July 3, 1945. J. A. HENDLEY 2,379,580

ELECTRICALLY-HEATED FABRIC

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Fig. 1.

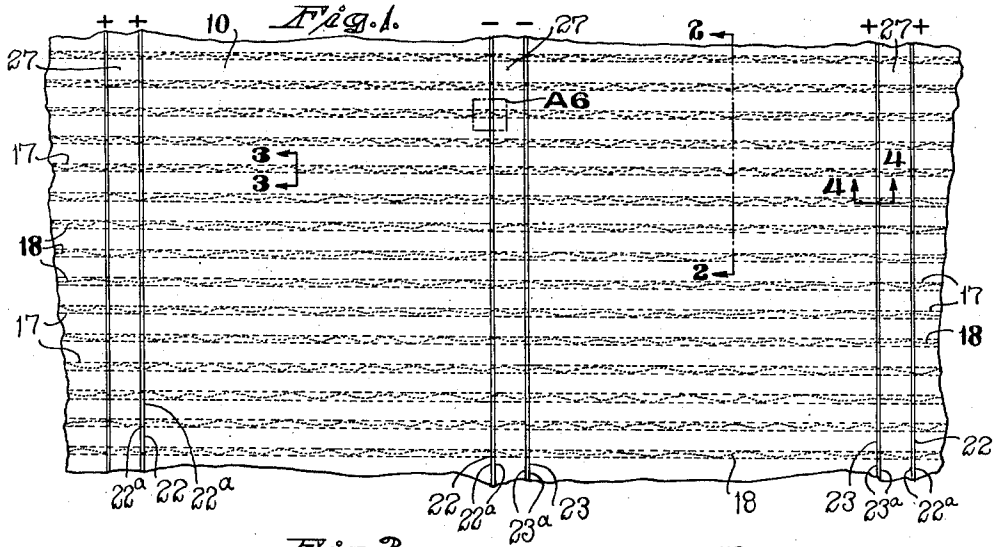


Fig. 2.

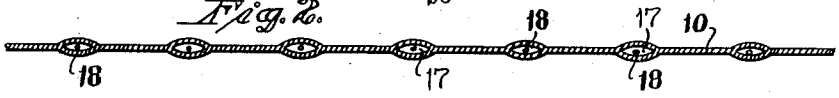


Fig. 3.

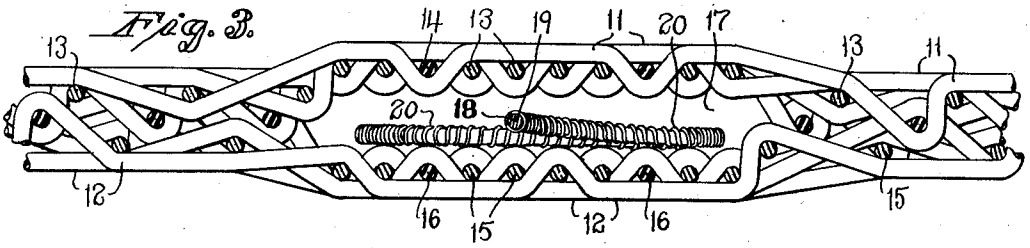


Fig. 5.

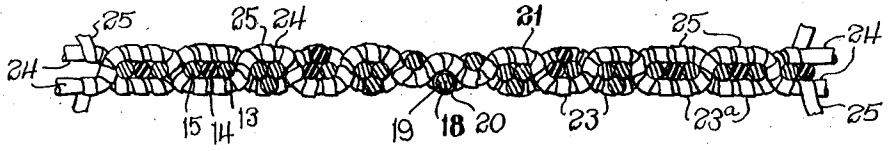
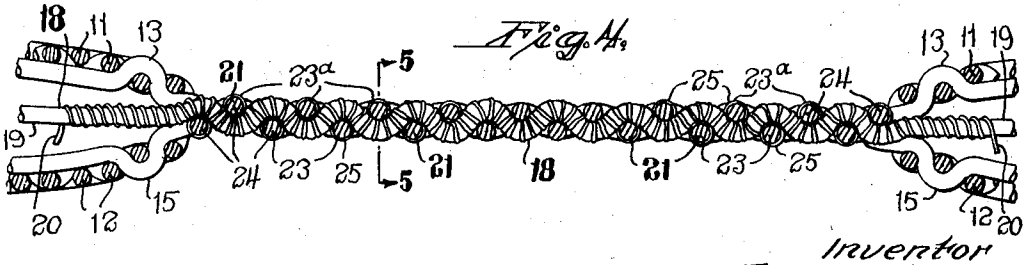


Fig. 4.



