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H. O. ANDERSON

1,840,282

INSULATED ELECTRICAL CONDUCTOR

Filed June 19, 1928

Fig. 1.



Fig. 2.



Fig. 3.

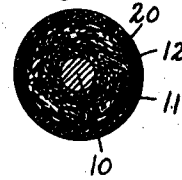


Fig. 4.

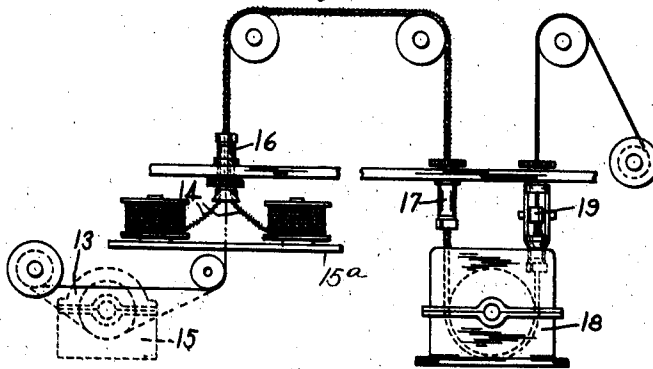


Fig. 5.



Fig. 6.

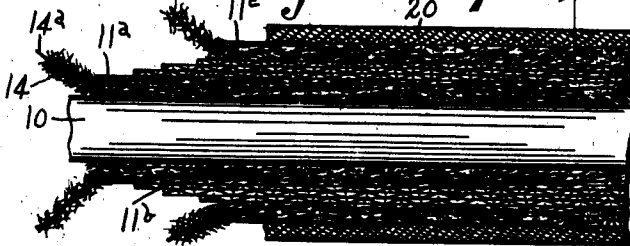


Fig. 7.

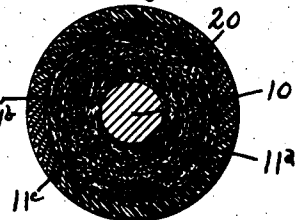


Fig. 8.



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INSULATED ELECTRICAL CONDUCTOR

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This invention relates to insulated electrical conductors.

The invention is especially directed to an improvement in insulated electrical conductors for wiring switchboards, but conductors of my invention may be used for wiring elevator control panels, car heating circuits, power and lighting circuits, resistance grids, rheostats, track signal systems, electric furnaces, and mining machinery, and for other service where an insulated conductor which is heat, moisture, acid, flame, oil and gas proof, is desirable.

The insulated conductors generally provided heretofore for switchboard and similar uses, have been provided with insulating sheaths which were likely to crack and open up so as to expose the conductor, especially when the conductor was sharply bent. Also, many of the coverings heretofore provided were not flame-proof, and would ignite and either burn or disintegrate upon the application for a short period of time, of a flame. These covers, therefore, did not insure permanence of insulation under extreme conditions, and could not be relied upon in emergencies that required a continuation of the operation of the circuits in which the wires were located.

One object of this invention is to provide a thoroughly insulated and fireproof electrical conductor, which will have high mechanical strength and ruggedness.

Another object of this invention is to provide an insulated electrical conductor, having an insulating covering of high dielectric strength, substantially flameproof and moisture resistant, said covering being characterized by its permanence and great resistance to strains, produced by bending of the conductor, that would destroy the insulating properties of ordinary switchboard wire.

Still another object is to provide an insulating covering for an electrical conductor, composed of a plurality of layers of different insulating materials, the material of one or more of the layers being adapted to act as a protector for another against damage by mechanical strains or distortions, or destruction or damage by heat, moisture, gas or

acid, as well as an insulation for the conductor.

A further object is to provide an insulating sheath for an electrical conductor, wherein a thin layer of insulating material having high dielectric strength, and comparatively frangible under certain conditions, is protected and cushioned by another layer of insulating material having somewhat less dielectric strength, but relatively soft and flexible, so as to preserve to a maximum degree the continuity of the first mentioned layer of insulation, should the covered conductor be subjected to mechanical strains by sharp bending.

