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(54) **FILLER CORD AND METHOD FOR ITS PRODUCTION**

(75) Inventors: **Karl-Heinz Eispert**, Kaiserslautern (DE); **Thomas Schoenung**, Freimersheim (DE)

(73) Assignee: **GARNTEC GMBH**, Neidenfels (DE)

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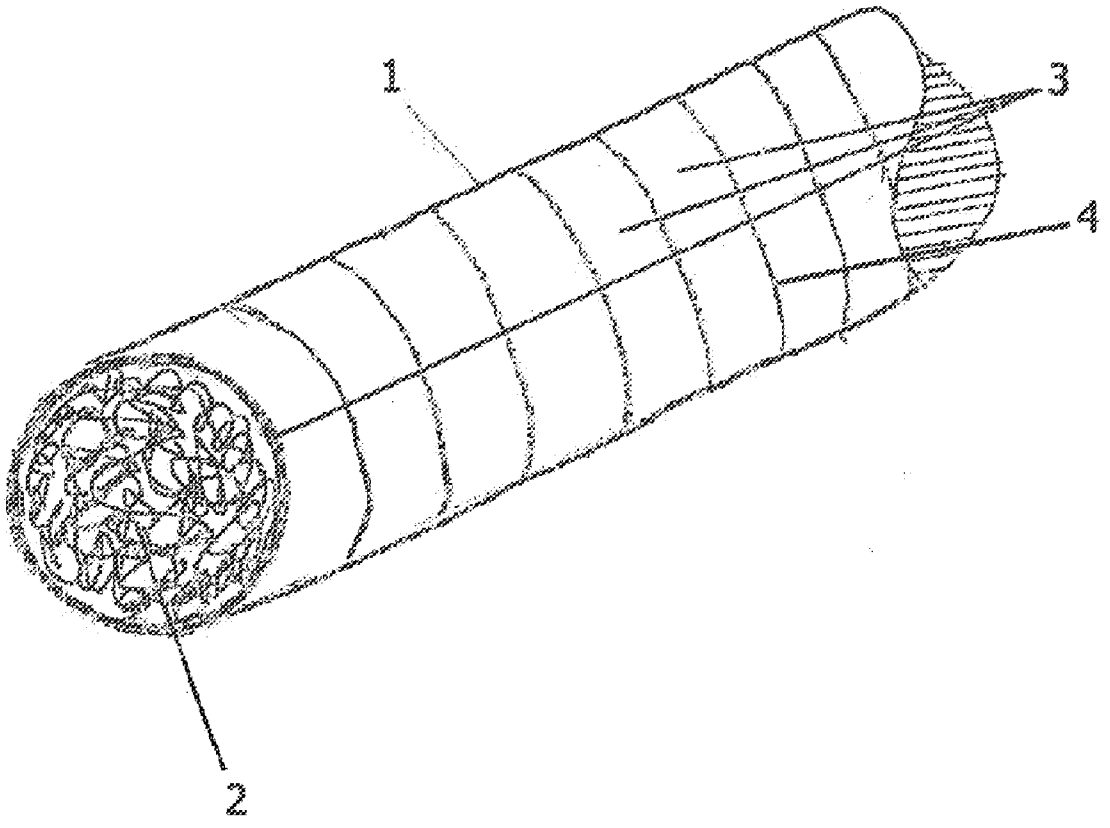
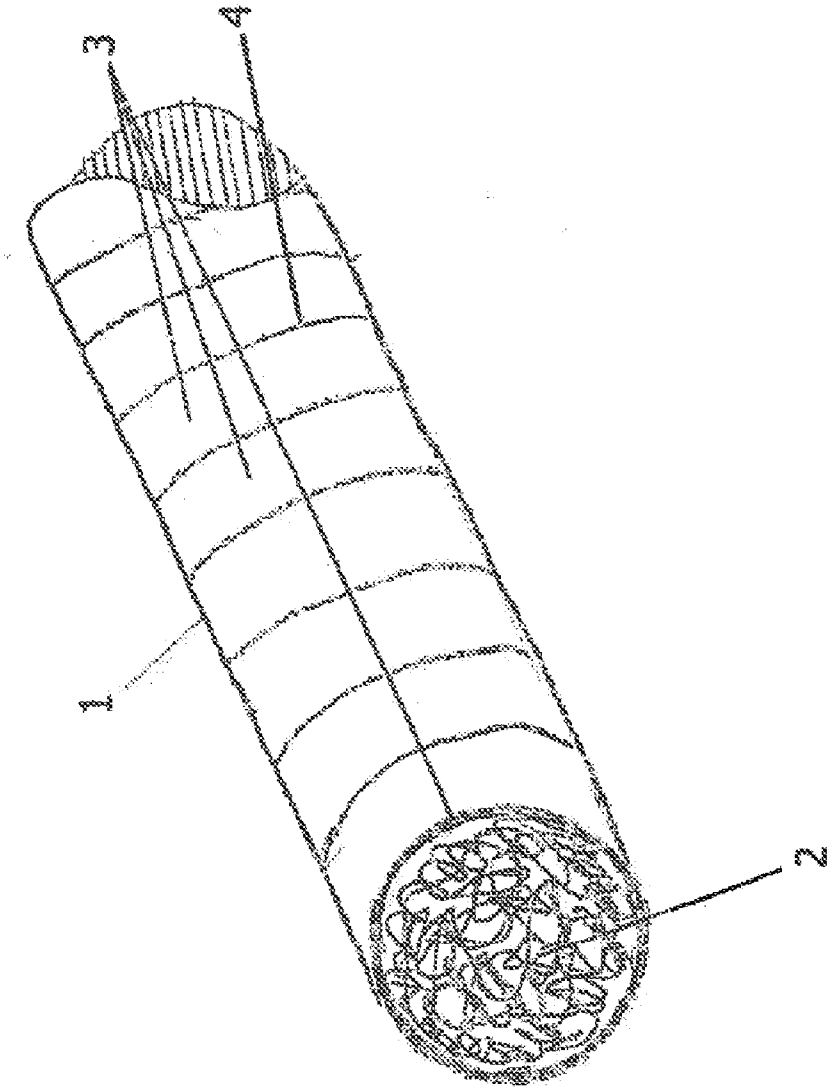
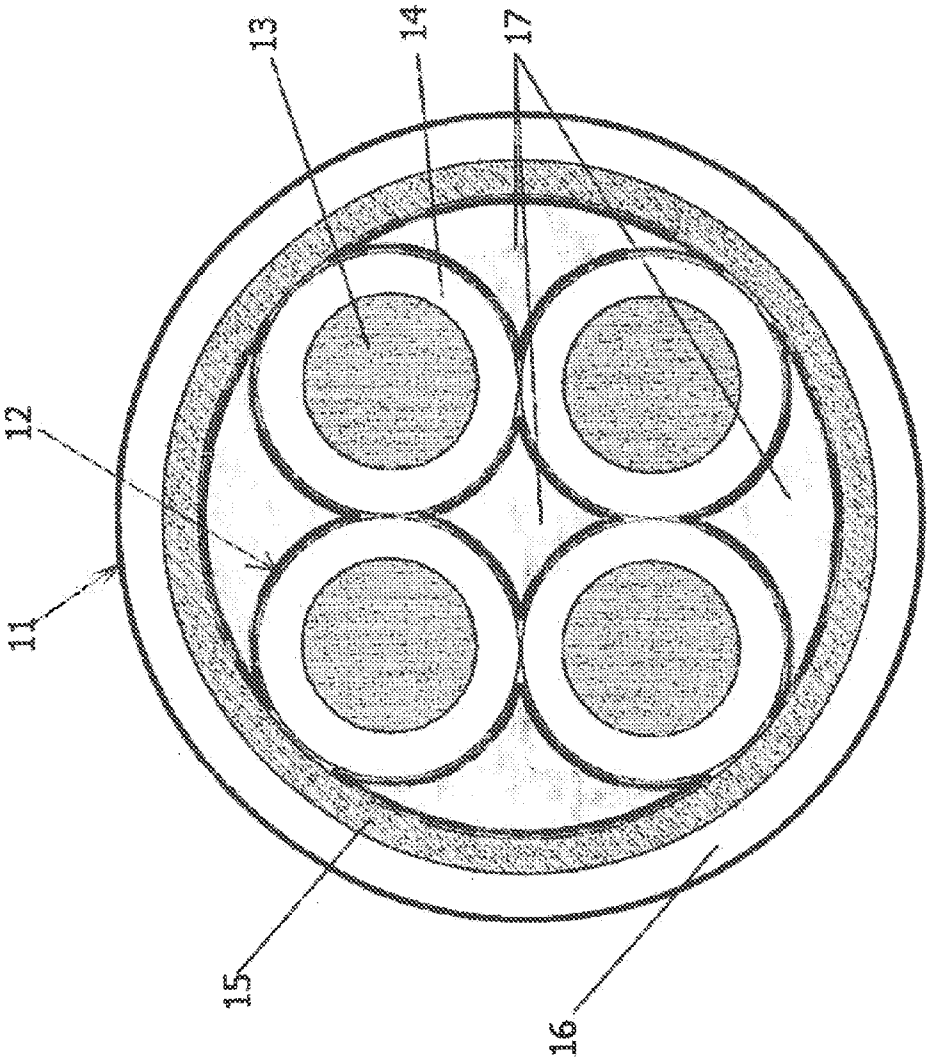
(57) **ABSTRACT**

