July 14, 1942. S. J. ROSCH 2,289,732

ELECTRICAL CONDUCTOR

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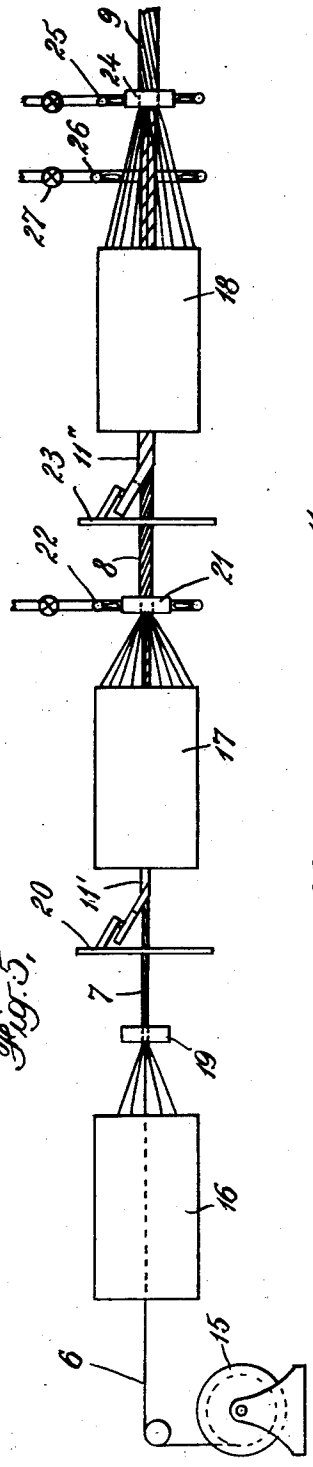


Fig. 5.

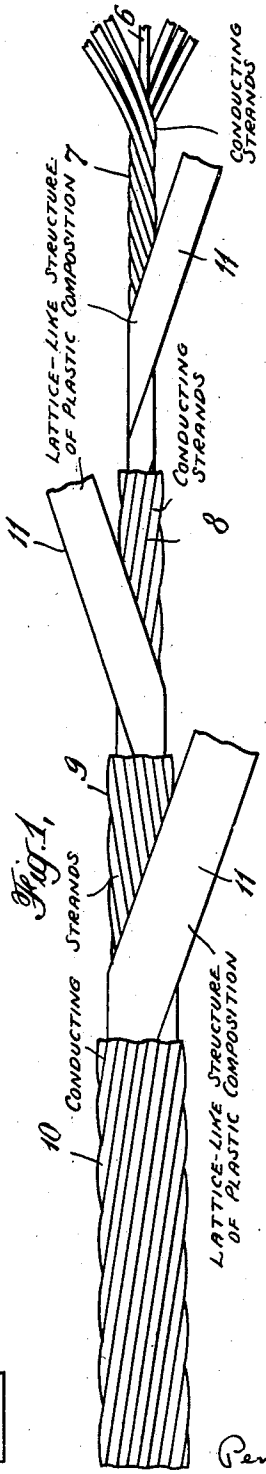


Fig. 1.

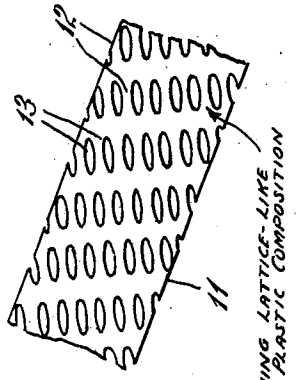


Fig. 4.

DETAIL SHOWING LATTICE-LINE STRUCTURE OF PLASTIC COMPOSITION

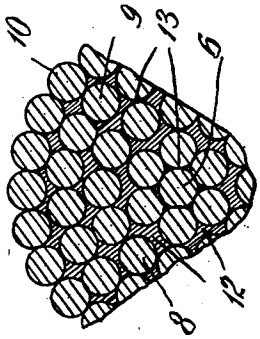


Fig. 3.

