

SPECIFICATION

An insulated electric wire and method of manufacturing the same

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This invention relates to an insulated electric wire and a method of manufacturing the same.

10 In a conductor rolling process or a conductor drawing process, a metal powder composed of the material of the conductor is produced and adheres to the surface of the conductor. Furthermore, foreign materials such as lubricants, grease, scales and modified layers formed during high temperature treatment, oxides formed during the storage, and dust in the surrounding atmosphere tend to adhere to the surface of the conductor.

15 It has been believed that since a conductor for an insulated electric wire is coated with an insulating paint and baked several times, it is not always necessary to remove such foreign materials from the surface of the conductor.

20 On the other hand, it has been considered that the foreign materials on a conductor may lower the characteristics of the insulated electric wire made thereof. Accordingly, a variety of methods of cleaning conductors have been investigated and proposed in the art.

25 In one of the conventional methods, a conductor is wiped with felt or cloth to remove the foreign materials therefrom. However, in this conventional method, the felt or cloth becomes dirty and its foreign material removing effect is lost in several minutes. Accordingly, the foreign materials on the conductor cannot be continuously removed without changing the felt or cloth every several minutes. This is obviously not practical, and the felt or cloth is generally changed for instance, once in several hours in practice, with the result that even if the conductor is wiped with the felt or cloth, the foreign materials cannot be effectively removed from the surface of the conductor.

30 The foreign materials may be removed from the surface of the conductor by allowing the conductor to pass through an organic solvent. In this method, the cleaning effect is significant until the organic solvent deteriorates. However, the cleaning effect is soon lost. In the case of a long wire such as an insulated electric wire, the extent of removal of the foreign materials is liable to become non-uniform.

35 The organic solvent is also in general, inflammable. In view of safety and sanitation, it is necessary to provide a local gas discharging device or an entire gas ventilating device.

40 An ultrasonic cleaning method utilizing vibrational energy is effective in removing foreign materials from the surface of a conductor. However, foreign materials strongly adhering to the conductor, or oil, fat, or grease cannot be completely removed from the con-

ductor using this technique.

Accordingly, the ultrasonic cleaning method and the method using an organic solvent are often used in combination. However, this combined method is still disadvantageous in that, since a local gas discharging device must be provided, the equipment necessarily becomes large in scale.

70 Recently, electric and electronic equipment has been extensively miniaturized and improved in performance, and accordingly, a strong demand exists to improve the qualities of components thereof. This demand is also applicable to a long wire such as an insulated electric wire. Thus the provision of an insulated electric wire whose insulating film and conductor are free of defects, i.e. excellent in quality over its entire length, is in great demand.

75 For example, the appearance of a thin insulated electric wire (0.10 to 0.008 mm in diameter) which is to be used as a coil in a time piece, acoustic device or electrical instrument and which is thinly coated with an insulating paint and baked is subjected to strict inspection procedures, the coiling of such wire being carried out under an optical microscope.

80 Furthermore, in order to ensure economic usage of materials, solventless or highly concentrated insulating paint is extensively used. In this case, the number of coating and baking operations is reduced. However, the coated film is liable to be wavy or uneven. As a result, the manufactured insulated electric wire is low in quality. Accordingly, a general requirement exists to eliminate these difficulties.

85 In addition, in order to improve the performance of electric motors there has been a tendency to increase the number of turns of the motor windings in a limited space. Accordingly, this constitutes a further requirement for providing insulated electric wire whose insulating film is thin and free of defects.

90 The invention resides in one aspect in a method of manufacturing an insulated electric wire comprising the steps of subjecting a conductor having a diameter of less than 0.1 mm to electrolytic cleaning by allowing electric current to flow at a current density of 0.1 mA/mm² to 50 mA/mm², between said conductor and an electrode in an aqueous electrically conductive liquid while said conductor is passed through said liquid, coating said conductor with a thin layer of electrically insulating material and baking said coated conductor, the material of said thin layer being applied to the conductor in a highly concentrated, or solventless form, and said layer not exceeding 0.020 mm in thickness.

95 In a further aspect, the invention resides in an insulated electric wire comprising a conductor subjected to electrolytic cleaning by

allowing current in the range of 0.1 mA/mm² to 50 mA/mm² to flow between said conductor and an electrode in an aqueous electrically conductive liquid, the diameter of said conductor being less than 0.1 mm, and said conductor having thereon a thin coating of electrically insulating material, said material being applied as highly concentrated, or solventless insulating material.