What is described is a filler cord, which comprises a core of (i) paper and (ii) other swellable flat or round filler materials, swellable nonwovens, and/or swellable yarns; optionally a swellable nonwoven as a covering around the core; and, to secure the core, which may or may not have a covering, a swellable yarn, which is wrapped around the core, as well as a method for the production of same.





Figur 1



Figur 2

FILLER CORD AND METHOD FOR ITS PRODUCTION

[0001] The present invention pertains to a filler cord which is suitable, for example, for filling the empty spaces in cables with precision and for sealing the cables longitudinally against water and also to a method for the production of same.

[0002] At present in the cable industry, gel compounds (such as jelly), swellable powder, swellable nonwovens, or thin swellable yarns are used as fillers for the production of longitudinally water-sealed cables. The method of production involved in bringing several strands together to form a cable results in the formation of empty spaces; these spaces must be filled to prevent the intrusion of water into the cable and to seal the cable. When the filler is incorporated, furthermore, care must taken to ensure that the cable maintains its correct shape when the outer gaps are filled. In the case of thin cables or cables with relatively small empty spaces, the attempt has frequently been made to use swellable yarns to fill the gaps. In the case of thick cables or those with large spaces, however, it has not been possible to fill the spaces completely with standard commercial fillers such as polypropylene yarns, polyethylene yarns, or yarns of jute, sisal, or paper, and thus it has not been possible to guarantee that the cable will have a uniform geometry. It has been possible only with a great deal of effort, furthermore, to seal thick cables or cables with large spaces longitudinally against water by the introduction of swellable powder or gel compounds. Because most fillers are not conductive and yet a semiconductive or conductive filler is recommended for many types of energy cables, it is has not been possible so far to fulfill all of the requirements simultaneously.

[0003] DE 10 2006 018 536 A1 describes an optical cable with: (a) a cable core with at least one optical transmission element, containing at least one optical fiber; (b) a first sheath of a paper-containing material, wherein the first sheath surrounds the at least one optical transmission element; and (c) a cable jacket, which surrounds the first sheath and contains a material made of plastic. An optical cable of this type, however, suffers from the problem of insufficient filling of the gaps and thus of insufficient longitudinal water-tightness.

[0004] DE 593 444 describes an electrical high-voltage cable, wherein the outermost layer of the conductive cable, designed as a solid rope cable, is stranded to form an open wire layer, and cheap fillers of paper cord, hemp cord, pressboard, or even semiconductive substances such as graphite paper are arranged between the conductive wires of the open stranded layer, wherein, in cases where semiconductive substances are not used as fillers for the outermost layer, the outermost layer of the conductive cable is surrounded by a conductive sheath.

