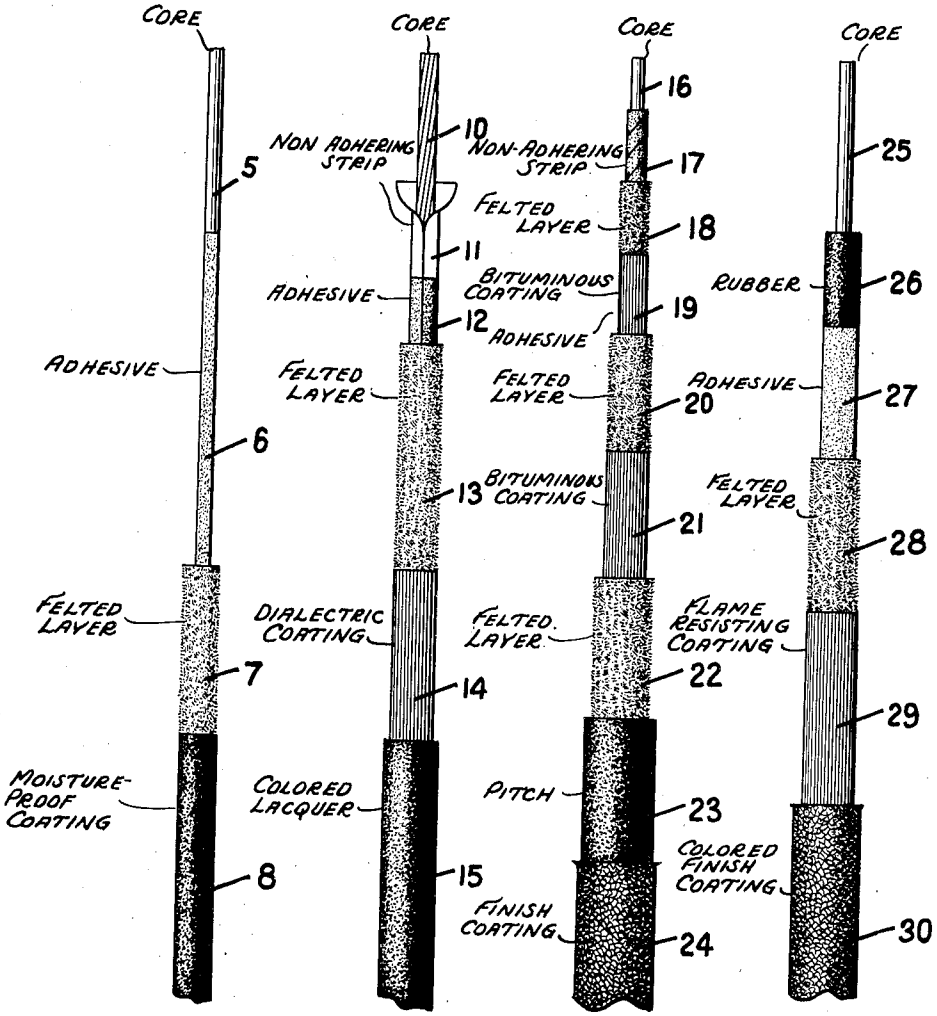
Jan. 16, 1940. F. M. POTTER 2,187,401

INSULATED ELECTRICAL CONDUCTOR

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Fig. 1. Fig. 2. Fig. 3. Fig. 4.



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Fig. 5.