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Fig. 6.

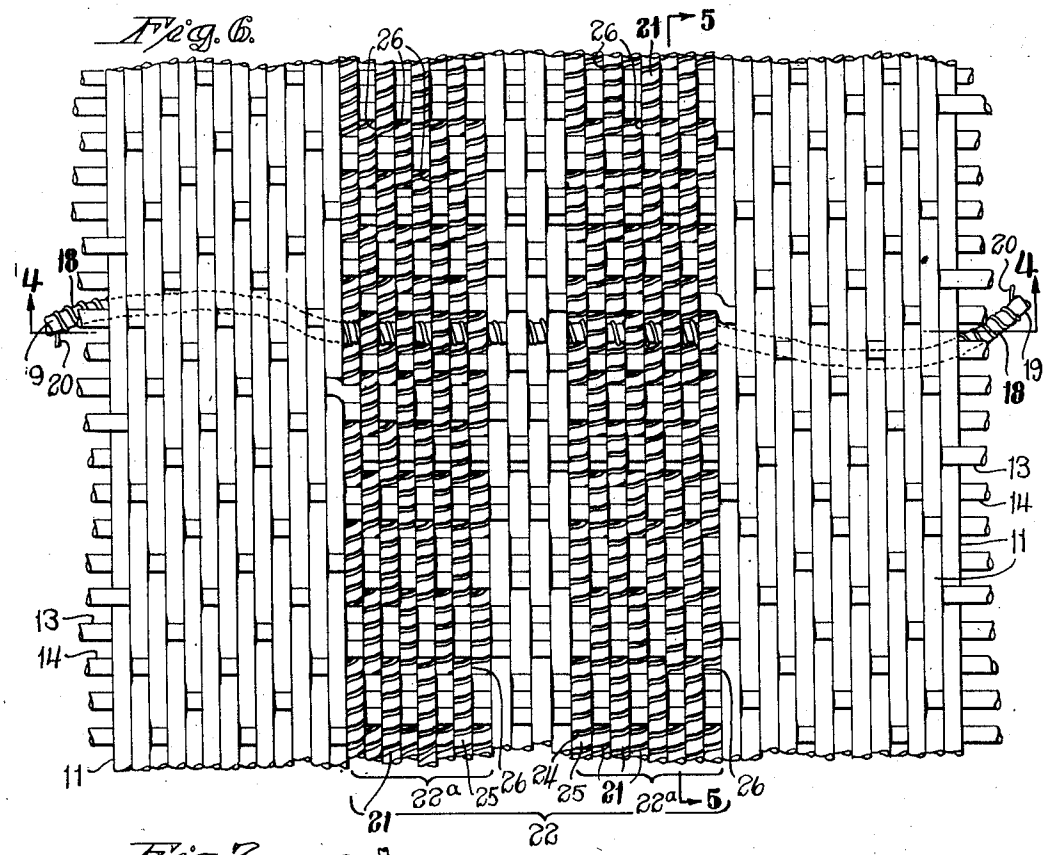


Fig. 7.

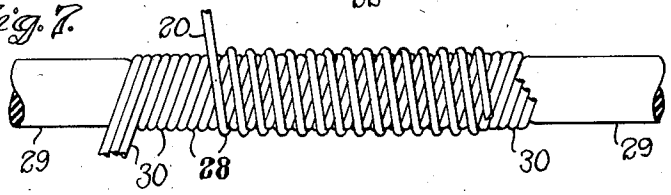
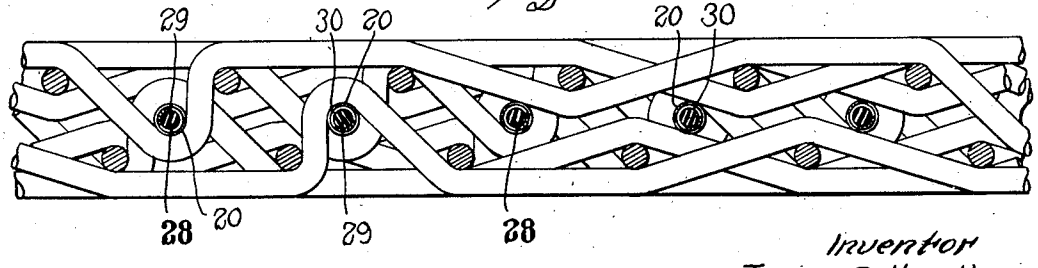


Fig. 8.



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UNITED STATES PATENT OFFICE

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ELECTRICALLY HEATED FABRIC

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Application November 25, 1942, Serial No. 466,843

3 Claims. (Cl. 219—46)

This invention relates to improvements in electrically-heated fabrics.