[0005] DE 198 39 900 A1 describes cables for communications and security systems subject to special usage conditions, especially for systems subject to severe vibrations, particularly for installation on the rails of railroad tracks. These cables consist of strands, which are combined into pairs, into groups of four, or into other types of stranding groups, and are surrounded by a jacket, wherein the insulated conductors of the group-of-four, of the pair, or of the other type of stranding group consist of litz wires. An internal damping element is provided in the central area, and another damping element is arranged around the insulated conductors. The insulated conductors are secured in such a way that the strands lie loosely against each other. Several of these basic elements can be brought together and arranged in layers, which are then surrounded by intermediate damping elements. The resulting configuration is surrounded by a jacket. The cable described here also suffers from insufficient filling of the gaps, because the filler material used does not adequately support the geometry of the cable.

[0006] The goal of the present invention is therefore to provide a filler which is able to satisfy all of the required properties cited above with respect to longitudinal water-tightness, conductivity, formability, and suitability for different types of cables.

[0007] The object of the present invention is thus a filler cord which comprises a core of (i) paper and (ii) other swellable flat or round filler materials, swellable nonwovens and/or swellable yarns, optionally a swellable nonwoven as a covering around the core, and, to secure the core, a swellable yarn, which is wrapped around the core, which core may or may not have a covering.

[0008] The longitudinal water-tightness of the inventive filler cord is achieved in that at least 20%, preferably at least 50%, of the filler consists of materials which swell on contact with water. According to a preferred embodiment, the inventive filler cord consists preferably of 20-100%, more preferably of 70-100%, and especially of 100% of materials which swell on contact with water.

[0009] In another preferred embodiment, the inventive filler cord is at least partially conductive. According to one embodiment, the inventive filler comprises, for example, a surface resistivity of $\leqq 10^9\Omega$, preferably of $\leqq 10^8\Omega$, and more preferably of $\leqq 10^4\Omega$, such as, for example, in the range of 1,000-2,000Ω, and/or a volume resistivity of $\leqq 10^{10}$ Ω×cm, preferably of $\leqq 10^9\Omega$×cm, and more preferably of $\leqq 10^5$ Ω×cm, such as approximately in the range of 1×10^5 to 1×10^7 Ω×cm.

[0010] This conductivity of the inventive filler cord can be achieved according to the invention by using a conductive swellable filler, swellable nonwoven, and/or swellable yarn. To make a swellable filler conductive, carbon black and/or graphite and/or a metal powder, for example, usually in amounts of up to 500 wt. %, preferably of up to 200 wt. %, especially of 100 wt. % based on the weight of the other swellable flat or round filler containing the conductive material, can be added to the swellable filler.

[0011] In another embodiment, the swellable nonwoven optionally wound around the core can consist of a conductive or nonconductive swellable nonwoven. If a conductive swellable nonwoven is to be used, a conductive material, as described above in conjunction with the swellable filler, can be incorporated into the swellable nonwoven. In another embodiment, a conductive swellable yarn can also be used inventively.

[0012] The paper which can be used in the invention can consist of cellulose, which is usually produced on papermaking machines and has a grammage in the range of 5-70 g/m^2, preferably of 15-50 g/m^2, and especially of 30-40 g/m^2 (according to the standard DIN EN ISO 12625-6). Examples of papers which can be used in the invention are those available commercially from Glatz under the designations KR 40 and/or KR 50.

[0013] The swellable flat or round fillers which can be used in the invention can consist of fibers or threads. Normally these materials can be swellable, conductive, semiconductive, or nonconductive swelling nonwovens. The swellable flat or round fillers are preferably commercially obtainable, low-cost papers of any desired grammage or polyester non-

wovens. When a swellable flat or round filler which is conductive (e.g., with a surface resistivity of approximately 1,000-2,000Ω and/or a volume resistivity of approximately 1×10^5 to 1×10^7 Ω×cm) is to be used, carbon black and/or graphite and/or a metal powder, usually in amounts of up to 500 wt. %, preferably of up to 200 wt. %, and especially of 100 wt. %, based on the weight of the other swellable flat or round filler containing the conductive material, can be added to the polymer or polymer blend normally used as swellable flat filler.