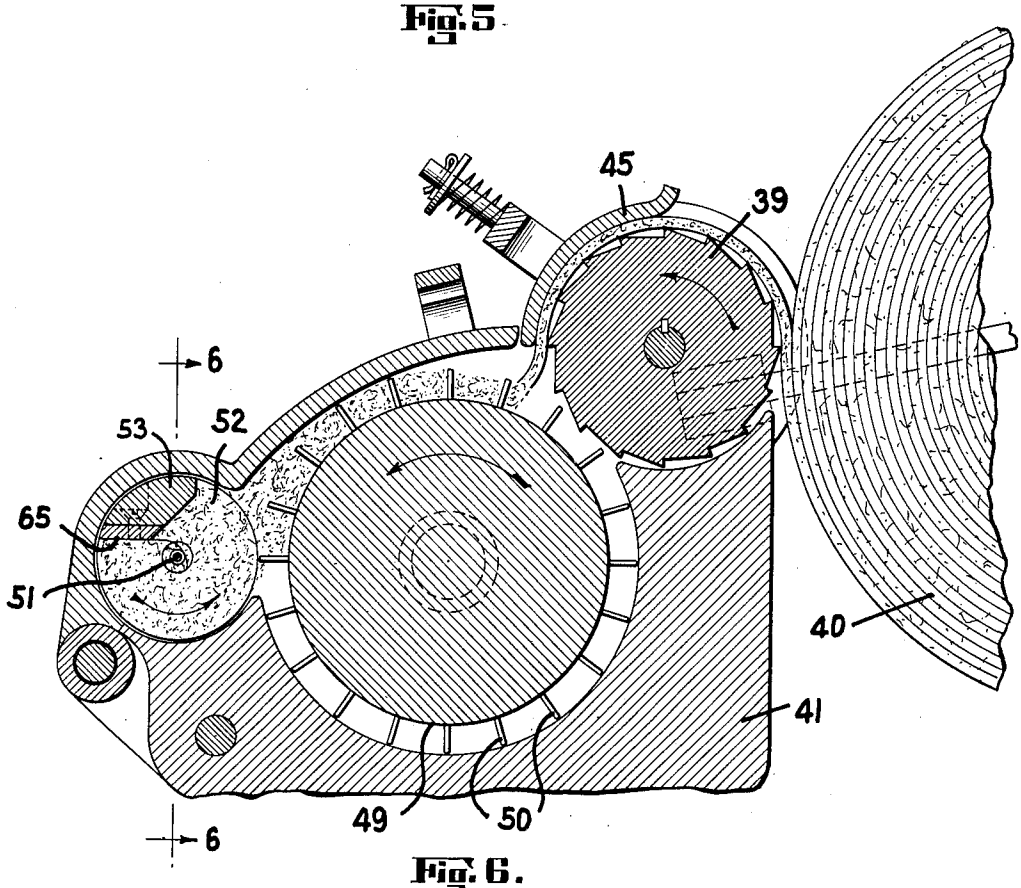
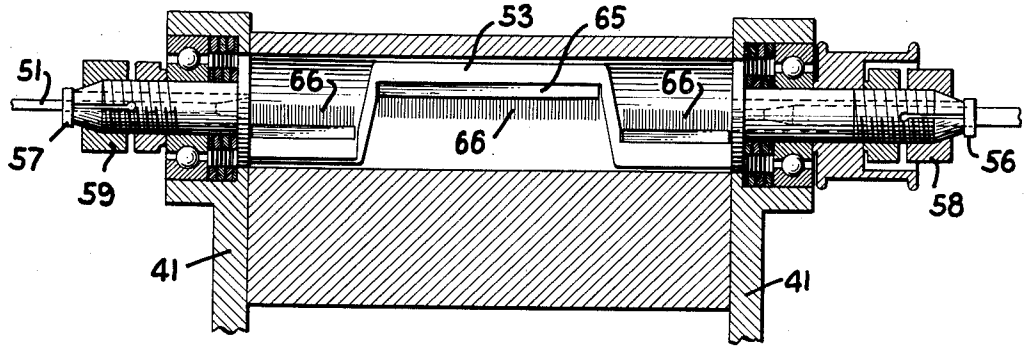


Fig. 6.



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Patented Jan. 16, 1940 2,187,401

UNITED STATES PATENT OFFICE

2,187,401

INSULATED ELECTRICAL CONDUCTOR

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Application April 19, 1938, Serial No. 202,815

10 Claims. (Cl. 174—121)

The present invention relates to insulated electrical conductors and has for an object the provision of improvements in this art.

This application constitutes a continuation in part of my co-pending applications Serial Nos. 604,208, 604,209, 604,210, and 604,211, all filed on April 9, 1932.

