

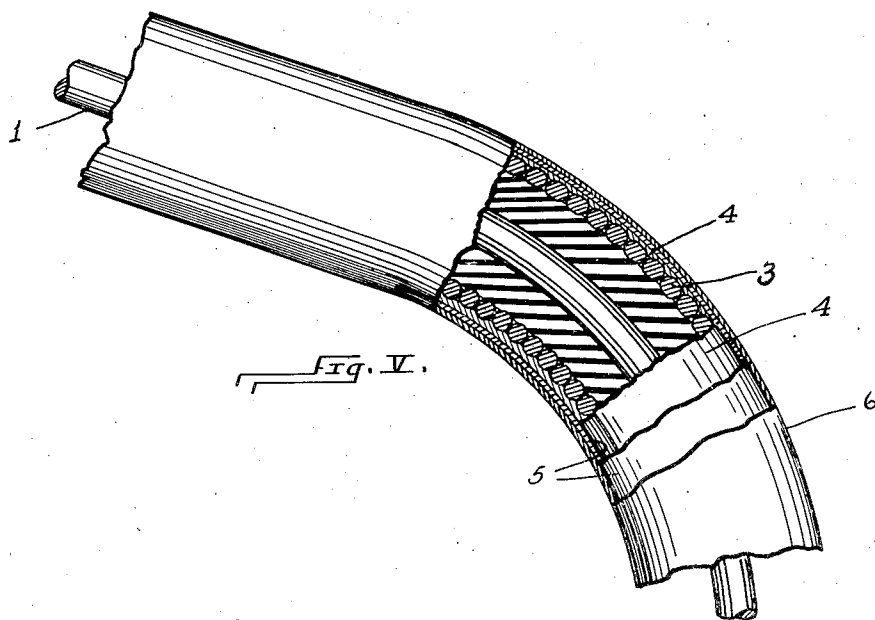
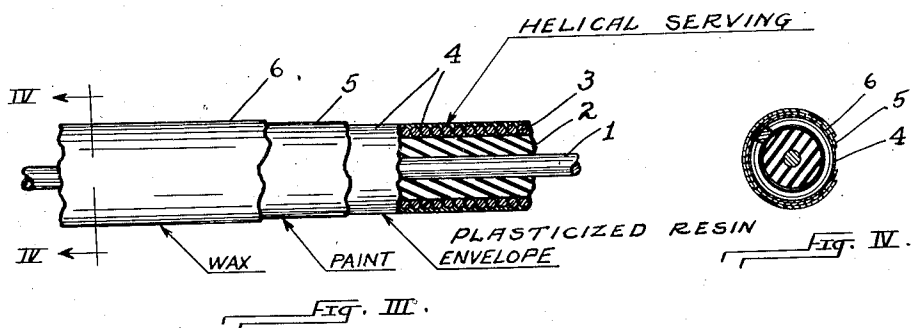
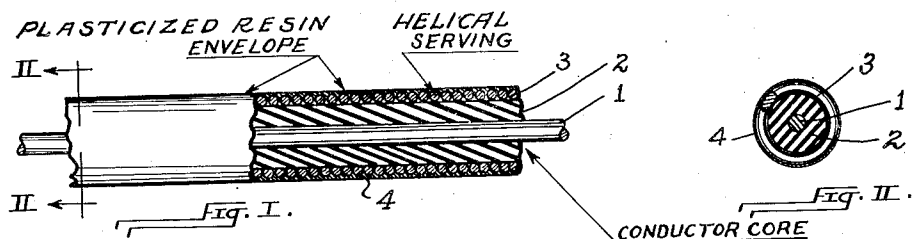
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O. A. FREDERICKSON

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ELECTRICAL CONDUCTOR

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INVENTOR
Otto A. Frederickson
by *Christy and Wharton*
His attorneys

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ELECTRICAL CONDUCTOR

Otto A. Frederickson, Glen Ridge, N. J., assignor
to National Electric Products Corporation, a
corporation of Delaware

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This invention relates to conductors for carrying electrical current, and more particularly to conductors of the rubber-sheathed insulated type.

In conductors of the rubber-sheath insulated type it has been common practice, used also to some extent in conductors which are otherwise primarily insulated, to apply a covering of braided yarn over the current-carrying element, and over the rubber sheath of the conductor if such sheath be present. Such braided covering is desirably impregnated with a moisture-resistant and flame-retardant saturant of suitable bituminous sort.