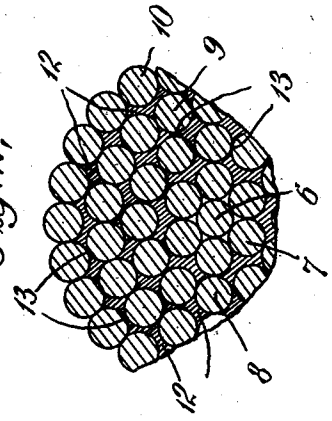


Fig. 2.

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ELECTRICAL CONDUCTOR

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8 Claims. (Cl. 174—114)

This invention relates to electrical conductors and has for its object the provision of an improved electrical conductor of the stranded wire type and method of making the same.

Electrical conductors of the stranded wire type must frequently be so constructed as to inhibit the conduction of water, acids, alkalies and oils through the interstices between the individual metallic conductors or wires thereof, whether the conductor is operating at atmospheric or higher pressures. This is particularly true of cables or conductors destined to operate in oil refineries, at the bottom of oil wells, at certain locations in submarine boats and in other similar installations. Conductors or cables for such uses have heretofore been commonly made by extruding a layer of unvulcanized rubber compound over the central strand and extruding similar layers of unvulcanized rubber compound over each of the surrounding layers of stranded wires. The outermost layer of stranded wires was covered with the requisite thickness of whatever type of insulation was deemed necessary, and it was expected that the stranded conductor, and especially the core or inner strands, would be pressure-tight against air or such liquids as would not affect the unvulcanized rubber compound used for filling the strand interstices. In most cases, the main outer insulation of the stranded conductor or cable was a rubber compound requiring vulcanization. During the vulcanization of this main insulation, the rubber compound used for filling the strand interstices also became vulcanized to a greater or less extent, and in some cases became bonded to the main vulcanized insulation. Stranded conductors of this construction possess certain disadvantages, among which may be enumerated the following:

1. The diameter of the stranded conductor is materially increased due to the presence of a layer of rubber of substantial thickness between the stranding layers. This increase in diameter is substantial since it is impractical to extrude a layer of unvulcanized rubber compound over a small diameter in less than 1/64 inch thickness, and over larger diameters in less than .025 inch thickness, which produces an increase in diameter of .030 inch and .050 inch, respectively, for each such application. Some of this increase in diameter might be eliminated by sinking or pressing the strands into the rubber layer, but in actual practice only a relatively slight decrease in diameter can be accomplished in this way.

2. Since it is impractical and uneconomical to place and operate a rubber extruding machine between each section of the stranding apparatus so as to apply the extruded layers of rubber simultaneously with the stranding operation, it is necessary to strand each layer of wires separately and to apply the layer of extruded rubber over each strand in a separate operation. Naturally, this tends to considerably increase the cost of producing a stranded conductor of this type. For example, a 61 wire stranded conductor contains four stranding layers which are commonly built up in one operation on a stranding apparatus of four sections. Where it is desired to extrude a layer of rubber over each stranding layer, it is necessary to first take the central strand and insulate it with a layer of rubber, then to apply six wires over the core thus formed, after which the 7 wire strand is taken to the extrusion machine in order to cover the 7 wire strand with a layer of rubber. The 7 wire core is then brought back to the stranding machine in order to wind the next layer of twelve additional wires thereon. Then the 19 wire core is taken over to the extrusion machine and covered with a layer of rubber, and so on until the last layer of 24 wires is applied.

3. The rubber compound used for filling the interstices of the metallic conductors supports combustion during any arc that is established in consequence of a cable failure or short circuit, such rubber compounds being good supporters of combustion. The rubber compound is also deleteriously affected by contact with oil, and contact with other chemicals, particularly acetic acid, exercises a bad solvent effect on the rubber compound.