[0014] The swellable nonwoven which can be used in the invention can be a nonwoven of staple fibers such as polyolefin fibers, viscose fibers, polyester fibers, cellulose fibers, or combinations of these fibers or a nonwoven of polymer filaments. The swellable nonwoven is preferably produced from polyester fibers. The swellable nonwoven used according to the invention is usually hydrophilic and has a basis weight in the range of 10-180 g/m^2, preferably of 30-100 g/m^2, and especially of 50-80 g/m^2. The swellable nonwoven used according to the invention can be produced in a manner known to a person skilled in the art by thermobonding, spinbonding, melt-blowing, or a dewatering process or by another process known to a person skilled in the art. Hydrophilic swellable nonwovens as they are preferred for use in the invention usually consist of hydrophilic fibers, such as polyester fibers, with a water contact angle of less than 90°. In another embodiment, the nonwoven made of staple fibers such as polyester fibers can be treated with an acrylic acid polymer such as a superabsorbent polymer. According to the invention, a conductive or a nonconductive swellable nonwoven can be used. If a conductive swellable nonwoven is to be used, a conductive material, as already described above in conjunction with the swellable filler, can be incorporated into the swellable nonwoven. In one embodiment, a standard commercial conductive or semiconductive swellable nonwoven obtainable from, for example, GarnTec, can be used (e.g., GTSB 50).

[0015] The swellable yarn which can be used in the invention can be a yarn of any desired length, which consists, for example, of one or more polyester threads treated with a swellable substance, preferably a superabsorbent polymer, e.g., an acrylic acid copolymer; comprises a tear strength of 5-120 N, preferably of 40-80 N, and especially of 50-60 N; and has a specific water uptake of at least 20 mL/g, ideally of 35-60 mL/g. According to the invention, a swellable yarn such as WPB 5000, obtainable commercially from GarnTec, can be used.

[0016] The inventive filler cord usually has a diameter of 4-140 mm, preferably of 8-80 mm. The inventive filler cord can have a wide variety of geometric forms, including round, flat, polygonal, oval, etc.

[0017] In the inventive filler cord, the ratio of (i) paper to (ii) the other swellable flat or round filler material, swellable nonwoven, and/or swellable yarn in the core is usually in the range of 20:80 to 80:20, preferably of 40:60 to 60:40; and in particular, the ratio is 30:70 based on the weight of the components.

[0018] The inventively used mixture of (i) paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn is usually in the form of a uniform mixture of strips of the above-cited components. In a preferred embodiment of the present invention, the core of (i) paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn is surrounded by a layer of swellable nonwoven in the form of a covering. This layer of swellable nonwoven can consist of a conductive, semiconductive, or nonconductive swellable nonwoven.

[0019] The swellable yarn used to secure the inventive filler cord surrounds the core of (i) paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn; that is, the swellable yarn is wrapped around the core, which may or may not have a covering, and thus secures the core. The wrapping can, according to the invention, be executed in the form of a spiral or crosswise wrapping of swellable yarn. The proportion of swellable yarn based on the total weight of the inventive filler cord will usually be in the range of 0.5-40 wt. %, preferably of 0.8-20 wt. %, and especially of 1-5 wt. %.

[0020] In addition, it is possible according to the invention to adapt the swelling properties of the inventive filler cord to the requirements of the desired product for which it is to be used through selection of the special composition of the components used. As a result, it is possible to achieve swelling properties of up to 160 mL of water uptake per gram or 25 liters of water per meter of the inventive longitudinally water-sealing filler cord, values which have not been achieved for fillers for cable production until now.

