Hacker

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[54] **MANUFACTURING FILLED CABLE**

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[52] **U.S. Cl.** **57/162;** 29/624; 57/7; 57/164; 117/7; 118/44

[51] **Int. Cl.** **D02g 3/36**

[58] **Field of Search** .... 29/624, 461; 57/7, 35, 57/162, 164; 156/48; 117/7, 8, 47 R, 34; 118/33, 44; 264/103

[56] **References Cited**

UNITED STATES PATENTS

1,251,032	12/1917	Hoover	118/44
1,745,285	1/1930	Whiffen	118/44
2,757,101	7/1956	Elling	118/44 X
2,763,563	9/1956	Clougherty et al.	117/7
3,244,545	4/1966	Marzocchi et al.	117/7
3,443,374	5/1969	Carnevale	57/162 X
3,695,027	10/1972	Copp	57/162
3,779,844	12/1973	Dorsch	118/44 UX
3,791,132	2/1974	Schutz et al.	57/164

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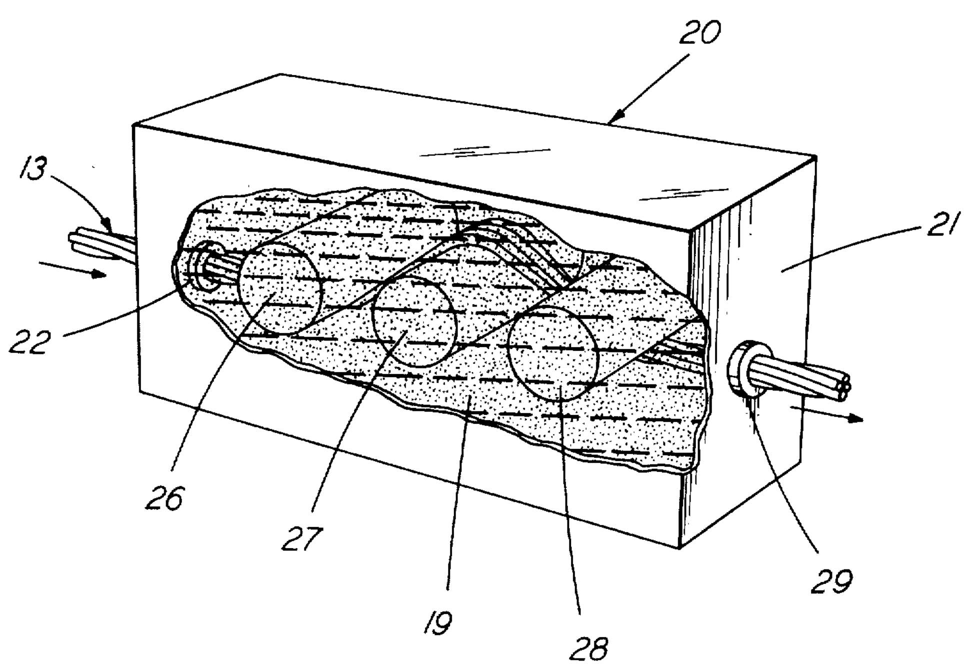
[57] **ABSTRACT**

A filled telephone service cable which runs from a distribution cable to a subscribers' premises or to a pay station is another link in a buried communications system having a water-resisting capability. A service cable is manufactured to include four individually insulated conductors constructed of a material having at least a predetermined yield strength twisted to form a spiralled quaded core. In order to impart water-resisting capability to the cable, the interstices between the conductors and between the conductors and a subsequently applied jacket are filled with a flame retardant water-resistant composition. The core, including the individually insulated conductors, is advanced into a bath of the waterproofing composition. The configuration of the core is changed as the conductors are advanced through the bath to permit substantially the entire periphery of the conductors to be exposed to the composition. Subsequently, the conductors are permitted to reform into the original core configuration with portions of the composition filling the interstices between the conductors. The reformation is facilitated by the changes in strain produced by the elastic recovery of the conductors. Excess composition is removed from the outwardly facing portions of the core as the core is advanced out of the bath.