One object of this invention is to provide an improved electrically-heated fabric which can be manufactured in any desired length which can afterward be cut into shorter lengths for making up into garments or for other uses.

Another object of this invention is to provide an improved electrically-heated fabric which can be readily manufactured on looms and other fabric-making machinery.

Another object of this invention is to provide an improved electrically-heated fabric characterized by its great flexibility and substantial freedom from breaking of the heating elements, due to flexing of the fabric.

Another object of this invention is to produce an improved electrically-heated fabric which is both flexible and elastic, whereby it can be readily made into garments which closely fit the body and readily permit of flexing of parts of the body during the wearing of the garment.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

In the accompanying drawings forming part of the present disclosure, in which certain ways of carrying out my invention are shown for illustrative purposes:

Fig. 1 is a face view of an electrically-heated fabric illustrating one embodiment of the present invention;

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

Fig. 3 is an enlarged conventionalized sectional view on line 3—3 of Fig. 1;

Fig. 4 is an enlarged conventionalized sectional view on line 4—4 of Figs. 1 and 6;

Fig. 5 is an enlarged sectional view on line 5—5 of Figs. 4 and 6;

Fig. 6 is an enlarged face view of the fragmental portion of the fabric indicated in dotted line outline at A6 in Fig. 1;

Fig. 7 is an elevational view of a modified form of resistor-strand; and

Fig. 8 is a sectional view similar to Fig. 3, of a modified form of fabric employing the modified resistor-strand shown in Fig. 7.

In the description and claims, the various parts and steps are identified by specific names for convenience, but they are intended to be as generic in their application as the prior art will permit.

In carrying out the invention in the way illustrated in Figs. 1 to 6 of the drawings, the fabric base or fabric 10 is mainly formed by weaving longitudinal or warp strands 11 and 12 with transverse or weft or filling picks or strands 13, 14, 15 and 16. The threads or strands 11, 12, 13 and 15 are preferably of cotton, wool, or other textile fiber strand, and the strands 14 and 16 are preferably of rubber or other suitable elastic material which may be thread-wrapped in any way well known in the art. The fabric shown consists of two plies which are bound together except at the locations where the two plies are separated to form ducts or channels 17 which extend across the fabric. While the term "across" the fabric in the particular construction illustrated extends parallel to the weft, it is not intended to necessarily give this limited meaning to this term, the term being used merely for convenience to indicate that the ducts extend from one margin of a fabric to another margin directly opposite.

In each duct 17 an electric resistor-strand 18 is placed, each strand 18 consisting of a central core-strand of cotton 19, about which is helically wrapped a metal conducting-wire strand 20 of any suitable conductive metal, such for example as nichrome which both has high resistance and retains a bright untarnished surface. None of the warps 11, 12 are interlaced or interwoven with the resistor-strands 18, but electric lead-strands 21 arranged in pairs of spaced-apart groups 22, groups 23, etc., are interwoven with the resistor-strands 18 and with the weft picks 13, 14, 15, 16, as clearly shown in Figs. 3, 4, 5 and 6. While each of the groups of lead-strands could consist of a single strand, it is preferred to have each of them consist of a group of strands. In the particular example illustrated, each group consists of sixteen strands separated into two near-together sub-groups 22*a*, 23*a*, etc., of eight strands each, each lead-strand 21 having a cotton core 24 about which is helically wound a wire 25. Preferably, the wires 20 are round and the wires 25 are flat in the form of tinsel.

The fabric is woven while stretched in the direction of the wefts or filling strands to a suitable extent which may amount to 50% or more, and since the resistor-strands 18 are substantially non-elastic, when the woven fabric is released from the loom and contracts, the resistor-strands 18 assume an undulated or wrinkled form in the contracted or shortened ducts 17, somewhat as illustrated in Fig. 1. It would be possible to weave the fabric as an ordinary fabric with

the resistor-strands 18 tightly woven in as the other wefts are woven in the fabric, but to do this in an elastic fabric having rubber weft strands as in the present case, would result in such considerable wrinkling of the non-elastic weft resistor-strands as to cause objectionable wrinkling or sticking out transversely of the general plane of the fabric, whereas by providing each duct 17 of a size considerably greater than the diameter of each of the resistor-strands 18, when the fabric is permitted to contract from its stretched condition, the strands 18 take an undulating or back-and-forth arrangement in the ducts in the general plane of the fabric without poking out transversely of the fabric to any substantial extent, to thus provide a neater appearing fabric.