A still further object is to provide an insulating sheath for an electrical conductor, wherein a layer of insulating material having a comparatively high dielectric strength, though ordinarily subject to the destroying or disintegrating effects of extreme heat or moisture respectively, is thoroughly protected by another layer of insulating material having somewhat less dielectric strength, but flame-proof and relatively high in moisture resistance, so as to insure that the first mentioned layer of material will not be subjected to such effects.

Still another object of this invention is to provide switchboard or like wire which is covered by such a combination of layers of insulating materials having different characteristics, that, should one of the insulating materials be damaged, disintegrated or destroyed, due to excessive strain, heat or moisture, the material of another layer or layers of insulation will be of sufficient dielectric strength to continue to act as an effective insulation for the conductor, and thereby obviate the possibility of damage to adjacent circuits, controls or mechanisms.

To these and other ends, the invention consists in the novel features and combinations of parts to be hereinafter described and claimed.

In the accompanying drawings:

Fig. 1 is a side view of a switchboard wire embodying the features of this invention, with the different layers of insulating material exposed;

Fig. 2 is a greatly enlarged longitudinal section of the conductor shown in Fig. 1;

Fig. 3 is a section on line 3—3 of Fig. 2;

Fig. 4 is a diagrammatic view, showing one manner in which a part of the insulating covering may be applied to the conductor;

Fig. 5 shows a somewhat modified form of conductor;

Fig. 6 is a greatly enlarged longitudinal section of the conductor shown in Fig. 5;

Fig. 7 is a section on line 7—7 of Fig. 6, and

Fig. 8 is a side view of a stranded conductor, having the arrangement of insulating material shown in Fig. 5.

The improved insulated electrical conductor of this invention comprises a cable strand or wire, having a covering comprising a plurality of layers of insulating materials of different characteristics. Insulating materials of comparatively high dielectric strength and which are relatively thin, are generally stiff or unyielding in nature and readily torn, fractured or otherwise ruptured by sharply bending or otherwise straining the same. An example of this type of insulating material is specially treated textile fabric such as varnished cambric, which is used to quite an extent as an insulating covering for electrical conductors, customarily by applying to the conductor a plurality of layers of this material in strip or sheet form, which are folded or wrapped about the wire, after which an outer textile cover is superposed on the cambric by a braiding or similar operation. Such a conductor cannot be bent abruptly without the danger of rupturing at least the outer layers, and in many instances all of the layers of insulation as well as the outer cover, are cracked or opened up, when sharply bent, whereby the wire will be exposed. In any event, such damage will result in a loss of the insulating properties of the insulation at the bend and expose the remaining covering to excessive electrical strain or to the action of moisture, gas, etc. Further, this kind of covering, although having, initially, excellent electrical insulating properties, provides poor heat insulation, being in many instances totally destroyed when the conductor becomes overheated due to excessive overloads of electrical current, or when the covering is exposed to the action of a flame at the exterior thereof.

Other insulating materials of somewhat less dielectric strength but possessing the characteristics of softness and high flexibility, have also been used as an insulating covering for a conductor. Such covers possess the advantage of not being readily ruptured, provided they are applied to the conductor as a compact homogeneous mass. Among these materials is insulating fibre such as asbestos fibre, which when applied to a conductor according to the method de-

scribed in a patent to Beauford H. Reeves, No. 1,789,882, issued Jan. 20, 1931, is an excellent insulating and fireproofing medium. However, when this material is used alone or as primary insulation in locations where very high dielectric strength is required, the covering necessarily has more bulk than would be required if a material of higher dielectric strength could be successfully used, such bulk resulting in a larger conductor diameter, and somewhat reducing facility of manipulation.

The insulating covering of the improved electrical conductor of this invention, comprises a novel combination of materials of both of these classes, which materials are arranged upon the conductor in such a manner that the advantages of both will be obtained and the disadvantages of both will be obviated. The resulting insulating covering, therefore, is one which possesses a relatively high dielectric strength and is flame-proof, as well as moisture-resistant, while being mechanically strong, durable and flexible.

In the form of my invention shown in Figs. 1, 2 and 3, the conductor 10 is first covered with a plurality of, in this instance two, layers of insulating fabric 11, such as varnished cambric. These layers are applied by winding narrow strips of this material directly upon the surface of the conductor, preferably staggering the layers or alternating the direction of winding the different layers (see Fig. 8) so that the overlaps or joints of one layer will be out of line with those of the other, and so that a uniform thickness of material will be secured. Upon this structure, a layer 12 of fibres of another insulating material, such as asbestos, is formed. This layer is preferably formed of interentangled asbestos fibres pressed into a compact mass. Preferably, the layer 12 is formed directly upon the surface of the outer layer of fabric, by felting the asbestos fibres into a homogeneous mass thereabout in a machine and by a method disclosed in the above mentioned patent.

