Aug. 24, 1943. S. ADAMSON 2,327,756

ELECTRICALLY CONDUCTIVE FABRIC

Filed Oct. 15, 1941

Fig. 1

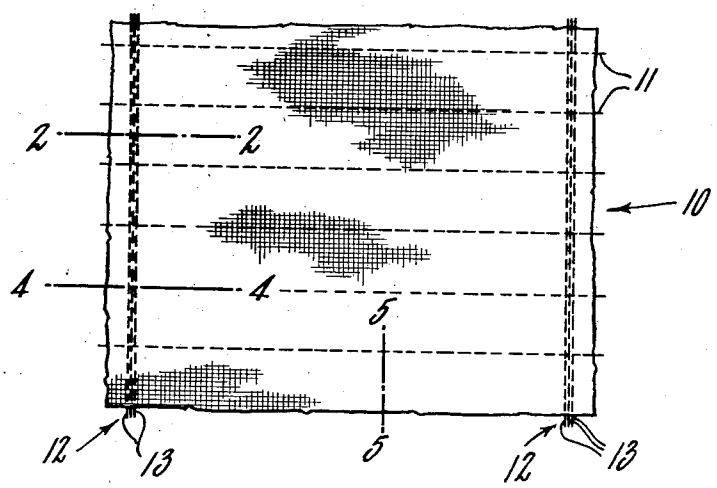


Fig. 2

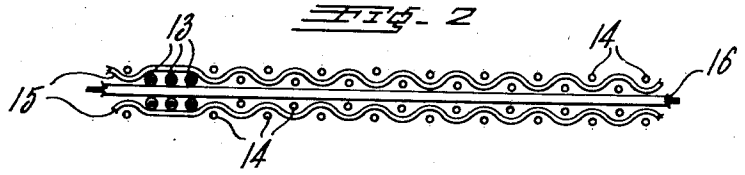


Fig. 3

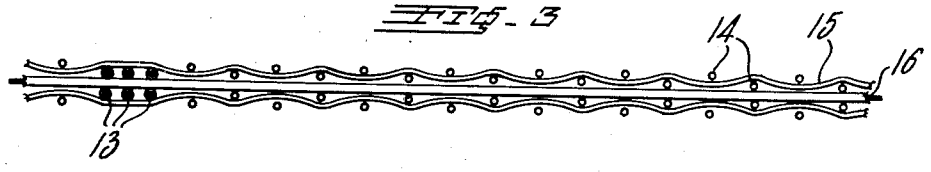


Fig. 4

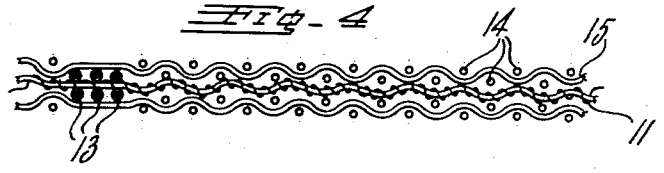
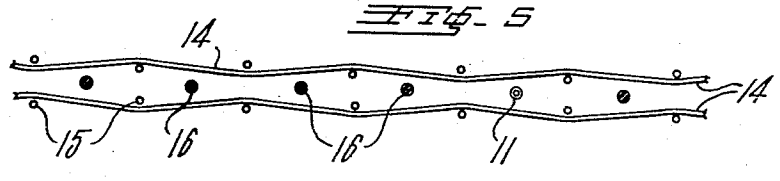


Fig. 5



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UNITED STATES PATENT OFFICE

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ELECTRICALLY CONDUCTIVE FABRIC

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11 Claims. (Cl. 219—46)

This invention relates to a soft, flexible, textile fabric having electrical conductors embodied therein, primarily for the purpose of heating the fabric.

It has been proposed heretofore to heat fabrics electrically by securing electric heating wires to a face of the fabric or by introducing such wires in the body of the fabric. These heating wires have usually been folded back and forth in successive runs so that each wire served to heat a substantial portion of the fabric.

These prior constructions are open to the objection that the heating wires render the fabrics relatively stiff, and if a wire breaks a relatively large area of the heating element for the fabric is rendered inactive. While these prior electrically heated fabrics work fairly well in outer garments they are not at all well adapted for use in undergarments, since undergarments should be soft and flexible and should stretch and contract with the body movement, and these prior constructions lack these properties.