8 Claims, 6 Drawing Figures



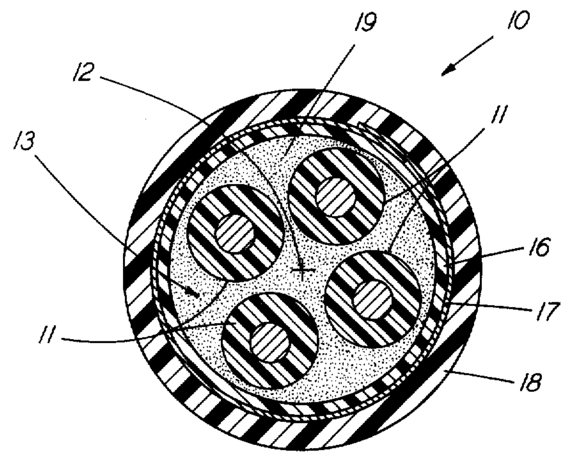


FIG. 1

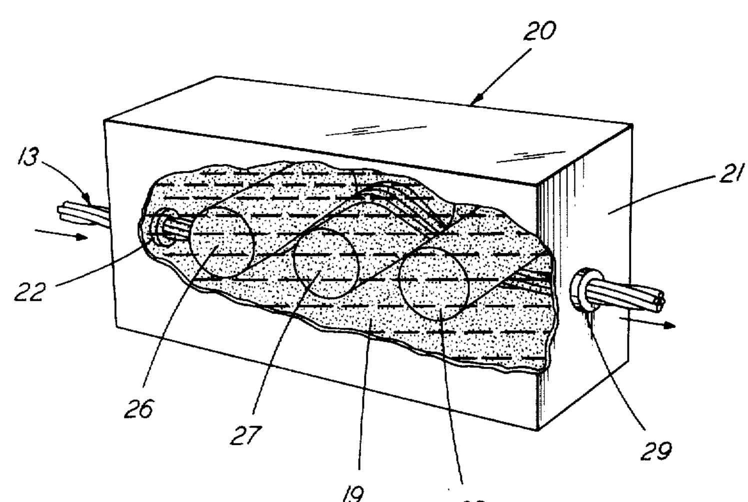


FIG. 2

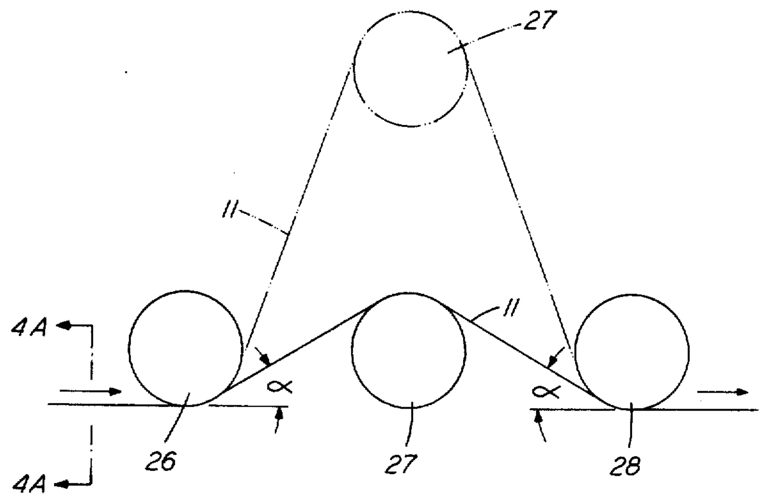


FIG. 3

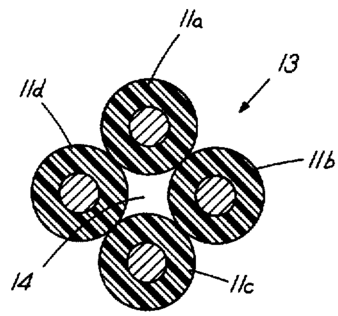


FIG. 4A

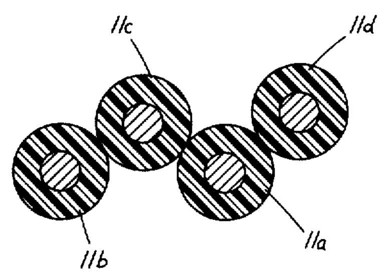


FIG. 4B

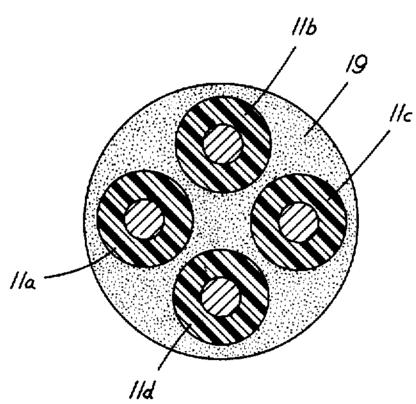


FIG. 4C

MANUFACTURING FILLED CABLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods which may be used for manufacturing filled cable, and more particularly, to manufacturing a spirally quaded cable in which the interstices between the individually insulated conductors and between the conductors and any covering applied thereover is filled with a waterproofing, flame-retardant composition.

