United States Patent

Speekman

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[54] **ELECTRIC RESISTANCE HEATING CABLE**

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[51] **Int. Cl.**.....**H05b 3/34**

[58] **Field of Search**.....219/545, 548, 549, 528; 338/210; 336/222, 223

[56] **References Cited**

UNITED STATES PATENTS

3,461,275 8/1969 Poole.....219/548

FOREIGN PATENTS OR APPLICATIONS

290,451 5/1913 Germany.....219/549

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[57] **ABSTRACT**

An electric resistance heating cable having alternating sectors of different temperature during use obtained by winding a heating wire having sectors of comparatively high- and comparatively low-electric resistances on a core of an electrically insulating material and by enveloping the assembly with an electrically insulating covering.

3 Claims, 3 Drawing Figures

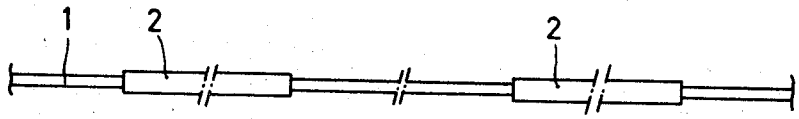

Fig. 1

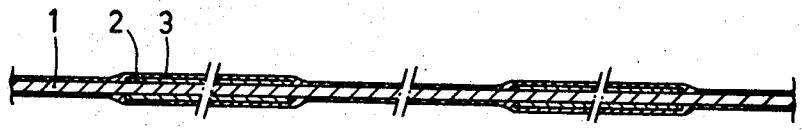

Fig. 2

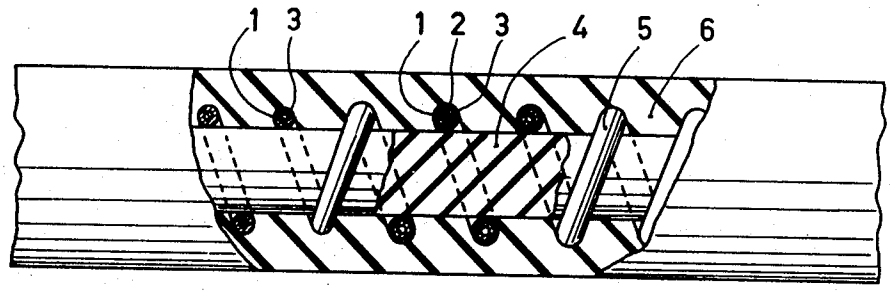

Fig. 3

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ELECTRIC RESISTANCE HEATING CABLE

The present invention relates generally to electric resistance heating cables, and more particularly to a cable having a flexible core of electrically insulating material, a heating wire wound helically around this core and extending throughout the length of the cable and a covering of electrically insulating material. The cable is divided into at least two groups of alternating sectors extending in the longitudinal direction of the cable. These sectors assume different temperatures during use of the cable.

A cable of this kind is known from German Pat. specification No. 820,943. In this cable the heating wire in the sectors which assume a comparatively low temperature during use is wound having a greater pitch than that in the sectors which assume a comparatively high temperature during use.

It has been found in practice that in such a cable the temperature differences between the sectors wound at different pitches are not particularly great during use, while the temperature of the heating wire in the various sectors is substantially the same.

A further construction of such a cable is described in U.S. Pat. No. 26,522.

In the electric resistance heating cable disclosed in this patent specification sectors whose temperature does not increase, or increases to a comparatively low value during use, are obtained by short circuiting a number of windings of the heating wire at given distances along the cable by means of better electrical conducting strip. In a cable according to this patent specification the strip is provided between the core and the windings of the heating wire.

When such a cable is kinked or is bent repeatedly there is the risk that the ends of the strips will slide out from the windings of the resistance wire and will be bent, thereby damaging the insulating outer covering and causing a short circuit between the cable and further metal parts which are in the vicinity of the cable during use. In addition, local variations in the resistance of the cable occur.

According to a proposal not previously published by the applicant a number of the mentioned drawbacks of the known constructions are obviated when using a cable in which in the sectors of the cable which assume a comparatively low temperature during use an odd number of helically wound layers of heating wire which are in electrical contact with one another and are wound alternately in the same direction as that in which the heating wire is wound in the sectors assuming a comparatively high temperature during use and are wound in the opposite direction, is located one on top of the other on the core, the number of layers provided one on top of the other exceeding the number of layers in the sectors assuming a comparatively high temperature during use by at least two. The first two layers are then preferably wound at a greater pitch than the third layer and the layers which assume a high temperature during use.

