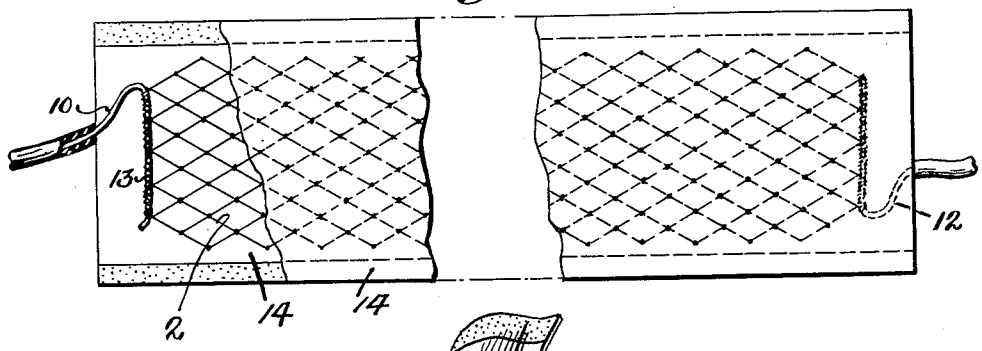
March 10, 1953 C. T. SUCHY 2,631,219

ELECTRICAL HEATING ELEMENT

Filed May 6, 1949

Fig. 1



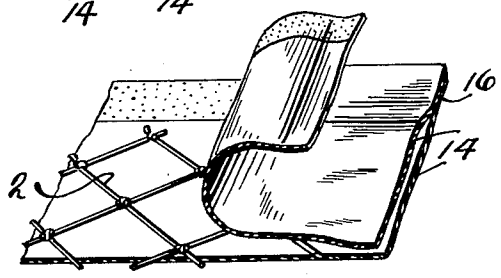


Fig. 2

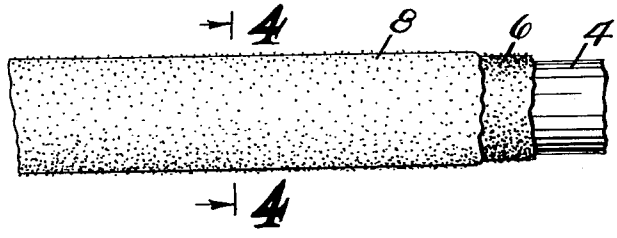


Fig. 3

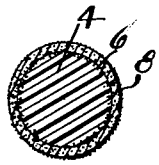


Fig. 4

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Patented Mar. 10, 1953

2,631,219

UNITED STATES PATENT OFFICE

2,631,219

ELECTRICAL HEATING ELEMENT

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Application May 6, 1949, Serial No. 91,711

2 Claims. (Cl. 219—46)

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My invention relates to an improvement in electrical heating elements and has for one of its objects to provide a heating element which is negligible in weight, flexible to a maximum extent, and capable of being attached to an object to be heated by sewing, cementing, stapling, etc., and if it is to be detachable it may be attached to the object by snap fasteners, for example. My improved element is of such construction that it may be made in various shapes and sizes so as to adapt it for use with a vast variety of objects to be heated.

By way of example, but not by way of limitation, I may mention that my heating element is well adapted for use in connection with heated clothing, such as wearing apparel, heating pads, blankets, etc., wall papers for room heating purposes, draperies, etc., and with gun barrel sheaths, engine covers, air-foil de-icing equipment, etc.

I am aware, of course, that heating elements have been applied to electrically heated clothing, for example, long prior to my invention but that in these prior constructions, it is customary to employ wire for the heating elements. These elements, however, are inherently stiff and bulky and their life is relatively short if the object to which they are attached is subjected to a great deal of bending and flexing stresses, such as met with, for example, in heated flying suits. Then, again, these elements are relatively heavy so as to render them unsatisfactory for use in situations where weight is a factor to be taken into consideration.

I am aware, also, that it has been suggested to employ electrically conductive plastic compositions, such as a mixture of rubber and carbon particles. While this material in some respects is more acceptable than wire, yet it, too, is unsatisfactory owing to the great difficulty in producing a sheet of uniform electrical resistance so as to avoid the danger of hot spots in operation with resultant breakdown. While such material is fairly flexible, it may not be folded or creased with impunity without the risk of detrimentally affecting the electrical resistance of the sheet and tending to the development of failures in the elements.