A simple helical wrapping of fibrous yarn laid with its turns inside each other in a helical lay presents fundamentally great advantage over a braided covering and over analogous coverings which are woven or knit. Since in such wrapping the turns of yarn are not crossed, they do not tend to maintain open intervals between them to entrap air having a deteriorating effect on a metallic current-carrying element at the center of the conductor, or on a rubber sheath enclosing the current-carrying element. If a saturant be used, the fibrous covering is more uniformly and completely impregnated by it. A great advantage which a wrapped covering holds over a braided covering is that a wrapped covering may be applied with rapidity, several yarns or "ends" being simultaneously laid side by side helically on a core composed of a current-carrying element and sheath of rubber or other flexible dielectric material. Such rapid application so reduces the cost of applying this element of the conductor structure that increased care may be employed in making the conductor, while maintaining the cost of the conductor at a level permitting the general public to have the advantage of superior quality. A wrapping laid in a single layer without the overlapping of two layers as a braided covering, substantially decreases the overall diameter of the conductor. Thus a completely organized conductor may be of such decreased diameter as to give substantial advantage in its use in cables, conduits, and other installation assemblies, and decreased bulk in shipment and use.

A problem encountered in the use of a simple helical wrapping laid with its yarns or turns side by side, rises from the tendency for such a covering to shift when the conductor which includes it is flexed. This tendency is naturally greater in electrical conductors of the smaller size in which severe flexion and kinking is encountered. It is, however, present even in conductors and cables of larger size. Such shifting tendency with localized longitudinal movement of the yarn serving and a tendency to produce intervals between adjacent yarns, or turns of yarns, tends as an effect to destroy the coherence of the conductor structure, leaving the conductor core regionally unprotected by the fibrous covering of

the yarn, and tending to break coherent encapsulating layers of pitch, paint, wax, or the like, which may provide the outer finishing coats of the conductor.

A primary object of my invention is to provide in a current-carrying conductor, having a helical wrapping organized in its structure, improvement by which the shifting tendency of the yarns helically laid in the structure is compensated by an outer coherent structure or element which is of a character to flex in flexion of the conductor, and to expand or contract in accordance with the shifting movement of the helically laid yarn to maintain the coherence and integrity of the conductor structure under all conditions of use. Further, it is an object in providing such improvement to do so in such manner that the overall diameter of the conductor is not substantially increased nor its flexibility impaired. Also it is an object of my invention in providing such improvement, inherently by such improvement additionally to increase the resistance of the insulating assembly of the conductor to attack by petroleum oils, and to improve the moisture-resistance, flame-retardance, and aging qualities of the assembly.

In the accompanying drawing exemplary of an embodiment of my invention Fig. I is a fragmentary view, partly in elevation and partly in central longitudinal section through the interior assembly of an insulated electrical conductor organized in accordance with my invention, and including a current-carrying element, a rubber sheath therefor, a wrapped fibrous covering and an elastic binder envelope over the served covering. Fig. II is a cross-sectional view taken in the plane of section line II—II of Fig. I. Fig. III is a fragmentary view, partly in central longitudinal section and partly in elevation progressively broken away, showing an insulated conductor assembly which includes the outer coatings of a preferred commercial conductor. Fig. IV is a cross-sectional view taken in the plane of the section line IV—IV of Fig. III. Fig. V is a fragmentary view, similar to Fig. III in its arrangement, but illustrating the effect of flexion in the conductor assembly as modified by the presence of the elastic binder envelope surrounding the wrapped fibrous covering of the assembly.

Referring to the drawing, in which the conductor elements are designated by legends, as well as by reference numerals, and with reference also to the above general disclosure of my invention, the current-carrying core is shown to include an electrically conductive structure 1, and as is preferable in some types of electrical conductors also includes a rubber insulating sheath 2. Around the conductor core, there is a wrapping 3 of fibrous yarn, or yarns, laid helically with the turns of yarn side by side. It will be understood that it is desirable, but not inevitably necessary, that this fibrous cover-

ing 3 be impregnated by a moisture-resistant and flame-retardant saturant of bituminous or other suitable nature, which tends both to impregnate the wrapped covering and to integrate it to the core.

