This invention relates to electric heating wire and more particularly to flexible electric heating wire used in electrically heated fabrics such as electric blankets.

Various means have been proposed heretofore to protect electrically heated blankets from overheating when the blanket is bunched or folded upon itself while energized. One practice for preventing the overheating of an electric blanket has been to place a series of thermostats throughout the body of the blanket and connect the thermostats in series relation with the electric heating wire of the blanket. Another practice has been to employ a temperature-sensitive resistance material in close relation with the electric heating wire to control energization of the latter. Both of these arrangements function to deenergize the entire blanket heating circuit upon overheating of the blanket even though only a small portion of the blanket heating wire may have reached an abnormal temperature. Since such local overheating may readily occur in normal usage merely from a folding or rolling of the blanket upon itself, the prior arrangements did not always function to the entire satisfaction of the user. The series thermostat arrangement is also somewhat objectionable due to the additional weight and bulk of the thermostat as well as to their cost. The arrangement using a temperature-sensitive heating cable is disadvantageous in requiring the use of an expensive and sensitive relay.

It is, therefore, a principal object of this invention to provide an improved flexible heater wire for electrically heated fabrics in which the heater wire is so constructed that it automatically controls the maximum temperature reached by localized sections of the electrically heated fabric without deenergization of the electrically heated fabric.

Another object of the invention is to provide an improved flexible heater wire for an electrically heated fabric in which the heater wire is so constructed that the electrically heated fabric can be used in the normal manner without any danger of becoming overheated.

A further object of the invention is to provide an improved flexible heater wire for an electrically heated fabric in which overheat protection is afforded throughout the electrically heated fabric without using overheating thermostat relay control devices.

According to one form of this invention suitable for use in electrically heated fabrics, an electric heater wire is constructed of a flexible heating ribbon helically wound around an insulating core with successive convolutions thereof in overlapping engagement. The heating ribbon consists of a ribbon-like metal foil heater conductor and a layer of resistance material in intimate surface contact with the heater conductor. The layer of resistance material is essentially an electrical insulator at normal operating temperatures and at higher temperatures electrical conductor which will permit the flow of appreciable electric current therethrough between successive convolutions of the heater conductor. Thus, upon overheating of a localized section of the heater wire, the resulting reduction in resistance will limit the amount of heat expenditure therein automatically limiting the maximum temperature of the heater wire.

Other objects, advantages and features of the invention will be apparent from consideration of the following description taken in connection with the accompanying drawing in which:

FIGURE 1 is a view of a length of flexible heater wire illustrating a preferred form of the invention.

FIGURE 2 is an enlarged longitudinal sectional view of the heater wire shown with the insulating sheath removed.

FIGURE 3 is a schematic representation of an electric blanket control circuit using the heater wire and.

FIGURE 4 is a cross-sectional view of a modified form of heater wire.

Referring to FIGURES 1 and 2, the flexible heater wire 10 consists of a core 11 which may be formed of glass fiber strands, a temperature-sensitive heating ribbon 12 helically wound in overlapping relation over the core 11, and an insulating sheath 13 which may be a polyvinyl chloride material closely surrounding the heating ribbon 12. The heating ribbon 12 consists of an outer heater conductor 14 and an inner layer 15 of temperature-sensitive resistance material adhering to the inner surface of the conductor 14. The conductor 14 is in the form of a strip of metal foil such as copper forming the required electrical resistance necessary to expend the desired power when connected to an electric power supply. The material of the layer 15 is selected to have a relatively high resistance in comparison to the resistance of the conductor 14 at the normal operating temperatures of the conductor 14. In addition, the material of the layer 15 is selected to exhibit a large decrease in resistance when its temperature is raised to an abnormal temperature at which the heater wire would scorch an electrically heated fabric in which it is used. These electrical properties must remain stable throughout the life of the fabric in which the heater wire is used and must not be affected by severe flexing and folding of the heater wire. One resistance material which may be used for the layer 15 is silver-sulphide. The layer 15 also may be a coating upon the conductor 14 of a dispersion of temperature-sensitive semi-conductive material such as finely divided indium-antimoniode in a silicone alkyl resin.

FIGURE 3 illustrates the use of the heater wire 10 in an electric blanket control circuit. The reference numeral 20 indicates the outline of an electric blanket having the heater wire 10 distributed over it. The ends of the heater wire 10 are connected through a connector assembly 21 to a thermostat control 22 which may be of the type disclosed in United States Patent No. 2,835,767, granted on May 20, 1958, to Robert D. Graf and Leo L. Weber. The control 23 is shown diagrammatically as comprising a bimetal member 23, a heater 24 and the contacts 25. One of the contacts 25 is carried by the free end of bimetal member 23 and the other is connected to the heater 24. A plug 26 having terminals 27 and 28 is provided for connecting the control circuit to a suitable source of power such as the usual 115 volt, 60 cycle alternating current.