[0021] The inventive filler cord offers the advantage that, because of its design, it can be adapted flexibly to the empty spaces in the cable which are to be filled. This can be achieved, first, because the inventive filler cord is formed on a core of paper and swellable material, and therefore the filler cord can be deformed during cable production in such a way that it completely fills the empty spaces (gaps) between the individual cable strands and the cable sheath. Through the suitable choice of the incorporated amount of swellable material, it is possible to obtain the necessary counterpressure to the cable shielding in a cable such as a shielded energy cable. Second, because of its structure, the dimensions (especially the cross section) of the filler cord can be selected freely within the limits given above. This offers the advantage that the required filler cord , which is precisely adapted to the empty spaces in the cable to be filled, can be produced according to the specifications of the cable designer, so that, especially in cases of cables with large cross sections, the empty spaces can be filled up in optimal fashion. Filling up the empty spaces completely also offers the advantage that the geometry of the cable to be produced is positively influenced. Another advantage of the inventive filler cord is that, because of the lower density and/or weight of the swellable materials used according to the invention in comparison with those of conventional fillers, the finished cable is much lighter and more flexible, which makes it much easier to lay the cable and considerably lowers the cost of the laying process.

[0022] The object of the invention is therefore, in addition, the use of an inventive filler cord for longitudinal water sealing in cables, wherein, according to one embodiment, the filler cord is arranged in the longitudinal direction of the cable in such a way that the existing empty spaces in the cable are filled.

[0023] So that the present invention can be better understood, reference is made to the following FIGS. **1** and **2**:

[0024] FIG. **1** shows a perspective view of a section of an exemplary embodiment of an inventive filler cord; and

[0025] FIG. **2** shows the cross section of an exemplary embodiment of an arrangement of inventive filler cords in a cable.

[0026] FIG. **1** shows an exemplary embodiment of an inventive filler cord **1**. In the interior of the filler cord **1**, there is the core **2**, which, in the exemplary embodiment shown here, consists of pressed swellable nonwoven strips and tissue paper strips. A swellable nonwoven **3**, which can be either conductive or nonconductive, is wrapped around the core **2**. A swellable yarn **4** is wound around the core **2** and the swellable nonwoven **3**.

[0027] FIG. **2** shows a cable **11**. The cable **11** consists of several cable strands **12**, which are arranged next to and on top of each other. The cable stands **12** comprise a circular cross section and consist of cable cores or cable conductors **13** and are enclosed by a layer of conductor insulation **14**. The cable strands **12** are surrounded by a separating layer **15**, which consists of a nonwoven or paper. A cable jacket **16** is laid around the separating layer **15**.

[0028] Because of the circular cross section of the cable strands **12**, empty spaces (gaps) are formed between the cable strands **12** and the separating layer **15** during the jacketing of the cable strands **12** by the separating layer **15** and the cable jacket **16**. Inventive filler cords **17** such as those of the exemplary embodiment according to FIG. **1**, are laid in these gaps.

[0029] As can be seen in FIG. **2**, the inventive filler cords, which have an essentially round cross section when produced, become deformed during the production of the cable **11** in such a way that they conform to the empty spaces present in the cable and fill them up almost completely. In this way, the cable **11** is already sealed longitudinally against water very effectively as soon as the cable is produced; and if water does penetrate into the interior of the cable, this sealing action is optimized by the swelling of the swellable material in the inventive filler cords, which means that superior longitudinal water sealing can be achieved.

[0030] The method for producing the inventive filler cord is described briefly below:

[0031] The inventive filler cord, in contrast to previous practice for the production of cords and cables, is not produced by twisting (i) the paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn, but rather by pulling a mixture of (i) paper in strip form and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn through a die with a fixed diameter (the diameter of the die is usually in the range of 4.5-140.5 mm and thus 0.5 mm larger than the nominal diameter of the inventive filler cord to be produced) and then by immediately securing the achieved diameter by wrapping with the swellable yarn. In the course of the operation of pulling a mixture of (i) paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn which is to be covered with swellable nonwoven, a swellable nonwoven is laid around the strand consisting of (i) paper and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn before the mixture is introduced into the die, and then the structure thus obtained is secured by wrapping it with the swellable yarn. The inventive production method offers the advantage that the filler cord thus produced can be adapted with precision with respect to weight and diameter to the requirements of the empty spaces to be filled such as the gaps in a cable.