2. Description of the Prior Art

It has been an objective in the telecommunications industry to provide underground transmission media for various reasons. One of these, of course, is the aesthetic appeal of the absence of overhead lines. Another is the prevention of discontinuity of service due to fallen trees, windstorms and the like.

Of course, the burial of transmission media poses several problems which must be overcome to make such a system feasible. One of these is the problem of ingress of moisture into the buried cable with accompanying loss of transmission characteristics. In order to overcome this, the cable must be designed to prevent or resist the ingress of moisture.

The last link in a buried loop plant includes a so-called service wire or cable which extends from the distribution cable to a subscribers' premises or to a pay station. The service cable should be filled with a water-resistant composition and since the service cable extends to subscribers' premises, any waterproofing composition must also be flame-retardant

A composition which is water-resistant and flame-retardant for filling the interstices of a service cable is disclosed and claimed in an application filed of even date herewith in the names of J. M. Hacker and E. S. Sauer, Ser. No. 388,695.

Generally, the service cable is constructed to include four individually insulated conductors. The conductors preferably are twisted together, instead of in pairs, to form what is commonly referred to in the art as a spiralled, star-quad. The conductors are twisted about an imaginary longitudinal axis with the resulting core configuration including what appears as a star-shaped central opening.

It has been found that the prior art does not adequately include manufacturing methods for filling substantially the interstices, and more specifically the central core space, in a quaded cable. The filling of a quaded cable should be substantially complete in order to prevent any moisture which penetrates the service cable from running longitudinally along any core space causing damage to the conductors or diminution of the electrical characteristics thereof at various points along the cable.

SUMMARY OF THE INVENTION

This invention provides methods for manufacturing a filled cable. Specifically, the methods are used to produce a quaded service cable in which there is a substantial filling of the interstices of the cable including the central core space thereof.

A plurality of elongated members are stranded about a longitudinal center line to form a core with each of the elongated members having at least a predetermined yield strength. The predetermined yield strength is stated in terms of a unit stress to which the elongated

member is subjected will return to a certain percent of its original configuration when the load causing the stress is removed. The yield strength may be that of a material from which the conductive element of a single insulated conductor which comprises an elongated member is constructed. Or the yield strength may be a composite of the materials from which a twisted conductor pair is constructed.

The stranded core is advanced through a bath of a composition. Forces are applied to the core to (1) cause the core configuration to be changed to expose portions of the elongated members which in the original configuration of the core are not exposed to the composition, and then (2) permit the elongated members because of the elastic properties associated with the yield strength thereof to be reformed into the stranded core and cause the interstices between the elongated members to be filled substantially with the composition.

Excess composition is removed from the core to form a generally regularly shaped contour of the composition about the core.

BRIEF DESCRIPTION OF THE DRAWINGS

The various features of the invention will be more readily understood from the following detailed description when read in conjunction with accompanying drawings wherein:

FIG. 1 is a sectional view of a service cable which includes four individually insulated conductors and a waterproofing composition for filling the interstices of the core between the conductors and between the core and inner jacket, with the spacing between adjacent ones of the conductors being exaggerated for purposes of illustrating the coating thereof with the composition;

FIG. 2 is a perspective view of an apparatus for carrying out the principles of this invention which may be used to apply the waterproofing composition to the service cable;

FIG. 3 is an elevational view of a portion of the apparatus of FIG. 2 showing an arrangement of rollers over which the service cable is passed; and

FIGS. 4A–4C are a series of end views of the conductors which comprise the cable core at various stages in the construction and filling process.