Such a cable may be obtained by passing the core continuously in one direction through a winding device and to cause this device to perform a forward and backward movement along the core at the areas where layers of heating wire are to be wound one on top of the other. According to a further method a fixing winding point is used and the core is moved forward and backward when layers of heating wire are to be wound one on top of the other. Although the last-mentioned cable construction clearly has its advantages as compared with the previously described constructions, construction of this type cable as well as the previously described cables, require the use of specially equipped winding machines which operate very accurately and in reproducible manner.

An object of the present invention is to provide an electric resistance heating cable which may be manufactured without the need of specially equipped winding machines for this purpose.

According to the invention an electric resistance heating cable satisfying this condition is characterized in that the heating wire is provided with sections having a comparatively high resistance per unit of length alternated by sections having a comparatively low resistance per unit of length.

Such a heating wire may consist of, for example, a wire having sections of the same material of alternately small and large diameter, or of sections having a different conductivity and being cross-connected together by means of welding or by soft or hard soldering.

However, a preferred form of heating wire is one having a comparatively high resistance per unit of length and which is provided at regular distances with envelopes having a comparatively low resistance per unit of length and extending in the longitudinal direction of the wire. As a result great differences in thickness between the sections having a comparatively high and sections having a comparatively low resistance per unit of length are prevented. For example, silver, copper, gold and aluminum may be used for this purpose.

These envelopes need not completely surround the wire in a cylindrical manner. A wire in which the envelope surround the wire completely cylindrically may, however, be manufactured in a simple manner by a number of different methods. this case it is possible to start, for example, from a thick wire of a material having a high specific resistance, for example, a wire of nickel which is slid into a fitting cylinder of a material having a low specific resistance such as copper. The cylinder encloses the wire throughout its length. Subsequently the diameter of the assembly is brought to the desired size by means of swaging and drawing, whereafter parts of the copper covering are etched away at regular distances. An aqueous solution of $FeCl_3$ or $CuCl_2$ may be used as an etchant. Such etchants are known.

The parts of the copper covering not to be etched away may be protected from the etchant by providing these parts with a resist as a protection against the etchant, for example, a photoresist. It is alternatively possible to contact the etchant with those parts of the wire where the copper covering must be etched away. To this end the wire is wound on a coil and the coil is partly immersed into the etchant.

Instead of a covering wire obtained by swaging and drawing a wire jointly with an envelope, it is alternatively possible to start from a resistance wire which is electrolytically provided with better conducting material throughout the length of an envelope.

According to a further method, envelopes of better conducting material are provided only on certain parts of the resistance wire. To this end the parts of the wire not to be coated with better conducting material may be provided with a resist, for example, by means of a photochemical method. Subsequently the uncovered parts of the wire are provided with an envelope of electrically conducting material. This may be effected, for example, by means of electrolysis.

The core of the cable may consist of any electrically insulating organic or inorganic material which is resistant to the temperatures occurring during use of the cable. The core may have a single or composite structure and may comprise, for example, polyvinylchloride, silicon rubber, nylon, glass fiber, asbestos fiber, polytetrafluoroethylene and polyfluoroethylene propylene.

If desired, a central conductor may be present within the core so that contact can be established at one end of the cable, the central conductor is then connected to the heating wire at the other end of the cable.

The heating wire may in principle comprise any electrically conducting material. However, a material having a high positive temperature coefficient of the specific resistance is preferably used (0.002 or more per °C.), for example, nickel, copper. In fact, as a result thereof the occurring temperature difference in a given construction is increased and in case of a prescribed temperature difference less material may suffice than when using materials having a low temperature coefficient.

When using copper on a heating wire consisting of another metal such as nickel, a slow oxidation from the ends of the copper envelope takes place during use if the parts of the heat-

ing wire not covered with copper reach a temperature of several hundred degrees centigrade. As a result, the copper envelope becomes increasingly shorter and hence the sectors of comparatively low temperature become increasingly smaller. This may be avoided by providing the heating wire with an oxidation-resistant envelope of a metal, metal alloy or an oxide. It was found in practice that a thin nickel film of several microns thick was satisfactory for this purpose. Such an envelope is not necessary if instead of copper a noble metal is used such as gold or a metal which is coated with a protective oxide film such as aluminum.

Depending on the temperature occurring during use, the outer covering of the cable may consist of organic or inorganic materials which are known for this purpose. In principle the same materials may be used as those which are suitable for the core.

The cable may be obtained by passing the core, which will generally have a circular cross section, continuously in one direction through a winding device. The core wound with resistance wire is subsequently provided with an outer covering, for example, by winding and/or pleating it with glass or asbestos fibers or rayon or cotton, or by passing it through an extrusion device by which the cable is provided with a synthetic resin covering.