This invention comprehends among its objects the provision of an insulated electrical conductor which includes a self-sustaining jacket of integrally felted-on material which is uniform, homogeneous and seamless throughout its thickness and extent. The term "self-sustaining" as used herein means that the felted-on jacket will maintain its position and integrity on the cable or conductor without opening up even though the conductor may be bent sharply a number of times, and this in spite of the fact that the felted-on jacket is formed "dry", that is, without saturants or coating substances, and in spite of the fact that the felted-on jacket is not enclosed or supported by any braid, wrap or strands of sustaining material either internal or external. This is not to be taken to mean that saturants or coating substances or braids, wraps or strands may never be used, but that the dry felted jacket alone is self-sufficient for many or most purposes since it is dense, tight, continuous and seamless and highly resistant to wear and to separating forces in all directions.

Previously it has been known to apply strips or strands of fibrous material to cores and then to wipe, roll or rub the outer surface of this jacket. Such a jacket is not seamless, for while it may appear at the surface to be seamless it is not seamless internally and will readily open up or festoon when the conductor is bent or when it is exposed to weathering or other exacting conditions of use. Such a jacket usually requires support, either internal as by strands of stronger material, or external as by braids, wraps, strands or the like or the use of saturants or coating substances. Braids are commonly used but are not economical because not necessary per se and expensive to apply.

It has also previously been known to blow fibres upon a core which has been coated with adhesive, the fibres which adhere being rubbed or rolled down to form a jacket. While such a jacket is in a sense seamless it is not uniform because more of the fibres may collect at one side of the diameter or at certain points in the length than at other places. Moreover, such a jacket is not truly felted because all of the fibres of the jacket at any given point in its length are all placed at one time and the subsequent rubbing action only causes a felting at the surface of the jacket, leaving the interior without inherent inter-fibre tenacity. Such a jacket is not integrally felted nor self-sustaining (depending largely on adhesive, saturants, braids or the like for support) and will readily open up if subjected to exacting conditions in use.

One method and one form of apparatus which are suitable for forming a felted jacket of the type contemplated herein are disclosed in the patent to Sidney E. Borgeson, No. 2,078,228, granted April 27, 1937. According to this patent the individual fibres are fed in a thin layer to a longitudinally advancing core and the fibres are laid and combed or rubbed, in a sense drawn, circumferentially by a rapidly rotating applicator. The layer may be quite thin and discontinuous or somewhat thicker and more nearly continuous, depending on the size of the conductor and other considerations, but in any event the jacket is formed of a number of successively laid and felted layers so that the jacket may properly be described as "integrally felted".

It will be understood, of course, that the fibres of one layer intermingle and intertangle with the fibres of adjacent layers so that the layers cannot be distinguished in the final jacket by ordinary methods of observation. But the final jacket is dense, homogeneous, uniform, tight and highly tenacious or resistant to wear and to separating forces in all directions, so it is by these characteristics that the nature and method of formation of the jacket may be ascertained.

Other objects of the invention are the judicious and advantageous combination of the specified integrally felted-on jacket with various other conductor coverings to provide improved insulated conductors for various purposes.

The various objects, advantages and novel features of the invention may best be comprehended by those skilled in the art from a consideration of the following more detailed description, reference being made to the accompanying drawings illustrating certain embodiments of the invention and certain apparatus suitable for applying the integrally felted-on jacket.

In the drawings—

Fig. 1 is a plan view of a conductor particularly designed to be used as "magnet wire" and having a protective cover constructed in accordance with the invention;

Fig. 2 is a similar view of a cable embodying the invention and designed for general use, as for example, conductors commonly employed in

connecting the different parts of radio, automotive and other apparatus;

Fig. 3 is a similar view of a conductor embodying the invention and particularly designed for use as a "weatherproof cable";

Fig. 4 is a similar view of a conductor embodying the invention, particularly designed for use as "code wire";

Fig. 5 is a transverse section of apparatus suitable for applying the integrally felted-on jacket; and

Fig. 6 is a section on the line 6—6 of Fig. 5, showing the applicator.

The legends applied to the drawings are by way of illustration and not limitation.