The tinsel or wire 25 wound about each of the electric lead-strand cores 24 preferably is of high conductive metal such, for example, as copper, which may have a tin, cadmium or other coating or plating to maintain a bright untarnished surface providing good electrical conductivity. This is desirable in view of the mode of interlacing of the resistor-strands 18 with the conductor- or lead-strands 21, since the conducting of electricity from the lead-strands to the resistor-strands is brought about by contact of the surfaces of the metal wires of the lead-strands and resistor-strands. The successive convolutions of the tinsel 25 are preferably wound sufficiently close to one another so that under all or most circumstances, where each lead-strand crosses and presses upon a resistor-strand, the tinsel 25 of the lead-strand will be in contact with the wire 20 of the resistor-strand.

In any given group of lead-strands such as illustrated concerning the group 22 of lead-strands 21 in Fig. 6, where these cross one another in being woven back-and-forth through the fabric at such locations as 26, those in a sub-group jam transversely against one another and thus each lead-strand in the sub-group is in good electrical contact directly or indirectly with each adjacent lead-strand or strands of the sub-group. It will be clear that by thus providing a group of lead-strands, not only is maximum flexibility provided in the lead-strands which can have considerable current-carrying capacity in order to feed sufficient current to any desired or necessary number of resistor-strands 18, all of which resistor-strands are connected in parallel across between each two groups of lead-strands, but if any strand of a sub-group of lead-strands breaks, the other lead-strands of the sub-group are amply able to carry the necessary current to the resistor-strands 18.

The groups of electric lead-strands are placed at such distance apart as to give a proper degree of heating to the resistor-strands 18. In the case, for example, of suits of aviators to be made of the present fabric and to be heated, the maximum number of watts per square foot of cloth is considered to be 36 watts. Aviators' suits on airplanes have available for heating, direct current supplied at 24 volts, although it will be appreciated that by suitably proportioning the electrical conductor parts to be employed, the heating can be accomplished by any other voltage of current within reason.

While a fabric could be woven having only two groups of lead-strands adjacent its opposite side edges, inasmuch as such a construction would ordinarily result in a relatively-narrow fabric, it may be found preferable to weave a series of fabric areas side by side by running one or more pairs of additional groups of lead-strands. The space 27 between the pairs of groups of lead-strands can be as small as may be desired. If it is desired to slit or cut the fabric into strips by cutting it lengthwise in the space 27 between the pairs of groups of lead-strands, there will be enough of the raw edges of the adjacent fabric portions to permit of hemming or otherwise finishing these edges without interfering with the electrical characteristics of the groups of lead-strands. Also, if desired, the fabric can be employed in its full width without cutting or slitting longitudinally. In such case, each two closely-adjacent groups of lead-strands on opposite sides of a space 27 would be connected to one pole of the current which could for example be the negative pole, as indicated in Fig. 1 by the negative signs, and the other groups of lead-strands would be connected to the positive pole of the battery in order that the current would have to traverse a proper space between each pair of groups of lead-strands for proper heating. In this mode of use, of course, the narrow area of fabric between two closely-adjacent leads 20 and 21 would not be heated, but by having the pairs of groups of lead-strands spaced the same distance apart as the distance between each two adjacent resistor-strands 18, this would result in the entire fabric being heated with the same degree of uniformity. The distance between the groups of lead-strands of a pair will ordinarily be such that the smallest part of a person, such for example as his arm, can be properly covered with a strip of the fabric which is only slightly wider than the distance between the two groups of lead-strands of a pair. In any given instance, having determined what distance one desires to have between the groups of lead-strands of a pair, the proper degree of heating per unit of area produced by the resistor-strands is accomplished by selecting a resistor-metal having a suitable resistance, and making it into a wire of suitable diameter and winding it with a suitable number of convolutions per inch of length upon a core-strand of suitable diameter. Thus, it will be seen that several factors can be varied whereby it is possible to vary the distance between the current-supplying pairs of groups of lead-strands to bring about any desired degree of heating per unit area of the fabric.

Electrical connections from the battery or other current source can be made to the fabric, or the garment can be made up from the fabric by any suitable or well-known means, thus one way would be to provide electrical conductors having U-shaped clamping-clips on their ends which can be bent down into firm opposed gripping engagement with a group of lead-strands or conductor-leads to provide pressure contact against the tinsel wrapping of the surface of the lead-strands, or when the fabric is woven, wefts could be omitted for a few inches of section every so often by pulling the warps forward to thus provide free portions of lead-strand tails for attachment to the current source in any desired way. Moreover, the lead-strands, instead of being interwoven with the cloth over its entire length, could be run along the surface for a few inches to thus provide a free portion of lead-strands which could be readily cut and connected to the current source. Or the fabric could be woven continuously as one length of fabric and have its length cut somewhat longer than needed and enough wefts unraveled out from one or both ends to provide a

suitable length of the groups of lead-strands for connection with the electric source in the way desired.