Fig. 4 illustrates diagrammatically one method of applying the fibrous material to the fabric covered conductor. In this figure, the numeral 13 indicates the fabric covered conductor, and 14 indicates a sliver or roving preferably composed of a mass of asbestos fibres disposed about and adhering to a carrier element such as a cotton thread 14^a. (Fig. 2.) The fabric covered conductor 13 may have an adhesive applied thereto, if desired, by passing it through an adhesive bath 15 shown in dotted lines. After the sliver or slivers have been applied to the conductor (as by winding them thereon by means such as a rotary device 15^a), the conductor is passed through a rotary device 16 which smooths the asbestos fibres about the conductor and more completely interentangles the

fibres with each other, while partially compressing the mass. The conductor is then passed through a rotary device 17, which further condenses and compacts the fibrous mass, and thence it passes through a bath 18 of suitable flame-proof and moisture resistant material whereby the fibres are thoroughly impregnated and firmly bound together. The impregnant may advantageously consist of asphaltic material in solution, having a suitable flame proofing agent such as lead carbonate added thereto. The impregnated structure is then passed through a polishing device 19, which further compacts the fibrous mass and smooths the outer surface thereof.

The conductor, as thus covered, is then passed through a machine wherein an outer covering 20 is applied thereto, preferably by braiding strands of cotton or other suitable material directly upon the outer surface of the felted fibrous mass, which results in the outer covering snugly engaging the cushioning layer of fibrous material. This outer covering is then treated with an impregnant containing flame-proof paint or other flame-proofing agent, and is then permitted to dry.

A conductor such as that above described is admirably adapted for use on switchboards and in similar locations. It has very high mechanical strength and it can be bent so as to present sharp turns or angles, as required for switchboard use, without danger of breaking the wire proper. This advantage arises in part from the cushioning effect of the relatively bulky and yielding layer of fibres, which permits the metallic element to take the form of a curve, even when the outer covering presents a sharp angle. This cushioning effect of the asbestos or other fibrous layer also applies to the thin and somewhat frangible or fracturable layer of insulation, which is permitted to assume a gradual curve, in a similar manner, to such an extent as to prevent this thin layer from being fractured or ruptured by sharp bending of the exterior structure, or to reduce to a minimum the likelihood of the fabric layer being broken in this manner. When the conductor is sharply bent, the thin layer of insulation is placed under some strain at the outer curve of the bend, tending to pull it apart, but the yieldable covering of fibres supports this layer, by being more tightly pressed against it at this point, and prevents this action. Should a fracture of the cambric layer occur, however, the insulating effect is preserved in ample measure by the relatively thick protective fibre layer, and the rupture, if any, of the cambric layer is usually slight. Owing to the thinness of the inner textile layer, it is inherently more flexible than would be the case if a large number of superposed varnished cambric layers were employed, with the result that the flexibility of the conductor as a whole is increased, as compared to those

conductors having a large number of layers of varnished cambric, whereas, on the other hand, the dielectric strength is noticeably increased as compared to those conductors of the same size in which the main reliance for insulation is placed upon a layer of asbestos or like fibres.

The conductors of my invention will serve satisfactorily under conditions that would cause the early destruction of other types of wire. They present high dielectric strength, smooth appearance, have uniform diameter, and, in addition, are entirely resistant to exterior ignition whether the wire is straight or bent, owing to the complete envelopment of the cambric material by the flexible exterior asbestos layer.