With the foregoing considerations in mind, I have developed a new and improved conductor which will carry out all of the functional duties of a conductor of the foregoing type and yet do so without the disadvantages hereinbefore recited. The conductor of the invention comprises an inner metallic conductor strand, which may be a single conductor or a group of stranded conductors, surrounded by an outer layer of stranded conductors and having a lattice-like structure of tough plastic insulation between the inner and outer strands with the solid portions of the lattice-like structure filling interstitial spaces between conductors and the openings of the lattice-like structure permitting direct contact between radially adjacent conductors. Ordinarily, the conductor will have a plurality of concentric layers of spirally-stranded metallic conductors with adjacent layers having opposite directional spirality and the characteristic lattice-like structure of the invention will be arranged between the adjacent layers of the stranded conductors.

The plastic insulation is preferably a synthetic resin base with such incorporated agents, where necessary, as will impart to the lattice-like structure suitable flame-, acid-, alkali-, oil-, and moisture-proofness as the finished conductor may require in use. Moreover, the plastic insulation preferably possesses such thermoplasticity that when a layer thereof is interposed

between two stranded layers of metallic conductors and the resulting assembly is subjected to heat and compression, in accordance with the method of the invention, radially adjacent conductors are forced through the heat-softened insulation into contact with one another and the insulation is forced into interstitial spaces between conductors, thereby giving the insulation its characteristic lattice-like structure.

The novel features of the invention will be better understood from the following description taken in conjunction with the accompanying drawing, in which:

Fig. 1 illustrates a stranded electrical conductor or cable embodying the invention,

Figs. 2 and 3 are cross-sections of stranded conductors embodying the invention,

Fig. 4 is a detail view of a piece of the plastic insulation, illustrating its characteristic lattice-like structure, and

Fig. 5 diagrammatically illustrates an apparatus for making the conductor of the invention in accordance with the method of the invention.

The conductor of the invention, illustrated in Fig. 1, comprises a single central strand 6 surrounded by the next outer layer 7 of spirally-stranded metallic conductors. In this embodiment of the invention the central strand 6 is not covered with insulation. The stranded layer of conductors 7 is surrounded by concentric layers 8, 9 and 10 of spirally stranded metallic conductors, with the conductors of adjacent layers (i. e. 7 and 8; 8 and 9; 9 and 10, respectively) having opposite directional spirality. The metallic conductors may be tinned copper wires of any appropriate diameter.

A lattice-like structure 11 of tough plastic insulation is interposed between the adjacent layers or strands 7 and 8, 8 and 9, and 9 and 10, respectively. Preferably, the plastic insulation is non-adhering and may be readily stripped from the metallic conductors. When so stripped, the insulation will exhibit its characteristic lattice-like structure as illustrated in Fig. 4. When in position in the conductor of the invention, the solid portions 12 of the insulation will fill interstitial spaces between conductors while the openings 13 of the insulation permit close contact between radially adjacent metallic conductors, as illustrated in Figs. 2 and 3. Fig. 2 is a cross-section of the conductor illustrated in Fig. 1, while Fig. 3 is a cross-section of a similar conductor in which the lattice-like structure of plastic insulation is interposed between the central single strand 6 and the next outer strand 7.

Referring now to the apparatus illustrated in Fig. 5, the central strand 6, paid off from a supply reel 15, is led through the first section 16 of the stranding apparatus, which may be of the present standard construction. The section 16 cooperating with the closing die 19 applies a spirally wound layer of metallic conductors around the central strand 6, thus producing the strand 7.

The strand 7 is led through a taping head or device 20 which applies to or winds on the strand 7 one or more layers 11' of thermo-plastic insulation in the form of a tape. The width of the tape will vary depending upon the diameter of the strand over which it is wound. The thickness of the tape will also vary, depending upon the volume of the interstices to be filled and the amount of filling material required. Since there may be a price differential making certain combinations of width and thickness of the tape prohibitive in cost, I can overcome any such disadvantage by varying the number of taping heads 20, or I can vary the volume of filling material per unit length of conductor by applying the tape with the lap varying from an open butt to a 50% or greater over-lap.