DETAILED DESCRIPTION

Referring to FIG. 1, there is shown a cable, designated generally by the numeral **10**, which includes four polyethylene-insulated conductors **11—11**. The four conductors **11—11** are twisted together about a longitudinal axis **12** to form a spirally quaded core, designated generally by the numeral **13** (see FIG. 4A). The conductors **11—11** are arranged about the axis **12** so as to form a central star-shaped opening **14** (see FIG. 4A). Because of the shape of the opening **14**, this configuration cable is generally referred to as a star-quaded cable.

In the presently used environment, the individual polyethylene-insulated conductors **11—11** are enclosed by an inner jacket **16** (see FIG. 1) which includes a polyvinyl chloride constituent, a metallic microorganism shield **17** and an outer jacket **18.** Prior to the jacketing of the core **13,** the service cable **10** must have the interstices thereof, including the central opening **14,** filled with a waterproofing composition **19** such as that disclosed and claimed in the above-identified application filed on even date herewith in the names of J. M. Hacker and E. S. Sauer.

While the hereinbefore identified water-resistant, flame-retardant composition **19** is preferred, it should be understood that methods embodying principles of this invention may be used in conjunction with other compositions for filling the interstices of the service cable **10.**

By filling the interstices of the cable **10**, protection is afforded against entry of water even if the cable were surrounded by water and the jacket **18** and the shield **17** punctured by lightning or mechanical means. The shield **17** intercepts and absorbs the lightning but may have holes burned therein. Thus water can penetrate beyond the shield **17** but penetrates radially and longitudinally, limited only by the water-resistant effectiveness of the composition **19** filling the interstices.

Manufacturing methods have not heretofore been available for filling substantially the star-quaded cable **10.** Most of the difficulties arise in attempting to fill the central opening **14.** The twisting of the four conductors with a predetermined lay about the axis **12** causes the opening **14** to be sealed almost hermetically. This has prevented the filling of the opening **14** in the past. It is known that at least some manufacturers of this type cable ignore filling the central opening **14.** However, should the shield be punctured and water penetrate into the opening **14**, the water would have a channel along which to flow. This could result in undesirable losses in transmission characteristics of the cable.

Commonly used conductors are copper, aluminum, and steel as well as alloys and combinations of these materials. Moreover, it is common practice to tin conductors to aid in making solder joints and no complications are introduced by this conventional procedure.

In the application of the methods of this invention for filling the interstices of the cable **10**, it is important that the material from which the conductors is constructed have at least a predetermined yield strength which causes the core to tend to retain its initially formed configuration or to regain that configuration if deformed.

Increasing a stress above the elastic limit will cause a specimen of a material to elongate continually. The unit stress at which the elongation of the specimen reaches some arbitrarily specified value is referred to as the yield strength of the material. In other words, the yield strength is the unit stress at which a material exhibits a definite limiting set. The set is expressed as a unit of deformation and the limiting value is determined by the use of the material.

A yield strength of a material is generally quoted as a unit stress with a specified offset being stated as a percent. This physical property of the material indicates that the material subjected to the specified unit stress returns to only a specified associated percent of its original configuration when the load causing the stress is removed from the specimen. Annealed copper has a yield strength of 10,000 pounds per square inch at 0.5 percent offset. Hence, a specimen constructed from annealed copper will return to within 99.5 percent of its original configuration when subjected to a stress of 10,000 pounds per square inch.

The conductive elements comprising the core **13** and which are regrouped during the filling process must have at least a predetermined yield strength which has been found to be 10,000 pounds per square inch at 0.5 percent offset. It is important to realize that if the rearrangement of the core **13** is with respect to individual conductors **11—11**, as in the case of the quaded cable **10**, then the material of the individual conductors must have a yield strength of at least 10,000 pounds per square inch at 0.5 percent offset. If the cable **10** is comprised of individually twisted pairs of conductors and the rearrangement occurs as among the different pairs, then each pair must have a predetermined yield strength in excess of 10,000 pounds per square inch at 0.5 percent offset.

The elastic recovery of a given material and hence the spring-back characteristics thereof are proportional to the yield strength. Advantage is taken of the yield strength, to permit the conductors **11—11** to spring back and reform the core **13** to its initial configuration following the deformation of the core to allow exposure of generally all of the insulated conductor surface area to the waterproofing composition. Of course, care must be exercised during deformation so as not to cause a permanent set to occur in the conductor material.

Each of the conductors **11—11** of the quaded core **13** herein is constructed of a steel core center clad with copper and then insulated with polyethylene. It has been found that the composite copper-steel construction has a yield point in excess of 10,000 pounds per square inch at 0.5 percent offset.