Under some conditions of use, especially in locations where the wiring is subjected to high temperatures due to overloading of the apparatus, or where there is danger from interiorly conducted heat, the thin layer of textile material may be heat-insulated from the inside as well as from the outside, in which case a layer of fireproof material is inserted between the cambric and the metallic element. In Figs. 5 to 8 inclusive, I have shown conductors in which this feature is incorporated. In the particular cases shown in Figs. 5 to 8, an inner layer of felted asbestos fibres directly surrounds the metal conductor element, as shown at 11^a. Upon this layer of fireproof fibers is superposed a thin layer, 11^b, of varnished cambric strips, and upon this latter layer is superposed a further layer, 11^c, of asbestos fibres. In the use of this form of conductor, both layers of felted asbestos, that is to say, the inner layer and the outer layer, act as cushions for the fabric layer, and the inner asbestos layer effectively protects the textile layer and insulates it against heat generated in or conducted by the metallic element.

In the form shown in Fig. 8, the metallic element is constituted by a plurality of strands instead of by a single wire.

In the forms shown in Figs. 5 to 8, inclusive, also, the braided covering is formed of asbestos, whereas in the case of the wire shown in Figs. 1 to 3, the outer braid is preferably of cotton.

As an example of the relative thickness of the various layers of insulating material applied as above described, it has been found preferable to apply upon a #8 A. W. G. wire, which is .128 of an inch in diameter, two layers of varnished cambric, each approximately .005 of an inch in thickness, one layer of felted asbestos fibres approximately 30 mils thick, and a braided covering approximately 20 mils thick. The diameter of a completely insulated #8 A. W. G. wire will, therefore, be approximately .250 of an inch, which is the nominal diameter required of covered wire

for use in switchboard wiring, or for any of the above other uses.

While I prefer to use, as one of the insulating materials, cambric or like fabric having applied thereto a hard, lustrous coating of resinous material, such as varnish, such material being utilized in the form of a relatively small number of superposed strips, the relatively frangible layer of high dielectric strength may be formed of other material possessing equivalent or substantially equivalent insulating properties; and the cushioning and yielding protective layer for the first-mentioned layer, while preferably composed of interentangled and somewhat compacted asbestos fibres, need not in all cases be formed of this identical material, provided the protective layer is sufficiently yielding and bulky, and possessed of the requisite dielectric strength to serve the purposes above explained.

It will be obvious that where the sliver or roving is provided with a carrying filament, such as the thread 14^a, the latter will not only serve to hold in place the asbestos or other mineral fibres but will tend to secure and retain the fabric strips in the layer which is surrounded by such layer of asbestos fibre.

It will be observed that the fabric strips of the high dielectric layer are separate from the metallic element of the conductor and are of such a nature that they can be readily removed from the conductor when access is had thereto by the removal of the surrounding layer or layers of material. As the high dielectric layer can be readily stripped from the wire, the conductor can be more easily stripped or bared at the end for the purpose of making such electrical connections as may be necessary. The strip or strips of the high dielectric layer while fracturable and ignitable, is or are protected from undue mechanical strain by the surrounding somewhat yielding layer which also protects the high dielectric layer from chemical attack and moisture, as well as from ignition. The high dielectric layer as thus protected serves very satisfactorily, as it is of a permanent character and it will not break down, deteriorate or decompose or otherwise lose efficiency to an appreciable degree with the passage of time.

While I have shown and described preferred embodiments of my invention, it is understood that it is not to be limited to all of the details shown, but is capable of modification and variation which will lie within the spirit of the invention and the scope of the appended claims.

What I claim is:

1. An insulated electrical conductor comprising a metallic conductor element, a relatively thin insulating layer surrounding the same, formed of inelastic strip material of high dielectric strength, a relatively bulky and yielding protective layer of fireproof

fibrous material surrounding said first layer, and a flexible flameproof covering of fibrous material enveloping the conductor thus formed.

2. In an insulated electrical conductor, a metallic conductor element, a thin insulating layer of high dielectric strength surrounding the same and composed of a small number of superposed fabric strips coated with resinous material, and wound on the metallic element so that one strip closes the joints of another, a relatively bulky and yielding protective layer of asbestos fibres enveloping and compacted about said first layer and including in its structure a carrier filament which holds in place the said fibres and also the aforesaid fabric strips, said second layer being treated with a suitable impregnant and presenting a body which permits relative movement with respect thereto of the metallic element and the first-mentioned insulating layer when said body is sharply bent, and a braided covering enveloping said asbestos layer.