The strand 7, now covered with one or more layers of the spirally wound tape of plastic insulation 11', is led through the second section 17 of the stranding machine, where another strand or layer 8 of metallic conductors is wound over the layer of plastic insulation 11'. Although the strand 8 is calculated to fit snugly about the inner core, this snug fit can only be accomplished by compressing the strand 8 until the conductors thereof sink through the underlying layer of firm, tough plastic insulation until radially adjacent conductors are in contact with one another. To this end, I provide, at the point of strand convergence, a closing die 21 whose internal diameter is equal to a value corresponding to the theoretical diameter that should prevail had the intervening layer of plastic insulation 11' not been applied. The stranded core will be unable to pass through the die 21 when the plastic insulation 11' is a synthetic resinous material, since such materials are extremely tough and have a flow point of approximately 350° F. or even higher. Accordingly, a series of burners 22 of the Bunsen or similar type, capable of directing a gas flame at suitable high pressure at an object to be heated, are mounted with their flames directed on a metallic structure containing the closing die 21. In this manner sufficient heat is applied to soften the plastic insulation 11' and to permit the conductors of the strand 8 to sink in and cut through the plastic material, thereby enabling these conductors to make physical contact with the underlying conductors. The burners 22 supply heat at such a rate that the layer of insulation 11' achieves its softening temperature at the production speeds customary with stranding operations so as not to retard production.

The resulting stranded conductor next passes through another taping head or device 23, similar to the device 20, and one or more layers 11'' of plastic insulation in the form of tape are applied around the layer or strand 8. Another strand or layer of metallic conductors 9 is then spirally wound around the insulation 11'' by the third section 18 of the stranding apparatus. A closing die 24, heated by burners 25, compresses the strand 9 around the softened insulation 11'' to bring radially adjacent metallic conductors substantially into contact and to force the softened insulation into interstitial spaces between conductors.

As the number of metallic conductors, or their size, comprising a given strand or layer becomes larger, it may not be possible to provide sufficient heat through the burners 22 or 25 to effect the necessary softening of the underlying plastic insulation. The metallic conductors are at room temperature, or possibly even lower, when applied on the stranding apparatus, and consequently they serve to dissipate heat from the metallic housings of the closing dies 21 and 24. It may, therefore, be necessary to preheat the metallic conductors at the speed of stranding and without in any way interfering with either the rate of production or the general machine set-up. To this end, a ring burner 26 of suitable internal diameter is provided between the section 18 of the stranding apparatus and the closing die 24. The ring burner 26 may consist of

an ordinary metallic tube in the form of a circle with a suitable connection to a source of gas supply. A number of holes of appropriate diameter are drilled on the inner side of the ring thus formed so as to enable jets of gas and air to be projected toward the center thereof. The ring burner **26** is mounted in any appropriate manner in a vertical position concentric with the converging conductors of the strand **9**. The combination of gas and air flowing through the orifices of the ring burner is ignited, and the length of each jet of flame is regulated by a valve **27**. In this manner a circle of flame of any desired magnitude encompasses the individual conductors of the strand **9** and preheats them to the desired temperature.

The plastic insulation applied, heated and compressed in accordance with the method of the invention is a substantially homogeneous and perforated tube of firm, tough, flexible, plastic material. The insulation does not adhere to the metallic conductors and may be readily stripped or removed by cutting it for a given length parallel to the axis of the cable or stranded conductor. Fig. 4 of the drawing illustrates a rectangular section of the plastic insulation so removed or stripped from a cable. In this section there are a series of cross hatchings, the angles at which they occur corresponding to the angle of lay of the inner or outer strands between which the layer of plastic insulation was compressed. The openings or perforations are those portions of the insulation which were cut through by the overlying strand. The solid portions of the insulation occupied or filled the interstitial spaces between conductors.