The thermostat control 22 functions in a well-known manner to control the normal temperature of the blanket 20 in relation to ambient room temperature. At ambient room temperatures requiring heat, contacts 25 are closed by the bimetal member 23 to supply electric current through the heater 24 to the blanket heater wire 10. After some time, heater 24 sufficiently heats the bimetal member 23 to cause the contacts 25 to open. The bimetal member 23 then cools to close the contacts 25 and will continue to alternate opening and closing contacts 25 in response to heat supplied by the heater 24 and the ambient room temperature. The adjusting screw 29 permits manual adjustment of the bimetal member 23 to obtain the desired blanket temperature.

Normally, the heater wire 10 will operate at a tem-
perature of 110° F. to 150° F. at which the resistance of the inner layer 15 is considerably greater than that of the heater conductor 14. The inner layer 15 is essentially an electrical insulator at these temperatures and substantially all the heater wire current passes lengthwise through the heater conductor 14. When a localized section of the blanket 20 becomes overheated, the substantial rise in temperature of the layer 15 in the localized section is accompanied by a substantial drop in resistance to a value of resistance on the same order as the resistance of the heater conductor 14. In the localized section of increased temperature, the inner layer 15 then shunts the coils or convolutions of the heater conductor 14 and the conductive path of the heater wire 10 becomes a closed cylinder in the overheated area. This results in a substantial decrease in resistance of the overheated section and the latter will expend heat at a much lower rate since the heater wire current remains substantially constant, being determined by the total resistance of the entire heater wire 10. Thus, an increase in blanket temperature resulting from a folding or rolling of a section of the blanket 20 is automatically compensated for by a decrease in the heating effect at that section. For most fabric materials used in electric blankets, the maximum temperature of the heating ribbon 12 should not exceed about 300° F.

From the foregoing, it will be seen that the layer of temperature-sensitive resistance material could be applied as an overall coating 15a to both sides of the heater conductor 14a as shown in FIGURE 2. Since two layers of temperature-sensitive resistance material would appear between the convolutions of the heater conductors 14a, each layer 15a would have one-half the thickness of the layer 15 shown in FIGURE 2.

Conventional methods of manufacture may be used for the production of the heater wire of this invention. For example, copper foil may be plated with silver and the silver then may be converted to silver-sulphide by treatment with heated sulphur vapor or hydrogen sulphide. A coating of semi-conductor particles in a resin base may be applied to a continuous strip of metal foil by passing the foil through an agitated solution of the coating material and then through a vertical oven to cure the resin. Other known methods for applying semi-conductor resistance material to metal foil may also be used.

The heating ribbon 12 is tightly wound about the core 11 with an overlap of preferably 50 percent so that a considerable portion of each convolution of the ribbon 12 is in intimate surface contact with the successive convolutions. The insulating sheath 13 may be applied over the helically wound ribbon 12 by known extrusion methods.

While the invention has been illustrated and described in what is at present considered its preferred embodiments and has included certain details, it should be understood that the invention is not to be limited to the precise details herein illustrated and described since the same may be carried out in other ways falling within the scope of the invention as claimed.

What is claimed is:

1. An electric heater wire for use in electrically heated fabrics comprising a flexible electrically insulating core; a ribbon helically wound about said core with successive convolutions thereof in overlapping relation; a portion of each convolution of said ribbon being in intimate surface contact with the successive convolution; said ribbon including a flexible ribbon-like heater conductor of metal foil and a substantially uniform layer of flexible resistance material in continuous intimate surface contact with said heater conductor; said resistance material having a high negative temperature coefficient of resistance so as to be essentially an electrical insulator at normal operating temperatures and at a higher temperature becoming an electrical conductor of low resistance value which will permit the flow of appreciable electric current therebetween with successive convolutions of said heater conductor; and a tubular sheath of insulating material closely surrounding said ribbon.

2. An electric heater wire according to claim 1 wherein said resistance material is essentially an electrical insulator at a temperature of about 110° F. and becomes appreciably conductive at a temperature materially greater than 110° F. but below 300° F.

3. An electric heater wire according to claim 1 wherein said resistance material is silver-sulphide.

4. An electric heater wire according to claim 1 wherein said layer of resistance material consists of a coating upon said heater conductor of a dispersion of finely divided temperature-sensitive material in a silicone resin.

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