My invention provides a heating element in which the drawbacks and shortcomings of the prior structures have been eliminated. My improved heating element is as flexible as the material to which it is applied, does not add appreciable weight and the development of hot spots in the heating element apparently is eliminated completely.

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More specifically, the heating element I employ is composed of nylon fabrics which may be knitted, netted or woven, the nylon being impregnated with a metal, such as silver or copper, and dressed with gelatine, rice starch, cellulose lacquer, etc. The nylon is confined between very thin sheets of a suitable plastic, such as polyvinylchloride, for example, or other very flexible plastic capable of withstanding the heat of the element without deterioration. These plastic sheets are sealed to each other, heat sealed, for example, with the treated nylon confined between them. Suitable provision is made at the ends of the element for electrical connections.

Nylon is a material defined scientifically as synthetic fiber-forming polymeric amides having a protein-like chemical structure (The Condensed Chemical Dictionary, Reinhold Publishing Corporation, third edition, 1942).

It will be appreciated from this general description that the heating elements may be made up in any length and shape desired and due to their flexibility may be attached to the material of the clothing or other object to be heated by sewing, stapling, cementing, or in other fashion, if they are to remain permanently in place. On the other hand, the elements may be attached to the object by snap fasteners, for example, so as readily to be removable.

In the preparation of my improved heating element, the nylon as it comes from the manufacturer is first thoroughly scoured in boiling water for at least one hour to remove all dressings and chemical impurities.

The thoroughly clean nylon is then immersed in an aqueous solution of stannous chloride, after which it is washed and then impregnated by immersion in a colloidal metal solution and a reducing agent.

A suitable stannous chloride solution is one containing 2–3 grammes of stannous chloride to one litre of distilled water.

As above mentioned, I may impregnate with any suitable metal, as silver or copper, and in the impregnating step the nylon is immersed in a colloidal solution of the metal to be used and a reducing agent. If silver is to be used as the impregnating metal, a suitable solution of the same may be prepared by dissolving 200 grammes of silver nitrate in 1 litre of distilled water and adding an aqueous solution of ammonia of specific gravity of 0.88 to 0.90 until the initial precipitate is just dissolved. 100 grammes of caustic soda is then added and the precipitate just formed redissolved by adding slowly a very dilute ammonia

solution, for example, 100 cc. of 0.88 solution diluted with distilled water to, say, 20 litres.

The reducing solution may be prepared by dissolving 90 grammes of commercial cane sugar in 500 cc. of distilled water, adding 4 cc. of nitric acid of specific gravity 1.4 and heating for a few minutes at 90–95° C. The solution is cooled before using.

About 1/20 of a litre of this solution is required for each litre of the silver solution, the two being mixed only immediately prior to the immersion of the nylon therein.

In the impregnating step, the nylon is immersed in the mixture of metal solution and reducing agent, the nylon and/or the impregnating bath preferably being agitated.

It will be appreciated that at the completion of the impregnating step the interstices and voids of the threads of the nylon for a distance beneath the surface of each thread will have been filled with precipitated metal and that the thread will be coated with precipitated metal.

After removal of the metal impregnated and coated nylon from the impregnating bath the nylon is dried and then dressed, as by spraying, for example, with a suitable dressing such as gelatine, rice starch, cellulose lacquer, etc.

The nylon is then placed between two thin layers of flexible plastic, of which polyvinylchloride is an example, which are sealed, as by heat sealing, for instance, about the edges of the nylon.

The electrical conductors are then attached to the nylon and the element is then ready for use.

As above mentioned, I may employ copper as the impregnating metal, in which case I will use one of the well known colloidal copper solutions and a suitable reducing agent.

I have found electrical heating elements as thus produced to be particularly well adapted for use in connection with objects which are extremely flexible and in some instances are rather fragile in construction. The treated nylon is remarkably uniform so far as electrical resistance is concerned, and this characteristic seems to be unaffected by flexing, creasing, etc., and the development of hot spots even after long continued use of the element is avoided.

I have had tests conducted in connection with my improved electrical heating element wherein I have had an element composed of treated nylon netting run for 200 hours at 24 watts per square foot, giving a temperature of 125° F. without any deterioration whatever and without the development of hot spots. I have also had attempts made to overload such an element to find at what limit it would break down. When the current overload was 72.7%, at which time the surface temperature had risen to 235° F., the plastic sheets, between which the netting was sandwiched, began to break down so that this test had to be discontinued.