- 10 The invention is advantageous in improving the quality of the insulated electric wire. That is, unlike the conventional method, prevention of an uneven surface on the insulating film when the coated paint is baked is accomplished.
- 15 The number of bubbles which are formed in the coated paint around any foreign materials on the surface of the conductor is also minimised. Moreover, since the metal powder is removed from the surface of the conductor, no metal powder is entrained in the insulating film. As a result, the electrical characteristics of the insulating film are markedly improved. This is due to the fact that because the metal powder and the lubricant
- 25 are removed from the surface of the conductor by the method of the invention, the surface tension of the conductor is uniform. Furthermore, the invention is effective in preventing the conductor having a poor external appearance because of staining or colour change thereof.

- If a conventional method is employed in which after being cleaned with felt or cloth, or an organic solvent, or an ultrasonic wave, a conductor is coated with an insulating paint and baked, the metal powder or the lubricant is not sufficiently removed from the surface of the conductor. Accordingly the insulating film is wavy or includes bubbles. According to
- 35 existing statistical data, even if a polyester insulating paint is employed which is considered to be advantageous in manufacturing an insulated electric wire, the number of reels unsatisfactory because of the wavy insulating film and the formation of bubbles is 3% of the total number of reels. If the polyimide insulating paint "Pyre-ML" made by the Du-
- 45 pont Co. is employed, which tends to readily form bubbles, the number of unsatisfactory reels is about 10% of the total number. Accordingly, in this case, the insulated electric wire must be manufactured by significantly reducing the temperature of the baking furnace and decreasing the wire drawing rate.
- 50 Thus, the productivity is very low, about 50% of that in the case of polyester insulated electric wire.

- On the other hand, in the case when a conductor is cleaned according to the invention, the metal powder and the lubricant are completely removed from the surface of the conductor. Accordingly, the insulating film never becomes wavy or includes bubbles when polyimide insulating paint as well as the
- 65 polyester insulating paint is employed. Thus,

the effects of the invention are significant so that not only the quality but also the productivity is considerably improved.

- The case of a thin conductor i.e. having a diameter of 0.10 mm or less, will now be considered in detail. An insulated electric wire 0.060 mm to 0.010 mm in diameter used in a time piece is coiled under an optical microscope at 40 magnification, and therefore its
- 70 external appearance is strictly inspected. That is, the external appearance of the manufactured insulated electric wire is inspected with the optical microscope and only insulated electric wire satisfactory in quality is utilized.
- 80 The most serious matter of concern with such thin insulated electric wire is its poor external appearance due to foreign materials adhering to the surface of the conductor and especially black points caused by the same.
- 85 The black points lower the electrical characteristics of the insulating film and therefore they are serious defects. The black points are formed when the conductor is coated with an insulating paint and baked without removing
- 90 the foreign materials therefrom. Depending on the atmosphere used the black points merge to form a larger, continuous black point.

- Accordingly, a number of methods have been proposed to remove foreign materials from the surface of the conductor, but none of them have been successful. However, it is found that if the electrolytic cleaning method is applied to such a thin conductor, then a conductor free of such black points, excellent
- 100 in external appearance, can be obtained.

- Heretofore, foreign materials have been removed from a conductor by wiping it with felt or cloth, or by the organic solvent cleaning method, or by the ultrasonic cleaning method,
- 105 before the conductor is coated with an insulating paint. Nevertheless, the amount of conductor having black points is about 30% of the total. On the other hand, when the method of this invention is employed, then
- 110 the amount of a conductor having black points can be reduced to 2% of the total.

- Another significant effect of the invention is as follows. If a conductor is subjected to electrolytic cleaning, then an insulated electric
- 115 wire which necessitated a first class structure film thickness in the prior art can provide the required electrical characteristics with a second class structure film thickness. An insulated electric wire which necessitated a zero-th
- 120 class structure film thickness can provide the required electrical characteristics with a first class structure film thickness.

- Consider now the case where a conductor 1.0 mm in diameter is coated with a 40% polyester insulating paint and baked to manufacture a polyester insulated electric wire. If, in this case, the conductor is not subjected to electrolytic cleaning, then the average dielectric breakdown voltage is 7.5 KV in saturated
- 130 salt glycerol with a zero-th class structure film

thickness (0.050 mm). If the conductor is subjected to electrolytic cleaning, then the dielectric breakdown voltage is substantially equal to 7.5 KV with a first class structure film thickness (0.040 mm).