The plastic insulation may consist of any appropriate plastic material, preferably containing such additional agents, where necessary, as will render it flame-proof, acid-proof, alkali-proof, oil-proof and moisture-proof. In practicing the invention I prefer to make the plastic insulation of a suitable resinous base with such additional materials as may be required to meet the service for which the completed conductor is intended. I have obtained satisfactory results with polyvinyl chloride and other synthetic resins of this general type. Any resinous material which will not support combustion and will perform the functions required of a conductor in resisting the effects of gaseous or liquid pressure as well as the effects of contact with certain chemicals may be used as the base of the plastic insulation.

A 61 wire cable constructed without any insulation between adjacent strands, with the individual metallic conductors consisting of .052" diameter wire, should have a theoretical diameter of .470". The actual diameter of a cable so constructed was .471". The actual diameter of a cable embodying my invention and constructed substantially in accordance with Figs. 1 and 2 of the drawing had a diameter of .475". A similar 61 wire cable with a layer of unvulcanized rubber between adjacent strands, as heretofore made, has a diameter of .620" or more.

I claim:

1. A stranded electrical conductor comprising a metallic conductor core surrounded by a layer of stranded metallic conductors, and a homogeneous lattice-like structure of tough plastic insulation between said core and said surrounding layer of conductors with the solid portions of said structure filling interstitial spaces between conductors and the openings of the lattice-like structure permitting direct contact between radially adjacent conductors.

2. A stranded electrical conductor comprising a plurality of concentric layers of spirally stranded metallic conductors with adjacent layers having opposite directional spirality, and a lattice-like structure of synthetic resin base between adjacent layers of conductors with the thick portions of the lattice-like structure filling interstitial spaces between conductors while the open portions of the structure permit direct contact between radially adjacent conductors.

3. A stranded electrical conductor comprising a core of stranded metallic conductors surrounded by a layer of stranded metallic conductors, and a layer of non-adhering plastic insulation between said core and said surrounding layer of conductors filling interstitial spaces between the conductors while permitting direct contact between radially adjacent conductors in consequence of which relationship the plastic insulation has a substantially homogeneous lattice-like structure.

4. A stranded electrical conductor comprising a metallic conductor strand surrounded by a layer of spirally stranded metallic conductors, and a substantially homogeneous and perforated tube of tough plastic insulation between said strand and the surrounding layers of metallic conductors with radially adjacent conductors contacting through the perforations of the tube while the solid portions of the tube occupy interstitial spaces between conductors.

5. A stranded electrical conductor comprising a plurality of concentric layers of spirally wound stranded metallic conductors with the conductors of adjacent layers having opposite directional spirality, and a lattice-like structure of tough plastic insulation between adjacent layers of conductors with radially adjacent conductors contacting through the openings of said structure while the solid portions of the structure occupy interstitial spaces between conductors.

6. A stranded electrical conductor comprising a metallic conductor core surrounded by a layer of stranded metallic conductors, and a substantially homogeneous and uniformly perforated tube of tough plastic insulation between said core and said surrounding layer of conductors with radially adjacent conductors contacting through the perforations of the tube and the solid portions of the tube occupying interstitial spaces between conductors.

7. A stranded electrical conductor comprising a metallic conductor core surrounded by a layer of stranded metallic conductors, and a tough, flexible and lattice-like structure of synthetic resin base between said core and said surrounding layer of conductors with radially adjacent conductors contacting through the openings of the lattice-like structure and the solid portions of the lattice-like structure occupying interstitial spaces between conductors.

8. A stranded electrical conductors comprising a plurality of concentric layers of spirally wound stranded metallic conductors with the conductors of adjacent layers having opposite directional spirality, and a substantially homogeneous, tough, flexible and uniformly perforated tube of synthetic resin base between adjacent layers of conductors with radially adjacent conductors contacting through the perforations of the tube and the solid portions of the tube occupying interstitial spaces between conductors.

SAMUEL JOSEPH ROSCH.