Insulated electrical conductors, and particularly so-called magnet wire, usually comprise a core and a suitable protective and insulating covering which should have the thinnest wall possible commensurate with the required dielectric strength, together with the ability to be flexed and formed into coils without cracking or opening. At the same time the insulation should be moisture-repellant and capable of operating at elevated temperatures without deterioration.

According to the construction of conductor illustrated in Fig. 1, the usual metal core or conductor 5 may be bare, tinned or enameled, as desired, and has an adhesive coating 6 such as cut shellac, cellulose nitrate or the like, applied to its surface, over which is applied a protective cover or jacket 7 of felted fibres, preferably asbestos fibres.

The felted asbestos jacket 7 is formed of separate fibres, previously unfabricated and individually applied to the core in intertangled criss-cross relation and extending in all directions. These fibres are applied to the core in very thin layers, and are compacted thereon as applied. That is the fibres are integrally felted-on as the jacket is built up. The layers are built up to required thickness, the successive felting and compacting of each layer resulting in an extremely dense seamless insulating jacket which is uniform and homogeneous throughout its thickness and extent. The felted-on jacket may be of any desired thickness, from one so thin that the core 5 is discernible through it, to one of substantial thickness.

The superposed layers are applied in a general circumferential direction, and as the initial layer is in this embodiment adhesively united to the core, and the subsequent layers are intimately felted to preceding layers, the resulting jacket is securely attached to and tightly fits the core and is of dense, uniform consistency and strength.

One suitable form of apparatus for producing the felted-on jacket is shown in Figs. 5 and 6, these figures being the same as Figs. 5 and 6 of the Borgeson Patent No. 2,078,228 heretofore referred to. The entire apparatus disclosed in that patent is not shown herein, but only so much of it as is necessary to give an understanding of how the fibres are applied to the core.

Conveniently the fibrous material to be felted on the core is supplied in the form of a lap wound into a roll 40. The roll is mounted so as to move down toward the felting apparatus as the material is used up. This keeps the emerging portion of the lap pressed against a feed roll 39 which runs at slow speed.

The cover 45 over the feed roll preferably is pressed resiliently toward the feed roll so as to insure uniform feeding of the fibrous material into the machine as well as to hold the lap while the teeth or pins 50 of the separating roll 49 tear the fibres of the lap apart. The separating roll runs at high speed and tears the individual fibres from the end of the fleecy lap and projects them at high speed into the chamber 52 of an applicator 53.

The applicator 53 collects the separated fibres and applies them in a multiplicity of overlying thin layers on the core 51 (which may correspond to the core 5 of Fig. 1 herein) as the core moves longitudinally through the applicator chamber 52.

The applicator journals are hollow for the passage of the core and extend through suitable bearings in the frame 41. The ends of the journals may be provided with chucks 58, 59 for retaining replaceable core guides 56, 57 of different interior diameters for guiding different sized cores and different sized jacketed conductors.

The applicator has one or more offset sections, there being three in the illustrative embodiment, which give to it a crank shape. Desirably these offset sections are designed so as to counterbalance each other. Each of the offset sections is provided with a flat surface 65 for collecting the fibres in the chamber 52, and desirably with means such as a series of closely spaced, curved, spring wire teeth 66 for conveying the collected fibres to the core and for pressing the fibres on to the core.

The applicator 53 rotates very rapidly and the loose fibres in the chamber 52 collect on the surface 65 in the form of a loosely matted ribbon or layer the fibres so collected extending in any and all directions.

As the applicator rotates this ribbon of fibres is drawn toward and wrapped around the relatively slowly advancing core, and since the applicator rotates at a very high speed, the fibres will be applied and integrally felted on to the core in a multiplicity of overlying thin layers. Each layer will lie against the core at one edge and lie above all of the previously applied layers at the other edge.

The spring teeth 66 press the thin ribbon or layer of fibres on to the core and in a measure draw them circumferentially around the core, and this action on the variously and indiscriminately arranged fibres produces in the composite a felted fabric jacket about the core which is substantially uniform and homogeneous throughout its thickness and extent and which is self-sustaining, dense, tight and highly resistant to wear and to separating forces in any and all directions.