- 5 As is clear from the above description, by subjecting a conductor to electrolytic cleaning, foreign materials are removed from the surface of the conductor, the number of defects in the insulating film is reduced, the number of unsatisfactory insulated wires is decreased, and the quality level is improved. Furthermore, if a conductor is subjected to the electrolytic cleaning before it is coated with a solventless insulating paint or a high concentration insulating paint, the conductor has the same smooth external appearance and electrical characteristics as a conductor coated with an ordinary solvent type insulating paint.
- 10 Heretofore, a desired film thickness was obtained by applying the required number of coatings of a solventless insulating paint or a high concentration insulating paint. However, the insulating film often became wavy and exhibited a poor external appearance. It was believed that this difficulty was due to the use of these paints. Furthermore, with respect to the electrical characteristics of the film, such as for instance its dielectric breakdown voltage, the use of these insulating paints was not always satisfactory. Thus, the dielectric breakdown voltage was about 50 to 80% of that of an insulating film formed by using a solvent type insulating paint. It was believed that this was also due to the use of the aforementioned insulating paints.

- On the other hand, in the invention, a conductor is cleaned to completely remove metal powder or lubricant therefrom. Therefore, even if a solventless insulating paint or high concentration insulating paint is employed, the insulating film never becomes wavy and forms no defects such as craters. The dielectric breakdown voltage is equal to or higher than that of an insulating film formed by a solvent type insulating paint.

- It has been confirmed that the insulating characteristics of an insulated electric wire rectangular in section are markedly improved by following the method of the invention. The insulating paint at the corners of this type of wire flows at the high temperature in the baking furnace, and hence the thickness of the insulating film at the corners is liable to become considerably less than that of the insulating film on the flat surfaces of the wire. Typically, the thickness of the insulating film at the corners may be of the order of only 60% of that on the flat surfaces when conventional cleaning methods are employed. When, however, the electrolytic cleaning method according to the invention is applied to a rectangular section conductor, any lubricant is removed from the surface of the conductor. Accordingly, the flow of insulating

paint from the corners of the conductor is suppressed, and therefore the insulating film thickness at the corners is not so greatly reduced. That is, the film thickness of the corners is typically 80 to 95% of that on the flat surfaces, with the result that the insulating characteristics of the film are greatly improved.

- On the other hand, the portions of the insulating film on the flat surfaces of an insulated electric wire or rectangular section are liable to become uneven; that is, the film exhibits a poor external appearance. This uneven insulating film is attributed to foreign materials adhering to the conductor rather than dust in the baking furnace. Since the foreign materials are removed from the conductor according to the invention, the insulated film is substantially uniform.
- 85 In the electrolytic cleaning method of the invention, the electrolyte is constituted by water to which a small amount of an alkali salt, for example a carbonate or phosphate; or an acid, such as hydrochloric acid, sulfuric acid, nitric acid or oxalic acid has been added to ionize the water. Thus, during electrolysis of the resultant solution, gas is generated which then serves to physically remove foreign materials from a conductor passing there through. When the conductor is used as the cathode in the electrolytic process, hydrogen gas is generated and cathod reduction occurs. As a result, the conductor has a glossy surface.
- 100 When, on the other hand, the conductor is used as the anode, then oxygen gas is produced, and the conductor is dissolved. That is, electrolytic abrasion occurs. Accordingly, in order to remove foreign materials strongly adhering to a conductor, the conductor is connected as the anode to dissolve the conductor, and then the conductor thus treated is connected as the cathode for cathode reduction. The surface of the conductor is completely cleaned by this method. In general, when the electrolytic cleaning is applied to a conductor connected as the cathode, then the conductor is connected into a conductor having a metallic gloss and free of foreign materials.

- In the case where an insulated electric wire is manufactured by using a conductor from the surface of which foreign materials have been removed by electrolytic cleaning the conductor may be subjected to electrolytic cleaning either before or after it is softened.

- In the case where a conductor drawing process and an insulating film coating and baking process are arranged in series, the conductor may be subjected to wire drawing after electrolytic cleaning, and thereafter coated with an insulating paint and baked. Alternatively, the conductor may be subjected to electrolytic cleaning after it has been drawn out before it is coated with an insulating paint

and baked.