3. In an insulated electrical conductor, the combination of a metallic core, an insulating layer of high dielectric strength surrounding said core and composed of a small number of superposed fabric strips coated with resinous material, said strips being wound on the core but separate therefrom and readily removable for baring the core end in stripping the conductor, a protective layer of mineral fibres enveloping and compacted about said first layer in a smooth homogeneous mass, said second layer being impregnated with asphaltic material containing a flameproofing agent and presenting a body which permits relative movement with respect thereto of the metallic core and the first mentioned insulating layer when the conductor is sharply bent, and a braided outer cover of fibrous material snugly embracing said second layer, said braided covering being treated with an impregnant containing a flameproofing agent, and said conductor as a whole having sufficient flexibility to adapt it for use for switchboard and similar purposes.

4. In an insulated electrical conductor, the combination of a metallic conductor element, an insulating layer of high dielectric strength surrounding the same and composed of a small number of superposed fibrous strips treated with insulating material and wound about the metallic element so that one strip closes the joints of the other, said layer being ignitable and somewhat fracturable, a relatively yielding protective layer of mineral fibres enveloping and compacted about said first layer, said second layer being treated with a suitable moisture proofing impregnant and presenting a laterally flexible impregnated body which permits relative movement with respect thereto of the metallic element

and the first mentioned insulating layer when the conductor is sharply bent, said second layer being adapted to cushion the first and to protect it against rupture and against ignition from an exterior source, and a braided covering snugly embracing said second layer, said conductor as a whole being flexible and adapted for switchboard and similar use.

5. An insulated electrical conductor for switchboard and like purposes comprising a metallic conductor element, an insulating layer surrounding the same, said insulating layer being composed of superposed varnished cambric strips wound on the element and breaking joint with each other and said layer being inelastic, fracturable and ignitable but of high dielectric quality, a second layer in the form of a yieldable homogeneous cushioning sleeve of mineral fibres surrounding the first layer and adapted to cushion and protect it against rupture when the first layer is subjected to sharp bends, said second layer being impregnated with a material which moisture proofs the same but does not impair the lateral flexibility of said layer and a flexible flameproof covering of braided fibrous material snugly enveloping the second layer.

6. In an insulated electrical conductor, a metallic conductor element, a thin insulating layer of high dielectric strength surrounding said element and composed of superposed strips of fibrous material treated with insulating material, a relatively bulky and yielding protective layer of fibres enveloping and compacted about said first mentioned layer and including in its structure a carrier filament which holds in place the said fibres and also the aforesaid strips, said second mentioned layer presenting a body which permits relative movement with respect thereto of the metallic element and the first mentioned insulating layer when said electrical conductor is sharply bent.

7. In an insulated electrical conductor, a metallic conductor element, an insulating layer of inelastic frangible and ignitable material of high dielectric strength surrounding said element, a soft and yielding laterally flexible insulating layer disposed adjacent the first layer to protect the same and comprising a compacted felted mass of interentangled fireproof fibres, and a flexible flameproof cover surrounding and snugly enveloping the previously mentioned layers, said yielding layer cushioning the first layer and providing for the bending of the completed conductor at sharp angles without rupture of the layers.

8. In an insulated electrical conductor, a metallic conductor element, an insulating layer of high dielectric strength surrounding said element and composed of a small number of strips of high dielectric material in superposed relation wound helically about

the conductor with their edges overlapping and with the strips breaking joint with each other, another insulating layer disposed adjacent the first layer to form a protecting cushion therefor and comprising a substantially homogeneous tubular body of interentangled and compacted felted mineral fibres, said second layer containing a moistureproof non-hygroscopic non-stiffening flameproof impregnant and presenting a flexible yielding body which permits relative movement with respect thereto of the metallic element and the first-mentioned insulating layer when the conductor is sharply bent, and an outer layer of flexible flameproof material snugly enveloping the previously mentioned layers and braided thereon to maintain the second-mentioned layer in its protective relation to the first layer.

9. In an insulated electrical conductor, the combination of a metallic conductor element, an insulating layer of high dielectric strength surrounding the same and composed of inelastic ignitable strip of material wound around the element to form a closed sheath therefor, said sheath being separate from said element and readily strippable to bare the end of the wire in making electrical connections, a second insulating layer adjacent the first comprising a soft and yielding sleeve of interentangled and compacted felted fireproof fibres treated with a moistureproofing impregnant which leaves said layer flexible and adapted to cushion said first layer and protect it against rupture when the conductor is sharply bent, and a flexible flameproof covering of braided fibrous material snugly enveloping said layers and constituting the outer layer of the conductor.