The details of this apparatus and its operation are fully disclosed in the patent referred to and need not be repeated here.

The felted-on jacket may be formed of the fibres of any material which is subject to felting and which is otherwise suitable for the intended purposes in the insulated conductor. For example, cotton, flax, silk, wool, asbestos, glass or other fibrous materials or combinations thereof may be used. Inorganic fibres such as asbestos or glass may be preferred where fire resistance is a consideration.

The jacket produced by the exemplary method and apparatus described has the following characteristics:

1. It is felted-on as distinguished from applying previously felted strips, and by "felted" is meant that the fibres are criss-crossed and interentangled in all directions, being engaged with fibres on all sides as well as above and below, as is characteristic of felted fabrics, for example, hats.

2. It is integrally felted, not merely rubbed on the outer surface.

3. It is dense throughout.

4. It is seamless and continuous throughout its thickness and extent.

5. It is substantially uniform and homogeneous throughout its thickness and extent.

6. It is tight on the core, being in a sense circumferentially drawn in increments of thickness.

7. It is self-sustaining, requiring no braid, wrap, strands, saturants or the like, either internal or external for maintaining its integrity.

8. It is resistant to wear and to separating forces in any and all directions.

Whenever in the specification or claims a "self-sustaining, continuous, integrally felted-on jacket" is referred to, a jacket having most of all of the enumerated unique characteristics is intended.

After the seamless felted jacket of desired thickness has been applied to the core, it is advantageously polished down with water or a suitable emulsion to provide a smooth, dense, closely matted surface. Water is suitable for polishing some fibres, for example, asbestos and combinations of asbestos with other fibres, whereas fibres having resistance to wetting or a high surface friction, such as glass, may require the use of some other light fluid, such as a lubricating emulsion. Such a protective insulating jacket is so dense and compact, and the fibres are so thoroughly intertangled that the jacket uniformly has high resistance to separation and resistance in all directions.

For many purposes a magnet wire which is provided with such a felted insulating jacket polished down with water or a lubricating emulsion is sufficient. In some instances, however, it is desirable to further coat the jacket with a finish coating **8** of non-sticky material designed to increase the moisture-proof and heat-resistant properties of the insulation.

The protective cover **7**, constructed in accordance with the invention withstands high operating temperatures without deterioration and also resists cracking or opening up as a result of flexing or coiling of the wire due to the fact that the felted covering has high dielectric and temperature-resistant properties, and also is a continuous, seamless, cylindrical felted jacket having uniform resistance to separation of fibres in all directions.

In Fig. 2 I have illustrated the invention as embodied in a conductor particularly designed for general use, as for example those commonly employed in electrically connecting the different parts of radio, automotive or other apparatus.

In such conductors it is highly advantageous that the insulation be of such character that discoloration of the conductor core, such as might interfere with making soldered connections, be substantially prevented. Also the connecting and insulating cover should be so constructed and arranged that it may be easily stripped or moved relatively to the conductor to facilitate the making of such connections.

In the embodiment of the invention illustrated in Fig. 2 the usual conductor core **10** may be tinned and may either be stranded, as shown, or solid. A free stripping protective and insulating cover which will not discolor the conductor is provided and comprises a non-adhesive, substantially impervious separator **11**, which in the illustrated embodiment may be formed of tape or of transparent solidified viscose (commonly known as Cellophane) applied to the conductor, preferably longitudinally thereof. The tape or separator **11** not only protects the conductor **10** against discoloration, but also insures free stripping of the outer insulation from the conductor to facilitate making the soldered or other connections. At the same time the tape or separator provides a necessary dielectric strength.

A suitable adhesive **12** is applied to the outer surface of the tape or separator **11** over which is applied a continuous seamless felted-on jacket **13** corresponding substantially to the jacket **7** above described.