[0032] The inventive filler cord is usually produced on a standard commercial spiralizing machine such as that available from JBF in Hohentengen. (i) Paper in the form of strips, usually with a width of 10-300 mm and preferably a width of 150-250 mm and (ii) the other swellable flat or round filler, swellable nonwoven, and/or swellable yarn are brought together in the desired ratio and pulled through a die. As the outside layer, a nonconductive or a conductive swellable nonwoven can be laid around the strand, wherein care must be taken to ensure that the outer layer completely covers the structure. After the filler material has been passed through the die, the inventive filler cord is wrapped in spiral or crosswise fashion, for example, by the concomitant infeed of swellable yarns (e.g., one, two, or three concomitantly infed swellable yarns) and thus secured. It can then be wound onto a previously provided cable drum.

EXAMPLE

[0033] For the production of an inventive semiconductive filler cord with a diameter of 20 mm for filling and sealing a cable gap of 265 mm^2, **3** strips of paper with the designation KR 40 with a width of 250 mm, **1** strip of KR 40 paper with a width of 150 mm, and 3 strips of nonconductive swellable nonwoven with the designation GTST 20 with a width of 150 mm were hung in alternation in a draw-off creel and pulled into the spiralizing machine with a die diameter of 20.5 mm. Before entrance into the die, 2 semiconductive swellable nonwoven strips designated GTSB 50 with a width of 80 mm were laid around the strand as an outer layer in such a way that a complete semiconductive covering was formed. Immediately after the application of the outer layer and passage through the 20.5 mm forming die, the inventive filler cord was secured by the swellable yarn in spiral fashion to a diameter of 20 mm by means of a rotating carousel, on which 3 spools of WPB 5000 swellable yarn were mounted. After passage through the spiralizing machine, the finished filler cord was wound onto 1000-class cable drums by parallel laying up to about 5 cm below the outside edge of the cable drum.

1. A filler cord comprising a core of (i) paper and (ii) other swellable material selected from the group consisting of swellable flat or round filler materials, swellable nonwovens, swellable yarns, and mixtures thereof; a swellable yarn, which is wrapped around the core, to secure the core.

2. A filler cord according to claim **1**, wherein the paper comprises a grammage in the range of 5-70 g/m^2.

3. A filler cord according to claim **1**, which comprises a swellable nonwoven as a covering around the core of (i) paper and (ii) other swellable flat or material.

4. A filler cord according to claim **1** or claim **2**, wherein the ratio of (i) paper to (ii) the other swellable material is in the range of 20:80 to 60:40, based on weight.

5. A filler cord according to claim **1**, 20-100% of which consists of materials which swell on contact with water.

6. A filler cord according to claim **1**, wherein the filler cord comprises a diameter of 4-140 mm.

7. A method for producing a filler cord according to claim **1**, wherein the method comprises the following steps:

(1) pulling a mixture of (i) paper in the form of strips and (ii) the other swellable through a die; and then

(2) securing the diameter thus obtained by wrapping with the swellable yarn, which is wrapped around the core, to secure the core.

8. A method according to claim **7**, wherein, before the mixture is pulled through the die, a swellable nonwoven is

laid around the strand of (i) paper and (ii) the other swellable and then the structure thus obtained is secured with the swellable yarn, which is wrapped around the core, to secure the core.

9. A cable comprising a filler cord according to claim **1**.

10. A cable according to claim **9**, wherein the filler cord is arranged in the longitudinal direction of the cable in such a way that it fills up empty spaces in the cable.

11. A cable according to claim **10**, wherein empty spaces in the cable are formed between cable strands in the cable and a separating layer, which surrounds the cable strands.

12. A filler cord according to claim **6**, wherein the filler cord comprises a diameter of 8-80 mm.

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