Around the serving 3, and completely and coherently enclosing it, there is a binder envelope 4, in the provision of which my invention chiefly resides. This envelope 4 is a thin, unitary sheath of tough, elastic, abrasion-resistant, and oil-resistant character, which is also moisture-resistant, and flame-retardant. The substance of the envelope desirably is plastic composition which has in measure the elastic properties of rubber, but which has greater toughness, abrasion resistance, flame-retardance, oxygen resistance, and resistance to aliphatic solvents than is possessed by vulcanized rubber. The plastic composition also presents a lesser resistance to surface contact movement, or "drag," than does vulcanized rubber. By the term "plastic composition," as I use that term, I mean a composition consisting of high polymers, or micelles, of resinous sort plasticized to a rubber-like consistency and capable of being rendered fluid, or workable, by the use of solvents, heat, or by utilizing both heat and solvents. Compositions suitable for my purpose may be made of polyvinyl esters, such as polyvinyl chloride, the so-called co-polymers of polyvinyl esters, acryloid resin, acryloid-paracoumarone blends, high polymer ketone resins, polystyrene resins, and other high-polymer resins having high tensile strength, and high resistance to aliphatic solvents; plasticized with suitable plasticizers, such as di-butyl phthalate, di-amyl phthalate, tri-cresyl phosphate, acetyl ricinoleate, dibutyl tartrate, low melting glycerol phthalate, and other resin plasticizers.

I may also use one of the available pre-plasticized resinous compositions, such as the aleuritinsates and hydroxystearates of polyvinyl alcohols, or the butyrates of polyvinyl alcohols. Such compositions may be used with little or no additional plasticizer.

If desired, the plastic composition may be applied by passing a prepared assembly of conductor core and wrapped yarn covering through a bath consisting of plastic composition rendered fluid by suitable solvent, such as ethyl acetate, acetone, and the mono-ethyl-ether of ethylene-glycol, and gentle heating. After passing through such bath, the coated assembly is wiped in dies.

My preferred procedure is to heat the plastic composition, with or without the addition of a small quantity of solvent, to a workable consistency. The plastic composition is then wiped on the prepared assembly, in the manner in which unvulcanized rubber is applied, to form a sheath surrounding the conductive element of the current-carrying core. Regarding this application, it should however, be understood that the plastic composition, having inherently greater toughness and cohesion than unvulcanized rubber, may be applied in a much thinner film.

The wiping effect desirably is produced in extrusion apparatus of the sort used in applying unvulcanized rubber around the current-carrying element of a conductor, but the substance of the envelope may otherwise be wiped on the core. In whatever manner the envelope material be applied, it is a matter of moment that it be applied in a thin film. If the film be very thin, plastic compositions which would tend toward brittleness if applied in a thick coating, are ade-

quately tough and elastic at all temperatures fully to satisfy my requirements. The thickness of film which I prefer for conductors of the smaller sizes is no more than about 2 or $\frac{3}{1000}$ ths of an inch, and for the larger size conductors I prefer that the thickness should be no more than 8 or $\frac{9}{1000}$ ths of an inch.

As exemplary of a plastic composition suitable for the film or envelope embracing the served covering, I may give a composition consisting of polyvinyl chloride plasticized to a rubber-like consistency with a plasticizer such as acetyl ricinoleate. Various suitable compositions consisting of high polymer resin and appropriate plasticizer may readily be made up in accordance with known practice in the art of making plastic compositions, having regard to the requisite properties of the binder envelope of my conductor structure. In them isobutylene polymers, having the character of a synthetic, unvulcanizable rubber, resistant to aliphatics and to oxygen, may suitably be included with the high polymer resin and plasticizer.

It should particularly be understood that the material of the binder envelope is not, and should not be, a saturant for the fibrous yarn of the wrapping, but on the contrary is, and should lie as, a thin and structurally unitary envelope around the wrapping. If, as is desirable, a saturant for the wrapping is used, it tends to adhere the envelope to the wrapping. Not being a saturant for the serving, but primarily being an overlying and enclosing envelope of tough and elastic character, the envelope may shift locally with longitudinal shifting of the wrapped covering and may accommodate itself to a tendency for the adjacent yarns, or turns of yarn, of the wrapped covering to separate in flexion of the conductor. In such accommodation it maintains a coherent covering for the current-carrying core of the conductor. In the assembly the yielding fibrous covering, for its part, gives a backing for the thin binder envelope which tends to protect the envelope against puncture, tearing, or cracking.

The conductor assembly shown in Figs. I and II may be considered to be a complete conductor. Merely as comprising the elements there shown, it may be used for various purposes, and may even be used as "building" wire. For that purpose it is desirable that a "slick" finish, of wax or other lubricant, be applied to the binder envelope of the assembly.