In this invention, the number of times a conductor is subjected to electrolytic cleaning is not limited to a single application. That is, the conductor may be subjected to electrolytic cleaning many times at necessary positions. For instance, if the wire drawing process and the baking process are arranged in series, a conductor may be treated as follows. First, the conductor is subjected to electrolytic cleaning before wire drawing. Then, in the insulating paint coating and baking process, before being softened, the conductor is further subjected to electrolytic cleaning. Then it is coated with an insulating paint and baked.

In addition, the conventional cleaning method using an organic solvent and the conventional cleaning method utilizing an ultrasonic wave may be employed in combination.

Any electrolyte containing electrically conductive ions in water can be utilized as the electrolytic cleaning liquid. However, an aqueous solution obtained by dissolving carbonate, caustic soda, phosphate, silicate or a mixture of them, or a dilute aqueous solution obtained by diluting acids such as hydrochloric acid, sulfuric acid or nitric acid with water is preferable as the electrolytic cleaning liquid. Such an electrolytic cleaning liquid can be readily removed from the surface of the conductor and can be readily treated.

An electrolytic cleaning bath 10 cm to 100 cm in length is sufficient. However, the length of the electrolytic cleaning bath is not limited thereto or thereby. That is, it can be selected according to the conductor diameter, the wire drawing rate, and the adhesive strength of foreign material to the conductor. The value of the current employed in the electrolytic cleaning depends on the conductor diameter and the length of the electrolytic cleaning bath, the current density being in the range of 0.1 mA/mm² to 50 mA/mm². Where foreign materials strongly stick to the surface of a conductor, a high current density is necessary to remove them.

The invention includes a technique where a conductor is softened by utilizing the current which is used in the electrolytic cleaning. That is, if current is applied to a conductor to the extent that it is softened and immediately after this the conductor is subjected to the electrolytic cleaning, then the conductor softening process necessitated before the insulating paint coating process in the conventional method can be eliminated. In the conventional conductor softening process, a conductor is softened by being passed through an electric furnace or a gas furnace. In this case, the energy used to soften the conductor is about 10% of the total energy and the remaining energy is used to maintain the temperature of the furnace itself or to radiate heat from the furnace. Most of the conductor softening fur-

naces are provided with pipes. A conductor is softened by being passed through the pipe of the furnace. However, the conductor softening furnace is disadvantageous in that a conductor may be broken in the pipe, which reduces the efficiency in manufacturing insulated electric wires. Especially, in the case of a thin conductor smaller than 0.1 mm in diameter, frequent breakage in the pipe is common.

Furthermore, a conductor may come into in contact with the inner wall of the pipe. As a result, foreign materials are shifted from the inner wall to the surface of the conductor and accumulated on the insulating paint coating felt. As a result, the conductor may be broken.

In the method of the invention, the provision of the conductor softening furnace is completely unnecessary, which contributes to the economical use of energy and the improvement of the manufacturing efficiency.

When a conductor is softened by current, the color of the conductor may be changed. If the color change is slight, it can be completely eliminated during the electrolytic cleaning process. However, if it is serious, then it may be difficult to remove it during the electrolytic cleaning process. However, this difficulty can be overcome by allowing the conductor to pass through an inert gas for preventing the oxidation of the conductor, a gas such as steam, or a reducing gas atmosphere.

This invention will now be described with reference to the accompanying drawings, in which;

Figure 1 is a diagrammatic illustration of a method of manufacturing an insulated electric wire according to one example of the invention, and

Figure 2 is a diagrammatic illustration of a method according to a further example of the invention.

Referring to Fig. 1, in the method of said one example, a conductor 2 fed from a supply reel 1 is introduced into an electrolytic bath 3 containing an electrolytic cleaning liquid, where it is subjected to electrolytic cleaning. Then, the conductor 2 is washed with water in a water bath 7, and is then introduced into a heat treatment furnace 8, where it is softened. Thereafter, the conductor is coated with insulating paint by an insulating paint coating device 9, and is then baked by a baking furnace 10. Finally, the conductor is wound onto a winding reel 15. In the case where the insulating paint coating and baking processes are repeatedly carried out, guides 11, 12, 13, and 14 are used.

In the electrolytic bath 3 containing the electrolytic cleaning liquid, the conductor serves as the counter electrode of an electrode 5 placed in the bath 3, and it is connected to a current supplying terminal 6. In Fig. 1, reference numeral 4 designates a DC power supply source.