The four conductors **11-11** are twisted together about the axis **14** by methods and apparatus well known in the art to have a right or left-hand twist of a predetermined lay. The resulting quaded core **13** has a configuration such as that shown in FIG. **4A.**

Referring now to FIG. **2** there is shown an apparatus, designated generally by the numeral **20**, which may be used to further carry out the principles and methods of this invention. The apparatus **20** includes a tank **21** for containing the composition **19** and having an entrance opening **22.** The opening **22** is sized to permit the core **13** of the cable **10** to be advanced therethrough in a direction shown in FIG. **2.**

Interior of the tank **21** are three spaced rollers **26, 27** and **28.** The rollers are arranged as shown in FIGS. **2** and **3** and are mounted rotatably on parallel axes within the tank **21.** The core **13** of the service cable **10** is passed under the roller **26**, up over and around the roller **27**, and then down under the roller **28.** From there, the core **13** is advanced through a wiping die **29** and exits from the tank **21.**

The construction of the rollers **26, 27** and **28** is important in practicing the methods of this invention to produce a filled quaded cable **10.** Desirably, the rollers **26, 27** and **28** each have a diameter of approximately three-fourths of an inch. The rollers are constructed with a polished steel surface so as not to damage the insulation of the conductors **11—11** as the conductors are advanced thereover.

The arrangement of the rollers **26, 27** and **28** within the tank **21** is also important in order to avoid undue deformation of the conductors **11-11** and to facilitate the changing of the core configuration and the subsequent reforming thereof. The angle which each of the conductors **11—11** makes with the horizontal, i.e. a line parallel to a line joining the centers of the rollers **26** and **27**, when being passed from engagement with the roller **26** into engagement with the roller **27**, or from the roller **27** to the roller **28**, is defined herein as the angle of attack, α, (see FIG. 3).

In order to determine an optimum arrangement, extensive experimentation of the positioning of the rollers with varied line tension was conducted. Advantageously, it has been found that the preferred angle of attack lies within the range of 20° to 70° (see FIG. 3). More specifically, the most preferred angle of attack has been found to be approximately 30°. The angle of attack is also important in permitting the inherent spring-back characteristics of the conductors **11—11** to cause the regrouping of the conductors into a core following the coating thereof.

If the angle of attack is greater than 70°, the tension forces applied to the conductors **11-11** becomes excessive and may tend to crush the insulation. Also, an unduly high angle of attack may attach some difficulty to the subsequent reforming of the core **13**, since the material of the conductors **11-11** may undergo a permanent set. If the angle of attack is less than 20°, the engagement of the conductors **11-11** with the surface of the roller **27** is less than that desired.

It should be noted that the tension in the manufacturing line is important in order to avoid deforming the conductors as the conductors are advanced over the rollers **26, 27** and **28** in the coating tank **21**. It has been found that an acceptable tension in the line is approximately 15 to 20 pounds as applied by a capstan (not shown).

The roller arrangement and coating bath combination may be used to coat successive sections of the conductors **11—11** of the core **13** of the service cable **10** provided that the conductors may be successfully regrouped prior to exiting from the tank **21** from the wiping die **29**. In order to accomplish this, the material from which the conductors **11—11** is constructed must have at least the predetermined yield strength sufficiently high to permit the regrouping.

If the yield strength were not sufficiently high enough, the conductors **11—11** would be supple as they are advanced over the rollers. In that situation, the initial configuration of the core **13** could be changed from that at the entrance die **22** to the tank **21**. However, the conductors **11—11** could not then be reformed into the initial configuration (such as that shown in FIG. **4A**) prior to the exit die **29**.

It should be understood that the term "initial configuration" refers to the shape of the core **13** formed by the conductors **11—11** and the positioning of each of the conductors in the core relative to the other conductors. The reformation of the conductors **11—11** into the initial configuration does not necessarily require that the orientation of the cross-section of the core **13** with respect to some coordinate axes system be the same as that when the core was advanced into the tank **21**.

The roller arrangement used in practicing the methods of this invention, coupled with the conductors being constructed from a material of sufficient yield strength, allow the conductors **11—11** which have been rearranged from the initial core configuration shown in FIG. **4A** to unexpectedly spring back together as the conductors are advanced over the rollers. The roller arrangement, the yield strength of the material, and the permanent cast of the conductors **11-11** which was acquired during the twisting of the quad, facilitates the regrouping of the conductors **11—11** into the initial core configuration adjacent roller **28** prior to exiting from die **29**.