One important feature of the present invention resides in a soft, flexible woven fabric having fine heating conductors woven in the interior of the fabric so that their presence is hardly discernable so far as the feel and appearance of the fabric is concerned.

Another feature resides in the construction whereby the fine heating conductors are spaced near enough to each other to produce a nearly uniform heating action in a thick warm fabric, and each heating conductor is independently connected to two conductor leads so that if any heating conductor fails it will not render inactive the adjacent heating conductors.

Another and extremely important feature of the present invention resides in the construction whereby an electrically heated elastic fabric having a substantial range of stretch is provided. Such an elastic fabric is peculiarly well adapted for use in electrically heated undergarments, since garments made of this material may be constructed to fit snugly but comfortably and will stretch and contract with the body movement, and when supplied with electric energy will furnish the body with additional heat.

The above and other features of the invention will be more fully understood from the following description when read in connection with the accompanying drawing illustrating one good practical embodiment thereof.

In the drawing,

Fig. 1 is a plan view of an electrically heated elastic fabric constructed in accordance with the present invention;

Fig. 2 is an enlarged sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 2 except that the fabric is shown as stretched in Fig. 3;

Fig. 4 is an enlarged sectional view taken on the line 4—4 of Fig. 1, and

Fig. 5 is an enlarged sectional view taken on the line 5—5 of Fig. 1.

Certain features of the present invention may be embodied in a non-elastic fabric but the invention has been developed primarily for use in an elastic fabric. In either case, the fabric which is provided with the electric conductors as herein contemplated is preferably given substantial thickness so that the conductors, or at least those which constitute the heating elements, may be completely concealed in the interior of the fabric so that they will not be exposed at either surface thereof.

The fabric 10 illustrated in the drawing has a substantial stretch in the direction of its weft, preferably not less than 25% and may be as high as 60% or more. The conductors 11 which constitute the heating elements extend transversely of the fabric in spaced relation to each other as shown, and are woven in the fabric as weft. These conductors are supplied with heating current by causing them to engage the spaced conductor leads 12 which are woven in the fabric as warp.

While the conductor leads 12 should be sufficiently small and flexible to avoid making the fabric 10 stiff they should be capable of carrying sufficient current to operate the various heating elements 11 that are arranged electrically in parallel relation between the conductors 12. Therefore each conductor lead 12 is preferably formed of a group of small wires 13 as shown in Figs. 2 and 3 so as to avoid appreciably increasing the stiffness of the fabric. In the construction shown, each conductor lead 12 is formed of six small wires 13 which are preferably arranged so that they lie at each side of the heating wires 11 and contact therewith as in Fig. 4, to thereby provide a good electrical contact between the conductors 11 and 12.

The wires 13 are preferably formed of copper because of the high conductivity of this metal and while round wires may be used, it is deemed preferable to use the copper tinsel yarn shown consisting of a cotton yarn having a fine copper ribbon wound helically about the yarn.

The heating conductors 11 are preferably

formed of a metal of lower conductivity than copper so that a relatively short length of wire will give the desired heating action. "Nichrome" is well adapted for this purpose and is preferably employed in the form of a tinsel in which a fine "Nichrome" ribbon is wound around a cotton yarn.

The fabric 10 is preferably constructed with an unusually large number of warp threads 14 per inch to thereby increase the thickness of the fabric so that the heating conductors 11 may be entirely concealed in the interior of the fabric as will be more fully described.

In order to make the fabric 10 stretchable transversely it is woven of elastic and non-elastic weft threads preferably in the ratio of two non-elastic wefts 15 to each elastic weft 16 as shown in Fig. 5 and the heating conductors 11 are introduced in the fabric as individual wefts at the desired distance from each other.

The weave shown in the drawing is a two-ply construction in which each ply is formed of the warps 14 and non-elastic wefts 15 with the elastic wefts 16 lying in a straight line between the two plies, and these plies are secured one to the other between the rows of elastic wefts 16 by causing some of the warps 14 to pass from one ply into the other.