Referring now to Figs. III, IV and V of the drawing, the envelope 4 is shown as overlaid by a coating 5 of paint or varnish, which tends to give a hard finish to the conductor and which serves to carry printed data concerning the conductor. Over this hard finish there is desirably, as shown in these figures of the drawing, a "slick" finish 6 of wax or other suitable material, having lubricating properties. It will be seen in Fig. V of the drawing how the thin envelope 4, by virtue of its coherence and elasticity, can accommodate itself to shifting movement of the wrapping. In all figures of the drawing, the film, or envelope, 4 is shown of greatly exaggerated thickness; but it is to be understood that if it be made of preferred minimum thickness, it forms with the wrapping an element having a thickness substantially less than that of a braided covering, thus giving a conductor having a smaller overall diameter than that of a conductor which includes a braided covering.

I am aware that plastic composition as herein defined has been used in thick layers in, or as, the insulation of an electrical conductor. I am not aware that plastic composition has prior to my invention been used in assembly with a helical yarn wrapping in a thin binder envelope confining, and yieldingly backed by, the wrapping.

It is to be understood that the word "yarn," as herein used, is a term of description, and not of limitation, and although it is desirable the material of the wrapping be fibrous, and that it be absorbent to receive a saturant, neither of such qualities is to be considered compulsive in the assembly. For example, the wrapping may be, or include, one or more of the silk-like synthetics, twisted paper, or other coherent and yielding cord, or cord-like wrapping material. The word "yarn" is herein used in distinction from matted, or incoherent, fibrous bodies, such as cotton sliver or the like, and in distinction from materials of relatively unyielding sort, such as metallic wires and the like.

Since the gist of my invention resides in the provision of a binder envelope characterized by the above-noted qualities, organized to envelope and integrate a helical wrapping around a conductor core, I do not purpose to limit my invention to the use of any particular substance, or class of substance, for the binder envelope, the above disclosure as to substances suitable for the envelope being exemplary. Also in the general conductor assembly the rubber sheath shown as a part of the conductor core may be replaced by a sheath of another suitable substance, or the current-carrying core may consist merely of the current-carrying element itself.

I claim as my invention:

1. In an electrical conductor including an inner conductive core, in combination an insulating body surrounding the core, a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core, and a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer synthetic resin plasticized to rubber-like consistency closely surrounding the said protective jacket, the said film binding the jacket against disruption and being of a thickness not substantially exceeding .009 inch and being impervious to air and moisture, and the said film permitting movement of the turns of the protective jacket relative to each other when the conductor is bent.

2. In an electrical conductor including an inner insulated conductive core and a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core; a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer synthetic resin plasticized to rubber-like consistency, the said film having a thickness of substantially .003 to .009 inch, the said film being wholly and immediately outside the surface of the said protective jacket and of the yarn composing the said film forming a structurally unitary binder envelope directly covering and binding the turns of the jacket against disruption but, by its elasticity, permitting movement of the turns relative to each other when the conductor is bent.

3. In an electrical conductor including an inner conductive core, in combination an insulating body surrounding the core, a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core, and a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer polyvinyl resin plasticized to rubber-like consistency closely surrounding the said protective jacket, the said film binding the jacket against disruption and being of a thickness not substantially exceeding .009 inch and being impervious to air and moisture, and the said film permitting movement of the turns of the protective jacket relative to each other when the conductor is bent.

4. In an electrical conductor including an inner insulated conductive core and a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core; a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer polyvinyl resin plasticized to rubber-like consistency, the said film having a thickness of substantially .003 to .009 inch, the said film being wholly and immediately outside the surface of the said protective jacket and of the yarn composing the said film forming a structurally unitary binder envelope directly covering and binding the turns of the jacket against disruption but, by its elasticity, permitting movement of the turns relative to each other when the conductor is bent.

5. In an electrical conductor including an inner conductive core, in combination an insulating body surrounding the core, a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core, and a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer synthetic resin plasticized to rubber-like consistency and isobutylene polymers closely surrounding the said protective jacket, the said film binding the jacket against disruption and being of a thickness not substantially exceeding .009 inch and being impervious to air and moisture, and the said film permitting movement of the turns of the protective jacket relative to each other when the conductor is bent.

6. In an electrical conductor including an inner insulated conductive core and a protective jacket composed of a single layer of strands of yarn wound helically around the conductor core with its turns closely spaced without overlap and movable relative to each other and to the core; a unitary, self-contained and non-saturant single elastic film composed essentially of high-polymer synthetic resin plasticized to rubber-like consistency and isobutylene polymers, the said film having a thickness of substantially .003 to .009 inch, the said film being wholly and immediately outside the surface of the said protective jacket and of the yarn composing the said film forming a structurally unitary binder envelope directly covering and binding the turns of the jacket against disruption but, by its elasticity, permitting movement of the turns relative to each other when the conductor is bent.