10. In an insulated electrical conductor, the combination of a metallic conductor element, an insulating layer of high dielectric strength surrounding the same and composed of inelastic fracturable insulating material in strip form wound around the element to form a closed sheath therefor, a second layer located adjacent the first and comprising a soft and yielding sleeve of considerable bulk composed of mineral fibres adapted to cushion and protect said first layer, said second layer containing an impregnant which proofs it against moisture and its flameproof, said impregnant being of a character to prevent said layer from substantially stiffening or restricting the bending of the structure, and a flexible flameproof covering of braided fibrous material snugly enveloping said layers, said fibrous sleeve being adapted to prevent the cracking of said covering or said layers when the completed conductor is bent at sharp angles.

11. In an insulated electrical conductor, the combination of a metallic conductor element, an insulating layer of high dielectric strength surrounding the same and compris-

- ing a narrow strip of non-elastic insulating material wound around the element to form a closed sheath therefor, said sheath being separate from said element and readily strip-
 5 pable to bare the end of the wire in making electrical connections, a second layer located adjacent the first and comprising a sheath of interentangled mineral fibres adapted to cushion said first layer and protect it against
 10 rupture, said second layer containing an asphaltic filler and also containing a material which renders it flameproof, and a flexible flameproof outer covering snugly enveloping said layers and constituting the outer layer
 15 of the conductor.
12. In an insulated electrical conductor, the combination of a metallic core, an insulating layer of high dielectric strength surrounding said core and composed of a small
 20 number of superposed fabric strips coated with insulating material, one of said strips being wound about the core and another strip being wound on top of the first strip but having its joints out of line with those of the
 25 first strip, said strips being separate from said core and readily removable for baring the core end in stripping the conductor, a yielding and flexible protective layer comprising mineral fibres enveloping the core
 30 and compacted against said first layer in a smooth homogeneous mass, said second layer containing a non-hygroscopic moisture proofing filler which leaves said layer flexible, and a braided outer cover of fibrous material
 35 snugly embracing said previously mentioned layer, said braided covering being treated with an impregnant containing a flameproofing agent.
13. In an insulated electrical conductor,
 40 the combination of a metallic conductor element, an insulating layer of varnished cambric tape surrounding the same and forming a closed sheath for said element, a second layer located adjacent the first comprising a
 45 yielding and flexible body which cushions the first, said second layer comprising a felted compacted mass of interentangled fireproof fibres and a binder which moisture proofs said layer but leaves it flexible so that it will
 50 take sharp bends without breaking, said second layer being flameproof, an adhesive on the outer surface of the first layer which causes the second layer to adhere to the first, and a flexible flameproof covering of braided
 55 fibrous material snugly enveloping said layers.
14. In an electrical conductor, a conductor core member, a braided flexible outer jacket, and a plurality of layers of insulating material interposed between the core member and jacket and held in place by the latter, the material of one of said layers being inelastic, fracturable and ignitable, the material of another of said layers being yieldable and fireproof, said latter layer comprising
 60 felted interentangled fibres forming a substantially homogeneous body, said layer containing a moistureproofing impregnant which does not materially detract from the flexibility thereof and being disposed adjacent
 65 the first-mentioned layer to cushion the same and protect it against damage by excessive heat or abrupt bending and whereby sharp bends or turns can be made in the completed conductor without cracking the
 70 jacket or the layers.
15. In an electrical conductor, a conductor core member, a flexible flameproof outer cover, and a plurality of layers of insulating material interposed between the core
 75 member and cover and held in place by the latter, one of said layers comprising strips of inelastic fracturable and ignitable material laid so as to break joint with one another, another of said layers comprising
 80 felted interentangled inherently fireproof fibres forming a substantially homogeneous body, said last-named layer containing a moistureproofing impregnant which does not materially detract from the flexibility thereof and being disposed adjacent and exteriorly of the first-mentioned layer to cushion
 85 the same and protect it against damage by heat from an exterior source.
- In witness whereof, I have hereunto set my
 90 hand this 18 day of June, 1928.
- HERBERT O. ANDERSON.