This elastic ply fabric is woven in the stretched condition and when removed from the loom is allowed to contract. The elastic threads 16 lie in a straight condition at the center of the fabric when the fabric is stretched as in Fig. 3 and also when contracted as in Fig. 2.

An important feature of the present invention resides in the construction whereby the heating conductors 11 are so woven into the fabric that they are normally retained by the weave in a crimped condition as shown in Fig. 4 so that these conductors can straighten out a substantial amount as the fabric is stretched. As a result of this construction the elastic fabric may stretch and contract repeatedly without disturbing the proper operation of these heating conductors 11 to heat the fabric when stretched or relaxed.

This is accomplished by merely introducing a conductor 11 in the fabric, where desired, in place of an elastic thread 16, by inserting the conductor so that it will lie in a straight extended condition as the fabric is woven, but so that when the fabric is allowed to contract these electric conductors will be crimped as shown in Fig. 4. It is this construction that permits the elastic fabric to stretch and contract repeatedly without injuring the heating conductors 11, and the tinsel construction of these conductors gives them greater softness and flexibility than a solid wire, and will not injure a sewing machine needle.

While a fabric embodying the features of the present invention may be variously constructed, and may be formed of any of the well known or preferred yarns depending largely upon the nature of the use of the same, it has been designed more particularly for use in electrically heated undergarments adapted to be worn by aviators flying at high altitudes and by other persons who are exposed to low temperatures while near a source of electric energy suitable for supplying the heating current to the fabric. When the present fabric is used in an undergarment which is worn next to the body, the face thereof which contacts the body is preferably napped or given a fleeced finish. The elastic property of the present fabric is highly desirable in such undergarments since it enables the garments to be made so that they will fit the wearer snugly and comfortably while at the same time they will stretch freely to accommodate his movements, and such a garment will retain its shape for a long period without bagging. When the fabric 10 of Fig. 1 is embodied in a garment or otherwise used it should be so constructed that the length of the wires 11 extending between the conductor leads 12 will have sufficient resistance to provide the desired amount of heat when a different electric potential of preferably not over 24 volts is maintained between the two conductors 12 shown.

One good practical example of an electrically heated elastic fabric embodying the features of the present invention has the following construction:

Warp

The body of the fabric is formed of 230 warp ends per inch of 1/21.10/2 ply spun blend of 65% viscose rayon staple and 35% wool. Six ends of copper tinsel yarn forming a warp group are introduced at two or more points at approximately ten inches apart in the present case, to form the conductor leads. The selvage edges may be formed as desired.

Weft

Formed of 81.5 picks per inch consisting of:

54.6 picks of 1/36.00/2 ply spun blend of 65% viscose rayon staple and 35% wool.
26.1 picks of elastic yarn.
0.8 picks of "Nichrome" covered cotton yarn—4560 yards to the pound.
The heating element comprising a cotton yarn having a fine ribbon of "Nichrome" wound thereupon had a resistance of 12.8 ohms per inch in the unstretched fabric.
The present fabric had a 30% stretch.

Fabric weight

23.4 ounces per square yard.

Heating tests

24 volts circuit, one-half ampere in 10 minutes created a temperature of 116 to 118 degrees F. in the fabric.
No scorching of this fabric appeared as long as the circuit was kept below 45 volts.

In the construction shown in the drawing the conductor leads 13 are covered only by the weft threads 15. Should it be desired to cover these conductors more completely with insulating material, this may be done by providing asbestos warp threads (not shown) which will overlie the conductors 13 at both sides of the fabric. Another way of covering these conductors is to deposit a stream of plastic latex composition over the conductors in the form of a strip or ribbon extending lengthwise of the fabric. The fabric 10 is also preferably treated so as to render it both flame repellent and water repellent, and the selvage or side edges of the fabric may be covered with binding tape or otherwise.

It is to be understood that the term "elastic thread" as used herein in the specification and claims is to be construed as meaning a thread formed partly or entirely of rubber or rubber-like plastic material, and that the term "elastic fabric" is to be construed as meaning a fabric embodying such "elastic thread" in its construction.

While as above stated the elastic feature of the present electrically heated fabric is considered extremely important, it is not essential in

all embodiment of the invention and in some cases it may be desirable to use ordinary non-elastic threads in place of the elastic threads 16 to thereby produce a non-elastic conductive fabric.