After the felted cover has been built up to the desired thickness, it may be polished with water or other light fluid to provide a dense, compact protective covering, or in some cases it may be saturated with a flexible saturant **14** having a high dielectric strength to increase the dielectric properties of the insulation and assist in binding the fibres together. Such a saturant may consist of a vegetable oil such as corn oil; a bituminous compound such as a suitably processed pitch or a resin compound. The saturated felted layer is then covered with a coating of colored lacquer **15** which provides an outer surface resistant to moisture and oils and having a smooth finish with a distinctive color for identification purposes.

As has been previously stated, the felted covering may be built up to a suitable thickness by applying the individual fibres in circumferential layers on the separator **11**. The separator not only forms in itself a layer of insulation around the conductor, but prevents the insulation from sticking to the conductor and provides for free stripping at all times. The product is flexible, smooth finished and is especially adapted for radio, automotive hook-up and other uses.

In Fig. 3 I have illustrated the invention as embodied in a "weatherproof" cable, commonly employed in exposed locations, such as pole lines. Such conductors advantageously comprise an inexpensive coating or covering which suitably insulates and protects the conductors and which are resistant to a high degree to deterioration upon exposure to weather, such as usually causes festooning of the insulation, leaving the conductors bare in places and producing a generally hazardous condition.

According to the form of invention illustrated in Fig. 3 the conductor core **16** may be solid or stranded as desired, and is preferably provided with a separator **17** which may be in the form of a paper tape or cellulose nitrate. Such separator is provided to permit easy stripping of the insulating cover from the conductor core when desired. If a paper separator is employed, an adhesive (indicated by dotted shading) is applied to the outer surface of the paper and a seamless felted-on jacket **18**, similar to the felted jacket described hereinabove, is formed over the adhesive and bound to the separator thereby. If cellulose nitrate is employed as a separator, a separate adhesive need not be used, provided the felted jacket **18** is formed while the cellulose nitrate is wet, as the cellulose nitrate is sufficiently adhesive when wet to cause the fibres to adhere thereto.

A coating **19** of high melting point bituminous material, such for example as blown asphalt or other compound, may be placed on the felted jacket **18**.

A second felted-on jacket **20** similar in every respect to the felted-on jacket **18** is then provided over the coating **19** and when built up to desired thickness, a second bituminous coating **21**, similar

to the coating 19 is applied to the felted-on jacket 20. The superimposed layers of felted-on jackets and bituminous coatings are preferably surrounded by a binding protective sheath which advantageously comprises a third felted-on jacket 22 applied in the same manner as the previously described jackets 18 and 20.

The fibres of the different felted jackets may, as above described, be of any suitable material. In making weatherproof wire, however, the lower felted jackets will usually be formed with cotton fibres but the outer jacket 22 may be of a mixture of different fibres, such for example as cotton and asbestos fibres or cotton and flax fibres mixed to increase resistance to abrasion. The outer felted jacket may be covered by a coating 23 of a protective compound such as a suitable pitch, and a surface 24 of some finished material, such as mica, size or a hard wax is applied over the pitch to provide a satisfactory finish.

The number of felted jackets and the thickness of the individual jackets will, of course, be such as to provide the necessary dielectric characteristics. Advantageously no finishing compound or braid need be used as the surface of the felted jacket 22 can be smoothed down and polished and, when so treated, will be satisfactory for many uses without further finishing.

In Fig. 4 I have illustrated the invention as applied to electrical conductors known as "code wire", so-called because it complies with the requirements of the National Electric Code which specifies a rubber insulation and a protective cover of suitable material therefor. Heretofore, it has been customary to protect the insulated conductor of the type referred to against flame by employing a braid and suitable non-inflammable compounds which are used to fill and/or coat the braid to render it flame-resistant and to protect the rubber insulation against combustion. It is also sometimes desirable to provide such flame-resistant code wire with surfaces of different colors for identification purposes. However, the cost of manufacturing satisfactory colored conductors has been relatively high, and my invention aims to provide an insulated conductor of the type set forth having an improved form of rugged protective cover, constructed and arranged not only to provide the desired flame-resistance and color but to be, at the same time, relatively cheap to manufacture.