The wiping die **29** is constructed so as to have an opening therethrough slightly greater than the outside diameter of the core of the service cable **10**. For example, looking at FIG. **1**, the distance between outwardly facing surfaces of the insulation of opposed ones of the conductors **11—11** as measured along a line connecting their centers is approximately 0.145 inches. The size of the opening in the die **29** is approximateley 0.150 inches. This leaves a 2.5 mil thickness of the waterproofing composition **19** around the quaded core **13** as the core is advanced through the wiping die **29**.

METHOD OF COATING THE CONDUCTORS

In practising the methods of this invention, the core **13** comprising the conductors **11—11** is advanced through the entrance die **22** into the tank **21** and then along a torturous path into and then out of engagement with each of the rollers **26, 27** and **28**.

The configuration of the core **13** as initially twisted into a spiralled quad is that shown in FIG. **4A**. As can be seen from FIG. **4A**, it would not be possible to fill the central opening **14** with the compositions **19** by moving the core **13** in that configuration through a bath of the composition. In fact, because of the configuration shown in FIG. **4A**, it has been found that even pressure filling techniques with or without vacuum evacuation are not successful in filling the opening **14**.

It should also be observed in FIG. **4A** that the conductors **11—11** have been designated **11**a, **11**b, **11**c and **11**d, in a clockwise direction. This designation will become important in following the reorganization of the conductors **11—11** as they are advanced through the tank **21**.

As the core **13** is advanced through the roller **26** and toward engagement with the roller **27**, the conductors **11—11** tend to become displaced from the so-called star-quad array of the core **13** being advanced into the tank **21**. The conductors **11—11** are displaced into a general side-by-side arrangement as shown in FIG. **4B** as the conductors are passed over the roller **27**.

It can also be observed from FIG. **4B** that the position of the conductor **11**a has become displaced angularly as well as laterally from that position occupied in FIG. **4A**. This is due to the twist of the quaded core **13** and as the core is advanced through the tank **21**, the coroe tends to rotate in the direction of the twist lay.

This behavior is extremely important in applying a coating of the composition to the outer periphery of the conductors **11—11**. This constant reording of the conductors **11—11** causes the air therebetween in the opening **14** to be pushed out and composition to be moved in. As disclosed in the above-identified application filed on even date herewith in the names of J. M. Hacker and E. s. Sauer, the composition **19** tends to cling to the individually insulated conductors **11—11**.

Then, as the conductors **11—11** are further advanced in the tank **21** into engagement with the roller **28**, the conductors tend to spring back into a quaded configuration to reform generally the original core shape (see FIG. **4C**).

The reformed core **13** then is advanced through the exit die **29**. The exit die **29** wipes excess amounts of the composition **19** from the core **13** with a **2.5** mil coating of the composition remaining about the outside surfaces of the conductors **11—11** (see FIG. **4C**). In this way, after the inner jacket **16** is extruded over the core **13**, there is a layer of the waterproofing composition **19** between the quaded core and the inner jacket to further insure complete waterproofing of the service cable **10**. The wiping die **29** produces a smooth regularly shaped generally circular outer contour of the coating composition **19** compatible with the inner jacket **16** to be extruded thereover.

Referring now to FIG. **4C**, it can be seen that the conductors **11**—**11** have been further displaced angularly. For example, the conductor designated **11***a* occupied what may be called a 12 o'clock position as the core **13** entered the tank **21** and a so-called 3 o'clock position when passing over the roller **27**. The conductor **11***a* occupies generally a 9 o'clock position as the core exits from the tank **21**.

ALTERNATIVE APPLICATIONS OF METHODS

While the methods of this invention appear ideally suited to produce a waterproofed star-quaded service cable **10**, it should be realized that other cable may be produced thereby. The methods are equally applicable to waterproofing a ten conductor, five twisted pair, service cable (not shown).

The five pair conductor service cable (not shown) includes five twisted pairs of conductors, each conductor pair again being constructed of a material or combination of materials having a total yield strength of at least approximately 10,000 pounds per square inch at 0.5 percent offset. This construction cable is generally manufactured with a predetermined lay with the five pairs stranded about the axis **12**. This results in an unstable configuration.