The outer covering may optionally consist of a plurality of apertured bodies of ceramic material.

Since it is advantageous to be able to recognize the sectors of different temperature also when the cable is not used, for example, when mounting it in apparatus or when providing connecting pieces, it is recommended to provide marks on the outer covering. In the covered cable the sectors having a comparatively low temperature can be found back by magnetic or electric means. A marking device may be coupled to a device suitable for this purpose.

Cables according to the invention may be used in devices where heat is to be generated locally while the temperature of intermediate parts and connecting points are not to increase.

Cables according to the invention may be used, for example, in heaters for hair curlers in principle consisting of a plurality of hollow cylinders or "fingers" to be heated which project from a bottom plate onto which the hair curlers can be slid. The sectors of the cable which reach a high temperature during use are accommodated in the fingers while the parts which remain comparatively cold are provided in the bottom plate.

Cables according to the invention may alternatively be used in defrosters for refrigerators.

Furthermore, the cables according to the invention may be used in electrically heatable clothing, coffeemakers and for the purpose of heating rooms.

In order that the invention may be readily carried into effect, some embodiments thereof will now be described in detail by way of example with reference to the accompanying drawing, in which:

FIG. 1 shows in a side view a wire which is provided at regular distances with better conducting envelopes.

FIG. 2 is a cross section of a wire which is provided at regular distances with better conducting envelopes and is subsequently provided throughout its length with a layer resistant to oxidation at high temperatures.

FIG. 3 shows a cable partly in cross section and with the outer covering removed provided with a wire according to FIG. 2.

The heating wire according to FIG. 1 consists of a core 1 of nickel having a diameter of 0.18 mm. and a resistance per meter of 4 ohms. Envelopes of copper are provided at regular distances over a length of 60 cm., the total diameter of the wire at this area being 0.285 mm. The resistance per meter of the covered wire is 0.4 ohm. The uncovered parts have a length of 1 meter. A cable may be obtained with this wire whose heating sectors reach a temperature of 400° C. when loaded and these sectors are flanked by sectors which reach a temperature of only 80° C.

Under these circumstances oxidation of the envelopes of copper may occur at the ends where they also assume a comparatively high temperature due to thermal conductivity. To prevent this, a preferred embodiment is shown in FIG. 2 in cross section in which the heating wire is provided with an oxidation resistant covering 3 of nickel which extends throughout the length of the wire. This nickel covering may have a thickness of, for example, 10 μm. and does not essentially change the electrical properties of the heating wire.

FIG. 3 shows an embodiment of a cable according to the invention. The heating wire 5 is wound on a core of glass fiber 4. The assembly is enveloped by a glass fiber covering 6. The cable according to the invention has inter alia the following advantages as compared with the known constructions:

1. The cable has a simple structure and as a result fewer rejects occur during manufacture of the cable.
2. Before the heating wire is wound on the core of the cable it can be determined whether the used heating wire has any faults. When maintaining the pitch accurately during winding, there is little risk of the cable being unsatisfactory in an electrical respect after checking the heating wire.
3. The cable is less stiff than cables in which the heating wire is located in some areas in different layers one on top of the other or in which metal strips are provided in some areas along the cable between the heating wire and the core.
4. Since no oxide films can be formed between the better conducting parts and the resistance wire which oxide films may give rise to high contact resistances and local overheating, the cable can be used for a longer period than cables in which a number of turns of the heating wire are short circuited by metal strips and the like.

What is claimed is:

1. An electric redistance heating cable comprising a flexible core of electrically insulating material, a heating wire wound helically around said core and extending throughout the length of the cable and a covering of electrically insulating material, the cable being divided into at least two groups of alternating sectors extending in the longitudinal direction of the cable, which sectors assume mutually different temperatures during use of the cable, said heating wire comprising sections having a comparatively high resistance per unit of length alternated by sections having a comparatively low resistance per unit of length.

2. The electric resistance heating cable as claimed in claim 1, wherein the heating wire comprises a wire having a comparatively high resistance per unit of length which is provided at regular distances with envelopes having a comparatively low resistance per unit of length and extending in the longitudinally direction of the wire.

3. The electric resistance heating cable as claimed in claim 1, wherein the heating wire comprises a wire having a comparatively high resistance per unit of length which is provided at regular distances with envelopes having a comparatively low resistance per unit of length and extending in the longitudinal direction of the wire, and further comprising an envelope extending throughout the length of the wire comprising a material which is still resistant to oxidation at the highest temperature which is reached during operation of the cable.

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