In forming code wire such as illustrated in Fig. 4, in accordance with the present invention, the metallic core or conductor 25 of tinned copper, either stranded or solid, is surrounded with the usual layer of rubber 26 to provide the desired insulation. The surface of the rubber is then covered with a suitable adhesive material 27 which may be a varnish comprising a phenol condensation product, a cut shellac or a pitch in a suitable solvent. Over the adhesive I provide a felted-on jacket 28, similar to the felted-on jackets 7, 13, 18, 20 and 22, above described. The fibres of the jacket are preferably of asbestos or other non-combustible material to contribute to the flame-resistant properties of the finished product. However, where flame-resistance is not sufficiently important, other fibres, such as cotton and mixtures of cotton and asbestos or other suitable material may be employed. Usually in code wire the fibres are preferably of asbestos or a mixture of cotton and asbestos such as will provide a dense, flexible, heat-resistant insulation and which will provide mechanical protection to the rubber as well.

After the felted-on jacket 28 has been built up to desired thickness, it may be provided with a coating 29 of suitable material which is flame- and heat-resistant, for example a bitumen, which also renders the fibre layer moisture-resistant and improves its dielectric strength.

Over the coated felted-on jacket a colored or pigmented finish coating 30 is formed to provide the finished conductor with the desired color and finish and also to prevent migration and aging of the coating 29. This coating 30 may be formed of a suitable colored bituminous coating compound, of a stearin pitch-linseed oil paint, of a lacquer, of chlorinated waxes, or of any suitable colored finishing compound.

Conductors of the types described above heretofore have required an outer protective braided covering as the so-called felted coverings formed from a spirally wound slivers or otherwise did not possess the necessary resistance to tear and to fibre separation to permit braids and the like to be omitted, whereas the covering constructed according to the present invention is adequate without braids or other supporting agents.

I claim:

1. An electrical conductor comprising a conductor core, and a compact, seamless, continuous tubular felted, insulating and protective jacket surrounding said core, said felted jacket being composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings.

2. An electrical conductor comprising a conductor core, and a compact, seamless, continuous tubular felted insulating and protective jacket surrounding said core, said felted jacket being initially composed for the most part of dry unsaturated vegetable fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings.

3. An electrical conductor comprising a conductor core, and a compact, seamless, continuous tubular felted insulating and protective jacket surrounding said core, said felted jacket being initially composed for the most part of dry, unsaturated inorganic fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings.

4. An electrical conductor comprising a conductor core, and a compact, seamless, continuous tubular felted insulating and protective jacket surrounding said core, said felted jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings, and a moistureproof coating for said felted jacket.

5. An electrical conductor comprising a conductor core, a layer of non-adhering material surrounding said core, and a compact, seamless,

continuous tubular felted insulating and protective jacket surrounding said core, said felted jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings.

6. An electrical conductor comprising a conductor core, a protective covering therefor including a plurality of compact, seamless, continuous, tubular, felted jackets, each jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions, and intervening layers of coating material separating said felted fibrous jackets.

7. An electrical conductor comprising a conductor core, a protective covering therefor including a plurality of compact, seamless, continuous, tubular, felted jackets, each jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions, and intervening layers of high melting point bituminous material separating said felted fibrous jackets.

8. An electrical conductor comprising a conductor core, a protective covering therefor including a plurality of compact, seamless, continuous, tubular, felted jackets, each jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions, and intervening layers of high melting point bituminous material separating said felted fibrous jackets, and an outer protective coating for the outermost jacket.

9. An electrical conductor comprising a conductor core, a layer of plastic insulating compound surrounding said core, and a compact, seamless, continuous, tubular felted protective jacket surrounding said insulating compound, said felted jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings.

10. An electrical conductor comprising a conductor core, a layer of plastic insulating compound surrounding said core, and a compact, seamless, continuous, tubular felted protective jacket surrounding said insulating compound, said felted jacket being initially composed for the most part of dry, unsaturated fibres integrally felted together into a homogeneous jacket of substantially uniform thickness and density throughout its circumference and length which is self-sustaining and uniformly resistant to separating forces in all directions without the use of external braids or wrappings, and a coating of flame-resistant material applied to the outer surface of said jacket.

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