Having thus described my invention, what I claim and desire to protect by Letters Patent is:

1. A woven electrically heated elastic fabric having a substantial stretch, formed of interwoven textile and elastic threads and having woven in the fabric at spaced intervals as warp or weft heating conductors that normally are held by the fabric weave in a crimped condition whereby these conductors can straighten out at least 25% as the fabric is stretched, and conductor leads extending across and contacting said heating conductors for supplying an electric current thereto.

2. A woven electrically heated elastic fabric having a substantial stretch, formed of interwoven textile and elastic threads and having woven in the fabric at spaced intervals as warp or weft heating metal conductors that normally are held by the fabric weave in a crimped condition whereby these conductors can straighten out at least 25% as the fabric is stretched, and spaced conductor leads for supplying an electric current to said heating conductors.

3. A woven electrically heated elastic fabric having a substantial stretch, formed primarily of interwoven non-elastic and elastic threads and having woven in the fabric in one direction spaced conductor leads and woven in the fabric at right angles thereto spaced heating conductors that contact the conductor leads and supply them with current, at least one set of said conductors being normally held by the fabric weave in a crimped condition whereby the conductors can straighten out a substantial amount as the fabric is stretched.

4. A woven electrically heated elastic fabric having a substantial stretch, formed primarily of textile and elastic threads interwoven to form a multi-ply fabric and having woven in the interior thereof so that they are not exposed and at spaced intervals to each other heating conductors that normally are held by the fabric weave in a crimped condition, whereby these conductors can straighten out a substantial amount as the fabric is stretched, and conductor leads for supplying an electric current to said heating conductors.

5. A woven electrically heated elastic fabric having a substantial stretch, formed primarily of elastic and non-elastic threads and having woven in the fabric at spaced intervals heating conductors that normally are held by the fabric weave in a crimped condition whereby these conductors can straighten out a substantial amount each time the fabric is stretched, and conductor leads extending across and contacting said heating conductors for supplying an electric current thereto.

6. A woven electrically conductive fabric having a substantial stretch, formed primarily of non-elastic and elastic threads and having woven in the fabric at spaced intervals electric conductors that normally are held by the fabric weave in a crimped condition whereby these conductors can straighten out a substantial amount each time the fabric is stretched, and means for supplying an electric current to said conductors.

7. An electrically heated woven fabric, formed primarily of interwoven fibrous threads and having woven in the fabric in one direction spaced conductor leads and woven in the fabric at right angles thereto spaced metal heating conductors that contact the conductor leads and are supplied by the latter with the heating current, each heating conductor being arranged to provide an approximately direct path between the conductor leads.

8. An electrically heated woven fabric, formed primarily of interwoven textile threads and having woven in the fabric in one direction spaced conductor leads and woven in the fabric at right angles thereto a number of spaced metal heating conductors that contact the conductor leads, each heating conductor being arranged to provide an approximately direct path between the conductor leads whereby it is independently supplied with current from the conductor leads.

9. An electrically heated woven fabric, formed primarily of textile threads interwoven to form a multi-ply fabric and having woven therein in one direction spaced conductor leads and at right angles thereto spaced metal heating conductors, the latter being positioned at the interior of the fabric so that they are not exposed and contact the conductor leads which supply the current, and each heating conductor being further arranged to provide an approximately direct path between the conductor leads.

10. An electrically conductive woven fabric, formed primarily of interwoven textile threads and having woven in the fabric in one direction spaced conductor leads and woven in the fabric at right angles thereto a number of spaced metal conductors that contact electrically with said conductor leads, each of said spaced metal conductors being arranged to provide an approximately direct path between the conductor leads.

11. A woven electrically heated elastic fabric having a substantial stretch, formed primarily of non-elastic and elastic threads and having woven in the fabric at spaced intervals electric conductors that normally are held by the fabric weave in a crimped condition whereby these conductors can straighten out a substantial amount each time the fabric is stretched, each of said conductors having the form of a highly flexible tinsel comprising a textile core with a fine metal ribbon wound thereupon, and means for supplying an electric current to said conductors.

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