As above pointed out, it is of great importance in electrically heated clothing and de-icing equipment that the heating element be able to stand up under continued flexing and even under distension. An elasticity test of my improved element showed that the element did not sever until it was distended to 162.5% of its original length.

A flexing test was conducted by attaching the middle of the element to the needle of a sewing machine; for 200,000 cycles the increase in resistance was but 3.7%.

In the accompanying drawings:

Fig. 1 is a fragmentary plan view of one of my improved heating elements;

Fig. 2 is an enlarged fragmentary view of a portion of the element illustrated in Fig. 1;

Fig. 3 is an elevational view, on a very much enlarged scale of a piece of the treated nylon thread; and

Fig. 4 is a section through Fig. 3 taken on the line 4—4.

Referring to the drawings in detail:

2 designates the base material of the element, illustrated as nylon netting, although nylon fabric may be employed if desired. I have employed a nylon thread of 45 denier for the netting with excellent results.

The netting as it is received from the manufacturer is thoroughly scrubbed in boiling water so as certainly to remove all dressings and chemical impurities from the nylon.

The netting, as above pointed out, is then immersed in a stannous chloride solution and after removal and washing in water is impregnated and coated with metal by immersion in a colloidal metal solution and an appropriate reducing agent. The impregnating step takes about twenty minutes and can be accurately controlled so as to ensure that the nylon has the desired characteristics. In this step, minute metal particles are deposited within the nylon and upon the surface of the same. In Figs. 3 and 4 I have designated one of the nylon threads as 4 and the precipitated metal particles as 6. This treatment renders the nylon electrically conducting.

The netting in this condition is dressed, as by spraying, dipping, or other method, with a suitable dressing, such as gelatine, rice starch, cellulose acetate, etc., designated 8.

The electrical conductors 10 and 12 may now be attached to the netting, or this may be done later. The conductors may readily be attached to the netting by wrapping the end of the netting about the bared conductor and then binding with a thin wire 13.

The element is now enclosed or sandwiched between two strips of a suitable flexible non-electrically conducting material 14. I have used thin plastic strips of polyvinylchloride with good results. These strips are secured to each other about the edges of the nylon strip 2 as shown at 16, by heat sealing, cementing, etc.

It will be understood that the heating elements may be of any shape and size desired. It is usual to make them in elongated strips of any convenient length. They may be attached permanently to the object to be heated by stitching through the edges of the plastic strips 14, for example, or they may be attached by snap fasteners if it is desired to have them removably attached.

As far as the number and relative arrangement of the elements in a given instance are concerned, this is a matter of choice. For example, in incorporating the elements in a flying suit I have employed six elements, each 7 feet, six inches long, which were attached to the inside of the suit, the elements being arranged in parallel in the body of the suit, three on each side and extending from the ankle over the shoulder and down to the middle of the back. In addition, one element extended along the interior of the back of each leg, up to the sleeve and an element was attached to the interior of each arm in the form of a helix.

Electrically heated socks and gloves can be made up in similar fashion with electrical stud connections to the heating elements of the garment body.

It will be understood that the elements may be attached in any convenient location to the object to be heated and that thermostats may be provided at any point or points desired automatically to open the circuit of the elements when a predetermined temperature has been reached.

It is to be understood that changes may be made in the details of construction and arrangement of parts hereinabove described within the purview of my invention.

What I claim is:

1. An electrical heating element comprising a flexible strip consisting of nylon netting into and upon which metal particles have been precipitated out of solution, a sheet of electrically non-conductive flexible plastic material at each side of said netting, said sheets being heat sealed to each other about their edges and means for connecting the netting in an electric circuit, said means comprising a conductor about which a portion of the netting is wrapped and bound thereto.

2. An electrical heating element comprising a flexible strip consisting of nylon netting into and upon which metal particles have been precipitated out of solution; a coating for said netting of an electrically non-conductive, flexible material; a flexible sheet of polyvinylchloride at each side of the coated netting, said sheets being

heat-sealed to each other about their edges; and means for connecting the netting in an electric circuit comprising an electric conductor about which a portion of the netting is wrapped.

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