Fig. 2 illustrates a method of manufacturing an insulated electric wire which utilizes a series of wire drawing and baking processes, in which an electrolytic cleaning device is provided on the supply reel side of a wire drawing bench. A conductor 17 fed from a supply reel 18 is passed through an electrolytic bath 18 containing an electrolytic cleaning liquid. After this electrolytic cleaning process, the conductor 17 is introduced into a water bath 22, and is then delivered to a wire drawing bench 23. At the wire drawing bench 23 the diameter of the conductor is reduced by a wire drawing die 26, while capstans 24 and 25 are rotated and the conductor thus treated is advanced to the subsequent baking line.

In the electrolytic cleaning bath 18, an electrode 20 is provided and it is connected to a DC power supply source 19. The conductor to be treated serves as the counter electrode of an electrode 20 in the cleaning bath 18, and is connected to a DC power supply source 19.

Any metal or alloy can be used as the electrode in the electrolytic cleaning bath. However, when the electrode serves as the anode, then it may dissolve in the electrolytic cleaning liquid. Therefore, the electrode is made of a metal or alloy which is not dissolved in the cleaning liquid. It is desirable that the electrode is, for instance, a stainless steel plate. However, it is not always necessary to limit the material forming the electrode to a metal or alloy which is not dissolved in the electrolytic cleaning liquid. That is, the effect of the invention can be sufficiently obtained even with metal which is liable to dissolve to some extent in the liquid.

The invention will be further described with reference to the following examples and Comparison Examples:-

Comparison Example (1)

After being softened, a bare copper wire 0.025 mm in diameter was coated with a polyurethane insulating paint and was then baked by being passed through a baking furnace (1.5 m in length, and at a temperature of 360°C). The wire was coated with the paint and baked eight times to an insulating film thickness of about 3 μ .

The wire was wound on a 30 g winding reel at a wire winding rate of 250 m/min. The wires wound on eighty-five (85) reels were observed with a microscope of 40 magnifications ($\times 40$). As a result, black points were observed on the wires of thirty reels, and color changes were observed on the wires of fifteen reels. The wires of the remaining reels were found satisfactory in external appearance.

Comparison Example (2)

All the data are equal to those in Compari-

son Example (1) except for the following:

Before subjected to softening, the wire was passed through a cleaning bath containing "Triclene"; that is, the wire was subjected to organic solvent cleaning.

The wires wound on eight-five reels were observed. As a result, black points were observed on the wires of twenty reels, and color changes were found on wires of eighteen reels. The wires of the remaining reels were found satisfactory in external appearance.

Example (1)

All the data are equal to those in Comparison Examples (1) and (2) except for the following:

A conductor was cleaned by being passed through an electrolytic cleaning bath (30 cm in length) containing a 0.5% sodium carbonate solution. In this operation, the conductor was used as the cathode, a stainless plate in the electrolytic cleaning bath was used as the anode, and a voltage was applied between the electrodes so that the current density at the surface of the conductor was 8.5 mA/mm². The conductors wound on eighty-five reels were observed. No black points were found on the conductors of all eight-five reels. Slight color change was found on the conductors of only two reels. The conductors of the remaining reels were found satisfactory in external appearance. In this example, the conductor was softened by current before subjected to electrolytic cleaning. Therefore, it was unnecessary to use the wire softening furnace before it was coated with the insulating paint and baked.

CLAIMS

1. A method of manufacturing insulated electric wires comprising the steps of, subjecting a conductor having a diameter of less than 0.1mm to electrolytic cleaning by allowing electric current to flow at a current density of 0.1mA/mm² to 50mA/mm², between said conductor and an electrode in an aqueous electrically conductive liquid while said conductor is passed through said liquid, coating said conductor with a thin layer of electrically insulating material and baking said coated conductor, the material of said thin layer being applied to the conductor in a highly concentrated, or solventless form, and said layer not exceeding 0.020mm in thickness.
2. A method as claimed in claim 1, comprising the further step, after electrolytic cleaning, of subjecting the conductor to wire drawing, said conductor subsequently being coated with the insulating material and baked.
3. A method as claimed in claim 1 or claim 2, wherein said electrolytic cleaning is carried out with said conductor connected at the cathode.
4. A method as claimed in any preceding claim, wherein after being subjected to said



Fig. 2 illustrates a method of manufacturing an insulated electric wire which utilizes a series of wire drawing and baking processes, in which an electrolytic cleaning device is provided on the supply reel side of a wire drawing bench. A conductor 17 fed from a supply reel 18 is passed through an electrolytic bath 18 containing an electrolytic cleaning liquid. After this electrolytic cleaning process, the conductor 17 is introduced into a water bath 22, and is then delivered to a wire drawing bench 23. At the wire drawing bench 23 the diameter of the conductor is reduced by a wire drawing die 26, while capstans 24 and 25 are rotated and the conductor thus treated is advanced to the subsequent baking line.