It has been found that as the five pair cable is advanced into, through and out of the tank **21**, and as the conductor pairs thereof are displaced and reformed into a configuration for jacketing, the lay changes. However, the lay advantageously becomes a random lay along the length of the cable thereby tending to eliminate undesirable capacitance characteristics of the cable.

The use of copper conductors in the five pair cable does not detract from the spring-back feature of this process. Soft copper has a yield strength of approximately 10,000 pounds per square inch, at the lower limit of the specified range for this process. Moreover, the twist in the individual pairs imparts to each pair a certain amount of permanent cast which is of assistance on the regrouping step of the process.

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 to fall within the spirit and scope thereof.

I claim:

1. A method of making a stranded core having the interstices thereof filled with a composition, which includes the steps of:

stranding a plurality of elongated members about a longitudinal center line to form a core, each of the elongated members having at least a predetermined yield strength;

advancing the stranded core through a bath of a composition;

applying forces to the core to first cause the configuration of the core to be changed to expose portions of the elongated members which in the original configuration of the core are not exposed to the composition and then to permit the elongated

members because of the elastic properties associated with the yield strength thereof to be reformed into a stranded core and cause the interstices between the elongated members to be filled substantially with the composition; and

removing excess composition from the reformed core to form a generally regularly shaped contour of the composition about the core.

2. A method of making a cable core having the interstices thereof filled with a composition, which includes the steps of:

stranding a plurality of insulated conductors about a longitudinal center line to form a core, each of the conductors having a conductive element thereof made from a material having at least a predetermined yield strength;

advancing the stranded core through a bath of a composition;

applying forces to the core by directing the core into and out of engagement with a plurality of prearranged surfaces within the bath to first cause the configuration of the core to be changed to expose portions of the conductors which in the original configuration of the core are not exposed to the composition and then to permit the conductors because of the elastic properties associated with the yield strength thereof to be reformed into a stranded core and cause the interstices between the conductors to be filled substantially with the composition; and

removing excess composition from the reformed core to form a generally regularly shaped contour of the composition about the core.

3. A method of making a quaded cable having the interstices thereof filled with a composition, which includes the steps of:

forming spirally a plurality of insulated conductors about a longitudinal center line, each of the conductors having a conductive element thereof made from a material having at least a predetermined yield strength;

advancing the spirally quaded core through a bath of the composition;

directing the core into and then out of engagement with a plurality of surfaces within the bath to cause the configuration of the quaded core to be changed to expose portions of the conductors which are inaccessible in the original configuration of the quaded core to the composition;

further directing the core into and then out of engagement with at least one other surface such that the elasticity associated with the predetermined yield strength of the material of which the conductors are made causes the conductors to become reformed into the original configuration of the quaded core; and

removing excess composition from the quaded core to form a generally regularly shaped contour of the composition about the core, the reformation of the core and the subsequent removal therefrom of excess amounts of the composition causing the interstices thereof to be filled with the composition.

4. The method of claim **3**, wherein the predetermined yield strength is 10,000 pounds per square inch at 0.5 percent offset.

5. A method of applying a waterproofing composition to a stranded core comprised of a plurality of elongated members which includes the steps of:

advancing the core through a bath of a composition, which is to fill the interstices of the core and coat the exterior thereof, in a predetermined tortuous path to first cause forces to be applied to the core to (1) change sequentially the configuration of successive sections of the core to expose substantially the entire periphery of each of the elongated members to the composition and then (2) to facilitate the reformation of the core because of the yield strength of the material from which the members is made being at least a predetermined value; and

removing excess amounts of the composition from the reformed core to yield a core having a regularly shaped envelope of composition, the reformation of the core and the subsequent removal therefrom of the excess amounts of the composition causing the interstices thereof to be filled with the composition.

6. The method of claim 5, wherein the predetermined value of the yield strength is 10,000 pounds per square inch at 0.5 percent offset.

7. The method of claim 5, wherein the core is advanced in a path into, and through the bath in the predetermined tortuous path and then in a path out of the bath of the composition, the tortuous path including a portion at some predetermined angle to the path into the composition and a portion at some predetermined angle to the path out of the bath.

8. The method of claim 7, wherein the predetermined angle lies in the range of 20° to 70°.

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