Instead of winding the nichrome or other resistance-metal wire **20** about a substantially-non-elastic thread such as cotton, as has been described concerning the resistor-strands **18**, an elastic resistor-strand **28** can be made by winding the nichrome or other metal wire **20** about a rubber or other elastic core-strand **29** which may have a wrapping of cotton or similar strands **30** intermediate the wire **20** and the core-strand **29**, as shown in Fig. 7. The strands **30** will ordinarily be wrapped on, while the rubber core-strand **29** is in stretched condition, to permit of giving a pre-tension to the rubber core-strand **29**, as it well known to those skilled in the art of elastic fabric weaving. Where such an elastic resistor-strand as shown in Fig. 7 is employed, it would not be necessary to weave ducts for the resistor-strands, it being only necessary to include the elastic resistor-strands **28** as weft strands interwoven with the warp strands of the fabric in the same way that the other weft strands or picks are interwoven, as shown in Fig. 8.

While it is preferred to make the electrically-heated fabric by weaving, and then manufacturing the woven fabric into blankets, and garments such as underwear, suits, gloves, socks and so forth, it will be appreciated that this improved fabric which includes a group of resistor-strands which are interlaced with spaced-apart electric lead-strand means each consisting of one or more strands, may be produced otherwise than by weaving.

If desired, a non-elastic fabric could be produced without the necessity of using any rubber weft strands or rubber-cored resistor-strands or lead-strands, by merely weaving a construction similar to that illustrated in Fig. 8. And if it was desired to produce a two-way-stretch instead of a one-way-stretch fabric, this could be done not only by employing rubber weft strands and rubber-cored resistor-strands such as are employed in the construction shown in Figs. 1 to 6, but by also employing rubber-cored lead-strands and employing a weave construction such as illustrated in Fig. 8, since it would be unnecessary to produce any ducts.

The electrically-heated fabric made in accordance with the present invention can be used for any heating purpose desired such, for example, as the manufacture of apparel of various sorts for aviators, divers, and so forth.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. An elastic electrically-heated flexible fabric comprising: an elastic flexible fabric base mainly formed of interlaced textile strands and providing ducts extending generally parallel to one another, and including elastic strands extending generally parallel to said ducts; said fabric and said elastic strands being stretchable longitudinally of said elastic strands and of said ducts; a flexible electric resistor-strand in each of said ducts and lying loosely therein in undulating arrangement in the general plane of the fabric when said fabric is in unstretched condition, the width of each said duct in the general plane of the fabric being more than twice as great as the diameter of the resistor-strand in such duct; and two spaced-apart flexible electric lead-strand means extending transversely across and electrically connected to said electric resistor-strands so that said electric resistor-strands are electrically connected in multiple.

2. An elastic electrically-heated flexible fabric comprising: an elastic flexible fabric base mainly formed of interlaced textile strands and providing ducts extending generally parallel to one another, and including elastic strands extending generally parallel to said ducts; said fabric and said elastic strands being stretchable longitudinally of said elastic strands and of said ducts; a flexible electric resistor-strand in each of said ducts and lying loosely therein in undulating arrangement in the general plane of the fabric when said fabric is in unstretched condition, the width of each said duct in the general plane of the fabric being more than twice as great as the diameter of the resistor-strand in such duct, each of the resistor-strands having a metal electric conducting-strand extending helically around a core-strand; and two spaced-apart flexible electric lead-strand means extending transversely across and electrically connected to said electric resistor-strands so that said electric resistor-strands are electrically connected in multiple, each of the lead-strands having a metal electric conducting-strand extending helically around a core-strand.

3. An elastic electrically-heated flexible fabric comprising: an elastic flexible fabric base mainly formed of interwoven textile weft strands and warp strands and providing ducts extending generally parallel to said weft strands, and including elastic strands extending generally parallel to said weft strands; said fabric and said elastic strands being stretchable longitudinally of said elastic strands and of said ducts; a flexible electric resistor-strand in each of said ducts and lying loosely therein in undulating arrangement in the general plane of the fabric when said fabric is in unstretched condition, the width of each said duct in the general plane of the fabric being more than twice as great as the diameter of the resistor-strand in such duct; and two spaced-apart groups of flexible electric lead-strands extending generally parallel to said warp strands, the lead-strands of each said group of lead-strands extending transversely across and being woven as warp strands into electrical engagement with said electric resistor-strands, each of said lead-strands having a metal electric conducting-strand.

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