In the electrolytic cleaning bath 18, an electrode 20 is provided and it is connected to a DC power supply source 19. The conductor to be treated serves as the counter electrode of an electrode 20 in the cleaning bath 18, and is connected to a DC power supply source 19.

Any metal or alloy can be used as the electrode in the electrolytic cleaning bath. However, when the electrode serves as the anode, then it may dissolve in the electrolytic cleaning liquid. Therefore, the electrode is made of a metal or alloy which is not dissolved in the cleaning liquid. It is desirable that the electrode is, for instance, a stainless steel plate. However, it is not always necessary to limit the material forming the electrode to a metal or alloy which is not dissolved in the electrolytic cleaning liquid. That is, the effect of the invention can be sufficiently obtained even with metal which is liable to dissolve to some extent in the liquid.

The invention will be further described with reference to the following examples and Comparison Examples:-

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The wire was wound on a 30 g winding reel at a wire winding rate of 250 m/min. The wires wound on eighty-five (85) reels were observed with a microscope of 40 magnifications ($\times 40$). As a result, black points were observed on the wires of thirty reels, and color changes were observed on the wires of fifteen reels. The wires of the remaining reels were found satisfactory in external appearance.

Comparison Example (2)

All the data are equal to those in Compari-

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Before subjected to softening, the wire was passed through a cleaning bath containing "Triclene"; that is, the wire was subjected to organic solvent cleaning.

The wires wound on eight-five reels were observed. As a result, black points were observed on the wires of twenty reels, and color changes were found on wires of eighteen reels. The wires of the remaining reels were found satisfactory in external appearance.

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CLAIMS

1. A method of manufacturing insulated electric wires comprising the steps of, subjecting a conductor having a diameter of less than 0.1 mm to electrolytic cleaning by allowing electric current to flow at a current density of 0.1 mA/mm² to 50 mA/mm², between said conductor and an electrode in an aqueous electrically conductive liquid while said conductor is passed through said liquid, coating said conductor with a thin layer of electrically insulating material and baking said coated conductor, the material of said thin layer being applied to the conductor in a highly concentrated, or solventless form, and said layer not exceeding 0.020 mm in thickness.
2. A method as claimed in claim 1, comprising the further step, after electrolytic cleaning, of subjecting the conductor to wire drawing, said conductor subsequently being coated with the insulating material and baked.
3. A method as claimed in claim 1 or claim 2, wherein said electrolytic cleaning is carried out with said conductor connected at the cathode.
4. A method as claimed in any preceding claim, wherein after being subjected to said

electrolytic cleaning said conductor is washed with water.

5. A method as claimed in any preceding claim, wherein said aqueous electrically conductive liquid used in said electrolytic cleaning is an alkali salt solution or an acidic solution.

6. A method as claimed in any preceding claim, wherein said conductor is softened by the electric current used in said electrolytic cleaning step.

7. A method as claimed in any one of the preceding claims, wherein said electrically insulating material is a polyimide paint or a polyamideimide paint.

8. An insulated electric wire comprising, a conductor subjected to electrolytic cleaning by allowing current in the range of 0.1 mA/mm^2 to 50 mA/mm^2 to flow between said conductor and an electrode in an aqueous electrically conductive liquid, the diameter of said conductor being less than 0.1 mm , and said conductor having thereon a thin coating of electrically insulating material, said material being applied as highly concentrated, or solventless insulating material.

9. An insulated electric wire as claimed in claim 8 wherein said electrically insulating coating is a polyimide or a polyamideimide.

10. An insulated electric wire substantially as hereinbefore described, with reference to the examples.

11. A method of manufacturing an insulated electric wire substantially as hereinbefore described, with reference to Fig. 1 or Fig. 2 of the accompanying drawings and the examples.

12. An insulated electric wire produced by a method as claimed in any one of claims 1 to 7 or claim 12.

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